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Intelligent Management of Pollution at Sea

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ABSTRACT

The Ocean is one of the major reasons why humans survive in this world. That is why the issue of ocean pollution is important and needs to be addressed as soon as possible. Ocean pollution is becoming a major problem. One such technology, namely ‘Artificial Intelligence’ (‘AI’), can be used to understand and monitor marine pollution, The AI systems have emerging opportunities and risks associated with the use of AI in managing marine environmental pollution through sustainability. To strengthen the argument, use-cases of AI in the marine environment and their scalability are discussed.

KEYWORDS

1. Intelligent Management of Pollution at Sea Using Artificial Intelligence (AI System)
2. Analysis of AI System
3. CNN The Working Algorithm of AI System
4. AI & Robotics in Ocean Pollution
5. Quantum Cascade Laser Imaging (LDIR) And Machine Learning for The Identification of Environmentally Exposed Microplastics And Polymers

INTRODUCTION TO MARINE POLLUTION

Marine pollution is a growing problem in today’s world. Our ocean is being flooded with two main types of pollution: chemicals and trash. Chemical contamination, or nutrient pollution, is concerning for health, environmental, and economic reasons. This type of pollution occurs when human activities, notably the use of fertilizer on farms, lead to the runoff of chemicals into waterways that ultimately flow into the ocean. The increased concentration of chemicals, such as nitrogen and phosphorus, in the coastal ocean promotes the growth of algal blooms, which can be toxic to wildlife and harmful to humans. The negative effects on health and the environment caused by algal blooms hurt local fishing and tourism industries. Marine trash encompasses all manufactured products—most of them plastic—that end up in the ocean. Littering, storm winds, and poor waste management all contribute to the accumulation of this debris, 80 percent of which comes from sources on land. Common types of marine debris include various plastic items like shopping bags and beverage bottles, along with cigarette butts, bottle caps, food wrappers, and fishing gear. Plastic waste is particularly problematic as a pollutant because it is so long-lasting. Plastic items can take hundreds of years to decompose. This trash poses dangers to both humans and animals. Fish become tangled

and injured in the debris, and some animals mistake items like plastic bags for food and eat them. Small organisms feed on tiny bits of broken-down plastic, called microplastic, and absorb the chemicals from the plastic into their tissues. Microplastics are less than five millimeters (0.2 inches) in diameter and have been detected in a range of marine species, including plankton and whales. When small organisms that consume microplastics are eaten by larger animals, the toxic chemicals then become part of their tissues. In this way, the microplastic pollution migrates up the food chain, eventually becoming part of the food that humans eat.

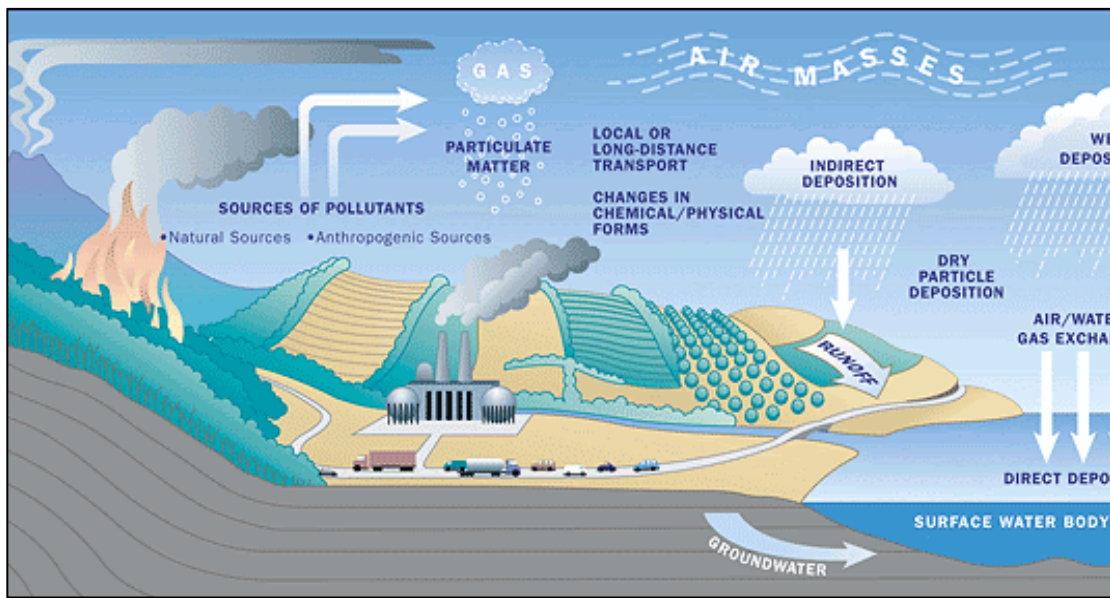


Fig 1. Intelligent Management of Pollution at Sea Using Artificial Intelligence (Ai System)

The marine environment has deteriorated to the extent that it has begun to impact human health and the planet itself. The primary causes of this deterioration are an increasing population, the Industrial Revolution, and the increased use of fossil fuels. While the damage done to the environment cannot be undone, the impact can be lessened with a better understanding of the ocean and with monitoring future pollution using technology. Such an effort will help achieve sustainability, as laid out by the Sustainable Development Goals 2030 of the United Nations. Though efforts have been made to monitor the ocean for pollutants, both physically and remotely, interpreting the data collected is a humungous task due to the high volume of data. In reply, technology again provides a solution. One such technology, namely ‘Artificial Intelligence’ (‘AI’), can be used to understand and monitor marine pollution, The AI systems have emerging opportunities and risks associated with the use of AI in managing marine environmental pollution through sustainability. To strengthen the argument, use-cases of AI in the marine environment and their scalability are discussed. However, these cases are considered merely a stimulus for a better and a larger variety of solutions to follow in the ever-evolving domain of AI.

The practical AI systems are AI flying drones and Underwater Autonomous Robots. The systems can be used in the detection of microplastics. Microplastics can enter in to human body while eating sea food. However, researchers suggested new approaches to microplastic detection with the help of ML methods. For example, one of the recently developed techniques for MP identification is based on advanced machine learning techniques and microscopy. In addition, AI has been trained to **identify plastic cells**.

ANALYSIS OF AI SYSTEM

How this AI system is changing the ocean clean up, by combining machine learning, satellite data, and drone technology, scientists are equipped to remotely detect plastic waste hotspots, quantify marine litter, and even detect tiny plastic pieces floating in oceans. In the past, ocean clean up missions have been restricted to shorelines and coastal waters due to a limited human capability to reach and collect plastic circulating far out at sea. Plus, **cleaning up large patches of ocean debris can be a tedious and labour-intensive process**. Current methods of tracking debris distribution in the ocean typically “involve surveying the damage from planes and boats”. Detecting plastics in the ocean is “notoriously challenging”, being that plastics come in many colours, sizes, and shapes, and are made from “a variety of chemicals”. Nurdles are the pre-production plastic pellets used as the building block for all our other plastic products, and can be made of a variety of plastic chemicals.

Satellites typically offer the best way to detect objects floating on the ocean surface, but as is the case of nurdles, plastic debris is often too small for their resolution to detect. To tackle this issue, researchers in the UK have for the first time used **satellite data to detect patches of tiny plastic pieces down to 5 millimetres in size**. Scientists at the Plymouth Marine Laboratory used the combined efforts of two European Space Agency Sentinel-2 Earth Observation satellites equipped with 12-band multi-Spectral instrument (MSI) sensors to repeatedly collect data “from all coastal locations around the world every 2 to 5 days”.

Materials can be distinguished using light signal based on which wavelength of light they reflected in AI system, while water absorbs light in the near-infrared to shortwave infrared light range, floating materials like plastic and debris reflect in the near-infrared (NIR) instead. Using the satellite data, researchers trained a machine-learning algorithm to analyse the images pixel by pixel and **associate certain NIR light signals with floating plastic debris**. “They also taught the algorithm to distinguish between plastic and natural materials such as seaweed, driftwood, and seafoam”

ALGORITHM OF WORKING AI SYSTEM

Deep learning is the ultimate of machine learning approach, which is concerned with utilizing Artificial Neural Networks (ANNs) to solve computer vision tasks such as image classification, object detection, and pose estimation. Pattern recognition applications have been one major success of deep learning which makes it relevant for this study. A few algorithms of Artificial Neural Networks can extract features from various data formats such as text, images, videos etc. These algorithms are Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN) and, Deep Neural Networks (DNN).

CNN

Convolutional Neural Network (CNN) In Deep Learning, a Convolutional Neural Network (CNN or Convolutional Neutral Network) is a group of Deep Neural Networks most frequently used in analysing visual imagery. Convolutional Neural Networks were inspired by how the human brain works - biological processes that show the connectivity pattern between neurons resembling the organization of the animal visual cortex. Convolutional Neural Networks have a different architecture than regular Neural Networks. In CNN, every layer is a set of nodes called neurons where each layer becomes fully connected to all neurons in the preceding layer.

The predictions are the representation of the result layer, which is the last fully-connected layer. CNN are sometimes applied elsewhere but were designed specifically for computer vision. Convolutional layers, which differ from conventional or thick stacks in canonical ANNs, are the source of the name Convolutional Neural Network. They were created with the purpose of receiving and processing pixel data, which is a key element to our study Convolutional Neural Network is one of the AI techniques form Deep Learning that takes in input images, assigns significance, what are referred to as discoverable weights and biases, to various aspects of the image, and can differentiate one features from the other. Comparing other classification techniques and CNN, the initial preparation of data for modelling requirement in CNN is much lower. The architecture of a CNN, which is comparable to the way network of Neurons are formed in the brain of a human being, was motivated by the positioning of the lens of human eyes called visual cortex. Each of the nodes (neurons) reacts solely to impulses in the Receptive Field, a limited portion of the field of vision. A group of homogeneous attributes can be piled on top of one another to fill the whole visual field. An image is nothing more than a pixel value matrix. A Convolution layer could strongly render the dimensional and transitory associations in a picture by using appropriate filters. The CNN construction provides better fitting to the picture dataset because of the reduced number of variables required and the reusability of weights. This means that the network could be trained to discern the image's complexity. CNN makes use of spatial correlations found in the input data. Some input neurons are connected by each concurrent layer of the neural network. A local receptive field is the name given to this area. Hidden neurons are the centre of the local receptive field. The input data is processed by the hidden neuron inside the given field, with no awareness of changes outside the defined limit.

HOW CNN WORKS?

There are three layers in a Convolutional Neural Network. We can comprehend each layer individually with the help of an illustration of a classifier. It can be used to classify an X and O image. As a result, we will be able to comprehend all four layers with the help of the instance. Convolutional Neural Networks are activated by volume and utilize multi-channelled picture. CNNs, on the other hand, cannot tell the difference between flat images with simply width and height, as perceived by humans. CNNs blend the three colours to generate the range of colours that people view since RGB encoding is utilized in digital colour images. A Convolutional network consumes such images as three distinct colour strata stacked on top of each other. The width and height of a typical colour image are defined by the number of dots in those measurements. The depth levels of the three layers of RGB colour that CNNs understand are called channels. The Convolutional layer is the first layer of a CNN network and is the foundational structural piece that does the main work of the computation. Filters or kernels could be used to combine data or images. Filters or kernels are small units utilized to apply to data in a sliding window. The depth of the image is the same as the input; for instance, if the RGB value of depth for a colour image is 20, a filter with a depth of 20 is used. For each sliding movement, this method involves taking the element-wise product of filters of the image and adding those specific values. A convolution with a 3d colour filter would yield a 2d matrix. Convolutional Neural Networks have the following layers: 1. Convolutional 2. ReLU Layer 3. Pooling 4. Fully Connected Layer A number of steps are involved in this process. It is important that the dataset is first downloaded and the function to encode the labels is run. This would be followed by picture resizing to 50 by 50 pixel and converted to grayscale. The data is then split

in a ratio of 80:20 for training and testing in that order. The data is reshaped appropriate for TensorFlow after which a model is built and a loss function is then calculated.

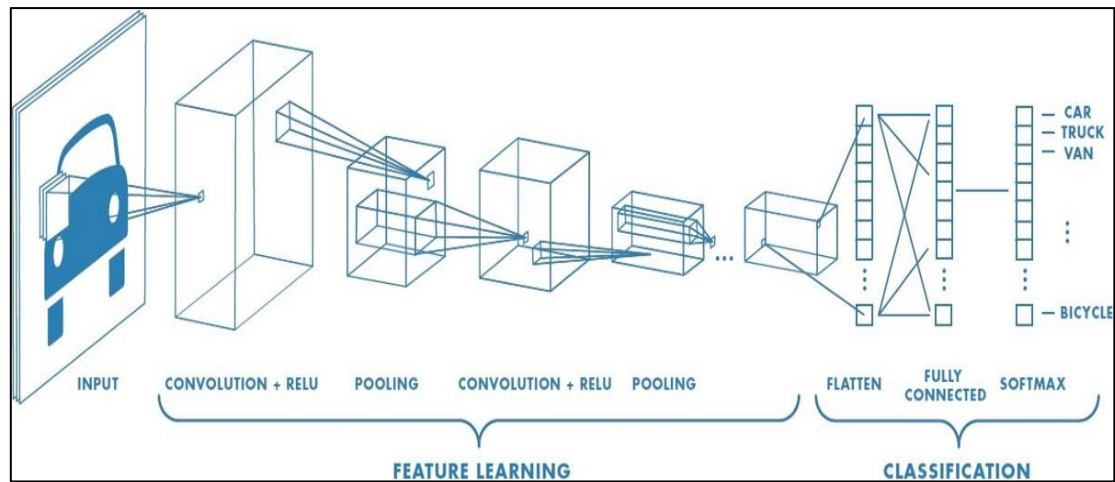


Fig 2. Block Diagram

RESULTS

AI and Robotics to Reduce Ocean pollution, AI is being utilized in **Autonomous Underwater Vehicles (AUVs)** and **Unmanned Surface Vehicles (USVs)** to clean up plastic and other forms of pollution. USVs are robots designed for the efficient and cost-effective collection of commercial ocean data on the surface. Similarly, AUVs are robots pre-programmed to collect data from specific parts of the deep ocean while scientists conduct research on board a ship or land. “Ideally, AUVs should be able to perform complex, long-duration missions without the need for human intervention. This requires state-of-the-art (or beyond) artificial intelligence (AI) techniques”. Companies like Liquid Robotics, a Boeing company, are overcoming roadblocks to ocean data by **utilizing a network of drone boats gathering ocean data globally**. Liquid Robotics designed the Wave Glider, a USV powered by wave and solar energy, that can operate individually or in fleets, delivering a variety of ocean data from the depths to the surface. The Wave Glider is designed to support a wide range of sensors, allowing “partners to develop and deliver unique solutions to customers”

Using USVs, XOCEAN provides “turnkey data collection services to surveyors, companies and agencies” from mapping the seabed to environmental monitoring. XOCEAN recently adopted Marine AI’s ‘Guardian Vision’ AI software to enhance their USV’s situational awareness. Marine AI is a software engineering firm “specializing in edge-based artificial intelligence software”. Their goal “is to deliver sensor-driven cognitive artificial intelligence to enhance maritime capability, on or below the water”.

Razer partnered with marine waste cleaning start up Clear Bot “to advance the use of AI and robotics to reduce ocean pollution”. They announced their partnership in celebration of World Oceans Day in June 2021. The team designs **robots that leverage AI-powered computer vision to identify marine waste and retrieve it** to be responsibly disposed of. The “Clear Bot” is a marine trash collecting drone that’s solar powered, self-navigating, and equipped with vision AI that use machine learning to optimize its capability over time. Through the partnership, Clear Bot was able to utilize Razer’s technical expertise to optimize their mission

and improve the Clear Bot design by making it more efficient, marketable, and scalable. “Clear Bot is calling on the community to upload photos of marine plastic waste commonly found in open waters to their website that will be used to help improve the robot’s waste detecting AI algorithm”

CONCLUSION

Artificial intelligence could help solve the problem of microplastics. Machine learning algorithms can accurately detect the minuscule plastic particles and provide an accurate image of how they dispersed. ML has a wide array of applications. ML can apply to many different fields using vast amounts of data to help predict future trends and improve efficiency by making better decisions. AI could be one solution to detecting microplastic particles accurately. Artificial intelligence could help solve the problem of microplastics. Machine learning algorithms can accurately detect the minuscule plastic particles and provide an accurate image of how they dispersed. ML has a wide array of applications. ML can apply to many different fields using vast amounts of data to help predict future trends and improve efficiency by making better decisions. AI could be one solution to detecting microplastic particles accurately. Artificial intelligence could help solve the problem of microplastics. Machine learning algorithms can accurately detect the minuscule plastic particles and provide an accurate image of how they dispersed. ML has a wide array of applications. ML can apply to many different fields using vast amounts of data to help predict future trends and improve efficiency by making better decisions. AI could be one solution to detecting microplastic particles accurately.

ACKNOWLEDGEMENTS

Tokyo, July 3, 2020 – NEC Corporation (NEC; TSE: 6701), in cooperation with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), announced the development of a system to automatically detect microplastics from seawater and sediment samples at high speed by using AI-based image recognition techniques. This development aims to increase the sophistication of microplastic measurement techniques for evaluating the dynamics and environmental impact of marine plastic waste.

In recent years, marine pollution caused by microplastics, which are minute plastic particles with a size of 5mm or less, has been expanding worldwide. As a result, there are growing concerns not only about the impact on the ecosystem, but also about the adverse impact on the human body through the food chain. In order to accurately grasp the actual conditions of marine microplastics, it is necessary to analyse the number, size, and type of microplastics in each sea area and identify the source, route, and destination of the outflow.

Until now, it has been common practice to scoop seawater and sediment with fine mesh, then to use a microscope to pick and analyse each microplastic manually. However, this is not only time-consuming and labour-intensive, but also has the problem of underestimating the volume of small particles of 300µm or less that pass through the mesh.

JAMSTEC, a national research and development agency that conducts comprehensive research on marine science and technology, has been engaged in research and development of technologies for automatically detecting and analysing ocean microplastics. For this project, NEC provided a system to detect microplastics at high speed and with high accuracy using

image recognition technology based on "RAPID Machine-Learning," which incorporates the deep learning technology of the state-of-the-art AI technology portfolio "NEC the WISE."

Specifically, NEC developed software that leverages JAMSTEC's R&D expertise for staining microplastics in samples with fluorescent dyes, allowing video to be taken of microplastics with a fluorescence microscope while flowing at an optimum speed for detection. The software automatically extracts image data for each microplastic that appears in these videos. Then, by utilizing AI-based image recognition technology, it is possible to automatically sort and aggregate sizes and shapes of the microplastics at a processing speed of 60 per minute. This has enabled NEC to automate and upgrade the detection of microplastics that was formerly done manually.

"It is expected that by establishing and popularizing this measurement method, and by clarifying the actual situation of microplastic pollution, we will be able to contribute to the formulation of appropriate emission regulations," said Dr. Masashi Tsuchiya, Deputy Group Leader, Marine Plastics Research Group, JAMSTEC. "NEC has been engaged in R&D on a coastal disaster simulation system utilizing the 'Earth Simulator' JAMSTEC supercomputer, and we will continue to strive for the realization of a sustainable society through 'environmental management' with AI and other advanced technologies," said Yosuke Taira, Senior Manager, 1st Government and Public Solutions Division, NEC Corporation.

APPENDICES

Quantum cascade laser imaging (LDIR) and machine learning for the identification of environmentally exposed microplastics and polymers

Monitoring of microplastics in environmental samples is relevant to the scientific world, as well as to environmental agencies and water authorities, in particular considering increasing efforts to decrease emissions and the growing concern of governments and the public. Therefore, rapid accurate detection and identification of microplastics including polymers, despite their degradation in the environment, is crucial. The degradation has a significant impact on the **infrared spectra** of the microplastics and can impede the identification process. This work presents a novel approach to addressing the problem of identification of weathered microplastics. A **quantum cascade laser (LDIR) was used to record the infrared spectra** of various polymeric particles (81,291 individual particles). Using a combination of pristine and weathered particles, two supervised machine learning (ML) models, namely Subspace k-Nearest Neighbour (Sub-KNN) and Boosted Decision Tree (BDT), were trained to recognize the spectrum characteristics of labelled particles and then used to identify unlabelled samples, with an identification accuracy of 89.7% and 77.1% using 10-fold cross validation. About 90% of the samples could be identified via the Sub-KNN or BDT models. Subsequently, a non-supervised ML model, namely, Density-based Spatial Clustering of Applications with Noise (DBSCAN), was used to cluster samples which could not be labelled from the supervised ML model. This enabled the detection of additional subgroups of microplastics. Manual labelling can then be carried out on a selection of spectra per group (e.g., **centroids** of each cluster), hence accelerating the identification process and allowing to add new labelled samples to the initial supervised ML. Although expert efforts are still needed, the proposed method greatly lowers labelling efforts by using the combined supervised and unsupervised learning models. In the future, the use of deep neural networks could further boost the implementation of these kinds of approaches for polymer and microplastic identification in environmental settings.

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Sustainable Transportation: Key to Atmanirbhar Bharat

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ABSTRACT

The integration of Information and Communication Technologies (ICT) in the shipping sector has led to significant improvements in efficiency, safety, and cost-effectiveness. This has been achieved using various digital tools such as vessel tracking systems, electronic data interchange, electronic chart display and information systems, and electronic ship reporting systems. These tools enable real-time monitoring and communication between ships, ports, and shipping companies, reducing paper-based transactions and increasing operational efficiency. The adoption of ICT has also facilitated compliance with regulatory requirements, improved risk management, and reduced environmental impact. Overall, the integration of ICT in the shipping industry is transforming the way the sector operates, and is expected to play a crucial role in its future growth and development.

KEYWORDS

Global position system (GPS), Electronic Data Interchange (EDI), Electronic booking system (EBS), Port Community System (PCS), Supply Chain Management (SCM).

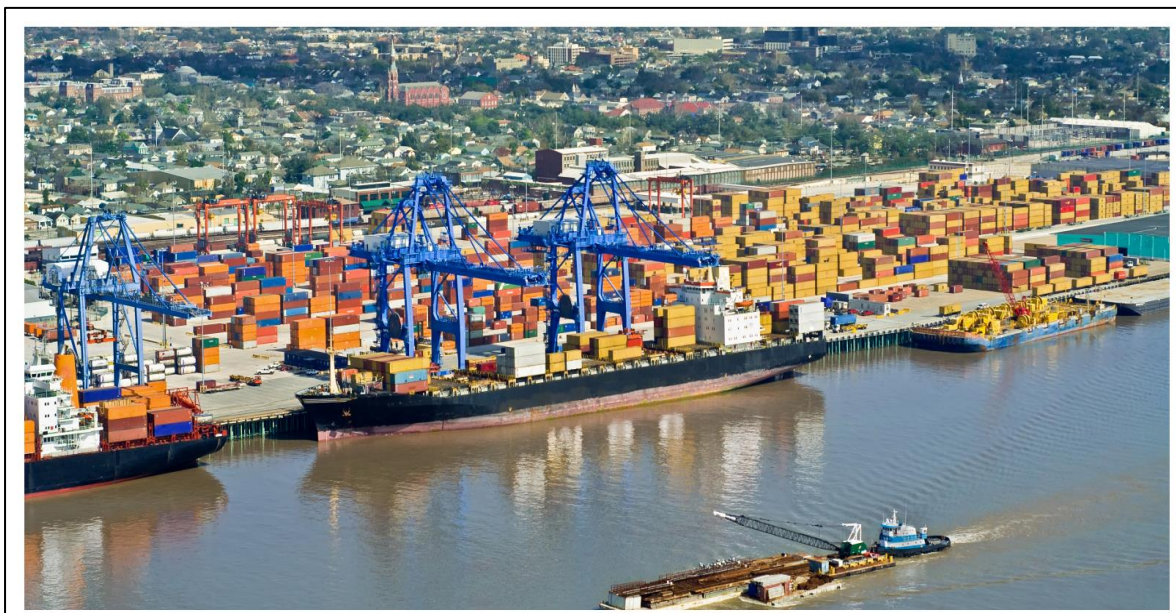


Fig 1. Port

INTRODUCTION

Information and Communication Technology (ICT) has had a profound impact on the maritime sector, transforming the way that shipping companies operate and interact with their customers.

ICT tools such as artificial intelligence, blockchain, big data, the Internet of Things (IoT), and virtual and augmented reality have revolutionized the shipping process, making it more efficient, cost-effective, and transparent.

The introduction of ICT in the maritime sector has allowed shipping companies to automate many of the manual and repetitive tasks that were previously performed by human workers, reducing the risk of errors and improving accuracy. For example, ICT tools such as big data and machine learning can be used to optimize shipping routes, predict maintenance needs, and improve the management of cargo.

Additionally, ICT tools such as blockchain and the IoT have increased transparency in the shipping process, making it easier for customers to track their shipments and receive real-time updates. This has improved customer service and increased customer satisfaction.

Information and Communication Technology (ICT) has been playing a crucial role in the shipping industry for decades, but with the rapidly changing technological advancements, it is poised to become even more critical in the future. ICT has the potential to revolutionize the entire shipping process, from cargo booking to delivery, and everything in between. This paper will examine the role of ICT in future shipping and its impact on various aspects of the industry.

First, ICT has the potential to improve the efficiency and accuracy of cargo booking and management processes. Electronic Data Interchange (EDI) and Electronic Booking Systems (EBS) are already in use in the shipping industry, but with the development of advanced technologies like blockchain, these systems are expected to become even more efficient and secure. Blockchain technology can provide a decentralized ledger that enables all parties involved in a shipping transaction to access and share information in real-time, eliminating the need for intermediaries and reducing the risk of fraud and errors. This will also increase the transparency and accountability of the shipping process.

Second, ICT can help improve the management of vessel operations and maintenance. The implementation of systems like Fleet Management Systems (FMS) and Maintenance, Repair and Overhaul (MRO) software can help ship owners and operators to monitor the health of their vessels and make informed decisions about maintenance and repair. Additionally, the use of autonomous ships equipped with ICT systems will enable ships to operate more efficiently and reduce the need for human intervention. This will result in lower operating costs, improved safety, and reduced emissions.

Third, ICT has the potential to enhance the security of shipping operations. The use of real-time monitoring systems, such as Global Maritime Distress and Safety System (GMDSS), will enable authorities to monitor ships' locations and movements in real-time and respond to emergencies quickly. Additionally, the use of blockchain technology will provide a secure and tamper-proof record of all transactions and communications, reducing the risk of cyber-attacks and fraud.

Fourth, ICT can help improve the sustainability of shipping operations. The use of digital tools to optimize routes and reduce emissions, as well as the use of green technologies such as electric and hybrid propulsion systems, will help reduce the environmental impact of shipping operations. Additionally, the use of ICT to monitor and manage the disposal of hazardous waste will help reduce the risk of environmental pollution.

Finally, ICT can help improve the overall customer experience in the shipping industry. The use of digital tools and platforms to provide real-time information about the status of shipments and delivery schedules will help customers make informed decisions about their shipping

needs. Additionally, the use of technologies like augmented reality (AR) and virtual reality (VR) will enable customers to visualize the shipping process and get a more immersive experience.



Fig 2. Key to Innovation

Information and communication technology (ICT) tools are playing an increasingly important role in the future of shipping. These tools are helping shipping companies to improve efficiency, reduce costs, increase transparency, and provide better customer service. Here are some of the key ICT tools that are expected to have a significant impact on the shipping industry in the future.

1. Artificial Intelligence (AI)

Artificial intelligence has the potential to revolutionize the shipping industry by automating many of the manual and repetitive tasks that are currently performed by human workers. For example, AI can be used to optimize shipping routes, predict maintenance needs, and reduce the risk of accidents and malfunctions. This will not only improve efficiency but also help to reduce costs and increase safety.

2. Blockchain

Blockchain is a decentralized ledger system that provides a secure and transparent way to track the movement of goods and information throughout the shipping process. By using blockchain, shipping companies can track the location and condition of their shipments in real-time, reducing the risk of fraud and errors. This will also make it easier for customers to track their shipments and get real-time updates on the delivery process.

3. Big Data

Big data refers to the large amounts of data that are generated by shipping companies, such as information about shipping routes, cargo, and customer preferences. By analyzing this data, shipping companies can gain valuable insights into the shipping process, improve their decision-making processes, and provide better customer service.

4. Internet of Things (IoT)

The Internet of Things (IoT) refers to the growing network of connected devices that are being used in the shipping industry. For example, shipping containers can be equipped with sensors that monitor temperature, humidity, and other factors that can affect the safety and quality of

the cargo. This information can be used to improve the management of shipments and reduce the risk of damage or loss.

5. Virtual Reality (VR)

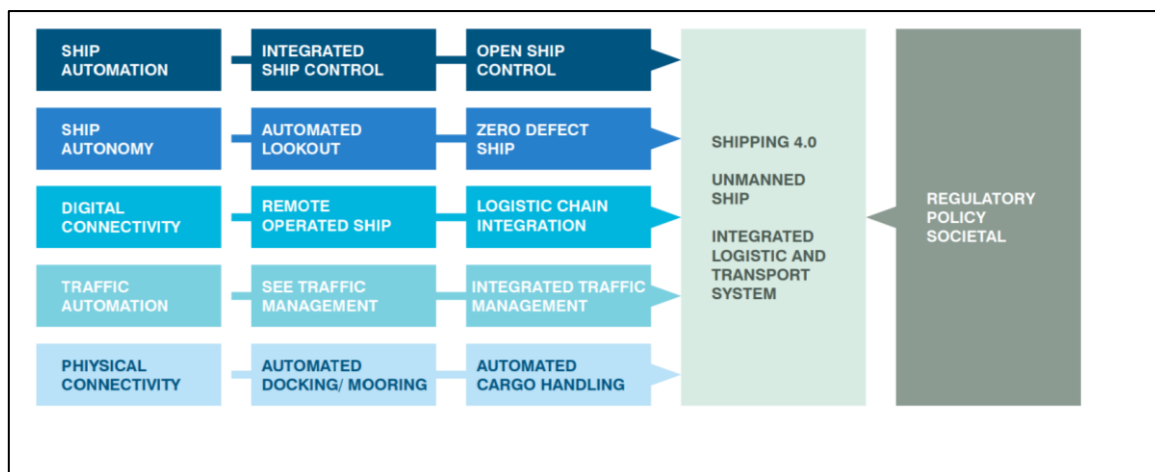
Virtual reality (VR) is a technology that allows users to experience a simulated environment as if they were there. This technology can be used in the shipping industry to simulate different scenarios, such as ship operations and maintenance, and provide training to workers. This will improve safety, reduce costs, and increase efficiency.

6. Augmented Reality (AR)

Augmented reality (AR) is a information and communication technology (ICT) tools are playing an increasingly important role in the future of shipping. These tools are helping shipping companies to improve efficiency, reduce costs, increase transparency, and provide better customer service. Here are some of the key ICT tools that are expected to have a significant impact on the shipping industry in the future.

7. Drones

Drones are small unmanned aerial vehicles that can be used for a variety of purposes, including surveillance, delivery, and inspection. In the shipping industry, drones can be used to inspect ships and cargo, reducing the risk of damage, and increasing safety. They can also be used to deliver goods to remote locations and reduce delivery times.

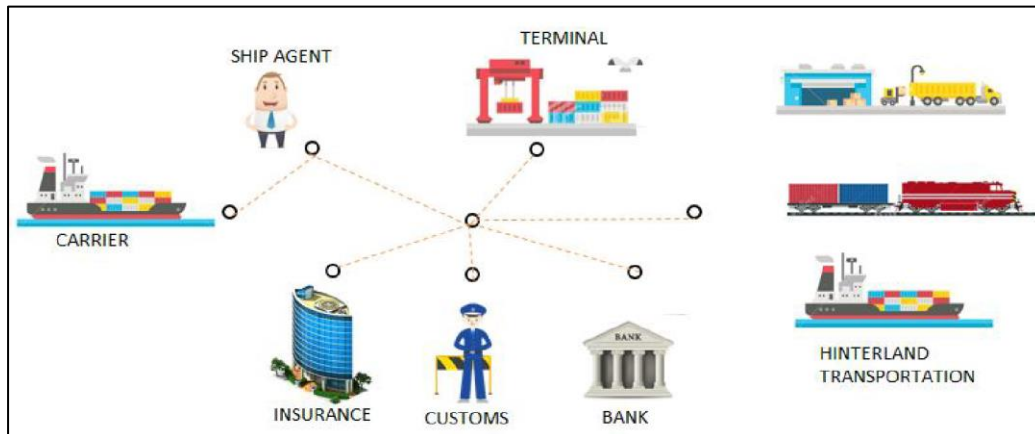


The main work of ICT in the future shipping industry will be to improve efficiency, reduce costs, increase transparency, and enhance customer service. Here are some specific ways that ICT is likely to impact the future of the shipping industry:

1. **Optimizing shipping routes:** ICT tools such as big data and machine learning will be used to analyse shipping data and optimize routes, reducing transit times and fuel consumption. This will result in lower operating costs and a more sustainable shipping process.
2. **Automating manual tasks:** The use of ICT tools such as robotics and automation will automate many of the manual and repetitive tasks that are performed in the shipping process, reducing the risk of errors and improving accuracy.
3. **Improving cargo management:** ICT tools such as the IoT and blockchain will be used to improve the management of cargo, providing real-time updates and increasing

transparency in the shipping process. This will help to prevent losses, improve delivery times, and enhance customer service.

4. Facilitating autonomous shipping: The use of ICT tools such as artificial intelligence and machine learning will facilitate the development of autonomous ships, reducing the need for human crew and improving safety in the shipping process.
5. Enhancing sustainability: ICT tools such as big data and the IoT will be used to monitor and analyze environmental data, helping shipping companies to reduce their carbon footprint and improve their sustainability.



There is limited data available on the exact future of ICT in the maritime sector, as the industry is constantly evolving and new technologies are being developed. However, here are some predictions and trends that are likely to shape the future of ICT in the maritime industry:

1. Increased adoption of digital solutions: The maritime industry is expected to adopt more digital solutions in the future, such as blockchain, artificial intelligence, and the Internet of Things (IoT). This will help to improve efficiency, reduce costs, and increase transparency in the shipping process.
2. Growth in smart port development: The development of smart ports is expected to continue to grow, as shipping companies seek to improve efficiency and reduce costs. Smart ports use ICT tools such as IoT, big data, and automation to optimize the shipping process and improve cargo handling.
3. Rise of autonomous shipping: The use of autonomous ships is expected to grow in the future, as shipping companies seek to reduce operating costs and improve safety. Autonomous ships use ICT tools such as artificial intelligence, machine learning, and the IoT to navigate, monitor cargo, and make decisions.
4. Expansion of e-commerce: The expansion of e-commerce is expected to drive growth in the maritime industry, as more goods are shipped globally to meet the demands of online shoppers. Shipping companies will need to use ICT tools such as big data, blockchain, and automation to improve their processes and meet the growing demand.
5. Increased focus on sustainability: The maritime industry is expected to place a greater emphasis on sustainability in the future, as shipping companies seek to reduce their carbon footprint and improve their environmental impact. ICT tools such as big data, machine learning, and the IoT will play a key role in helping shipping companies to achieve their sustainability goals.

Here are some basic ideas of how ICT is used in the shipping industry

1. Streamlining operations: ICT tools such as big data, machine learning, and automation can be used to streamline operations, improving efficiency, and reducing costs in the shipping process.
2. Improving cargo tracking: ICT tools such as the Internet of Things (IoT) and blockchain can be used to improve cargo tracking, providing real-time updates, and increasing transparency in the shipping process.
3. Enhancing safety: ICT tools such as autonomous ships and virtual and augmented reality can be used to enhance safety in the shipping process, reducing the risk of accidents and improving overall safety.
4. Improving communication: ICT tools such as cloud computing, video conferencing, and instant messaging can be used to improve communication between shipping companies, ports, and customers, enhancing customer service and reducing transit times.
5. Enhancing sustainability: ICT tools such as big data and machine learning can be used to monitor and analyse environmental data, helping shipping companies to reduce their carbon footprint and improve their sustainability.

These are just a few examples of how ICT is used in the shipping industry. As technology continues to evolve, it is likely that ICT will play an increasingly important role in shaping the future of the industry and helping shipping companies to stay competitive.

The effects of ICT in the future maritime sector are likely to be significant, transforming the way that shipping companies operate and interact with their customers. Here are some of the key effects of ICT in the maritime sector:

1. Improved efficiency: The use of ICT tools such as big data, machine learning, and automation will improve the efficiency of the shipping process, reducing transit times and fuel consumption, and improving the accuracy of operations.
2. Increased transparency: The use of ICT tools such as the Internet of Things (IoT) and blockchain will increase transparency in the shipping process, providing real-time updates and making it easier for customers to track their shipments.
3. Enhanced safety: The use of ICT tools such as autonomous ships and virtual and augmented reality will enhance safety in the shipping process, reducing the risk of accidents and improving overall safety.
4. Better customer service: The use of ICT tools such as cloud computing, video conferencing, and instant messaging will improve communication between shipping companies, ports, and customers, enhancing customer service and reducing transit times.
5. Increased sustainability: The use of ICT tools such as big data and machine learning will help shipping companies to reduce their carbon footprint and improve their sustainability, helping to address the global challenge of climate change.

These are just a few examples of the effects of ICT in the future maritime sector. As technology continues to evolve, it is likely that ICT will have an even greater impact on the industry, shaping the way that shipping companies operate and interact with their customers.

FUTURE TOPICS

1. **Automated Shipping Operations:** The use of advanced technologies such as artificial intelligence, machine learning, and robotics will automate the shipping operations, thereby reducing the need for human intervention and improving efficiency.
2. **Predictive Maintenance:** The use of predictive analytics and the Internet of Things (IoT) will enable shipping companies to predict and prevent equipment failures, reducing downtime and maintenance costs.
3. **Blockchain Technology:** Blockchain technology will enhance transparency and security in the shipping sector by providing a tamper-proof ledger for transactions and contracts between shippers, carriers, and ports.
4. **Big Data Analytics:** Shipping companies will use big data analytics to gather and analyze vast amounts of data from various sources such as sensors, GPS, and social media, to gain insights into consumer behavior, market trends, and shipping routes.
5. **Digital Twin Technology:** The use of digital twin technology will provide shipping companies with a virtual replica of their vessels and operations, allowing them to optimize performance, predict potential issues, and improve safety.
6. **Autonomous Shipping:** The development of autonomous ships will revolutionize the shipping industry, reducing the cost of operations and improving safety by eliminating the need for human crew members.
7. **Cloud Computing:** Shipping companies will adopt cloud computing to store, manage, and process vast amounts of data in a centralized, secure, and scalable manner.
8. **5G Network:** The rollout of 5G networks will provide faster, more reliable, and more secure connectivity for shipping companies, enabling real-time communication and data transfer.

CONCLUSION

In conclusion, ICT in the maritime sector has had a significant impact on the industry, improving efficiency, reducing costs, increasing transparency, and providing better customer service. As these technologies continue to evolve, they are likely to have an even greater impact on the industry in the future.

The role of ICT in future shipping will be crucial in improving the efficiency, security, sustainability, and customer experience of shipping operations. The implementation of ICT systems will require significant investment, but the benefits in terms of reduced costs, improved safety, and enhanced customer satisfaction will outweigh the costs. The shipping industry must embrace the changing technological landscape and invest in ICT to ensure that it remains relevant and competitive in the future.

ICT tools are playing an increasingly important role in the future of shipping. By using these tools, shipping companies can improve efficiency, reduce costs, increase transparency, and provide better customer service. As these technologies continue to evolve, they are likely to

have a significant impact on the shipping industry in the years to come. echnology that enhances the real world with virtual information. This technology can be used in the shipping industry to provide workers with real-time information about their surroundings and improve their ability to perform their tasks. For example, AR can be used to display information about the cargo, the location of other workers and vehicles, and safety procedures.

The future of ICT in the maritime industry is expected to be characterized by increased adoption of digital solutions, growth in smart port development, the rise of autonomous shipping, the expansion of e-commerce, and a focus on sustainability. These trends and predictions will shape the future of the industry and help shipping companies to improve efficiency, reduce costs, and increase customer satisfaction.

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Green Energy Power Generation using VAWT's on Ships

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ABSTRACT

Vertical Axis Wind Turbines (VAWTs) represent a unique form of power-generating technology. With increased concern for environment now days led to the research for more eco-friendly sources of energy and with this considerations wind energy can be deliberated as a feasible option in this regard. Wind energy is one of the non-conventional forms of energy and it is available in affluence in sea. Electricity can be generated with the help of vertical axis wind turbine. This projects aims of utilizing this wind energy in most effective manner to get the maximum electric output, and therefore we can use our ships as our installation site. In this project a small model has been created for testing purpose. This project also aims for maximum output with minimum cost indulged. Vertical Axis Wind Turbine (VAWT) is relatively simple to implement on ships and the development of appropriate design of VAWT will open new opportunities for the large-scale acceptance of this technology.

KEYWORDS

Vertical Axis Wind Turbines (VAWTs), Green energy, Blue Economy, Savonius rotors, Darrius rotors, Helix-shaped blades.

INTRODUCTION

It is well known that to run various machineries onboard a vessel we require electricity which is being generated through the installed generators which run on Marine diesel oil and add to the ever-increasing list of deterrents that add to pollution and carbon emission every day. New researches are being undertaken to reduce pollution through ships controlling and monitoring agencies like MARPOL which have laid down regulations and goals along these parameters. Wind energy is associated with the kinetic energy of flowing wind. . For our study, the optimum conditions for working of VAWTs were determined. The details of these methods and principles along with the major findings of the researchers on the vertical axis Wind turbines are reviewed in this paper. Upon a closer look at the concepts the fact that VAWTs are suitable for power loads where the conditions are not favourable over the traditional HAWTs Such as in high wind velocity and turbulence due to fluctuation in the wind is established. Another major advantage is that VAWTs are Omni-directional thus is able to harness wind from any direction, without the requirement of a yawing mechanism. And a comparison between VAWTs vs. HAWTs is made in *Table 1*. This table makes it clear that a number of promising features which, if properly exploited can be a better option over traditional solutions. Wind energy is freely available in the atmosphere as renewable energy source. We propose to utilize wind energy to generate electricity and to store the same electrical energy by using wind turbine. For a long time, the horizontal wind turbine was popular as a renewable energy development medium. With research, study and development, the vertical axis wind turbine also developed and the latest trend of art of technology is

becoming popular in experimentation and installation of same vertical axis wind turbine due to compactness and being lighter in weight than its horizontal counterpart thus enabling the vertical axis wind turbines to be easily installed in all types of ships.

Table 1. Merits of vertical axis wind turbines over horizontal axis wind turbines

	Horizontal axis wind turbine (HAWT)	Vertical axis wind turbine (VAWT)
Tower sway	Large	Small
Yaw mechanism	Yes	No
Self-starting	Yes	No
Overall Set-up Formation	Complex	Simple
Generator location	Not on ground	On ground
Height from ground	Large	Small
Blade's operation space	Large	Small
Noise produced	high	Relatively Less
Wind direction	Dependent	Independent
Obstruction for birds	High	Less
Ideal efficiency	50–60%	More than 70%

OBJECTIVE

Around 80 per cent of global trade by volume and over 70 per cent of global trade by value are carried by ships worldwide. Ships burn HFO and MDO that emits compounds of Sulphur, Nitrogen and Carbon. On average Bulk carriers emit 440 million metric tonnes of CO₂, while container ships emit 140 million tonnes of CO₂. This proves to be quite a threat to the environment and these emissions add massively to the ever-increasing problem of air pollution and global warming. Our goal is to propose a system to reduce these emissions with VAWTs (Vertical Axis Wind Turbines). Vertical axis wind turbines (VAWT) are capable of producing a lot of power, and offer many advantages over (HAWT). The main objective of this study is to design and build a self-starting vertical axis wind turbine to operate in low/high wind speed condition in seas on ships.

CONCEPT

Vertical axis wind turbines are wind turbines whose rotors rotate around a vertical shaft the main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the base of the turbine. With vertically oriented blades, they produce electricity by utilizing wind power the same way horizontal axis wind turbines do: Wind drives the rotor to turn, the rotation connects to the generator, and the generator converts the mechanical energy into electricity. Vertical axis wind turbines, on the other hand, are more geographically flexible and not restricted as much by governmental policies due to its versatile and compact nature compared to its horizontal counterpart.

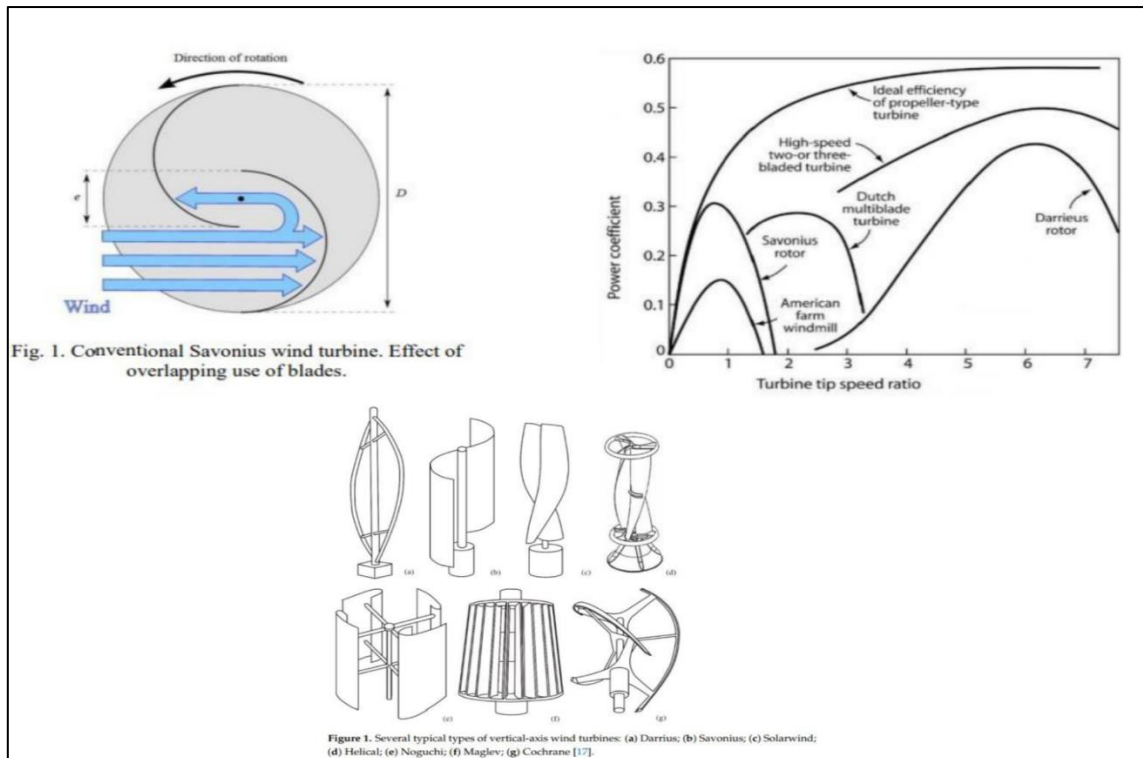


Fig 1. Conventional Savonius Wind Turbine

WORKING PRINCIPLE

This turbine works once the wind turns the turbine. Here, the savonius VAWT is used in this system. Once this turbine rotates, then the generator will get it as mechanical input and generate the output as electrical energy. The shape of turbine wings is curved to get the wind for revolution from the sea breeze where wind speed will make this turbine rotate. Here, wind speed is used in different ways based on our requirements.

A vertical axis wind turbine is connected to the Gearbox which includes gears. This gearbox is directly connected to the electric generator shaft. This turbine will revolve once the wind blows & the gearbox in this system will enhance the turbine rotations internally & send these rotations to the generator like a mechanical input. So the generator will generate the output as the electrical energy by using this input so that this output will be stored within the rechargeable battery.

In this way, electricity is generated and stored in the battery.

As the name implies, the rotation axis of this type of wind turbine is perpendicular to the ground and also perpendicular to the direction of the wind, because most of the wind blows along the ground. Vertical axis wind turbines do not need a yaw mechanism to face the wind direction, because wind from all directions can drive the wind turbine to rotate, which is one of the major features. Vertical axis wind turbines can be divided into drag-type and lift-type according to the principle of operation.

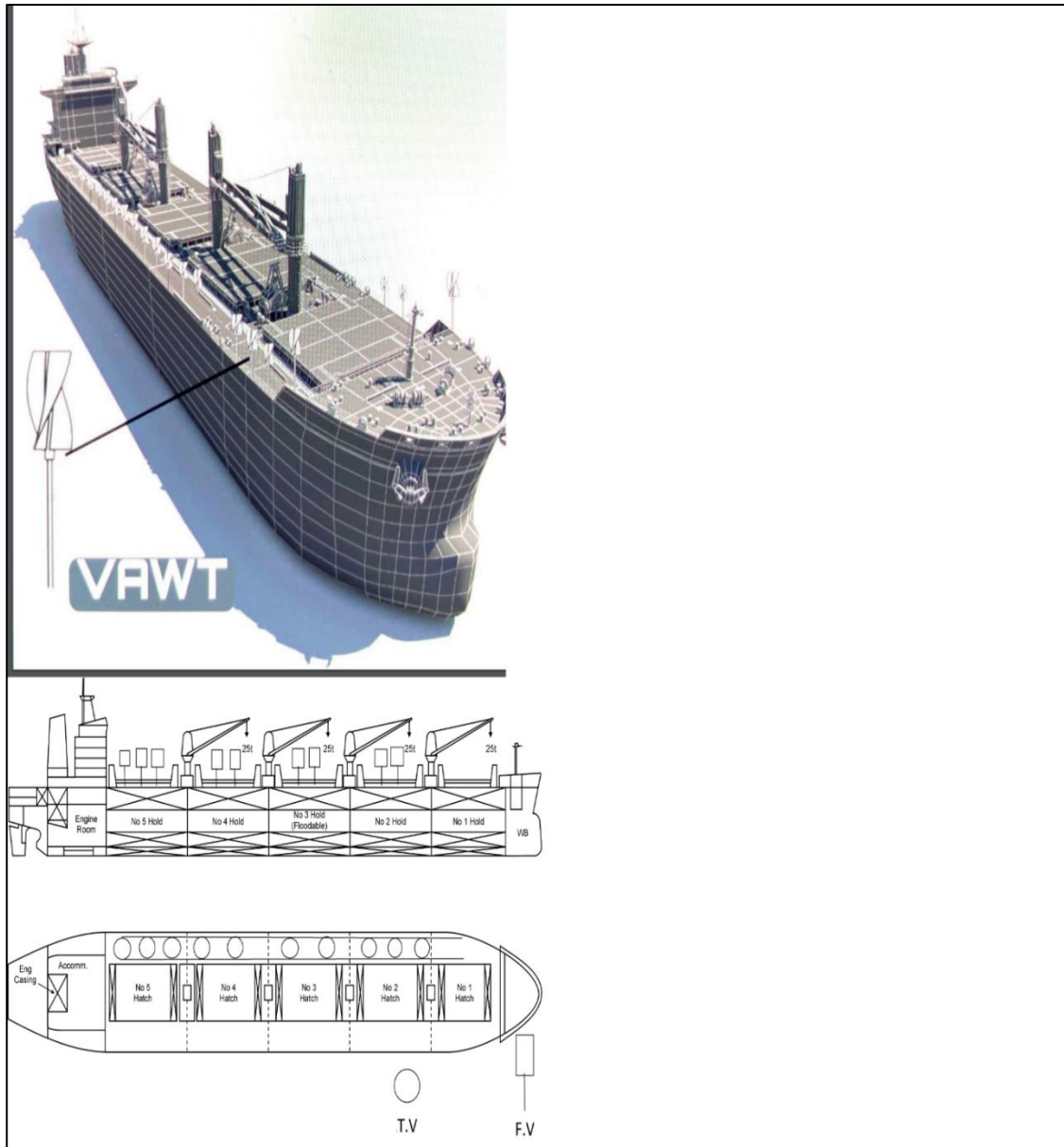


Fig 2. 3-Dimensional models of the VAWT system on-board ship and schematic diagram of the VAWT system

RESULTS AND DISCUSSION

In 2008, in a particularly high-profile example, the manufacturer Pac Wind integrated 16 of its drum VAWTs into a Times Square billboard. The project was supposed to save as much as \$12000 to \$15 000 per month in electricity costs and prevent 16.3 metric tons of carbon from being released into the air yearly (Collins, 2008).

CALCULATIONS AND OVERVIEW

The average natural wind speed to be 6 m/s. Density of air is 1.204 Kg/m³. Turbine 1.2 m in diameter and 1.0m height, the power of the Wind is given by,

$$P_w = \frac{1}{2} \rho A u^3$$

Where,

P_w - power of the wind (W)

ρ - Air density (kg/m³)

A - Area of a segment of the wind being considered

U - Undisturbed wind speed (m/s)

$$A = D l_b$$

Where,

A- Swept area (m²)

D-diameter of the turbine (m)

l_b - length of the turbine Blades (m)

$$A = (1.2) * (1.0) = 1.2 \text{m}^2$$

$$P_w = \frac{1}{2} * (1.204) * (1.2) * (6)^3$$

$$= 156.03 \text{ watt}$$

Table 2. Comparison between Theoretical and Experimental Mechanical Power

Wind Velocity (m/s)	mechanical power (W) (Theoretical)	mechanical power (W) (Experimental)
4.5m/s	65.8watt	48.8 watt
5.5m/s	120.18watt	102.3 watt
7.5m/s	304.76watt	260.68 watt
10m/s	722.40watt	610.74 watt

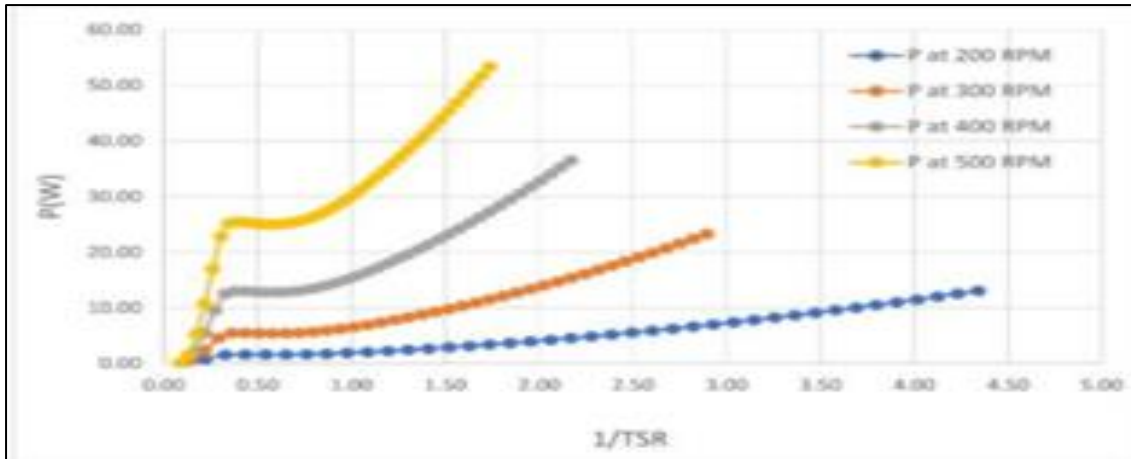


Fig 3. Power (W) vs. 1/tip speed ratio (TSR) for 3 blades of VAWT with different speed using multiparameter DMS simulation in Q Blade.

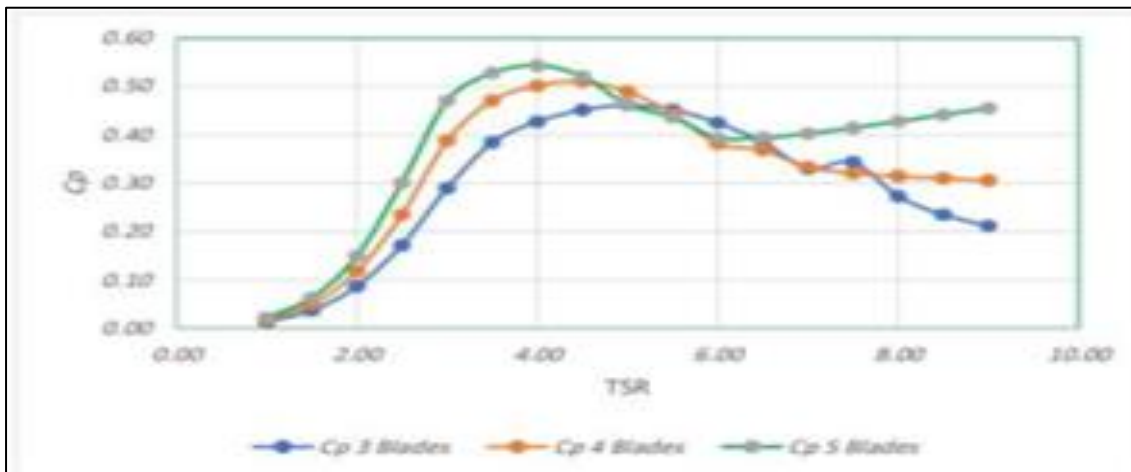


Fig 4. Coefficient of performance (Cp) vs. tip speed ratio (TSR) for 3,4 and 5 blades of VAWT

The study focused mainly on finding the optimal values of the design parameters of VAWT blade aerofoil. Significant influence of the number of blades on the performance of the vertical axis wind turbine was found. It was concluded that 4 blades of turbine rotor are more efficient than the rotor turbine with 3 blades of rotor. On the other hand, the 5-blade turbine rotor showed better efficiency than the 3-blade model, but it failed for the condition of TSR greater than 9. Additionally, it was found that the power increased at the high rotational speed (500 rpm). The maximum power coefficient of the 3 blades VAWT was identified at TSR = 5. This work is considered the first step in the project to study and analyse the vertical axis wind turbines, and it will be followed by other research that will study other types and designs of wind turbines in different promised sites. (In our case on ship)

CONCLUSION

As this is a proposed model, it is built at very low cost. Instead of plastic, if Fiber Reinforce Plastic (FRP) is used it will yield to more output. In such system, electricity can be produced by more than one source at a time like Wind and solar. There are various methods to generate hybrid energy like wind-solar, Solar- diesel, Wind- hydro and Wind –diesel. Among the above listed hybrid energy generation module the wind-Solar hybrid module are more crucial because it is available abundant in nature and it is also very much environment friendly Although the efficiency of a VAWT is generally lower than that of a HAWT, it is actually very close in theory. And vertical axis wind turbines can accept wind in any direction, so there is no need for a yaw mechanism, and the generator can be installed under the main shaft. The low centre of gravity also makes the structure simple, and It also has the characteristics of being able to operate in unstable air flows, so it is suitable for installation in environments with complex spaces, such as mountains, urban buildings, etc. Therefore, although vertical axis wind turbines have not yet been successful on a large scale Commercial operation, but still have the potential for application on ships. Therefore we can create a wind harness power plant on ships to reduce usage of MDO and can be also help in reducing carbon emission. In 3.5 years a VAWT can recover its installation cost and average self-life of a VAWT is around 20 years so it is also economically feasible.



Fig 5. Prototype model of our proposed VAWT system

ACKNOWLEDGEMENT

We would like to thank Tolani Maritime Institute, Induri, for providing us with an opportunity to do a research project on GREEN ENERGY GENERATION USING VERTICAL AXIS

WIND TURBINES. We would like to express our sincere gratitude to our teachers, seniors and batch mates for their constant guidance and encouragement in carrying out this research project.

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Innovative Transport System Design for Energy Efficiency

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ABSTRACT

“LNG as an energy efficient and environment friendly alternate fuel”

In current scenario, the global warming is increasing and proving hazardous to living life on earth, causing climate change and other undesirable events. One of the reasons for it is emissions from the Internal Combustion Engines. Traditionally ships are operating on diesel fuel engines thus a renewable fuel such as LNG (Liquified Natural Gas) can be a potential alternate to it. One of the major challenges of LNG is higher flammability that causes different hazards. This paper concentrates on overview of proper and efficient utilization of LNG for sustainable development.

KEYWORDS

Liquified natural gas, Diesel, Dual Fuel, Energy efficient, emissions, sustainable development, dual fuel engines.

OBJECTIVE

Analysis, review, and comparison of Liquified Natural Gas (LNG) with Diesel Fuel for a better energy efficient, Less emissions and Environment friendly Transportation.

INTRODUCTION

Currently in industrial and transportation sector diesel is mainly used which is a fossil fuel, this produces a large amount of greenhouse gases which ultimately causes global warming. In this situation alternative fuel source such as Natural Gas will be helpful and more effective to reduce components of greenhouse gases.

Among many alternative fuels such as bio fuels, LPG and LNG are the potential ones. Seeing the economic aspects and availability makes LNG a realistic solution as compared to other fuels.

LNG (LIQUIFIED NATURAL GAS)

Liquified natural gas (LNG) is natural gas that is methane CH₄, with some mixture of ethane C₂H₆ that has been cooled down to liquid form for ease and safety of non-pressurized storage

or transport. It takes up about 1/600th the volume of natural gas in the gaseous state at standard conditions for temperature and pressure.

LNG is odorless, colorless, non-toxic, non-corrosive, safe and clean form of natural gas.

Lower calorific value of LNG is 21MJ/L &

Higher calorific value of LNG is 24MJ/L at -164 C

COST AND LIFE CYCLE OF LNG

Figure 1 shows the worldwide LNG price as of June 2021. South Korea and China had the highest landed price of LNG in the world. Netback price is taken into consideration for the determination of these prices, which is based on the effective price for a seller and producer at a definite location.

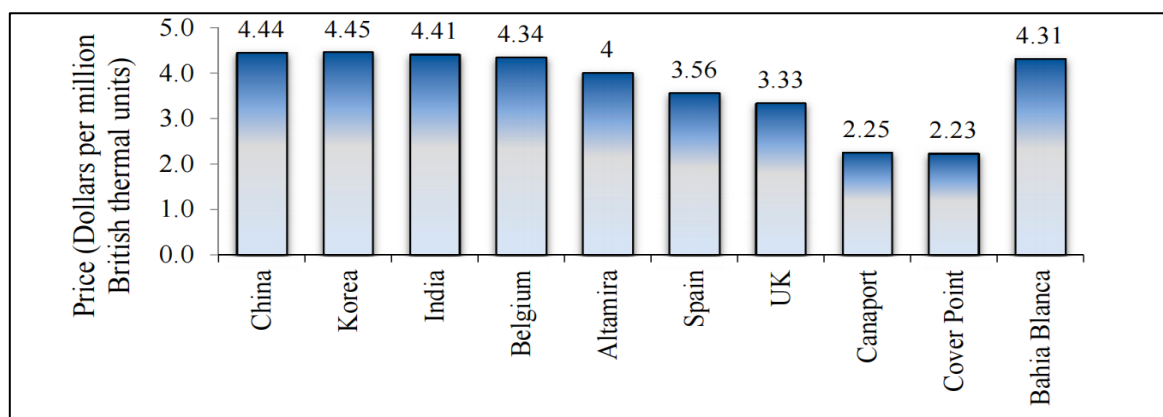


Fig 1. Graph

Figure 2 represents a schematic diagram of the LNG life cycle. With the help of the pipeline extracted raw natural gas is sent to the plant for liquefaction, where LNG is obtained as a byproduct.

Mainly, the ship is used to carry LNG to the regasification terminal.

Meanwhile, a small amount of liquid is drawn off and carried by small tanker trucks to the service station for fueling LNG trucks. On the other hand, in each transport and storage, phase boil-off gas is produced, which can be fully recovered for the purpose of using as a gaseous fuel.

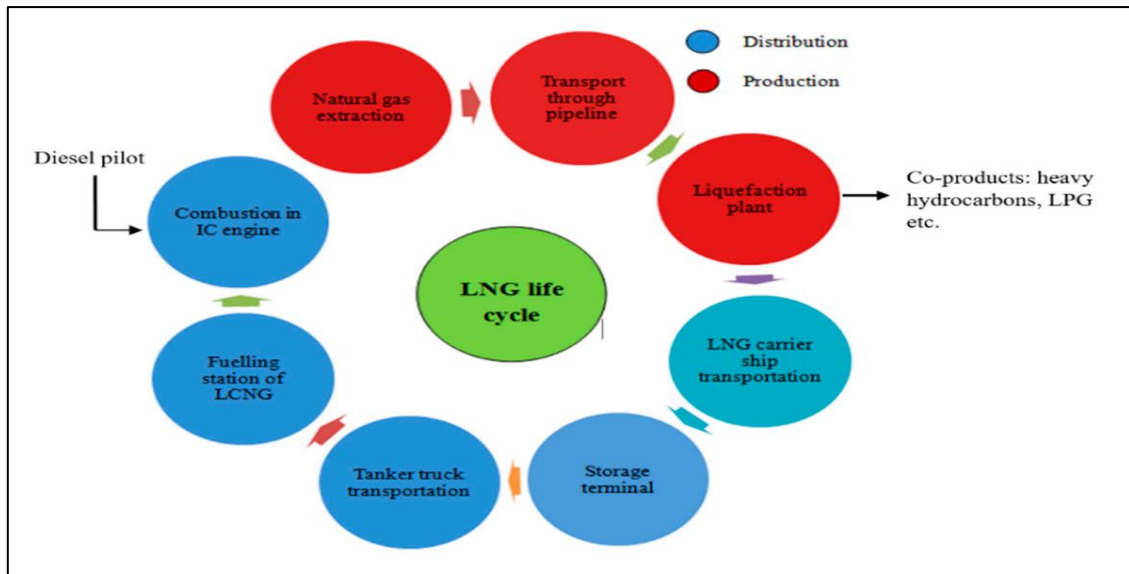


Fig 2. LNG Life Cycle

CONCEPT

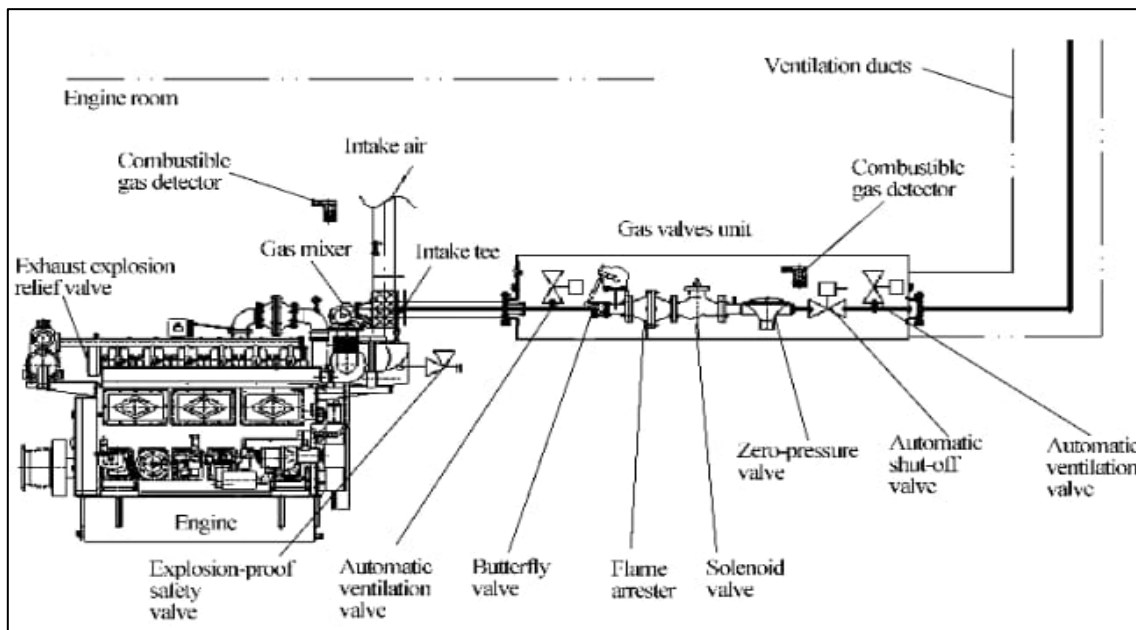


Fig 3. LNG in gaseous form enters into the unit by gas piping

The above diagram shows that LNG in gaseous form enters into the unit by gas piping, fuel gas shut off valve, fuel gas pressure regulator valve, A gas filter, Flame arrester, combustible gas detector and solenoid valve for actuation then it enters into the gas mixer. At this point the liquified gas is mixed with pressurized air and then passes to engines for further combustions.

WORKING PRINCIPLE

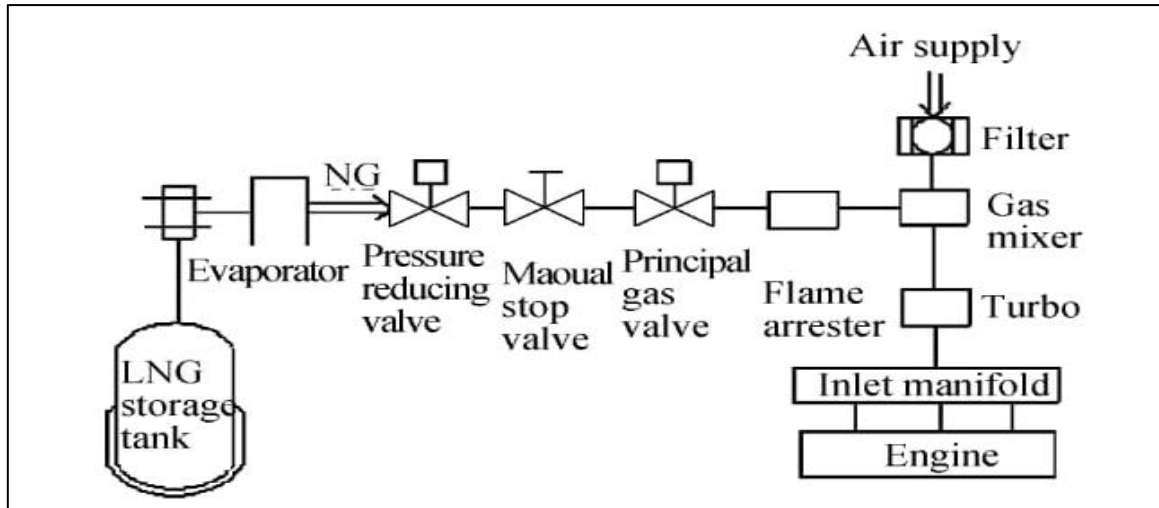


Fig 4. Working principle of manifold intake before entering Engine

The above figure represents the working principle of LNG fired engine.

Firstly, the LNG stored in storage tank at specific temperature and pressure is then passed through the evaporator where its phase changes.

Then this natural gas is passed through pressure reducing valve, which is then supported by a stop valve in case of higher pressure to restrict or obstruct the natural gas instantly. Then a flame arrester is also fitted in between the gas mixer and the gas valve to restrict the flame in case the fire occurs. After that the natural gas is passed on to gas mixer.

In this device the fresh air is mixed with the natural gas and then passed on to turbocharger. In turbocharger the pressure of this mixture is increased and through the inlet manifold is fed to the engine.

RESULTS

After screening various articles, citations and journals the above-mentioned points and study is carried out. Which in all aspects shows that LNG is better choice, reliable renewable source for transportation than any other fossil fuel-based engines. It has lower hazardous aspects on environment as compared to fossil fuels.

Below table mentions the desirable properties that LNG have as compared to other fossil fuels.

Property	LNG	DIESEL	GASOLINE
Phase	Cryogenic liquids	Liquid	Liquid
Fuel material	Underground Reserves and renewable bio gas	Crude oil	Crude oil

Composition	CH ₄ -99.8% C ₂ H ₆ -0.1% N ₂ -0.1%	Typically, alkanes, polyaromatics, cycloalkanes or naphthene	Alkanes (vol.) 4– 8% Alkenes (vol.) 2– 5% Iso-alkanes (vol.) 25–40% Cycloalkanes (vol.) 3–7% Cycloalkenes (vol.) 1–4% Total Aromatics (vol.) 20–50%
Density	435 at 20 MPa	175 at 20 MPa	850.4 at 15 °C
Octane number	120+	120+	-
Centene number	NA	NA	40–55
Lower heating value	49,244	46,892.16	43,400
Toxic	no	no	yes
Health hazards	none		none

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Role of Information and Communication Technology in Future Shipping

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ABSTRACT

Considering various development in technologies and solutions to boost trade, the role Information and Communication Technologies provides a new dynamic and dimension to the Shipping industry. After the first successful adaptation of containerisation in 1956, the industry has not looked back to older methods for transporting goods. Keeping this in mind the next step lies in the digitising these containers. With the coming of new age information and communication technologies, real time data tracking and management of these containers has been made possible. The role of Information and communication technology does not end but opens a plethora of opportunities and solution to boost trade and help each and every shareholder. Information and commutation technology is the solution to boost trade and improve the overall efficiency of the shipping Industry.

KEYWORDS

Containerization, Digital data stream (DDS), Internet of Ship (IoS), Green routing, Smart Ports.

INTRODUCTION

Shipping industry accounts for 90% of all global trade. With this sort of volume, innovation in shipping becomes an important aspect of the industry. Seeding new ideas and using them in the industry changes the dynamics of transportation of cargo. Therefore, it becomes crucial to seed new ideas and adapt on them to increase the efficiency, which benefits all the shareholder. With the increasing role of information and communication technologies throughout the world, shipping industry cannot miss this opportunity.

CONTAINERIZATION, ROLE OF EFFECTIVE SOLUTION

Now, when the consider important innovation in shipping industry, we tend to forget the most important of them. Earlier the cost of transporting goods (transportation system) was an important factor in the price of items, with containerization this cost has been reduced drastically. Because of the global adoption of containerization, “It is better to assume that moving goods is essentially costless than to assume that moving goods is an important component of the production process”.

For instance, the cost of transporting a kilogram of coffee from Asia to Europe is only fifteen cents, or one percent of item cost. This has been the impacts of global adaptation of containers.

The first notion of containerization appeared as early as the 18th century. However, the first load of 58 containers was moved on a converted tanker from Newark, New Jersey to Houston,

Texas, in 1956. This seed idea by Malcom McLean germinated other innovations that were necessary to make containerization efficient.

Because of McLean's success, containers captured the attention of the transport industry in the late 1950s, but efficiency was blighted by the many different container sizes and both intra and intermodal incompatibilities. In 1958, the standardization process was initiated by the United States Maritime Administration, but because of the variety of interests affected by an international standard, it was not until the mid-1960s that the specification was completed in the form of ISO 668. Over the last half-century, the economic benefits of the containerization system have driven down shipping to a negligible component of the total cost for many items. Containers implement the principle of comparative advantage globally.

Ideas such as these have helped the global shipping to grow and become the giant it is now. Now before considering new ideas and innovations, one must keep ideas such as these which help the industry grow effective and efficient solutions.

THE FUTURE AHEAD - INFORMATION AND COMMUNICATION TECHNOLOGY

Information and communication technology proves to be the way to move forward. With the ever-increasing trade activities, real time tracking and management of goods becomes an essential part of the industry. Information and communication help with these areas as well as many more. Following chart shows how Information and communication technologies can further help.

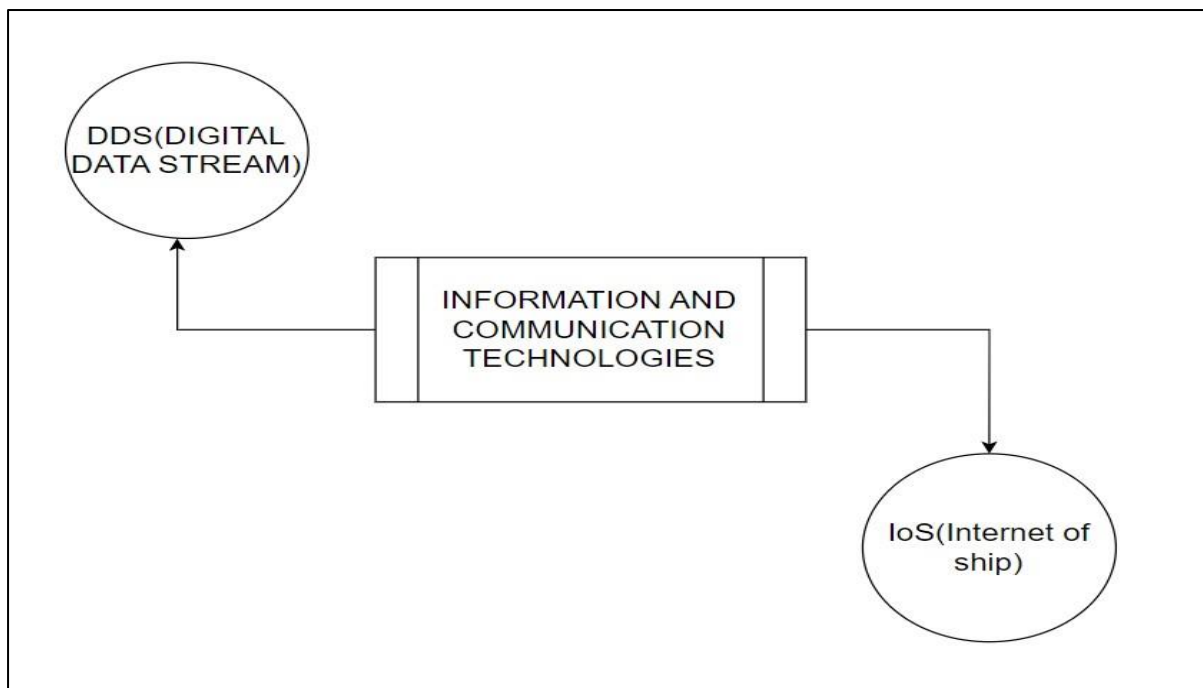


Fig 1. Flowchart

DDS (DIGITAL DATA STREAM)

Digital data streams (DDS) are innovation for digitizing shipping. A DSS is a continuous digital encoding and transmission of data describing the state of an entity, such as the location, direction, and speed of a ship. DDSs allow managers to dissect events in real-time, to shorten

the decision cycle, and deepen understanding of customers at the same time. A DDS enables every asset to stream data about its current state and for the asset to be potentially controlled remotely.

The first shipping use of a DDS was in the form of an Automatic identification system (AIS), which provides data about a vessel's state automatically every 3-10 seconds, depending on its speed. In 2000, IMO mandated that by 2005 all cargo ships above a certain gross tonnage and all passenger ships had to deploy an AIS transceiver and regularly transmit specified unencrypted status data. The AIS data stream for individual ships can be detected and made publicly available (e.g., www.marinetraffic.com).

GREEN ROUTING AND GREEN STEAMING

The availability of AIS data provided the raw data to investigate the potential value of implementing two innovations: green routing (the shortest safe distance) and green steaming (the lowest operational speed to arrive on schedule).

Green routing means a ship can take the shortest route, constrained by safety and regulations. Such routes are computed by using AIS data on current sea traffic, environmental conditions (e.g., wind and tide), and characteristics of the ship. Safety requires that ships continually operate within a moving zone, or safe haven, and that there is sufficient distance from other ships and the shore both fore and aft, starboard and port, and adequate keel clearance. Based on AIS data analysis, green routing offers potential energy savings of 12% for commercial shipping operating in the Kattegat, a portion of the Baltic Sea between Sweden and Denmark.

Green steaming aims to reduce the amount of energy a ship consumes by promoting just-in-time arrival. The amount of energy used by a ship is determined by its size and speed. Above 14 knots, fuel consumption is an exponential function of speed. Thus, arriving too soon at a port is a waste of fuel and increases costs. Using AIS data on ships arriving at the Port of Gothenburg in Sweden, green steaming can produce emissions and fuel savings of about 4%. The savings are dependent on the level of port congestion. As it rises and a greater percentage of ships need to anchor, the savings will rise, and vice versa.

IOS (INTERNET OF SHIP)

The international seaborne containerized trade increase 1127 million tons in 2009 to 2631 million tons in 2020. So, this drastic increase in containerized trade requires efficient operations at the sea and terminal to serve the growing demand. However, lack of efficient navigation system and inefficient communication system among vessels and ports increase the risk of accidents and unwanted situations, e.g., delays in departure and arrivals

“Internet of Ships (IoS) is the interconnecting of sensing objects like ships, crews, cargoes, on-board equipment, waterway environment, waterway facilities, shore-based facilities and other navigation elements, which are embedded with a variety of sensor and heterogeneous network technologies to enable these objects to collect and exchange data”.

IOS ARCHITECTURE

- Sensing layer
- Heterogeneous network layer

- Data computation layer
- Services & application layer
- Exhibition layer

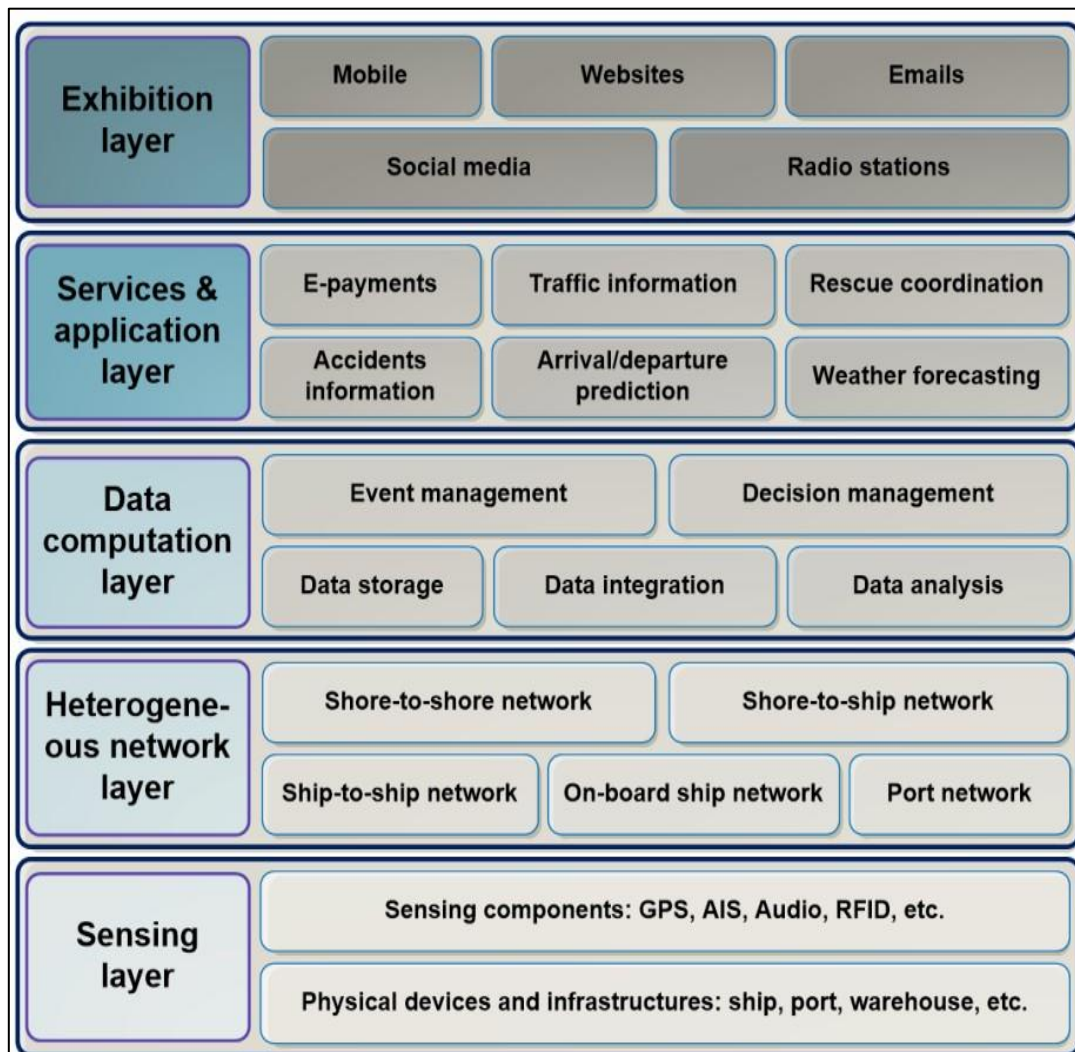


Fig 2. IoS Architecture

IoS ELEMENTS

The realization of the IoS architecture depends on several existing technologies and communication protocols, which form the necessary building blocks of IoS. These building blocks are categorized into six key elements:

Table 1. IoS Element and their examples

IoS Elements	Example technologies/protocols
Identification	Naming: uCode, EPC Addressing: IPv4, IPv6
Sensing	Smart/Embedded sensors, actuators, RFID tags
Communications	Satellite, RFID, NFC, UWB, Bluetooth, BLE, 802.15.4, Z-wave, WiFi, WiFi-direct, LTE
Computation	Hardware: SmartThings, Arduino, UDOO, T-Mote Sky, Phidgets, Intel Galileo, Raspberry Pi, FriendlyARM, ZI, Mulle, Gadgeteer, BeagleBone, Cubiebone, Smart Phones Software: Contiki, TinyOS, LiteOS, RiotOS, Android Cloud platforms: Nimbits, ThingWorx, OpenIoT, Xively
Services	Models: Identity-related, Information-aggregation, Collaborative-aware, Ubiquitous; Discovery: multicast DNS (mDNS) and DNS Service Discovery (DNS-SD)
Semantics	Efficient XML Interchange (EXI), Web Ontology Language, Resource Description Framework (RDF)

SOLUTIONS BASED ON INFORMATION AND COMMUNICATION TECHNOLOGIES

Here are the technologies developed based on information and communication technologies.

1. IOT ENABLED SHIPPING CONTAINER

The containerisation process which began in 20th century is now ready for its next phase of development. The Tracking of shipments is critical in managing global trade and logistics activities. The volume of global container movement along with information opaqueness and complexity necessitates the need for implementing a robust technology solution with real-time tracking and monitoring capabilities to ensure the integrity and safety of shipped items. Usually, containers carry items that could easily be damaged due to a rise in temperatures, humidity, exposure to sunlight or more traditionally, through sudden jolts or shocks to especially fragile items. The cold supply chain is a temperature-controlled system that ensures that the temperature does not rise beyond a certain threshold during shipping of goods such as vaccines, perishables, and life organs.

The other problem many customers face is the delay or even complete loss of items inside the containers. This can be solved through a tracking system that continuously monitors the current locations of the container and shares these locations with stakeholders. Also, being sensitive by nature, some of the transported items are not meant to be opened during their shipment process. Therefore, there is a need for a system to monitor the exterior of the case to ensure that the container is neither opened nor tampered with during its shipment. Also, the system should share the state of the container with the stakeholders to guarantee the integrity of containers. For this purpose, the system must ensure that the container should be connected and accessible via Internet anytime anywhere

Implementation

- Designing, architecting, and developing an automated monitoring system that will measure the environmental conditions inside the shipping container to alert the user in case certain violations or event occurs.

- Employing a technological solution for transmitting telemetry data from the container to a cloud-based environment where it is aggregated, recorded, and analysed.
- Deploying messaging protocol.
- Developing a mobile-based application for accessing information about the current status of the container and its position.

2. IOT HELPING TO AVOID SHIPPING ACCIDENTS

Maritime shipping, with a significant role in global trade, confronts various accidents leading to loss of lives, properties, and the environment. IoT technologies are scaling up to address this problem by employing real-time data-driven technologies, including cyber-physical systems, advanced tracking and tracing, intelligent systems, and big data analytics.

Cyber-physical systems in maritime transportation are technologies that interconnect physical and computational infrastructures. Big data analytics and the internet of things can be utilized within cyber-physical systems to manage the enormous amount of data for interpretation and smart vessels development. These data can be used further to help save ships from DDOS and other such attacks which may cause accidents.

Augmented reality is an abstract view of the environment that can be developed using a real-world database to make the actual environment more tangible. This technology can utilize 3D technology and virtual reality to detect congestions. It is becoming widely applicable in seafarers' training and within the shipbuilding industry. When training the personnel, augmented reality can help determine their performance when confronting a challenging situation such as an accident.

Big data analytics examines large amounts of data to uncover hidden patterns, correlations and other insights” (SAS,). This is done to facilitate and manage various processes related to a wide range of maritime activities. Other areas where BDA provides value are network design, container routing. The data obtained from monitoring the routes and processes can determine the congestions in maritime routes. Therefore, the risk of accidents, the length of travel time, and the number of carbon emissions can be mitigated. It can also be used to divide maritime areas into clusters of varying congestion levels, which can be used to regulate the transportation of vessels and their time of travel.

3. IOT-ENABLED SUPPLY HUB IN INDUSTRIAL PARK (SHIP)

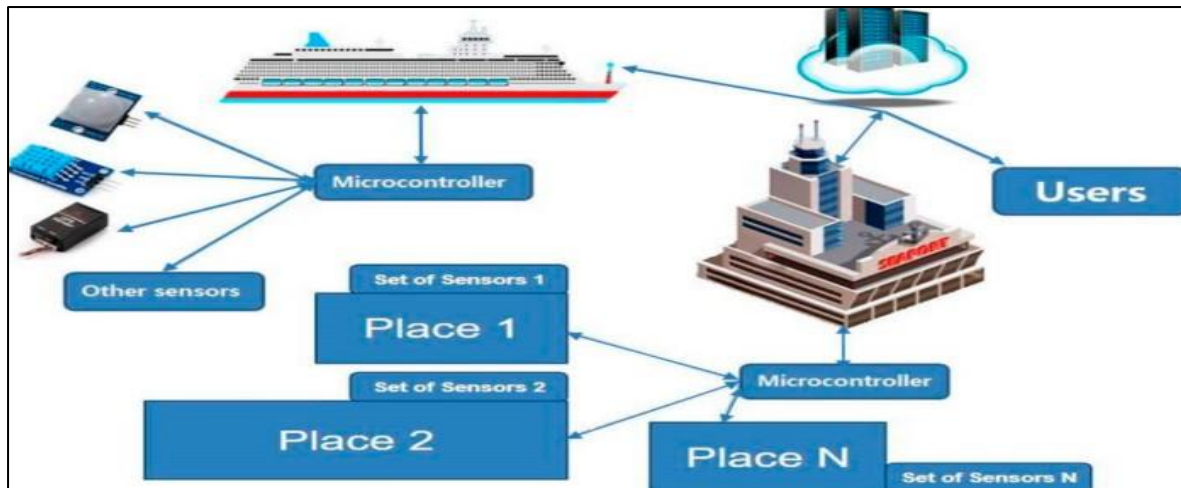
SHIP is defined as a public provider of warehousing and transportation services for manufacturing enterprises located within an industrial park. The establishment of SHIP brings a new transformation and upgrade for manufacturing industries as member enterprises in an industrial park. SHIP can be regarded as a special scenario of supply chain with the key characteristic as follows: (1) member enterprises pay SHIP for the physical assets and services they use; (2) the same physical asset can be used by various enterprises successively; (3) all finished products and raw materials are held at SHIP. The adoption of SHIP could bring about a series of benefits. In this way, the original idle spaces are made use of by products with different seasonal patterns. Hence, the demand variances are mitigated and the space utilization is improved. Through enjoying SHIP’s logistics services, member firms could reduce capital investment, and save a great deal of expenses on inventory holding and management. Due to

the proximity between SHIP and manufacturers, items are delivered frequently in small batches straightforward to the production line.

4. AN IOT-BASED SHIP BERTHING METHOD

Currently, ships waste too much time in berthing at the port as the task may last from two hours to several days. One reason for this problem is the presence of a crowd of ships in the port and the other trade-off is the huge amount of information exchanged between ships and ports. The data required by the port includes complete information regarding the name of the ship, the owner, the crew, the overall dimensions of the ship and its condition, as well as the expected time of arrival and departure of the ship. In these days such a vast amount of the data transfer procedure is managed with the help of portable radio transmitters. That is one of the main reasons so much time is wasted during berthing. Besides that, having exchanged the data, a responsible member of the port staff must arrange a place for the ship to moor and this procedure may cause trouble as well as inconvenience. As an example, we include in this paper a typical dialogue between a port and a ship that are exchanging data before the ship gets permission to berth.

This IoT-based smart berthing system can help vessels and ports in such situations. The principal purpose of the system is to help to berth vessels which have arrived at the port and help exchange data regarding their situation. The system is able to manage several tasks automatically like receiving all the data about available berths by means of a set of ultrasonic sensors affixed at the port and having obtained the data, it transfers it to the vessels looking for a place to berth. The system categorizes the online data received from the set of sensors and offers the ship an optimal place concerning location, quantity, and other criteria.

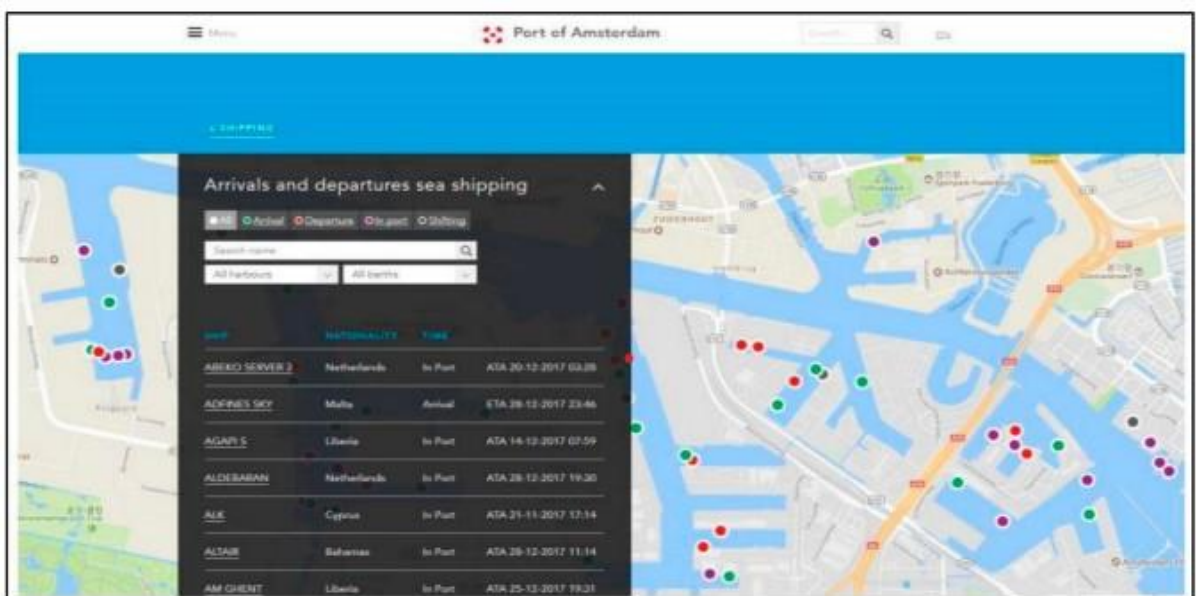


5. Smart Ports

Smart ports are also considered as a novel concept like smart ships and smart cities. It is based nearly identical to those of smart ships and smart cities. As a topic regarding the types of the ports that requires extensive clarification, we only focus on smart port building for traditional ports. Thus, smart ports aim to include various technologies and amenities. Smart ports are equipped with various communication technologies to exchange data with other ports, smart ships and with smart cities as well. The services created in smart ports are composed of automatic monitoring and controlling the location of the ships at the port, the movement schedules of the ships, loads, and the ride of the passengers and so on. The communication between smart ships and smart ports is depicted in Figure



Amsterdam, has launched multiple apps. The “I am Port” app offers real-time information on ships’ location and itineraries at the port. In addition, we can find information about arrivals and departures, size, draft and berth of each ship at the port. They also mark ships with different colours but here colour does not mean a type of ship, but rather it means a status of that ship. For example, greens are arrivals, reds are departures, as seen in Figure



6. EMERGING APPLICATIONS OF IOS

- **Energy Efficiency:** Minimizing fuel consumption and carbon emissions have become a big challenge for sea transportation. It requires new vessels or energy efficiency measures (technical and operational) for current vessels.
- **Automatic Fault Detection and Pre-emptive Maintenance:** Fault detection and self-diagnosis are also among the key motivating factors for shifting the traditional maritime industry to IoS-based intelligent shipping.
- **Collaborative Decision Making:** Collaborative Decision Making (CDM) enable intelligent data driven decisions in sea transportation and port operations.
- **Cargo Environment Monitoring:** Cargo environment monitoring and management represent yet another need of IoT in the maritime industry because some goods require specific conditions (e.g., temperature, humidity, etc.) during traveling or when placed in the warehouses.

- Advanced cargo management (hub and port system): With IoT system implementation transportation and management of cargo can be smoothed which further boost the ideas of an integrated cargo management process.

CHALLENGES & FUTURE OPPORTUNITIES

Satellite Communications: According to current communication standards, it is not easy to enjoy at sea the high bandwidth and low latency of the internet provided at shore. At sea, the internet is usually provided by communicating between a satellite and an antenna on the ship. So, it is challenge of IoS to maximum relay on satellite communications.

- Security and Privacy: Considering that IoS is mainly based on wireless and satellite communication technologies, IoS will not only face the conventional security threats but will also face newly emerging threats caused by its complex, geo-distributed, world-wide, network environment.

- Maritime Data Collection: Due to the frequent movement of ships, data gathered in the shipping sector may be incomplete, inaccurate, or unreliable in specific times or at locations. So accurate data collection is also an open issue.

- Maritime Data Management and Analytics: Current IoS technologies are also facing data management problems. A huge amount of data is generated from IoS objects, which turns to data mining, big data analytics, and data visualization into significantly challenging issues in the maritime domain due to high computation and communication complexities.

- Autonomous Shipping: One of the fundamental challenges of the maritime industry is to develop and operate Autonomous Ships (AS).

CONCLUSION

With the coming of new age technologies, it becomes significantly important to adapt and evolve with them. These technologies pave the way for future development which ease human life and also saves a ton of marine lives. The information and communication technology is one of such technology which can help shipping industry grow and adapt to oncoming new world. At last, we would like to conclude by quoting Stewart Brand “Once a new technology rolls over you, if you’re not part of the steamroller, you are part of the road.”

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Reduction of Carbon Footprints in Transportation

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ABSTRACT

Carbon footprint, the amount of carbon dioxide (CO₂) emissions associated with all the activities of a person or other entity (e.g., building, corporation, country, etc.). It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, the carbon footprint concept also often includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs). CO₂ is the chemical formula for Carbon Dioxide emissions, a colorless gas that is naturally present in the air and is produced by burning carbon and organic compounds. CO₂ emissions originate from the burning of fossil fuels (coal, natural oil, and gas) and cement production.

KEYWORDS

Carbon footprints, emissions, climate change, CO₂, oxides of nitrogen, oxides of sulphur, Sulphur, miller cycle, fossil fuels, exhaust gas.

1. INTRODUCTION

Climate change is one of the most prominent global issues that has attracted the attention of global academic researchers, policymakers and other related professionals. Climate change has caused several issues, such as global warming, ecological imbalance, technological issues, economic issues, and societal issues. Increasing concentration of greenhouse gas emissions is considered as a prime cause for these issues. Thus, greenhouse gas reduction has become a key agenda of the global community. The Kyoto Protocol specified six main greenhouse gases which significantly impact the environment: namely CO₂ (carbon dioxide), CH₄ (methane), N₂O (nitrous oxide), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF₆ (sulfur hexafluoride). Amongst them, carbon dioxide has been considered as the most prominent contributor to global climate change. For instance, carbon dioxide emissions have increased from 22.15 Gt in 1990 to 36.14 Gt in 2014.

1.1 Understanding Various Components of Exhaust Gas Emissions from Ships

The primary airborne pollutants from ships are present in the exhaust/flue gases generated by the main and auxiliary engines, together with the boilers. These pollutants are produced by the combustion of hydrocarbon fuels and the main products resulting are listed below.

- Carbon Dioxide (CO₂)
- Oxides of Nitrogen (NO_x)
- Oxides of Sulphur (SO_x)
- Carbon Dioxide

Carbon dioxide in the atmosphere is a major greenhouse gas, and internationally, great effort is being made to reduce the amount released. It is the major product of combustion and is more than 5% of the exhaust gas from a diesel engine and 13% from a water-tube boiler. In shipping, the reductions are being achieved by gradual improvements in fuel consumption involving modifications to the propulsion system (engines and propellers), smoother hull coatings and design changes to the hull form. CO₂ is the chemical formula for Carbon Dioxide emissions, a colorless gas that is naturally present in the air and is produced by burning carbon and organic compounds. CO₂ emissions originate from the burning of fossil fuels (coal, natural oil, and gas) and cement production.

- **Oxides of Nitrogen (NO_x)**

This term covers the combinations of nitrogen and oxygen produced as a by-product of the combustion of fuel in the air. The gases produced are predominately nitric oxide (NO) and nitrogen dioxide (NO₂) with traces of other complex chemicals including nitrous oxide (N₂O) and nitrates (NO₃). All of these gases combine with water and oxygen in the atmosphere to produce nitrous and nitric acids which are highly corrosive. Nitrogen dioxide is a reddish-brown highly toxic gas which causes lung damage. At sea level, these gases react with organic compounds to produce low-level ozone (O₃), a significant pollutant and creator of smog. In the upper atmosphere, these same gases, especially NO₂, react to remove ozone. As these gases readily travel great distances from the actual source of production, the impact of the resulting pollution (smog, acid rain etc.) can be many miles away from the source. The emission levels of oxides of nitrogen are at present complied with by modifications in the engine design. Regulation 13 of MARPOL Annex 6 divides marine diesel engines into groups by date of manufacture, stating the maximum emissions that are permitted. However, if the engine is modified, the rebuilt engine must comply with the level applicable at the date of modification.

- **Oxides of Sulphur (SO_x)**

Fuel burnt in the engine has certain percentage of Sulphur which is capped at 3.5% presently combines with the oxygen during combustion to produce SO₂ and this further oxidizes to form SO₃. Finally, part of the SO₃ gets converted to H₂SO₄. Causes Acid rain when the SO_x combine with atmospheric moisture and other components to produce acidic nature compound including H₂SO₄. It can get deposited on the lakes and streams to reduce their alkalinity. Marpol Annex VI allowed special Sulphur Emission Control Areas (SECAs) to be established with stringent controls on the emission of oxides of sulphur (SO_x). In these areas, the sulphur content of fuel oil used was not to exceed 1.5%. This limit reduced to 1.0% on the 1st July 2010 IMO will cap Sulphur in marine fuel at 0.5% globally from January 1st, 2020 from current 3.5%. This will apply outside ECA where the limit is already 0.1%. Ships will have to use cleaner fuels

2. MAIN BODY

2.1 Various methods to control CO₂ emissions on ship

2.1.1 Transition to renewables and cleaner sources of fuel

1. **Liquefied Natural Gas (LNG)**- LNG by far is the most viable solution currently available. Curtails all SO_x emissions as well as reduced particle matter emissions in turn reducing NO_x as well as CO₂ by about 20%.

2. **Liquefied Petroleum Gas (LPG)**- LPG is considered as a clean fuel. Studied to have no SOx emissions and reduce CO2 and NOx emissions to 15% and 10% respectively when compared to marine fuels.
3. **Methanol**_ In comparison with LNG, methanol as a fuel is a more logical solution as it has no direct global warming pollutants. Quickly dissolves in water, that makes a large methanol spill much less of an environmental hazard
4. **Biofuels**_ A sustainable source of energy that does not add more CO2 to the climate. Biofuels could only power up to 30% of the world's fleet.
5. **Ammonia**_ With the absence of carbon atoms in its structure, ammonia is a possible alternative for ship fuel. Ship owners could soon be allowed to utilize ammonia as fuel.
6. **Hydrogen**_ Fuel cells have been using hydrogen for years in small craft and passenger shuttles. The long-term onboard storage of hydrogen, especially in cryogenic liquid form requires expensive technologies.
7. **Solar & Wind Propulsion**_ These methods of propulsion and generating power onboard are then most green solutions available. Can be utilized as hybrid systems with conventional energy sources.

2.1.2 ENERGY ON BOARD SAVING

1. SPEED SELECTION OPTIMIZATION

- Follow identified speed optimization measures.
- Follow slow speed steaming at capped consumption (Voyage chartered vessels)

2. OPTIMIZED ROUTE PLANNING

- Communicate economical impacts and choices of voyage orders to Operations Managers in shore office.
- Follow weather routing.

3. TRIM OPTIMIZATION

- Optimize trim that gives minimum resistance.

4. OPTIMUM BALLAST

- Adjust ballast taking into consideration the requirements to mast optimum trim and steering conditions and optimum ballast conditions achieved through good cargo planning.
- Ballast water exchange should be reviewed for energy efficiency - but not at the cost of exchange objectives.

5. OPTIMIZATION OF LOAD ON GENERATORS

- Maximize D/G load, when possible, to run on one generation when it is safe to do so.
- All non - essential machineries and equipment's not affecting safety must be stopped whilst in port and at sea to reduce the load on generators
- Check on compressed air leakages in engine room and on deck to avoid frequent cutting in / cutting out or continuous running of main air compressors / deck air compressor / service air compressor.
- Identify the high electrical consumers and try to reduce their use as much as possible.
- Regulate number of engine room fans depending on climate especially at anchorages.
- Stop M/E LO + Camshaft LO Pump in port If M/E standby notice allows. (The Chief Engineer can use his discretion on this practice.)

6. WINDLASSES AND MOORING WINCHES

- Post mooring / anchoring operation, winches and windlass power to be switched off when not in use.
- Hydraulic leakages must be eliminated to ensure efficient functioning of the equipment.
- In port, mooring winches to be run only when required for attending to moorings.

7. BOILER AND STEAM LOAD OPTIMIZATION

- Regulate use of hot water calorifier between steam / electric heating depending upon easy availability of steam.
- Ensure all steam and oil lines lagging is in good condition. Maintain steam trap regularly. All steam leakages to be minimized.
- Use composite boiler at every relevant opportunity.

8. EXHAUST GAS ECONOMISER EFFICIENCY

- The efficiency of an exhaust gas economizer (EGE) can be improved by increased soot blowing frequency.
- Recording the exhaust gas temperature difference and pressure drop can provide an indication of EGE cleanliness.
- Clean Composite boiler exhaust side regularly to keep the tube surfaces clean.
- For exhaust gas economizer water washing should be scheduled regularly.

9. PORT / ANCHORAGE OPERATIONS

- Pumps such as ballast pumps, fire pumps should not be run unnecessarily sea to sea.
- After finishing with main engine, lube oil, cam shaft pump etc. should be switched off after certain time.

10. CARGO LOADING AND UNLOADING

- During loading due consideration needs to be given for appropriate trim view fuel consumption in order to obtain better speed while at sea.
- Ballast Eductor use to be optimized.
- Ideal Trim to be maintained during discharge to improve efficiency.
- Cargo Crane power must be switched off during cargo recess except for cargo heaters.

11. LIGHTING ON BOARD

- Use lighting on board effectively. Exercise care to avoid the creation of new safety / security hazards when turning off electrical services (e.g., lighting).
- Lights in all common places such as recreation room for officers and crew, gymnasium, cargo control room, ship's office, pantry, galley, dining halls may be "switched off" after use during night and day and specially between 2200 and 0600.
- Use of halogen / sodium vapor lamp in engine room are to be regulated and put off when not required.

12. HANDLING OF OIL RESIDUE (Sludge)

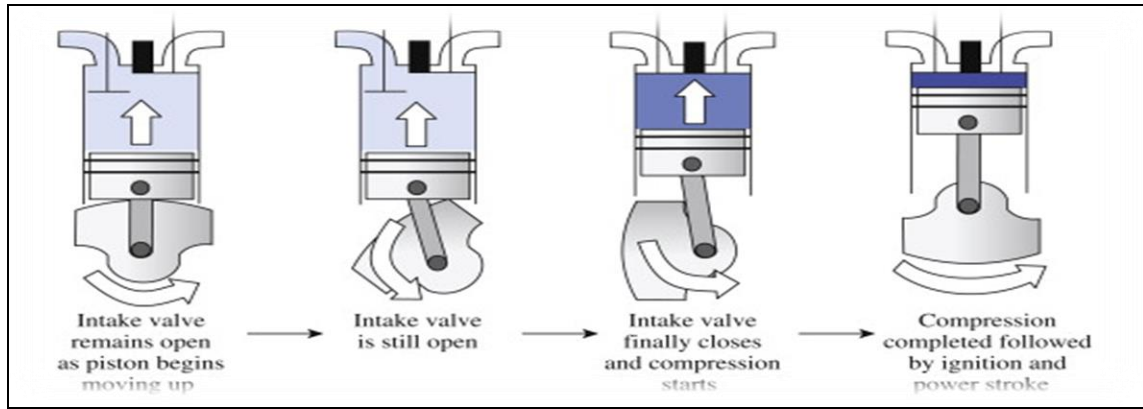
- Operation Manager to advise each voyage If it is possible where permitted to transfer engine slops to shore tanks to avoid diesel consumption in incinerator.
- Minimize water in sludge by settling and draining prior to transferring to slop tanks or Incineration.

13. BUNKER TANK HEATING

- Optimize bunker tank heating by monitoring temperature and consumption patterns of bunker tanks.
- Periodically inspect bunker tank vent and sounding pipes passing through cargo holds to prevent bunker tank contamination from hold ventilation / sounding pipe.

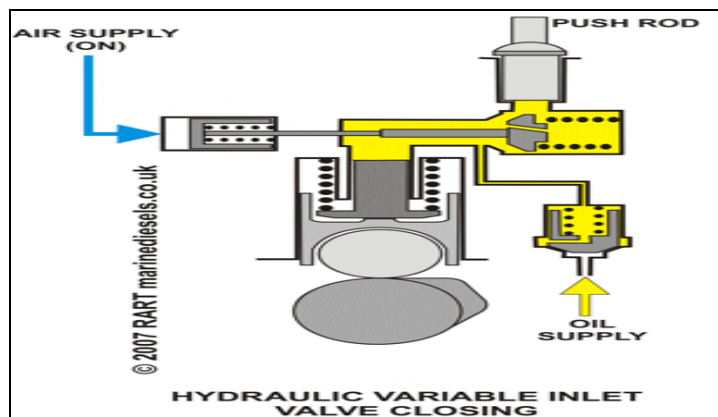
2.2 Miller Cycle for Reducing the engine NO_x emission

Engine cycles in which the *effective* compression ratio is smaller than the *effective* expansion ratio can be referred to as over-expanded cycles. In modern practice, over-expanded cycles are implemented with either early (EIVC) or late (LIVC) intake valve closing. The primary effect of EIVC and LIVC is a reduction in temperature at the end of the compression stroke. The lower temperature enables the use of higher geometric compression ratios that yield a longer expansion ratio and an efficiency benefit. Over-expanded cycles are commonly referred to as Miller cycles; referring to the inventors



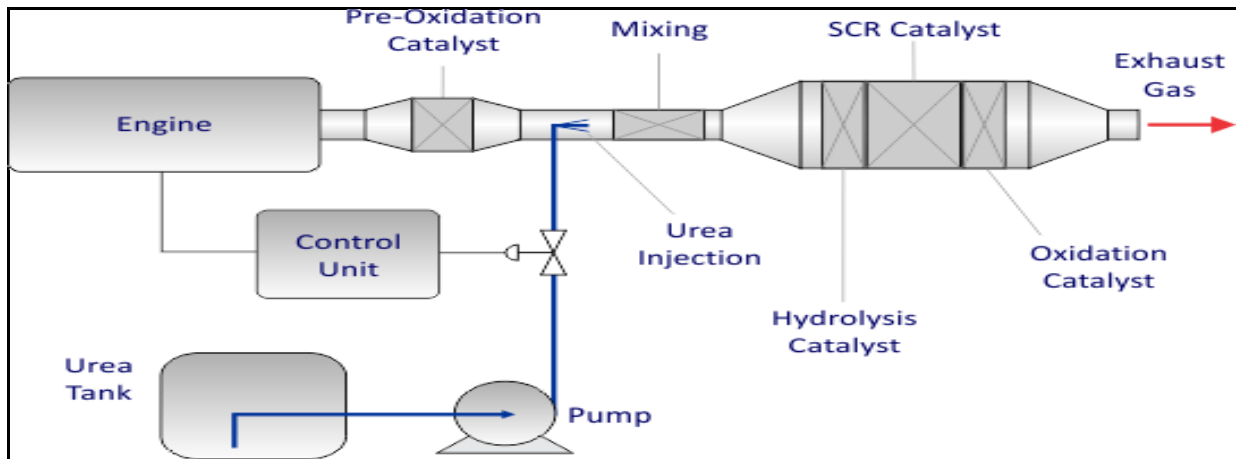
2.3 How the Miller cycle operates to control NOx emission?

Here in Miller cycle the compression begins later during the compression stroke in effect shortening the compression stroke. This is achieved by keeping the inlet valve open for a longer period compared to the conventional dual cycle otherwise in use. The compression stroke is cut short by as much as 30% hence remains 70% of the original. Here in Miller cycle the compression begins later during the compression stroke in effect shortening the compression stroke. This is achieved by keeping the inlet valve open for a longer period compared to the conventional dual cycle otherwise in use. The compression stroke is cut short by as much as 30% hence remains.

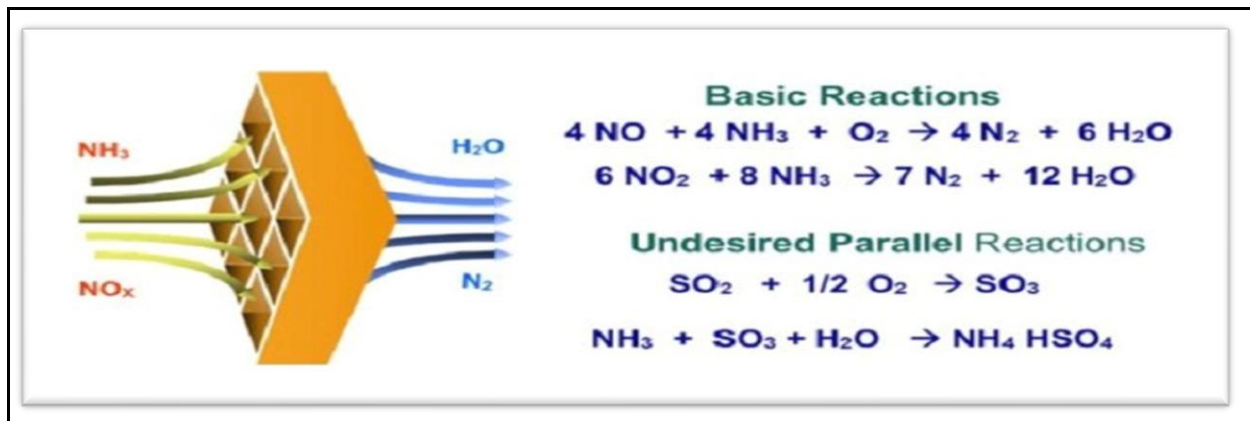
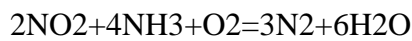
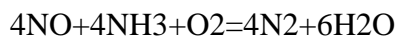


2.4 Selective Catalytic Reduction (SCR) System for Reducing the engine NOx emission

The Anhydrous ammonia is stored under pressure as it has a boiling point of -33 degree at atmospheric pressure. It is toxic in nature to handle and hence considered unsafe under engine condition. On the other hand, UREA solution is easily handled thru pumping system and has no storing related issues.



Chemistry involved in the process:



Quality of exhaust gas is monitored for the following reasons:

- the system is highly sensitive to plugging and contamination. The honey comb like structure provides ample of surface area required for the catalyst to work. There is a possibility of contaminating
- these spaces which drastically reduces the rate of reaction. Hence the exhaust gas is tested for the presence of particles.
- Monitoring the quality enables us to know the urea content which is left un-reacted or unused there by sending a clear signal regarding the effectiveness of the system in reducing the NOX.

2.5 Open loop system / Closed loop Scrubber System to control Sox emissions

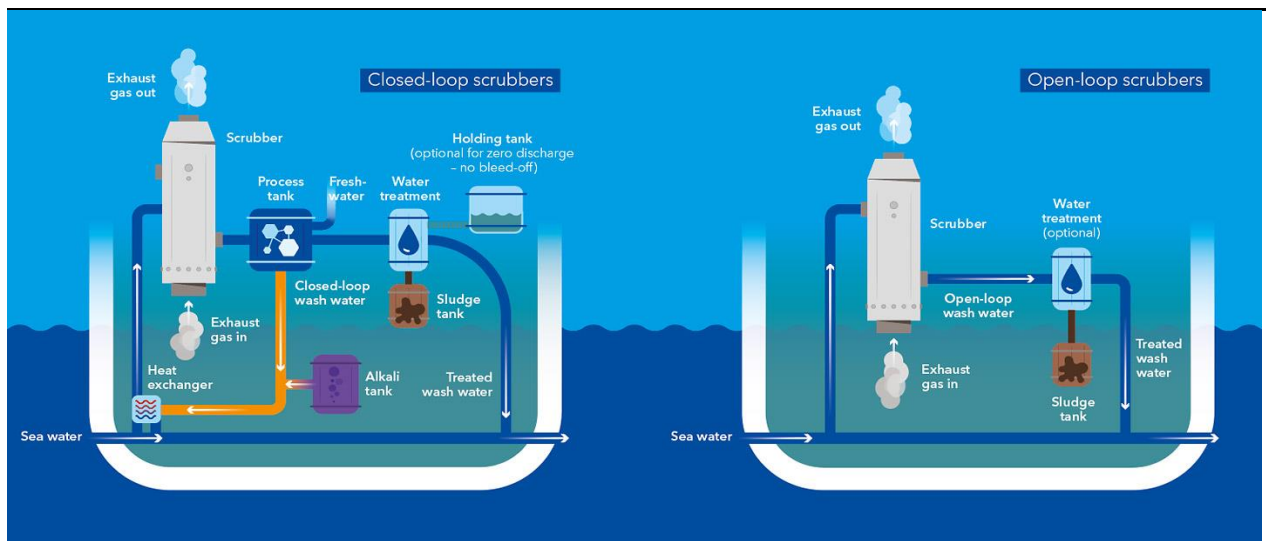
The system utilizes the natural alkalinity in the sea water for scrubbing and does not use or treated with caustic soda. This system is most suitable for ships plying in seas with high

alkalinity. During the process of scrubbing the alkalinity in sea water neutralizes the acid formed. The water from the outlet of the scrubber is monitored to ensure that it complies with MEPC184 (59). Thereafter after confirming the compliance the water can be discharged into the sea.

Fresh water is treated with NAOH is used for scrubbing. The efficiency of the scrubber can be as high as 97%. And the emission to atmosphere becomes equivalent to the exhaust with 0.1% Sulphur fuel. The system consists of two tanks separately located one of which contains fresh water and the other with caustic soda solution. The water from the fresh water tank is pumped thru a pump and cooled before entering the scrubber. A measured amount of Caustic soda is injected into the system before the pump. There is a provision for reuse of this water. Besides a small portion bled off from the circuit is monitored for quality in compliance with MEPC 184(59). In which case it could be pumped ashore. To economize the consumption of fresh water the same water could be recirculated after scrubbing.

The system utilizes the natural alkalinity in the sea water for scrubbing and does not use or treated with caustic soda. This system is most suitable for ships plying in seas with high alkalinity. During the process of scrubbing the alkalinity in sea water neutralizes the acid formed.

The water from the outlet of the scrubber is monitored to ensure that it complies with MEPC184 (59). Thereafter confirming the compliance, the water can be discharged into the sea



The closed type uses fresh water in "closed" fresh water circuit that is treated with an alkaline chemical such as caustic soda neutralization and scrubbing. The wash water is re-circulated and the losses is made up with additional freshwater. A small quantity of the wash water is bled off to a treatment plant before discharge to sea. Typically closed freshwater systems have a discharge rate of 0.1- 0.3m³/MW h. The system could also be designed with a holding tank for zero discharge for a certain period.

CONCLUSION

Uses of alternative sources

- Improve mileage, increase chance for renewable energy usage, better longevity, possible to save limited resources, tandem with consumption prediction
- At the start of 2020, the maximum allowable sulfur content in bunker fuel has been brought down to 0.5% (from 3.5%) in order to minimize sulfur emissions by 77% (i.e., 8.5 million tons a year). For its part biofuel blends with the aim of reducing greenhouse gas emissions by 15-20 % at first, then go up to the full potential reduction, at 80-90% over time.
- Biomass-derived fuels are also developed, to reduce CO₂ and sulfur emissions by up to 90%, although the competition with food production industry might constitute a barrier.
- Green hydrogen also has the potential to create 100% emission-free vessels, but the main challenge is the physical space required to store it for long voyages, because the company would not be able to carry as much cargo. Furthermore, using hydrogen needs the change of all engines, meaning significant capital investment. Last, it is much more expensive (+800%) than traditional bunker fuel but as solar and wind farm are developing to produce more green hydrogen, the costs should fall, allowing virtually unlimited shipping carbon emission reductions.

Uses of Miller Cycle

- Since a supercharger is used to boost the scavenge pressure to reasonably higher level at low load. The system also uses the air cooler to bring down the temperature of the gas entering the cylinder through the inlet valve. This ensures enough amount of cool air at the beginning of the EFFECTIVE compression stroke. The relative low temperature of the cool air couple to the rise in temperature at the end of the combustion helps in keeping the NO_x formation under control.
- Since final pressure is a function of compression stroke and the volume of air at the beginning of the effective compression stroke, the final compression pressure stays on the lower side and this allows us to vary the injection timing by beginning it slightly earlier. Here since the compression pressure is comparatively made less by regulating the closing of the inlet valve and peak pressure is a function of compression pressure and injection timing, we could make adjustment in that direction. This further brings about a decrease in specific fuel consumption and thermal efficiency

Uses of SCR System

- A selective Catalytic reducer is installed on board to get rid of the NO_x before the exhaust is emitted into the atmosphere. In this system UREA solution, which contains fair amount of Ammonia which otherwise has storing problem, when injected into a stream of exhaust gas the Ammonia in the UREA solution reacts with NO_x to convert it to Nitrogen and water. The catalyst used in the process is Titanium Dioxide to enhance the reaction speed. This process can reduce NO_x by 98%.

Uses of Open Loop/Closed Loop System

- The system is more suited to the ships plying in areas where the alkalinity of the sea is minimal like the Great lakes. Fresh water is treated with NAOH is used for scrubbing. The efficiency of the scrubber can be as high as 97%. And the emission to atmosphere becomes equivalent to the exhaust with 0.1% Sulphur fuel.

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Place: Lonavala.

Date:

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Use Of Catalytic Converter to Achieve Efficient and Economic Emission Reduction

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ABSTRACT

Stringent international emission rules according to MARPOL ANNEXURE VI have made, finding more economical ways to fight emissions, an immediate need of the hour. A major step in this direction can be taken by the inclusion of a Catalytic Converter which has proven time and again to be of immense use in reducing harmful emission gases up to a considerable level. Despite its use of expensive metals like platinum and palladium, the method is researched by us for its economical use in the shipping industry versus the conventional method already being used, i.e., Selective Catalytic Reduction. The Catalytic Converter inter-alia occupies less space for the same operation as an SCR plant.

KEYWORDS

Catalytic Converter, Red-ox Reaction, Efficiency, Emissions, Scrubber Unit

1. INTRODUCTION

In 1975, the EPA's regulations on reducing toxic emissions led to the widespread introduction of catalytic converters in American production vehicles. The Clean Air Act of 1975 mandated a 75 percent reduction in emissions for all new vehicles manufactured after 1975, which had to be achieved through the use of catalytic converters. Vehicles produce hydrocarbons, carbon monoxide, and nitrogen oxide without catalytic converters. The majority of ground-the catalytic converter on ships and take it to a whole new level. A catalytic converter is a straightforward device that uses fundamental red-ox reactions to reduce engine emissions. It has a ceramic honeycomb-like interior with insulating layers in a metal housing and reduces the amount of harmful gases produced by an automobile engine by approximately 98%. A washcoat of aluminum oxide covers the thin wall channels that make up the interior of this honeycomb. This coating has more surface area, is porous, and contains precious metals like palladium, rhodium, and platinum. This makes it possible for more reactions to take place. A single converter for a car engine can only hold between 4 and 9 grams of these precious metals. A ship's engine, on the other hand, will need more, but the ratio will be determined by the ship's power and capacity.

2. WHAT IS NO_x, AND WHERE DOES IT COME FROM?

NO_x pollution occurs when fossil fuels are burned at high temperatures and nitrogen oxides are released as a gas into the atmosphere. These nitrogen oxides consist mainly of two molecules, nitric oxide (NO) and nitrogen dioxide (NO₂) along with a few others that occur in much lower concentrations. The molecules of- Nitrous oxides are a major greenhouse gas and affects global climate change. When oxygen and nitrogen from the air interact during a high-temperature

combustion event, nitrogen oxides are formed. Internal Combustion Engines and electricity plants powered by fossil fuels both experiences these conditions.

Each marine diesel engine installed on a ship with a power output of more than 130 kW is subject to the NO_x emission limits outlined in Regulation 13 of MARPOL Annex VI. Any reciprocating internal combustion engine that runs on liquid or dual fuel is considered a marine diesel engine. Two exceptions exist, engines that are only used in emergencies and that are on ships that only operate in the waters of the state where they are flagged. The latter exception is only applicable if these engines are subject to a different NO_x control measure.

According to Table 1 and Figure 1, diesel engine NO_x emission limits are determined by the engine's maximum operating speed (n, rpm). The limits for Tier I and Tier II are applicable worldwide, whereas the Tier III standards only apply to NO_x Emission Control Areas.

Tier	Date	NO _x Limit, g/kWh		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier I	2000	17.0	45 · n-0.2	9.8
Tier II	2011	14.4	44 · n-0.23	7.7
Tier III	2016*	3.4	9 · n-0.2	1.96

* In NO_x Emission Control Areas (Tier II standards apply outside ECAs).

Fig 1: NO_x emission limits - MARPOL Annex VI

Optimizing the combustion process is expected to meet Tier II requirements. Timing of fuel injection, pressure and rate (rate shaping), area of fuel nozzle flow, timing of exhaust valve, and volume of cylinder compression are some of the parameters that engine manufacturers examine. Dedicated NO_x emission control technologies like exhaust gas recirculation or selective catalytic reduction, as well as various forms of water induction into the combustion process (with fuel, scavenging air, or in-cylinder), are expected to be required by Tier III standards.

Pre-2000 Engines. According to the 2008 Annex VI amendments, existing engines installed on ships constructed between January 1, 1990, and December 31, 1999, with a displacement of less than 90 litres per cylinder and a rated output of less than 5000 kW, are now subject to Tier I standards, provided an approved engine upgrade kit is available.

Testing. ISO 8178 cycles (E2, E3 cycles for various types of propulsion engines, D2 cycles for constant speed auxiliary engines, and C1 cycles for variable speed and load auxiliary engines) are used to test engine emissions.

The Tier III standards' inclusion of not-to-exceed (NTE) testing requirements is up for debate. NO_x emissions at each load point in the E2/E3 cycle would be subject to NTE limits that have a multiplier of 1.5. Even though residual fuels are typically used in real-world operations, distillate diesel fuels are used for engine testing.

The mandatory "NO_x Technical Code," which has been adopted under the guise of "Resolution 2," contains additional technical details regarding NO_x emissions, such as methods for controlling them.

2.1 SCR USED ONBOARD SHIPS

Ship & Shore Environmental provides Selective Catalytic Reduction (SCR) Systems for processes that need to reduce NO_x to meet air quality regulations and low NO_x limits. Ship & Shore can custom engineer, design, and manufacture an SCR system that is connected to a Regenerative Thermal Oxidizer (RTO) based on the Volatile Organic Compounds that are present during the manufacturing process.

The following are general components of an SCR and RTO abatement system:

2.1.1. SCR CATALYST & INJECTION GRID

The RTO stack will contain the SCR catalyst. Before entering the SCR catalyst, the RTO stack will be connected to a hot bypass to maintain a temperature of 500°F to 700°F. Through the injection grid and mixing plate, ammonia will be injected into the stack and mixed with the flow.

The catalyst media will receive the mixture of NO_x and ammonia. The SCR catalyst can be designed for up to 95% NO_x reduction efficiency and will react with NO_x and ammonia through the catalyst bed, resulting in the formation of N₂ and H₂O.

2.1.2. AMMONIA VAPORIZOR UNIT

Hot air atomization will be used to vaporize the aqueous ammonia (NH₃) that will be pumped out of a storage tank. At approximately 250°F, vaporized ammonia will be delivered to injection grids. The following components typically make up an ammonia vaporizer unit: ammonia filter, electrical heater, air blower, and control system

A substitute for aqueous ammonia is either urea or anhydrous ammonia. The application of anhydrous ammonia may raise some safety concerns. The "Urea to Ammonia" equipment must be added to the Urea option. For any given process, the possibility of both options can be investigated.

2.1.3. ANALYZERS

To keep an eye on NO_x or Ammonia slips at the exhaust stack, online analyzers are available. Controlling the rate of ammonia injection based on NH₃ or NO_x slip is also crucial. The rate of ammonia injection will be controlled by an analyzer signal.

Ammonia slip can be monitored with a laser cross-duct in situ NH₃ gas analyzer, and NO_x can be monitored with a chemiluminescent analyzer. The sampling system, probes, and analyzer enclosures are typically included in the analyzer system.

2.1.4. AMMONIA TANK AND PUMP

To transport ammonia to the vaporizer and store it, an ammonia tank and pump will be required. The tank's size can be determined by the frequency of loading and the space available. A 1000-GAL tank, for instance, will last one to two weeks at the highest NO_x concentration or three weeks at the average NO_x concentration.

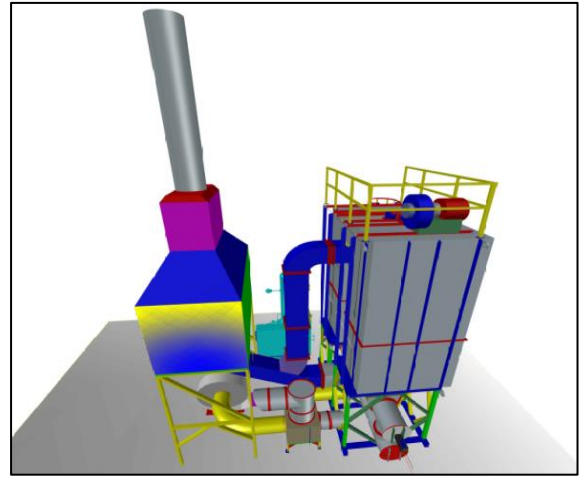
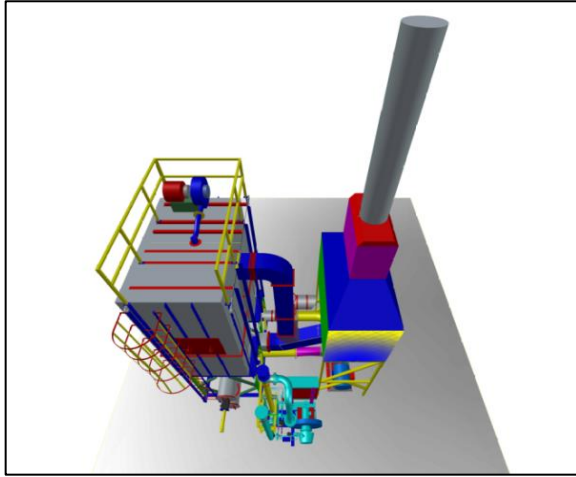


Fig. 2. 3D Rendering of a Ship & Shore RTO (left) + SCR System (right)

3. CATALYTIC CONVERTER

A catalytic converter transforms the harmful compounds in an engine's emissions into safe gases like steam in a chamber. The catalyst works by separating the hazardous molecules in car exhaust gases before they are released into the air.

The catalytic converter is a big metal box that is on the underside of a vehicle. Two pipes emerge out of it. During the process of making the gases safe to be expelled, the converter makes use of these two pipes as well as the catalyst.

The vessel's "input" pipe, which is connected to the engine, is where the gas enters. Over the catalyst, these are blown, triggering a chemical reaction that separates the pollutants.

The second pipe, or "output," that is connected to a vessel's tailpipe now transports the less harmful gases.

3.1. WHAT IS INSIDE A CATALYTIC CONVERTER?

So, what is a catalytic converter made of? Platinum or a similar metal like rhodium or palladium is typically used to make the catalyst in a catalytic converter. Within the cat housing, a ceramic honeycomb structure allows gases to flow through it. This is lined with metals that do particular jobs that help cut emissions. Two primary categories of catalysts may be found in automobiles:

- **Reduction catalysts:** Helps reduce nitrogen oxide pollution by removing oxygen. Nitrogen and oxygen gases, which are innocuous on their own, are formed when nitrogen oxides are broken down.
- **Oxidation catalysts:** Used to convert carbon monoxide into carbon dioxide through a process of addition of oxygen.

An oxygen (O₂) sensor is also close to the catalytic converter. This sensor tells the vessel's electronic control unit (ECU) how much oxygen is in the exhaust gases. This enables the engine to supply sufficient oxygen to the converter to complete the oxidation process, allowing the engine to run on a more effective air-to-fuel ratio.

3.1.1. TYPES OF CATALYTIC CONVERTERS

Reduction and oxidation are the two primary catalysts that can be utilized in an exhaust system to handle particular gases.

There may or may not be a reduction catalyst installed, depending on the vehicle's year and type of catalytic converter. Catalytic converters can be broken down into two main categories:

- **Two-way:**

Two tasks are performed simultaneously by a two-way catalytic converter: Carbon monoxide oxidation into carbon dioxide: $2\text{CO} + \text{O}_2 = 2\text{CO}_2$ Oxidation of hydrocarbons (fuel that has been burned completely or partially) into water and carbon dioxide: $\text{C}_x\text{H}_{2x+2} + [(3x+1)/2] \text{O}_2 \rightarrow x\text{CO}_2 + (x+1) \text{H}_2\text{O}$ (a combustion reaction). This kind of catalytic converter is frequently applied to diesel engines to lessen the amount of hydrocarbon and carbon monoxide that is released into the atmosphere. They were also installed on gasoline engines in automobiles sold in the United States and Canada until 1981. They were replaced by three-way converters because they were unable to control nitrogen oxides.

- **Three-way:**

There are three simultaneous functions of a three-way catalytic converter: Oxygen and nitrogen are converted from the nitrogen oxides: $2\text{NO}_x \rightarrow x\text{O}_2 + \text{N}_2$ Oxidation of carbon monoxide into carbon dioxide: $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$

- Oxidation of unburned hydrocarbons (HC) to water and carbon dioxide: $\text{C}_x\text{H}_{2x+2} + [(3x+1)/2]\text{O}_2 \rightarrow x\text{CO}_2 + (x+1)\text{H}_2\text{O}$. These three reactions take place most effectively when the catalytic converter receives exhaust from an engine that is running slightly above the stoichiometric point. This point is between 14.6 and 14.8 parts air to 1 part fuel, by weight,

Diesel engines employ the use of two-way catalysts, and the converters are also specifically designed to work with diesel exhausts. The converters used for such kinds of engines try and target particulates called soluble organic fractions. These are made from hydrocarbons bound to soot.

3.2 PROBLEMS WITH CATALYTIC CONVERTERS

So what happens when a catalytic converter fails? When the part starts to wear out, a variety of symptoms can occur due to the role it plays in the exhaust system of a vehicle.

Examples to be on the lookout for include:

- **Declining Fuel Efficiency:** A clogged catalytic converter can restrict the flow of air through your engine. Your engine might start burning more fuel than usual as a way to make up for the loss of fuel efficiency.
- **Check Warning Light:** A variety of things can cause a check engine light to come on. However, the catalytic converter can be tested by a diagnostic system on vehicles manufactured after 1996. The air-to-fuel ratio sensors may cause the warning light to come on if your converter is broken.
- **Rotten Egg Smell:** There may be internal damage to the catalytic converter that makes it difficult to convert exhaust gases. The result might smell like sulfuric "rotten eggs."
- **Issues Starting the Engine:** Your vehicle's exhaust gases must escape. As effectively, this can be prevented by a clogged catalytic converter. When you try to start your car, this can cause it to sputter or stall due to increased exhaust pressure.
- **Poor Acceleration:** The exhaust gases must again escape in some way. Acceleration might be difficult for you due to clogged converter pressure and a clogged exhaust. If you try to do so, you might notice jerking or stalling.
- **Failed Emissions Test:** Vehicle emissions testing is required by many states regularly, and if yours fails, your catalytic converter may be to blame. Failure to pass this test may be accompanied by the other symptoms listed above.

3.3. CATALYTIC CONVERTER USED IN AUTOMOBILES

A catalytic converter is a straightforward device that reduces automobile emissions by utilizing fundamental redox reactions.

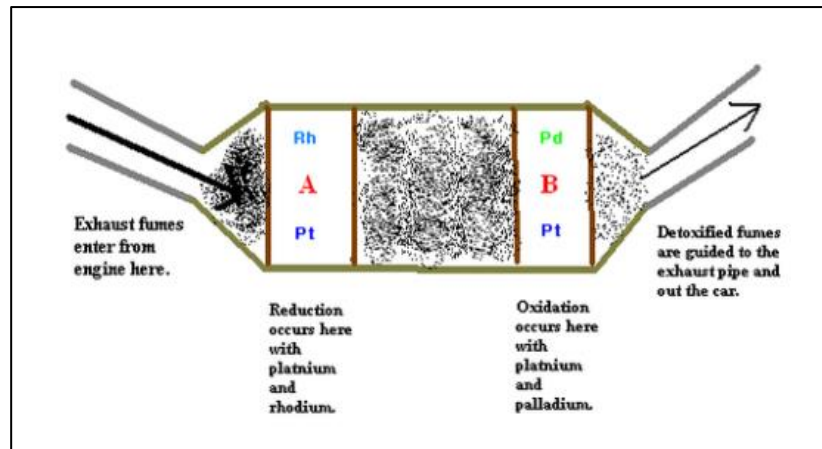


Fig. 3 Design of a Catalytic Converter

It reduces the amount of harmful gases produced by an automobile engine by approximately 98%. Catalysts like palladium and platinum are used in a catalytic converter. A Ceramic honeycomb or ceramic beads, which are housed in a package resembling a muffler and attached to the exhaust pipe, are coated with the catalyst. The catalyst aids the converter as it converts unwanted fumes through straightforward oxidation and reduction reactions. The engine produces the following three harmful pollutants:

- Hydrocarbons (in the form of unburned gasoline)
- Nitrogen oxides (created when the heat in the engine forces nitrogen in the air to combine with oxygen)
- Carbon monoxide (formed by the combustion of gasoline).



Fig. 4 Catalytic Converter in an Automobile

3.4. PARTS OF A CATALYTIC CONVERTER

Despite their similarities, a catalytic converter and muffler serve distinct purposes in your exhaust system. Ceramic honeycomb-shaped structure is housed in the converter; This component and precious metals in the converter facilitate a chemical reaction in your vehicle's

emissions. These components, which are referred to as catalysts, work to reduce harmful pollutants released by a vehicle.

PARTS OF A CATALYTIC CONVERTER INCLUDE:

- Substrate – A core made of ceramic honeycomb or metallic foil.
- Washcoat – Aluminum oxide, titanium dioxide, silicon dioxide, silica, alumina
- Catalyst – Platinum, palladium, rhodium

3.5. WORKING OF CATALYTIC CONVERTER

It is possible to significantly reduce the number of harmful components in vehicle exhaust, though it is not yet possible to eliminate all of them. An intake pipe draws exhaust fumes from the engine into the catalytic converter when your vehicle is running. The catalysts, which are made of ceramic honeycomb and metals like palladium or rhodium, move hydrocarbons, carbon monoxide, and nitrogen oxides over them. After that, the metals start two major chemical reactions inside the converter:

3.5.1. REDUCTION

By removing oxygen gas, this reduces the amount of nitrogen oxide in the exhaust. Pure nitrogen and pure oxygen are produced when the elements of nitrogen oxide are broken down. These components are harmless on their own.

3.5.2. OXIDATION

By adding oxygen to carbon monoxide, it becomes carbon dioxide, which is less harmful. Your vehicle's oxygen sensor is evaluating whether your fuel intake process contains sufficient oxygen for optimal performance during these conversions. Your car's computer can instruct the fuel intake process to adjust the amount of oxygen for a more effective combustion process if the ratio is found to be off.

The exhaust is routed through the muffler to reduce noise after the conversion is finished, and then it exits the vehicle entirely via the tailpipe.

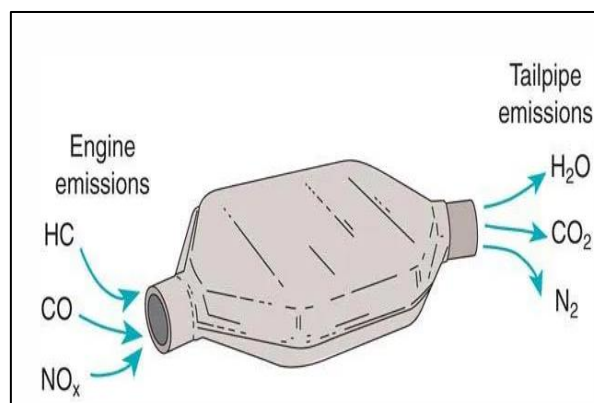


Fig. 5 A 3-Way Catalytic Converter

4. PROBLEMS AND COUNTERMEASURES

We thought about a few things before introducing this idea to the marine industry.

- Cost-effectiveness of the catalytic converter in comparison to the ship-based SCR currently in use. Efficiency, as the SCR currently in use reduces NOx emissions by 90%.
- Need of modifications to the ship required to fit the converter.
- Working temperature.
- Maintenance issues.
- Catalytic converter cleaning.

To tackle this we found out:

- If we use the three-layer catalytic converter instead of the current selective catalytic reducer, the cost was lower than anticipated. That is provided in the headline "Cost Analysis" Para 6.
- The catalytic converter in a 1400cc power car engine is 98% efficient, Therefore, using it as a countermeasure in the maritime industry can significantly alter the situation.
- No major modification is needed to be done as this can be retrofitted with the current system.
- A clogged catalytic converter should be replaced right away if sluggish powertrain performance, decreased acceleration, the smell of rotten eggs or sulfur coming from the exhaust, dark exhaust smoke, or extreme heat coming from under the vehicle is noticed.
- Is there a way to clean a catalytic converter?
- Using lacquer thinner and water is the best technique. However, since there is no tried-and-true method for cleaning the catalytic converter, in this manner, additive cleaners like Oxicat or Cataclean that help slowly remove carbon deposits.
- The time interval of replacement of a catalytic converter in automobiles is approximately 10 years continuous working.
- This works at about 600°C, so we are using a reheat system to raise the temperature to counteract this.
- To check for any deficiencies in the catalytic converter, an additional temperature sensor, oxygen analyzer, and output exhaust sensor will be installed.

5. PROPOSED INSTALLATION

The Catalytic Converter performs best at temperatures around 600°C. Therefore, it should have been situated between the turbocharger and the exhaust manifold. However, this could impede the flow of exhaust gases, reduce turbocharger efficiency, and cause turbocharger surging. Therefore, placing it after the scrubber unit would be preferable. The turbocharger would move the exhaust gases to the scrubber unit, with an economizer in between. After that, it would go through a reheater, which might heat the gas with electricity or steam. The heater is provided to achieve the most efficient working temperature range, which is less than 600°C. The scrubber

would dampen the majority of the vibrations in the exhaust gases, which may extend the catalytic converter's lifespan since platinum and rhodium now require more time to erode. This is another advantage of placing it after the scrubber.

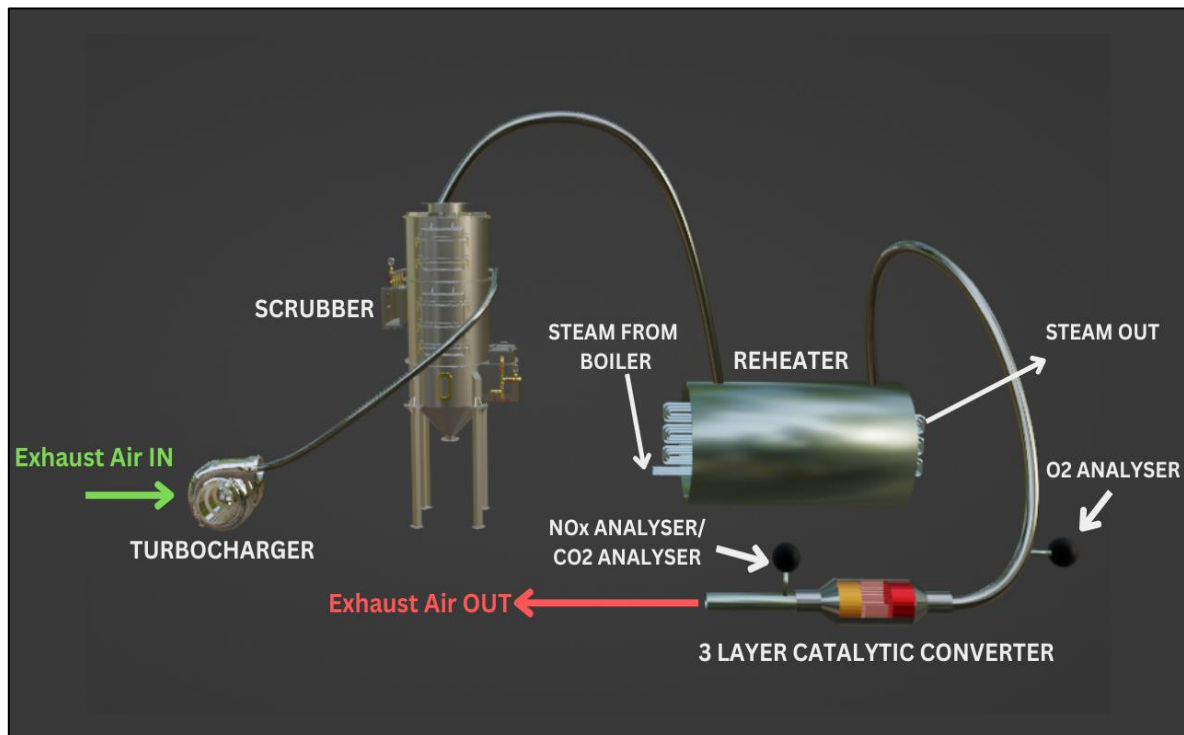


Fig. 6 Proposed Installation of Catalytic Converter on Ships

6. COST ANALYSIS

For an SCR Unit	For Catalytic converter
<p>Let's assume a marine diesel engine of 20 MW BHP, Since urea required would be 4-10 cubic metres per MW of engine power, Let's say 6 cubic metres per MW, Urea required would be 120 cubic metres. Density of urea is about 1.32t/m³ Amount of urea required= $1.32 \times 120 = 158.4$tonne Average cost of urea = \$550/tonne Cost of urea= $550 \times 158.4 = \\$87120$</p>	<p>Normally SUVs use a max of 7g of platinum Assuming the ship uses 100g of platinum Average cost of platinum=\$35.18/g Cost in converter= \$35180</p> <p>About 1-2 g rhodium is used in automobiles Assuming the rhodium used is 20g in ship Cost of rhodium=\$400/g Cost in converter=\$8000</p> <p>Total cost=\$35180+\$8000=\$43180</p>

8. CONCLUSION

The purpose of this research was to benefit the maritime sector by replacing the current SCR system which require a very high setup cost and is space-consuming, with an alternate system

that will be cost-effective, less space consuming and more effective in reducing the exhaust emissions that will be benefitting the shipping companies while complying with all the rules and regulations in a very efficient manner.

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Socio-economic analysis of blue fuel

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ABSTRACT

The renewed interest in cleaner energy sources due to the tightening of international maritime regulations and a general consensus for achieving net carbon neutrality has led to the development of emissions abatement technologies. The use of alternative fuels instead of marine diesel comes across as a feasible solution to the contemporary problem. Further advancements in alternative fuel technologies and deep research have created popular cleaner energy alternatives like LNG, LPG, Ethane, Methanol, and Hydrogen.

This study presents a socio-economic feasibility analysis of a novel type of fuel that uses PSW (Plastic Solid Waste) as a feedstock to form Blue Diesel using the thermal depolymerization process called Hydrothermal Liquefaction (HTL). The oil formed is from the HTL treatment of PP, PT, PS, and PTE, which are the four prevalent forms of plastic. The oil yielded from HTL of PS, PP has a High Heating Value (44-45 MJ/Kg) comparable to that of gasoline (43.4 MJ/Kg). A Business Canvas Plan is then developed to evaluate the economic viability of the process in India based on prior research done in Cairo, Egypt.

Further, a Life Cycle Analysis is reviewed to observe the Carbon Intensity and GHG emissions produced over the entire life cycle of the fuel. In this study, a holistic analysis of Blue Diesel encompassing a plethora of factors is conducted and comments for future developments are added.

KEYWORDS

Plastic, Blue fuel, Alternative Fuel, LCA of Bio-Fuel, Socio-Economic Analysis of Blue Fuel

INTRODUCTION

Maritime trade plays a crucial role in the world economy with 90% of all transportation taking place through sea routes. With about 90,000 merchant vessels sailing in the open ocean, their energy efficiency and impact on the climate becomes an utmost priority. The contemporary energy crisis created due to the peculiar circumstances between nations coupled with a raving climate crisis renews the interest in alternative fuels that are energy efficient with no or considerably less GHG emissions. IMO has itself consecrated the way to cleaner energy alternatives by enforcing regulations under MARPOL Annex VI that limit the emissions of

NO_x (Regulation 13), SO_x &PM (Regulation 14), and regulation on energy efficiency for ships for CO₂ emissions.

This has expedited the acceptance of alternative fuelled ships among ship owners and aided research into the development of novel ones. The most employed energy alternative comes in LNG, it is one of the cleanest fuels available with affordable pricing but requires special handling and bunkering facilities, this raises the entry barrier and inadvertently leads to a low acceptance. This trend is similarly observed with LPG-fuelled carriers. For Ethane fuelled ships multiple applications and projects have come-up and a surge in consumption is seen in the United States [1]. For Hydrogen, it's used as an additive to conventional fuels and requires an added level of precaution in its handling and storage. A lot of groundwork has been already done for the prior-mentioned alternative fuels so new pathways and feedstock should be examined for cleaner energy alternatives.

Thus, this paper presents a socio-economic feasibility analysis of a new type of fuel termed “Blue Fuel” that is attained through a depolymerization process of plastics called “Hydrothermal Liquefaction”. The process yields an oil of calorific value similar to that of gasoline at temperatures of more than 400 C° and pressure of 22MPa. This study investigates in detail the well-to-wake emissions of the blue fuel and its economic viability for the modern maritime industry. Later it adds ideas for future techniques to fasten the process and the increase the applicability of the blue fuel.

The **HTL** process not only has the potential to create an alternative fuel but provides a feasible solution to one of the issues that require immediate attention “The Plastic Problem”.

THE PLASTIC PROBLEM

Production of synthetic plastic solid waste (PSW) has reached 400 million tonnes annually [2]. Most of the PSW produced by weight is landfilled (76wt%), 9 wt.% is mechanically recycled, and the rest 15 wt.% is energy recovered. Furthermore, 15 million tonnes of plastic make their way to oceans every year, 2/3rd of which is through land-based sources. The most common forms of plastic recovered from oceanic gyres and landfills are single-use plastics like bottles, plastic bags, cotton bud sticks, sanitary items, and wet wipes.

To deal with the growing plastic problem mechanical recycling may seem like a viable option but due to the high cost (separation of feedstock, logistics) and the environmental impact (emission of Volatile Organic Compounds) it's not widely accepted.

Direct Energy recovery methods like incineration of plastics may be employed but due to the emissions of gases like sulphur and nitrogen, and the subsequent impact it has on the communities living near these incinerators, it's not considered a viable alternative. This is supported by the emissions data from Global Alliance for Incinerator Alternatives which estimates that in USA GHG emissions from plastic incineration will be reaching 91 million metric tonnes in 2050 from 4.9 million metric tonnes in 2015 [5].

Indirect energy recovery methods like Pyrolysis have been piloted as the energy recovery process from plastic. Pyrolysis of plastics produces energy-dense oils, gases, and chemicals as by-products. However, certain restrictions limit its applicability. The restrictions are the need for dry feedstock [6], the problem with the pyrolysis of Polyethylene terephthalate (PET) [7], and heavy wax products. These limitations can be overcome by processing using HTL.

HTL & BLUE FUEL

WHAT'S HTL?

At its initial stage, the process of HTL was used for the aromatization of biomass, but with the latest findings, it can be used for the valorisation of Plastic Solid Waste (PSW) to produce oil and chemical by-products.

It involves the use of water both as catalyst and solvent for non-polar organic compounds at temperatures near to or equal to supercritical temperature ($T > 362\text{ }^{\circ}\text{C}$) and high pressures of 22MPa. At such temperatures water's dielectric properties reduce and it acts as a good solvent for ionic or non-ionic organic compounds, this ramps up the speed of depolymerization reaction which essentially converts long-chained complex hydrocarbons of plastics to monomers in the liquid and solid phase.

The requirement of high pressure for this reaction to take place is one of the demerits of the process but as later projected in the study the socio-economic benefits starkly outweigh this demerit.

THE PROCESS

MATERIALS

In this study, the production of blue fuel has been restricted from the four significant forms of plastic Polypropylene (PP), Polyethylene terephthalate (PET), Polystyrene (PS), and Polycarbonates (PC). These plastics are introduced to the reactor in the form of cylindrical pellets of diameter in the range of (2.10 ± 0.09) mm to (3.64 ± 0.26) mm [3].

Deuterated Di-chloromethane of 99.99% purity is used for the separation of the generated oil from the rest of the by-products.

PROCEDURE

The process initiates by introducing solid cylindrical pellets (0.12 grams) of the selected form of plastic into the reactor. Three runs are made with each type of plastic, to get precise results. Then water is added (0.34 ml to 2.7ml), and a Sand bath is employed to heat the feedstock to sub and supercritical temperatures of 350°C and 450°C respectively. The reactor is taken off the Sand bath as the super-critical temperature is reached and is allowed to cool down in a water bath.

The Solution then is rested at room temperature for the equilibration to take place. This equilibrated solution contains potential oil monomers. To separate them from the rest of the products a DCM solution is introduced which dissolves the oil-containing matter. This DCM soluble solution is then passed through a micro-meter filter to remove the minuscule solid by-products.

The filtered DCM solution is centrifuged to obtain oil that can be used to generate "Blue Diesel", which is named so to honour its background.

OIL YIELDS

The highest oil yields for different materials are 32% for PP at a temperature of 420°C at a batch holding time of 30 minutes, 16% for PET (450°C), 86% for PS (350°C), and 60% for PC (425°C) [3]. The oil yields for PET and PC are less due to the high oxygen content which can be improved by the use of a catalyst.

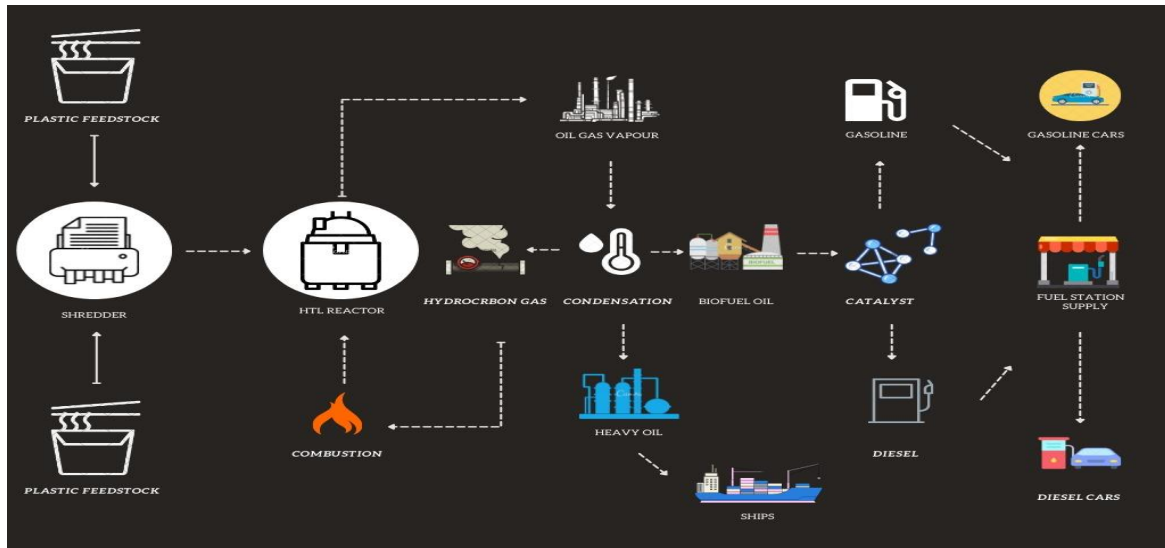


Fig. 1. The HTL Process of Plastics

BLUE DIESEL

Fig. 1 explains the production pathways and the products that can be attained from the HTL of Plastics. To attain “Blue Diesel” the hydrocarbon monomers in the HTL oil are further condensed to achieve a fuel that can be used onboard.

The fuel obtained is of calorific value (HHV 44 MJ/Kg) greater than that of conventional marine diesel oils (HHV 41MJ/Kg), this remarks the physical and thermodynamic feasibility of Blue Fuel.

ECONOMIC ANALYSIS

Methodology

The methodology incorporated in our study is based on the Business Canvas Model (BCM) developed in Cairo, Egypt by a collaboration between academic institutions and business owners [1] and has been used in relative terms to represent the Indian market and its scenario.

Feasibility of producing Blue Diesel from plastic

The plastic problem is profound in India, being a developing nation million tonnes of PSW is released into our systems. Like the world, most of this plastic is fed into an inefficient waste management system that goes around the detrimental loop of incineration and landfills.

A Business Canvas Model suitable for the contemporary state is developed on consultations with industry experts in the field. The BCM is reflected in Table 1.1 & 1.2

Key Partners	Key Activities	Key Resources	Customer Relations	Customer Segments	Distribution Channel
Plastic producers	Recycling	Recyclable materials	Consumer education/Awareness	Manufacturers	Circular economy platforms
Governmental agencies	Assist in managing the plastic waste	Machinery	Good business environment	Associations	Wholesalers
Financers	Authorities concerned with the environment	Financial support	Reliability	Ship Owners	Logistics - Pipeline, Transport Vehicles

Table 1.1

Value Proposition	Cost Structure
Less pollution	Plant design and outlay
Better waste management system	R&D costs
Lowering of the healthcare budget	Raw materials and supplier selection
Business opportunity	Revenue Stream
Better quality of life	Cost saving using recyclable materials flow
Job creation	Diversification (different types of plastic
Energy saving	Governmental support/grace period

Table 1.2 of BCM

According to the model, the investments and operational costs were identified to calculate the expenditure in setting up energy recovery plants and logistics to deliver the fuel to the ship owners.

The key assumptions for the feasibility study are mentioned in Table 2.

Key assumptions for the feasibility analysis	
Elements	Description
Daily active production capacity	13,000 tons of fuel (out of 20,000 tons of plastic waste) The 20,000 tons was based on the amount of plastic waste collected daily. The production of 13,000 tons of fuel out of 20,000 tons of plastic waste was based on a preliminary experiment executed at lab scale
Number of working days, Number of working months	26 days per month 12 months per year
Monthly rental of a prebuilt factory	EGP 35,000 per month
Utilities and electricity	Electricity costs INR 4770.48 per month Utilities oil and water-repellent costs INR 55511.04 per month
Price per ton of plastic waste	INR 6255 per ton
Labour	Total salaries (white- and blue-collar workers) = INR 625500 per month
Overheads, marketing, and other expenses	Overheads = 4% of Cost of Goods sold (COGS) Marketing expenses = 0.5% of COGS Other expenses = 0.5% of COGS Taxation = 22% of gross profit Depreciation = 20% of gross profit

Table 2

The operational cost is the daily running cost calculated monthly/annually and is represented in Table 3

Operational cost			
		For 1st year of operation	2nd year of operation
Building and utilities	Monthly rentals	₹ 17,51,400.00	₹ 19,26,540.00
	Electricity	₹ 5,72,457.60	₹ 5,72,457.60
	Utilities, oil, and water repellent	₹ 6,66,132.48	₹ 6,66,132.48
Raw materials	Plastic waste + catalyst	₹ 39,03,12,00,000.00	₹ 42,93,43,20,000.00
Labour	Blue and white collar	₹ 75,06,000.00	₹ 75,06,000.00
Cost of goods sold	Sum of the abovementioned expenses	₹ 39,04,16,95,990.08	₹ 42,94,49,91,130.08
Overheads	Management and administrative expenses	₹ 1,56,16,67,839.60	₹ 1,71,78,34,623.56
Marketing	Marketing	₹ 19,52,08,479.95	₹ 21,47,29,327.95
Others	Exceptional expenses (might include insurance)	₹ 1,56,16,67,839.60	₹ 1,71,78,34,623.56
Total operational expenses (INR)		₹ 42,36,02,40,149.24	₹ 46,59,53,89,705.15

Table 3

Revenue Projections

The revenue projections have been shown in Table 4. To keep the estimates conservative a mild increase in revenue is considered year on year to combat inflation.

Revenue Projection			
		Year 1	Year 2
Active production capacity in tons	13,000 tons will be produced every day (×26 days × 12 months)	40,56,000	4461600
% Sold	80% (year 1), 85%(year 2)	3244800.00	3792360.00
Price	Price per ton = INR 42504	₹ 1,38,01,43,23,200.00	₹ 1,61,30,42,40,240.00
Annual increase	Increase of selling price and costs mainly covering the inflation rate	10%	
Total Income (INR)		₹ 1,38,01,43,23,200.00	₹ 1,61,30,42,40,240.00

Table 4

Profitability

The process of the generation of Blue Fuel turns out to be profitable as can be comprehended in Table 5. On advice from experts and the view of academic professors, the biggest challenge remains the accrument of working capital that will finance the operation.

Profitability		
	Year 1	Year 2
Total income	₹ 1,38,01,43,23,200.00	₹ 1,61,30,42,40,240.00
Total costs	₹ 42,36,02,40,149.24	₹ 46,59,53,89,705.15
Gross profit	₹ 95,65,40,83,050.76	₹ 1,14,70,88,50,534.85
Taxation	₹ 4,78,27,04,152.54	₹ 5,73,54,42,526.74
Depreciation of equipment and office furniture	₹ 5,00,000.00	₹ 5,00,000.00
Net gains (INR)	₹ 90,87,08,78,898.23	₹ 1,08,97,29,08,008.11

Table 5

LCA Analysis

The Life Cycle Assessment (LCA) of maritime fuels has been a central topic at the 78th Session of the Maritime Environment Protection Committee (MEPC) of the International Maritime Organization (IMO). The study uses the framework provided at the MEPC 78th Convention and employs the Open-LCS software to estimate the carbon emissions of Blue Diesel throughout its life cycle. Climate change, human toxicity, and freshwater toxicity are the three major parameters considered in the study.

As shown in Table 6, the impact of Hydrothermal Liquefaction (HTL) on the production of Blue Fuel is much lower in terms of climate and freshwater toxicity than dumping plastics in landfills. Furthermore, human toxicity (carcinogenic) is lower than that resulting from pyrolysis or incineration of the same PSW. These results clearly indicate that the HTL process has a lower environmental impact compared to dumping or incinerating plastics.

Results of life cycle assessment		
Impact category	Reference unit	Amount
Climate change	kg CO2 eq.	52.33
Freshwater ecotoxicity	CTUe	29.53
Human toxicity—carcinogenics	CTUh	1.78 × 10 ⁻⁶

Table 6

It can be understood from Table 6 that:

- The impact of Hydrothermal Liquefaction (HTL) on Blue Fuel production on climate and freshwater toxicity is much lower than dumping plastics in landfills.
- Human toxicity (carcinogenic) is lower than obtained through pyrolysis or incineration of the same Plastic Solid Waste (PSW).

These results clearly show that the HTL process has a lower environmental impact than dumping or incineration of plastics.

CONCLUSION

The study has demonstrated the economic and environmental impact of incorporating Blue Fuel as a clean energy alternative in the maritime industry. The results were positive, with higher oil yields (86%), comparable High Heating Values (44 MJ/Kg), a profitable Business Canvas Model (BCM), and a solution to the pressing "Plastic Problem."

Blue Fuel, with its abilities, has the potential to become the preferred energy alternative used by ship owners. The integration of Blue Fuel needs to be expedited in the marine industry to address the ongoing climate and energy crisis. This can be achieved through favourable government policies, acceptance of new ideas within the industry, and further research into various aspects of Blue Fuel generation.

The only challenge posed by the oil generation through HTL is the requirement for high reaction pressures. This can be overcome in the coming years through the use of novel heat treatment and advanced oxidation processes.

Ocean clean-up will be the next sector where Blue Fuels will have a significant impact. The proposal for an onboard plastic-to-Blue Fuel reactor will completely change the landscape by eliminating the need for ocean clean-up vessels to make multiple round trips for refuelling. This will aid ocean clean-up start-ups to move towards autonomous ships.

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Economic Analysis of
Blue Fuel.xlsx

Reduction of Carbon Footprints in the Shipping Industry

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ABSTRACT

Achieving zero emissions by 2050, green ports powered by tidal power turbines, solar system. Conversion of ships from LSFO to ammonia and methanol fired engines. Adaption of Hydrogen fuels, development of E-fuels, High powered LTO batteries and Green Corridors. Stepping up of Blue Economy.

KEYWORDS

E-fuels; Blue Economy; Green Power; Green Corridors

1. INTRODUCTION

During the COP26, the 26th United Nations Climate Change conference, held at the SEC Centre in Glasgow, Scotland, United Kingdom, from 31 October to 13 November 2021, IMO set out for a commitment for reducing carbon emissions per transport work by at least 40% by 2030 and extending its efforts in achieving net-zero emission by 2050.

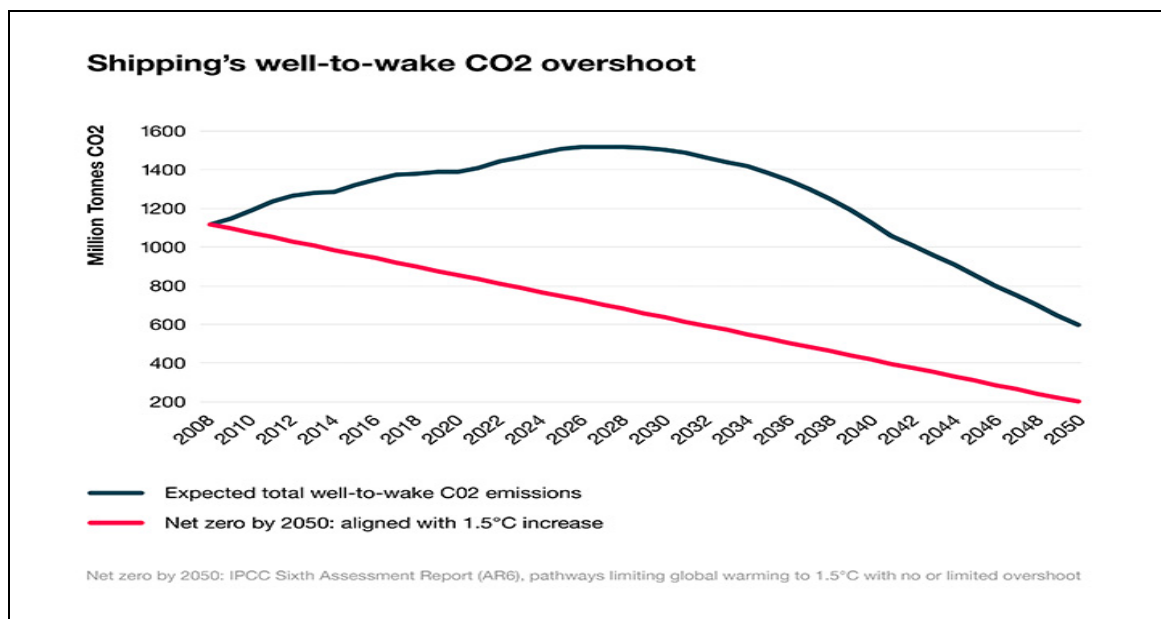


Fig 1 CO₂ Data Graph

Driven by the international trade and economic growth, the shipping industry is predicted to grow its fleet by 60% over the next 30 years, up from today's 3 billion deadweight tonnes to over 5 billion deadweight tonnes in 2050. The shipping industry been growing at this pace it is been assimilated to overshoot its carbon budget by 25 gigatonnes by 2050.

2. FOOT STEPS IN ACHIEVEMENT ZERO EMISSIONS BY 2050

Our shipping industry is contributing to near about 2.5% of total global emissions. Although the shipping industry been moving towards energy transitioning and reducing carbon foot. While transitioning, shipping's hidden carbon overshoot is a threatening problem. Although we are focusing towards greener fuels and using it as an alternate, the increasing large global fleet is a difficult barrier to overcome.

2.1. DEVELOPMENT OF E-FUELS AND HIGH-POWER LTO BATTERIES

With the concerning depleting levels of Fossil fuels, the carbon footprints developed due to the usage of it and high increasing demands of alternate green fuels, multiple companies have started to focus on developing better quality e-fuels with mass production.

Companies like Aramco, HIF, Sunfire, Norsk e-Fuel and many others have started their research on these e-Fuels and in improving its efficiency to replace it with fossil fuels. These synthetically produced e-fuels are made from electricity, water and carbon dioxide through the use of power-to-X technology, more precisely the power-to-liquid (PtL) process. In these fuels CO₂ is captured during production and is later emitted again during consumption.

These E-fuels have a humongous scope in replacing the conventional fuels as it has no sulphur content, has higher energy density, can transported cost-effectively over long distances, good stationary storability, however the biggest advantage of it in the shipping industry is that existing fleets can be operated in a climate- neutral way hugely reducing the amount in the carbon footprints currently generated by it.

Having all the above advantages, the energy efficiency is still four to six times lower compared to combustion engines, there are still air pollutant emissions and is still many times expensive than fossil fuels. Even if these e-fuels have a high chance of replacing the fossil fuels in the upcoming future, a lot of research and developments are still needed to be done in order to increase the efficiency and reduce the production cost of these e-fuels as these two factors would play a vital role for an ordinary person to chose e-fuels over fossil fuels.

High power LTO batteries is another alternate source of power that is been now looked upon to power up the fleets that are going to start operating in the upcoming years. As the name suggests these batteries are going to be made of lithium-titanate or lithium-titanium-oxide.

These High power LTO batteries consisting of lithium-titanate nanocrystals and their increased surface area are especially designed to enhance the lifetime of these batteries. With over 30 times larger surface area, this technology is able to recharge and discharge substantially faster and has a cycle count 10 times more than its more traditional alternative, the Li-Ion battery.

To manufacture these batteries the technology used is known for its high level of safety as Lithium Titanate batteries are entirely free of carbon, they avoid thermal runaway or overheating which is a main cause of fires in traditional energy storage systems, making it risk free of fires and explosions.

These batteries also have a much better low-temperature performance. Due to these low-temperature discharge characteristics, it is able to obtain up to 80% of its full capacity at a mere -30°C. This allows companies to start employing Lithium Titanate in even colder regions.

With an increasing importance of renewable energy options, the shipping industry is also looking forward to start using solar and wind energy. The Lithium Titanate batteries allow for a synergy between solar and wind power, battery storage and the grid.

These LTO batteries with a little more advancement have a bright future in the shipping and other transportation industries, providing zero carbon emissions and providing a greener future.

2.2. DEVELOPMENT OF GREEN PORTS

Green ports are the ports which all the countries are aiming forward to. These ports are supposed to be equipped with highly integrated network and infrastructure mainly powered by renewable energy and depending on non-renewable power sources just for auxiliary or emergency purpose.

These ports should be powered tidal, solar and wind energy and perform all the operations and even recharge fleets and tugs operating via batteries which would greatly reduce the carbon emission from the vessels operating nearby coastal regions and also the vehicles operating for loading and unloading of the cargo.

The cost affiliated in making of these ports are quite high however once the cost is been recovered these ports can be highly efficient and provide high returns with bare minimum maintenance. Meanwhile recovering the construction cost it would also emit almost zero carbon contributing in reduction of carbon footprints.

2.4. TRANSITION TO AMMONIA, METHANOL AND HYDROGEN FUELS

Keeping in mind the increase in carbon footprints at an alarming level, the shipping industry which carry over almost 80% of the world trade and contributing to 2.5% of total carbon emissions as mentioned above has started to transition to dual fuel engines to reduce the carbon emissions.

The use of Methanol has already been started as a fuel in dual fuel engines in some of the chemical tankers. Methanol is been used in internal combustion engines in pure form or in mixture with gasoline or diesel. The combustion of pure methanol has no nitrogen oxide (NO_x) emissions, no sulphur oxides (SO_x) emissions and very low particulate matter (PM) and carbon dioxide (CO₂) emissions compared to gasoline or diesel.

Hydrogen been a sustainable and inexhaustible resource can easily be used as an alternate fuel by the shipping industry. The transition to hydrogen as fuel can bring down carbon emission by the shipping industry to net-zero. The storage of hydrogen fuel requires -234°C of cryogenic temperature or holding pressure of 700 bar which makes it very difficult to store or produce. However, with proper technology it can play out to be a good alternative.

Among the board spectrum of technologies and fuel solutions ship designers, builders, owners and operators, anhydrous ammonia (NH₃) has been identified as a potential long-term fuel that could enter the market relatively quickly and offer a zero, or a near-zero, carbon solution. It has an energy density by volume almost 30% higher even than that of liquid hydrogen and it's easier to distribute. As ammonia contains no carbon it does not emit any when CO₂ when used to fuel an internal combustion engine. This creates the potential for truly zero carbon

propulsion. An additional small quantity of pilot of fuel is required for combustion however, which should also be zero carbon.

The main problem in transitioning to any of alternate fuel is to make the fuel bunkering station with the required criteria of the fuel to be bunkered available on shore. Specially for methanol and ammonia which require specialised bunkering and storage arrangement and fuel like hydrogen which require storage cryogenic temperature and pressure of -234°C and approximately 700bar respectively.

2.3. ADOPTION OF BLUE ECONOMY

The blue economy is the sustainable use of ocean resources for economic growth, reduced carbon footprints, improved livelihoods, and jobs while preserving the health of ocean ecosystem.

The concept of blue economy covers all the areas including development of green corridors, development of green ports, transition to dual fuel engines, usage of alternate fuels and development of E-fuels and High power LTO batteries.

In blue economy the use of ocean resources should be monitored and should be given sufficient time to replenish itself. It includes managing and reducing the waste disposed in the ocean every year, cleaning the wastes and plastics already been disposed in the oceans, shifting to lower carbon emitting fuels such as Methanol, Hydrogen, Ammonia, E-Fuels, High Power LTO batteries, developing green corridors and green ports to reduce the carbons emitted by the port and coastal city regions, supporting the fishermen and encouraging them to maintain the oceanic flora and fauna, etc.

Adoption of Blue Economy can effectively help in reduction of carbon emissions and reduce the persisting carbon footprints.

CONCLUSION

To reduce the carbon footprints the current shipping industry is open up to a lot options. However, the point is that which option is more efficient, cost effective and preferable. All the options have its own pros and cons.

The shipping industry is already on verge of adopting an alternate source of power to reduce the carbon emissions. The only awaiting factor is which alternate fuel develops faster and is made available in market and how much efficient is it compared to its other competitors. The pace with which the developments are ongoing and efforts that are been put on to reduce the carbon emissions by 2050, its not going to be further before which the transition is going to complete.

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Traffic guidance system in foggy weather

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ABSTRACT

The on-road visibility while driving is a particularly important parameter that severely affects driving there has been observed several accidents due to the reduce visibility while driving in the fog especially in the winter conditions. Therefore, it is extremely essential to measure fog effectively and quickly in order to guide the traffic and to inform the traffic about a safe driving speed.

Safe stopping sight distance is the distance in front of a moving vehicle which is required in order that a vehicle can stop safely after a driver sees any danger ahead while driving in fog also a safe stopping sight distance need to be provided however, if the visibility is less than the safe stopping sight distance there is a very high chance of accidents.

The safe stopping sight distance formula is given by:

$$SSD = vt + \frac{v^2}{2gf} \quad (1)$$

So, therefore the speed of the vehicles is an important parameter in this formula in our paper we are trying to estimate the fog using image based techniques and the basic definition of visibility. visibility can be calculated using image contrast of a black and white object and according to the obtained value of the visibility, safe stopping sight distance and therefore, speed can be calculated. This speed value needs to be flashed to the oncoming drivers so that they will get to know that under these fog conditions they can maintain and travel safely.

The application of this project is to demonstrate a real time visibility estimation from a field camera image an immediate transmission of safe speed limit in the fog this will greatly help in reducing the accidents in fog conditions.

KEYWORDS

Visibility, Speed, Stopping sight distance, Safe speed limit.

INTRODUCTION

Fog is a problem for drivers. Traffic movement and safety are adversely affected due to bad weather such as fog, rain, or snow. Fog ahead of the windshield scatters light and reduces visibility which increases the crash risk significantly. Fog is a meteorological phenomenon that can severely reduce visibility on roads, making it difficult for drivers to see other vehicles, road signs, and obstacles. This can increase the risk of road accidents, particularly those involving collisions. In some cases, fog can also cause drivers to lose control of their vehicles due to the reduced traction that results from the damp road surface. Studies have shown that driving in foggy conditions can increase the risk of accidents by up to ten times. To reduce the risk of road accidents due to fog, it is important for drivers to take certain precautions, such as slowing down, increasing the following distance between vehicles, and using low-beam headlights.

Additionally, authorities can implement measures to improve road safety during foggy conditions, such as installing fog lights on roads, improving signage, and deploying road crews to monitor and treat slippery roads. The Federal Highway Administration's Road Weather Management Program reports that roughly 1.3 million road accidents occur due to adverse weather conditions globally. Many drivers simply follow the taillights of the vehicle ahead (Al-Ghamdi et al. 2007). Other several studies have found headway decreases with visibility, but other studies had conflicting interpretations (Peng et al. 2018). Driver response time refers to the time it takes for a driver to recognize a hazard and take appropriate action, such as applying the brakes or steering away from danger. It is a critical factor in road safety and can be influenced by various factors, including a driver's age, attention level, reaction time, and experience. Research has shown that driver response time is longer when a driver is distracted, tired, or under the influence of drugs or alcohol. The average driver response time is estimated to be between 0.75 and 1.5 seconds. Research on weather effects has focused on snow- or rain-related crashes. However, there is a lack of understanding of crashes that occur during fog or smoke (FS). This study presents a comprehensive examination of FS-related crashes using crash data from Florida between 2003 and 2007. A two-stage research strategy was implemented (1) to examine FS-related crash characteristics with respect to temporal distribution, influential factors, and crash types and (2) to estimate the effects of various factors on injury severity given that an FS-related crash has occurred. The morning hours from December to February are the prevalent times for FS-related crashes. Compared to crashes under clear-visibility conditions, FS-related crashes tend to result in more severe injuries and involve more vehicles. Head-on and rear-end crashes are the two most common crash types in terms of crash risk and severity. These crashes were more prevalent on high-speed roads, undivided roads, roads with no sidewalks, and two-lane rural roads. Moreover, FS-related crashes were more likely to occur at night without street lighting, leading to more severe injuries.

Foggy weather can cause several types of road accidents:

1. **Reduced visibility:** Fog can limit the visibility of drivers, making it difficult for them to see other vehicles, pedestrians, and road signs. This increases the risk of collisions, especially at high speeds.
2. **Lane departure:** Poor visibility can cause drivers to drift into other lanes or onto the shoulder, leading to accidents.
3. **Braking confusion:** Foggy conditions can also confuse drivers' perception of speed, making them brake suddenly or incorrectly, which can lead to rear-end collisions.
4. **Hydroplaning:** If the road is wet from rain or mist, drivers may experience hydroplaning, which is when their tires lose contact with the road and skid uncontrollably.
5. **Confusion and disorientation:** Fog can also cause drivers to become disoriented, making it difficult for them to determine their location and navigate the road safely.

Overall, foggy weather conditions pose significant risks to drivers, and it is important for drivers to exercise caution and adjust their driving habits accordingly.

OBJECTIVES

- The purpose of a traffic guidance system in foggy weather is to provide safe and efficient navigation for vehicles.
- To reduce the risk of accidents caused by poor visibility.

- To detect and monitor road conditions in real-time and provide drivers with information such as road closures, detours, and alternative routes to ensure they reach their destination safely.
- To assist with traffic flow management, congestion reduction, and incident response to minimize disruptions and delays.

THEORY OF VISIBILITY

According to International Commission on Illumination (CIE), visibility is the length of the path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp, at a colour temperature of 2700 K, to 5 percent of its original value. As per ICAO Annex 3 Meteorological Service for International Air Navigation, visibility is the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background.

- Visibility measurement

There are several fog measurement devices developed by researchers,

- Secchi disk
- Visibility meter or Visiometer
- Optical sensors (OVSENÍK et al, 2012)
- Photovoltaic cell (Dumont et al. 2004)

Most devices are either very costly or very bulky for regular mobility or inaccurate and inconsistent. So, an indigenously developed device is necessary.

- Visibility estimation from image processing

Using camera calibration, the horizontal distance of that point from the camera is calculated. This distance is the visibility. Then this reference object (umbrella) is moved alongside the median of the road several times during data collection. A code is developed to obtain the contrast values of black portion of the object against white portion, for a particular frame. The developed algorithm calculates contrast ratio marked manually on the video frame by extractor. An extractor marks several points within boundaries of black and white region for several images till the object is no longer distinguishable as it moves away. For that purpose, initially brightness difference of the black and white portions of the object are calculated in clear weather condition (labelled as B). As the reference object is carried away from the camera, the brightness of black and white portions at different frames in the captured video is noted manually by mouse click.

In foggy conditions due to scattering of light the brightness of white portion decreases and brightness of black portion increases depending on intensity of fog (therefore value of A, difference between brightness of white and black part decreases). As the object moves away from camera the scattering intensifies and value of B reduces. As soon as $A/B = 0.05$, the position of the object is recorded and termed as visibility as per basic definition.

The image coordinate of black and white object in these frames are converted into field coordinates using camera calibration technique as devised in Fung et al., 2006. This distance between camera and object is considered as visibility by authors. This exercise is continued for every 15 min and visibility at every 15 min duration is obtained throughout the recording.



Fig.1 Visibility extraction using black and white object

A rectangular calibration pattern has been chosen with known on field measurements. With the help of MATLAB code and a rectangle of known on field length and width vide can be

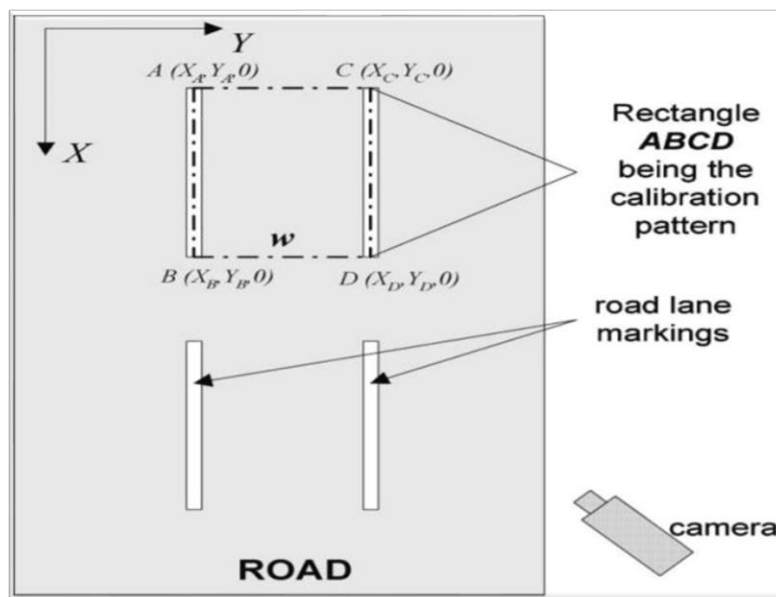


Fig.2 Top View of Calibration Pattern on road surface

calibrated. After calibration any point on the road can be just clicked on the video and on field coordinates can be found out..

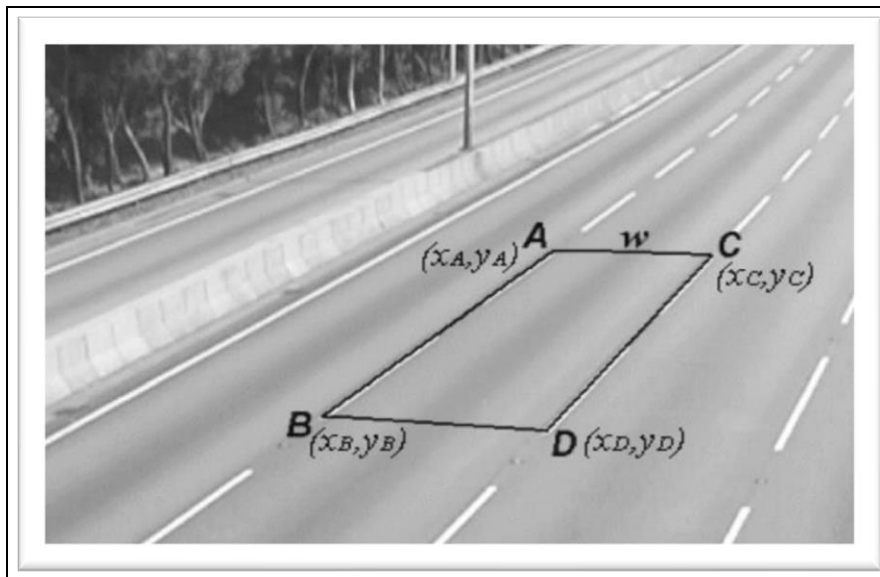


Fig.3 Rectangle ABCD

- **SSD (STOPPING SIGHT DISTANCE):**

DEFINITION

Stopping sight distance refers to the distance a vehicle travels from the time the driver recognizes a need to stop until the vehicle comes to a complete stop. It depends on the speed of the vehicle and the driver's reaction time. The goal is to ensure that the driver has enough time and space to stop the vehicle safely in emergency situations. We are assuming a 2.5 sec reaction time. we can calculate the standard speed for different stopping sight distance. Stopping sight distance is the minimum sight distance for the driver to stop without colliding at any point of the highway (Khanna, S. K., & Justo, 2011).

$$SSD = vt + \frac{v^2}{2gf} \quad (1)$$

Where,

‘v’ is speed in m/s

‘g’ is gravitational acceleration in m/sec²

‘f’ is longitudinal coefficient of friction

Hence, we have calculated the SSD for certain observed speeds to check. The SSD calculated for speeds 50,70, 80,100, 130 are 59 m, 97 m, 118.6 m, 168 m, 257 m.

Table 1 Calculated Vehicle speed from Stopping Sight Distance

STOPPING SIGHT DISTANCE(m)	VEHICLE SPEED(Km/h)
60	40
130	80
180	100
280	130
≥280	-

CALCULATION OF SAFE SPEED WHEN VISIBILITY IS KNOWN:

Image can be captured by a camera which is on the field, in that image stationary black and white object is known. From the stationary black and white contrast difference one can calculate the visibility as per the basic definition of visibility. Since, we know the visibility at a particular distance so we can calculate the distance up to which the driver can see this distance should be the safe stopping sight distance because a driver is not able to see beyond this distance. Therefore, any danger that happens to be beyond this distance driver has to stop within the visibility distance so therefore we will in this consideration we will assume that safe stopping sight distance is equal to the visibility. So, we can back calculate and get to know the safe driving speed(V) in the equation (1).

INSTRUMENTS REQUIRED FOR THE SET UP:

- Cameras are required to capture real time images and transmit the images by Wi-Fi and immediately calculate the contrast difference.
- One microcontroller board can calculate the safe stopping sight distance using the formula (1) and one can obtain the safe speed of driving.
- This safe speed of driving is being displayed through LED display board similar to speed limits display.

PROCESS:

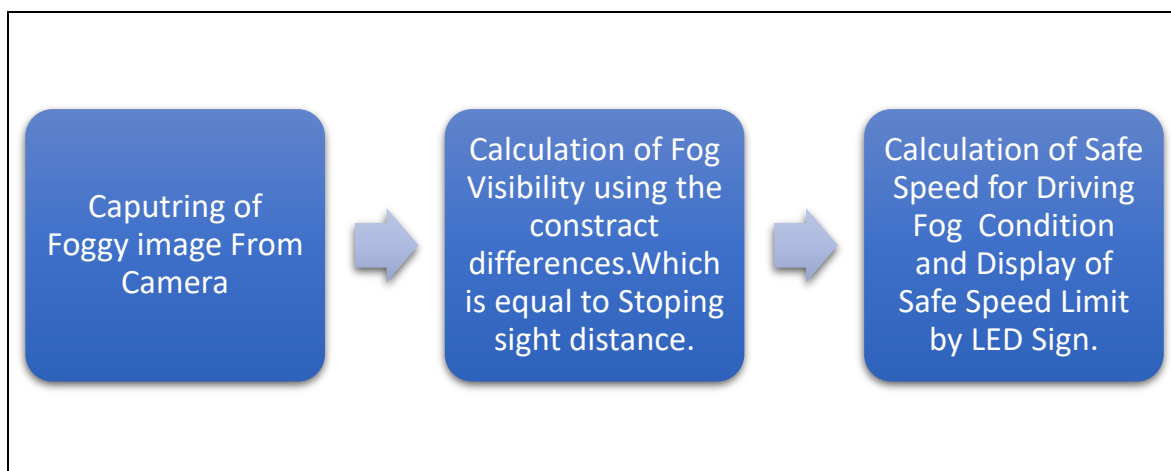


Fig 4

CONCLUSION

Variable design speed refers to the concept of designing transportation systems, such as highways, to accommodate a range of speeds for different types of road conditions. The goal of variable design speed is to improve safety, efficiency, and comfort for all users of the transportation system, by considering the different speeds at which different types of vehicles can safely travel. The concept is based on the idea that roads and highways should be designed to accommodate the speeds that are appropriate for the specific conditions, rather than enforcing a fixed speed limit for all type of condition. This study measures visibility real time at the road at various fog levels and calculates safe design speed for that specific visibility condition. These variable design speeds are displayed via VMS implemented in the road.

ACKNOWLEDGEMENT

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Whale safety system

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ABSTRACT

Whales are the biggest creatures on the planet Earth. Their existence depends on the ocean and other marine ecosystems. Scientists have discovered 90 species of whales all around the world, but, the interference of human beings in the ocean has created uncertainty of their existence for long time. Since 1992, ship traffic has increased by 300 percent. Whales and other marine mammals are difficult to be identified by a ship's operator as they are not clearly visible. Even if they are identified, there is very less time for the ship operator to change the path of the ship in order to avoid the whale. Hence, collisions between ship and whales and other marine animals take place. It becomes more dangerous for the whales when they come in contact with moving propeller of a ship. It results in brutal cuts throughout the whale's body which most of the times results in death of the whales. The Whale Safety System is designed to reduce the alarming number of whales dying due to collision with ship.

KEY WORDS

Whale, ultrasonic sensor, white light, buzzer, water pump.

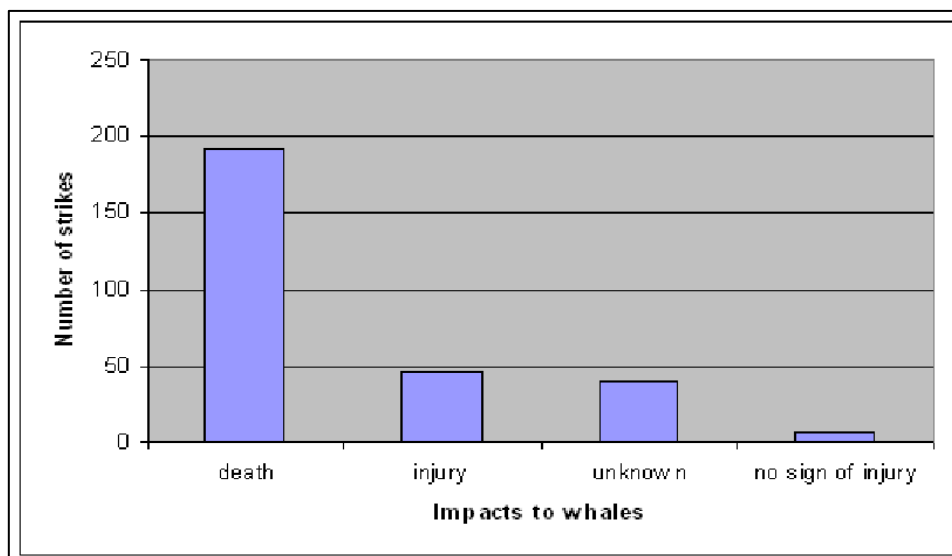


Fig.1 Result of ship strike to large whales

INTRODUCTION

Around 20,000 whales die due to collision with moving vessels every year. The New York State Marine Mammal and Sea Turtle Stranding Program revealed that 10.6% of all turtles exhibited evidence of propeller wounds.

One of the main anthropogenic causes of death for fin whales and sperm whales in the Mediterranean Sea is represented by collisions with boats. The probability of collision depends on the type of boat. The vessels most often involved in accidents with large cetaceans are usually those covering long distances, like ferries, cargos and cruise ships. These vessels often navigate with the autopilot, day and night. Even if these animals are particularly large, heavy ships may not realise when a collision occurs. Sometimes crews do not report such accidents, and therefore not all collisions are recorded.

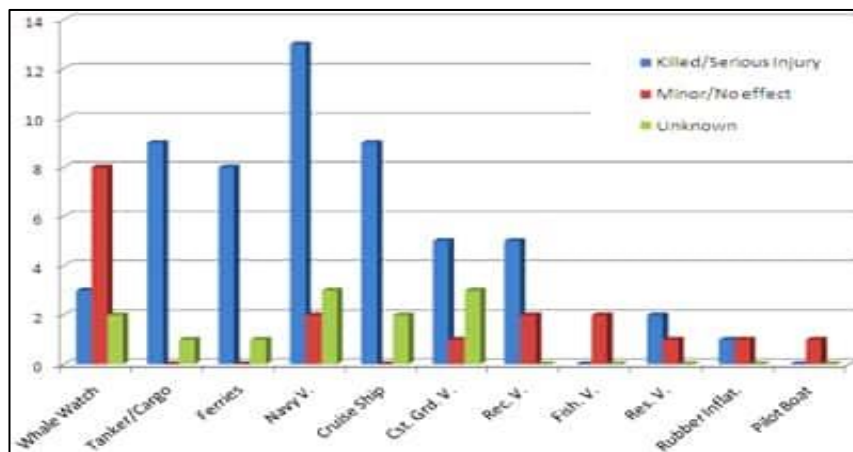


Fig.2. Number of ship strikes with fin whales by type of boat and type of injury

Cetaceans often do not survive or present serious injuries. However, a collision can also affect the ship and its passengers. Large tonnage vessels are not particularly at risk and an impact with a cetacean may not be acknowledged, however a collision event may be dangerous for small vessels.

The greatest number of accidents occur during the summer months, when maritime traffic, in particular of ferries and private boats, reaches its peak. As whales are not detectable by radar, chances to detect their presence is rather low. For this reason, at least during the day, it is important to have at least one observer scanning for cetaceans on the track line, to inform and alert the Captain and prevent hurting them. In addition to the risk of collisions, the intense maritime traffic is responsible for problems including pollution, noise and habitat degradation. In the Mediterranean Sea, the two species of cetaceans most threatened by

collisions with speed boats, cargos and ferries are the largest ones: the fin whale (up to 24 m in length) and the sperm whale (up to 18 m). Carcasses of 287 fin whales, found stranded along the coasts of the Mediterranean or adrift, were examined. 46 individuals (16%) died after a ship strike event. Between 1972 and 2001, 43 fatal strikes involving fin whales were reported, with an average of 1.43 animals per year. We also analysed a sample of 383 photo-identified fin whales, with 9 animals (2.4%) presenting scars directly related to a collision.

The main source of data regarding ship strikes and sperm whales is the Pelagos Cetacean Research Institute, which operates in Greece since 1997. Estimates indicate that, on average, 1.4 sperm whales per year strand along the shores of Greece and 70% of them show clear signs of a collision. Scars caused by impacts with boats are also frequent in live animals sighted in the Ionian Greece and in the western Mediterranean (Strait of Gibraltar).

The Strait of Gibraltar is one of the Mediterranean areas with the greatest abundance of cetaceans, including sperm whales. Due to the heavy traffic in this area, sperm whales are often injured and/or killed by collisions. The whale safety system prevents whales and other marine animals to come in contact with the rotating propeller of the ship. This system uses microcontroller, sensors, white light, buzzer and water pump.



Fig.3 High-risk locations for whale-ship collisions around the world Image: International Whaling Commission

Large whales need to come to the surface of water in every 15 to 30 minutes to inhale oxygen. These marine mammals see a limited amount of colours like red and yellow light is absorbed by water. This makes most objects underwater appear bluish-green. Due to this poor vision it



becomes difficult for whales to see the floating ships which results in collision. Collision with rotating propeller causes severe cuts on whale's body which sometimes leads to death. No such technology has been developed to protect whales coming in contact with moving propeller of the ship. The ship operators generally reduce the speed of the ship to 10 knots when they pass through high whale density region. However this method is not much effective to stop collision. They are still being killed by the moving vessels.

Fig.4. Severe cuts on whale body after collision with ship's propeller

WORKING PRINCIPLE

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, they are then reflected back as echo signals to the sensor, which computes the distance to the target based on the time-span between emitting the signal and receiving the echo.

CONCEPT

An ultrasonic sensor is fitted in the keel of the ship near the propeller. A white light and a buzzer is also fitted in the keel of the ship near the propeller. A number of water pump outlet is fitted in the keel close to the propeller of the ship.

The whale and marine animal safety system focuses of four senses of the whales. The senses are as follows:

- Vision sense

- Hearing sense
- Touch sense
- Ultrasonic waves

The ultrasonic sensor, white light, buzzer and water pump are electrically connected to a microcontroller. The microcontroller controls and gives signals to these components. The ultrasonic sensor senses the presence of marine mammal near the propeller of the ship. The system is programmed in such a way that whenever a whale comes near the propeller of the ship the white light, buzzer and water pump turns on. The white light continuously blinks which tests the vision of the whale. By seeing the bright blinking light the whale will change its path and will try to go away from the light. The buzzer is installed to produce loud noise under water. This will test hearing sense of the whale. As sound travels faster in water so by hearing the loud noise the whale will avoid coming near the ship. The water pump outlet is installed to sprinkle high pressure water on the whale's body. This tests the touch sense of the whale. The sprinkling of high pressure water will prevent the whale to come near the propeller of the ship. The ultrasonic sensor also does another job other than sensing the distance between the ship and whale, it continuously sends ultrasonic waves to the water. Whales have the ability to sense ultrasonic waves under water. They also communicate with other whales using ultrasonic waves. So, by sensing the ultrasonic waves coming from the ultrasonic sensor attached in the keel near propeller the whale will try to avoid it and will move away from the ship.

When no marine mammal is present near the propeller the ultrasonic sensor shows constant distance. The readings of ultrasonic sensor are constantly monitored from the bridge. Any change in reading indicates to presence of marine mammals near the propeller. The whole system working depend upon three ranges of the ultrasonic sensor. The three ranges are long distance range, short distance range and very short distance range. In long distance range the readings of the ultrasonic sensor changes but the marine mammal is at a safe distance from propeller. So, the white light, buzzer and water pump remains in off condition. When the marine mammal comes close to the propeller and enters short distance range then the white light, buzzer and water pump turns on. If the marine mammal still continues to come near the propeller of the ship, then it enters very short distance range. This is the most dangerous zone for the marine mammal as the distance between the marine mammal and propeller is very less. So in this range the white light, buzzer and water pump are in on condition along with that the propeller stops. Collision of marine mammal with

stationary propeller will not cause any harm to the marine mammal. As soon as the marine mammal goes away from the ship the propeller starts and white light, buzzer and water pump turns off.

The stopping of the propeller can be done in two ways in diesel driven vessels. Emergency air stop system and clutch disengaging system. The emergency air stop system can be used in slow speed vessels whereas clutch disengaging system can be used in medium and high speed vessels. As medium and high speed engines have gear box so when marine mammal is in very close distance range the propeller shaft is disengaged from engine crankshaft. Whereas in electric motor driven vessels the motor is simply turned off when the marine mammal is in very close distance range.

CHALLENGES FACED TO IMPLEMENT WHALE SAFETY SYSTEM

1. When the ship is in shallow water then the white light, buzzer and water pump may turn on and create disturbances. If water is too shallow, then the propeller may also stop. To avoid this situation, the ultrasonic sensor will be synced with eco-sounder. The eco-sounder gives the distance between ship's keel and ground level. If the eco-sounder reading and ultrasonic sensor reading are same then it confirms that ship is in shallow water. No marine mammal is near the propeller. The system is programmed in such a way that if ultrasonic reading matches with eco-sounder reading then the whale and marine animal safety system is turned off and vessel moves without any disturbances in shallow water.
2. Immediate stopping of propeller reduces the life of engine. This may lead to losses for the ship owner. To prevent this, senses tests are to be carried out with whales and marine animals. It is required to take many number of ultrasonic wave, vision, sound and touch senses tests. If the marine mammals are sensing at least one out of ultrasonic waves, white light, buzzer and high pressure water jet coming out from the water outlet and going away then the stopping of the propeller can be terminated. No need to stop the propeller if the chances of the marine mammal to come in very close distance range is very less.

CONCLUSION

The ultrasonic sensor, white light, buzzer and water pump outlet can be also installed in bulbous bow of the ship as many whales collide with bulbous bow. This way the death of

whales caused by collision with ships is going to decrease. Whale safety system fulfils the need of safety of marine aquatic life and can be easily installed in any ship.



Fig.5 Whale collision with bulbous bow of the ship.

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Innovative design idea for a smart safety helmet for Seafarers

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ABSTRACT

This paper aims at presenting a possible idea for enhancing the safety culture that has always been an important aspect of the maritime industry, particularly man overboard situation and during ships operations. This helmet can help the mariners to detect all the possible red signals onboard. Red signals include man overboard and any kind of health issues onboard. The authors have tried using the evolving modern technologies to contribute towards the safety measures of the industry. An attempt has been made to bring up the prototype with the required research which can help increase the safety measures just by wearing a safety helmet.

KEYWORDS

Technological innovation, safety culture, man overboard

1.INTRODUCTION

Safety in the maritime industry holds paramount interest and is of utmost importance, majority of the accidents happen due to the intentional/unintentional carelessness of the crew members, improper monitoring or insufficient information about the situation are the contributing factors.

This paper aims to reduce many such risks such as man overboard, consumption of alcohol etc. by making use of a smart safety helmet that could effectively monitor and send alarms to alert the bridge of untoward incidence to enhance safety. This paper comprises of the details of such a prototype developed by the author. We used various types of sensors fitted inside the helmet which detect many parameters while working on board.

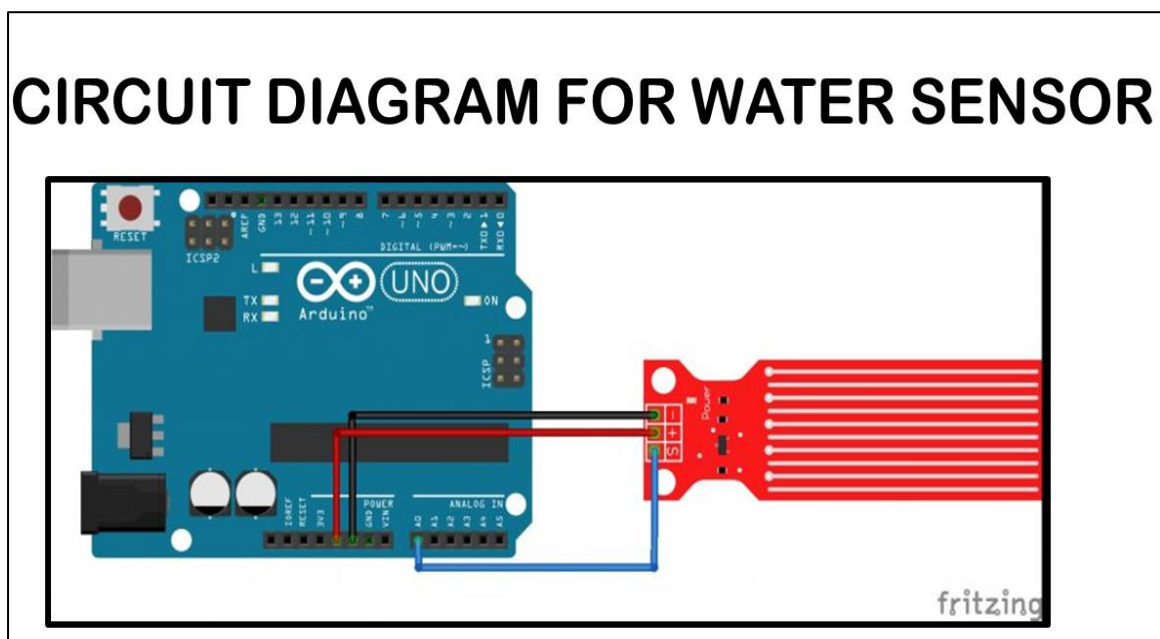
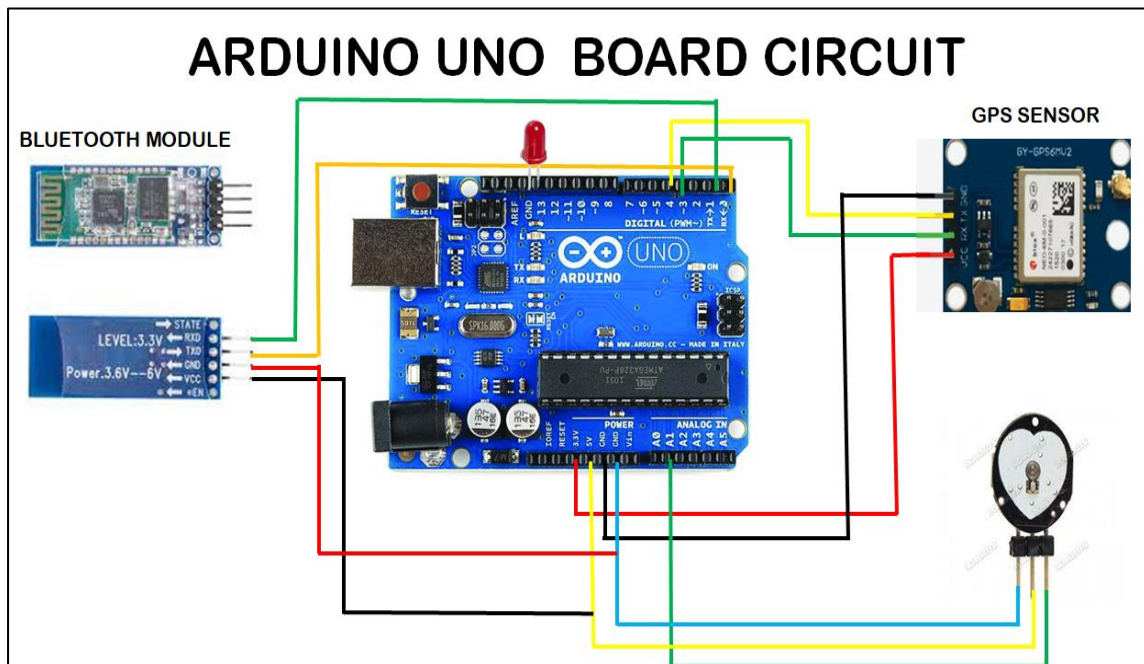
According to safety precautions onboard, the ship a person working on deck is supposed to wear a safety helmet at all times. Hence, adding smart features to the helmet would solve the monitoring and alarm-raising problems on board ships. The embedded sensors would trigger the alarm on the bridge which is always manned. The helmet would be connected to the monitoring unit through Wi-Fi direct/blue tooth or GPS system. Since each unit will have an assigned identity code every individual would be identifiable when on deck.

Any error or message received from the helmet will be displayed here along with the crew member's name and this will activate the desired buzzers and alarms to draw the attention of the Officer-on-watch.

Such smart safety helmets can be used in many areas such as onboard a ship, dock labor, dry docking, and repairs of the ship and many other places including mining railway workers, etc.

2. DESIGNING OF THE SAFETY HELMET.

The block diagram of the circuit components is shown in the following figure.



Smart helmet design comprises of following components.

A Safety helmet, Microcontroller Unit with Wi-Fi/blue tooth and GPS, Alcohol and Gas sensors, Pulse sensor

Accelerometer sensor, water sensor, pressure sensor, GPS module, and Li-Po battery (9 V).

3. WORKING OF THE SMART HELMET.

(a) Alcohol/Toxic gas Sensor

Alcohol sensors can measure as low as 0.04 mg/lts alcohol presence. It would be able to sense the breath of the crew member. If the person is found drunk, the helmet will send a message to the bridge and the LED on the helmet will glow along with the buzzer sound to alert the bridge and other personnel in the vicinity. This will be able to reduce the accidents caused by drunken crew members and hence be in compliance with the no-drinking policy of the shipping companies.

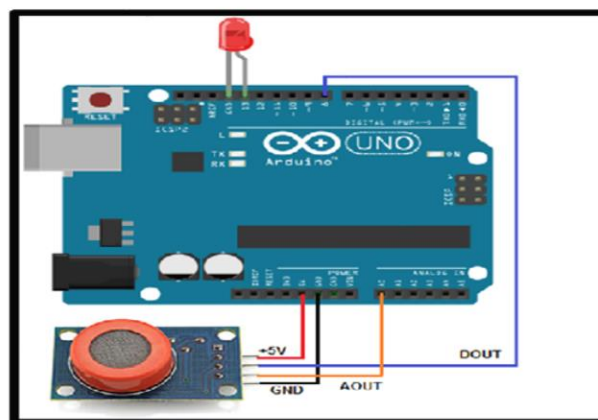
The Analog Output pin (AOUT) gives Analog Voltage Output in direct ratio to the amount of alcohol detected by the sensor which then triggers the Digital Output(high/low) based on the values received through the analog output. The Higher the amount of alcohol in a person's breath, the higher will be its analog output and vice versa. Once the Analog Value crosses its set threshold limit the digital output is triggered 'high' and the sensor will next activate the buzzer on the bridge and the helmet as a warning signal.

The Toxic Gas sensors can detect gases like Ammonia, Benzene, Methane, Hexane, LPG, and Carbon Monoxide thus giving an early warning to the person wearing it along with alerting the bridge. For the demonstration of concept MQ3, MQ135 sensors were used. There are sensors capable of detecting as low as 20 ppm of alcohol. Thus a system with foolproof detection of alcohol is viable. The Alcohol and Toxic Gas sensors are housed close to Mouth.

The actual photograph of the smart helmet and its use by wearing on the head is depicted in the following figure



CIRCUIT DIAGRAM OF ALCOHOL SENSOR



(b) Pulse Sensor

The second sensor would be a pulse sensor to read the pulse of the person wearing the helmet. The LED on the front side of the sensor is to be placed on a vein (here the ear tips). Veins have blood flow inside them only when the heart is pumping thus the pulse sensor monitors this blood flow to monitor the heartbeat. According to the data received by this sensor, various aspects of a person's health, in general, could be calculated like sleep tracking, anxiety, and consciousness [2].

Benefits of the pulse sensor.

It would confirm if the crew is **wearing a helmet** since it starts getting the pulse input from the nerves near our ears/from the smartwatch and hence ensure compliance with safety regulations. If it finds the pulse rate of the person is too low or too high, during enclosed space operations, it will alert the officer (both him and the watchkeeping officer on the bridge) of his **abnormal health**. If it fails then it will direct the ESP8266 WIFI module on the helmet to send a message to the bridge indicating his retarding wellness during the operation and needs immediate rescue. This will then combine the data from the toxic fumes sensor to **warn the incoming rescue party** about the atmosphere in the enclosed space.

(c) Accelerometer or Motion Sensor.

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static (gravitational) or dynamic - caused by moving or vibrating the accelerometer. [3]. These forces can be detected based on Axis-wise rotations. So, we try to set a parameter that after a specific Rotation (i.e. how much does the person receives an impact after falling in an accident) it will detect an accident.

The basic work of the accelerometer in the helmet is to detect a fall i.e. it calculates a fall based on the acceleration in all three directions- x, y and, z -axis.

Once a fall is detected either by free fall due to the gravity method in the accelerometer or by a change in the angle of the helmet method it sends out this data to the bridge alarming the officer on watch to take adequate actions immediately. The prototype has been adequately programmed to detect such cases (e.g. Man overboard) using the free fall and direction angle algorithm.

There have been a lot of cases where the person has become overboard and no one was able to detect this for hours resulting in never finding the person again, or maybe finding him dead because of drowning in the sea or animal attacks. Using the helmet this can be easily countered as the detection will be done as soon as the man falls overboard and hence the crew members will have enough time to take proper and effective actions.

The helmet will also have an additional water sensor to accurately detect that it is a case of man overboard. considering the situation where maybe by some error the buzzer goes on or where the crew member has fallen on the deck and is in no danger i.e. the fall isn't crucial then he will have a kill switch mechanism on the helmet to kill the buzzer alarm to prevent misinformation.

(d) GPS sensor

A GPS sensor is an electronic device that detects the exact location in terms of latitude and longitude along with supporting parameters like speed, course, altitude, etc in the provision we have used NEO 6M GPS module that is fitted in the circuit along with supporting sensors and this circuit will be fitted in the helmet and hence gives the real-time position of the person and its other parameters as stated above

(e) Pressure sensor

The MS5837-30BA is a new generation of high resolution pressure sensors with an I2C bus interface for depth measurement systems with a water depth resolution of 2 mm.



(f) Procedure of Sensor activation in a sequence.

The person wears the helmet

alcohol check, if negative continue

pulse rate monitoring on

accelerometer active throughout to detect fall

GPS sensor gets active and gives location throughout

water sensor backup for accelerometer

pressure sensor gets activated and gives the depth of water

Accident detection and related actions:

fall detected; sound bridge alarm

man overboard alarm and lights activated

pulse rate error and GPS location will be given on screens

activate the bridge alarm and call the rescue team

The water sensor detects water and the pressure sensor gives the depth of water

EXPECTED LOOK OF THE FINAL PRODUCT:



Features of this design

- An effective placing of all sensors
- Waterproof casing for battery and board
- Kill switch on the sides
- LEDs and buzzers inbuilt with no additional changes to the effective strength of the helmet
- Modified design to also accommodate the face shield/mask
- Cost for the project of the smart helmet.

The current prototype cost sheet is:

Material used:	Cost(INR)
1. Arduino Uno	400
2. Alcohol and gas sensor	160
3. Accelerometer sensor	260
4. Pulse sensor	355
5. DC jack wire	08
6. LED lights and buzzer	15

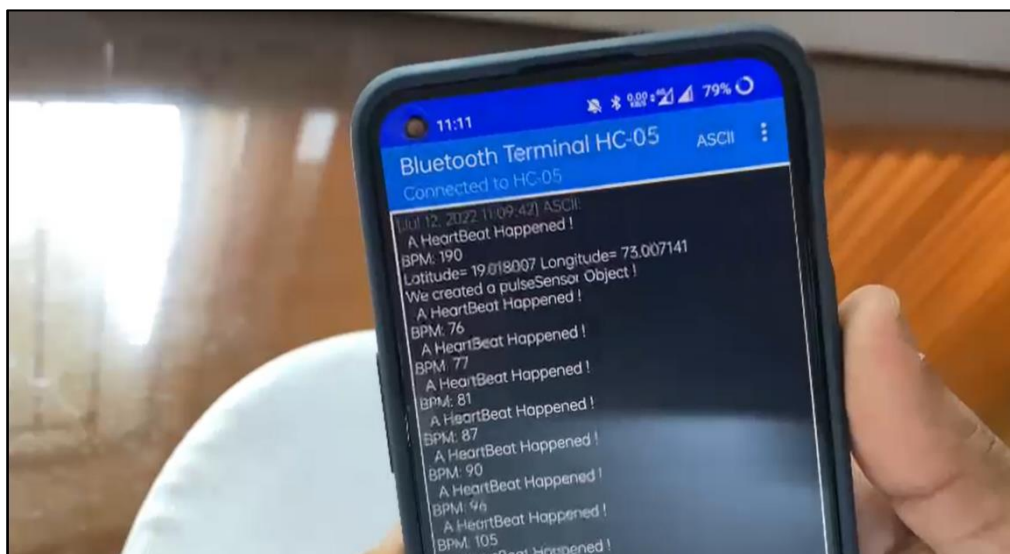
7. Wi-Fi MCU	190
8. Node MCU	270
9. 12-volt battery	15
10. A normal safety helmet	100
11. NEO 6M GPS SENSOR	500
12. MS5837 PRESSURE SENSOR	1000
13 BUZZER	20
14 BLUETOOTH MODULE	200
TOTAL	3493

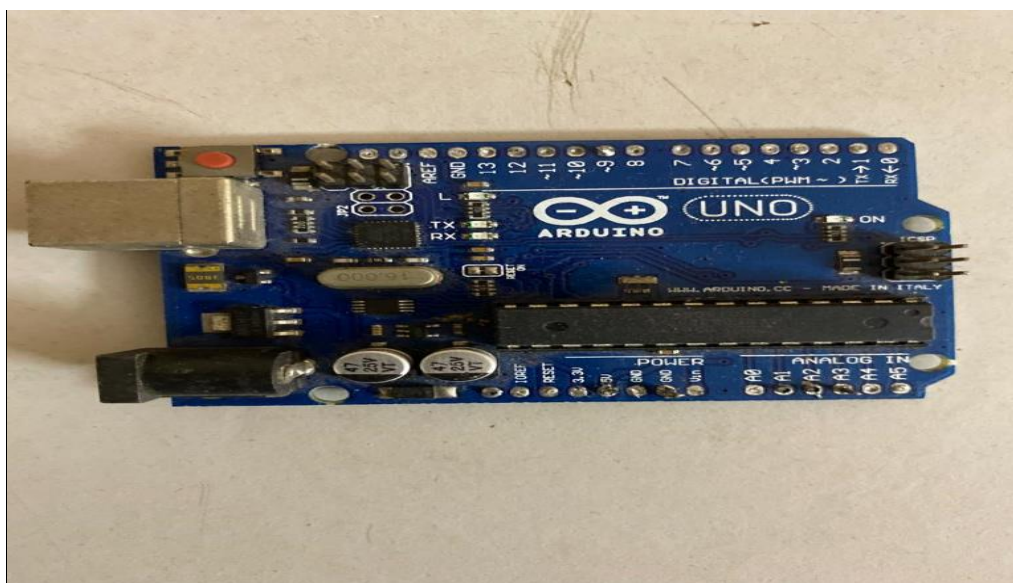
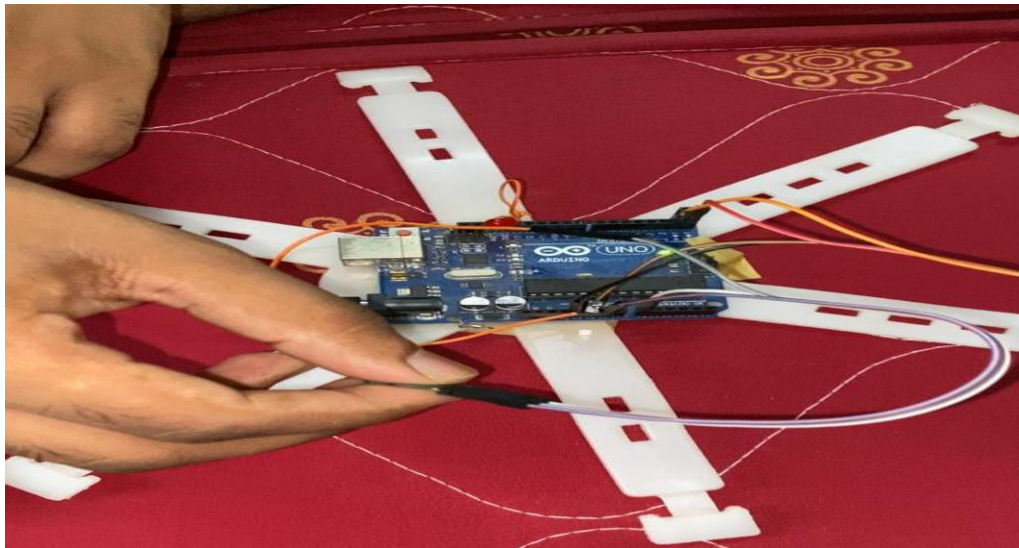
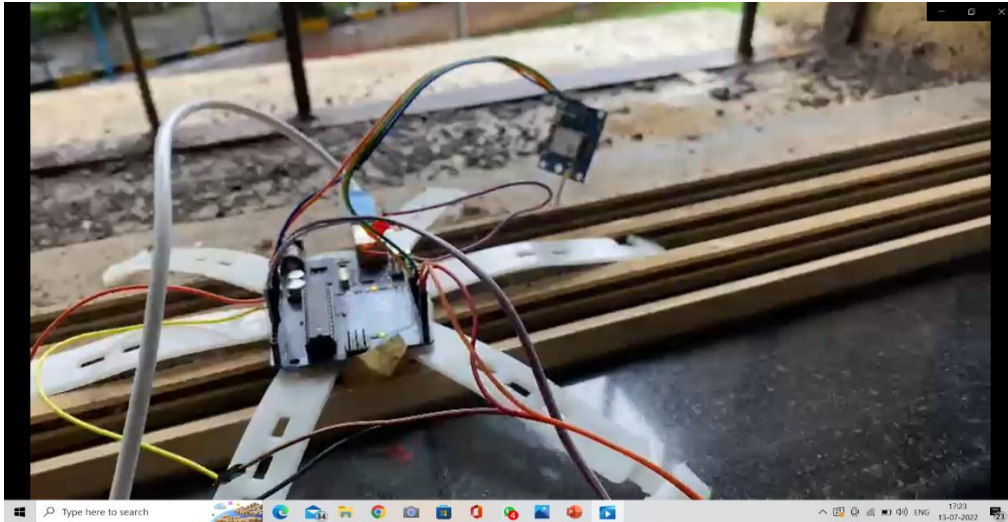
The Prototype was fabricated using components locally procured. It is possible to engineer the entire circuit as a single hermetically sealed module and shaped it to sit within the helmet without interfering with its basic safety function. The cost of the system could be lowered substantially when produced on an economic scale. Also, sensors with lower detection thresholds can be incorporated at a marginally higher cost.

(g) RESULTS AND CONCLUSION:

Reducing the chances of accidents and taking effective actions without wasting precious time is an essential way of preventing damage to life and property at sea. This paper thus explores the idea of using an advanced helmet that could cater to modern needs onboard. It comprises various sensors which collect real-time data of the crew member and alert others onboard as soon as any unfavorable situation comes up. This paper has outlined the major advancements that are possible in a safety helmet and has tried to promote a safe work environment through innovative ideas by making the right use of currently available technology.

WORKING ILLUSTRATIONS OF THE HELMET





Acknowledgment:

I would like to express my special thanks of gratitude to my mentor Dr. SM PURANIK as well as our HOD CAPT. MIHIR CHANDRA and our campus director CAPT. SUBROTO KHAN who gave me the golden opportunity to do this wonderful research on the topic “ behavior-based safety for improved maritime operation” which also helped me in doing a lot of Research I came to know about so many new things I am thankful to them.

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Innovative Transport System Design for Energy Efficiency

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ABSTRACT

The Fourth IMO Greenhouse gas study 2020 estimated that the emission of CO₂ from total shipping was 1,056 million tonnes in 2018, accounting for about 2.89% of the total global anthropogenic CO₂ emissions for that year, and that too under a voyage-based allocation method and the share of international shipping represented 740 million tonnes of CO₂ in 2018. The emissions over long-term economic and energy business-as-usual scenarios could grow up to 90-130% of 2008 emissions by 2050. For this, the IMO has been actively engaged to reduce the emission globally to further enhance ship's energy efficiency and to reduce greenhouse gas emissions.

KEYWORDS

1. Energy Efficiency
2. GHG
3. SEEMP
4. EEDI
5. EEOI
6. EEXI
7. Maritime Industry
8. MARPOL
9. Energy Efficiency Barrier.

INTRODUCTION

International shipping was projected to contribute about 1.8% of all anthropogenic CO₂ emissions in the year 1996 according to First IMO GHG Study 2000, about 2.7% in 2007 according to Second IMO GHG Study 2009, about 2.2% in 2012 according to Third IMO GHG Study 2014, and about 2.89% in 2018 according to Fourth IMO GHG Study 2020.

Depending on future energy sector improvements and future socioeconomic development, the study predicts that there could be a rise in the number of emissions produced by the shipping industry by a range of 50% to 250%. The rising sea level due to the melting of ice caps and glaciers, global warming, climate change, and seawater acidification are caused by the increased anthropogenic CO₂ and other emissions of GHG from maritime industries.

Environmental activists and concerned individuals developed pressures on United Nations (UN) and various country leaders regarding human health, environmental issues impacts, global warming, and climate change have led to legislative bindings to decrease human-caused

CO₂ and other GHG emissions. The Kyoto Protocol for the International Maritime Organization (IMO) was the reason behind the imposition of GHG emissions from shipping. The IMO approved the Energy Efficiency Design Index (EEDI) for new ships and Ship Energy Efficiency Management Plan (SEEMP) for existing vessels in 2011, four years before the COP21 climate change meeting in Paris.

The MARPOL Convention's Annex VI has been updated by including new regulations to reduce air pollution from the maritime industry. To enforce carbon emission requirements in the design and construction of new ships and the establishment of a Ship Energy Efficiency Management Plan (SEEMP), the changes include Chapter 4, which has been established with the Energy Efficiency Design Index (EEDI). For global shipping, the EEDI and SEEMP standards addressing the reduction of CO₂ emissions came into effect on January 1, 2013. A feasible method for monitoring ship and fleet overall performance and efficiency and some considerations for optimizing ship performance was offered by SEEMP.

IMO TIMELINE AND ACTION TO CUT GHG EMISSIONS AND INCREASE THE ENERGY EFFICIENCY OF SHIP

The time chart summarizes the activities that led to the adoption of chapter four of MARPOL annex six on energy efficiency for ships.

Year	Activities
1997	Resolution 8 “CO ₂ emissions From ships”.
2003	Resolution A. 963(23) “IMO policies and practice related to the reduction of GHG emission from the ship.
2005	MEPC Circ. 471, EEOL.
2008	GHG Working group 1 & 2.
2009	MEPC Circ.681 EEDI Calculation. MEPC Circ.682 EEDI Verification. MEPC Circ.683 SEEMP. MEPC Circ.684 EEOL.
2011	EEDI & SEEMP Regulations Adopted.
2013	EEDI and SEEMP enter into force.
2014	Approval of the Third IMO GHG study 2014.
2015	EEDI phase 1 in effect – 10% reduction in the carbon intensity of new ships.
2016	Adoption of a mandatory IMO Data Collection System (DCS) for ships to collect and report fuel oil consumption data from ships over 5000grt.
2019	IMO adopts a procedure to assess the impacts of States of candidate measures.
2020	Approval of the Fourth IMO GHG study 2020. EEDI phase 2 in effect – up to 20 reductions in the carbon intensity of new ships
2021	Adoption of short-term measures (EEXI, CII) to reduce the carbon intensity of all ships by 40% by 2030, compared to 2008
2022	EEDI phase 3 is in effect for certain ship types with up to 50% carbon intensity reduction for new build large containerships
2023	Revision of the IMO Initial GHG Strategy Start of carbon intensity data (CII) collection under the short-term measure
2025	EEDI phase 3 in effect -up to 30% reduction in carbon intensity for newly built ship

2030	IMO Initial GHG Strategy objective of 40% reduction of CO emissions per transport work compared to 2008.
2050	IMO Initial GHG Strategy objectives of 50% reduction of the total annual GHG emissions and a 70% reduction of CO ₂ emissions per transport work compared to 2008.

Chapter four of MARPOL annex six introduces two mandatory mechanisms as energy efficiency standards for ships the main objective of these standards is to reduce GHG emissions of international shipping through improved ship design and operations these regulatory mechanisms are:-

1. The energy efficiency design index for new ships e EEDI
2. The ship energy efficiency management plan for all ships is SEEMP

The IMO SEE framework or ship energy efficiency framework is a regulatory framework that incorporates several measures for ship owners or operators these include:-

- The SEEMP is the ship's energy efficiency management plan.
- The EEDI which is the shipyard design and construction or EE design index will be discussed in detail in later modules.
- The EEOI is the energy efficiency operational indicator.

SEEMP (SHIP ENERGY EFFICIENCY MANAGEMENT PLAN)

SEEMP is a management tool that establishes our mechanism for ship operators to improve the energy efficiency of the ship during its operational lifespan it works according to the cycle of continuous improvement of planning, implementing, monitoring, and reviewing several energy efficiency measures.

EEDI (ENERGY EFFICIENCY DESIGN INDEX)

The EEDI is an index that indicates the energy efficiency of a ship in terms of GE co₂ generated per ton-mile cargo carried for specific reference ship operation condition intention is by imposing limits on this index I am over which driver's ships technologies to be more energy efficient over time the EEDI is a goal-based technical standard that our supply cable to new ships ship designers and builders are free to choose the technologies that meet the e EDI requirements in a specific ship design over time the EDR level will be reduced and will gradually lead to more energy efficient ships.

$$EEDI\left(\frac{g}{ton - mile}\right) = \frac{FOC \times C}{Capacity \times Vs}$$

Some ship types are not part of EEDI regulations. The following list provides the ship type that is currently required to comply with the attained EEDI regulation 21

2.25 Bulk carrier	2.32 Passenger ship
2.26 Gas carrier (non-LNG)	2.33 Ro-Ro cargo ship (vehicle carrier)
2.27 Tanker	2.34 Ro-Ro cargo ship
2.28 Container ship	2.35 Ro-Ro passenger ship
2.29 General cargo ship	2.38 LNG carrier
2.30 Refrigerated cargo ship	2.39 Cruise passenger ship
2.31 Combination Carrier	

All the ships in the list must comply with the EEDI regulation 21 which is:-

- Attained EEDI \leq Required EEDI
- Required EEDI = $(1 - X/100) \times$ **Reference line value**

Where,

- X is a reduction factor
- Reference line value is estimated from the EEDI Reference line

EEOI (ENERGY EFFICIENCY OPERATIONAL INDICATOR)

Additionally, IMO has adopted a voluntary scheme for the calculation of energy efficiency in the EEOI. The main objective of this measure is to potentially use it as a monitoring performance indicator in shipping most likely about SEEMP.

$$EEOI \left(\frac{g}{ton - mile} \right) = \frac{Fuel(ave) \times C}{Cargo \times Distance}$$

SURVEYS AND CERTIFICATION (REG. 5.4)

Surveys

Ships in chapter 4 are also required to be subject to the surveys below

- An initial survey before a new ship is put into service.
- A general or partial survey, after the major conversion of a ship to ensure that the attained EEDI is recalculated as necessary.
- For major conversions regarded as a newly constructed ship the administration shall decide the necessity of an initial survey.
- For existing ships, the verification of having a SEEMP on board shall take place at the first intermediate or renewal survey whichever is the first on or after the first of January 2013.
- The survey and verification for EEDI shall be done according to IMO's EEDI survey and verification guidelines.

Certificate

- An IEE certificate needs to be issued to any ship of 400 gross tonnages and above before they took me engaged in voyages to ports or offshore terminals under the jurisdiction of other parties.
- Certificate must be issued or endorsed either by the administration or any organization duly authorized by it.
- No IAPP (International Air Pollution Prevention) Certificate or IEE certificate shall be issued to a ship that is entitled to fly the flag of a state which is not a party.
- The IEE certificate shall be drawn up in a form corresponding to the model given in appendix 8 of this annex.

Duration of validity of IEEC

- The IEEC shall be valid throughout the life of the ship subject to the provisions of paragraph 11.
- Paragraph 11, An IEEC issued under this annex shall cease to be valid in any of the following cases:-
 - a. If the ship is withdrawn from service.
 - b. If a new certificate is issued for a major conversion of the ship.
 - c. Upon transfer of the ship to the flag of another state.

DESIGN, OPERATIONAL, ECONOMICAL, INNOVATIVE SOLUTIONS TO IMPROVE ENERGY EFFICIENCY

- **Weather Routing & Voyage planning:** Careful planning and execution of voyages would result in achieving an optimum route and improved efficiency thus resulting in significant savings. Lack of awareness of ship crews, lack of information, operational difficulties, and conflict with the charter party requirements are some of the reasons hindering the implementation of this effective measure. Since this measure is an operational measure, no information or financial barrier is associated with this measure.
- **Just in Time / Virtual Arrival:** To facilitate the use of optimum speed, early communication with the next port should aim to provide maximum notice for berth availability. This approach is supported by the port operational procedures. Lack of awareness of ship crews, lack of information, operational difficulties, and conflict with the charter party requirements are the main barriers to the implementation of this measure.

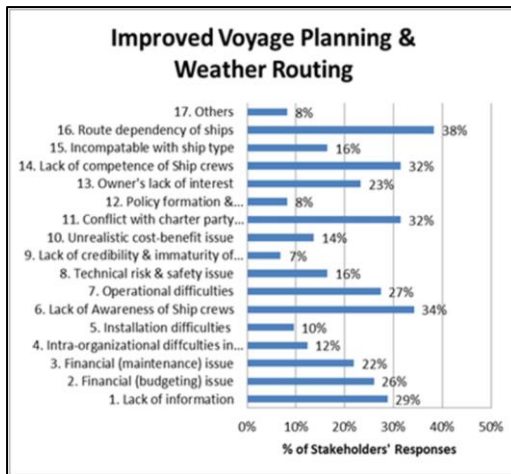


Fig. 1: Improved Voyage Planning & Weather Routing

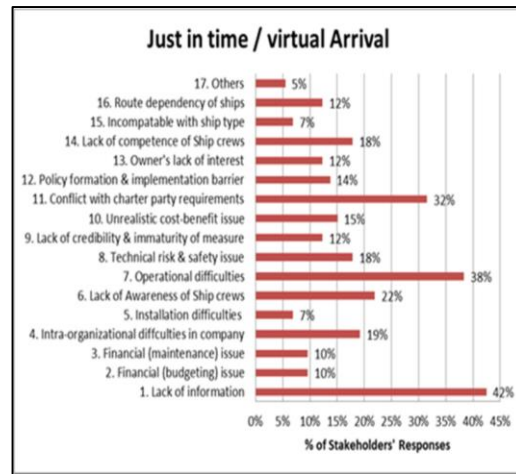


Fig. 2: Just in Time / Virtual Arrival

- Trim Optimization:** Significant fuel savings can be achieved by optimizing the trim as we know that loaded or unloaded trim greatly affects the resistance of the ship through the water. Operational difficulties, lack of competence of ship crews, lack of awareness of ship crews, and, lack of information are the main barriers to the implementation of this measure. Major related barriers are ship technical operation and ship crew.
- Ballast Optimization:** Steering conditions and autopilot settings are significantly impacted by the ballast condition of the ship. It should be noted that less ballast water will result in the highest efficiency. Operational difficulties, lack of competence of ship crews, lack of awareness of ship's crew, and lack of information are the main barriers to the implementation of this measure.

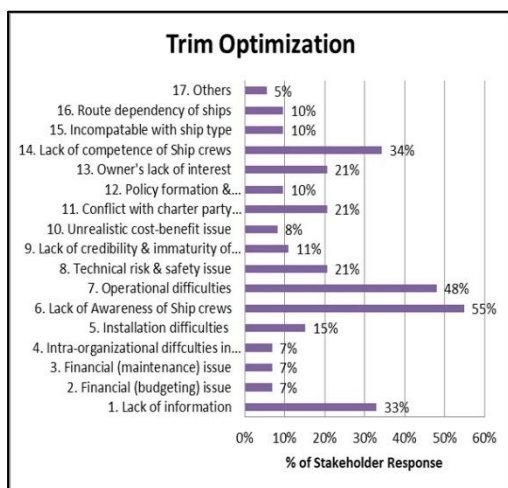


Fig. 3: Trim Optimization

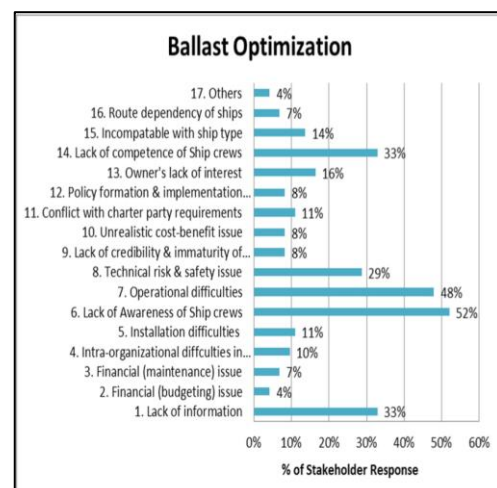


Fig. 4: Ballast Optimization

- Hull Cleaning & Coating:** Implementing new technology-coating systems along with cleaning intervals will result in the optimization of the Hull resistance. Better fuel efficiency can be ensured by making the hull smoother. The owner's lack of interest,

and financial (budgeting) issues. and financial (maintenance) issues are the major barriers to the implementation of this measure. Since this measure is related to costing thus financial issues and owner's interest are the key barriers to this measure.

- **Propeller Cleaning & Polishing:** Appropriate coating, propeller cleaning, and polishing may result in increased fuel efficiency. The owner's lack of interest, financial (budgeting) issues and financial (maintenance) issues are the major barriers to the implementation of this measure. Since this measure is related to costing thus financial issues and owner's interest are the key barriers to this SEEMP measure.

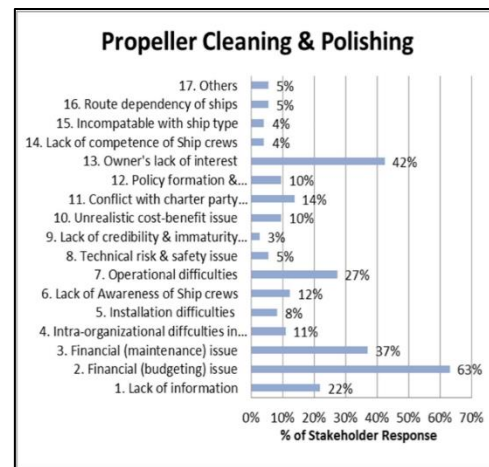
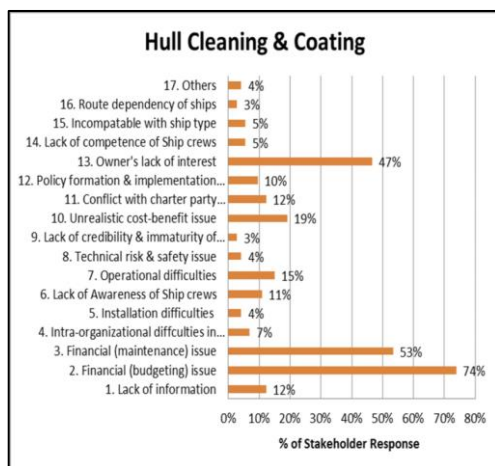


Fig. 5: Hull Cleaning & Coating
6: Propeller Cleaning & Polishing

Fig.

- **Speed Optimization/Slow Steaming:** Significant fuel savings can be achieved through speed optimization. Optimum speed is the speed at which the fuel used per tonne-mile is at the minimum level for that particular voyage. Slow-speed operations have adverse consequences such as increased vibration and problems with soot deposits in the exhaust system and also in the combustion chamber. Technical risk and safety issues are the major barriers to the implementation of this measure.
- **Main Propulsion Performance monitoring systems:** The new types of electronically controlled engines result in increased efficiency. For the maximum benefits, specific training for the relevant staff should be done. Lack of competence and lack of awareness of the ship crews, installation difficulties, and financial issues are the main barriers to the implementation of this measure.

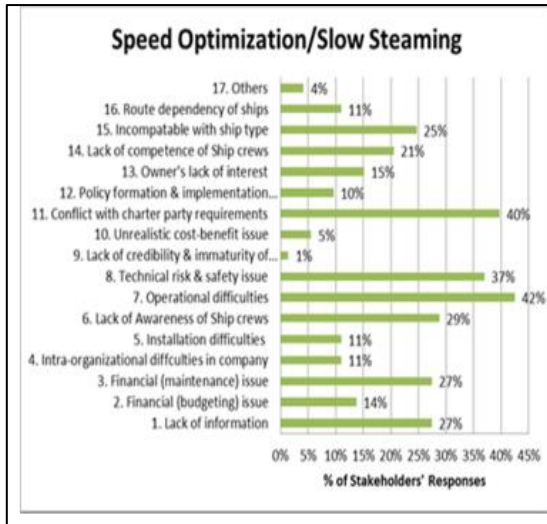


Fig. 7: Speed Optimization / Slow Steaming

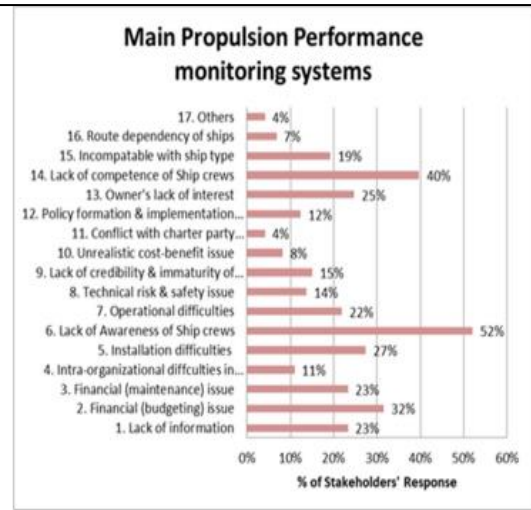


Fig. 8: Main Propulsion Performance

Monitoring Systems

Ship's Power Use Optimization: Proper ship power management may result in increased fuel oil savings. This practice can be achieved by optimizing the diesel generator. Optimization of the diesel generator load can be done by running the minimum number of generators in safe load conditions. Lack of competence and lack of awareness of the ship crews, and operational difficulties are some of the major barriers to the implementation of this measure.

- **Crew Awareness and Training on Energy Efficiency:** Using appropriate energy checklists may increase crew awareness. This checklist is developed based on the identified best practices after numerous Energy Audits. In addition to this, an incentive or bonus scheme can also be introduced for fuel savings. The owner's lack of interest, lack of information, and policy formation and implementation barriers are the main barriers to the implementation of this measure.

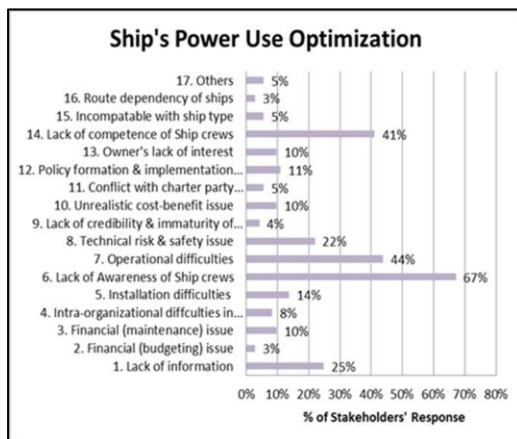


Fig. 9: Ship Power Use Optimization

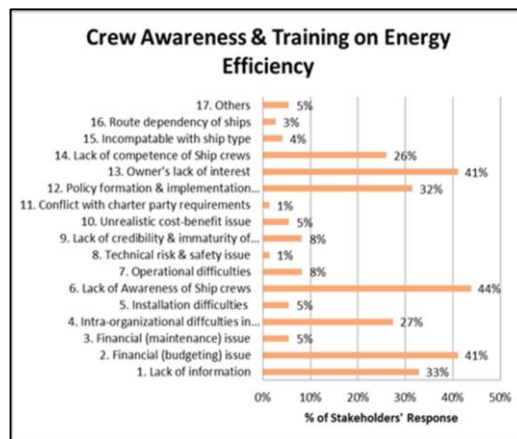


Fig. 10: Crew Awareness & Training on Energy Efficiency

List of barriers to implementation of energy efficiency measures

Information Barriers	<ol style="list-style-type: none"> 1. Lack of information 2. Overload of information 3. New-building contracts not including information technologies 4. Not using information 5. Not maintaining information 6. Inaccuracy of information 7. Improper form of information 8. Cultural differences regarding the required information 9. Adverse selection 10. Moral hazard and principal-agent relationships 11. Lack of credibility and trust in the source of information 12. Variations in circumstances
Financial Barriers	<ol style="list-style-type: none"> 1. Limited access to capital 2. External risk 3. Business risk 4. Hidden costs 5. Heterogeneity 6. Imperfect budgeting 7. Unrealistic basis for cost-benefit analyses
Intra-organizational barriers	<ol style="list-style-type: none"> 1. Organizational culture 2. Inertia 3. Bounded rationality 4. Lack of power 5. Lack of trust in the organization 6. Lack of time 7. Communication problems 8. Lack of trust in technologies 9. Split incentives 10. Ownership of vessels 11. Difference in risk perception
Technological Barriers	<ol style="list-style-type: none"> 1. Incompatibility between technologies and ship types 2. Immaturity Technical risk 3. Interference with main processes 4. Complexity of measures 5. Improvement in likeliness 6. Incompatibility between technologies and operations
Technical Barriers	<ol style="list-style-type: none"> 1. Crew's lack of technical knowledge 2. Crew's lack of awareness training 3. Crew's lack of competence 4. Managers without a technical background
Policy Barriers	<ol style="list-style-type: none"> 1. Policy formation barriers 2. Policy Implementation barriers 3. Lack of reviewing & amendment of policy 4. Conflicting policy regulations
Geographical Barriers	<ol style="list-style-type: none"> 1. Piracy area 2. Route dependency 3. Wind or tidal effect

CONCLUSION

According to this technical paper, technical managers on land and sailors at sea are crucial players in implementing cost-effective EE operational procedures into place. All operational EE measures related to navigation, deck, and ports are carried out by the master and deck crew.

On the other hand, all of the ship's propulsion engine operation, engine load monitoring, machinery operation, power generation, and management-related EE operational procedures are carried out by the Chief Engineer and the Engine crew. Modern commercial ships are fitted with intelligent software and tools that transmit real-time operational data and navigational information to shipping company offices ashore via satellite networks. These make it possible for technical managers ashore to track and evaluate vessel performance data from their workplace, provide ongoing feedback to the ship's captain and chief engineer, and give guidance on the adoption of SEEMP procedures on board ships. Practically, the ship's crew and technical supervisors ashore do not have full control over the ship's commercial activities. Commercial decision-makers interfere with ship technical operations and hinder ship energy efficiency. Cargo owners, ship charterers, and commercial ship managers make decisions for commercial ship operations affecting energy-efficient ship operations and emissions control from commercial ships. Because of this, ashore technical managers and crew members must constantly take instructions from the ship's commercial operation department into account while using a ship-based regulatory approach.

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Micro Bubble Drag Reduction a Model-Based Analysis & Innovation

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ABSTRACT

Innovation in the field of Transportation and energy-efficient systems is one of the significant necessities to reach the zero carbon emissions goals by the end of this century. One of the ways to increase efficiency and reduce the resistance in the Transportation of Cargo is the Lubrication of Microbubbles under the hull of vessels, also known as (Micro Bubble Drag Reduction). In this technical paper, a model-based analysis was done, and the change in the resistance was calculated using the *Froude ship model resistance* test. Innovation was also made through which, in the case of LNG carriers, the boiler exhausts can be directly used to lubricate the hull due to their pure nature.

KEYWORDS

1. BDR
2. Froude ship model resistance
3. Lubrication
4. Injection
5. Hull Resistance
6. Microbubble.

INTRODUCTION

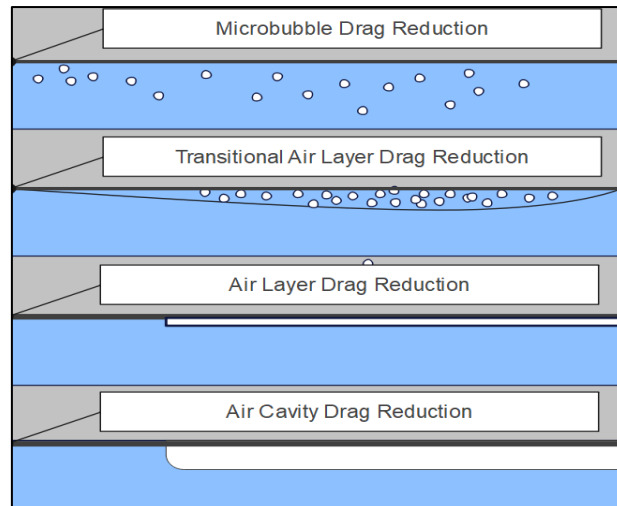
The marine field is a vast region of Engineering and Technology, from the old-day human-propelled vessels to the modern-day Man B&W 2-stroke dual-fuel engines. The Industry has advanced to such a level that much research and simulation must be done to install a new system. This technical paper explains the Micro Bubble Drag Reduction system through a model-based analysis. The change in ships' hull resistance with and without air injection is calculated. The model-based analysis is referenced through Froude's model testing on hull resistance but measured through distance and time reference. According to Froude, the ratio of the large ship to the smaller model is the square root of the original proportion of the large

vessel. The paper will lead to the working principle of the lubrication system. The machinery which is installed to make this system work. The minimum speed at which a vessel should be propelled to take the most efficiency out of this system. Content here also will include an innovative idea of using the LNG vessel's exhaust gases to lubricate the hull. The paper will give information on porous plates used to inject the air under the hull and the pipes used to transfer the compressed air under the hull, including the positions where to inject the air and the orientation of the nozzles—explaining the structure material and the area covered by the system under the hull.

1. Air Lubrication Drag Reduction

Drag reduction is necessary to increase the efficiency of vehicles running on the medium where solid-to-liquid contact is attained. This system involves trapping air or some gas particles under the solid surface and above the liquid surface. This layer gives a slight upward force due to buoyancy and rolls on the solid surface or, specifically, the hull when the solid surface is under motion. In short, we are injecting these micro air bubbles under the hull, which can reduce the metal-to-water contact and eventually reduce the water drag. The lubrication can be gained by making the solid surface hydrophobic and can create the Leiden frost effect. But making it hydrophobic is quite tricky in the case of the hull. Vessels travel worldwide at different ports, and to keep the hull surface hydrophobic, much maintenance care is required. Due to contact with marine creatures, the character may turn into a non-hydrophobic surface. There are many types of Microbubble air lubrication systems. Some of those are listed below. ^[13]

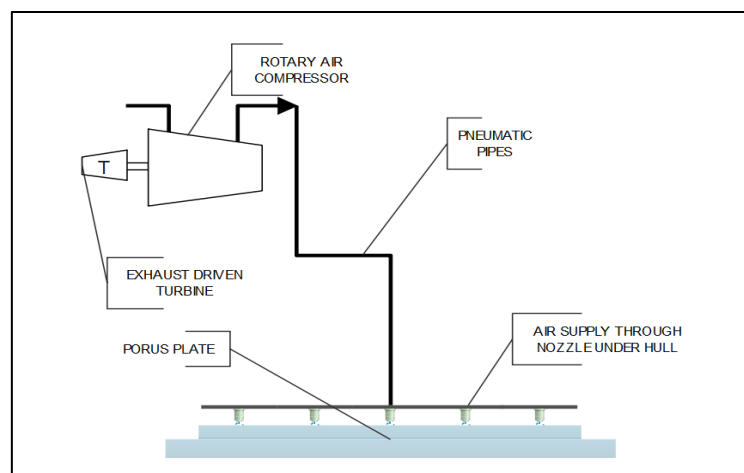
1. Microbubble Drag Reduction
2. Transitional Air Layer Drag Reduction
3. Air Layer Drag Reduction
4. Air Cavity Drag Reduction



**Fig. 1: Different Types of Air Reduction Injection Types Surface Water Contact
BLACK Line is Plate.**

MICROBUBBLE DRAG REDUCTION

The reason to choose the MBDR method from the four systems above is that the system provides enough control with drag reduction. MBDR is also a system that takes less volume or does not occupy more space. The air lubrication system tries to attain a thin sheet of air bubbles under the vessel's hull. Due to this, the fuel needed for the main machine will be cut off to some extent, and hence it will reduce carbon emissions. In the case of LNG carriers with an operational draught of 9 to 12 meters and an operational speed of 10 to 19 knots, the net savings is calculated as 6% to 9%, which is a considerable amount concerning emission control laws.



**Fig. 2: Line Diagram of the Air System Which Is Driven Through The Exhaust Gases of
the Main Engine.**

Pressure can be calculated as $P = \rho g H$ At a Draft of 10 meters the pressure at the point is $1025 \text{ kg/m}^3 * 9.8 \text{ m/s}^2 * 10 \text{ m} = 100450 \text{ Pascal}$ but the hydrostatic pressure will be roughly 1.0035 bar. There must be a pressurized gas source that can be supplied below the hull at a pressure. The air lubrication system will give its output according to the direction of the inlet angle, the ship's geometry, and the location of the outlet nozzles. A vessel with a flat bottom will be more efficient and effective for this system to work with a positive output. In the case of curved cross-section hull-type ships, the air injected will escape the contact surface area with a lesser time of metal-to-water contact. The gas pressure must be enough to inject air at a draught level of 10 to 12 meters.

2. Compressor and Types

A compressor is a mechanical device that takes air suction and delivers output air at high pressure and lower volume by doing some work inside. Most air compressors are Centrifugal, Axial, and Positive displacement types, primarily used in the maritime industry. Centrifugal compressors are attached to turbochargers of the main engine and Generator prime movers. They are used to deliver the air inside the air suction manifold of the engines at a pressure of roughly 3 bars. Positive displacement compressors, these compressors are generally reciprocating compressors and screw rotary compressors. Double-stage reciprocating compressors are the ones that are used majorly in the maritime field due to their higher pressure output and higher efficiencies. The compressor needs to be cooled somehow, as the compressor will be running continuously. Cooling can be achieved by directing the air toward the compressor installed at the ship's bow. It should be installed so that the pipes that will carry the air to the hull should be in the shortest length possible. Due to this, the cost of the piping will reduce, and the weight will also be reduced.

AIR SUPPLY STRUCTURE, NOZZLES

Snoots Microbubble injection position is one of the essential disciplines that need to be considered in the effectiveness of disunion reduction by microbubbles. The position of the microbubbles injection should be behind the mid-ship. It is the stylish position to achieve the most influential drag reduction and should beget about 6-9 % drag reduction. A possible explanation is the reduction of turbulence intensity caused by the microbubble, which increases the effective density of the water-bubble admixture. Hence, as a result, the vessel gets an upward lift dwindling the drag. Boat total resistance value can be attained from hauling test data. The total boat resistance consists of the frictional resistance and residual resistance. Still, the data attained cannot be used to gain the value of the disunion resistance and residual resistance specifically so that only the total resistance value of the model vessel is attained.

MODEL-BASED ANALYSIS

This model-based analysis calculated the time for the Model to travel a 50-meter distance. This was done using a Compressor and a DC 18 V power supply with stone, which is made of Porous Concrete and generates microbubbles. The air bubble needs to be injected to all be equal in size. If the injected bubbles are not similar, different-sized beads will create various buoyant forces at different levels. The stability of the ship will affect hugely if the buoyant force is not acted similarly in every vertical Z direction concerning the XY plane.



Fig. 3: Mild Steel Ship m\|Model



Fig. 4: Compressor Coupled With a 12 Volts DC Motor.

This motor is DC rated with high Torque which generated the air to inject at the depth of 10 cm under the hull the output of the compressor was connected with a pneumatic air transfer pipe and sent to the nozzle by drilling a hole of 5 mm in the hull.

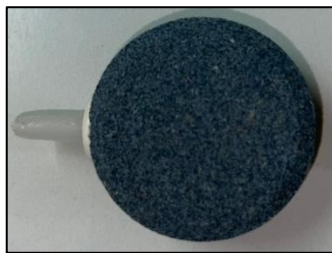


Fig. 5: Porous Concrete Injector Plate Which Generates Microbubbles.

The output of the compressor was connected with a pneumatic air transfer pipe and sent to the nozzle by drilling a hole of 5 mm in the hull. The concrete particles are stuck with each other with the help of adhesive, making them porous. The air passing through the pipe in a pretty free flow will be made into tiny bubbles when passed through the porous rock and hence turned small. Abrasive particles when added to adhesive make a strong bond that can handle high-pressure outputs.

The images below represent the different patterns of the flow of air bubbles with their structure.



Fig. 6: Bubbles Separated To Near The Hull.

The image above shows that the bubbles are separated too early, and hence the microbubble effect of air lubrication is attained but can be referred to as giant bubbles which can give different types of upward forces according to the bubble size. To compensate for this effect, we need to reduce the inlet pressure and increase the inlet flow, which will allow the injector plate to function properly



Fig. 7: The Rate of The Air Inlet Is Too Less And Hence The Microbubbles Aren't Created.

Above is the condition where the injection pressure, as well as the quantity of the air injection, is significantly less. If these are the stagnation conditions, then it is hard to achieve drag reduction, and in some cases, it may increase the resistance

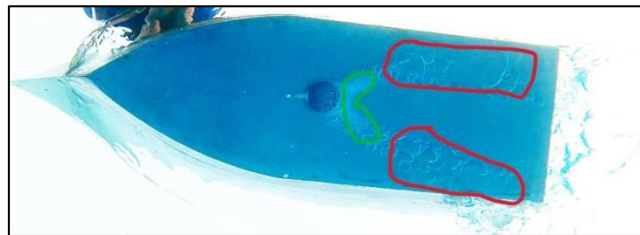


Fig. 8: Green Part Shows High-Density of Small Bubbles Red part Shows The Piling Up effect.

The aim is to get high-density microbubbles injected; when this high-density microbubble piles up together and the piled-up bubbles also pile up, they create an air cavity, and the cavity has the potential to give vibrations to the hull. The injector plates should be placed so that the microbubbles are high-density and more petite in radius and should not pile up. They must be dragged till the end of the hull and only must be escaped the aft of the vessel.

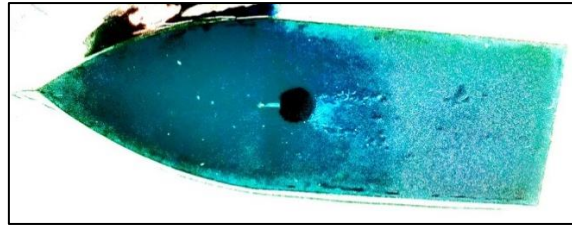


Fig. 9: The Area Near the Nozzle Plate is Piled Up When The Air Goes Towards The End of The hull It Separated And Shows Almost Perfect Hull Lubrication (The Above Image Has Been Edited For The Visibility of The Microbubbles)

Equally distributed microbubble air injection is the perfect type of microbubble air injection. The condition can lead to the maximum hull drag reduction possible. The area near the nozzle in the above image is inside the condition where the air bubbles are in huge quantity, and this point will stay the same till the ship is at constant velocity. Once the velocity is increased, the bubbles need to be injected with higher pressure and a higher flow rate. Some of the bubbles in the above image are huge at the center of the hull, but this will not affect the drag as they are covered with a vast amount of microbubbles to compensate for the large volume bubble.

CALCULATIONS

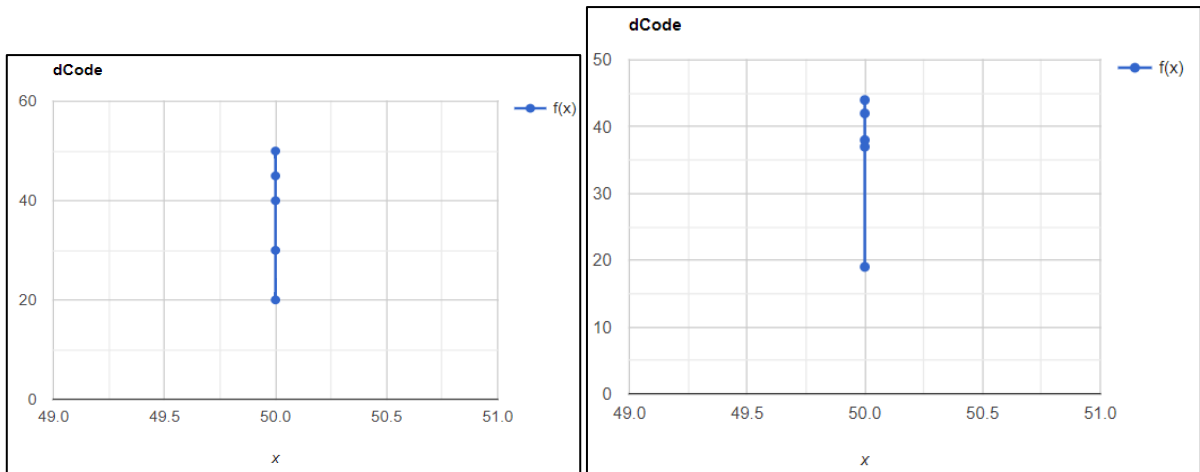
The ship was made to move with the constant pulling force of a motor with a radius of the pulley to be 3 mm. The motor is DC powered with 18 Volts, and the distance was 50 meters. This process was done with and without an air lubrication system installed. The draft is 7 cm. The table below shows the readings of time distance and the air inlet pressure

Table 1: Readings Without Air Inlet

Sr no	Distance	Time required	Pulling force (Regulated motor with different rpm)
1	50 meters	50 seconds	0
2	50 meters	45 seconds	0
3	50 meters	40 seconds	0
4	50 meters	30 seconds	0
5	50 meters	20 seconds	0

Table 2: Readings With The Air Inlet With The Same 5 Motor Stages and Pressure of 1.3 bar

Sr no	Distance	Time required	Air Pressure
1	50 meters	48 seconds	1.3 bar
2	50 meters	39 seconds	1.3 bar
3	50 meters	32 seconds	1.3 bar
4	50 meters	28 seconds	1.3 bar
5	50 meters	19 seconds	1.3 bar



The graph on the left shows the time and distance at particular speeds without air lubrication and the distance on right shows the time and distance at the same pulling force but with the air lubrication. According to the readings, it is proved that the air lubrication is effective with the speed limit of 1.11 meters per second to 1.66 meters per second the air lubrication is not that useful for operational conditions at speeds less than 1.1m/s and more than 1.6m/s. The drag reduction with the speed and distance calculations can be measured and is given in the table below.

Table 3: %Reduction In Time Taken To Cover The Same Distance.

Speed	%Reduction
1m/s	4%
1.1m/s	14%
1.25m/s	20%
1.66m/s	7%
2.5 m/s	5%

These are the reduction found on the model-based speed distance analysis, not the ship hull drag resistance calculation. Hence, these readings are apparent to have some error percentages. However, with this analysis, we can prove that air lubrication can reduce drag at a smaller scale where the waves are made to be ignored, and the air resistance is. Achieving 20 percent drag reduction is a challenging task. This can be only possible in model structures as they are lightweight and with a lower draft and a much smoother surface compared to the vessel's hull. Now moving to the case where the vessels are injected with air bubbles instead of this small model, they are equipped with a bulbous structure bow with a huge surface area to encounter air resistance and rusting, which increases the friction of the hull with all these conditions calculated the MBDR system can promise to achieve a drag reduction of 10 to 7 percent in case of the average merchant ship.

AIR DISCHARGE POSITION

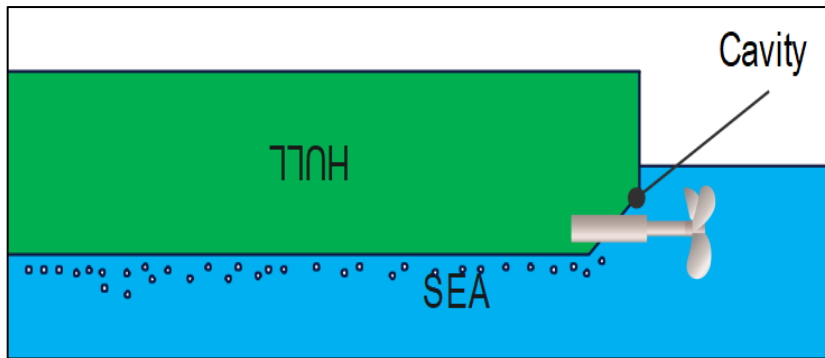


Fig. 10: Cavity For the Air Bubble to Escape.

When the bubbles travel below the hull, they are pretty good in their micro nature, but once they reach the end, they should be sent to air, so they do not come in contact with the propeller. Suppose they are in contact with the propeller. In that case, they may cause cavitation in the propeller, which will highly reduce the pushing force of the propeller and result in significantly lesser efficiency.

USAGE OF THE BOILER FLU GASES TO GENERATE POWER TO DRIVE THE AIR COMPRESSOR.

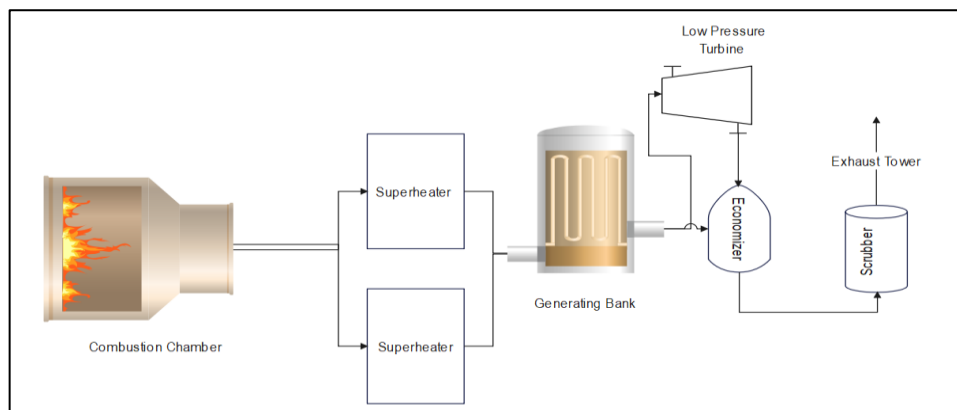


Fig.11: Installing an LP Turbine That Can Propel an Alternator with Pressure Flaps

The flu gases from the combustion chamber have a temperature of 1423°C. The pressure noted is 77.51 mm in the height of the water column. These flue gases are then diverted to 2 different superheater columns, SH1 and SH2, at a temperature of 1406.9 ° Celsius to a temperature of 1201° Celsius. They are then sent to a generating bank after losing 100 ° Celsius by the pipes, and these steam-generating tubes generate the majority of steam from a temperature of 944.27°Celsius to 348.44 ° Celsius, followed by an economizer where the temperature after the exchange is dropped to 160.65°c and then sent to scrubbing tower and sent to the atmosphere. Now innovation can be done where around 5 percent of superheater pipes can be decreased. The temperature difference of 944°Celsius to 340°Celsius can be used and sent to the turbocharger, where the turbocharger is coupled to the alternator. This alternator can provide sufficient power to run the compressor installed at the bow of the main deck. Those using some amount of flu gas heat and providing the power to the alternator. There is a need to install pressure flaps to create a minor pressure difference for the low-pressure turbine to work. This innovative idea can be only implemented in a vessel with LNG Carriers [14]

CONCLUSION

Concluding this paper, the microbubble drag reduction method is a valuable method to reduce drag reduction; the different types of injections and the air bubble structure were explained. When where and how much to inject the air pressure was given in the paper, the drag reduction was measured with the function of speed distance and time notations. It was observed to range between a maximum of 20 percent at the velocity of 1.23m/s and a lease of 4 percent at 1m/s. The graph was noted between distance and time. The images of the underwater hull show the different types of cavitation. Model-based analysis was performed, and as a result, the MBDR system is quite efficient. The paper went through the installation location of the system. The boiler flue gases generated the power required to drive the compressor in our paper by placing a turbine in between the boiler generating tubes which has a temperature range of 945° Celsius to 340° Celsius coupled with an alternator, and this can provide the compressor enough power to compress the air. This system of injecting microbubbles has already been used by the company named ‘Silverstream Technologies’ and is implemented by the company on a majority of Gas carriers and cruise liners to reduce carbon emissions; microbubble drag reduction is already operational in the maritime field also MAN B&W WHRS waste heat recovery system is the efficient engine which can be used for the ships fitted with microbubble air lubrication.

REFERENCES

1. Figure 1: Different types of Air Reduction injection types surface water contact BLACK line is plate.
2. Figure 2:- Line Diagram of the Air System which is driven through the exhaust gases of the main engine.
3. Figure 3:- Mild steel ship model
4. Figure 4:- Compressor coupled with a 12 volts DC motor.
5. Figure 5:- Porous Concrete Injector plate which generates Microbubbles.
6. Figure 6:- Bubbles Separated too near the hull.
7. Figure 7: The rate of the air inlet is too less and hence the microbubbles aren’t created.
8. Figure 8: Green Part shows High-Density small bubbles Red part shows the Piling Up effect.
9. Figure 9: The area nozzle plate is piled up when the air goes towards the end of the hull it separated and shows almost perfect hull lubrication (The above image has been edited for the visibility of the microbubbles)
10. Figure 10:- Cavity For the air bubble to escape.
11. Figure 11: Installing an LP turbine that can propel an alternator with pressure flaps
12. Table 1:-Readings without air inlet
13. Table 2:-Readings with the air inlet with the same 5 motor stages and pressure of 1.3 bar

14. Table 3: % reduction in time taken to cover the same distance.
15. **Micro-bubble Drag Reduction by Multi Discrete Hole Plate on Self Propelled Barge Ship Model Yanuar^{1,*} Kurniawan T Waskito¹, Gunawan¹, Bagus D Candra², Aufa Y. Perdana²** ¹ Department of Mechanical Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia ² Graduated Student of Mechanical Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia
16. **Research Progress of Air Lubrication Drag Reduction Technology for Ships by Hai An Haozhe Pan And Po Yang** College of Aerospace and Civil Engineering, Harbin Engineering University, Harbin 150001, China Author to whom correspondence should be addressed.
17. Kongsberg Engine Room Simulator for NMIT. The values given are from the Kongsberg engine room simulator installed at the East Block Simulator room at Tolani Maritime Institute.

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The figures are made by the AUTHOR using Wonder share E draw Max Application.
The images of the underwater hull were taken using GO PRO waterproof camera
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- 3. Current Technology–CE Vishwas Mehendale – Tolani Maritime Institute.**

The Potential of Ammonia as Marine Fuel

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ABSTRACT

The maritime industry faces several substantive challenges, mostly driven by increasingly stricter air emissions and climate legislation. Among the broad spectrum of technologies and fuel solutions, anhydrous ammonia has been identified as a potential long-term fuel that could enter the market relatively quickly and offer a near-zero carbon solution.

Ammonia is known to have reduced carbon footprint. It also emits no sulphur oxides, particulate matter, and only a small amount of nitrogen oxides.

The following paper will discuss various aspects dealing with Ammonia's potential as Fuel, comparing various fuels used in marine fields.

KEYWORDS

1. Ammonia
2. Ship Fuel
3. Reduced Carbon footprint.

INTRODUCTION

Anhydrous ammonia is a compound of nitrogen and hydrogen and is a widely used, commercially available chemical. It is a building block for many chemical and pharmaceutical products, notably as fertilizer for food production. It is typically traded as aqueous ammonia (usually 28% ammonia in water), or as anhydrous ammonia.

Current global production is approximately 235 million tonnes (Mt) and for comparison, the annual consumption of conventional residual and distillate fuels by international shipping is currently estimated at 285 Mt per year (equivalent to about 650 Mt of ammonia on an energy basis).

EXISTENCE OF AMMONIA

Availability:

Ammonia is currently produced in large quantities as an input for products in the fertilizer and chemical industries. For maritime shipping, its production capacity, along with that of renewable electricity and green hydrogen, will need to grow tremendously; the current global

installed capacity of wind and solar farms, and especially the electrolyzers needed to produce the necessary green hydrogen for ammonia production, are dwarfed by the capacity required.

Current projections for the growth in global production would appear to indicate there will be enough renewable electricity to produce the volumes of green ammonia needed for the maritime fleet alone by 2040.

Comparison:

Item	Ammonia	MGO
Energy density (MJ/L)	12.9	35.95
Latent heat of vapourisation (LHV) (MJ/kg)	18.8	42.8
Heat of vapourisation (kJ/kg)	1371	250-450
Autoignition temperature (°C)	651	250
Liquid density (kg/m ³)	696 (at -33 °C)	840 (at 15 °C)
Adiabatic flame temperature at 1 bar (°C)	1800	2000
Molecular weight (g/mol)	17.031	54
Melting point (°C)	-77.7	-26
Boiling point (°C)	-33	154
Flash point (°C)	132	60
Critical temperature (°C)	132.25	654.85
Critical pressure (bar)	113	30
Flammable range in dry air (%)	15.15 to 27.35	0.7 - 5
Minimum ignition energy (mJ)	8	0.23
Cetane number	0	40
Octane number	~130	15-25

PRODUCTION PATHWAYS

Electrolysis and Haber-Bosch synthesis (pathway 1)

The main process that for decades has been used to produce fertilizer from ammonia involves converting fossil fuels into hydrogen and extracting nitrogen from atmospheric air using cryogenic air separation, pressure swing absorption, or membrane permeation

The hydrogen and nitrogen are then converted to ammonia using the Haber-Bosch ammonia synthesis process. It is an exothermic process that uses high operating temperatures (400-500 °C) and pressures (150-300 bar). In the process, nitrogen and hydrogen are directly combined. This process is accelerated by the presence of a metal catalyst

Direct solar hydrogen production (pathway 2)

An alternative way to produce renewable hydrogen is through ‘direct solar hydrogen’ (also called photo-electrochemical hydrogen), a process where hydrogen is directly produced from water without using an electrolysis unit. This technology makes use of a photo-electrochemical cell, which drives water-splitting redox (reduction-oxidation) reactions. The electrical energy

for this process could be generated using concentrated solar power (which bundles sunlight using mirrors or lenses), photovoltaic (PV) cells, or photoactive material.

This process is still in an early development stage, making it hard to present reliable figures on its energy efficiency. A potential energy requirement of 200 MJ per kg of produced ammonia is given, which translates to an energy efficiency of 9%.

Biogenic hydrogen production (pathway 3)

Another way to produce renewable hydrogen is to decompose hydrocarbon molecules from biomass. There are different technological processes to do this. Dark fermentation is an anaerobic process (in the absence of oxygen) in which biomass is decomposed into hydrogen, CO₂, and other intermediate products, using bacteria

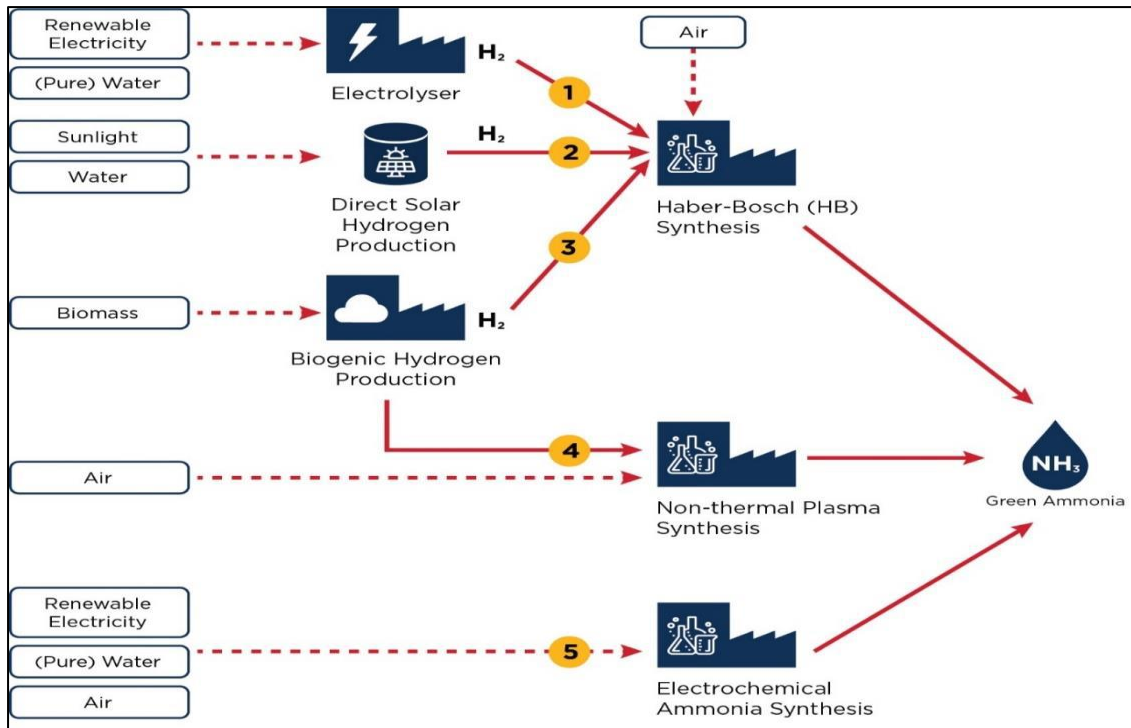
Non-thermal plasma synthesis (pathway 4)

A second alternative to the Haber-Bosch process is non-thermal plasma synthesis. This synthesis process, which is also in the research-and-development stage, operates at low temperature (around 50°C) and pressure (around 1 bar), does not operate on fossil fuels, has a low capital cost, and is suitable for small-scale ammonia production.

However, the three challenges to developing this technology are nitrogen-gas fixation, back reactions, and improving conversion and energy efficiencies

Electrochemical ammonia synthesis (pathway 5)

A pathway for producing green ammonia that does not require a separate process is electrochemical ammonia synthesis. Voltage is applied to the electrodes of the cell, releasing ions that pass through a separation membrane and an electrolyte to the electrode of opposite charge. This induces a chemical reaction in which either the water is broken into oxygen and hydrogen, after which the hydrogen reacts with nitrogen to form ammonia, or in which hydrogen ions (H⁺) are transferred to nitrogen and form ammonia without having to first form hydrogen molecules (H₂).



STORAGE AND BUNKERING

Ammonia is usually transported and stored in its liquid form to reduce its volume and avoid undetectable leakage. The liquefaction can be carried out at a low cost through pressurization or cooling. Ammonia can be stored in refrigerated tanks at -33°C at 1 bar or in pressurized tanks at 25°C at 10 bars. Ammonia is, for example, easier to store and transport than hydrogen, but less convenient compared to methanol. The storage conditions of ammonia (temperature and pressure) are very similar to liquefied petroleum gas (LPG). Despite existing vessels transporting ammonia, LPG carriers may also be used for transporting ammonia as cargo. Ammonia has 3.5 times the volume of HFO in other words, the tank size would be 4.1 times larger than an MGO tank and twice the size of an LPG tank due to the lower energy density.

The properties of ammonia thus require ammonia-fuelled vessels to have larger fuel tanks onboard vessels to bunker an equivalent amount of HFO based on the energy content. Retrofitting larger ammonia tanks on vessels might thus lead to cargo space loss. Instead, a ship could refuel more often to avoid any loss of cargo space. A higher refueling frequency might in turn lead to time losses and thus revenue losses. A study carried out on the application of hydrogen FCs on deep-sea container shipping routes in the Pacific Ocean indicates, however, that cargo space loss due to larger fuel tanks will likely be very limited and that refueling stops can be mostly avoided in return for a very small percentage of cargo space loss, even on long-range Pacific routes. As the energy density of ammonia is higher than that of hydrogen, the impact on operation and refueling might be even lower. It is not necessarily a given, therefore, that using ammonia results in significant revenue losses due to refueling or cargo space loss. The extent to which a higher refueling frequency will be necessary is subject to more detailed research on different vessel types and routes.

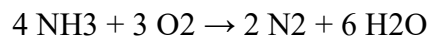
Bunkering of ammonia can take place via terminals or trucks onshore and via a bunkering ship. Safe loading and unloading of ammonia from/to terminals are possible, but safety might be improved if bunkering takes place via a bunkering ship as an intermediate between the terminal and the ammonia-fuelled vessel. Especially in the case of large amounts of ammonia, like for deep-sea vessels, the use of a bunkering ship should be preferred as well as in densely populated areas. For a fast and cost-efficient expansion of ammonia bunkering, small gas tankers could be converted to ammonia bunker barges. The use of bunkering ships was also applied for LNG to reduce bunker infrastructure investment costs and provide flexibility. The differences can lead to challenges, for example, in terms of safety.

METHODS TO UTILIZE AMMONIA AS FUEL

Combustion

Using ammonia as a fuel is new for the shipping industry, so new systems will need to be used onboard, each with its specific requirements and risks. But ammonia is not new as a cargo; therefore technologies, materials, and procedures are already in place and just need to be adapted and developed for this new application.

Both compression ignition (CI) engines, like the diesel engine, and spark ignition (SI) engines, e.g. engines following the Otto principle, are investigated. Most research focused on smaller, automobile-sized engines, not suitable for use in large ships. The overall reaction of ammonia combustion is



Ammonia is generally a flammable gas, but it is relatively hard to ignite. The following properties are challenging for combustion: high auto-ignition temperature (651°C), low flame speed, narrow flammability limits, and high heat of vaporization. These can result in unstable combustion conditions at very low or very high engine speeds. Although some researchers have successfully operated an engine on ammonia only, the engine performance is limited compared to ammonia mixtures with for example hydrogen.

Challenges of pure ammonia combustion exist for both CI and SI engines. Due to its high-auto ignition temperature, ammonia requires a higher compression ratio (35:1 and higher) than used in typical CI engines (16-23:1). It is difficult to design such an engine and therefore studies on CI engines have mainly examined mixing ammonia in different fuel ratios under various conditions. The addition of a second fuel, with a lower auto-ignition temperature, can help to combust the mixture and allows for more stable combustion. As the minimum ignition energy of ammonia is high, the design of SI engines, like the ignition plugs, would have to be adjusted for combustion. Complete combustion of ammonia would still be difficult due to its low flame speed. Therefore, also research on SI engines has focussed on the combustion of ammonia in mixtures. SI engines running on ammonia would likely be used for smaller ships, whereas modified two-stroke (dual fuel) CI engines could be suitable for larger ships.

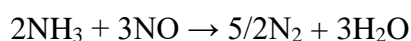
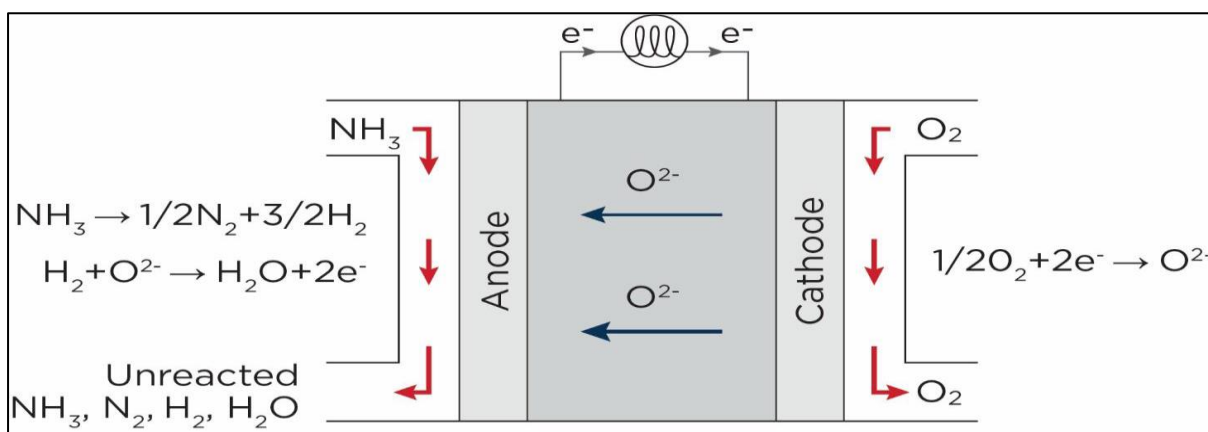
Fuel type	LHV [MJ/kg]	Volumetric energy density [MJ/l]	Storage pressure [bar]	Storage temperature [°C]	Tank volume*
Liquefied Ammonia	19	12.7	1 or 10	-34 or 20	4.1
Liquefied Hydrogen	120	8.5	1	-253	7.6
Methanol	20	15.8	1	Ambient	2.3
Methane	50	23.4	1	-162	2.3
LPG	46	25.5	1	-42	2
MGO	43	36.6	1	Ambient	1
HFO	40	35	1	Ambient	1

Notes: LHV: lower heating value; *tank volume relative to conventional MGO tank
Sources: KR (2020), Vries (2019), MAN (2019)

While for SI engines, ammonia might preferably be better mixed with gaseous fuels like methane, fuels with higher cetane numbers (like diesel) are better suited to enable the combustion of ammonia in CI engines. Significant amounts of pilot or ignition fuel were used for both of these engine types in most studies. However, studies confirm up to 95% ammonia share (by energy) in a CI engine in dual fuel mode with diesel. Tests have also been on using hydrogen as a secondary fuel to ammonia in SI as well as CI engines.

Fuel Cell

A fuel cell is a device that converts chemical energy from a fuel into electricity through an electrochemical reaction of the fuel with oxygen or another oxidizing agent. Fuel cells differ from batteries in that they require a continuous source of fuel and oxygen (usually from the air) to sustain the chemical reaction; a battery's chemical energy is fixed by the number of chemicals in the battery.



The use of ammonia in fuel cells (FC) has the potential for higher efficiency, less noise, reduced air pollutants, and reduced space compared to ICE (Internal Combustion Engine). However,

ammonia fuel cell systems for marine applications are currently costlier than the use of ICE, which is considered a main bottleneck for their uptake in shipping. In principle, there are two options: either ammonia is used indirectly as a hydrogen carrier or directly in a fuel cell.

POLLUTION

The table below shows the comparison of ammonia with three other fuels if used in an ICE based on key environmental criteria. The comparison is done horizontally across fuels. The higher the given number, the better the performance of each fuel in the category

Comparison of post-fossil fuels and fossil HFO based on key environmental criteria				
Criterion	Ammonia	Hydrogen	Methanol	HFO
GHG reduction potential	4*	5	5**	1
Air pollutants	3	5	4	1
Aquatic ecotoxicity	2	5	5	1
Human toxicity	2	5	3	3
Flammability	2	1	2	5
Explosion risks	4	2	5	5

Notes: Ranking: 1= high risk/ low performance to 5=low risk/ high performance, *uncertainty about N₂O emissions, **well-to-wake
Source: Authors' own compilation

The GHG reduction potential of ammonia used in ICE. Even though ammonia does not emit any CO₂, there is uncertainty around N₂O emissions. Until the issue is clarified or solved, ammonia's GHG reduction potential should be evaluated with caution. Methanol, if based on renewable energy and CO₂ from the air, can be considered climate-neutral from a well-to-wake perspective as the CO₂ emitted should equal the CO₂ captured from the air. A comparison based on tank-to-wake would naturally result in a different ranking but would not reflect the complete climate impact. Compared to current fossil fuels, green hydrogen will likely achieve a 100% reduction.

Air pollutants are not the focus of this study. They are relevant, however, when comparing the overall environmental impacts of fossil fuels to post-fossil fuels. The comparison provided is based on the emission of air pollutants directly from the engine, without the installation of exhaust gas after treatment systems. Hydrogen is again expected to perform very well. Green methanol still emits small amounts of NO_x. NO_x levels from ammonia combustion are not yet quantifiable. HFO performs the worst as in addition to NO_x emissions other pollutants like SO_x and black carbon are also emitted when HFO is combusted.

The Aquatic Ecotoxicity of ammonia to aquatic organisms is very high and is in a similar order of magnitude as the acute toxicity of HFO. Ammonia also has long-term toxic effects on aquatic organisms, but under real environmental conditions, ammonia concentrations will decrease rapidly after a spill and will be assimilated by algae and microorganisms. However, this degradation through uptake as a source of N leads to significant eutrophication. Unlike ammonia, HFO also has short - and long-term toxicity to birds. Methanol is not very toxic to aquatic organisms. Hydrogen is not considered toxic.

CONCLUSION

Marine ammonia engines do not yet exist, but various research and industry projects are underway. Ammonia will likely be combusted in mixtures with other fuels to overcome ammonia's difficult combustion properties. Ammonia-hydrogen-mixtures are particularly interesting for the complete decarbonization of the sector.

In conclusion, ammonia is a candidate for future marine fuel as it is a carbon-free post-fossil fuel and thus likely to be cheaper than other post-fossil fuels. Due to its risk profile, its use may not be applicable in all segments of the maritime sector, e.g. passenger ships. The maritime sector will likely rely on different post-fossil fuels in the future depending on the market segment. If ammonia is to contribute to short-term emissions reductions in shipping, the pace of engine development and subsequent deployment needs to increase. In line with the precautionary principle and to provide incentives for the new technologies to avoid all GHG emissions, environmental integrity needs to be ensured using stringent regulations which cover all greenhouse gases and particularly include N₂O.

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Sensor technologies for intelligent transport system

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ABSTRACT

Transportation is one of the very important parts of day-to-day life in this fast-moving modern world and there are some serious problems associated with it such as traffic congestion, increased pollution and safety. To tackle these problems use of advanced sensors, computers and communication technology has been exploited under Intelligent Transport System (ITS). Manufacturers and Government, both are trying to use the modern technology to achieve a smarter and safer transport system and integrating vehicles with sensors or applying different sensing devices on roadside surely helped them. In this paper, we have discussed about different sensing devices that can have a very vast application in sustainable transport system and how can they be applied for safety and traffic control. Some challenges and future scope of sensors in ITS has also been discussed to a limited extent.

KEYWORDS

Sensors, vehicles, Intelligent Transport System (ITS), sustainable

1. INTRODUCTION

The transport has a crucial role in economic growth. Several states around the globe have been facing problems like uncontrolled growth of traffic, leading to traffic jams which indirectly leads to increase in amount of fuel used, pollution, accidents, and degradation of quality life in modern society. According to several reports published, such problems are going to worsen in future due to increase in population and migration to urban areas. The advancements in technology are making its way in the transportation infrastructure also which enabled automobile industries to produce vehicles which are easier and safer to drive, powerful and most importantly environment friendly making the way to Intelligent Transport System (ITS). The ITS is mainly based on collection and processing of data obtained from sensors to save lives, money, environment and energy.

With integration of sensing technologies in transportation infrastructure data can be collected to know the real-time conditions on roadways, such as traffic jams, accidents, bad weather etc. and the collected information can be used to alert drivers or motorists and provided to transportation management systems for processing, analyzing and taking required decisions. Installation of cameras and many other sensors along road can detect the presence of vehicles and GPS (Global positioning System) can track the vehicle throughout the complete journey. Sensing devices can be classified in two categories consisting of in-vehicle sensors (intra-vehicular) and in-road sensors.

The Indian Ministry of Road Transport and Highways has reported about 1,54,000 deaths and 3,84,500 injuries due to road accidents in the year of 2021. To reduce the number of accidents or collisions various researches has been made, both government and private firms are working

for the integration of advanced sensor-based technology to improve the safety of automobiles. Reducing the chances of driver error by taking the person out of control loop and automating the driving will surely help.

Installation of wired system carry some difficulties on a crowded road so the wireless sensor technology has also gained attention of the researchers in large numbers. AMRs, microphone sensors, acoustic sensors, ultrasonic sensors and aerial images is being used as a part of identifying vehicles with wireless sensing technology. This paper discusses the application of sensors and how to use them in transportation to make them smarter, where sensors can be placed, the type of data they collect.

2. SENSOR TECHNOLOGY

Over past 15-20yrs, sensor technology has attracted a lot of attention. In transportation, sensor technology supports the design and development of a wide range of applications for traffic control, safety, and entertainment. In recent years, sensors, and actuators such as tire pressure sensor and rear-view visibility systems have become mandatory in the manufacturing of vehicles and the implementation of intelligent transportation systems, aimed at providing services to increase drivers' and passengers' satisfaction, improve road safety and reduce traffic congestion. Other sensors are optionally installed by manufacturers to monitor the performance and status of the vehicle, provide higher efficiency and assistance for drivers. Based on the type of application the sensor is intended to support, four categories of sensors are identified:

TABLE 1. Classification of Sensors used in a Vehicle

Category of Sensors	Description	Example
Safety	Form the basis of safety systems and focus on recognizing accident hazards and events almost in real-time.	Micro-mechanical oscillators, speed sensors, cameras, radars and laser beams, inertial sensors, ultrasonic sensors, proximity sensors, night vision sensors, haptic.
Diagnostic	Focus on gathering data for providing real-time information about status and performance of the vehicle for detecting any malfunction of the vehicle.	Position sensor, chemical sensors, temperature sensors, gas composition sensors, pressure sensor, airbag sensor.
Convenience	Responsible for gathering data that provide support for comfort and convenience applications.	Gas composition sensor, humidity sensors, temperature sensors, position sensors, torque sensors, image sensors, rain sensors, fogging prevention sensors, distance sensors.
Environment	Monitor the environment conditions, offering drivers and passengers alert and warning services	Pressure sensors, temperature sensors, distance sensors, cameras, weather conditions.

2.1 In-Vehicle Sensors

In ITS, identifying the type of sensors to develop applications that contribute to address problems such as: traffic congestion and parking difficulties, longer commuting times, higher levels of CO2 emissions, and increase in the number of road accidents, among others is of critical importance for improving a vehicle's performance as well enhancing the driving experience. Figure 1 depicts some of the most widely used sensors in vehicles today.

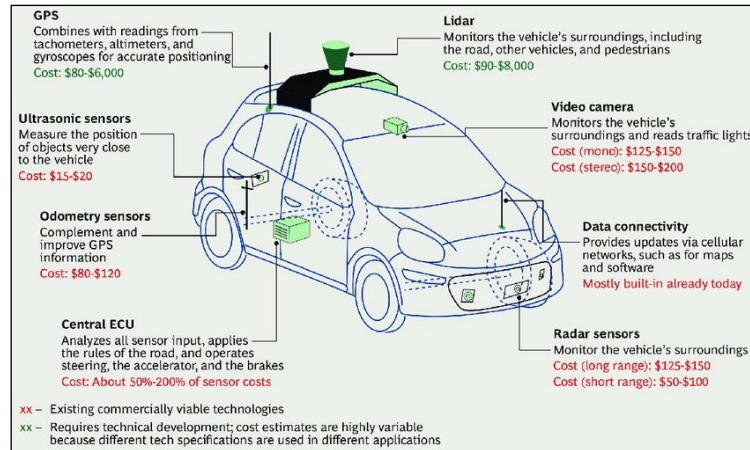


Fig . Different Types Of In-Vehicle Sensors.

2.1.1 Applications for In-Vehicle Sensors

Tire-pressure monitoring is an application that uses a sensor located in the wheels. It measures the air pressure in each tyre.

Proximity, ultrasonic and electromagnetic sensors are used in parking assistance and reverse warning applications. Proximity sensors can detect when a vehicle gets close to an object. Ultrasonic sensors use a type of sonar to identify how far the vehicle is from an object, alerting the driver when the vehicle gets closer than a set threshold. Electromagnetic sensors alert the driver when an object enters an electromagnetic field created around the front and back bumpers

Radio Detection and Ranging (RADAR) and laser sensors constantly scan the road for frontal, side and rear collisions and allow safety applications to adjust throttle and activate brakes to prevent potential collisions or risk situations by using radio waves to determine the distance between obstacles and the sensor. The application notifies the driver if something close to the vehicle is detected and automatically activates the brakes to avoid a collision.

Radar and speed sensors are used in applications that warn the driver of potential danger if changing lanes or wandering out of the lane is detected. The driver is usually warned through vibration in the seat or steering wheel or acoustically using an alarm.

LIDAR (Light Detection and Ranging) has become in a key component for the evolution of autonomous vehicles. LIDAR enables a self-driving car (or any robot) to observe the world with a few special characteristics such as continuous 360-degree visibility and highly accurate depth information.

2.1.2 In-vehicle sensor Technologies

- a) Navigational aid is provided by a set of on-board sensors including speed gauge, compass, indicators for travel distance, time, location, remaining distance and time to destination, turn-by-turn guidance for drivers, as well as real-time traffic information
- b) Lane departure warning system is a driver assist technology that is designed to alert a driver when the vehicle begins to depart from its lane without the proper use of a turn signal
- c) Drowsy driver warning system uses video technology to monitor eye movements and detect when a driver is showing signs of fatigue. The system then sends audio, visual, or vibration alarm feedback to the driver to help avoid dangerous driving situations. Drowsy driving could also be detected from the driver's steering behavior, speed, lateral and longitudinal acceleration.
- d) Blind spot monitor is a sensor with a warning system on a vehicle that detects other vehicles entering in its blind spot, on the sides and rear of the vehicle. Warnings could be provided using visual and audible signals. Cameras and side radar sensors could be employed to monitor vehicles in the blind spot or vehicles that are fast approaching to enter the blind spot
- e) Adaptive cruise control (ACC) is similar to conventional cruise control in that it maintains the vehicle's preset speed, however ACC can automatically adjust speed in order to maintain a safe following distance. The technology uses forward looking radar to detect the distance and speed of the vehicle ahead. If the lead vehicle slows down or if another object is detected by the radar, the sensor sends a signal to the engine control to decelerate the vehicle. Then when the road is clear the ACC re-accelerates the vehicle back to the set speed.
- f) Traffic sign recognition is a technology of sensors and computation that enable a vehicle to recognize traffic signs put on roadways, such as speed limit, turn ahead, or traffic signals. Typically, this technology is based on visual sensors and real-time image processing operations for detection and recognition of the traffic signs on a road. Such driver assist system aids the driver in significantly improving driving safety as well as for enabling autonomous operation of intelligent robotic self-driving vehicles.
- g) Collision avoidance system (CAS) represents a change of focus in the way car manufacturers look at automotive safety. CAS is based on a system of sensors placed within a car to warn its driver and/or take action when necessary to avoid imminent dangers that may lie ahead on the road. It is an extension of the other safety systems described above including lane departure warning, blind spot monitor, and adaptive cruise control.
- h) Automatic crash notification system uses on-board units, such as airbag deployment or other sensors, to detect evidence of a collision. When the vehicle's sensors detect collision, the crash notification system automatically communicates with a call center and transmits information about the accident and the vehicle's location.

2.2 Roadway Sensors

The automotive industry has invested a lot of money to increase safety, performance and comfort in vehicles using sensors within the vehicle; traffic data collection using mechanisms located along the roadside has become one of the main challenges for intelligent transportation systems. Sensor deployment within a transportation network provides drivers with new

services such as smart parking (e.g., matching drivers with available parking spots) and reduced pricing according to congestion levels on the road. Sensors collect environmental data in real-time which is then processed and analyzed to improve transportation networks and make them resilient. Sensors can be classified into two categories based on their location i.e., **Vehicle detection system:**

2.2.1 Intrusive Sensors

Intrusive sensors are installed on pavement surfaces. They have high accuracy, but they also have high installation and maintenance costs. Basically, intrusive sensors (as shown in Figure 2) can be classified into three groups: (1) passive magnetic sensors which are installed on roads and are connected either wired or wirelessly to processing units (2) pneumatic tube sensors placed across the road which transmit data to processing units through wired/wireless media, (3) inductive loops that are wire coils buried into roads and send data to processing units.

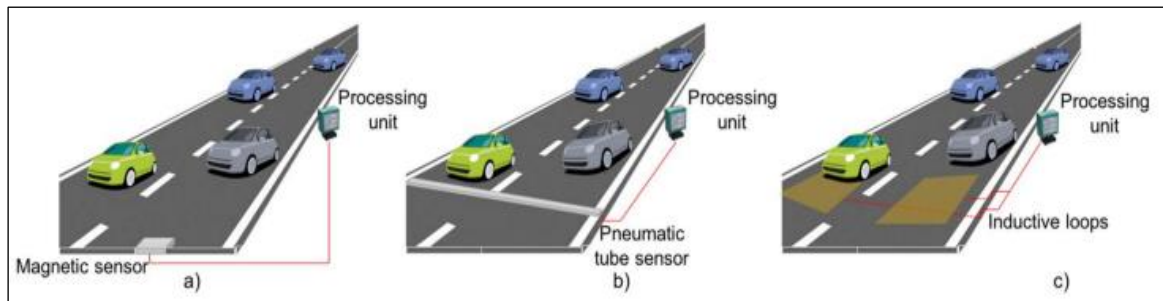


Fig 2. Intrusive sensor groups, (a) Embedded magnetometers, (b) Pneumatic tube sensors and (c) Inductive loops.

The main advantage of road sensors is their technology maturity. They have been widely implemented and have high accuracy in detecting vehicles. However, the main disadvantages of road sensors are: high installation costs, traffic disruption during installation, maintenance, and repairs.

2.2.2 Non-Intrusive Sensors

Non-intrusive sensors provide many of the intrusive sensors functions with fewer difficulties. However, they are highly affected by climate conditions such as: snow, rain, and fog, among others. Accurate traffic data is of utmost importance to make informed decisions to improve traffic conditions. Non-intrusive sensors are more easily spotted by drivers, resulting in different and faster reactions such as: slowing down, and using the correct drive lane, among others after detecting those devices. The challenge is not just the installation of these sensors, but also reducing the drivers' reactions times based on the collected data and provide them with a more precise view of the context and the reality of the road or avenue.

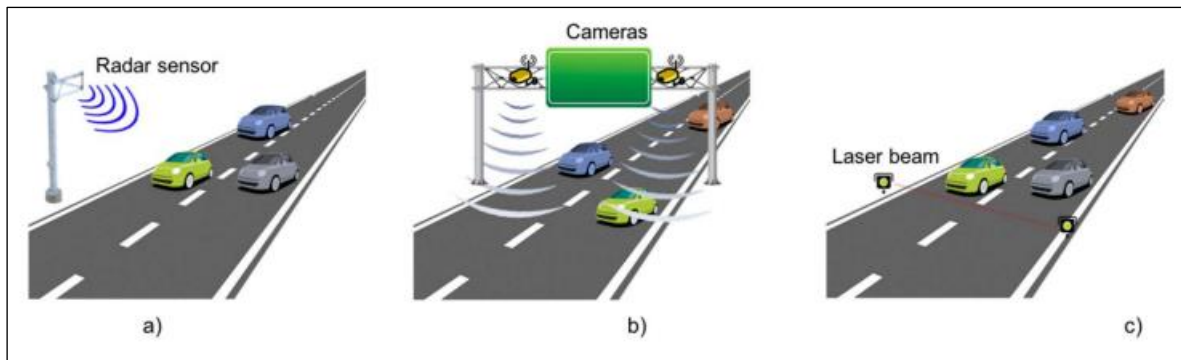


FIGURE 3. Non-intrusive sensor groups, (a) roadside mast-mounted, (b) bridge mounted and (c) across roadside.

2.2.3 Applications of Vehicle Tracking System

Tracking Criminals

Police officers can install a GPS tracker for the suspected vehicle. The device can monitor every move and direction of the vehicle. The GPS devices track the vehicles continuously, and can help police to track any stolen or missing vehicles and criminals.

School buses

The tracking devices installed in the school buses will give the current location and the distance from the school to home and vice versa.

Fleet and Traffic Management

For fleet management, the organizations keep the database of the information and track the transport vehicles traveling throughout the journey. It keeps the information related to the driver, types of goods, its capacity, halt record, etc. It consists of database information, telematics, and GPS tracking. It can help prevent delays in delivery, fuel consumption, reduce road accidents, track and recover lost vehicles.

Roadway sensor Technology

For effective realization of the ITS services, roadway and in-vehicle infrastructure has to be deployed to collect and communicate timely, accurate and reliable information about traffic flow and road conditions. Here are some currently available roadways ITS infrastructure technologies:

2.2.4 In-roadway sensor technologies

An in-roadway sensor is one that is either embedded in the pavement of the roadway, or embedded in the subgrade of the roadway, or taped/attached to the surface of the roadway. Examples of in-roadway sensors are discussed below:

- i) Pneumatic road tube sensor sends a burst of air pressure along a rubber tube when a vehicle's tires pass over the tube. The pressure pulses close electrical switch, which is detected by a counter. The road tube, is commonly used for short term traffic counting, traffic classification by axel count and spacing, for the purpose of planning and research studies.

ii) Inductive loop detector (ILD) senses the presence of a conductive metal object by inducing currents in the object. The magnetic field in the loop induces current in metallic objects passing over the loop. The induced current in turn reduces the loop inductance, which is sensed by the attached electronics unit as a vehicle detection. The data obtained from conventional ILD include vehicle passage, presence, count and occupancy. The ILD is the most commonly used sensor in traffic management applications.

iii) Magnetic sensors are passive devices that indicate the presence of a metallic object by detecting the perturbation created by the object in the Earth's magnetic field. Two types of magnetic sensors are used for traffic flow management. The first-type is two- and three-axis fluxgate magnetometers, these sensors identify stopped and moving vehicles. The second type of magnetic sensor is induction or search coil magnetometer. It normally detects only moving vehicles (with speeds > 5 mi/hr.) by measuring the change in the magnetic lines of flux caused by a moving ferrous metal vehicle.

iv) Piezoelectric sensors employ piezoelectric materials that generate a voltage when subjected to mechanical impact or vibration. The measured voltage is proportional to the force or weight of the vehicle. These sensors are used to classify vehicles by axel count and axel spacing and to measure vehicle weight and speed (with the use of multiple sensors).

2.2.5 Over-roadway sensor technologies

These sensors do not require the installation directly onto, into, or below the road surface. Over-roadway sensors are mounted over the center of the roadway or to the side of the roadway. Examples of over-roadway sensors are discussed below:

i) Video image processor (VIP) typically consists of one or more cameras, a microprocessor-based unit for digitizing and processing the imagery, and software for interpreting the images and converting them into traffic flow data. A VIP can replace several in-roadway inductive loops, provide detection of vehicles across several lanes, and perhaps lower maintenance costs. VIPs can classify vehicles by their length and report vehicle presence, flow rate, occupancy, and speed for each class.

ii) Microwave radar. Radar (radio detection and ranging) uses radio waves in the microwave frequency spectrum (1 GHz to 30 GHz) for object detection and measurements of distance and speed. Roadside mounted microwave radar sensors transmit radio waves toward an area of the roadway from an overhead antenna. When a vehicle passes through the antenna beam, a portion of the transmitted energy is reflected back towards the antenna. The detection system in the receiver can then calculate the vehicle data such as volume, speed, occupancy, length, etc. Two types of microwave radar sensors are used in traffic management applications, continuous wave (CW) Doppler radar and frequency modulated continuous wave (FMCW) radar.

iii) Infrared sensors. Active and passive infrared (IR) sensors are available for traffic monitoring applications. Active infrared sensors illuminate detection zones with low power infrared energy supplied by laser diodes operating in near infrared spectrum at 0.85 μm . Active infrared sensors provide data on vehicle presence at traffic signals, volume, speed, length, and queue measurement. Passive infrared sensors detect the energy emitted from vehicles, road surfaces, other objects in the field of view, and from the atmosphere. Passive IR sensors can measure vehicle counting, volume, lane occupancy detection, and queue detection.

iv) Ultrasonic sensors transmit sound energy at frequencies above the human audible range between 25 kHz and 50 KHz. Most ultrasonic sensors operate using pulse waveforms to measure distance to the road surface and vehicles by detecting the arrival time of reflected waves coming towards the sensor from an area defined by the transmitter's beam width. The sensor provides vehicle count, presence and occupancy information.

v) Passive acoustic array sensors operate by using two-dimensional array microphones for detecting acoustic energy produced by vehicular traffic from a variety of sources within each vehicle and from the interaction of a vehicle's tires with the road. An increase in sound energy recognized as a vehicle passes through the detection zone is processed by the signal-processing algorithm to generate a vehicle presence. These sensors can measure vehicle passage, presence, and speed.

2.3 Vehicle detection by wireless Sensor

Wiring makes up one of the major cost components of installing the in-roadway and over-roadway traffic monitoring infrastructure. With the use of wireless networking solution, installation and maintenance cost could be drastically reduced. Furthermore, the system will have greater flexibility as it allows easy replacement and upgrade of sensor nodes, and easy reconfiguration of the network setup.

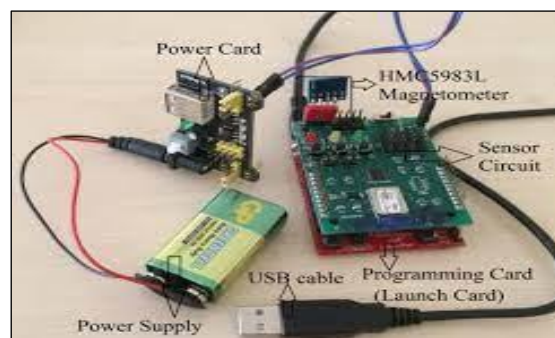


Fig 3. A sensor circuit designed for vehicle detection.

Wireless sensor networks are scattered network structures in which many sensors or sensor nodes are in wireless communication. Wireless communication occurs between a receiver and a transmitter without cable connections via light or electromagnetic waves. The main components of a sensor node are the microcontroller, receiver–transmitter, power supply, memory and one or more sensor components.

3.SOME EXPERIMENTAL RESULTS BASED ON SENSOR TECHNOLOGY

3.1 Developing a multi sensors system to detect sleepiness to drivers from transport systems:

In the past few years, the efforts in the engineering field were focused on developing methods for monitoring the cardiac or respiratory cycle, without involving the physical contact with the patients (subjects), but by means of sensors. The benefits of such an approach are obvious in situations where the investigated subject is the victim of an accident for testing the staff working in the Transportation and Critical Infrastructures field.

The EEG signals acquisition for drivers in the Transportation field can be achieved by using a contact system, helmet type (for example, EMOTION Kit) or a non-contact system, capacitive type. The capacitive sensor is installed in the driver seat backrest (headrest) and it monitors/acquires EEG signals from the occipital area. According to research in the field and to studies, we found that alpha and beta waves are associated to the movements of the eyes open / closed, and this variation of alpha and beta waves can highlight the installing state of sleepiness and decreased concentration of drivers in transportation systems.

Achieving the correlation of the power spectra obtained for the specified points, we can determine with quantitative precision the performance of attention / relaxation of the conductors and determination / predict the development of fatigue and drowsiness.

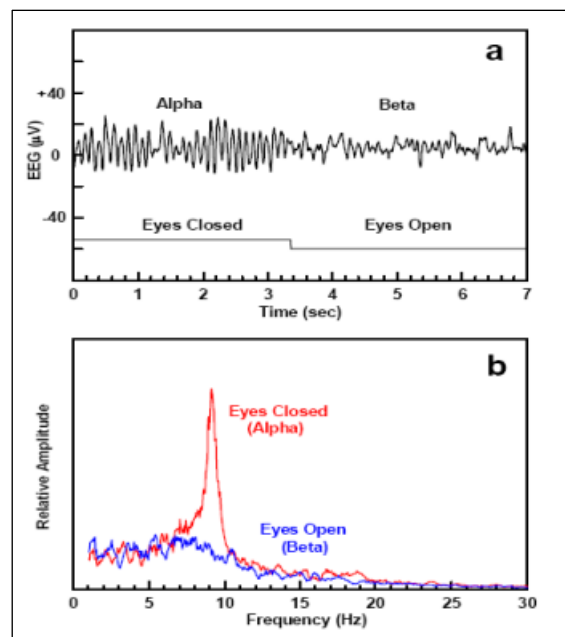


Fig 5. Representation the alpha and beta EEG signals in the time domain (a) and the frequency domain (b)

3.2 Using Multi-sensor Data Fusion to Predict Dangerous States of LNG Transport Tank

As global energy demand rises, natural gas plays an important strategic part in energy supply. The consumption of NG (Natural Gas) is rising rapidly. Some researchers believe that it may overtake oil as the prime fuel between 2020 and 2030. The origins of natural gas always locate far from city where people intensive lives. Therefore, the transportation and storage of LNG must be considered in LNG industry. Fig. 6 illustrates the basic chain architecture of LNG production. It can be observed that immense number of LNG transportation containers such as tank containers are needed between the LNG receiving terminals or LNG plants and satellite LNG stations. Although LNG has maintained an excellent safety record for many years, the accident occurred in Spain on 22 June 2002 showed great destructive power.

The prediction system of LNG tank consists of eight heterogeneous sensors, which are gas sensor, temperature sensor, humidity sensor, pressure sensor, liquid level sensor, acceleration sensor, angle sensor, and switch sensor. Each of the sensors gets one or more features of LNG tank container. The velocity of tank can be obtained from the vehicular GPS, which is used for uploading data, while other sensors are installed on the tank. The object of prediction system

is to fuse the characteristics using multi-sensor methods, and provide relative scientific results of the tank's dangerous state.

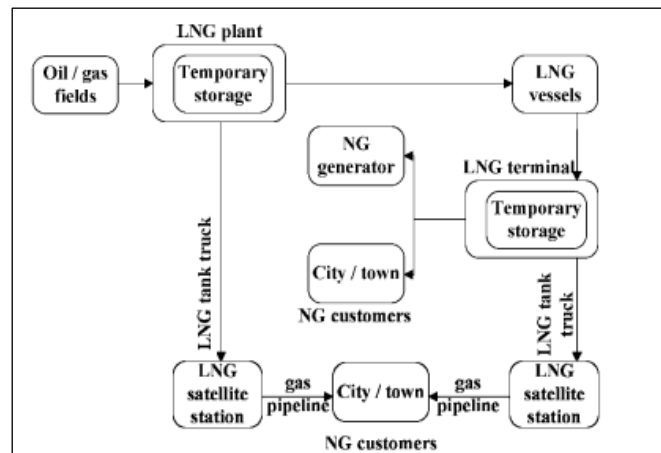


Fig 6. Schematic diagram of LNG industry chain

4. CHALLENGES AND OPPORTUNITIES

Within the scope of intelligent transportation systems applications, here are some challenges that need to be addressed in the future to improve transportation systems, the mobility and safety of drivers and passengers.

Currently, sensing systems are faced with a lack of or damaged infrastructure such as: blurry or erased transit lines, inadequate or, in some cases, inexistent traffic signals, fast object detection (pedestrians, cyclists, gravel, tire residues or animals) or risky road conditions (holes in the road, a sudden change in road surface from pavement to another material, and road floods or environmental conditions that could pose a threat to the vehicle's passengers). However, we must carefully determine where the real constraints (e.g., sensor reachability, the algorithms that process the sensor information) exist.

Traffic management organizations are aware that intelligent transportation systems face the challenge of how to improve mobility. Sensors by themselves cannot solve the mobility challenge. To improve transportation systems, we need the integration of other technologies and devices such as data analytics, automated operation tools, decision-making tools, and social and mobile networks to fulfill the requirements for a complete integration to capture, analyze and share in real time, with the relevant parties, all the information generated by all the different sources.

The type of data and the different data sources are crucial in addressing many challenges related to transportation systems, such as seamless integration of data from a set of independent data sources that respond in real-time to the needs of actual traffic requirements.

The privacy and security of vehicles highly depend on reducing intrusiveness at two levels. First, to keep the vehicle's occupants from disclosing any information that could lead to a potential privacy risk, we should include security and privacy protocols into the communication devices that are supported by the communication networks to protect drivers' or passengers' privacy within the vehicular network environment.

5. CONCLUSIONS

In this paper, we have discussed the application of sensor technology for Intelligent Transport System. This promises the development of smart applications for ITS in future which aims at improving the safety and traffic control. Integration of advanced sensors with transport system helps in using roadways facilities at its most, making vehicle detection and driver assistance easier and minimizing fuel consumption, traffic jams and the risk of accidents. The real potential of sensors can be felt by analyzing the obtained data for betterment of transportation infrastructure. Not only wired technologies but wireless sensors have also been explored and is expected to be used at greater scale in the upcoming time. Different algorithms of artificial intelligence can also be applied very positively for smooth transportation.

6. ACKNOWLEDGEMENT

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Marine ADAS system

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ABSTRACT

Automakers are increasingly installing advanced driver assistance systems. Adaptive Cruise Control, Lane Departure Warning, Forward Collision Warning, and Parking Assistance are just a few of the functions offered by ADAS. Ships are now getting similar features, including drive-on warning, collision warning, and berthing assistance, from growing hazard awareness systems. Microwave and wireless technology enable these systems. various sensors that scan the area right around the ship. We examine a few hypothetical sensors and systems. We go over how they could work in concert with dynamic positioning systems.

KEYWORDS

ADAS (Advanced Driver Assistance Systems), ARPA (Automatic Radar Plotting Aid), ESG (Environmental, Social & Governance)

INTRODUCTION

In recent years, both merchant shipping and the oil and gas industry have made enormous strides in terms of safety. The bulk of injuries on commercial ships around the world is caused by collisions with other vessels and contact with other structures. So the technology has introduced the autonomous ship concept. The first autonomous ship MV Yara Birkeland 120 TEU container ship sailing fertilizer between ports Heroya and Brevik. The autonomous ships give centralized control, reduce the risk of collision, enhance manoeuvring, and ease docking operation.

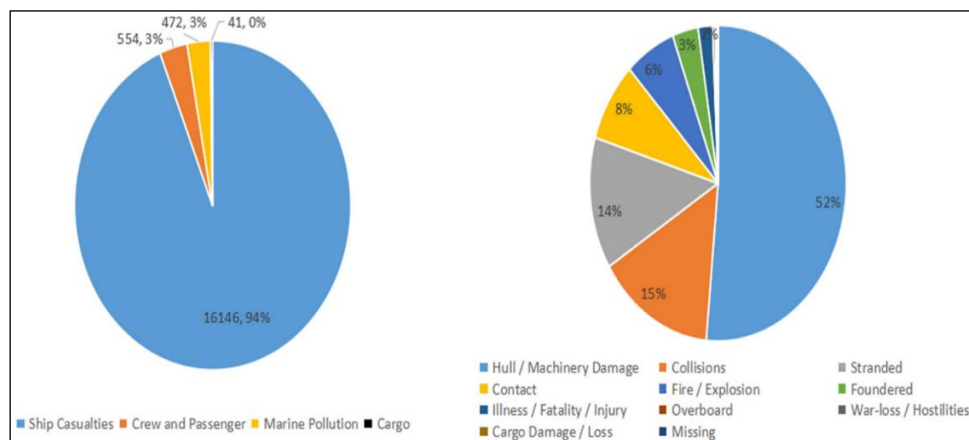
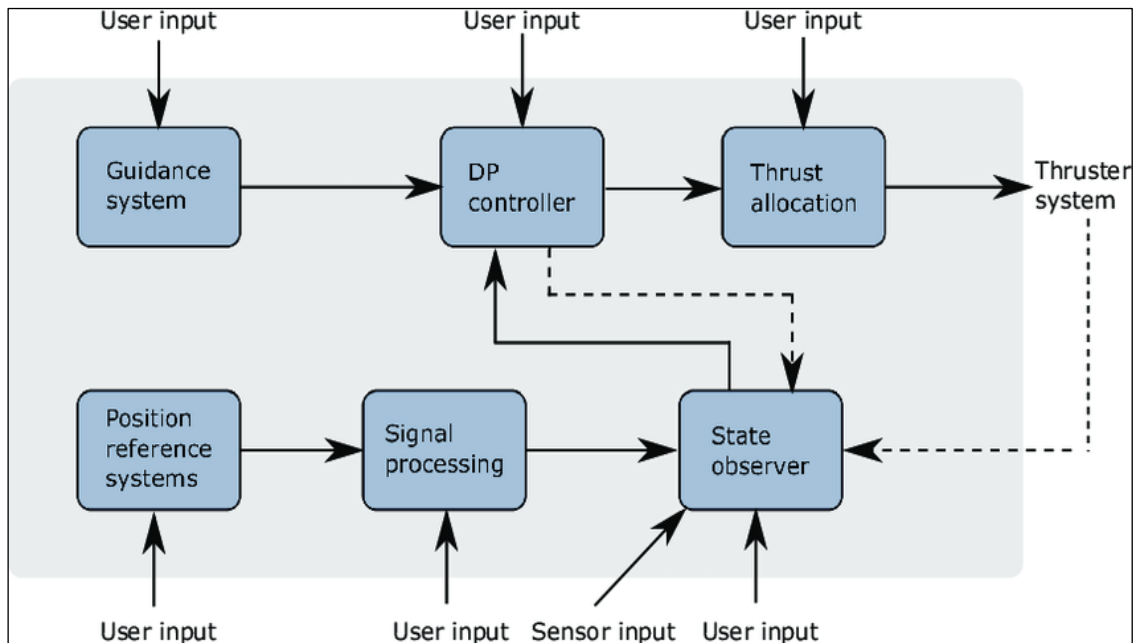


Fig 1. Merchant vessel casualties report

MAIN WORK

What is hazard detection?



The conventional dynamic positioning method involves performing precise vessel manoeuvres close to an oil rig using feedback from a highly accurate global positioning system. A GPS receiver with inertial aid is used in the PiLoNav project to provide location feedback for the autonomous management of river barges. This system provides global accuracy without local sensing to support precise movement across a large working area. Such a strategy depends on more than just great global positioning precision. Additionally, it depends on a thorough map, in which every feature's exact location must be known with great accuracy.

A fresh strategy has been employed more lately. We could refer to this as "Marine ADAS" by drawing an analogy with recent advancements in automotive technology.

In the AUTOSEA project, the system envisaged uses a multitude of sensors to look at the area around the ship. The project takes its inspiration from self-driving cars rather than ADAS and concentrates on collision avoidance for autonomous vessels on the open sea. We adopt a similar strategy, except we're somewhat more focused on safety during close manoeuvres.

What is ADAS?

In order to increase traffic safety, advanced driver assistance systems were created to assist drivers while they are behind the wheel.

These auxiliary systems keep a close eye on the environment around the car and the driver's actions to identify potentially harmful circumstances as soon as they arise. These systems alert and actively assist the driver in critical driving circumstances and, if necessary, automatically intervene in an effort to prevent a collision or lessen the effects of one.

These technologies include but are not limited to, adaptive cruise control, autonomous emergency braking, lane departure warning, collision avoidance, night vision, traffic sign recognition, blind spot detection, and driver fatigue detection.

POTENTIAL OF MARINE HAZARD DETECTION SYSTEMS

By comparison with ADAS, we may define a number of qualities that a maritime Hazard Detection System must have:

➤ **Drive-on protection**

A vessel is anchored close to an offshore structure. The vessel starts to move toward the structure as a result of sensor failure, actuator failure, a software bug, or operator error. If the condition is not found in time, with the risks and expenses that would come with it, an accident may happen over time.

Using the appropriate sensor system, the hazard can be identified and the crew warned. We require both a low false alarm rate and a high probability of hazard detection for this to be effective. We can see a scenario in which the drive-on protection system could take over the vessel once a hazard is identified, allowing it to drive away from the collision automatically. However, this would necessitate a very high level of hardware and software integrity from the hazard detection subsystem.

When the vessel is connected to the platform via a pipe or cable, a similar drive-off risk exists.

➤ **Collision avoidance**

A vessel is travelling among other boats, floating objects, buoys, etc. at a moderate to high speed. We need a system that can alert the vessel to the possibility of a collision so that it can take the necessary evasive action.

➤ **Traffic surveillance**

This capability focuses on a stationary platform, a ship that moves slowly, or a ship that maintains a station. There are one or smaller boats cruising nearby. From the platform, we want to keep an eye on those boats and warn of any unauthorised movements or potential collisions.

➤ **Gap maintenance**

Operating close to an offshore structure is a vessel. There must always be a minimum gap. When the gap is too tiny, the sensor system measures it and issues a warning. If the gap is too wide, it might also issue a warning.

We can use the feedback to automatically maintain the gap within limits, going beyond a simple monitoring system.

For instance, we could take a few measurements of the distance between a ship's stern and a tower housing an offshore wind turbine. This feedback can be combined with gyrocompass feedback to control the vessel's heading as well as its position in relation to the tower.

Another illustration is the control of a support vessel to follow a weathervane FPSO or a pipe-laying vessel using the feedback from the gap monitoring system.

➤ **Berthing assistance**

A ship comes up to a quay or other immovable object. The ship must approach very closely and possibly make contact, but any contact must occur at a very slow pace.

Feedback on the vessel's position and speed in relation to the dock is provided by the sensor system.

➤ **Automatic sign recognition**

We may see a system that reads channel buoys and other markers using camera imagery, similar to the automatic sign recognition systems found in vehicle ADAS.

For a ship that already has GPS and electronic aids, it's unclear whether this would add much value.

➤ **Depth monitor**

We may see a system that processes camera photos to read channel buoys and other markers, similar to the automated sign recognition systems found in automobile ADAS.

It's unclear how much benefit this would offer to a ship that already has GPS and computerised charts.

➤ **Sensor modalities**

We can classify sensors by their modality, that is, the physical principle that they rely on:

- Radar
- Lidar
- Camera
- Infrared
- Ultrasonics
- Hydroacoustic

➤ **Radar**

Systems called ARPA (Automatic Radar Plotting Aid) help ships in open waters identify hazards.

Due to their relatively weak minimum range and range resolution, current systems primarily employ data from pulsed radars operating in the X band, which limits their utility in tight manoeuvring. A pulsed radar's high peak power makes it problematic to use it close to an oil production platform.

For the same reasons that it has been successful for automotive ADAS, microwave radar recommends itself for use in a marine short range hazard detection system. It has a capable all-weather sensing system.

The X and S bands, which are frequently utilised for marine navigation radar, are less desirable for hazard detection than the K and W bands. Resolution tends to increase with frequency, so we don't require long range or tremendous power. The expense of development, however, frequently increases. Regulations governing spectrum management further restrict the radio

frequency options. The finest compromise is provided by the spectrum between 24.05GHz and 24.25GHz.

- Camera

Cameras can be used in different ways:

- Machine Vision

The video sequence is interpreted by a computer programme to determine where various things are in the scene. This could even extend to a multi-modal sensor data fusion system that combines data from many sensor kinds.

A camera system is relatively subject to the elements, as well as to dirt or water film on the window, much like lidar is. Although additional illumination in delicate areas can frequently solve this problem, the lighting conditions around the vessel are highly varied, which provides difficulty for a camera system.

- Infrared

Anything warm in the scene can be detected by a thermal imager operating at a wavelength of approximately 10 nm. Because it can identify an intruder using both body heat and engine heat, it is advantageous for security applications. Cold impediments like a harbour wall or an oil platform leg are harder for it to identify. As a result, obstacle detection is less useful.

- Ultrasonics (in the air)

At 40 to 50 kHz, car parking sensors are in operation. The detection range can go as far as 2.5 to 5.0 metres.

The range of car ultrasonic sensors is likely too short for them to be effective for vessel operations. More potent sensors will be able to see farther, but as we move away from the mass-produced gadgets backed by the automotive sector, a significant price increase is to be expected.

Ultrasonic background noise is thought to be mostly produced by breakers and white caps. On the impact above the water, there is a dearth of experimental data. As a result, in-air ultrasonic sensing may be less effective in inclement weather. Additional research would be necessary.

- Range Guard

A 24GHz FMCW radar called Range Guard is offered by Guidance Marine and is packaged for use in a marine setting. The resolution of the range is 0.75 m. It is possible to measure the range to a point target far more precisely—to the closest inch. It is crucial for detecting items that short-range microwave radar finds difficult to detect, such as the bow of a ship, because it has a high sensitivity and low noise level.

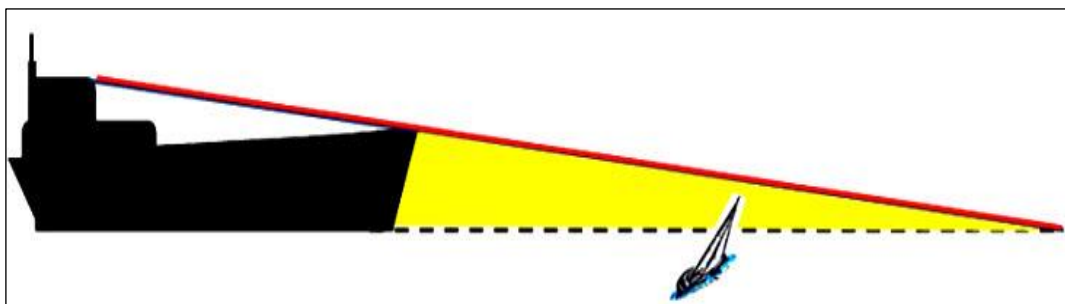
The "spot" variant of the sensor emits an 11° wide, slender circular beam. For taking precise measurements, this is helpful.

The "flood" version of the Range Guard sensor has a large 110° azimuth beam that is tailored to have a sharp edge. Generally speaking, it's a better option for detecting obstacles, while it can also be better for gap monitoring.

These sensors have a single beam. Imaging and multi-beam sensors are very possible. In a small device, it is simple to achieve useful angular resolution (on the order of 10°). In the near future, we can anticipate the availability of reasonably priced marine-compatible equipment.

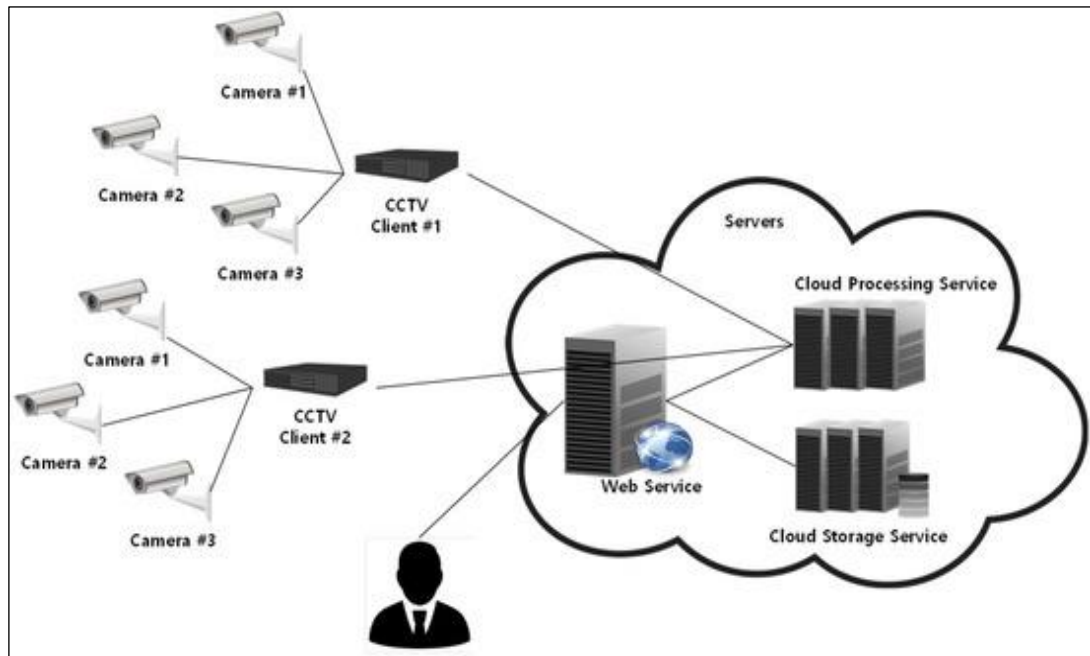
BLIND SPOT DETECTION

- The size of ships is increasing while staffing levels remain constant, adding to the workload of already overworked seafarers. Due to a lack of real-time visibility onboard, fleet management teams also experience a gulf between workers on board and shoreside when ships are at sea.
- These two interrelated issues are increasing operational inefficiencies and Environmental blind spots, particularly for the social and Governance, which puts shipowners and operators at undue risk.
- Although it is often stated that human error is to blame for 96% of at-sea events, no seafarer is hurt intentionally. Wearing hard helmets in specific areas of the ship is one example of the everyday operational decisions and regulations that go into fostering a culture of safety. Without a visual fleet management system, shoreside management or aboard leadership teams are unable to monitor even daily activities to make sure they are carried out according to plan and procedure.



- One choice for increasing visibility and strengthening social and governance onboard is maritime CCTV. You can see daily activities with the use of numerous cameras placed in crucial sections of a ship, such as on the engineering deck, in the cargo hold, and on the bridge. Even with a dedicated resource to monitor the food, it can be challenging to catch everything in the 10,000+ hours of footage produced on each ship each month.

- However, by integrating AI and computer vision technology with CCTV, ship operators can receive contextual, AI-driven safety alerts in real time, generating strong and quantifiable visual intelligence without the need for nonstop surveillance. With the combination of these technologies, operators now have a strong system for comprehending any technical or operational problems relating to cargo handling, security, piloting, or maintenance.



- Fleet Vision technology also promotes effective corporate governance—the "Governance" in ESG—by enabling KPI tracking, inter-fleet benchmarking, and the sharing of best practices among vessels. These real-time alerts regarding operational, maintenance or security problems could prove costly if discovered too late.
- Most importantly, if an incident does happen, these technologies can enable quick response to keep seafarers safe and enhance conditions onboard—the social Think about the Felicity Ace, a roll-on/roll-off cargo ship, sinking in March 2022. A network of AI-powered cameras may have identified smoke on the cargo deck right away in a situation like this, alerting the bridge and management on land. This would have automatically initiated emergency and evacuation procedures, saving crucial minutes to assure the crew and cargo's safety.
- Ship operators are better able to improve their own performance and governance while also providing stakeholders and the larger community with true accountability when they are able to record and analyse onboard events. This gives ship operators a clear picture of how to prevent incidents from reoccurring.
- Another crucial issue is maritime security. Soldiers are trained; sailors are not. Despite the fact that they don't carry weapons or ammo, they face bodily danger when passing

through particular vessel trading routes. A FleetVision system can warn crew members of the danger when pirates attack and board ships, as they did in January 2021 when they kidnapped 15 crew members and killed one on the containership Mozart and in March 2021 when they kidnapped 15 crew members from the chemical tanker Davide B. This gives the crew members time to take potentially life-saving measures.

- Another risk comes from stowaways. In 2018, as the tanker Nave Andromeda approached London, a number of stowaways attacked the crew, making this starkly obvious. While posing a physical risk, stowaways also cause a major logistical issue. Stowaways must be returned to their nation of origin at a cost of thousands of dollars in delays and fees once crews find them on board. Not only does this cause the ship to depart from its intended course, but it also incurs additional expenses for shipowners and operators in the form of medical care, food, clothes, and repatriation.
- The crew members themselves can occasionally be the source of a security problem. On the containership MSC Gayane, authorities discovered a record-breaking 20 tonnes of cocaine in June 2019. Speedboats had been used to smuggle it onboard as the ship travelled from the Panama Canal to Pennsylvania. Some crew members assisted in loading the parcels, and after concealing the drugs amid the legal goods, they resealed the containers with bogus seals.
- These security threats, however, can be identified early and possibly avoided with the correct technologies in place. FleetVision can detect suspicious craft automatically and notify bridge commanders so they can take the appropriate security measures, thwart a pirate attack, or stop potential drug smuggling activities.
- Assisting in the efficient application of the ISPS Code procedures for identifying and discouraging actions that jeopardise marine security is AI technology combined with visual analytics. This is accomplished by monitoring unauthorised access to restricted areas (such as the steering gear room or lifeboats) and digitally logging other operations such as security patrols and stowaway searches. The technology can also offer reliable access control with digital logging of the people who have been given permission to join the ship.
- It's crucial that fleet owners, operators, captains, and crew recognise the increased issues they confront given the megaship trend's enduring popularity and the persistent growth in maritime security concerns. With technology that provides a full 360-degree view of onboard operations, life on board can be improved. Blind spots can be removed with FleetVision technology, ensuring that operations are optimised. By providing improved onboard crew assistance, enhancing safety and security, and guaranteeing correct governance across even the largest fleet, it can also create improvements in ESG.

- Even the loftiest objectives in ESG can be supported by technology.

BENEFITS OF MARINE ADAS SYSTEM

- Greater consistency and predictability of shipping routes and schedules, as autonomous ships may adhere to predetermined paths and timetables more faithfully than crewed ships.
- Enhanced capability to carry out missions like search and rescue since autonomous ships can be fitted with cutting-edge sensors and other technologies that can help identify and react to emergency situations.
- The ability for autonomous ships to be outfitted with cutting-edge networking and communication systems that enable data sharing and movement coordination will lead to improved communication and coordination amongst ships.
- An improvement in the monitoring and enforcement of environmental rules thanks to the capacity of autonomous ships to be fitted with cutting-edge sensors and other technologies that can identify and report environmental infractions.
- An improvement in the monitoring and enforcement of environmental rules thanks to the capacity of autonomous ships to be fitted with cutting-edge sensors and other technologies that can identify and report environmental infractions.

Is it a wise decision?

Operations may not always be safer with more instrumentation. When they should be looking out the window, operators sometimes find themselves staring at the instruments. Users may grow accustomed to disregarding the sensor displays if there is a high occurrence of false alarms. Individuals, on the other hand, may become overly reliant on the sensors, causing them to become unfocused and detect all dangers. Customers can feel "out of the loop." These issues must be handled by a careful user interface design that gives users a sense of control and provides just enough information to draw their attention to the danger while preventing them from using their eyes.

Furthermore, it is widely recognised that the phenomenon of behavioural adaptation prevents better safety systems from always resulting in safer operations. Users who see themselves as safer will take more risks, partly diminishing the safety gains as they pursue other perks like faster speed.

Warnings will be recorded by the danger detection system at the moment, along with other ship data. This might encourage compliance. There isn't always a need for a formal procedure for this. Users may follow the guidelines out of a sense of security.

CONCLUSION

Systems for detecting hazards are starting to appear, filling a critical gap in conventional DP. Recently, certain sensor coverage gaps were closed, especially where close manoeuvring was concerned. Situational awareness and safe and effective operation should be supported rather than substituted by an integrated strategy. We may anticipate Hazard Detection Systems to be a significant trend in marine technology in the upcoming years, given the great advancement that equivalent systems have achieved in the automobile industry.

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Auto dock using Sensor System

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ABSTRACT

The future is automation. Auto-Dock is an automation-based system that enables the vessel with bow and stern thrusters to dock herself without the involvement of humans. Auto-dock uses a sensor-based setup which would be installed on the hull's port and starboard sides. The sensor cluster consists of sensors like LIDAR, RADAR, and Cameras. The auto-dock system works using industrial-grade hardware and software fused together using a computer(Auto-Dock Computer) that can handle thousands of processes at a time. Auto Docking eliminates human error and makes docking a super easy task. Algorithms like EKF(extended Kalman filter) predicts the future states accurately and dock the ship without any possibility of an accident.

KEYWORDS

Neural engine, Aeries II, EKF (Extended Kalman Filter), HMI (Human Machine Interface)

1. NEED FOR AUTOMATION (INTRODUCTION)

In the modern world, everything revolves around sensors and automation. This paper proposes the process and method for implementation of sensors on board to make Auto-Dock possible for cargo, cruise, and autonomous ships. The use and description of all sensors required as well as the computer to be designed for this process and its algorithm have been briefly explained. This complex yet easy-to-use system would be a great help to the officers on board in performing docking, which is considered one of the most hectic operations.

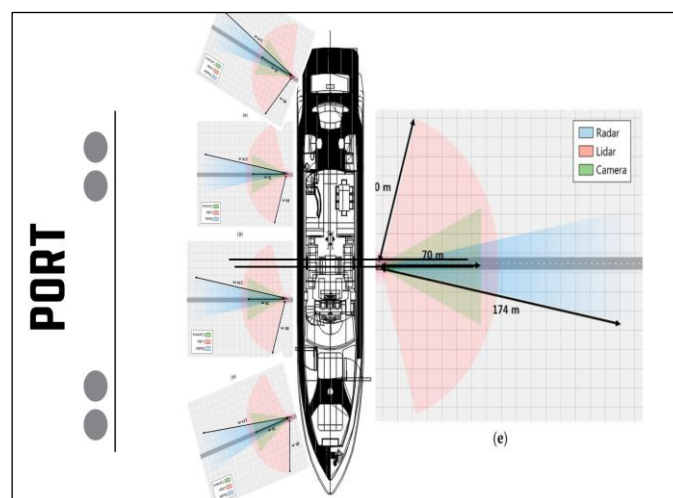


Fig 1. Representing the basic sensor set used for auto-docking

1.1 Need for Auto-Dock

Automation is much faster than humans specifically the human mind. It can do work at the same efficiency for endless hours which is impossible by a human mind. Auto-Dock is needed to eliminate human error to prevent all berthing accidents. Auto-Dock using thrusters eliminates the use of tug boats completely. It saves time and money as the ship can be berthed faster as well as leave the port faster. Due to Auto-Dock, the requirement of a lot of officers on watch is reduced and thus they can be employed at other important work on board.

2. MAIN WORK

2.1 Chipset Computer Components

The system chipset that would be used in this would be a customized computer that will contain a CPU, Neural Engines, Image signal Processor, Safety System, etc. As a reference, we can take the FSD chip made by Samsung for the Tesla or Tegra Xavier - Nvidia. Taking that, as a concept, the paper proposes that a specific computer will be designed for the purpose of collision detection, trajectory prediction, motor control, thruster pitch control, display imaging, etc.

This computer is the heart Auto-Dock. The logic of various components as in how they will work, perform functions, and work together to provide data calculation is provided below:

Neural Engine : A neural engine is a processor used to perform complex calculations requires for AI and deep learning applications. A neural engine teaches a computer to process data in a way that is inspired by the human brain. It takes data, processes it, and provides output just like the neurons in the brain. It is also used in autonomous vehicles to recognize objects.

Camera Serial Interface : CSI acts as an interface between a host processor and a camera. It is a protocol that connects the camera sensors to a host processor. It takes input from the camera sensors and transmits that data to the host process.

Image Signaling Processor : ISP consists of sets of algorithms and techniques used to enhance the quality of digital images captured by a camera. This system includes operations such as color correction, noise reduction, and image stabilization.

Safety System: This system provides immense redundancy and overlapping protection and only allows the execution of codes that have been approved by the authorized signatory.

Accelerated Processing Unit (APU) : All autonomous machinery require a computer on board to process everything happening with the vehicle in real time. Autonomous machinery requires extreme processing power, so rather than traditional CPUs, they utilize APUs. APU has both CPU and GPU for processing and rendering data.

2.2 Sensors

Sensors play a major role in making Auto-Dock successful. The section proposes various sensors with features that are compatible and are used by Auto-Dock. The sensor information is processed by the computer and it processes the data and makes necessary calculations and then provides the output which basically controls the thrusters accordingly. The Sensors used in Auto-Dock are:

AERIES II- This is the heart of the sensor cluster and captures all the essential data, information, image signals which would be then processed by the auto-dock computer for calculation and prediction.

Instant velocity detection- This feature allows for assured detection and tracking of dynamic objects of concern, specifically for our purpose it will help the system detect the docking port.

Ultra long range- This sensor can detect objects at distances up to 500-1000 m.

Compact design- The compact design allows a wide range of sensor integration points in automation applications.

LiDAR on chip- AERIES II has a top quality LiDAR that is immune to sunlight, ensuring ample performance in any lighting conditions.

Camera Level Ultra Resolution- This sensor's resolution is 20 times better when compared to standard LiDAR sensors.

Object detection and tracking- It can detect even small object like corals, buoys, small boats, etc.

This sensor also calculates the speed, acceleration, and yaw rate of the vessel

Ultrasonic Sensors:

An ultrasonic sensor is basically an electronic device that is used for measuring the distance of an object by emitting sound waves and then converts reflected sound into an electric signal.

These waves travel faster than audible sound i.e these are the sounds that humans can hear, these sensors have two main components which consist of a transmitter and a receiver. Ultrasonic sensors can be seen used in automobile self-parking technology and anti-collision safety systems.

Cameras:

Cameras placed around the vessel are used to provide a side view of the surroundings and will be used in docking when in manual mode.

Anemometer:

Anemometers are instruments used to measure wind speed on ships. They are often located on the mast or on other high points on the ship to provide accurate wind speed readings, which are important for navigation and safety. Anemometers on ships can be mechanical or electronic, with electronic anemometers being more common due to their ability to provide real-time wind speed data and increased accuracy.

3. KALMAN FILTER

The Auto-Dock computer uses a lot of algorithms for processing data and accurately predicting the next step while the ship is docking. Kalman filter is one of the most important algorithms that takes part in sensor fusion and accurate prediction. This helps in the accurate functioning of Auto-Dock.

Kalman filtering is an algorithm that provides estimates of some unknown variables given the measurements observed over time. Kalman filters have been demonstrating their usefulness in various applications. Kalman filters have a relatively simple form and require small computational power. The Extended Kalman filter on the other hand is an extension of the Kalman filter. It works on prediction and uses it to predict the next state. This algorithm can be used to fuse the sensor data as well as detect collision. The Kalman filter works on matrices and differential equations.

To predict the next state, the Kalman Filter uses a two-step process:

Prediction: The filter uses the mathematical model of the system is estimated to predict what the state of the system will be in the next time step. The prediction takes into account the current state estimate and any control inputs that may have been applied to the system.

Correction: The filter then incorporates the latest measurement of the system state to correct the prediction, taking into account the measurement noise and any discrepancies between the actual measurement and the predicted measurement.

The extended Kalman filter is used by autonomous vehicles, for sensor fusion and state prediction.

The mathematical logic behind the Kalman filter is as follows:

Prediction step: The prediction step uses the linear approximation, $F(k)$, and the current estimate of the state covariance, $P(k)$, to predict the next state estimate, $\hat{x}(k+1)$, and the corresponding covariance, $P(k+1)$, using the following equations:

$$\hat{x}(k+1) = F(k) \hat{x}(k) \quad P(k+1) = F(k) P(k) F(k)^T + Q(k)$$

where $Q(k)$ is the process noise covariance matrix.

Also, in the Extended Kalman Filter (EKF), the process noise covariance matrix is a matrix that represents the uncertainty in the model of the system is estimated. The process noise represents the fact that the actual evolution of the system may deviate from the model used in the filter. The covariance matrix is a way of representing the uncertainty in the process noise in a quantitative manner.

Correction step: The correction step uses the linearized measurement function, $H(k+1)$, the measurement residual, $y(k) = z(k) - h(\hat{x}(k+1))$, and the measurement covariance, $R(k)$, to update the state estimate

Kalman Gain-In the Extended Kalman Filter (EKF), the Kalman gain is a scalar or a matrix that determines the weight given to the measurement in updating the state estimate. It represents the amount by which the prediction of the state is corrected based on the measurement.

The general equation of the Kalman filter is:

$$\hat{X} = A\hat{x} + Bu + k(y - h(\hat{x}))$$

Here k represents the Kalman gain.

```

import numpy as np

def predict(x, P, F, Q):
    x = np.dot(F, x)
    P = np.dot(F, np.dot(P, F.T)) + Q
    return x, P

def update(x, P, z, H, R):
    y = z - np.dot(H, x)
    S = np.dot(H, np.dot(P, H.T)) + R
    K = np.dot(P, np.dot(H.T, np.linalg.inv(S)))
    x = x + np.dot(K, y)
    P = P - np.dot(K, np.dot(H, P))
    return x, P

def ekf(z, x, P, F, H, Q, R):
    x, P = predict(x, P, F, Q)
    x, P = update(x, P, z, H, R)
    return x, P

```

Fig 2. Representing basic EKF (Extended Kalman Filter) basic python code

3.1 Sensor fusion using Extended Kalman Filter

In sensor fusion, multiple sensors provide measurements of the same system, and the goal is to combine these measurements to produce a single, more accurate estimate of the system's state. The EKF is well suited for this task because it can handle non-linear models and can incorporate multiple measurements into its estimate. In the EKF, the system's state is represented by a set of variables, and the measurements from each sensor are modelled as functions of these variables. The EKF uses a linearization of these functions at each iteration to estimate the state of the system. In each iteration, the EKF first predicts the state of the system using the current estimate and the system model, and then corrects this estimate using the measurements from the sensors. By combining multiple measurements in this way, the EKF is able to produce an estimate that is more accurate than any of the individual measurements. This is because the EKF takes into account the strengths and weaknesses of each sensor, weighing the measurements appropriately in order to produce the best overall estimate. The result is a single, integrated estimate of the system's state that is more accurate than any of the individual sensor measurements.

3.2 Collision detection using Kalman Filter

The Kalman filter can be used in collision detection by modeling the movement of objects and using measurements of their positions to estimate their future states. The filter can then use these estimates to detect potential collisions by evaluating whether the estimated positions of objects intersect at some point in the future.

In simple words, the filter compares the predicted positions of objects over time to determine if they will intersect.

The filter uses equations and any deviation/error can be corrected by Gaussian variables and covariance matrices.

This is done using two processes:

Prediction Step: The filter uses the motion model and the current state estimates to predict the future state of each object.

Let's take an example, a ship moving at a constant speed of 1 knot. The filter will make an equation based on it.

$$\begin{bmatrix} x_{t+1} \\ \dot{x}_{t+1} \end{bmatrix} = \begin{bmatrix} 1 & \Delta t \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_t \\ \dot{x}_t \end{bmatrix}$$

$$x_{t+1} = 0x_t + 1x_t$$

$$x_{t+1} = 0x_t + \Delta t \dot{x}_t$$

Here x is the position of the vessel and t+1 is the corresponding time

These equations are written in the form of a matrix.

$$\Sigma_0 = \begin{bmatrix} \Sigma_{xx} & \Sigma_{x\dot{x}} \\ \Sigma_{x\dot{x}} & \Sigma_{\dot{x}\dot{x}} \end{bmatrix}$$

Any error and noise can be corrected by a Gaussian variable and a covariance matrix.

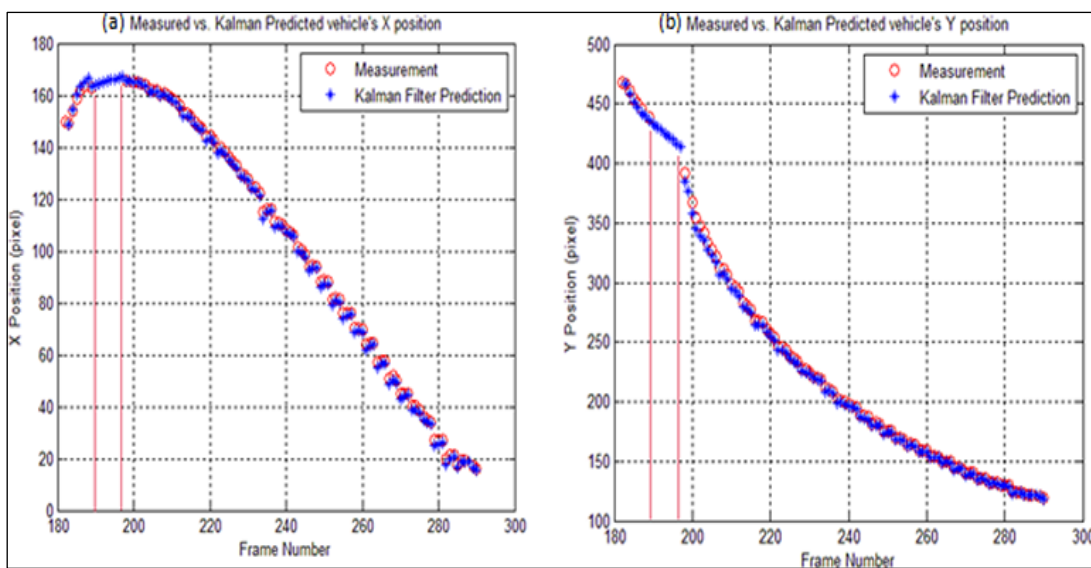


Fig 3. This Graph Shows The Accuracy Of The Kalman filter.

Here Σ_{xx} represents the uncertainty of position and $\Sigma_{x^0x^0}$ represents the uncertainty of speed.

Update/Correction Step: In this step, this filter updates and improves the previous step. It takes new measurements of the system which are noisy and have some deviation. This deviation in the initial estimation is called “surprise term” by calculating the surprise term and combining both these estimates in a single term, a final output estimate is generated.

4. RADAR

Radar is an acronym for Radio Detection and Ranging. It works by emitting a radio frequency signal and is detected by the reflection of an object to determine its range and direction.

The radar’s data is used by the auto-dock computer to detect traffic around the ship.

As Radar is an active sensing device it is having its own source of illumination for locating targets. Radar is being operated in the microwave region of the electromagnetic spectrum which is measured in hertz. However it has also been seen used in the lower frequencies spectrum i.e in optical and infrared.

5. GNSS

A series of satellites that are situated strategically to produce and transmit location, timing, and navigational data from space to linked sensors on the earth is known as a global navigation satellite system (GNSS).

Additionally, it is widely employed in the transportation sector, including in the rail, air, and maritime sectors. With rail transportation, you may map the positions of other trains, track the whereabouts of all locomotives and cars, and reduce accidents, delays, etc. Pilots will become disoriented in the air without GNSS. GNSS systems direct the whole aviation system from takeoff to landing while negotiating unforeseen atmospheric conditions. The same holds true for maritime transportation. Through GNSS-enabled techniques, captains can determine their precise location and bearing.

6. THRUSTERS

Thrusters are a type of propeller-shaped system fitted either on the bow (forward part) and stern part (known as a stern thruster) of the ship. They are smaller in size as compared to the ship’s propeller and help in better manoeuvrability of the vessel at lower speeds.

They have pitch control and work on an electro-hydraulic system.

The prime mover of thrusters can be a electric or an hydraulic motor.

6.1 Motor and hydraulic pitch control

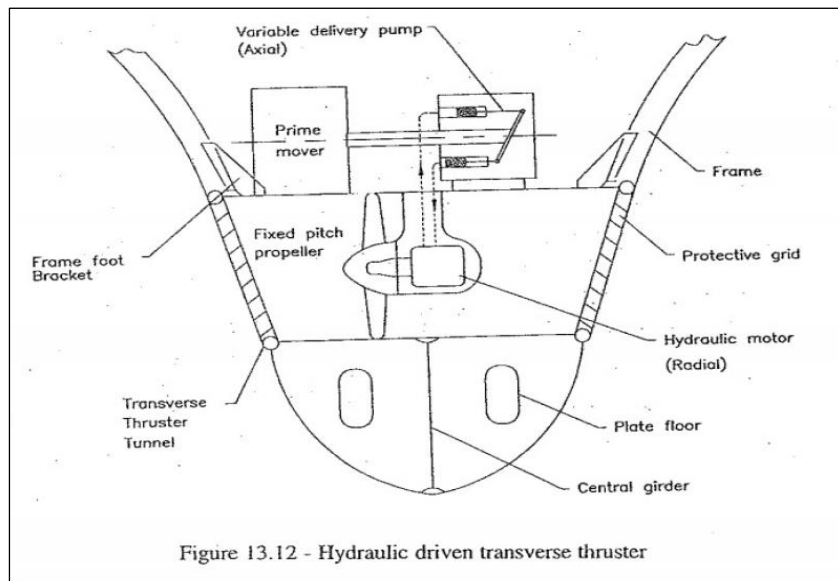
An ADC is an analog-digital converter that is used in ships for converting analog signals from various sensors into digital signals which have been processed by digital services.

An analog-digital-converter is used for precise measurement and monitoring of parameters such as temperature, humidity, pressure, and propeller rpm. The use of ADC can help

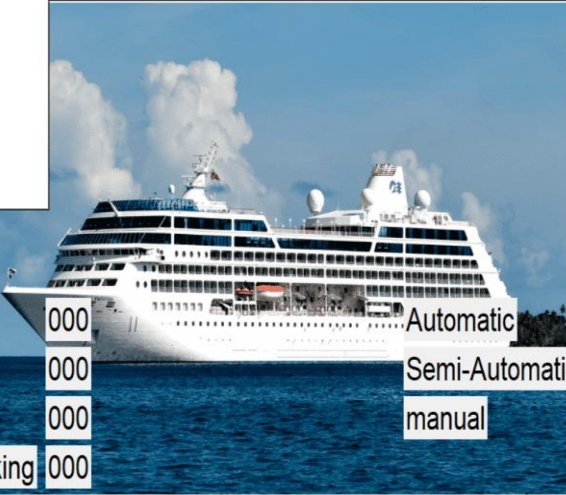
in improving efficiency, safety, and navigation by providing information to the crew and decision-making systems.

It works by sampling the analog signal at a specified rate and quantizing the samples into a finite number of levels which is then encoded into a digital format. ADC plays an important role in ship's monitoring as it allows accurate measurement.

A DAC is a digital to analog converter that converts digital signals into analog signals. This device is used to control different parameters in ship's system and components such as actuators, motors, and valves. The DAC takes a digital signal such as binary and converts it into an analog signal such as voltage level.



Autodocking



Thruster rpm	000	Automatic	Running
Speed	000	Semi-Automatic	Not running
Ship's lateral speed	000	manual	Not running
Estimated time of docking	000		
CPP pitch orientation	Forward	Possible Error	None

7. HUMAN-MACHINE INTERFACE

This display is made using a programming language (Python). The display provides essential information like thruster rpm, and CPP pitch orientation as shown below in the display panel. It enables the officer to input as well as change the necessary parameters like the landing speed and landing angle of the fenders. The display also shows any possible error in the sensor cluster or the program.

8. WORKING OF AUTO-DOCK

As the vessel approaches with its port or starboard side of the hull facing the port/jetty and when the ship's speed is zero knots, the officer would have to just click on the Auto-Dock button present on the display panel. Then the officer will be prompted with a pop-up window where he would have to enter all the essential parameters as provided by the pilot. After entering the information the officer would click on confirm and the autodocking process will start.

The system has three modes available which are automatic, semi-automatic, and manual, even after having zero errors, sensors may fail due to any unknown reason, so to counter that, manual mode is available in the Auto-Dock system where the officer can use the standard joysticks to control the thrusters and berth the vessel. Semi-automatic mode is provided for AI-assisted berthing of the ship using a joystick with the support of cameras and various sensors which may assist the officer while the ship is berthing by giving him the manual speed control of the thruster while the ship controls parameters like the ship's yaw and continuously monitors the environmental condition and keeps informing the officer via prompts on the display panel to make it an easy task when if done manually.

At first, the sensors present in the sensor cluster will scan the environment and the surrounding conditions like the wind speed using Anemometer and traffic around the ship using the radar.

The LiDAR sensor (Aeries II) will create an image of the port and surroundings and send the data to the Auto-Dock computer which will then process it and make a prediction for future states using algorithms like the Extended Kalman filter. After the computer has done so, it will send the signal to the Digital to Analog Converter (DAC) which will start running the thruster motors accordingly. The sensors at this point will provide real-time information like imaging by the cameras, and distance to the port by the ultrasonic sensors. Signals from Aeries II will be processed by the computer in real-time which will help the Auto-Dock system navigate the vessel towards the dock, detect any obstruction in the path and predict collision. The sensors and the thrusters would keep working until the ship has reached the dock. The computer would stop the Auto-Dock as it confirms using the sensors that the ship has touched the fenders on the port. The camera-like image signal resolutions by the Aeries II enables to scan every detail and it would help the computer to start and stop the docking process.

As we know, the Centre of mass of the ship shifts according to the cargo/load present on board. Due to this, the bow and stern thrusters cannot run at the same speed. If they do, then the yaw will change with respect to its original position when the docking starts. To prevent this, the yaw data from Aeries II would be fed to the computer when the docking starts. As the yaw angle changes with respect to the original state, the computer will increase the speed of the bow or the stern thruster accordingly; so the yaw of the ship returns to its original state.

9. SAFETY SYSTEM OF AUTO-DOCK

According to any environmental conditions or any hardware problems, the auto dock is made to be robust, so that it can take decisions according to the changes.

Some of the problems that occur during docking are as follows:

Q. Ship's lateral is speed faster than the speed due to the thrust of the thruster because of heavy winds or waves?

Ans. When the docking starts, actuators, and the computer work together. The computer is preset with the speed that the vessel should maintain. It keeps taking speed information from the doppler log. Due to any abnormal environmental conditions, if the ship starts moving faster than expected, the ultrasonic sensor would detect the distance reducing faster than expected with the thrust provided by the thrusters. In such a critical situation, the vessel may tend to approach the dock in a harmful way and collide with the dock. To prevent this when the computer senses such a condition and is in auto mode, it will indicate the pitch controller and the thrusters will change the pitch orientation which will control the speed accordingly. If the ship is moving too fast and is getting too close to the port, the thrusters would be indicated to provide thrust in the opposite direction and make the vessel move away from the port, and cancel the docking process. The abnormal conditions may happen due to strong wind currents or waves. The Anemometer is already installed on ships. Its data will be used by the computers for this process.

Q. Failure in the sensor system.

Ans. When the autodocking starts, the computer runs a scan on the hardware and the software to check for any malfunctions. If the computer finds any, it will indicate to the officer a display prompt and appropriate troubleshooting options. If any sensor fails in the midway through the docking process, the computer will automatically sense the sensor failure and make the ship return back to its original position using the Global Positioning System (GPS).

Q. Assisted docking in the case of sensor failure.

Ans. Looking at the above condition, if the ship is now at the original position and says a sensor cluster is not working. To counter that each sensor cluster is also provided with a backup camera which will run through a separate channel from the other sensors so in case a sensor cluster fails, the officer can dock the ship safely using the backup and all the other cameras.

12. CONCLUSION

This paper proposes a way to dock a vessel that is equipped with bow and stern thrusters autonomously. This eliminates human error and also makes docking accurate and faster than usual which in turn saves a lot of time and money for the crew and the company respectively.

The paper includes all the necessary components and logic which are used in the Auto-Dock system like sensors, Auto-Dock computer, algorithms, etc., and also explains the way of working of the system.

During operation, water is forced through the tunnel to push the ship sideways either to port or starboard as required. The unit is mostly bridge controlled and is most effective when the ship is stationary.

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Digital Transformation in Transportation and Logistics

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ABSTRACT

In today's fast-paced world, With the advent of technology in the modern era, AI has been a boon to the globe's transportation sector. According to our research, the cost of implementing AI is much lower than the money and resources lost as a result of human errors. We intend to investigate the impact of AI on the shipping industry in this research by dividing our analysis into two distinct categories: AI on board ships and offshore operations. Our research shows that using AI is the wave of the future and will be used in all spheres of human endeavour.

KEYWORDS

Artificial Intelligence, Automation, Robotic process automation (RPA)

INTRODUCTION

The incorporation of Artificial Intelligence (AI) technologies has triggered a significant digitalization in the shipping sector. The simulation of human intelligence in machines designed to adapt like humans is referred to as artificial intelligence (AI). It entails the creation of algorithms and computer programmes capable of performing tasks that would normally require human intelligence, such as visual perception, speech recognition, decision-making, and information extraction.

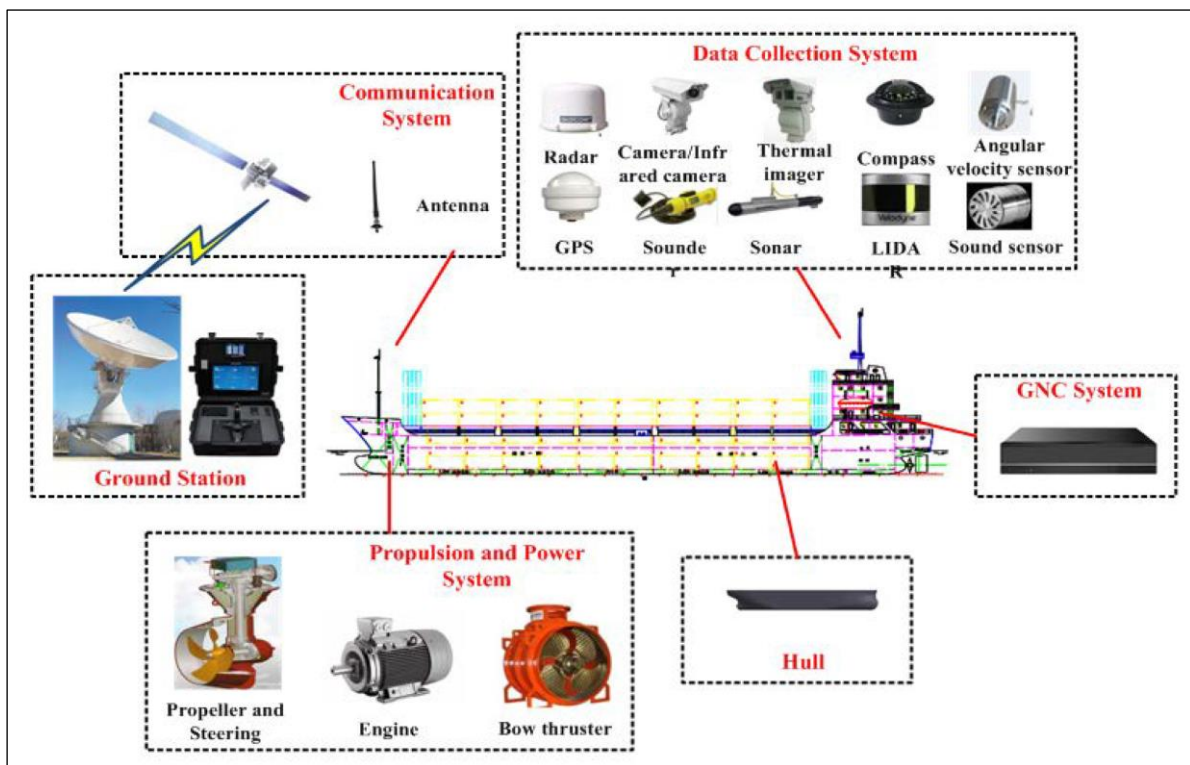
Machine learning, supervised learning, computational linguistics, and computer vision are some of the AI technologies that can be classified. By adopting this strategy, improving decision-making, and enabling new and innovative applications, AI has the potential to reinvigorate a wide range of industries.

The use of artificial intelligence (AI) onboard ships has the potential to transform the way ships operate, from navigation to cargo handling and maintenance. Deployment onboard ships can improve efficiency, lower costs, and increase safety. Ships can process vast amounts of data and make decisions faster and more accurately than ever before with the integration of AI technologies.

Artificial intelligence (AI) has revolutionized the world in many sectors, including the navy. AI is transforming the way operations are carried out in the navy, making them more efficient and effective.

AI-powered systems can assist in automating various processes, reducing human error, and increasing overall efficiency. Predictive Maintenance, AI algorithms can be used to monitor ship machinery, predicting and preventing potential malfunctions and reducing downtime. Enhanced Safety, AI-powered systems can be used for real-time monitoring of ships and cargo, reducing the risk of accidents and improving safety. Increased Visibility, AI can provide shipping companies with real-time data and insights into their operations, allowing for better decision-making and improved visibility into their supply chain.

AI-based training simulations are assisting navy personnel in honing their skills and remaining prepared for real-world scenarios. The use of artificial intelligence in the navy is paving the way for a more secure, efficient, and effective future.

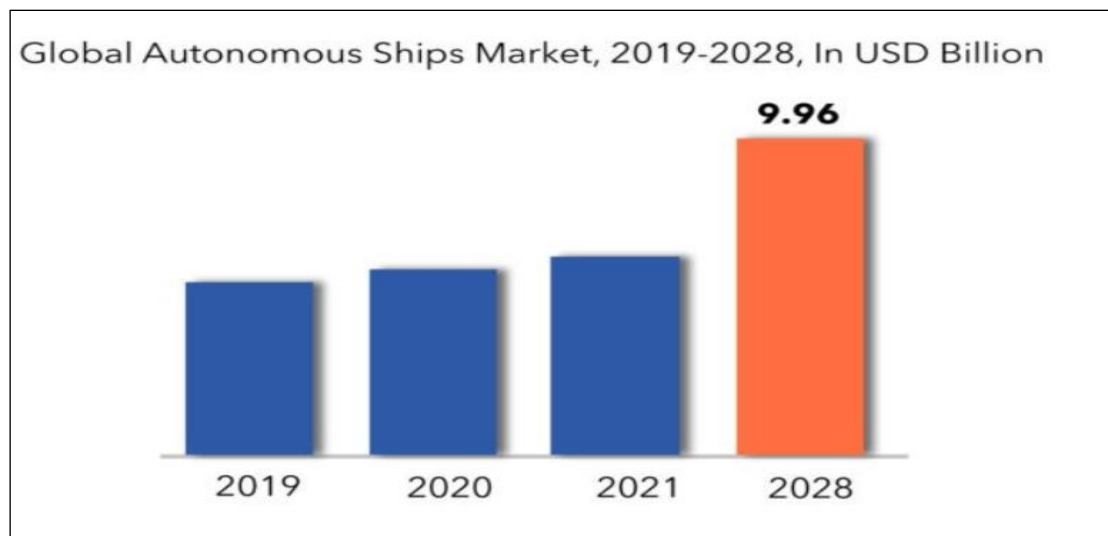


MAIN

The shipping industry has seen tremendous advancements in recent years, particularly with the integration of artificial intelligence (AI) into various aspects of shipping operations. The rise of artificial intelligence (AI) is transforming the shipping and offshore industries. From container tracking to automation of port operations, AI is revolutionizing the way these industries handle their operations. AI-driven technologies such as robotic process automation

and machine learning are enabling companies to gain valuable insights into how to optimize their processes.

AI-powered systems are also helping to reduce safety risks by analysing data and making recommendations on how to best manage operations. With AI-driven solutions, companies can improve efficiency and reduce costs while ensuring that operations are safe and compliant. This article explores the impact of AI on shipping and offshore operations, focusing on how AI is transforming the way the industries conduct their operations.



AI'S IMPACT ON OFFSHORE OPERATIONS

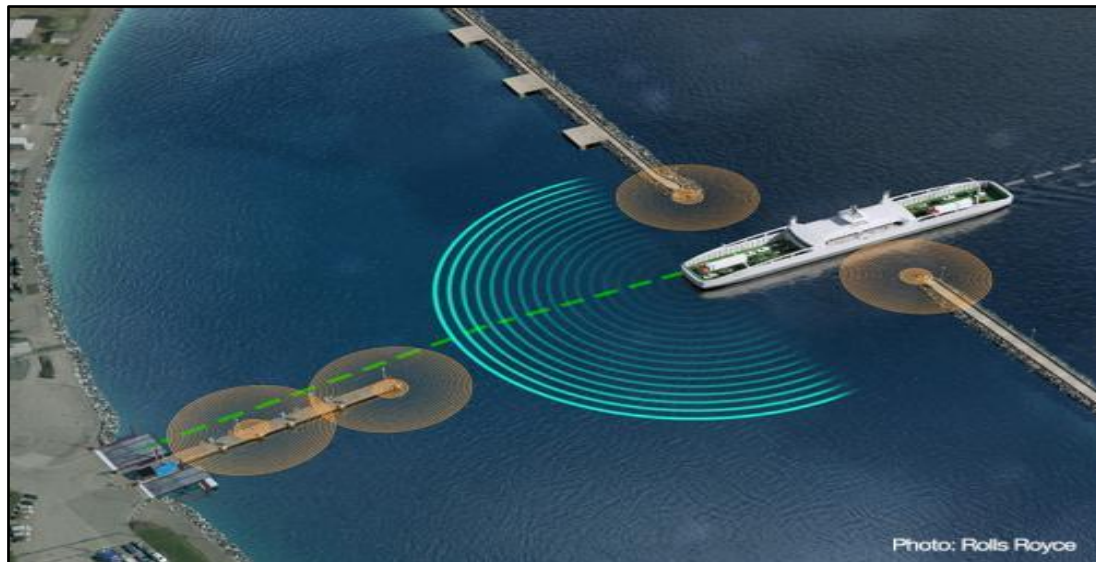
Artificial intelligence is revolutionizing how shipping and offshore operations are conducted. AI has enabled companies to gain valuable insights into how to optimize their processes. AI-driven systems are also helping to reduce safety risks by analysing data and making recommendations on how to best manage operations. With AI-enabled systems, companies can improve efficiency and reduce costs while ensuring that operations are safe and compliant.

Onboard and offshore operations have become more efficient and safer due to the implementation of AI. The rise of AI has enabled companies to gain valuable insights into how to optimize their processes. AI-driven systems are also helping to reduce safety risks by analysing data and making recommendations on how to best manage operations. With AI-enabled systems, companies can improve efficiency and reduce costs while ensuring that operations are safe and compliant.

AUTOMATION OF PORT OPERATIONS

Automating the operation of ports is another way AI is disrupting the shipping and offshore industries. AI is leading to the automation of port operations, with software responsible for everything from scheduling and shift planning to employee scheduling and tracking. AI is also

contributing to the automation of the track and trace process, with the technology helping to identify potential risks and issues with containers and ships. By automating the operation of ports, companies are able to reduce costs associated with hiring workers and scheduling shifts. They can also reduce their reliance on outsiders by using software to schedule shifts. This automated system helps to avoid misunderstandings and miscommunication between employees and managers, while also reducing the risk of human error.



CONTAINER TRACKING

Tracking the movement of containers is another area where AI has helped to transform shipping and offshore operations. With AI-powered solutions, companies can trace the movement of containers through the supply chain. This enables them to monitor inventory, detect potential issues, and prevent delays. By tracking containers, companies can reduce inventory risk and ensure that shipments arrive on time, minimizing delays and lost revenue.

Deep analysis of data enables AI-powered solutions to make real-time decisions and make recommendations. This means that companies can trace the movement of containers through the supply chain. This enables them to monitor inventory, detect potential issues, and prevent delays. By tracking containers, companies can reduce inventory risk and ensure that shipments arrive on time, minimizing delays and lost revenue.

ROBOTIC PROCESS AUTOMATION

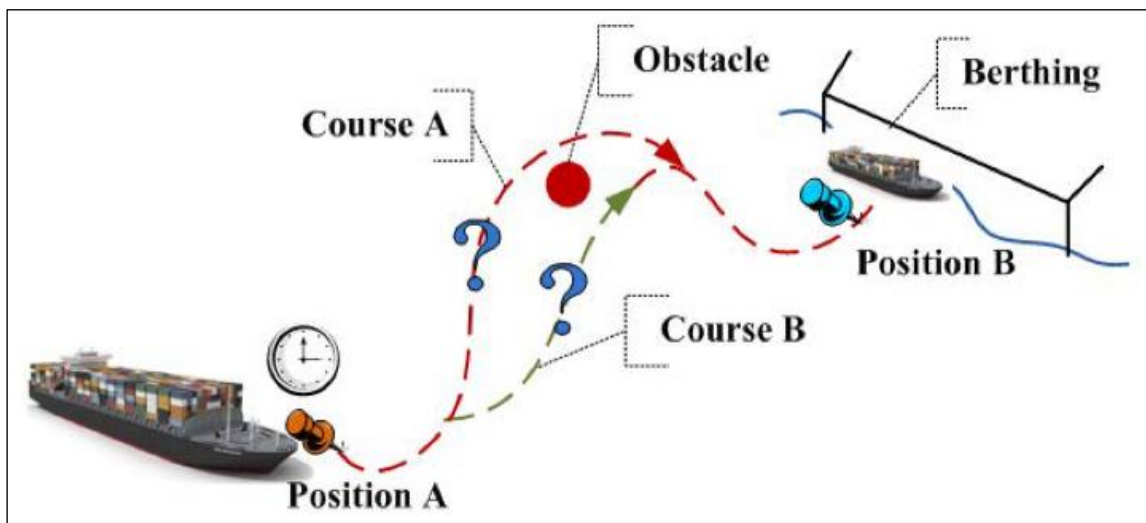
Robotic process automation (RPA) is another area where AI has transformed shipping and offshore operations. RPA enables companies to automate processes using software to manage workflows, such as customer relationship management (CRM) and sales operations, RPA technology also lets companies automate tasks that were previously managed manually, such as account reconciliations and incident investigations.

By automating business processes using AI, companies can reduce costs and increase operational efficiency. RPA has been widely implemented in the shipping and offshore industries, with companies in these industries reporting noticeable benefits.

MACHINE LEARNING

Machine learning is another area where AI is helping to transform shipping and offshore operations. Machine learning enables companies to create models based on data and make predictions based on historical information. With AI, companies can use machine learning to analyse and make predictions based on integration of data from a variety of sources. This type of technology can be used for a variety of applications, such as optimally routing ships and optimizing route maps. Machine learning can also be used for predictive analysis and decision making, including the prediction of future outcomes.

AI is helping to transform shipping and offshore operations by enabling companies to create models based on data and make predictions based on historical information. This kind of technology can be used for a variety of applications, such as optimally routing ships and optimizing route maps



AI-POWERED SYSTEMS FOR IMPROVED SAFETY

AI is helping to reduce safety risks by analysing data and making recommendations on how to best manage operations. With AI-enabled systems, companies can improve efficiency and reduce costs while ensuring that operations are safe and compliant. By automating the operation of ports, companies are able to reduce costs associated with hiring workers and scheduling shifts. They can also reduce their reliance on outsiders by using software to schedule shifts.

This automated system helps to avoid misunderstandings and miscommunication between employees and managers, while also reducing the risk of human error. AI has enabled

companies to gain valuable insights into how to optimize their processes. AI-driven systems are also helping to reduce safety risks by analysing data and making recommendations on how to best manage operations. By automating the operation of ports, companies are able to reduce costs associated with hiring workers and scheduling shifts. They can also reduce their reliance on outsiders by using software to schedule shifts.

This automated system helps to avoid misunderstandings and miscommunication between employees and managers, while also reducing the risk of human error.

AI-DRIVEN SOLUTIONS FOR EFFICIENCY AND COST REDUCTION

Deep analysis of data also enables AI solutions to make real-time decisions and make recommendations. This means that companies can optimize their operations and gain greater efficiency by making use of the information that AI provides. By automating the operation of ports, companies can reduce costs associated with hiring workers and scheduling shifts. They can also reduce their reliance on outsiders by using software to schedule shifts. This helps to optimize operations and reduce costs associated with hiring workers and scheduling shifts. This also helps to reduce reliance on outsiders by making use of the information that AI solutions provide.

EXAMPLES OF COMPANIES USING AI IN SHIPPING AND OFFSHORE OPERATIONS

Corporations are using AI to transform shipping and offshore operations, such as in the management of crew assignments. One company is using AI to help manage crew assignments by analysing data on a variety of factors, including the type of job and the qualifications necessary for it. This company uses AI to help to accurately assess the qualifications of candidates and optimize the use of limited resources. Another company is using AI to optimize operations and reduce costs in relation to crew deployment. As a result, the company has been able to reduce the number of people required for operations, allowing it to implement time-saving solutions.

In today's world, technology is advancing faster than ever before, and Artificial Intelligence (AI) is at the forefront of this revolution. AI is transforming almost every industry, from healthcare to transportation, and the shipping industry is no exception. AI has begun to revolutionize the onboard shipping industry, providing the tools and resources to help companies streamline their shipping processes, increase efficiency, and solve complex problems.

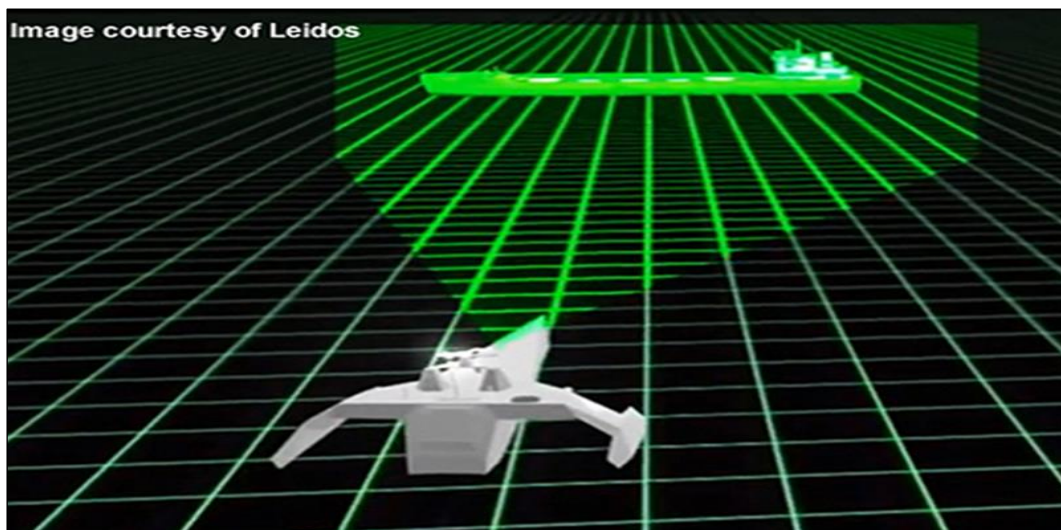
AI technology is allowing shippers to automate mundane tasks, such as tracking shipments, monitoring containers, and providing real-time insights into the entire shipping process. In addition, AI is helping shippers to reduce costs, improve customer service, and increase their competitive edge. With these advantages, it's no wonder why AI is quickly becoming an integral part of the shipping industry.

HOW AI IS REVOLUTIONIZING THE ONBOARD SHIPPING INDUSTRY

AI technology is changing the way shippers track and monitor their shipments. As the ability to track shipments is essential for the shortening of transit times and the assurance of delivery, AI is enabling more accurate data analysis and tracking in order to reduce the risk of missing or rerouting a shipment.

Even though this has been possible with manual processes for some time, AI is making it easier and more efficient. Intelligent planning AI can be used to help shipping companies optimize their planning processes, making it easier to find the best shipping route at the right time of the year while taking into consideration weather conditions, market demand, and the availability of shipping services.

Quality assurance AI can help shippers to ensure the quality of their shipments, both at the time of transportation and at the time of receiving and storing. Through the use of inspection and tracking technologies, AI can help to ensure that every shipment gets inspected before it is stored, helping to avoid problems like incorrect weight and volume calculations.



AUTOMATION OF MUNDANE TASKS

One of the most significant benefits of AI in the shipping industry is the automation of mundane tasks. As the shipping industry is the most capital-intensive in the retail industry, it is crucial to reduce the costs associated with the transport of goods. In order to achieve this, companies need to find ways to save on the expenses related to the transport of goods. AI can be used to automate some of these expenses, leading to significant savings. Through the use of AI, companies can find ways to improve their quality assurance processes, minimizing the need

for audits. With the reduction of manual labour, companies can reduce their operating costs and remain competitive in the market.

AI-DRIVEN TRACKING AND MONITORING

Tracking and monitoring is yet another area where AI can bring significant benefits to the shipping industry. Through the use of AI, companies can automate tracking and monitoring processes, enabling more accurate data analysis and helping to reduce risk. The ability to track shipments in more detail allows companies to identify and avoid delays, which can prove to be costly in terms of lost revenue and customer dissatisfaction. Through the use of AI, companies can find ways to visualize complex data and make it easier to understand, which can help to reduce errors and make better decisions.

REAL-TIME INSIGHTS INTO THE ENTIRE SHIPPING PROCESS

Another significant benefit of AI is the real-time insights into the entire shipping process. Through the use of AI, companies can automate manual processes and make them more accurate and reliable, enabling tighter control over the entire shipping process. This can help to reduce costs and lead to significant savings, while also helping to deliver goods to customers faster. Through the use of AI, companies can find ways to optimize their operations and make better use of their resources, increasing their competitiveness.

COST REDUCTION AND CUSTOMER SERVICE IMPROVEMENTS

Finally, one of the most significant benefits of AI is cost reduction and customer service improvements. Through the use of AI, companies can automate and make more accurate decisions, leading to cost reduction and improved customer service. This can help to make sure that every shipment gets tracked, inspected, and transported as efficiently as possible, resulting in cost reduction for the company while also providing customers with better service.

AI TECHNOLOGY AS A COMPETITIVE ADVANTAGE

As can be seen, most of the benefits of AI are due to the automation of the tracking and monitoring processes, which is vital to reducing the costs associated with the transport of goods. Through the use of AI, companies can track shipments in more detail, identifying and avoiding delays, leading to significant savings. This can result in significant cost reduction for the company, while also leading to improved operational efficiency. Real-time insights into the shipping process can also help to improve operational efficiency, leading to cost reduction while also enabling more efficient transportation. The implementation of AI can result in cost reduction and improved customer service.

CONCLUSION

AI has been a boon to the globe's transportation sector, providing accuracy and efficiency that humans cannot match. Recent advances in machine learning have allowed for even more sophisticated AI-powered transportation solutions, such as autonomous ships. AIs can automate the entire process of shipping; from the moment the order is placed to the moment it arrives at the customer's door. This will help to streamline the shipping process and reduce the amount of time and money wasted on unnecessary steps.

AIs can help to reduce the number of human errors made during the shipping process. By automating the process, AIs can help to ensure that all steps are followed properly and that no steps are missed. This will help to reduce the number of mistakes made during shipping and ensure that orders are delivered on time and in the correct condition.

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Digital Transformation in Transportation and Logistics

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ABSTRACT

This article's goal is to thoroughly examine how the transportation sector has gone digital. The evaluation of the digital transformation of transportation comprises looking at emerging trends, problems with the digital transformation of transportation, and important tactics. Strategies implemented to assure the success of the transportation industry's digital transformation. The findings demonstrated the importance of emerging trends in the digital transformation of transportation, including artificial intelligence, the internet of things, cognitive computing, robotic process automation, and big data analytics.

KEYWORDS

Digital transformation, technologies, logistics, transportation

1. INTRODUCTION

The topic we are going to articulate is about transportation and logistics sector of India and how shifting of this sector to a digital mode will be a game-changer not just for the whole industry but also for the economy of our nation.

‘Transportation and Logistics’ is prominently the most vital sector of any country. When we hear the term transportation, we overlook it by assuming that it is just about transferring goods and inventories from one place to another. But it is not just limited to goods such as electronic items, books, art & crafts, etc, it is also linked with agriculture and pharmaceuticals. These two are inarguably “the most” important pillar for sustainable growth and development of a nation. India being an agricultural dominant nation, rely a lot on logistics management. Medical sector on the other hand holds the power to strengthen the human resource management. Logistics industry contributes to 14.4% of India’s total GDP and by 2025, there’s an estimate that it will hit \$380 billion market capital. In spite of such enthralling numbers, the challenges and obstructions are numerous. So, our entire topic of discussion would revolve around getting educated about the logistics industry, frameworks and methodologies on which this department operates, its potential growth and return of investments and the ways to overcome the obstructions faced by this industry. Moreover, our prime focus will be concentrated on presenting how digitisation of logistics and transportation sector can prove to be boon for economical and sustainable development of India.

1.1 Logistics and transportation

The movement of goods and inventories within or across a nation. It takes into considerations a wide range of activities, including transportation by road, rail, sea, and air; warehousing and storage; and supply chain management. The logistics and transportation industry in India plays a crucial role in supporting the country's economic growth and competitiveness by enabling the efficient movement of goods and raw materials to and from various regions. This industry has undergone toppling changes in past few decades in the quest to be more efficient and less expensive.

2. EVOLUTION OF INDIAN LOGISTICS

The Indian logistics sector has undergone **significant changes over the past few decades**. Here are some key milestones in the evolution of this sector:

- 2.1 **Pre-Liberalization Era (pre-1991)**: The logistics sector was largely unorganized and dominated by small players. Infrastructure was limited, and transportation was mainly done through roadways.
- 2.2 **Post-Liberalization Era (1991-2000s)**: With the opening up of the Indian economy, the logistics sector began to see significant growth and modernization. The introduction of economic reforms led to the growth of industries such as e-commerce and manufacturing, leading to an increase in demand for logistics services.
- 2.3 **Emergence of 3PLs (2000s-2010s)**: 3PL refers to third party logistics and separate logistics company that other companies can outsource. The rise of third-party logistics (3PL) providers marked a turning point in the evolution of the Indian logistics sector. 3PLs offered comprehensive logistics solutions, including transportation, warehousing, and supply chain management.
- 2.4 **Growth of e-commerce (2010s-present)**: The growth of e-commerce has been a major driver of change in the Indian logistics sector. The increasing popularity of online hopping has led to a surge in demand for reliable and efficient logistics services.
- 2.5 **Focus on Technology and Innovation (present-future)**: The Indian logistics sector is now focusing on the adoption of technology and innovation to improve efficiency and reduce costs. This includes the use of digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain.

Overall, the Indian logistics sector has come a long way and is now bound to grow above par in the coming years prominently because of technological advancements. In order to know how digitisation can benefit the logistics sector, we need to have a thorough knowledge of how the industry works.

3. FUNCTIONING AND PROCESSES INVOLVED

The functioning of the Indian logistics sector involves several key components and processes, including:

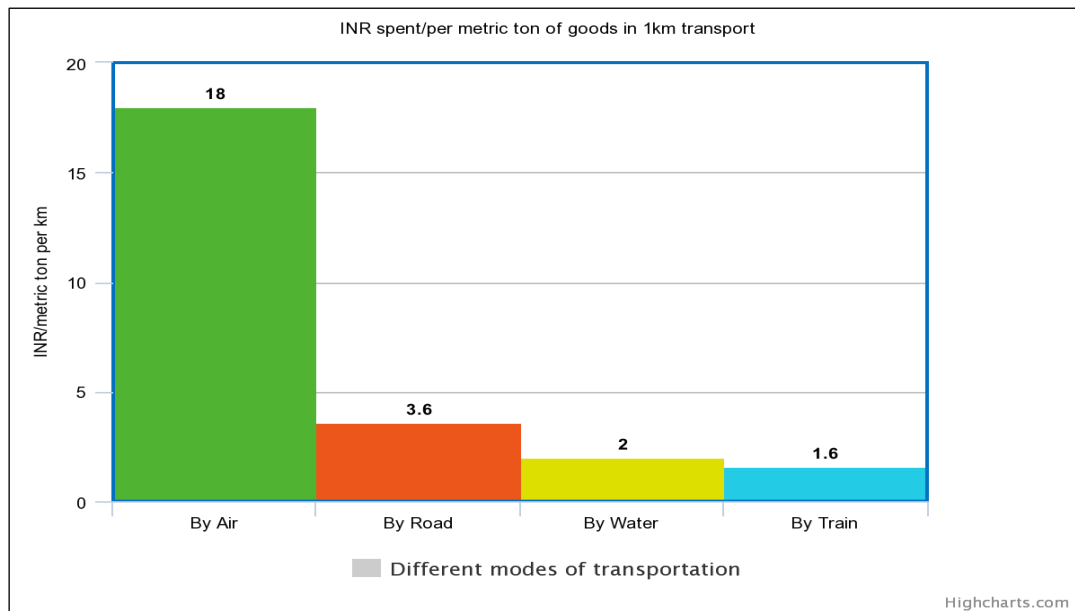
- 3.1 Transportation:** As the name indicates, transportation is the operation involved in the actual physical delivery or movement of products from one place to another. It's part of the larger system of logistics and considers factors such as secured item packaging, best delivery route, and the most appropriate mode of transport. There are two key aspects of transportation management:
- i.** Vehicles and fleet management: Fleet management is a practice that allows organizations to manage and coordinate delivery vehicles to achieve optimum efficiency and reduce costs. In this digital era, fleet management software acts as the central point to monitor otherwise time-consuming processes on a real-time basis, and thus acts as a critical component in making efficient business decisions.
 - ii.** Infrastructure Management: It involves securing all infrastructures involved in the logistics process such as roads, ports, airports, canals, rails, and pipeline networks, among others. Better infrastructure leads to smooth operations and less storage hinderance.
- 3.2 Warehouse and storage:** Logistics is not just about movement of goods. Storing the goods from supplier's end to demand area is equally needed. All these transportations are meaningless if we are not able to cater the demand of the marketplace. Different types of goods require different types of warehouses. One of the best examples can be food items and chemical items; both need different types of treatment and environment of storage.
- 3.3 Supply chain management:** Supply chain management (SCM) is the centralized management of the flow of goods and services and includes all processes that transform raw materials into final products. By managing the supply chain, companies can cut excess costs and deliver products to the consumer faster and more efficiently. It seeks to optimize projecting, inventory and transportation to boost efficiency, lessen cost, understand the movement of goods and line up supply chain networks.
- 3.4 Freight forwarding:** This involves the arrangement and management of shipments, including customs clearance, documentation, and transportation. There are so many freight forwarding agencies who handles the shipment processes, their trackage and manages all the logistics network.
- 3.5 Reverse logistics:** In any supply chain system, the need for reverse logistics has risen over the couple of decades. It has come into picture for a better CSR (Customer Satisfaction Ratio) in any business. The goods and items are picked from customer's location, packaged again at the warehouse and transferred back to seller's or manufacturer's location.
- 3.6 Technology and innovation:** Technology is playing an increasingly important role in the Indian logistics sector, with the adoption of digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain helping to improve efficiency and reduce costs. The whole topic of discussion is around these technological advancements which holds the potential to accelerate the growth of this industry up to a marvellous level.

4.OBSTRUCTIONS FACED

Before knowing how the digital transformation is going to mark a dent in the logistics sector, we need to be aware of the obstructions and challenges it is currently facing and how digitisation can eradicate these challenges majorly. Transportation and logistics sectors are the critical pillars of Indian Economy yet at times it seems to be a nightmare for Indian Businesses. It happens because of the heavy challenges and obstructions they face not just by the intermediaries but sometimes by the government as well.

Consider a practical case study about the transportation of metal ton of goods in India –

Table 1: Money spent per metric ton of goods in 1kilometre transportation.



Transporting a metal ton of goods by rail is the cheapest as we can see from the above histogram but still, we have data showing that 71% of the transportation is carried away by roadways. Just because railways are cheap doesn't mean that they are ready to cater the demand of the market. Following are the reasons why roadways are the most preferred way of shipping products from one place to another:

- 4.1 We don't have sufficient rail and rail tracks to cater the enormous demand of goods and inventories. Moreover, both passenger trains and goods trains run on the same track with passenger trains being given more preference. This leads to delays.
- 4.2 When we something ship the goods by rail, we need to opt for multi-modal transport system for last mile and first mile connectivity. To comprehend it more, we will have to ship our product from the factory to the train station by truck, then unload and load it, get it shipped to a particular location through train and then another truck would pick it up from the destination station and drop it in the warehouse. This whole process would not just need one type of vehicle/transport system. We need trucks for rail transportation as well.
- 4.3 One of the biggest issues in rail transportation is security. Security via train is so minimal that there is no certain guarantee that our product will reach the destination safely. Logistics companies don't offer even a reasonable amount of trackage of items and routes the train is taking. Apart from this, there is a high

chance of rash handling. In case of materials whose quality as well as packaging cannot be compromised, companies hesitate a lot to choose rail transportation.

4.4 There are also chances of theft.

Apart from rail transportation, the problems in inland waterways are also numerous. Inland waterways are very important to be considered if want to strengthen our import export network. Import export networks are important weapons in making India a self-reliant nation.

5. INLAND WATERWAYS

5.1 It involves a lot of certifications, documentations and approvals from different segments of the government. To our misery, these government bodies are neither connected nor modernised for fast processing.

5.2 You'll spend more time in getting certification than in shipping or transporting your product itself.

These reasons are enough to justify why roadways are the most preferred way of transportation. Companies simply rely on trucks to go from point A to point B without any botheration of loading, unloading and warehousing. Also, the security is much better as there is an active involvement of truck drivers in shipping and guarding the goods.

By choosing these options, we almost spend 13-14% of our GDP. The price and the time of transportation surge higher because of problems lying here as well.

Out of 30 billable days, most trucks run for only 15-16 days. For instance, after leaving, let's say a city, Pune, full of goods and reaching Chennai, due to improper networking, it takes one and half days to even three days sometimes to reload the truck and ship the items back to Pune. Even worse, many a times, these trucks have to return empty because of manufacturing delays or warehousing problems.

Talking statistically, In India, trucks on an average covers 300 kms per day compared to a global average of 500- 700 kms per day. Empty running rates of trucks is close to 40% in India.

6. REVOLUTIONARY CHANGE DUE TO DIGITISATION

To overcome the challenging scenarios, transportation and logistics industry in India is undergoing a digital transformation, with the adoption of technology and digitization of processes.

6.1 This includes the use of GPS tracking, route optimization software, and e-commerce platforms for delivery. The government is about to come up with something called **Unified Logistics Interface Platform** abbreviated as 'ULIP'. The concept behind this is to make it as conducive as easy to use as UPI. Just as the way UPI has brought a revolutionary change in the payment paradigm of India, ULIP is intended to revolutionise the whole logistics sector. This platform will allow companies, or more precisely, the goods owners and the logistics agencies to come up at one common place. Here the product owners will input the category and quantity of the products to be shipped. Now the application will recommend the available and best suited way to get the products delivered with an

estimated cost. It will take into consideration the multi modal way of transportation. Let us consider a simple case to understand it better –

Assume that there's a biscuit manufacturing company 'Ankur' and two logistics agencies 'BestKart' and 'RailKart'. BestKart deals with local shipping while RailKart deals with rail transportation. Ankur wants to ship his biscuits from Pune to Jaipur. Now in this case, Ankur would come to ULIP and will enter the category of his product and the amount of quantity he wants to transport. Now based on the algorithms, application would recommend Ankur to go as–

- Pune Warehouse to Pune railways station via truck.
- Pune Station to Jaipur Station via train
- From Jaipur station to warehouse via truck again.

In this case, the app shows an estimated overall cost along with the other alternatives available such as by taking only roadways, or air transportation for that matter. Now after placing the order, BestKart and RailKart both will get the notification of this order they'll proceed with the shipping work. While all this happens, Ankur will have a clear tracking system available through the ULIP app. Since this whole process will work in a unified way, government would tie up with agencies like RailKart for transportation of items within different states. Government would also give authority to RailKart type agencies to track the goods trains and to have a constant communication with the railway transporting staffs. RailKart will constantly monitor the shipment and will provide updates on the ULIP app. If Ankur wants any information regarding his shipment, he can check it on the application. After the payment is done, government will keep its train charge to itself through ULIP and rest will get distributed to BestKart and RailKart.

This is just a rough idea of how ULIP is supposed to function. This unification of multiple modes of transportation will require a lot of efforts from government as well as business owners' side. The Indian government has made significant **investments in improving the infrastructure** of the transportation and logistics sector, including the development of highways, ports, and airports. This is aimed at reducing bottlenecks and improving the speed and efficiency of transport and delivery. The government has also launched initiatives such as the **National Logistics Policy**, which aims to make India a global logistics hub by improving the efficiency and competitiveness of the industry.

For ULIP to operate smoothly, we require:

- Appropriate road connectivity,
- Data network to truck drivers located in remote areas of our company
- Multiple language support in the application
- Robust technology with almost null server and technical errors
- Sufficient Infrastructures like warehouses and factories.

There are multiple aspects of technological advancements in the field of Indian Logistics. Some of which are discussed as follows:

- i. The Indian government has also launched initiatives such as Digital India and Make in India, which aim to increase the use of technology in the country, including in the transportation and logistics sector.

- ii. Growth of e-commerce and online shopping has increased the demand for efficient and reliable delivery networks, leading to an increase in investment in technology and infrastructure. The success of e-commerce in India has built a trust and genuineness among local peoples.
- iii. The use of drones, autonomous vehicles, and the Internet of Things (IoT) is also being explored to further enhance the efficiency and effectiveness of the industry. IoT can help in managing the loading and unloading of goods in the warehouse.
- iv. Another aspect of it is the increased use of automation and artificial intelligence (AI). AI algorithms can analyse large amounts of data and make predictions and recommendations, leading to improved efficiency and decision-making. For example, AI algorithms can be used to optimize routes, predict demand, and manage supply chains more effectively. The use of automation is also reducing the need for manual labour, freeing up workers to focus on higher-value tasks and reducing the risk of human error.
- v. Use of big data and analytics is another aspect of technological advancement. Companies are using data to gain insights into their operations and make data-driven decisions. This includes using data to optimize routes, manage fleet utilization, and improve customer service. The use of predictive analytics is also becoming more widespread, allowing companies to proactively identify potential problems and make adjustments before they occur.
- vi. The use of digital technology will help **to increase transparency** between the company and logistics agency. Transparency would result in a better trust factor and smooth conduct of queries from both the parties.
- vii. Hassle free documentation, less time-consuming approvals and orders is a major relief that technological upgradation can bring to the table. Electronic documentation, online tracking, and digital payments have reduced the need for manual processes, reducing the risk of errors and fraud. This has also helped to reduce the time and cost associated with transport and delivery, making it more accessible and affordable for businesses and consumers alike.
- viii. Another benefit of the digital transformation of transportation and logistics in India is **the increased focus on sustainability**. Companies are using **technology to optimize routes, reduce emissions, and minimize waste, leading to a more environmentally friendly industry**. For example, the use of real-time tracking and monitoring allows companies to reduce the number of empty trips, reducing fuel consumption and emissions. The use of electric vehicles and other alternative fuels is also being explored, further reducing the industry's impact on the environment.
- ix. Looking at the bigger picture, the digital transformation is also providing new opportunities for small and medium-sized businesses (SMEs). By using digital platforms and technologies, SMEs can compete more effectively with larger companies, reducing the barriers to entry and making it easier for them to reach new customers. This has the potential to drive economic growth and create new jobs, particularly in rural areas where access to transportation and logistics services is limited.

7.IMPACT

- 7.1 **Overall**, the digital transformation of transportation and logistics in India is a positive development that is **improving the efficiency, competitiveness, and sustainability of the industry**. It is also helping to drive economic growth and create new employment opportunities, making it a key driver of India's digital economy.
- 7.2 The digital transformation is helping to improve the overall customer experience. With the use of real-time tracking, customers can now monitor their deliveries in real-time and receive more accurate delivery times. The use of chatbots and other digital channels is also making it easier for customers to communicate with logistics companies, reducing the time and effort required to resolve issues.
- 7.3 Digitalisation is a multi-faceted process that is providing significant benefits to the industry, the economy, and society as a whole. The continued development and adoption of technology and digital platforms is essential to ensure that the industry remains competitive and continues to drive economic growth in the future.
- 7.4 This whole transition is helping to **improve the overall customer experience**. With the use of real-time tracking, customers can now monitor their deliveries in real-time and receive more accurate delivery times. The use of chatbots and other digital channels is also making it easier for customers to communicate with logistics companies, reducing the time and effort required to resolve issues.
- 7.5 The technological edge we're having currently in the transportation and logistics sector of India is also leading to increased collaboration between different stakeholders in the industry, including logistics providers, shippers, and customers. This is facilitated by the use of digital platforms and technologies that allow for real-time communication and data sharing. For example, shippers can now use digital platforms to find the best transport options and negotiate rates in real-time, reducing the need for intermediaries and improving efficiency.
- 7.6 It is also having a positive impact on the safety and security of transport and delivery. With the use of real-time tracking, companies can now monitor their vehicles and deliveries more closely, reducing the risk of theft, loss, and damage. The use of digital documentation and e-signatures is also reducing the risk of fraud and increasing transparency.
- 7.7 Finally, the digital transformation of transportation and logistics in India is helping to reduce the cost of logistics for businesses and consumers alike. By reducing the need for manual processes, reducing waste and inefficiencies, and increasing efficiency, the cost of logistics is being reduced. This is particularly important for businesses operating in India, where the cost of logistics is a significant proportion of the total cost of goods sold.

CONCLUSION

It is a complex and ongoing process that is providing significant benefits to the industry and the wider economy. The continued investment in technology, infrastructure, and skills will be essential to ensure that the industry continues to thrive and drives economic growth in the future.

ACKNOWLEDGEMENT

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Technical Write-ups for Models

Reduction of carbon footprint using variable frequency drives

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I. ABSTRACT:

Energy efficiency plays the most important role in CO₂ emission reductions, accounting for up to 53% of total CO₂ emission reductions. In pump and fan applications on board vessels, using Variable Frequency Drives (VFD) can cut the energy consumption for these applications by as much as 60%. The systems on existing ships are not energy efficient and have not been fully optimized for minimizing overall fuel consumption. To date, most marine installations adjust for changes in environmental conditions by inefficient methods, such as ‘throttling’ and ‘by-pass loops’. The onboard ship systems most suitable for improving energy efficiency are systems with large pumps and fans, which are not required to run continuously and at full capacity. When applicable, electric motors could be fitted with VFD (variable frequency drive) to operate pumps and fans more efficiently in partial loads during slower sailing speeds or with reduced ventilation requirements.

II. OBJECTIVE:

To demonstrate the use of VFD to control the speed of a motor and inter-alia the pump with response to temperature changes

III. INTRODUCTION:

CO₂ is the most common GHG and the shipping industry today accounts for 3-4% of total GHG emissions. It is estimated that this figure will grow rapidly if the shipping industry does not do anything to make the vessels more energy efficient. In “business as usual” scenarios it is estimated that there would be an increase to 2.5 – 3.5 billion tons of CO₂ emissions from shipping by 2050.

Pumps and fans onboard vessels are often a vital application. If these are not working the vessel will not sail. On board vessels there are a lot of different pump applications; sea water cooling pumps, boiler feed pumps, HVAC pumps, bilge water pumps, lubrications pumps, fire pumps, waste water pumps and many other kinds. It is common for pump applications to be over-dimensioned. This is simply because the design criteria are set to meet the extreme conditions in which the vessel may operate. For example, the sea water temperature is generally dimensioned for above normal operating conditions.

Although it is required for a ship to be able to operate in extreme cases and environments, every-day operations rarely come close to such conditions. While maximum allowed engine load is typically 75-90% of maximum, heat is always recovered from the system and seawater temperature very seldom reaches design value.

A lot of energy is easily saved by letting pumps and fans be controlled by a VFD, either standalone or with a pressure or temperature sensor loop control. Using a VFD to adjust the power demand to the operational conditions is the most effective method to optimize the shipboard systems.

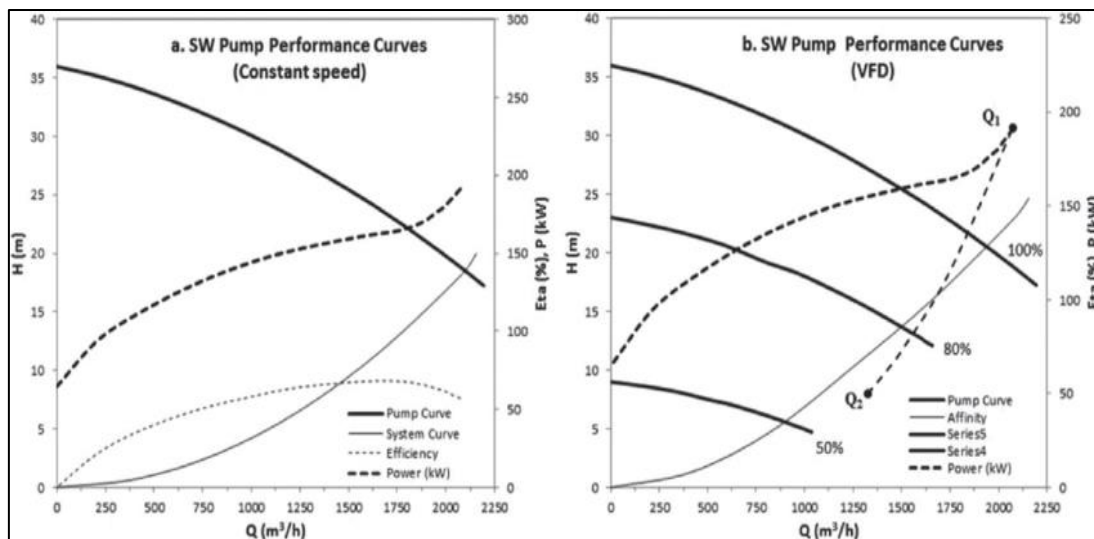
IV. CONCEPT:

A reduction in the pump speed of 10 % will save 27% of the power consumed; thus resulting in lesser fuel consumption thereby reducing the carbon footprint

V. WORKING PRINCIPLE:

In a conventional system, seawater is used for cooling the fresh water. The centralised cooling system of a ship is designed accordingly to obtain the required cooling effect at maximum load conditions. Therefore the sea water cooling pumps always operate at constant speed with maximum capacity irrespective of the sea water temperature.

In case of the lower seawater temperatures, the fresh water temperature control is carried out with the help of a thermostatic bypass element. The seawater flow rate is always constant irrespective of seawater temperature resulting in constant power consumption. Reduction in energy consumption by use of a VFD to alter the speed and of pump and the sea water flow commensurate to the heat exchange provides an elegant solution in the effort to reduce the carbon footprint. A comparison between a constant speed pump vis-a-vis a VFD driven pump is illustrated below;



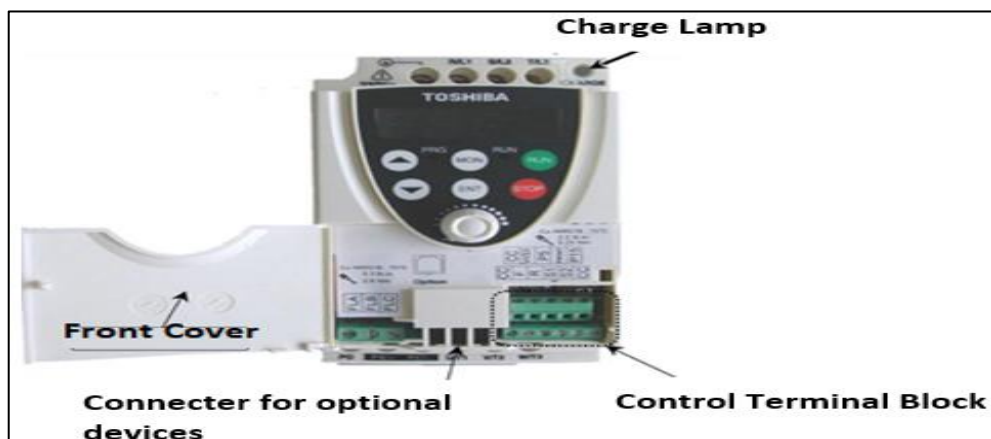
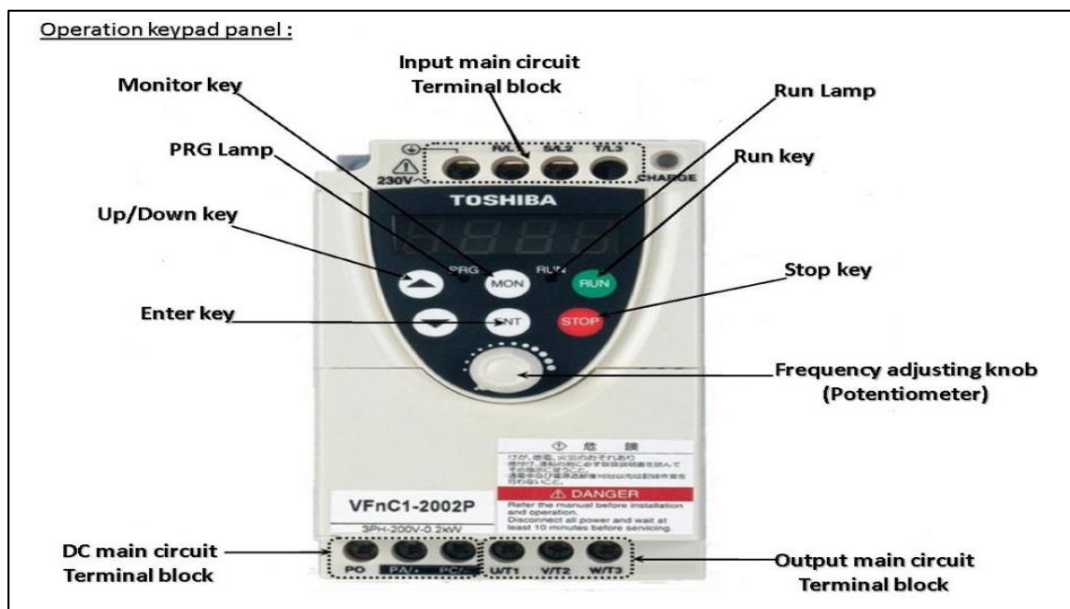
Comparing constant speed pump performance curves and VFD pump performance curves, it can be seen that there is significant savings in power at low mass flow rates.

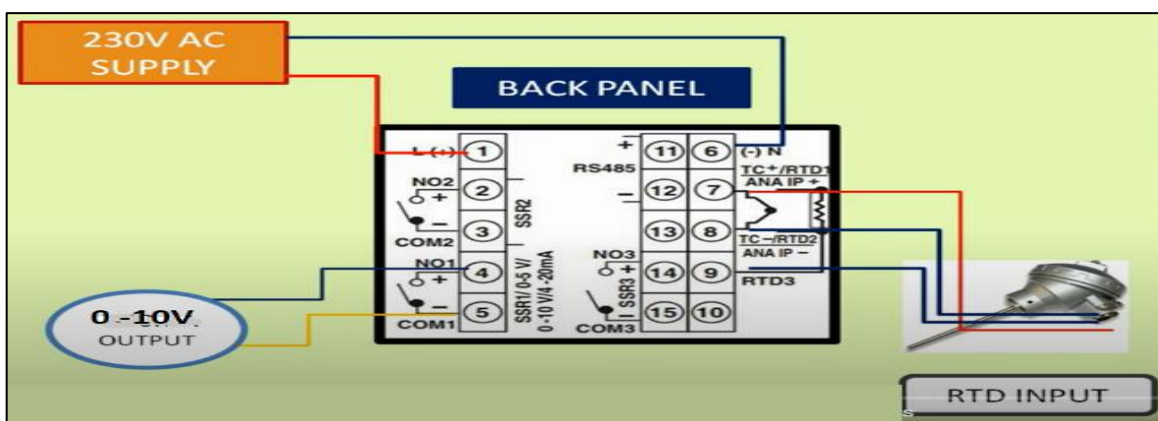
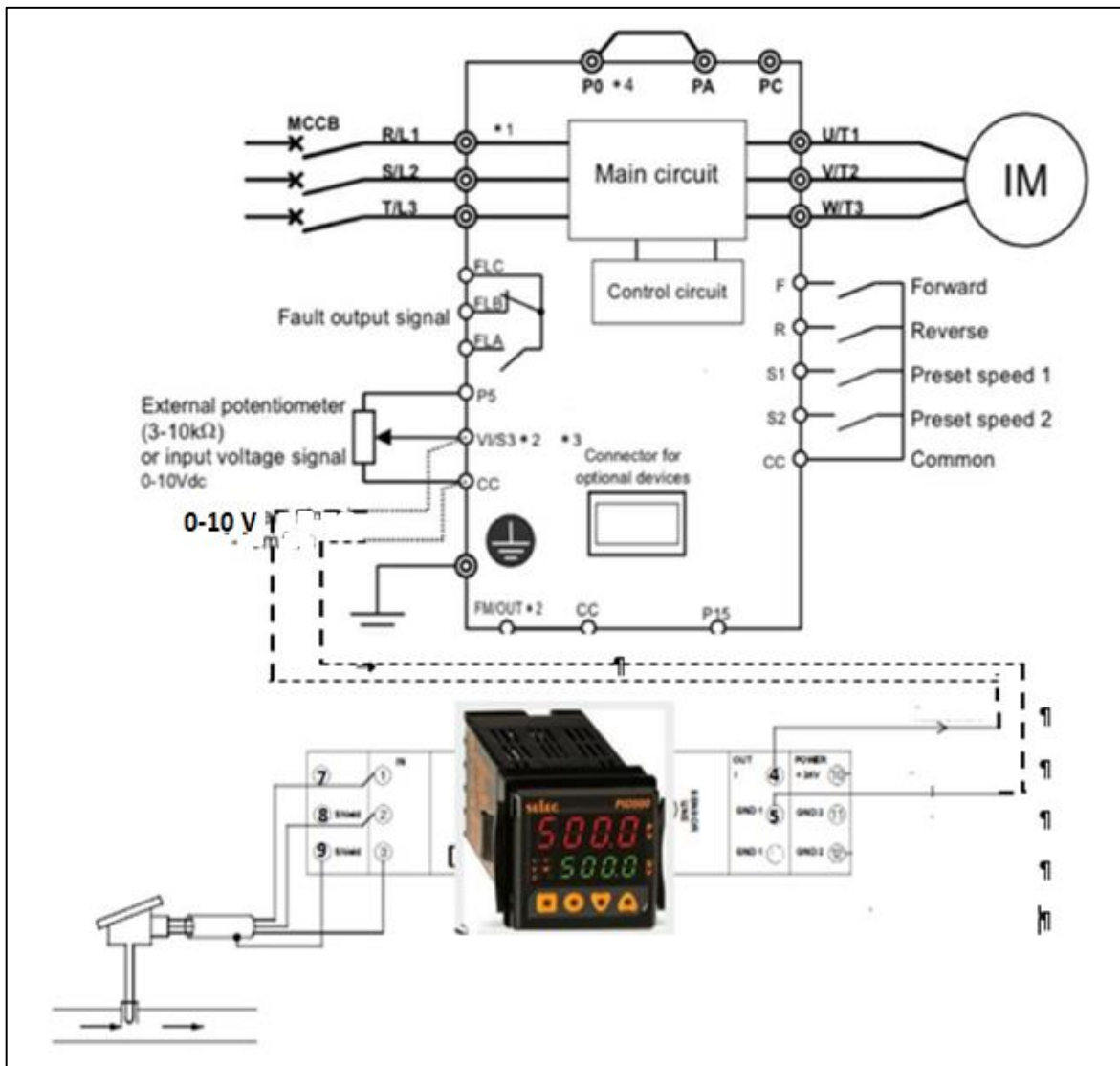
The VFD can be controlled by a 4-20 mA or 0-10 volt input signal that comes from a microprocessor controller. When the input signal for the VFD is provided from a controller, the system is considered to be a closed loop. The use of Pulse width modulation VFD is an effective method that is used to control the amount of power delivered to a load without dissipating any wasted power.

Working of a Variable frequency drive (VFD)

First stage of a VFD, is the Converter comprising of six diodes, which allow current to flow in only one direction shown by the arrow in the diode symbol. This is called a “six-pulse VFD”, which is the standard configuration has a rippling effect. By adding a capacitor we can get rid of the AC ripple into the DC bus bar and delivers a smooth dc voltage. The actual voltage will depend on the voltage level of the AC line feeding the drive, the level of voltage unbalance on the power system, the motor load, the impedance of the power system, and any reactors or harmonic filters on the drive. The converter that converts the dc back to ac is usually referred to as an “inverter”. By closing the top/bottom switches of the inverter we can make any phase on the motor become positive or negative at will and can thus generate any frequency that we want. So, we can make any phase be positive, negative, or zero. The output from the VFD is a “rectangular” wave form. VFD’s do not produce a sinusoidal output which though not a good choice for a general purpose distribution system, is perfectly adequate for a motor.

VI. DETAILED DIAGRAM:





PID Temperature Controller

RESULTS (TABLES/GRAPHS)

Sl No	TEMPERATURE OF SEA WATER In Degree C	OUTPUT FREQUENCY (Hz)	R.P.M OF MOTOR
1	27	50	1026
2	23	48	1020
3	20	42.5	903
4	15	32.3	738
5	10	21.8	543

VII. CONCLUSION:

When operating a centrifugal pump or a fan you can get a fairly big reduction in energy consumption by even a small reduction in rpm of the pump.

Cavitations are another important issue when talking about pumps and dimensioning of pumps. Cavitations inside a pump result in severe damage to the material, especially to the impeller which is often badly damaged. When using a VFD to decrease the pump speed you reduce the chance of cavitations, and the risk of damage to the pump

By far the most commonly used flow controls in pump applications are throttle controls and by-pass loops to control the temperature. As a consequence pumps are running at 100% loads continuously, even though the requirement would be actually about 40% in average. Using these antiquated control methods is as ineffective as controlling a car's speed with the brakes while going at full throttle. In other words, we not only waste energy but also exacerbate the equipment wear. The majority of vessels in operation today and future newbuilds can make substantial energy and cost savings, and dramatically reduce emissions by installing variable speed drives on onboard electric motors.

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Flettner Rotor System

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I. Abstract:

Flettner rotor is an innovative technology that has been proposed as a sustainable solution for energy generation in the shipping industry. The Flettner rotor is a cylindrical rotor that rotates around a vertical axis and generates lift force due to the Magnus effect. This lift force can be used to propel the ship and generate electrical power. In this paper, we discuss the basic principles of Flettner rotor technology, its advantages and limitations, and its potential to reduce greenhouse gas emissions in the shipping industry. We also review some of the recent studies that have been conducted to investigate the performance of Flettner rotor systems in various conditions. The results of these studies suggest that Flettner rotor technology has the potential to significantly reduce fuel consumption and greenhouse gas emissions in shipping. However, the technology is still in its early stages of development, and there are some technical and economic challenges that need to be addressed. In conclusion, the Flettner rotor technology is a promising solution for clean energy generation in the shipping industry, and further research and development are needed to fully realize its potential.

II. Objective:

The objective of this model is to design an innovative transport system design for energy efficiency.

III. Introduction:

Flettner rotors, also known as rotor sails, have gained significant attention in recent years as a potential solution for reducing the carbon footprint of the shipping industry. These rotating cylinders mounted on the deck of a ship harness the power of wind to provide additional propulsion, thus reducing the reliance on traditional fuel sources. In this technical paper, we will delve deeper into the principles of Flettner rotors and analyse their effectiveness in reducing emissions and increasing fuel efficiency. We will also discuss the design and implementation considerations for integrating Flettner rotors onto existing ships, as well as the potential for further development and optimization of this technology in the future.

IV. Working principle:

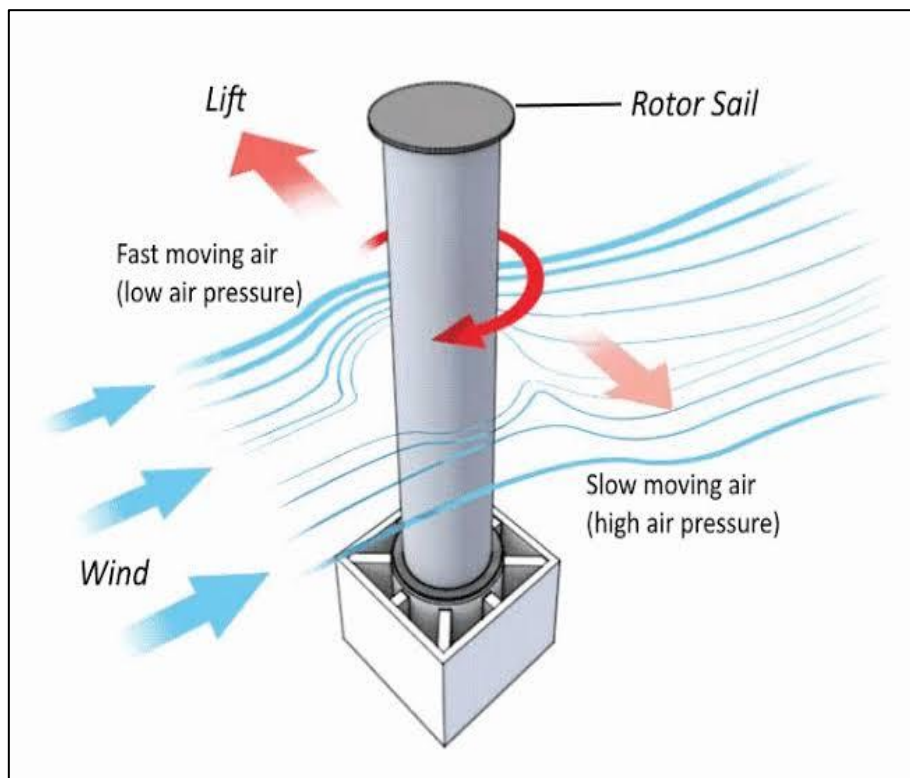
The concept of Flettner rotor is based on the principle of Magnus effect, which describes the relationship between the rotation of a cylindrical object and the airflow around it. When a cylinder is rotated around its axis, the airflow on the side of the cylinder moving in the same direction as the wind is accelerated, while the airflow on the opposite side is decelerated. This leads to a pressure difference between the two sides, creating a net force perpendicular to the direction of the wind.

In the case of a Flettner rotor, this force can be harnesses to provide additional propulsion for a ship. The rotor consists of a tall, cylindrical mast with one or more rotating cylinders mounted vertically on it. As the wind flows past the cylinder, the rotation of the cylinder creates a lift force perpendicular to the wind direction, which can be used to provide thrust for the ship.

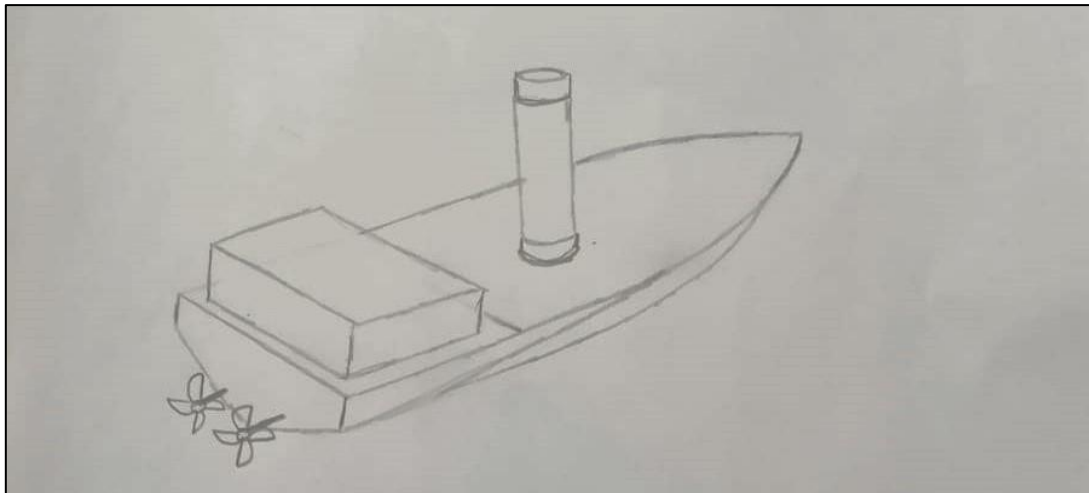
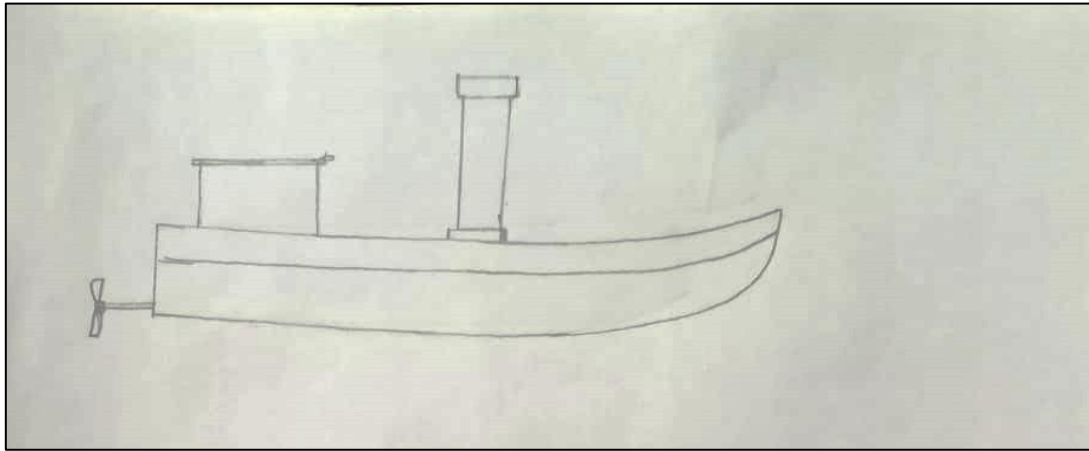
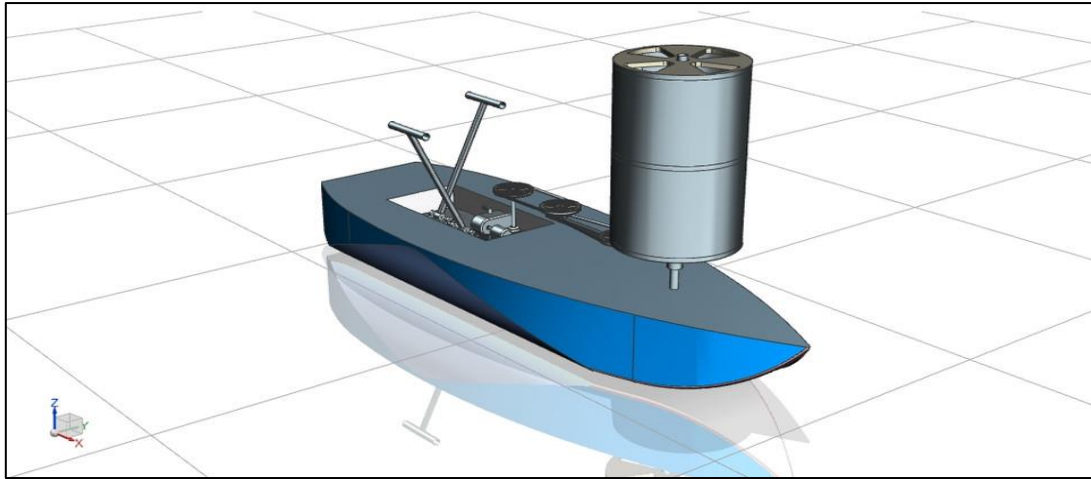
The size and number of Flettner rotors used on a ship can vary depending on factors such as the ship's size, speed, and cargo load, as well as the wind conditions in the area where it operates. Generally, larger rotors and more rotors can provide greater propulsion force, but there are also practical limits to the size and number of rotors that can be used on a ship.

The implementation of Flettner rotors on ships requires careful consideration of several design and operational factors, such as the placement and orientation of the rotors, the control and monitoring systems, and the impact on the ship's stability and manoeuvrability. Additionally, the cost and feasibility of retrofitting existing ships with Flettner rotors must be weighed against the potential fuel savings and emissions reductions.

Despite the challenges and limitations, Flettner rotors have shown promise as a cost-effective and environmentally friendly solution for reducing the carbon footprint of the shipping industry. Ongoing research and development of this technology will likely lead to further optimization and implementation in the future.



V. Detailed Picture:



VI. Conclusion:

Despite several limitations, the Flettner rotor holds promise as a viable solution for reducing the environmental impact of shipping. Further research and development are necessary to optimize the design and increase the efficiency of the technology, as well as to explore its potential applications in different types of ships and routes.

Garboprobe: Intelligent Management of Pollution at Sea

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I. ABSTRACT:

Trillions of bits of plastic are currently polluting the seas, rivers, lakes, and oceans, endangering sea life, ruining ecosystems, and clogging beaches. The hand-cleaning technique is frequently employed for drainage and small streams. Due to the numerous contaminants in the water, this situation is undesirable since it may cause health issues and infections for the operator. Artificial intelligence (AI) control boats can be a powerful remedy for the serious problem of hazardous waste in our environment.

Garboprobe is an amphibian boat used to clean and survey oceans, streams, and drainage systems. The garbage collector boat is designed to be a small, automated watercraft that can collect floating solids and liquid waste from the water's surface and temporarily store them.

Garboprobe offers a special cooperative computer vision-based method for locating sources of hazardous waste according to the particular place of interest.

The purpose of the Garboprobe is to track and eradicate the sources of toxic waste. Garboprobe is equipped with sensors and microcontroller that can detect and record various data points, including the water quality level, water temperature, and gases like methane, CNG, natural gas, LPG, butane gas, and carbon monoxide. It can also send an automatic message to the authorities to notify them and map the level of pollution in the river.

Garboprobe enables us to locate and eliminate potentially harmful waste before it has a chance to do any harm by covering more ground faster and more thoroughly than traditional methods. This technology is especially helpful in remote areas where manual clean-up and survey operations could be challenging or impossible.

Using it we will be able to reduce work labour and death caused due to hazardous waste removal in our rivers and oceans. This is a crucial step towards protecting our environment from further degradation and safeguarding public health and safety.

II. OBJECTIVE:

Garboprobe is designed to reduce the amount of dangerous and destructive waste that is entering our waterways and has been rising alarmingly in recent years. Trash pollutes our ecosystem, including the air, water, and land, causing severe environmental harm as well as human misery. The government of India has taken charge to clean rivers and banks

The Garboprobe design's sole goal is to locate and eliminate the sources of toxic waste. It can also detect oceanic oil spills and assist in controlling them in a specific area.

Our objective to design Garboprobe is to collect and identify potential sources of hazardous and harmful waste in water bodies. Employing technology to recognize and gather hazardous trash before it reaches our environment, assists us in preventing additional harm and contamination to the ecosystem.

To reduce the amount of work labour and deaths caused by hazardous waste removal, we are exploring the use of artificial intelligence (AI) and boats to help with this process. We intend to use Garboprobe boats to lessen the amount of manual work necessary for hazardous garbage disposal while simultaneously lowering the risks involved. This would make it possible to remove dangerous materials from our rivers in a safer, more effective manner.

III. INTRODUCTION:

The dumping of hazardous trash and untreated sewage poses a serious environmental threat to India's sacred river. Stretches of this river are currently covered in toxic foam brought on by industrial waste, endangering the health of millions of people in Delhi and other parts of India.

Garboprobe is specially designed to operate in both shallow and deep waters and is capable of navigating rapidly changing river conditions. This has prompted concerns about the river's safety, and the government should indeed act quickly to address this problem.

In order to address this issue, a smaller trash collector boat has been developed that can collect waste and floating solids from a constrained space, such as a drainage system or a small stream. The trash collector boat may be remotely controlled from a distance and has an automatic conveyor system to gather the floating solids. Additionally, the prototype is user-friendly, portable, and environmentally friendly.

Garboprobe is a specialised autonomous boat made for collecting and analysing floating marine waste. which are often made of plastic, wood, or metal, it can hold a range of trash, including organic and plastic materials. It has tools like nets, scoopers, and other unique debris-collection equipment. Garboprobe is crucial for maintaining the health of our water bodies because they

lessen the amount of trash that ends up in landfills and assist in removing dangerous toxins from the water.

Garboprobe is specially designed to operate in both shallow and deep waters and is capable of navigating rapidly changing river conditions.

IV. CONCEPT AND WORKING PRINCIPLE:

Garboprobe identifies waste using an Ultrasonic sensor attached at the front; it can redirect and float toward waste, it collects the waste from the river and stores it in its storage tanks using a mechanical platform.

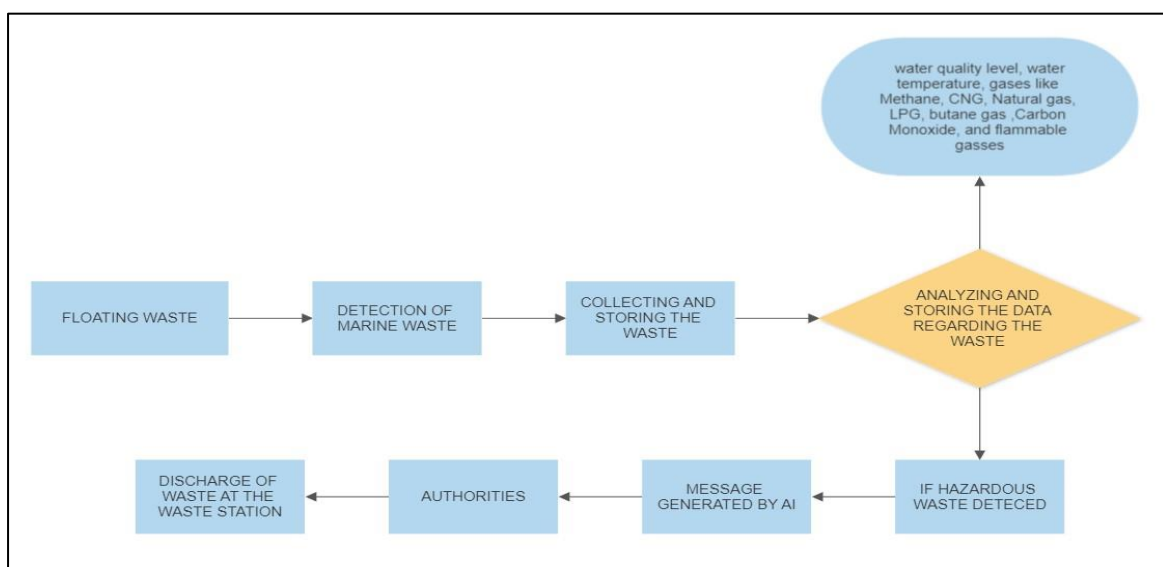
Garboprobe is outfitted with sensors that can detect and record water quality level, water temperature, and gases like Methane, CNG, Natural gas, LPG, butane gas, Carbon Monoxide, and flammable gasses. and other data points.

It is also equipped with powerful cameras, allowing operators to monitor the river from a distance.

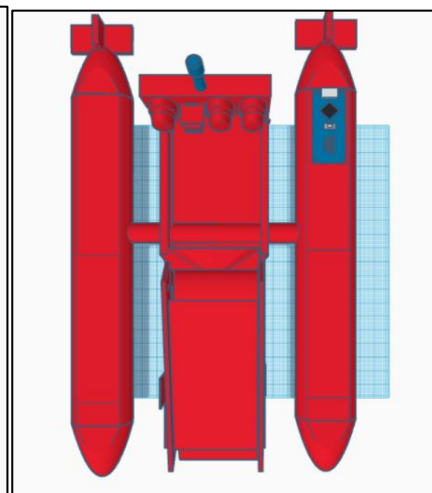
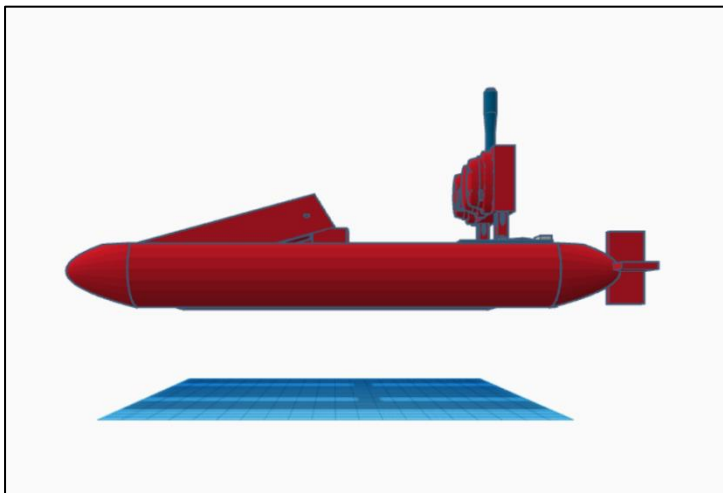
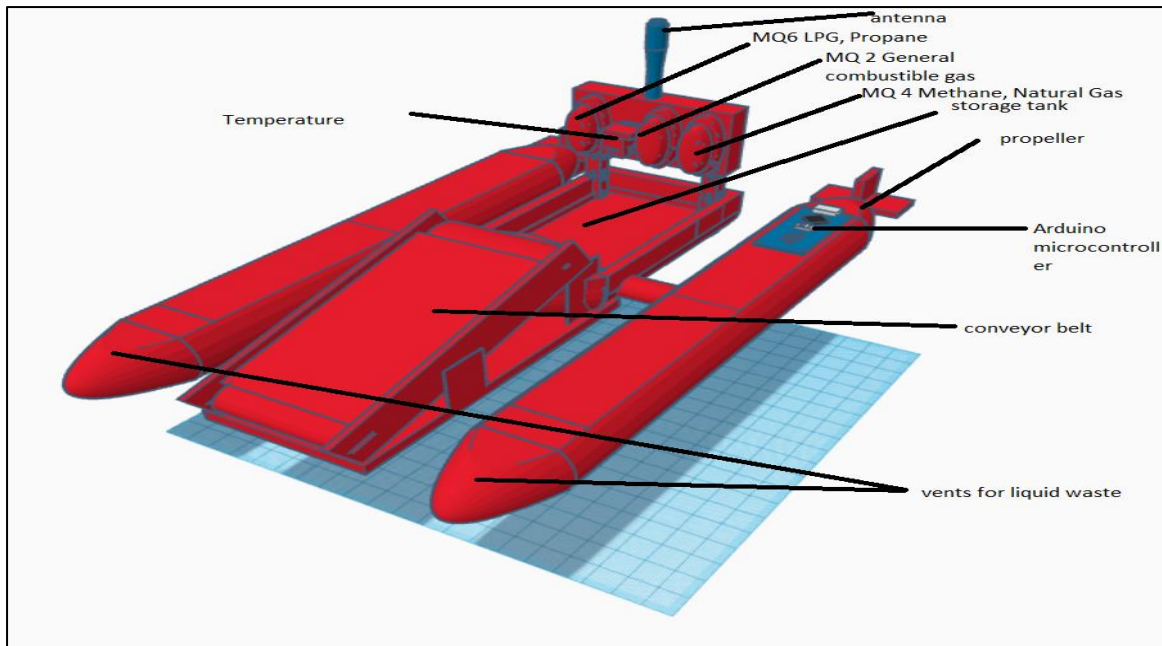
It can also send an automatic message to the authorities to notify them and map the level of hazardous pollutants in the river. By collecting this data, scientists, engineers, and other professionals can gain valuable insight into the health of rivers and the potential risks associated with them.

When monitoring and gathering data from hazardous river settings, the garbo probe, which Can be used for surveying hazardous rivers, will become an increasingly crucial tool. Garboprobe is specially designed to navigate treacherous waters, as well as collect data from these waters.

Garboprobe can become increasingly popular for surveying hazardous rivers, as It provides a safe and cost-effective way to gather data without putting personnel in danger.



V. DETAILED DIAGRAM:



VI. CONCLUSION:

Garbo probe is an autonomous amphibian boat designed to collect and survey floating marine waste in lakes, rivers, and drainage systems. It uses computer vision and ultrasonic sensors to locate hazardous waste, and it can store the waste in its tanks. The boat is equipped with sensors that can detect water quality, temperature, and gases like methane and carbon monoxide. It can also send an automatic message to the authorities to report the level of pollution in the river. The goal of Garboprobe is to reduce the amount of hazardous waste in waterways and reduce the risks involved in manual waste removal. By collecting data and mapping the level of pollutants, Garboprobe helps professionals gain insight into the health of rivers and potential risks.

Hydrogen Generator and Carbon Emission Tester

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I. ABSTRACT:

As times are progressing and we are becoming more stringent about preserving nature and the planet for the future generations we are finding more ways and innovate and make newer modifications in the field of shipping to reduce our carbon footprint and make this industry more sustainable as the years progress.

The main issue we are facing currently is to find a better source of alternative fuel than heavy fuel oil as HFO has its disadvantages like storage onboard, rising costs, declining quality dependence on external sources, as it is a fossil fuel the carbon emissions after combustion are significant, etc. Hence, we have found hydrogen to be a good source of alternative fuel and this is because it has higher energy density compared to HFO. And most importantly the carbon emissions are close to zero, so that is a huge advantage that we must keep in mind. We have tackled the problem of carbon emissions in two parts: -

Part 1.- Modifications that ship builders should make that they can make this shift towards hydrogen fuel (onboard production and consumption).

Part 2 – Steps that current ships can take to reduce carbon emissions without incurring much additional cost or workload onboard.

This is a two-part model that we have made showing the working of the same. And we have also provided ideas on the implementation of the following ideas in the present maritime scenario.

II. OBJECTIVE:

This project is a representation of how our model is going to work onboard. We are showing the major parts of our project here and we will show to you in the end of how effective this prototype is. We aim to reduce carbon emissions on board ships in both ships which are newly getting commissioned into service and ships which are already in commission. As we are also seeing that the current measure to reduce sox and NOx emissions are proving to be non-environment friendly. We aim to introduce hydrogen as a one stop solution to these problems.

III. INTRODUCTION:

The main problem with the usage of heavy fuel oil is that we see the production of carbon emissions, Sox and NOx gasses. These in the long run are the main factors that contribute to natural calamities such as acid rain, climate change etc. We present to you a solution that eliminates the problem itself. This is by the usage of hydrogen as fuel. Since major

modifications are not possible in the ships which are currently in commission, we can closely monitor the ships for their emissions and hence smoothen the transition between ships running on HFO to ships that will be running on hydrogen, more importantly the transition towards a greener future.

IV. CONCEPT:

In order to reduce our carbon footprint and make the shipping industry more sustainable as time goes on and we become more concerned about protecting nature and the planet for future generations, we are finding more and more ways to innovate and make newer changes in the field of shipping.

Finding a better alternative fuel source than heavy fuel oil is our top priority right now because heavy fuel oil has several drawbacks, including onboard storage, rising costs, a reliance on external sources, a declining quality, and significant carbon emissions following combustion because it is a fossil fuel. Because hydrogen has a higher energy density than heavy fuel oil, we have discovered that it is a good source of alternative fuel. Most importantly, the carbon emissions are almost zero, which is a huge advantage that we must keep in mind.

V. WORKING PRINCIPLE:

The main principle we are using is the principle of electrolysis. This forms the basis of our entire project of producing hydrogen onboard. Electrolysis of sea water to produce hydrogen on board ships involves using an electrical current to split water (H₂O) into hydrogen (H₂) and oxygen (O₂) gases. A specialized electrolyzer, commonly made of a proton exchange membrane (PEM), is used to separate the positively charged hydrogen ions from the negatively charged oxygen ions. The process takes place through the application of an electric potential difference across the electrodes in the electrolyzer. The hydrogen ions move towards the cathode, where they gain electrons and form hydrogen gas. At the same time, oxygen ions move towards the anode, where they lose electrons and form oxygen gas. The hydrogen produced through this process can be stored and used as a fuel source for ships.

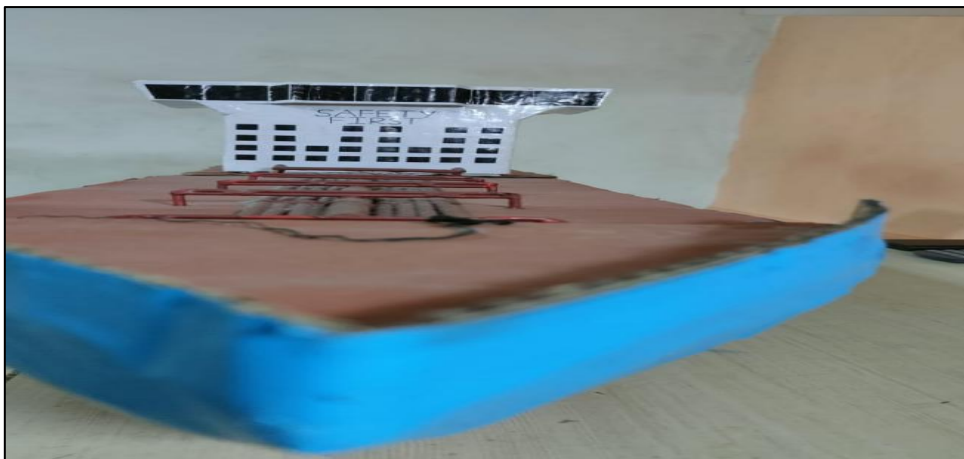
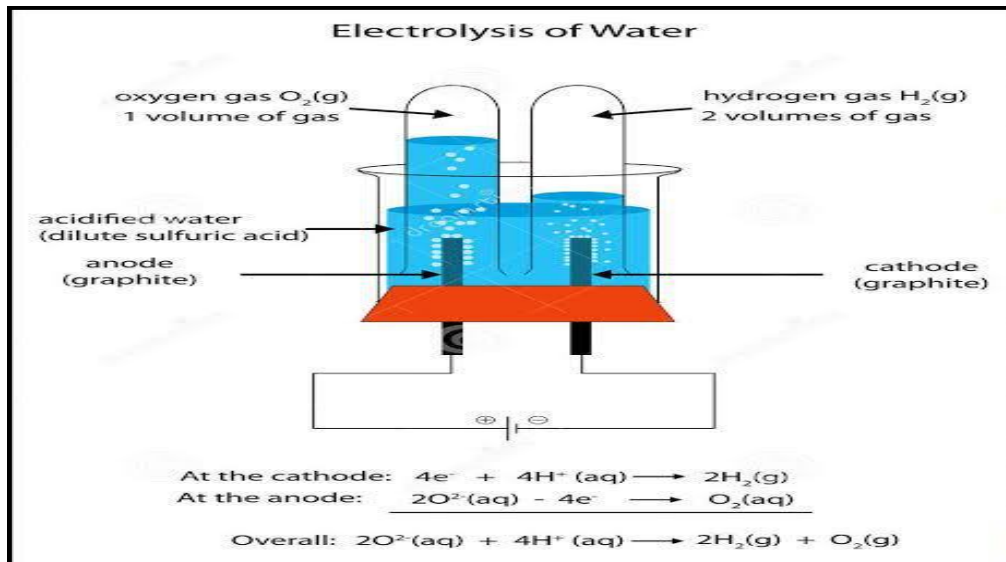
The working principle of carbon emission sensor

The working principle of tracking carbon emissions of a ship through an **MG-811 sensor** and a pellistor sensor involves measuring the levels of carbon dioxide (CO₂) in the exhaust gases of the ship's engines. The MG-811 is a type of electrochemical sensor that uses an electrode to measure the concentration of CO₂ in the surrounding air. The sensor works by passing an electric current through the electrode and measuring the voltage difference across the electrode. As the CO₂ in the exhaust gases reacts with the electrode, it creates a change in the voltage difference, which is proportional to the concentration of CO₂. This change in voltage is then used to calculate the level of CO₂ emissions from the ship. The information obtained through the sensor can be used to monitor and reduce the ship's carbon emissions and improve its environmental performance.

***We have embedded these systems on a replica of a ship to show exactly how and where these systems can be applied.**

VI. DIAGRAM:

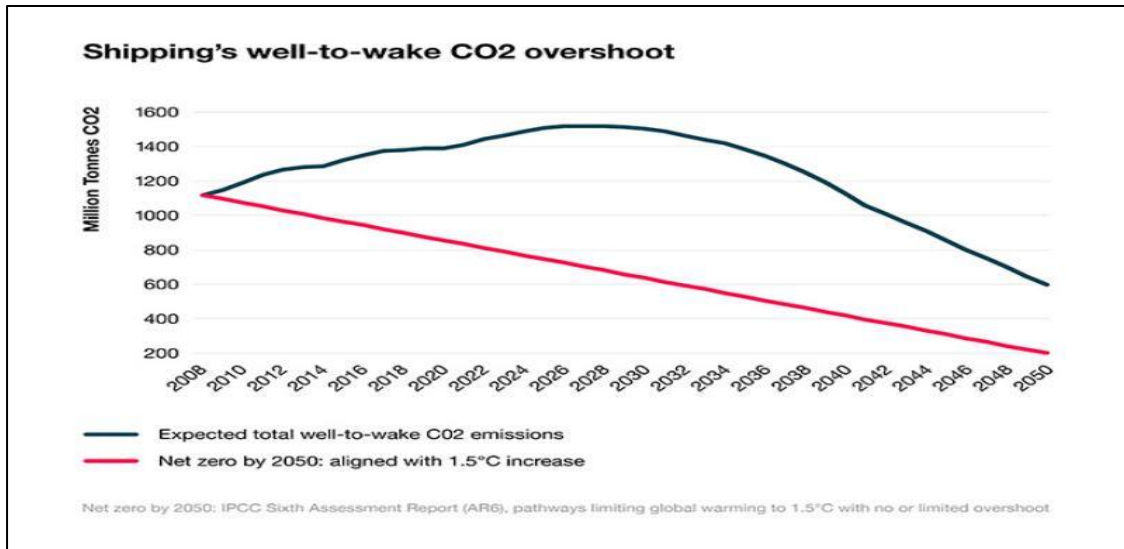
The following diagram shows the basic idea behind the hydrogen generator. We just need to connect the following setup with a battery system which are charged by solar panels to show the generation of electricity onboard.



*The prototype we have made

VII. RESULT:

The graph below shows how we are overshooting the carbon emission as the years are progressing (grey line). The red line shows that if we start using hydrogen powered engines the carbon footprint that will be produced will be significantly lower. This will be the direct result of incorporating hydrogen fuel engines in new ships and carbon emission tester in commissioned ships.



VIII. CONCLUSION:

As we have seen above one of the quickest ways to reduce carbon emissions is by incorporating hydrogen fueled engines on board and the usage of carbon emission testers. Since we are talking about producing and consuming hydrogen on board will be like a one-time investment and the only maintenance, we will require is renewal of solar panels after their life is completed this might seem as a high investment at first but is a more economically viable option in the long run. Carbon emission testers coupled with an AI monitored database will enable authorities to strictly monitor, enforce and inspect ships which emit a high amount of carbon. This way we can implement these ideas and ensure a greener maritime industry in the future.

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Split Rudder Thrust Reversal and Braking System Design (S.R.T.R.B.S.)

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I. ABSTRACT:

The Split Rudder Thrust Reversal and Braking System or S.R.T.R.B.S. is an alternative design approach for the modern semi-balanced rudder used commonly among merchant vessels. As the name implies the design takes inspiration from the aviation industry as well as rudder design innovations from the early 20th century. It fulfils the purpose of an emergency braking device as well as a non-conventional method to provide aft propulsion to the equipped vessel. These two properties of the S.R.T.R.B.S. cannot be mimicked by the semi-balanced rudder system currently in use. The split rudder appendage on the S.R.T.R.B.S. provides the vessel to conduct reverse thrusting manoeuvres by redirecting the flow of water provided by the propulsion system. By these standards the objective of this paper is to introduce the primary principles and working mechanism employed by the S.R.T.R.B.S.

II. OBJECTIVES:

- To innovate a rudder design capable of simultaneous performance in reduction of speed and reversal of thrust while controlling the heading of the vessel.
- To produce an alternative to emergency braking methods such as the crash-stop.
- To further advance the degree of movement available to the vessel without the use of tugs in the aft direction.

III. INTRODUCTION:

Thrust reversal is a process commonly used in aircraft to redirect the high-pressure flow of engine thrust towards the direction of the aircraft to reduce its speed as much as possible during an emergency event such as a rejected take off, while landing and in some cases during flight. This function of the aircraft is performed with the help of appendages such as clam-shell doors, cold-stream process, bucket doors and by changing the pitch of the propeller. The latter two systems are already being employed in smaller boats and controllable pitch propulsion vessels. A split rudder is a design used in an aircraft where two independent rudder flaps are integrated on the vertical stabilizers to aid in reduction of speed as an additional airbrake. The split rudder formation is employed by means of mechanically actuated cable system as opposed to a hydraulic system as vertical stabilizer cannot house the hydraulic machinery outside the control surface. Famous implementations of this design have been used in the Russian and American space shuttles as well as smaller recreational aircrafts as it provides beginner aviators areas for error. This design also uses the properties of a kitchen or “bucket” rudder designed by John G.A. Kitchen to conduct the thrust reversal process. The kitchen rudder system was invented in the early 20th century and has been employed of smaller crafts ever since its potential was

recognised by mariners and aviators alike and has been implemented in the gate rudder design and bucket thrust reversal in jet aircraft respectively. In the current work we investigate the combination and integration of both split rudder and kitchen rudder designs into a common semi-balanced rudder system used in most merchant vessels.

According to sources such as Allianz Safety & Shipping as well as notable sources cited by IMO, machinery failure is accounted for more than one in three incidents globally, this includes loss of control of the vessel which can lead to collisions with enormous consequences. A majority of these incidents are results of human error and late response that results in action not taken in due time, such instances call for emergency manoeuvres necessary to avoid collision by forms of reduction of vessel speed and control, positive to the situation of the vessel in danger. Measures taken commonly in such situations are high and low frequency rudder cycling, turning under full helm, inertia stop and the infamous crash stop.

The crash stop manoeuvre is one of the last measures taken by the OOW to avoid collision and is executed by ordering the engine room to go full astern resulting in reverse propulsion of the propeller against the direction of the vessel. This manoeuvre is termed infamous above due to its multiple disadvantages involved as the last straw action that is taken by the officer in watch, disadvantages of the crash stop manoeuvre includes severe stress imposed on the main engine, low efficiency due to creation of vortices behind the propeller, loss of directional control of the vessel and delayed response time of the vessel. In order to combat these faults, the S.R.T.R.B.S. single-handedly uses the rudder to slow down the vessel and engage controlled thrust reversal.

IV. CONCEPT:

The concept behind the S.R.T.R.B.S. involves the use of control surface panels integrated into the semi-balanced rudder system and is actuated using hydraulic power to pivot the panels against the incoming water to redirect the flow. The system is held in place by a base plate that extends from the rudder horn partially while the area directly below the rudder horn is intact to the base plate and is not involved in the movement. The straight edge running parallel to the actuator and perpendicular to the root chord and tip chord draws the boundary required to separate the moveable and stationary panels on the rudder plate. The moveable panels located port and starboard of the rudder plate is pivoted horizontally by the basis of a hinge system integrated at the trailing end of the rudder plate. This process is actuated using two independent subsea hydraulic rams that run from the base plate to the moveable panels. The hydraulic lines required for the functioning of the rams run through the rudder stock and into the baseplate where they connect with the subsea hydraulic rams. Once actuated and in control the two flaps can act independently or in communion to perform multiple vectoring manoeuvres or thrust reversal.

WORKING PRINCIPLE:

The S.R.T.R.B.S. works on the principle of thrust vectoring, which in this case mainly involves thrust reversal. A thrust reverser allows the generation of a rearward-directed thrust force when deployed. It reduces the overall stress exposed to the main engine by allowing the propellers to continue directing the flow forwards and not abruptly stalling the engine. An increase in vessel speed forward can be implemented to simultaneously redirect the thrust in the opposite direction therefore achieving an increase in efficiency of thrust reversal and not causing irreversible damage to the engine. A common problem faced during the process of going full astern at the crash stop position is the creation of a partial vacuum on the trailing end of the propeller that is caused due to the inertia of the vessel moving forward and the rotation of the propeller acting aft resulting in low efficiency from the reduced intake of water. This phenomenon is diverted while using the S.R.T.R.B.S. Another advantage of the S.R.T.R.B.S. over the crash stop procedure is its ability to provide directional control over the vessel as the flow of water passes over the rudder and the rudder remains functioning during the deployment of control surface panels from the base plate.

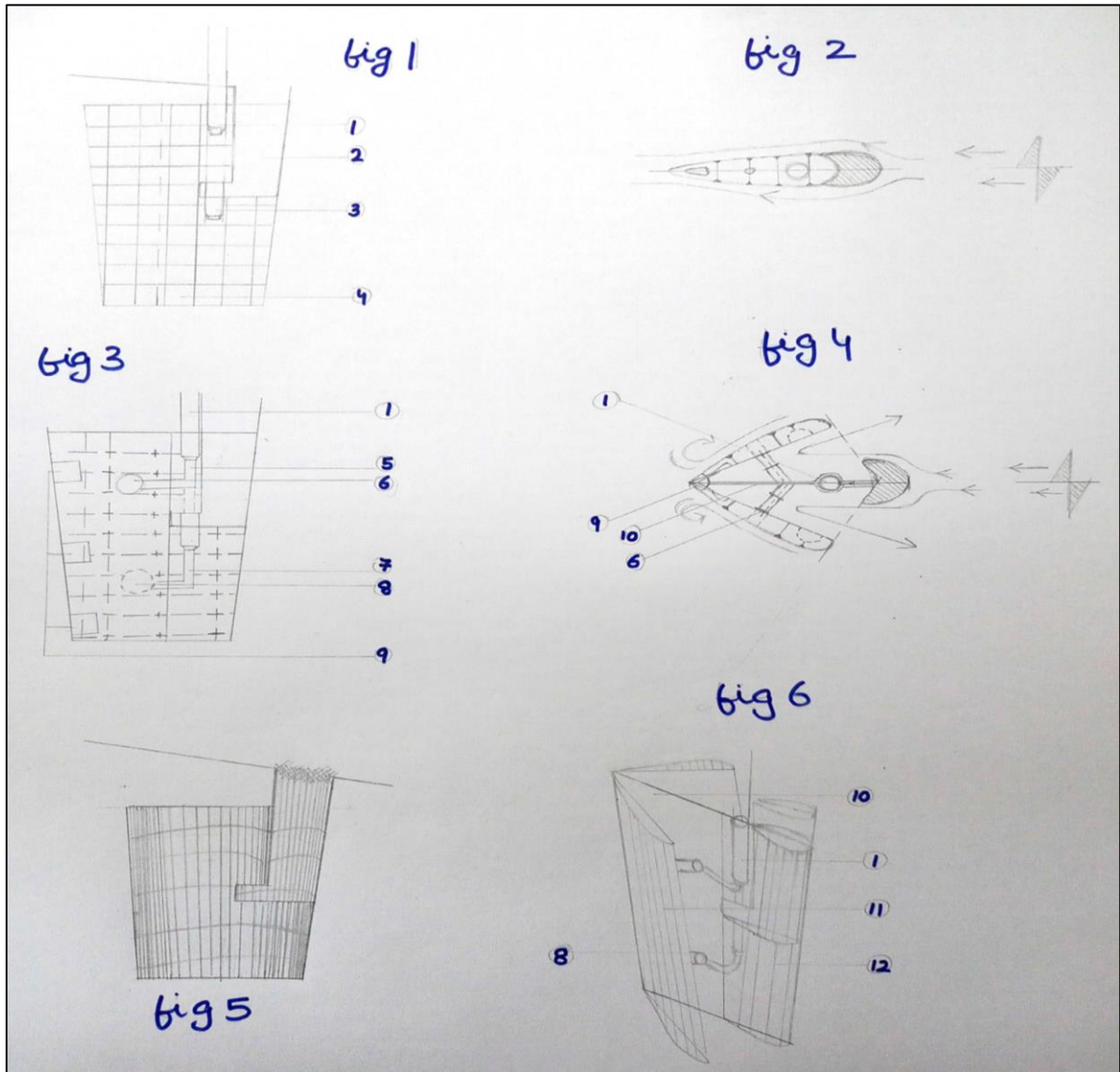
V. DETAILED DIAGRAM:

- 1) Rudder stock
- 2) Rudder horn
- 3) Pintle
- 4) Rudder plate
- 5) Hydraulic line 1
- 6) Position of hydraulic ram 1
- 7) Hydraulic line 2 (optional)
- 8) Position of hydraulic line 2 (optional)
- 9) Vertical stabilizing hinges
- 10) Rudder base plate
- 11) Moveable rudder plate appendage
- 12) Immoveable rudder plate appendage

VI. CONCLUSION:

Statistical evidence shows us that there has been a gradual but steep decline in the number of ship related accidents in the maritime field, but the existence of the few incidences should be enough reason for us to strive towards the development of safety modules into the maritime industry. Collision related incidents are a key group that is found in all maritime casualties. Developing this region allows us to implement safety systems that can counteract some of the causes leading to this. One of the main contributors to collision is the loss of control over the vessel and its speed. In order to quickly integrate a safety system in the already existing merchant vessels the split rudder thrust reversal and braking system (S.R.T.R.B.S.) can be used.

The design involves an easy integration of control surfaces and hydraulic actuators to perform thrust reversal and vectoring manoeuvres in an emergency. This modification can be limited to the loss of hydraulic control if a high thrust is provided aft and is subjected to further research in the theoretical aspects proposed in this paper before practical employment.



Digitalization of Transportation and Logistics

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I. ABSTRACT:

A tech-based logistics company specializes in the transportation and delivery of goods using innovative technology solutions. The company uses data-driven algorithms to optimize routes and delivery times, reducing costs and increasing efficiency. our platform integrates with existing systems, allowing real-time tracking and communication with customers. The company prioritizes sustainability, utilizing efficient delivery methods and minimizing damage through smart packaging solutions. The goal of the tech logistics company is to revolutionize the delivery industry, providing fast, reliable and efficient solutions to meet the evolving needs of businesses and consumers.

II. OBJECTIVE:

Focus on helping your customers through market turbulence and leave carrier connectivity and shipment workflow automation to us. The only platform that can provide you with the visibility, analytics, and workflow capabilities you want, seamlessly integrating with your systems and partners, is Movement by Ocean freight Global. Finally, real-time supply chain visibility that goes above and beyond shipment tracking to deliver trustworthy insights that save your team time and money

III. INTRODUCTION:

Sticking to the theme of the topic we have decided to create and publish a web page on the internet which will explain our model

The web page will simulate a shipping or logistics company and will have all the features expected to be seen in a professional company website

Such as but not limited to

- Real time route tracking
- Placement of order
- Ship schedule
- About the company
- Routes and dates
- Technology backed services the customer can avail

In addition to this web page there will be a physical model of the supply chain structure of the shipping industry on the over view of a warehouse-to-warehouse structure and this will be used to explain the various web pages and how it will benefit both the consumer and operator

There we will also explain how a tech backed company will reduce the work force and reduce the error from the shipping company side making transportation of goods more reliable

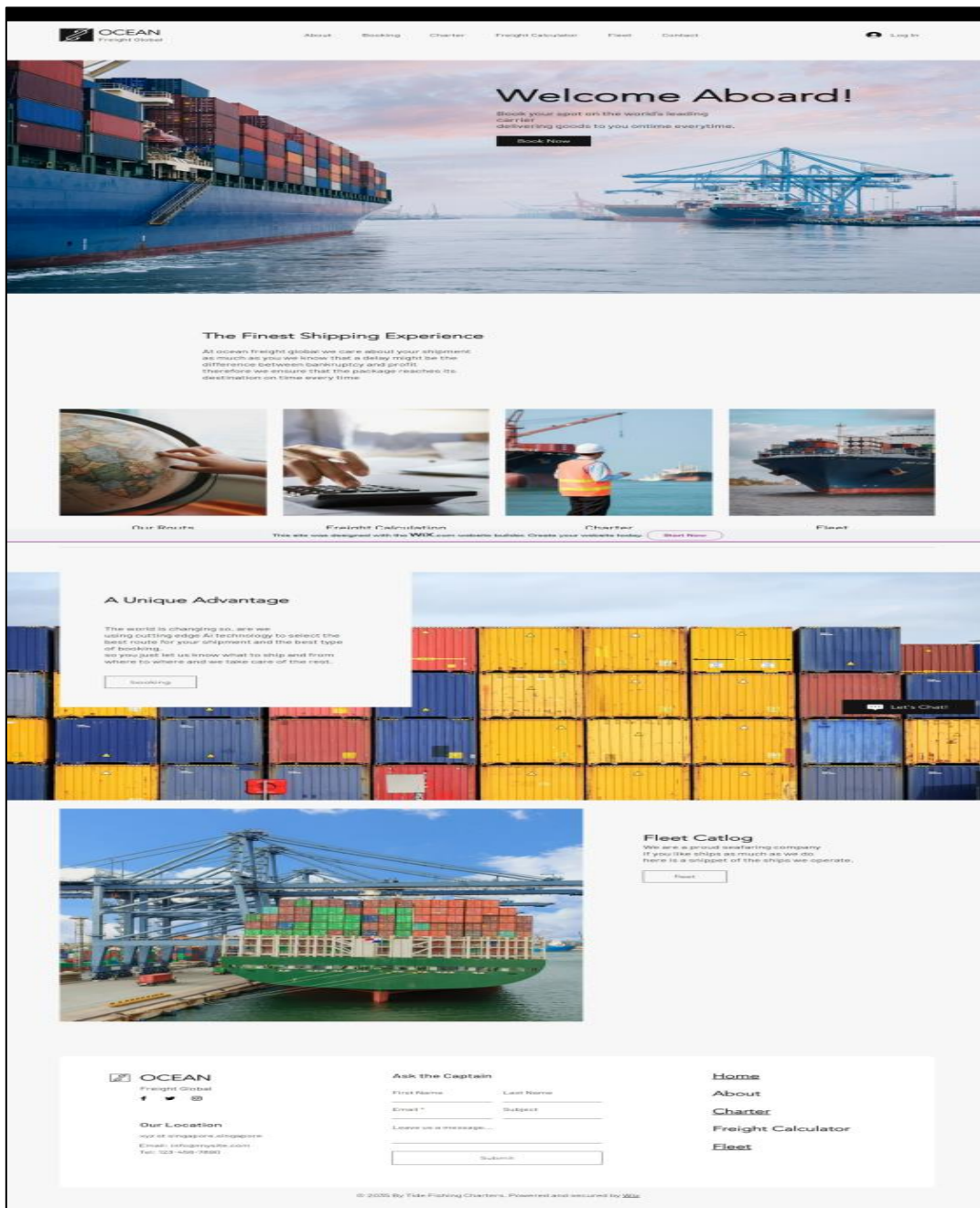
IV. CONCEPT:

We believe that technology is the future of business so we are trying to create a website which replicates a company which uses AI and ML backed technology to provide the consumer with real time data and optimized personal solutions for the consumer to choose from for the transport of his/her goods in the fastest and the most efficient way

V. WORKING PRINCIPLE:

Application of AI and ML algorithms with the addition of existing logistics frame work to provide the best solution for the consumer.

VI. DETAILED DIAGRAM: (DIGITAL DIAGRAM):



VII. RESULTS (TABLES/GRAPHS):

a) **IMPROVED PERSONNEL PRODUCTIVITY-** Machine-learning delivers quality, order-level data with less time spent manipulating spreadsheets.

b) **PROACTIVE MANAGEMENT-** ETAs and alerts focus teams on what's important while predictive insights keep you ahead of the curve and set you apart from the competition.

c) **REDUCED LOGISTICS COST-** Avoid burdensome D&D fees with better and more timely visibility, reducing excessive costs from unnecessary expedites.

d) **REALTIME GLOBAL VIEW OF PORTS-** Gain real-time insights to port, terminal, and vessel activity to help manage port congestion, blind spots, and black swan events, Port Intel delivers global, accurate, real-time intelligence on port and vessel activity so supply chain professionals can plan proactively, respond to exceptions, and meet customer expectations. Use macro global views to understand regions of risk and changes in congestion for any lane and any port, globally. Stay informed for any port of interest with an interactive web application. Gain real-time insights on container import and export dwell, vessel anchor and berthing dwell, vessel counts, congestion, and more. Get the latest information on global ports via API for integration with your TMS, ERP, Planning, or system of record.

e) **SERVICE VOYAGE DETAILS-** We provide you with all shipment details, e.g. departure and arrival dates, service names and codes, as well as vessel and voyage numbers from all shipping lines. This ensures smooth operational handling for your cargo and supply chain management. Discover all connecting services and feeder trans-shipments that are available to get your cargo from A to B with detailed information for up to two trans-shipments, including trans-shipment port information.

f) **OPTIMIZED PLANNING WITH BARGE VISIBILITY-** Accurately assess and optimize capacity for barge moves with accurate water depth data for inland waterways, improving reliability of barge legs of multimodal shipments.

g) **REDUCED IT AND OPS COST-** With Ocean freight global's easy-to-use SaaS platform, you can finally retire inflexible, obsolete legacy systems that monopolize development time and require complex integrations.

VIII. CONCLUSION:

With visibility into your supply chain operations, you can take the right actions at the right time and be in control of your logistics operations. OCEAN FRIEGHT GLOBAL can get you there and keeps your cargo flowing and transitioning towards integrated supply chain management, mass flow allows you to know everything, upload and share post, track activities in progress, manage all your bookings from one place, monitor crucial processes, documentation, and cargo milestones. It assists you in overcoming challenges and disruptions, brings end-to-end visibility and control to your supply chain operations which is easy and quick to implement. Reduction manual work due to introduction of digitalization in our supply chain helps you execute your supply chain as planned and gives you access to performance data so you can work smarter not harder.

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Marine Pollution Preventing Ro-Boat : Marine Shield

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I. ABSTRACT:

This project focuses more on “Remote Controlled Unmanned Marine Cleaning Bot.” Marine pollution caused by oil spills from merchant ships is a significant environmental issue. These spills not only harm marine life, but they can also have devastating impacts on local communities that depend on the ocean for livelihoods and recreation. The problem is further compounded by the fact that merchant ships often carry large amounts of oil, which can result in large-scale spills that are difficult to contain and clean up. Despite efforts to prevent spills, they continue to occur, often due to operational errors, equipment failure, or natural disasters. To mitigate the impact of oil spills from merchant ships, it is essential to implement and enforce strict safety regulations, invest in the development of new technology to prevent spills, and promote collaboration between industry, government, and environmental organizations.

II. OBJECTIVE:

To change the conventional methods based on manual basis to control the marine pollution produced by merchant ships as well as shoreside. This all-remote operated floating robot required less manpower, less risky, less costly and less time-consuming method. This is eco-friendlier as it is equipped with a solar tracking device to recharge it with abundant natural resource.

III. KEYWORDS:

Marine Pollution, Oil spills. Remote controlled.

IV. INTRODUCTION:

The Over two thirds of Earth's surface is covered by water; less than a third is taken up by land. As Earth's population continues to grow, people are putting ever-increasing pressure on the planet's water resources. In a sense, our oceans, rivers, and other inland waters are being "squeezed" by human activities so their quality is reduced. Poorer water quality means water pollution. This invention relates to skimmer boats, i.e., work boats for collecting and disposing of floating solid waste materials and oil pollution in harbours as well as in sea.

The invention is more specifically directed to merchant vessels equipped with means for picking up floating debris or oil spills storing the debris on the vessel, and means for discharging the waste products from the vessel to a storage area, which may be ashore or which may be another vessel such as barge.

This robot “Marine shield” used in that places where there is waste debris and oil contamination in the water body which are to be removed. This machine is consisting of waterwheel driven

conveyer mechanism which collect & remove the wastage, garbage & oil spillage from water bodies. This also reduce the difficulties which we face when collection of debris take place. A machine will lift the waste surface debris from the water bodies, this will ultimately result in reduction of water pollution and lastly the aquatic animal's death to these problems will be reduced. It consists of Belt drive mechanism which lifts the debris from the water. The use of this project will be made in sea, rivers, ponds, lakes and other water bodies for to clean the surface water debris from bodies.

V. CONCEPT:

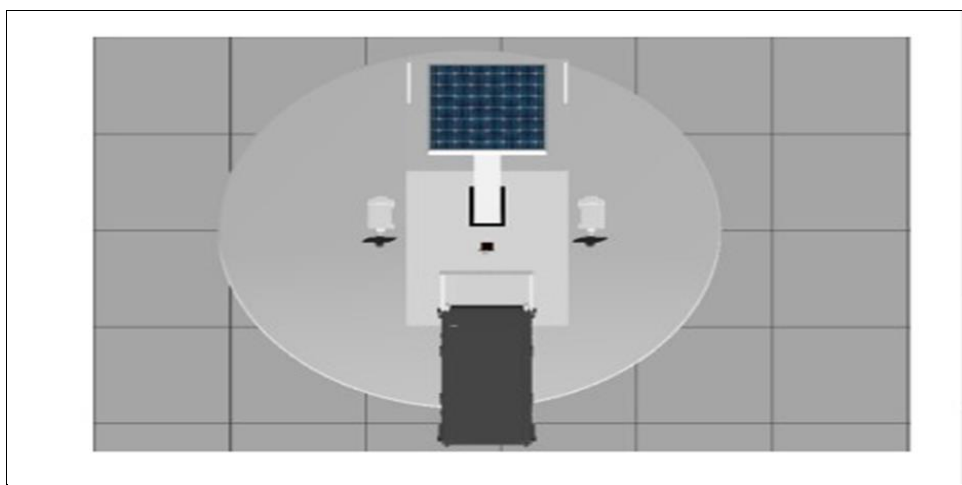
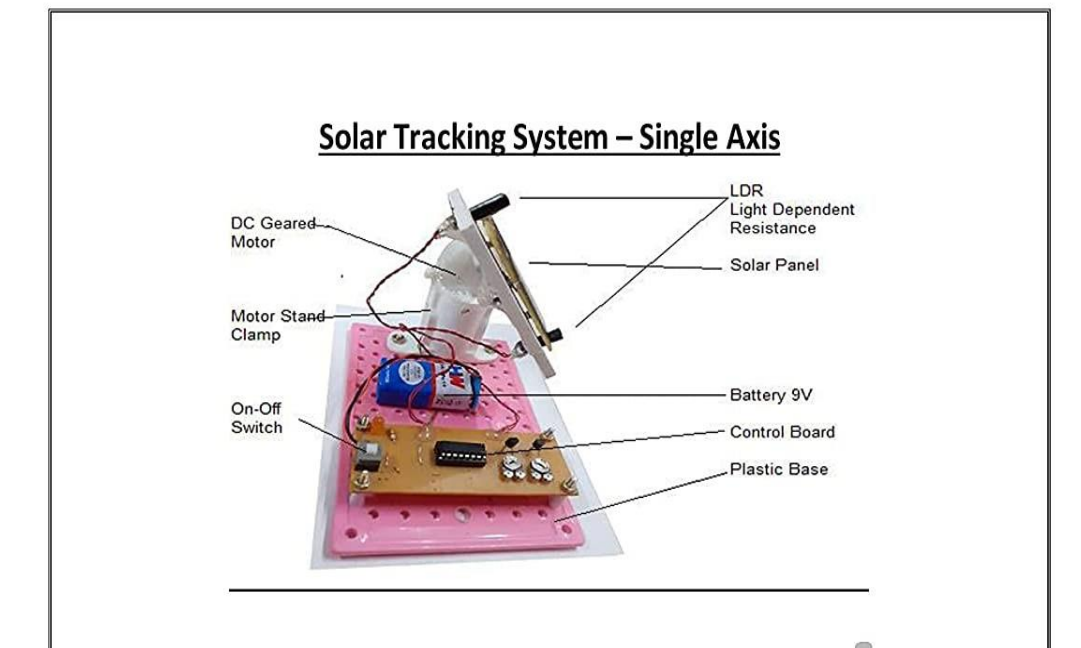
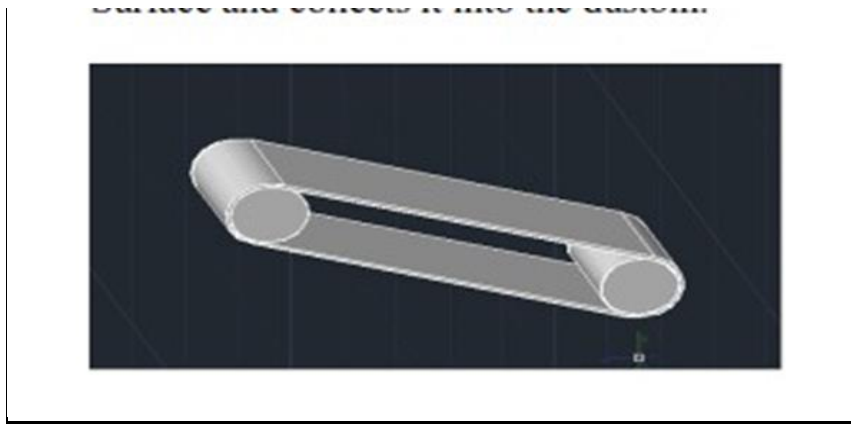
Our project itself is 'Eco-friendly' as its primary aim is to reduce water pollution by cleaning of water resources, thereby helping the environment. In addition to that one of its secondary aims which include remotely controlling the system reduces the human interaction with the polluted water thereby reducing the diseases which can affect them. The working principle of our system viz. using conveyors, chain drive, coupling & motors for cleaning & collecting the river waste is by far the most 'Effective' method. Also, the use of remote controller to control the entire system further increases the effectiveness.

Collecting Mechanism is employed in our project to beat real time issues as thanks to water tension garbage is difficult to collect. By using this four-bar mechanism, it rotated at a particular angle intended to gather the rubbish for the model. it's two windows open and shut as the user wishes using remote to ON and OFF the mechanism. Water wheel is bolted on a shaft which is placed aboard the frame. The aim of a water wheel (propeller) is to manoeuvre the machine forward or backward on water. Motor is used to rotate the water wheel with the assistance of a chain drive mechanism. In this project tracking system is additionally implemented which is helpful to regulate angle of solar array with reference to sunrays. So that we get more solar output.

VI. WORKING PRINCIPLE:

In this project the foremost aim of this machine is to absorb the oil film from the water surface and prevent the oil film from spreading onto large surface area. After the absorbent pad is fully soaked we can bring it back to replace it with a new one and again sent it back. It consists of an arrangement of conveyor which is placed on the shaft of the motor. Due to rotation of motor conveyor rotated. Because the conveyor is moved, it collects oily water mixture from the surface or any debris. because the machine is placed within the water the oil film in water will get lifted. Propeller is used to drive the machine on the river and run with the help of a PMDC motor. The total electrical devices are controlled by an RF transmitter and receiver which are used to manage the machine remotely. Collecting Mechanism is employed in our project to beat real time issues as thanks to water tension oil film is difficult to collect. By using this four bar mechanism, it rotated at a particular angle intended to gather the rubbish for the model. it's two windows open and shut as the user wishes using remote to ON and OFF the mechanism. Water wheel is bolted on a shaft which is placed aboard the frame. The aim of a water wheel (propeller) is to manoeuvre the machine forward or backward on water. Motor is used to rotate the water wheel with the assistance of a chain drive mechanism. In this project tracking system is additionally implemented which is helpful to regulate angle of solar array with reference to sunrays. So that we get more solar output.

VII. DIAGRAM:



Solar tracking device for self charging

2D

Solar Panel



Batter
Charger

12 V Battery



DC Motor



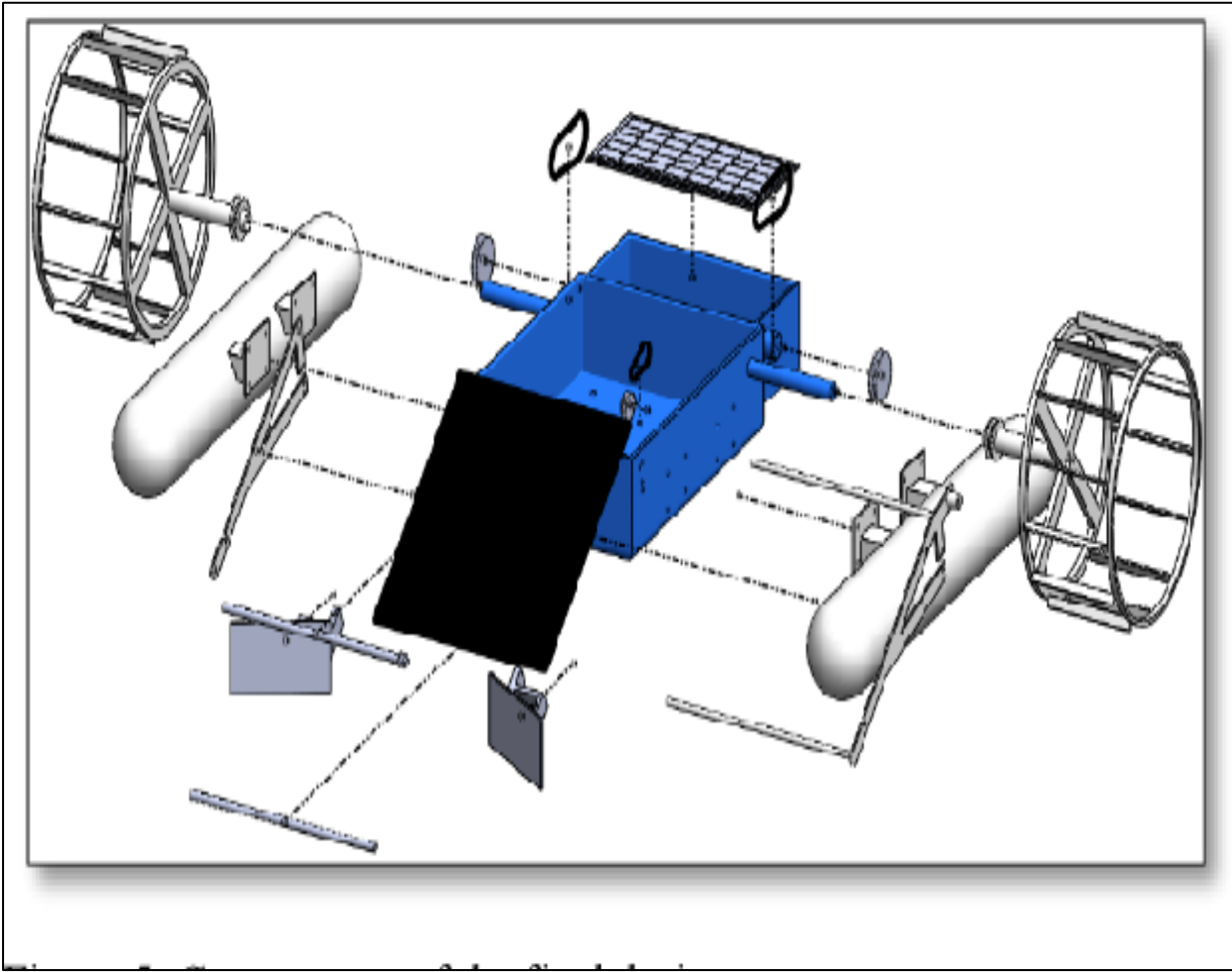
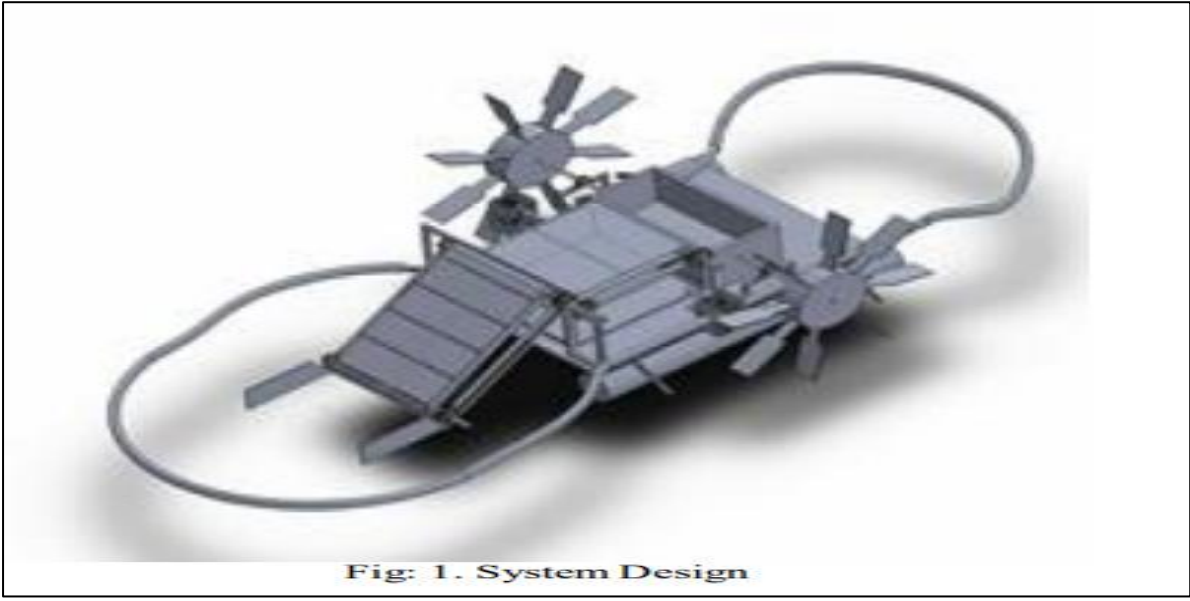
Chain
Sprocket

Block Diagram



Complete Working Model

3D



VIII. RESULTS/OBSERVATION:

During the project, we learned many things and made various observations. A brief summary of the observation made is as follows. The efficiency of the traditional water cleaning mechanism is too low thus, we observed that by replacing the traditional method with this water cleaning mechanism could increase the efficiency drastically with minimum expenses.

IX. CONCLUSION:

This project emphasizes supply flexibility in operation. This is often easy to operate and the price of maintenance is low. Hence this project “Remote Controlled Unmanned Floating Cleaning Machine” is usually designed to form a system considerably economical and helpful to get rid of water impurities like plastics, trashes, water debris and oil spills which is floating on water surface. This is mainly very useful maintaining human health and for increasing the lifetime of aquatic animals.

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Integration Of Sensors in Navigation, Guidance and Safety

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I. ABSTRACT:

To understand these advances in the smart ship, there are 4 main elements to be understood namely, navigation, guidance, physical ship and control. Together these 4 elements form the backbone of the sensor applications on a ship. Sailing the smart ships with increased sensors would help to ensure safe and efficient sailing speed where the power is calculated and proposed to the skipper based on the ETA desired. The sensors would help us to provide with the real time knowledge about the following parameters which would make sailing more efficient.

- The ship, including its current status, position, direction and speed
- Ship to ship interaction
- Sailing environment

This type of sailing would help in lower fuel consumption and lessen the human intervention which will indeed lower the costs of operating the ships. This sailing would help to avoid unnecessary idle hours on the ports and would make better use of the acquired time.

We have modelled our approach based on the Rolls-Royce Intelligent awareness system. Watch keeping today on the vessel bridge predominantly relies on human senses but risks such as human fatigue prevail and visibility is often restricted particularly at night, during adverse weather or in congested ports. Annually more than 100 people lose their lives in maritime accidents, 3000 ships are involved in incidents each year (3145 in 2017) and almost 90% of marine accidents are caused by human error.

Intelligent Awareness brings reliable situational awareness to Vessel Bridge in the form of intuitive user interfaces, allowing the captain to shuffle amongst four user modes; Virtual Reality 2D and 3D modes, Augmented Reality mode and Precision mode. The IA data can also be streamed to head office onshore, enabling advanced fleet management. Wearables are electronic technology or devices incorporated into items that can be comfortably worn on a body. Wearable devices can help improve safety while enhancing the productivity and connectivity of workers in the field by delivering data, documents and applications in real-time.

II. OBJECTIVE:

Rolls-Royce has unveiled an Intelligent Awareness (IA) system that uses multiple sensors with intelligent software to mitigate against the safety risks navigators face when operating vessels at night, in adverse weather conditions or in congested waterways.

Smart wearable provides personal safety of crew with the help of sensor technology imbedded in it which help alert ship about the situation of Man Overboard.

III. INTRODUCTION:

The system combines state-of-the-art technology including advanced LIDAR, radar, AIS with cameras and advanced software, much of it new to the marine commercial sector. Apart from hardware such as the sensors and camera's, this also comprises highly sophisticated software algorithms with machine learning and intelligent fusion of data allowing the system to detect and identify, both moving and static objects in vessel surroundings.

IV. CONCEPT:

What IA does is fuse data from multiple sources to provide a comprehensive overview of the vessel's external situation in four user interface modes; virtual reality (2D and 3D), augmented reality and precision mode. The technology creates a 3D map of a vessel based on Light Detection and Ranging (LIDAR), which is a remote sensing method that uses light in the form of a pulsed laser beam to measure distances. It can be linked to GPS data to create 3D environments that allow crews to 'see what the human eye cannot'. Smart wearable provides personal safety system of a crew in case of accident or Man Overboard. The system

We plan to integrate this system thesis into our model in threefold approach –

- Using **THERMAL SENSORS** as an anti-piracy measures- we plan on fitting an array of thermal cameras on the ship's hull which would be calibrated to be triggered under a specific range of temperature to prevent unnecessary constant alarm.
- **WHALE PROTECTION PROGRAM**-A unique blend of sensors will be used to prevent collisions between ships and the blue, humpback, and fin whales that migrate through that narrow and very busy waterway. Called 'Whale Safe,' the system combines acoustic buoys that listen for whale sounds with whale sightings by naturalists and guides. It overlays that data with a whale habitat model developed using data collected from 104 satellite-tagged blue whales to determine likely whale locations. That information is sent to satellites that downlink it to ships in the channel to help them avoid whale collisions
- **SAFE LOCK OPERATIONS**- Sailing through the locks and bridges would be very efficient as the coordination between the ships and locks and bridges would be achieved through sensor technologies. The communication between a smart ship and smart lock/bridge help as the sensors would inform the exact status of the ship such as time of arrival and sailing schedule to book a slot prior to the travel. Now the lock/bridge would communicate back with the full proof plan. This would make the operations smoother.

According to the International Labor Organization (ILO), every 15 seconds a worker dies from a work-related accident or disease and 153 workers have work-related accidents. With more than 2.3 million deaths per year resulting from industrial accidents and diseases, it's clear why there is a keen interest in technologies that improve safety. Wearables are electronic technology or devices incorporated into items that can be comfortably worn on a body. These wearable devices are used for tracking information on real time basis. They have motion sensors that take the snapshot of your day to day activity and sync them with local data base on ship and upload data at regular intervals on a shore based server. This would involve the use of block

chain to efficiently store the data as well as protect the privacy of all users as this data will be in a continuous cycle, never being stored in data banks precluding all concerns of user data privacy.

We have based our approach on the ideation of a Norwegian maritime IoT company SCANREACH that introduced an innovative solution to on-board emergency situations. Its new In: Range service has been dubbed ‘Superman’ by the company’s chief commercial officer, thanks to its ability to quickly locate members of the crew on a vessel or offshore installation in real time.

As part of the programmed, each member of the personnel is given personal bracelets, connected to interior and exterior sensors on the vessel, which allows people from any location – such as fleet management offices, shipowner offices, insurance companies, coastal services and rescue departments – to have an overview of the team and, if need be, intervene in a targeted and precise rescue operation.

We have taken this one step further and plan to integrate this into essential shipboard operation such as –

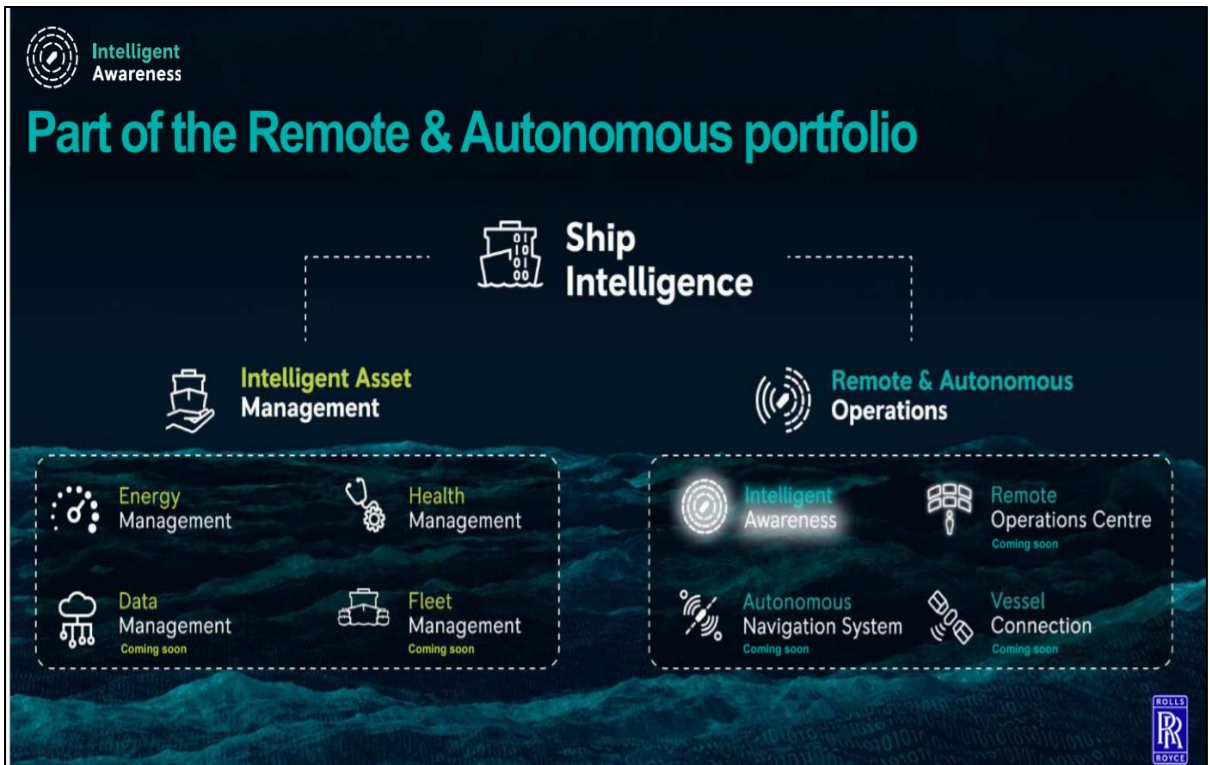
- **Dead man alarm-**
This would take the dead man alarm one step forward by not only having the duty engineer give prompts to the bridge every few minutes but also continuously tracks his vitals giving a more complete idea of engineer’s condition.
- **Fall detection (man overboard)-**
This makes use of three axis accelerometer which can be found on any and every wearable and integrates it into a man overboard scenario. This would provide for a very early warning and detection if any such case arises not relying visual cues by officers that might happen to witness the incident. It also provides the accurate location of the wearer leading to quicker rescue operation.
- **Entering enclosed spaces-**
Again thus would provide live tracking of vitals of any engineer that enters the enclosed spaces and knowledge about which specific personnel in the area.
- **Apart from this the essential benefit that wearable technology offers in today’s modern world would come bundled in like- heart rate monitor, SPO2, Sleep tracking, activity tracking, stress tracking, calories tracker etc.**

V. WORKING PRINCIPLE:

Together there are 4 elements that forms the backbone of the sensor application in ship namely, navigation, guidance, physical ship and control.

Wearable -3 axis accelerometer detects movement and tracks direction. 3 axis accelerometer is the most common sensor that you will find inside a wearable. This sensor can track forward and backward movements, sense gravity and determine body’s orientation, position and also rate of speed change.

VI. DETAILED DIAGRAM:



VII. RESULTS (TABLES/GRAPHS)



VIII. CONCLUSION:

The use of sensors will provide an excellent opportunity to improve the efficiency and safety of ships. Collecting high quality ship data with reliable sensors would help in optimizing the life cycle of the vessel.

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Submerged Tube Type FWG

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I. ABSTRACT :

A substantial amount of fresh water is consumed in a ship. Around 70 litre/person/day of fresh water is being used by the crew and in a passenger ship; consumption can be as high as 225 litre/person/day. Machinery spaces need water for cooling system that may be fresh water or distilled water but distilled water is essential for steam plant where there is a water tube boiler. Nowadays, it is common practice to take on only a minimal supply of potable water in port and to make up rest by distillation of sea water. The saved storage capacity for water is available for cargo and increases the earning power of the ship. A fresh water generator system is sufficiently reliable to produce continuous and unattended operation, the water needed for the engine room and domestic consumption.

II. OBJECTIVES :

To demonstrate the working of a Submerged Tube Type Fresh Water Generator.

III. INTRODUCTION:

The model will be a simple working model.

It will be an energy efficient model.

It will be easy enough to explain and demonstrate the working step by step.

Person not having knowledge of the topic should be able to understand it's working.

Since the model will be consisting of transparent parts, the flow of water and regulation can be identified with ease.

IV. CONCEPT:

This model shows the concept of Freshwater Water Generator which is based on low evaporation method with help of acrylic tubes and LED lights.

V. WORKING PRINCIPLE:

- The fundamental idea behind every low-pressure freshwater generator is that you can lower water's boiling point by lowering the pressure of the air around it. Water can be boiled at low temperatures, such as 50 degrees Celsius, by maintaining a low pressure.

Waste heat rejected by the main engine jacket cooling water could be the source of heat for the fresh water generator.

- Two sets of shell and tube heat exchangers, one serving as an evaporator or heater and the other as a condenser, are the foundation of the freshwater generator.
- By forcing sea water through the water ejector and delivering sea water provided by the ejector pump to be delivered to the ejector for taking away the brine (concentrated saltwater) and air, the water ejector provides evaporator chamber vacuum conditions.
- Due to the vacuum in the evaporator chamber, feed water evaporates as it enters. The deflector installed on top of the evaporator and a built-in demister work together to partially separate the water spray and droplets from the vapour. The water ejector extracts the brine as the split water droplets fall back into it.
- After passing through the demister, the desalted vapour is drawn into a vapour chamber, where it is chilled by incoming seawater before being condensed.
- The distillate pump, which is an incorporated freshwater pump, extracts the distilled water under the direction of a solenoid valve and salinometer. If the produced water has a high salt content, a solenoid valve directs the freshwater to the freshwater generator's shell side and sounds an alarm.
- The condenser's seawater and the evaporator's jacket cooling water are both controlled by thermometers. These thermometers allow for the heating and cooling of these machines to be controlled.
- The salinometer, also known as a salinity indicator, is connected to a remote alert so that extremely excessive salinity is promptly noted in the ship's engine room.

VI. COMPONENTS:

- **Condenser-** The clean vapour is condensed by being cooled again in the condenser by the process of heat exchanging with sea water.
- **Evaporator-** In the evaporator, the seawater is heated, typically by using waste heat from the ship's engine. Because of vacuum evaporation starts at a low temperature.
- **Ejector Pump-** The ejector pump supplies seawater to the ejectors and also to the heat exchanger. The seawater goes to the ejectors in order to create a vacuum in the boiling section. This vacuum serves to lower the boiling point of the water, and to allow the brine from the desalinated water to be returned to the sea.
- **Demister-** Demister helps to remove the carryover of sea water droplets and water spray. It is made of layered knitted wire of Monel metal.
- **Freshwater Pump-** The freshwater pump supplies the freshwater tank with desalinated seawater (now freshwater) from the FWG and is thereby an essential part of the freshwater system. This newly produced freshwater is pollution free and has been softened significantly and the clean high quality water is then ready for human consumption or feed water for diesel engines and boilers of any type.

- **Salinometer-** This device is fitted at the outlet of the FWG which is responsible for checking the salinity of the distilled water generated by FWG.

Materials to be used in making this model are listed below-

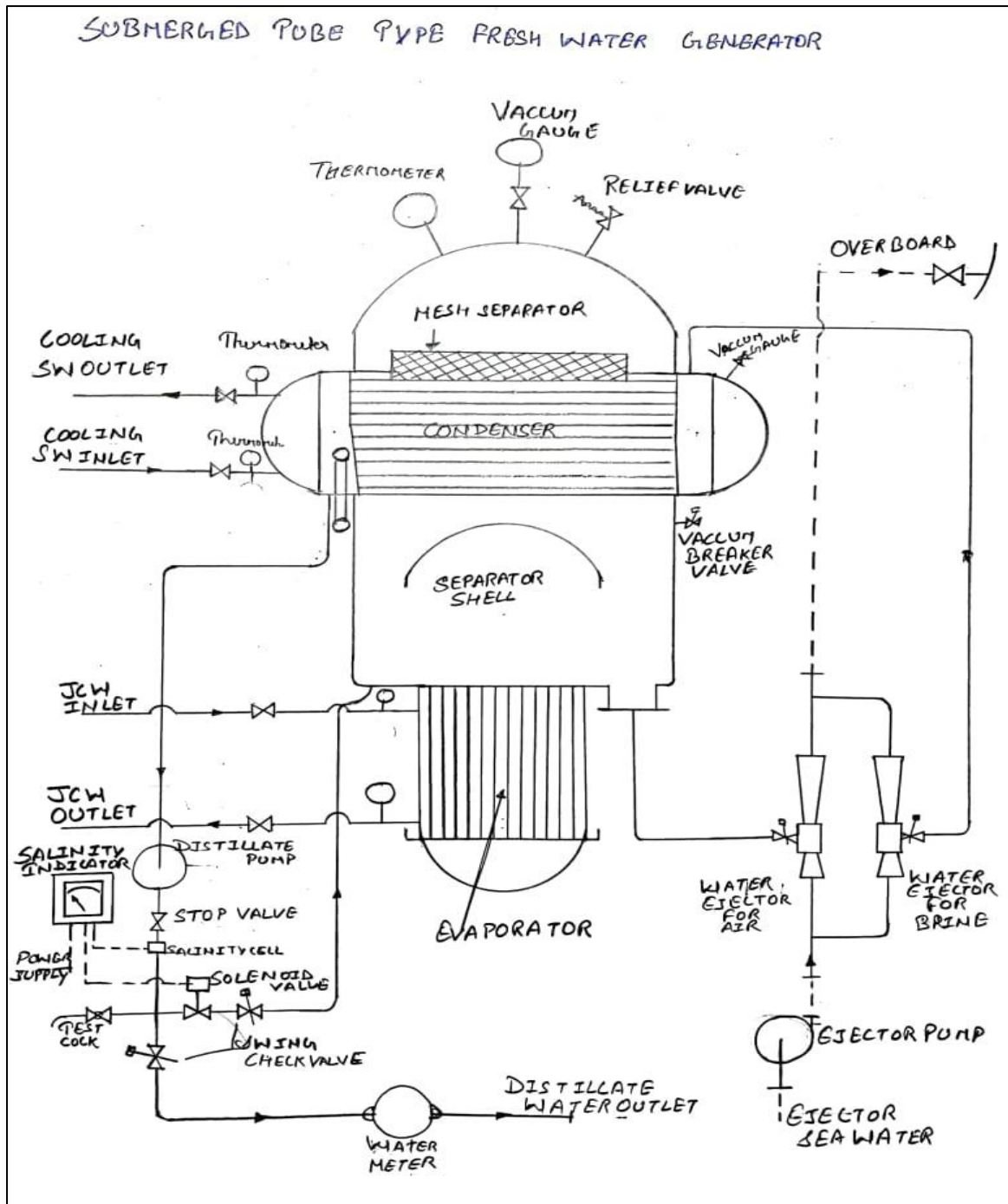
- Acrylic tubes, LED lights(different colours), Dimmers, Hot glue gun, Neon lights, soldering iron, soldering wire, soldering paste, Copper wire, Transparent plastic cylinder(2), 220V AC Power Supply.

VII. PROCEDURE:

- We will be making a circulating sea water inlet and outlet line and connect it to the condenser unit.
- Then we will place shell & tubes in the condenser unit and one line from the circulating outlet line will connect to the evaporator unit and another line will be connected to the overboard line.
- Then we will make an evaporator unit in which we will be placing shell & tube.
- Then we will make a inlet and outlet line of jacket cooling water to the evaporator unit.
- An air ejector and brine ejector line will be connected to condenser and evaporator unit and overboard line and will place a dimmer.
- Then we will make another line which will connect outlet of evaporator unit to the inlet of condenser unit with the dimmers and then lastly we will make a line in which salinometer will be fitted to check the salinity of the water generated.

VIII. DIAGRAM:





IX. RESULTS:

- The salinity content of distilled water generated from FWG is found to be around 1-2ppm.
- The water produced from the FWG is used in engine room and for domestic consumptions.

X. CONCLUSION:

This model will be able to demonstrate distillation of sea water to make fresh water by using waste heat of the main engine. Since the model is going to be a transparent one, it shall clearly indicate the flow of water inside condenser and evaporator unit through the shell and tubes and also shall indicate the flow of jacket cooling water through the pipes.

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Low Carbon Emitter Engine: Stirling Engine

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I. ABSTRACT:

Energy seems to be the subject at the heart of many of the greatest issues and debates facing the world today. Global warming is a huge issue that promises to change the face of the planet in unimaginable and irreversible ways. This alone is considered as a major driving factor in development of energy efficient technologies for various purposes including marine transportation for sustainable development. The predominant source of power in a ship is the Diesel engine which has evolved as a highly efficient means of generating necessary power for propulsion and auxiliary uses, however it is widely recognized that about 30% of the total energy converted in a Diesel engine is rejected in the exhaust gas.

On large ships some of this heat is recovered partly using exhaust gas boilers. However, on a majority of small ships or on large ships on short voyage durations, there is no or limited mechanism to recover this energy. The recently mandated energy efficiency design index (EEDI) has the provision to deduct the power produced from any energy saving device thereby giving credit to the design. While some of the energy saving devices being contemplated, use wind and solar power, it is being recognized that some of the energy from the engine exhaust gases and cooling water can still be tapped to generate power resulting in improved energy efficiency of the plant.

One of the ways of utilizing waste heat without conversion to steam is to use a Stirling engine. A Stirling engine requires only an external heat source (such as external combustion chamber or waste heat) for its operation. For marine use this engine could be utilized to generate some amount of power from the exhaust gas. This paper advocates the use of heat balance studies for improving the efficiency of the marine power plant. An estimation of the power which could be generated from a Stirling engine is presented based on estimation of the power which could be produced from the exhaust gas of a high speed (560 KW) propulsion engine and expected savings in fuel.

II. OBJECTIVE:

Since, the energy input to the Stirling engine will be from waste heat, it is expected to help reduce fuel consumption for electric power generation without adversely increasing the ship's overall carbon footprint and greenhouse gas emissions.



Fig. 1 : The simple working model of Stirling Engine.

III. INTRODUCTION:

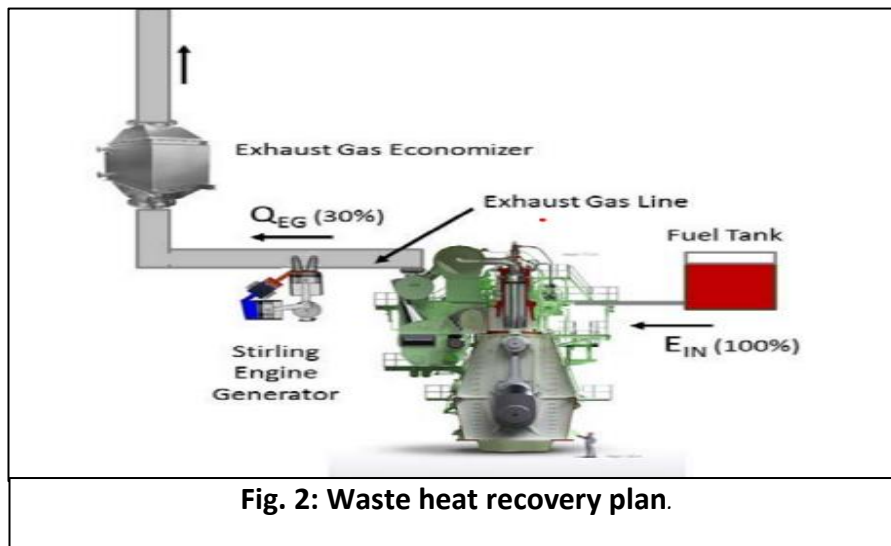
Energy efficiency is a research area that is seen to help address environmental concerns related to global warming and sustainability, including issues posed by the depletion of fossil fuel reserves. For example, in the shipping industry, ship designers and operators have come up with various designs, concepts and means to help reduce the fuel consumption of international ships.

In this study, the possibility of using a Stirling engine generator to help reduce the fuel consumption onboard a ship has been investigated. It is intended to function as a waste heat recovery unit fitted in the exhaust gas line of the main propulsion Marine Diesel Engine and operates by means of recovering waste heat energy from the exhaust gas and converting it to mechanical work to drive an electric generator. The electric power generated will then be directed to the ship's main switchboard to help supplement the electric power requirements onboard.

Furthermore, due to the potential appeal of the Stirling engine as the "Engine of the future", a number of studies have already been conducted on its application. For example, in shipping, a notable study conducted by Hirata and Kawada (2005) suggests the Stirling engine capable of generating 700 kW of power from the exhaust of a 20000-kW diesel engine. The study also included the use of a Stirling engine as the prime mover for a large freight ship and a Stirling engine hybrid system for a smaller passenger vessel.

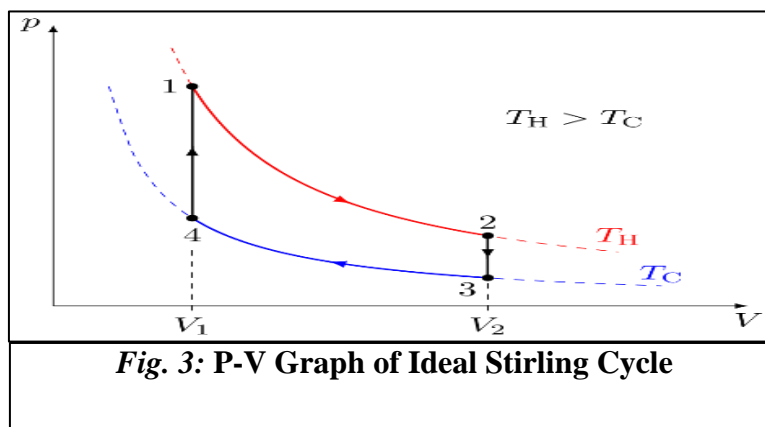
IV. CONCEPT:

The Stirling Engine will be prime mover for the alternator, to produce Electric Power, for various marine applications. Unlike internal combustion engines or steam engines, a Stirling engine doesn't require fuel combustion to operate. Instead, it uses an external heat source, such as 'waste heat' from the Marine Diesel Engine used for propulsion. Considering this, we are making an auxiliary Stirling engine which will provide Mechanical energy to the Alternator and replace the Diesel auxiliary engine onboard the ships.



V. WORKING PRINCIPLE:

The engine is a closed-cycle regenerative heat engine which operates by cyclic compression and expansion of the working fluid at different temperatures, such that there is a net conversion of heat energy to mechanical work. The heat energy source for the engine is externally generated rather than by internal combustion as with the Otto cycle or Diesel cycle engines. In addition, some other positive attributes of the Stirling engine include quiet operation, high thermal efficiency, safe operation, ease of operation and the ability to function on any form of thermal energy; this would include both traditional combustion and non-polluting sources, such as biomass, solar energy and geothermal energy.



The Stirling Cycle comprises of 4 processes: -

- i. Isothermal Compression,
- ii. Isochoric Heat Addition,
- iii. Isothermal Expansion,
- iv. Isochoric Heat Rejection

VI. CONCLUSION :

In this paper, we informed the characteristics of the Stirling engine and discussed about the marine applications. It is difficult to develop a large-sized and high-pressurized Stirling engine. Therefore, it has possibility to apply the Stirling engine to the prime mover of an alternator for large ship.

Even though the emissions are still present, use of Stirling engine may be termed as the ‘first step’ in reducing emissions. With further advancements in science and research, we can overtime achieve the feat of zero carbon emissions.

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Numerical Design and Performance Analysis of Hydrogen Fueled Tugboat

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I. ABSTRACT:

Around 130,000 metric tonnes of soot, or 1.7% of the total global emissions, are released each year by commercial ships, much of it close to densely populated coastlines. Compared to other vessel types, tugs emit nearly a gram of carbon soot per every kilogram of fuel burnt which is twice as much as any other commercial vessel. Thus, the aim of this model is to design and analyse the hydrogen fuel cell propulsion system for a tugboat in order to significantly reduce emissions near the ports. In doing so, certain procedures will be followed. These involves calculating the total resistance, speed and efficiency of the model. Analogy will be done by using froude's law of similarity. Results will show efficiency and well to wake GHG emissions analysis compared to diesel tug

II. OBJECTIVE:

Reduction of Carbon Footprints in Transportation.

III. INTRODUCTION:

While the IMO focuses much of its attention on international shipping, emissions from Tug boats, which are subject to domestic regulations, go largely unnoticed. During the design of the ships, a propulsion system is selected that can provide the required power to achieve the desired maximum service speed. In marine propulsion systems, strong diesel machines are generally preferred as primary movers. Nevertheless, marine diesel engines have the best fuel consumption efficiency at 70–85% nominal load. While this is an advantage in many of the existing ships, it may be a disadvantage for ships operating short-distance transportation or navigating in low-load operation profiles such as tugboats [1]. A tug boat is a small but very powerful vessel used in towing (pulling) or tugging bigger vessels that cannot move by themselves or are not self-propelled like some barges. Tug boats can also be used as fire fighters, ice breakers etc. the strength of a tug boat and its ability to manoeuvre effectively depends solely on the propulsion system installed. Tugboat engines produces power ranging from 500 - 2500 KW (680 - 3400 HP). Since tugboats are designed to be highly manoeuvrable, different kinds of propulsion systems have been developed [2]. "Tugboats may have become the main source of air pollutants at ports, with a potentially high impact on air quality," says Tongji University School of Automotive Studies professor Dengguo Liu. Report says replacing a tugboat engine could remove an average of 14.9 tons of nitrogen oxides emissions annually.

Therefore, this model will be significant for the feasibility test and design calculations of a tugboat propelled by hydrogen fuel cells with zero emissions.

IV. CONCEPT

The model will be designed to run by a small PEM fuel cell and its speed with the total resistance and efficiency will be measured.

- A) Calculation of required power by the hydrogen fuel cell tugboat with standard dimensions from a model test with specific (testing) dimensions using Froude's law of similarity:

Total resistance,

$$\text{Equation 1: } RT = RF + RR,$$

RF is the frictional resistance and RR is the residuary resistance.

Wetted surface area,

$$\text{Equation 2: } s = C\sqrt{\Delta L},$$

C is the Taylor's coefficient, Δ is the displacement and L is the length of a vessel.

1. The frictional resistance of the model is calculated using froude's formula,
Equation 3: $RF(m) = f(m) * s(m) * v(m)^n$

(m) denotes that it is being taken for calculation of model.

'f' denotes coefficient which depends on length(L) of the model,

$$f = 0.417 + 0.773/(L+2.862).$$

'v' denotes speed and 'n' is another coefficient = 1.825.

2. Equation 4: $RR(m) = RT(m) - RF(m)$.
3. To get the standard tugboat's residuary resistance,
Equation 5: $RR(t) = (\Delta t / \Delta m) * RR(m)$
't' denotes for standard tugboat.

4. Corresponding speed of the tugboat,
Equation 6: $v(t) = \sqrt{L(t)/L(m)} * v(m)$.

5. Frictional resistance of the tugboat,
Equation 7: $RF(t) = f(t) * s(t) * v(t)^n$

6. Tugboat's total resistance,
Equation 8: $RT(t) = RF(t) + RR(t)$.

Effective power required,

$$\text{Equation 9: } ep = RT(t) * V(t) * 1.15$$

1.15 is the tugboat's co relation factor.

- B) Creating energy

In place of the battery pack, we will be connecting a load to the fuel cell and determining how much energy the fuel cell uses to run the motor. Measure both the supplied voltage (across the fuel cell) and the voltage drop across the resistor at these time points, and use the alligator clips to attach the motor to the rest of the circuit. Start timing. The multimeter is used to take voltage readings across the fuel cell and the resistor at 30 sec, 1 min, and 1.5 min after the motor started running.

Connect the motor in the same way as the battery pack and clip the black alligator cable to the black wire from the motor. When the motor is running, start timing. If the motor does not appear to be running, confirm that the paperclips and motor have a good connection by turning on the battery pack. As the reaction of the fuel cell continues, the hydrogen in the storage tank is being consumed and water is re-entering the inner cylinder. Stop timer when motor stops running, record time.

Determining Efficiency

Ohm's law is used to calculate the input current, which is divided by the voltage drop across the resistor. Calculate the electrical power using Equation 1, using the average voltage as the voltage and the average input current as the average current [5].

Equation 10:

Power=AverageCurrent×AverageVoltage

$$\mathbf{P=(I)(V)}$$

P is the power in watts (W)

I is average current in amperes (A)

V is average voltage in volts (V)

Energy is the amount of power expended in an amount of time. For time, use the seconds it took for the hydrogen tank to become full.

Equation 11:

Energy=Power×Time

$$\mathbf{E=(P)(t)}$$

E is energy in watt-seconds or joules (J)

P is power in watts (W)

t is time in seconds (sec)

Equation 12 combines Equations 10 and 11 to solve for energy

Input Energy = (Average Input Current) × (Average Input Voltage) × (Time to Electrolyze)

$$\mathbf{E= (I)(V)(t)}$$

E is the energy in joules (J)

I is the average current in amperes (A)

V is the average voltage in volts (V)

t is the time taken in seconds to electrolyze a full storage tank of hydrogen.

Using Ohm's law to calculate the average current, Equation 4 to calculate the output energy, and time to run the motor.

Output Energy = (Average Current Supplied by FC) × (Average Voltage Supplied by FC) × (Running Time of Motor)

E is the output energy in joules (J)

I is the average current supplied by the fuel cell, in amperes (A)

V is the average voltage supplied by the fuel cell, in volts (V)

t is the time the motor runs in seconds

Calculate the efficiency of a fuel cell using Equation 13.

$$\text{Equation 13: Efficiency } (\eta) = \frac{\text{output energy}}{\text{input energy}}$$

The most important details are to take the inner cylinder out of the outer cylinder, disconnect the storage tanks from the fuel cell, and use a syringe to blow air into the fuel cell.

Fuel cell and Hydrogen System Mass and Volume calculation

$$\text{Equation 14: Specific power} = \frac{kW}{Kg} = \frac{\text{Output power}}{\text{Fuel cell Mass}}$$

$$\text{Equation 15: Power density} = \frac{kW}{m^3} = \frac{\text{Output power}}{\text{Fuel Cell Volume}}$$

Equation 15.1: Energy needed for voyage = Average shaft power * time.

For a hydrogen fuel cell system, Equations below calculates the amount of hydrogen stored in the LH2 or 5000 psi hydrogen vessel. Since the efficiency of FC is not 100%, energy loss due to thermal inefficiency must be taken into account. Assuming an FC efficiency of η %, the energy required for hydrogen can be calculated by dividing the energy required for flight by the efficiency (η) [3].

Step 1:

$$\text{Equation 16: Energy H}_2 \text{ [kWh]} = \frac{\text{Energy needed for voyage [kWh]}}{\eta}$$

Next, convert from kWh to kg by using the conversion of kWh to MJ and lower heating value of hydrogen (LHV) to find the mass of the required hydrogen.

Step 2:

$$\text{Equation 17: Mass of H}_2 \text{ [kg]} = \text{Energy H}_2 \text{ [kWh]} \times \frac{3.6 \text{ MJ/kWh}}{119.96 \text{ MJ/kg}}$$

Now that the mass of H₂ is calculated, the mass and volume of the tanks of LH₂ and 5000 psi hydrogen can be easily calculated.

Step 3:

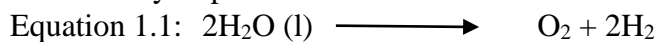
$$\text{Equation 18: Mass of Tank [kg]} = \text{Mass of H}_2 \text{ [kg]} \times \text{Gravimetric spec} \left[\frac{\text{kg Tank}}{\text{kg H}_2} \right]$$

(The total mass of the fuel and tank is then found by summing the tank mass and the fuel mass.)

$$\text{Volume of Tank [L]} = \text{Mass of H}_2 \text{ [Kg]} \times \text{Volumetric spec} \left[\frac{\text{L Tank}}{\text{kg H}_2} \right]$$

V. WORKING PRINCIPLE:

Fundamentally, a fuel cell is an electrochemical medium that combines gases to produce electricity. There are several types of fuel cells, but they are all based on the same basic process to generate electricity. To understand how a fuel cell works, first look at the electrolysis process.



In this reaction, an electric current provides activation energy (EA) as the electrolyte flows through the dissolved water to form oxygen gas and hydrogen. Looking at the diagram of the reaction, a current conductor connects two electrodes made of platinum (Pt) partially immersed in a dilute electrolyte. Pt is the catalyst for this reaction and reduces the activation energy. A circuit is created between the two electrodes, and reversing this process results in the following reaction in the fuel cell:

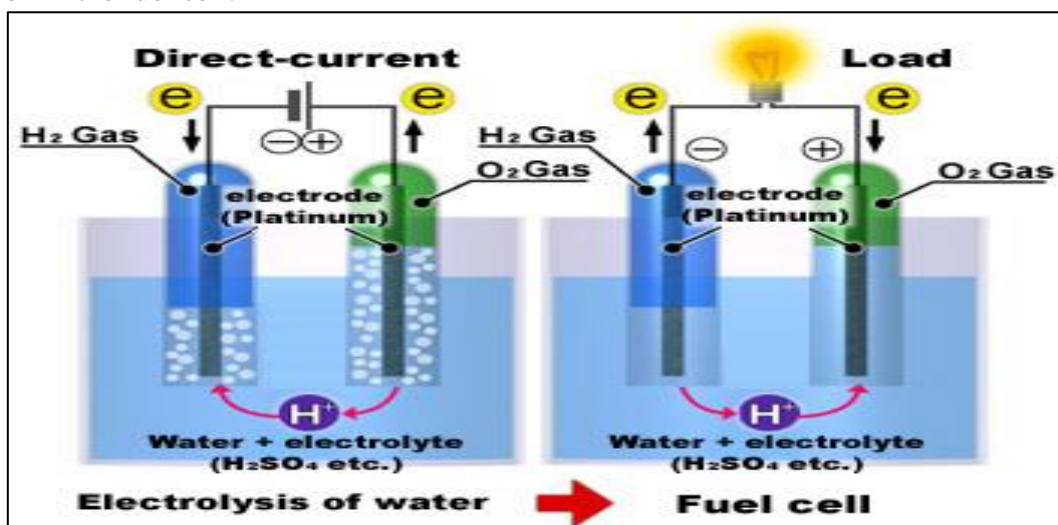
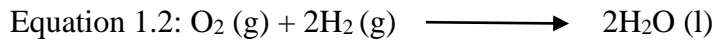
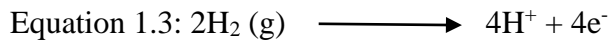


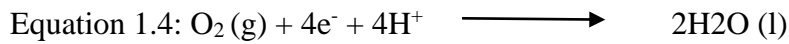
Figure 1: Schematic diagram of a Fuel cell [3].



Each electrode has a half-reaction. At the anode (hydrogen consumption/ionization site):



Hydrogen ionizes electrons and releases them down the wire, creating protons (H^+) that pass through the current (flowing from - to +) and through the electrolyte to the cathode. At the cathode:



Oxygen (usually in a filtered atmosphere), electrons and protons (H^+) combine to form water. Electrons travel through the electrical circuit to reach the cathode and protons travel through the electrolyte. This basic process takes place inside a hydrogen fuel cell. There are many types of fuel cells, but in this model, proton exchange membrane FC or PEMFC will be considered [3].

Proton Exchange Membrane Fuel Cells (PEMFC)

The PEMFC is one way to turn the theoretical reaction described above into a practical power plant with minimal size and weight. Reactions at the cathode and anode can only occur where the gas, electrode and electrolyte meet. To maximize this area, the electrodes are made into thin porous layers and bonded together. A PEMFC has a “sandwich” of cathode, electrolyte, and anode installed between two “anode” plates.

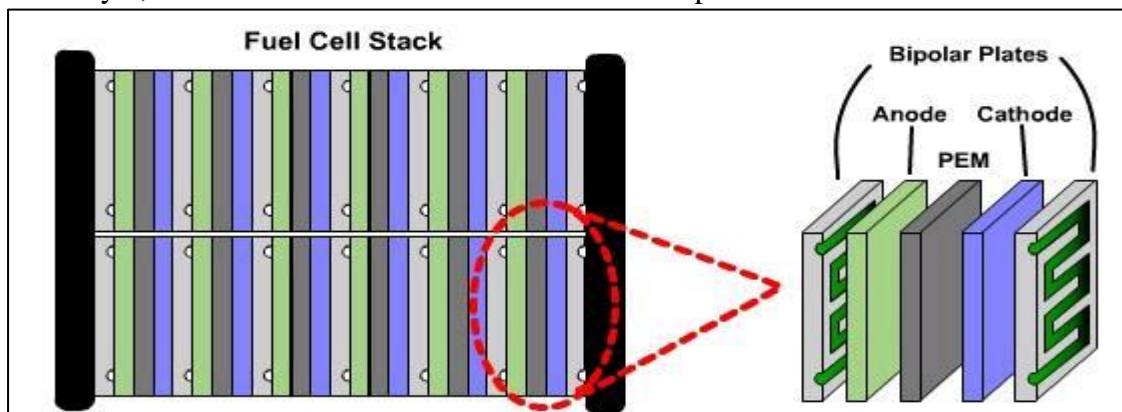


Figure 2: PEMFC [3].

The electrolyte between the cathode and anode is chosen to only allow protons to pass through (prevents air, other gasses, ions, electrons, or anything besides mobile ion [H^+] to pass through), and is commonly made of a material called Nafion. This material operates at a low temperature [60 to 80 degrees Celsius] and can withstand a rapid starts and stops without degradation, necessary for transportation power which can frequently change speeds. The bipolar plates have channels etched into them to allow the entrance of either oxygen or hydrogen on each side (depends which side bipolar plate is facing) and the discharge of produced water. In addition, the bipolar plates connect multiple FCs to form a “stack,” and allow the stacks to connect in series to maximize the output.

The only waste products are water vapor and heat; a great advantage over conventional ICEs, which produce GHGs and criteria pollutants. ICEs are also less thermally efficient and expel large amounts of heat. The thermal efficiency of a PEMFC is about 50% compared to 30% by diesel ICE and an even greater thermal efficiency can be achieved by taking excess heat and using it elsewhere in the energy production process (combined cycle fuel cell system) [3].

VI. DETAILED DIAGRAM:

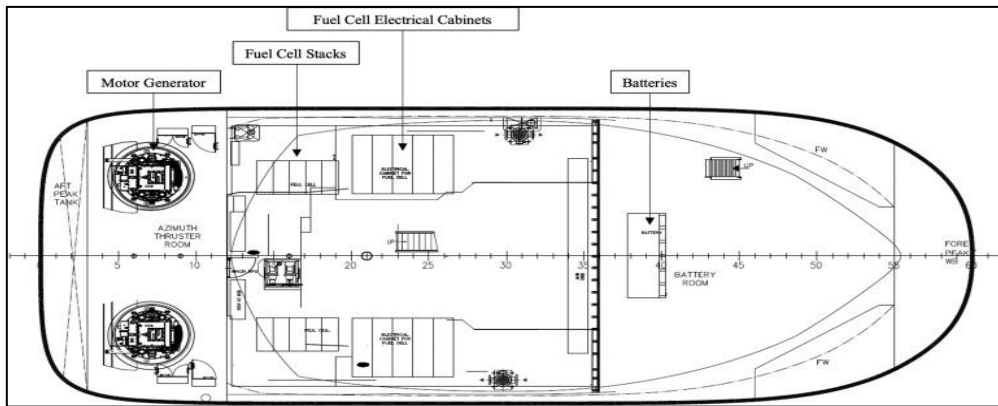


Figure 3: General layout of fuel cell powered tugboat [4].

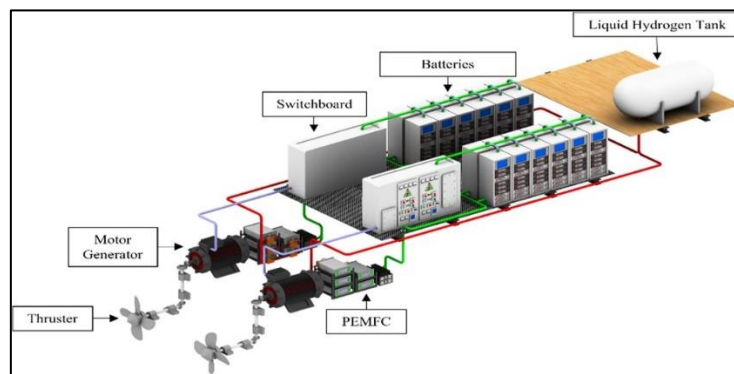


Figure 4: Powertrain configuration of fuel cell [4].

VII. RESULT:

Indicated power of the hydrogen fuelled tugboat,

$$\text{Equation 15: } IP = ep/\eta.$$

We can also plot the efficiency of the fuel cell and compare it to a standard internal combustion engine.

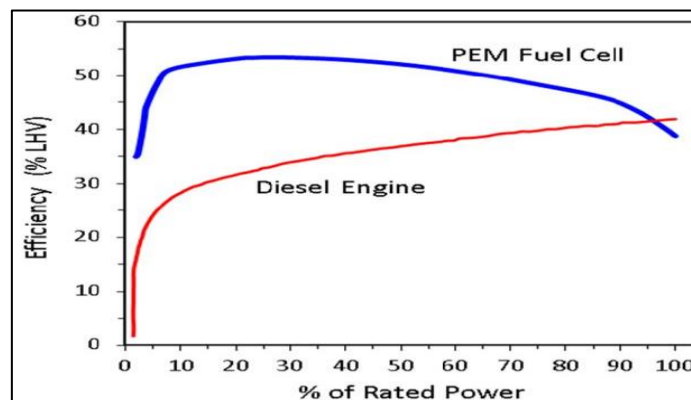


Figure 5: Efficiency of Fuel cell vs diesel engine [3].

WTW emission analysis can also be conducted with an objective to provide a comparative overview of the consequence derived from the source of the fuel.

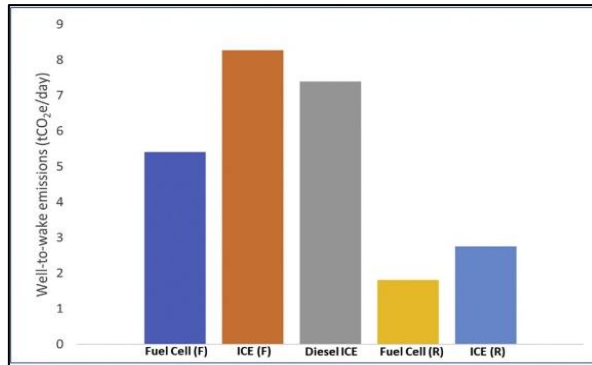


Figure 6: Daily well-to-wake (WTW) GHG emissions of different power train configurations of hydrogen from fossil-based (F) and renewable energy (R) sources and similarly sized diesel-powered tug (1 column) [1].

VIII. CONCLUSION:

A hydrogen fuelled tugboat has the potential to revolutionise the harbour craft industry with zero carbon emissions during operation. The PEMFC can be designed with an energy storage system to provide the necessary dexterity to handle transient loads. The PEMFC system provides a better outlook when considering the operational costs albeit a higher capital outlay compared to hydrogen in ICE. PEMFC have a strong track record for land based stationary power and automotive applications, which boosts the confidence of marinizing this technology. A consortium of companies has already started designing world's first hydrogen fuel powered tugboat, 27-m vessel "Hydrogen One" to push barges along inland waterways with almost zero emissions.

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Sleep Arrester- Device To Minimize The Accident Onboard Ship

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I. ABSTRACT:

We know that 'maritime shipping' has a huge impact on the world economy and almost 90% of international trade is carried by merchant ships. The maritime field is now adopting various methods as per the need of time. This project aims for minimizing the accident that take place on ship very often due to human error.

The eye is one of the sense organs that can give users better interaction closer to them. Need by observing the change of the eyes (open or closed). It is considered as a rich source for Gathering information on our daily life. So, this project aims of minimizing the accidents that take place on board ship with very easy and effective way.

II. OBJECTIVE:

To minimize the accident onboard ship during night watch on bridge, engine room and also during cargo handling.

III. INTRODUCTION:

Eye blinking is one of the informative and non-verbal behavioural Cues for solving many problems. As we all know on-board seafarers has very tedious and hectic schedule. Even after regular working hours they need to work at night when there is loading or discharge of cargo. Also, they have night watches. According to research many accidents have taken place due to a seafarer slept during watch. The main purpose of this project is to develop a real time self-adaptation eye blink system. The developed system is provided to be a low cost and robust than similar systems.

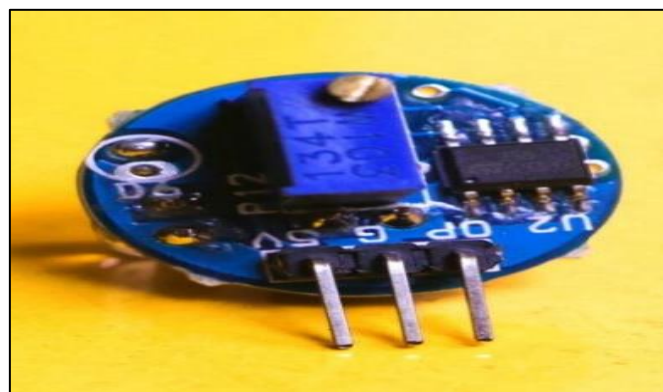
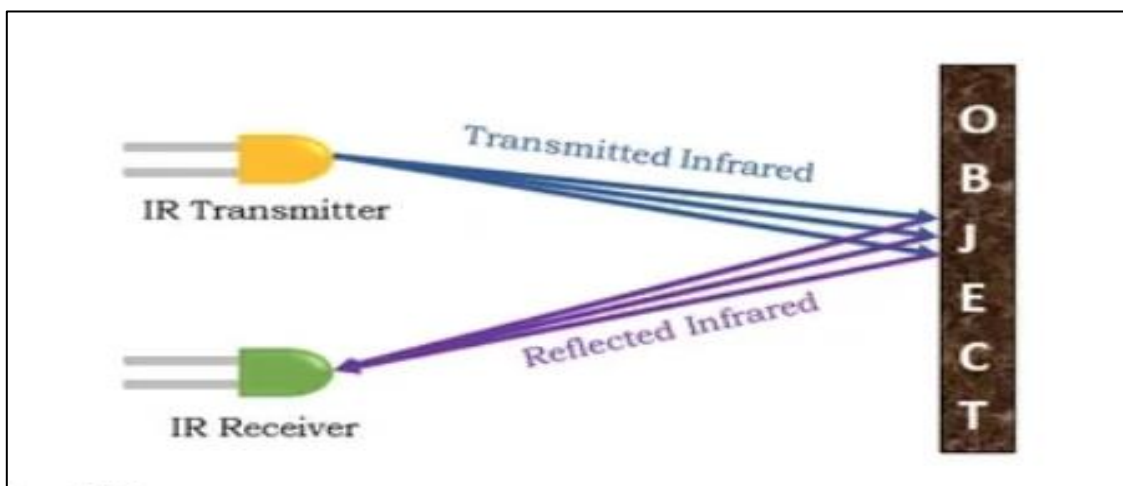
IV. WORKING PRINCIPLE:

The eye blink sensor works based on the principle of IR. The IR array contains two components, an IR Emitter, and an IR Photodiode.

The IR Emitter emits an IR light towards the eye. The IR Photodiode is designed to detect if the radiation of the same wavelength is reflected and detected. If the eye is closed, the IR rays will reflect with a larger intensity and the photodiode will detect it. If the eye is open, the IR rays will wither go into the eye or scatter across the eye thereby causing a very low intensity of reflected IR light. Therefore, by monitoring the Photodiode, we can come to a reasonable conclusion if the eye is indeed closed or not.

The module also comes with an onboard potentiometer which can be used to tune the sensitivity of the Photodiode. So with this principal in this project, we have set 2 alarms that will work on the movement of the eyes of the person. If the watch keeper is sleeping and his eyes are closed for more than 10 sec than one self-alarm will be given if he does not respond to it than after 20 sec second alarm will be given to that chief and master.so if he is fainted then chief will come to know and he can get medical service asap and also accident can be avoided.

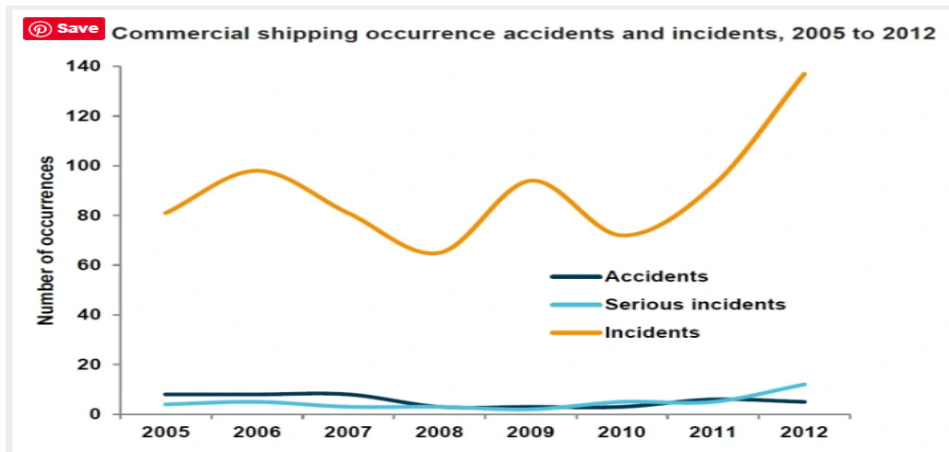
V. DETAILED DIAGRAM:



VI. RESULTS(TABLES/GRAPHS):

TYPE of SHIP	TYPE of MARINE ACCIDENTS						
	Collision	Grounding	Damages to ship or equipment	Occupational accident	Fire/explosion	Flooding/sinking	Other
Bulk Dry/ General Cargo	97	66	52	20	23	10	20
Container	41	12	13	19	4	2	5
Oil Tanker	14	10	4	9	6	2	4
Chemical Tanker	15	6	9	7	4	2	1
Gas Tanker	2	1	1	4	3	-	-
Passanger Ship	4	7	3	4	3	3	6
Passanger Ro/Ro Cargo	15	2	5	2	4	1	2
Ro/Ro Cargo	7	8	5	6	7	2	1
Total	195	112	92	71	54	22	39

Occurrence category	2005	2006	2007	2008	2009	2010	2011	2012	Total
Accidents	8	8	8	3	3	3	6	5	44
Serious incidents	4	5	3	3	2	5	5	12	39
Incidents	81	98	81	65	94	72	92	137	720
Total occurrences	93	111	92	71	99	80	103	154	803



VII. CONCLUSION:

So, after this we can conclude that if we make use of new technology, we can minimize the hazards on-board. But along with this all seafarers also should make sure that safety should be their priority because negligence in safety will lead to human loss economic loss etc. so with this project, we can minimize the accidents that take place on-board due to fatigue or if the seafarers on watch sleeps.

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3. <https://www.slideshare.net/>
4. <https://www.marineinsight.com/>

Piezoelectric Generator

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I. ABSTRACT:

A piezoelectric generator in a ship would typically consist of a piezoelectric material, such as PZT or AlN, that is mechanically coupled to a vibrating or oscillating source, such as oceanic current, hull, engine, or propeller. As the source vibrates, it causes the piezoelectric material to deform or compress, which generates an electrical charge across the material. This charge can then be collected and used to power various systems or devices on the ship.

To increase the efficiency and power output of the generator, multiple piezoelectric elements can be arranged in an array, and electrical circuitry can be used to optimize the impedance matching and power conversion. In addition, various design considerations, such as the choice of piezoelectric material, the placement of the generator, and the frequency characteristics of the vibration source, can affect the performance of the generator.

Overall, a piezoelectric generator can provide a potentially valuable source of power for various applications in a ship, such as structural health monitoring, vibration control, and energy harvesting.

II. OBJECTIVE:

Our model aims at imparting light on an innovative idea of electricity generations using an piezoelectric generator. At present this technology is under an area of research as it has a potential to emerge as new source of electricity unlike solar energy. This technology has potential to reduce our dependence on fossil fuels used onboard as it converts oceanic current which is experienced by ship into electricity.

III. INTRODUCTION:

Ideal model ships is a blueprint for the future generations as we intend to combine multiple ecological, cost efficient and sustainable operation/methods to promote the idea of power generations through vibration losses/ocean currents

IV. CONCEPT:

Our main intent with our model is to regenerate and recover the energy losses through various machineries especially the vibration losses which get damped by the ship's hull into the ocean.

As we know ocean has ample amount of energy which is still unused that can be extracted and converted into electrical power.

Piezoelectric generators can be installed in various locations on a ship where mechanical vibrations or strain occur. Our major area of concerns are:

Bulbous Bow:

It is a portion of ship which experience maximum forces, some estimates suggest that the force generated by a bulbous bow can range from around 1 to 5% of the displacement of the ship. For example, a 100,000-ton ship may experience a force of around 1,000 to 5,000 tons on its bulbous bow during sailing and making it a potential location for piezoelectric generation.

Hull:

The ship's hull experiences various forces and vibrations while sailing, and these forces vary on numerous factors, making it a potential location for piezoelectric generators.

Propellers:

The rotating motion of the propellers creates mechanical strain that can be converted into electrical energy by piezoelectric materials.

Engine:

The vibrations generated by the ship's engines can also be harnessed by piezoelectric generators.

Pumps and compressors:

Similar to engines, pumps and compressors can produce mechanical vibrations that can be converted into electrical energy.

V. WORKING PRINCIPLE:

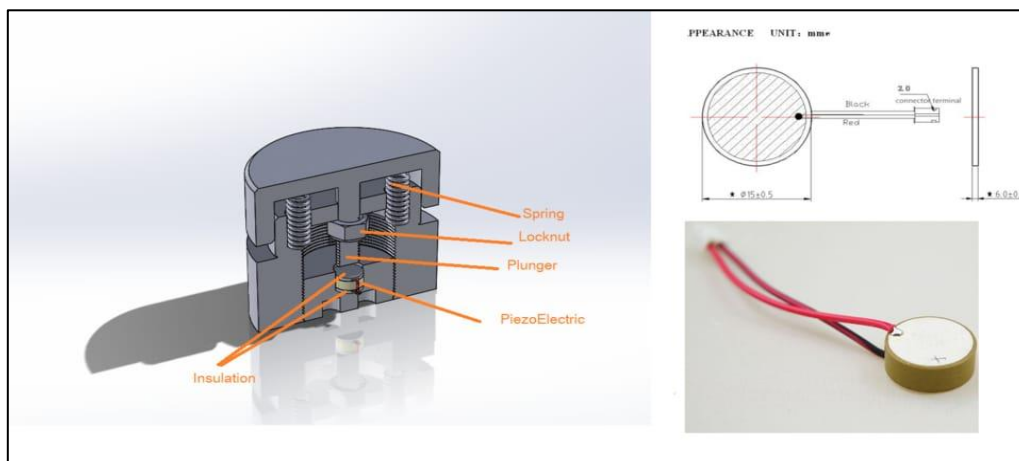
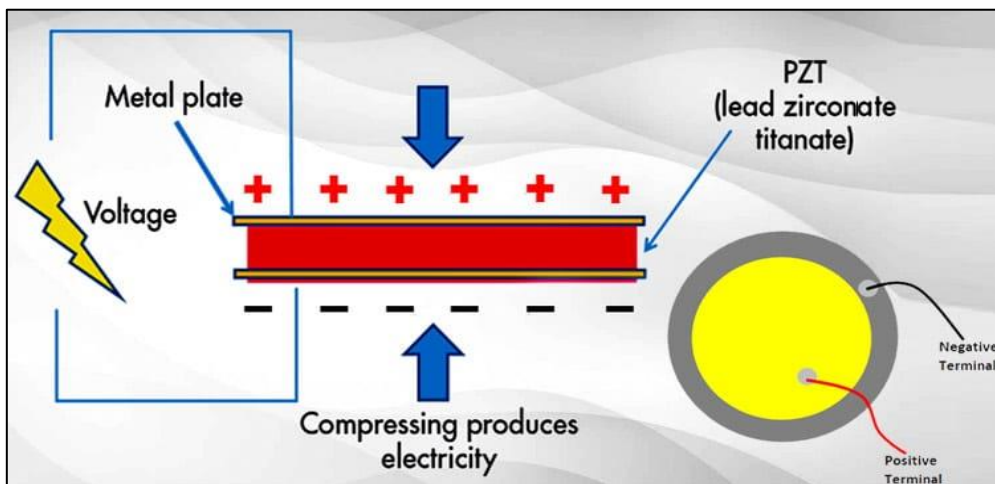
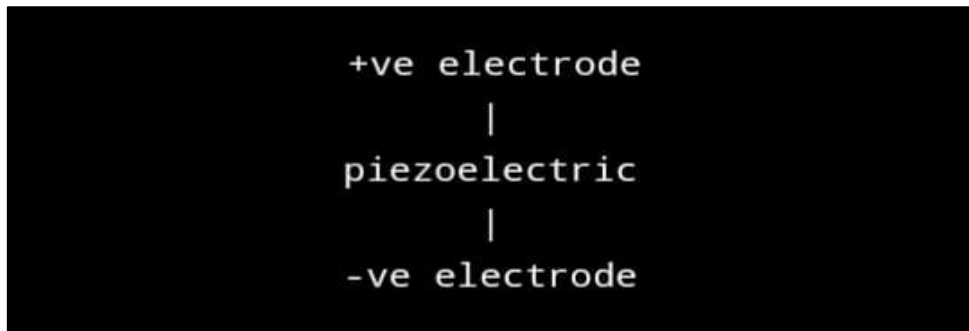
A piezoelectric generator is a device that generates an electrical charge when mechanical stress is applied to a piezoelectric material. The working principle of a piezoelectric generator is based on the piezoelectric effect, which is the ability of certain materials to generate an electric charge in response to an applied mechanical stress.

Piezoelectric materials are characterized by their ability to generate an electric charge when they are subjected to mechanical stress, such as pressure, vibration, or bending. When a piezoelectric material is mechanically stressed, its internal crystal structure is deformed, which generates a flow of electrons that can be collected by an electrode.

In a piezoelectric generator, a piezoelectric material such as a crystal or ceramic is placed between two electrodes. When the material is subjected to mechanical stress, it generates an electric charge that is collected by the electrodes and used to power an electrical circuit or charge a battery.

Piezoelectric generators can be designed to harvest energy from a variety of mechanical sources, such as vibrations, pressure waves, or bending motions. They are often used in applications where small amounts of electrical power are needed, such as in sensors, remote monitoring devices, or low-power electronics.

VI. DIAGRAMS:





VII. CONCLUSION :

Piezoelectric transducer is a promising technology for generating electricity on ship. It is a reliable, cost- effective, and environmentally friendly way of generating electricity. This technology has the potential to reduce the reliance on traditional fossil fuels and increase the efficiency of the ship's operations.

In the future, this technology may be further developed and improved, allowing for more efficient and cost- effective generation of electricity on ships. This could lead to a more sustainable and efficient shipping industry in the future.

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- <https://encyclopedia.pub/entry/20694>
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Solar Propulsion and Rotor Sail

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ABSTRACT:

As we all know nowadays ship and IMO are working on reducing the toxic gas which are being emitted to the atmosphere, to reduce such emission we need to switch the fuel method which is being used in past. To overcome such situation, we can use renewable resources as a method to run the ships as a fuel. One of the main resources is, using rotor sail as a fuel input. The wind is a renewable and natural phenomenon which uses wind to propel the ship using wind as a energy. Such invention is possible in today's scenario. This project of ours is based on solar energy using rotor cell as an energy source and some safety equipment which can be used onboard to protect human life.

I. OBJECTIVE:

Our main objective is reducing the fuel consumption and the release of NOX and SOX into the atmosphere. As per the IMO agenda of reducing the toxic emission into the atmosphere, reducing to the amount by 50 % by 2050. To come up with this agenda renewable resources has to be used to reduce the emission. Our model consists of solar panels used for the propulsion system.

II. INTRODUCTION:

Ships Are widely used for transporting cargoes , goods ,fuels etc around the world and the percentage is about 80%.So Shipping industry plays an vital role in international trade so it possess many advantages and disadvantages. these merchant ships consumes heavy amount of fuels so this fuels emits heavy pollutants such as SO{x}, NO{x},N2O,Black Carbon. So, these pollutants contribute as an major factor for GLOBAL WARMING. So, There is an need for renewable energy as a substitute for fossil energy in order to reduce the occurrence of global warming effect. The most important thing is to build a renewable source of energy that can ensure the electric motor propulsion have a good efficiency to produce effective power to propel the ship with the desired speed service and provide the electric energy throughout. In shipping, the IMO is working on various fronts to reduce the emissions of polluting gases (sulphur oxides, nitrogen oxides and particulate matter) and of greenhouse gases (mainly CO₂) into the atmosphere. This paper tries to open some directions into development and implementation of solar thermal systems as part of renewable infrastructure for marine transportation. The main purpose of adopting various alternative propulsion system and renewable energy-based systems on board merchant

marine vessels is to reduce consumption of fuel. Solar energy is one of the renewable energy sources which can play a vital role in meeting the increasing energy demand and save the depleting fossil fuel resources.

III. CONCEPT:

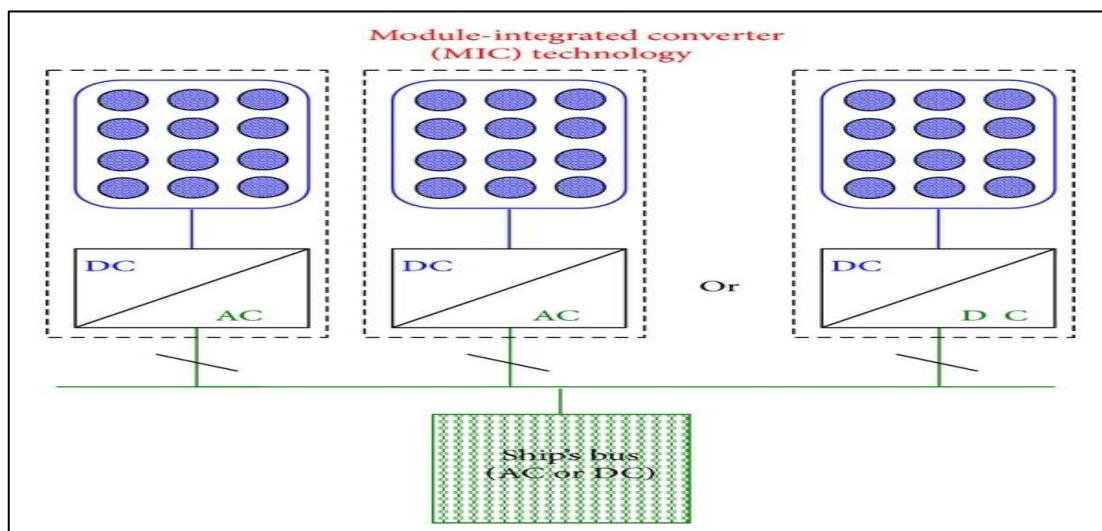
Wind assisted propulsion is the practice of using sails or a type of wind capture device. With the onset of the steam and the diesel engine, sails became more for recreational use. However, With increasing fuel costs and the sails ability to help in fuel consumption decrease, there is a renewed interest in using wind power to propel commercial ships. Also, it acts as an alternative to those systems that emit large quantities of carbon dioxide (CO₂).

These "hybrid powered" ships will use wind and solar power together as a source of energy and propulsion (along with the ship's main engines) to reduce harmful emissions and lower fuel consumption. An on-board solar power array can either mounted on the sails or on deck areas of the vessel (or both). source: Wind and Solar Energy.

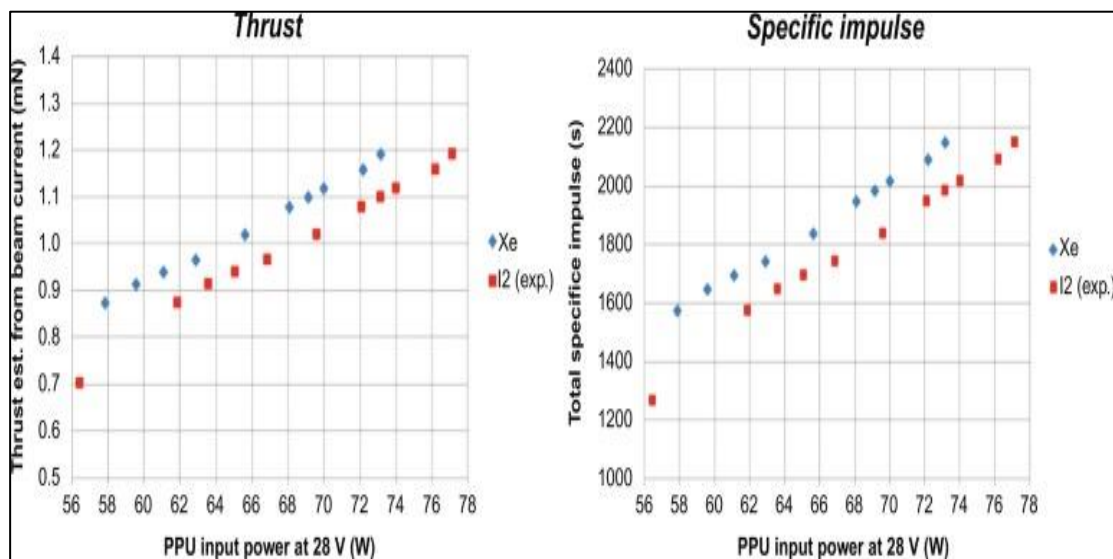
IV. WORKING PRINCIPLE:

Most solar cells are a few square centimeters in area and protected from the environment by a thin coating of glass or transparent plastic. Because a typical 10 cm × 10 cm (4 inch × 4 inch) solar cell generates only about two watts of electrical power (15 to 20 percent of the energy of light incident on their surface), cells are usually combined in series to boost the voltage or in parallel to increase the current. A solar, or photovoltaic (PV), module generally consists of 36 interconnected cells laminated to glass within an aluminum frame. In turn, one or more of these modules may be wired and framed together to form a solar panel. The back of each solar panel is equipped with standardized sockets so that its output can be combined with other solar panels to form a solar array. The simplest deployment of solar panels is on a tilted support frame or rack known as a fixed amount. Using 4 hours of full sun can give us around 1 kWh (250-watt panel x 4 hours) in a day per 250-watt panel (Solar Energy, 2017). Modern solar panels of size 69 inch by 39 inch (efficiency of around 18.7%) are able to generate a minimum of 320 watts. Using this analogy, for a ship consisting of at least 20 solar panels of similar size, the amount of energy harnessed for a minimum time of 6hrs, would be roughly around 38400 watts.

V. DETAILED DIAGRAM:



VI. RESULTS (TABLES/GRAPHS):



VII. CONCLUSION:

In designing a propulsion system on a solar powered electric water recreational boat. There are 3 sub system that is calculated that is resistance of the boat; propulsion of the boat; steering system. The aim of this paper is the presentation of the most popular trends of the mainland PV technologies on the fields of solar cell types and the PV systems, and how they can be applied in ship applications. The electric grid of a typical marine vessel is described, the main parts are distinguished, the typical electric magnitudes are defined, and the preferable areas where the PV plants can be attached are spotted. The PV system must be tolerant to the special marine environmental conditions and especially the wind, humidity, shading, corrosion problems, and limited installation areas. The resulting restrictions are the parameters that define not only the type of the solar cells but also the applied PV system technology which refers to the interconnections types between panels and converters.

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Dual Axis Solar Tracker

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I. ABSTRACT

The limitless energy of the sun can be used for powering variety of ocean-going vessels such as Bulk Carriers, Super Tankers, Ferries etc. thereby reducing fuel consumption, emission of greenhouse gases and noxious exhaust emissions. Using a variety of Technologies including Dual Axis Solar Tracker can be a solution for new or existing vessels that will help the ships take advantage of the latest technologies to harness the power of renewable solar energy. Some ideal applications for the use of solar power include cruise boats, tourist catamarans, fishing vessels, offshore support vessels, survey ships, oil tankers, cargo ships, Ro-Ro ships, patrol vessels and passenger ferries.

KEYWORDS

Solar Energy, greenhouse gases, fuel consumption

II. OBJECTIVE

To produce power using solar panel, with zero carbon emissions and increasing the panel efficiency by introducing a dual axis solar tracking system.

III. INTRODUCTION

The model depicts the construction and outlook on the use of solar panel on board ships with dual axis tracking system. Constructional view on how one can eliminate power producing machineries onboard ships by having zero carbon emissions to protect environment and consumption of fossil fuels. The concept can maximize the generation of solar power on board by changing the orientation of solar panel.

IV. CONCEPT

COMPONENT	SPECIFICATION
Solar Panel	20W
LDR Sensor	50-100 Kilo Ohm
Stepper Motor	6V
Power Supply Module	12V
Arduino NANO	-
LCD Display	5V DC LCD
Header	-
Circuit Board	18 x 13 sq.cm
Gears	-
Push type switch	-
Wires	5m
Nut Bolt	-
Plywood	56 x 41.5 x 1.5 cu. cm
Caster Wheel	-
Paint	Red and White
MPMC case	-

- Use wooden plywood of rectangular shape(560*420mm) to make bottom base of the model.
- Align a circular wooden structure of 340mm diameter and make it rotatable using caster wheels.
- Place the Microprocessor (Arduino nano) and LED lights on the rectangular base.
- Place Stepper motor on the panel mounting block and connect it with the Microprocessor.
- Align solar panel of 780sq.cm and connect it to the LED indicating lights which will show the intensity of light falling on the solar panel.
- Add display in the Microprocessor block to show the mode and output of the power produced.

V. WORKING PRINCIPLE

A working model which uses light dependent resistors which detect the light and send signal to the arduino. When they send a signal to the Arduino, it will guide two Servo Motors to better place the solar panel to maximize its efficiency. Four LDR's are divided into top, bottom, left and right:

•For angular deflection: The analog values from two top LDRs and two bottom LDRs are compared and if the top set of LDRs receive more light, the vertical servo will move in that direction and if the bottom LDRs receive more light, the servo moves in that direction.

For east–west tracking of the solar panel, the analog values from two left LDRs and two right LDR are compared. If the left set of LDRs receive more light than the right set, the horizontal servo will move in that direction and if the right set of LDRs receive more light, the servo moves in that direction.

VI. DETAILED DIAGRAM

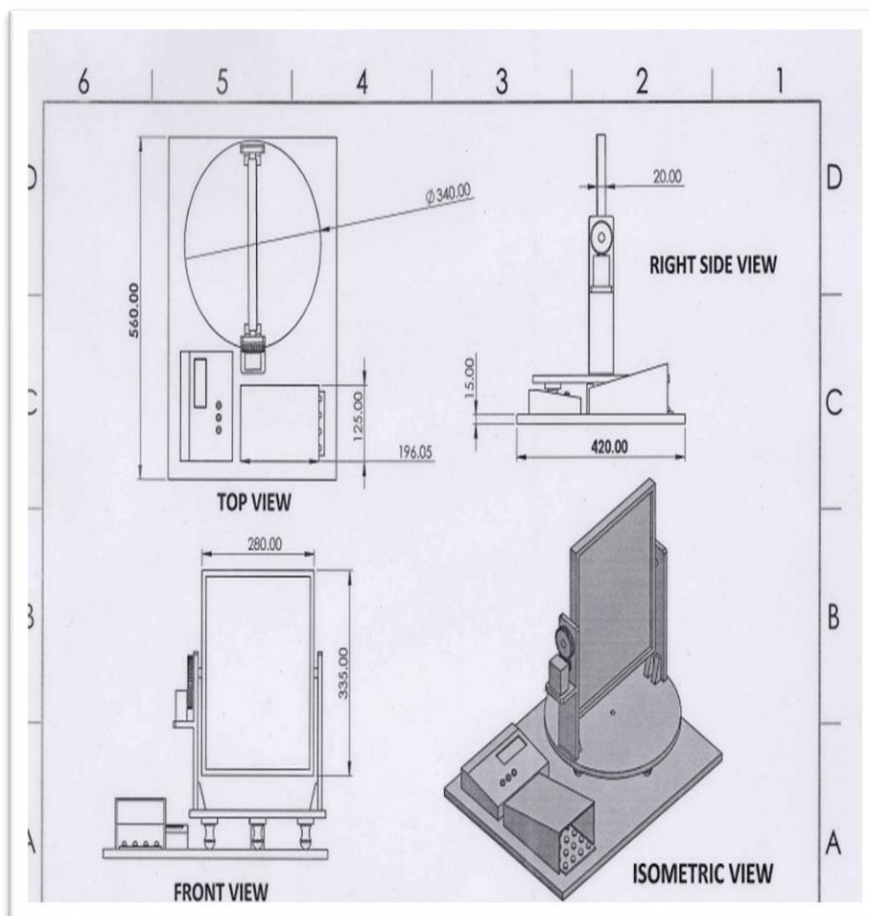


FIG 1: Dual Axis Solar Tracker

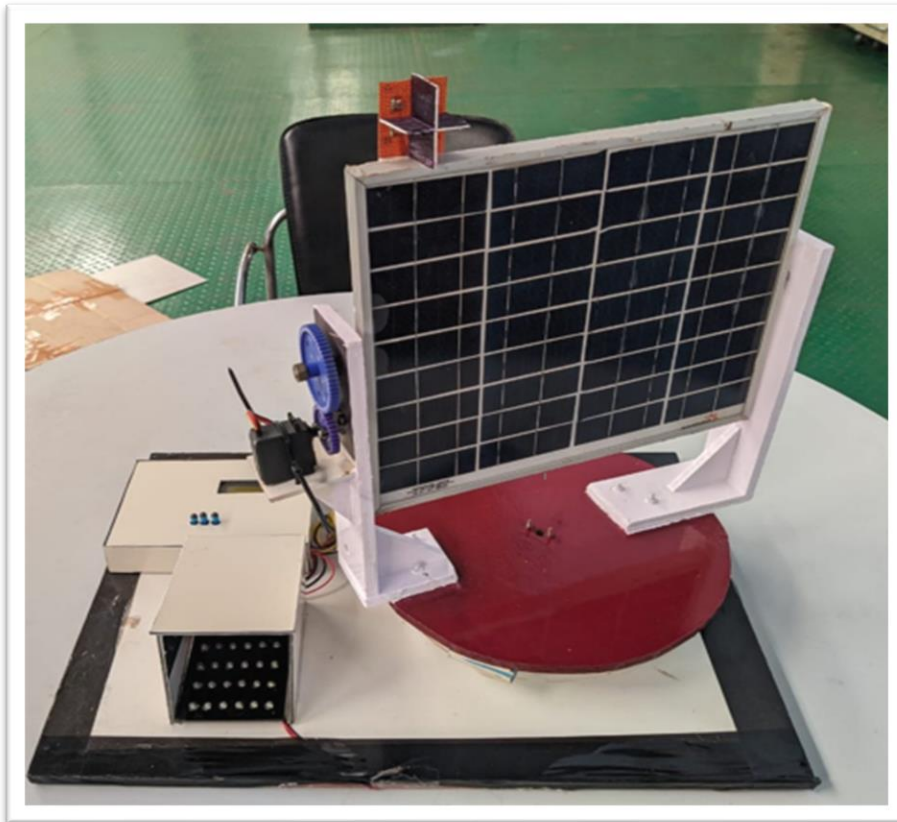


FIG 2: Dual Axis Solar Tracker (Physical working model)

VII. RESULTS

Stationary mode:-

Time	Power(P)
1st Hour	9.51
2nd Hour	6.88
3rd Hour	4.63
4th Hour	3.67

Total Power generated in 4 hours = 24.69 watts

Average Power = 6.17 watts

$\eta = \text{Power Output} / \text{Power Input}$

Power Output = $6.17 / 0.078 = 79.10 \text{ watts/m}^2$

Power Input = 1000 watts/m^2

$\eta = 7.91\%$

If sun is there for 8 hrs for 1m^2 panel, so it can produce 632.8 watts /day which makes it approximately 18.984 KWH per month.

VIII. CONCLUSION



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Eco-One Hybrid Ballast Water Management System

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I. ABSTRACT

Ballast Water is used to maintain vessels draught. As we know that due to ballasting and de-ballasting, the ballast water from the same vessel can be discharged in different water bodies which can lead to the introduction of foreign marine pathogens into the local marine ecosystem. These foreign marine species could be invasive and attack the local marine life, in turn affecting the local marine ecosystem. To avoid this, the Ballast Water Management Convention or BWM Convention (full name International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004) was adopted by the International Maritime Organization (IMO) in order to help prevent the spread of potentially harmful aquatic organisms and pathogens in ships' ballast water. According to this convention from 8 September 2017, ships must manage their ballast water so that aquatic organisms and pathogens are removed or rendered harmless before the ballast water is released into a new location. This will help prevent the spread of invasive species as well as potentially harmful pathogens. Hence there is a need for a Ballast Water Management System to be installed on board

II. KEYWORDS

Ballast Water, De-ballasting, BWM Convention

III. INTRODUCTION

From the date of entry into force, ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. Ships have to carry:

- A ballast water management plan - specific to each ship, the ballast water management plan includes a detailed description of the actions to be taken to implement the ballast water management requirements and supplemental ballast water management practices;
- A ballast water record book - to record when ballast water is taken on board; circulated or treated for ballast water management purposes; and discharged into the sea. It should also record when ballast water is discharged to a reception facility and accidental or other exceptional discharges of ballast water; and
- An International Ballast Water Management Certificate - (ships of 400 gt and above) – this is issued by or on behalf of the Administration (flag State) and certifies that the ship carries out

ballast water management in accordance with the BWM Convention and specifies which standard the ship is complying with, as well as the date of expiry of the Certificate.

There are two ballast water management standards (D-1 and D-2). The D-1 standard requires ships to exchange their ballast water in open seas, away from coastal areas. Ideally, this means at least 200 nautical miles from land and in water at least 200 m deep. By doing this, fewer organisms will survive and so ships will be less likely to introduce potentially harmful species when they release the ballast water. This standard consists of three methods Dilution method, Sequential method, Flow-through method. The D-2 standard specifies the maximum number of viable organisms allowed to be discharged, including specified indicator microbes harmful to human health. It involves installing special equipment to treat the ballast water.

IV. CONCEPT

During ballasting, the ballast pump takes sea water from the sea chest. The sea water passes through an Automatic Filter (Manufactured by FilterSafe). The Filter consists of an initial primary coarse screen and a secondary weave-wire screen of 40-micron mesh size. The filter also consists of a backflushing arrangement with a rotating suction scanner onto which proximity nozzles are mounted. The proximity nozzles are pressed up against the weave wire screen, the nozzles suck the impurities stuck in the wire mesh. A suction pump is provided to flush the filter using ballast water and discharge the impurity containing water overboard. A bypass line is also provided to bypass the filter in case the water turbidity is high, to prevent choking of the filter.

The disinfection of ballast water is done by chemical injection of Chlorine Dioxide – ClO_2 . The ClO_2 is produced on board by mixing Sulfuric Acid (H_2SO_4) and Purate (Mixture of Sodium Chlorate NaClO_3 about 40% by wt. and Hydrogen Peroxide (H_2O_2) about 7 to 7.9% by wt. and the remaining portion is water). Sulfuric acid and purate are stored in two different metering tanks provided with dosing pumps. Dosing pumps feed these two chemicals in controlled condition into a mixing column, where ClO_2 is produced. The ClO_2 is injected into the ballast line by means of an eductor. The motive fluid for the eductor is taken from a tapping from ballast line after the auto backflushing filter. Once a low-pressure area is created in the mixing chamber of the eductor, ClO_2 is produced in the mixing column by combination of 78% sulfuric acid and purate. The eductor then sucks in the chlorine dioxide and injects it into the main ballast line. A ClO_2 control valve is provided in the injection line to control the amount of ClO_2 being injected. In the same line a optical ClO_2 analyser is provided which monitors ClO_2 concentration in the ClO_2 solution downstream the eductor. The quantity of ClO_2 being injected is maintained at 4.25 mg/L in all waters. The injection is by means of ClO_2 injection quills which allows uniform injection in ballast water piping.

The filter and ClO_2 generator can be arranged in following ways for 2 ballast pumps:

- One filter and one ClO_2 generator for each pump
- Common filter for both pumps and one ClO_2 generator for each pump
- One filter for each pump and common ClO_2 generator for both pumps

- Common filter and ClO₂ generator for both pumps

V. DETAILED DIAGRAM

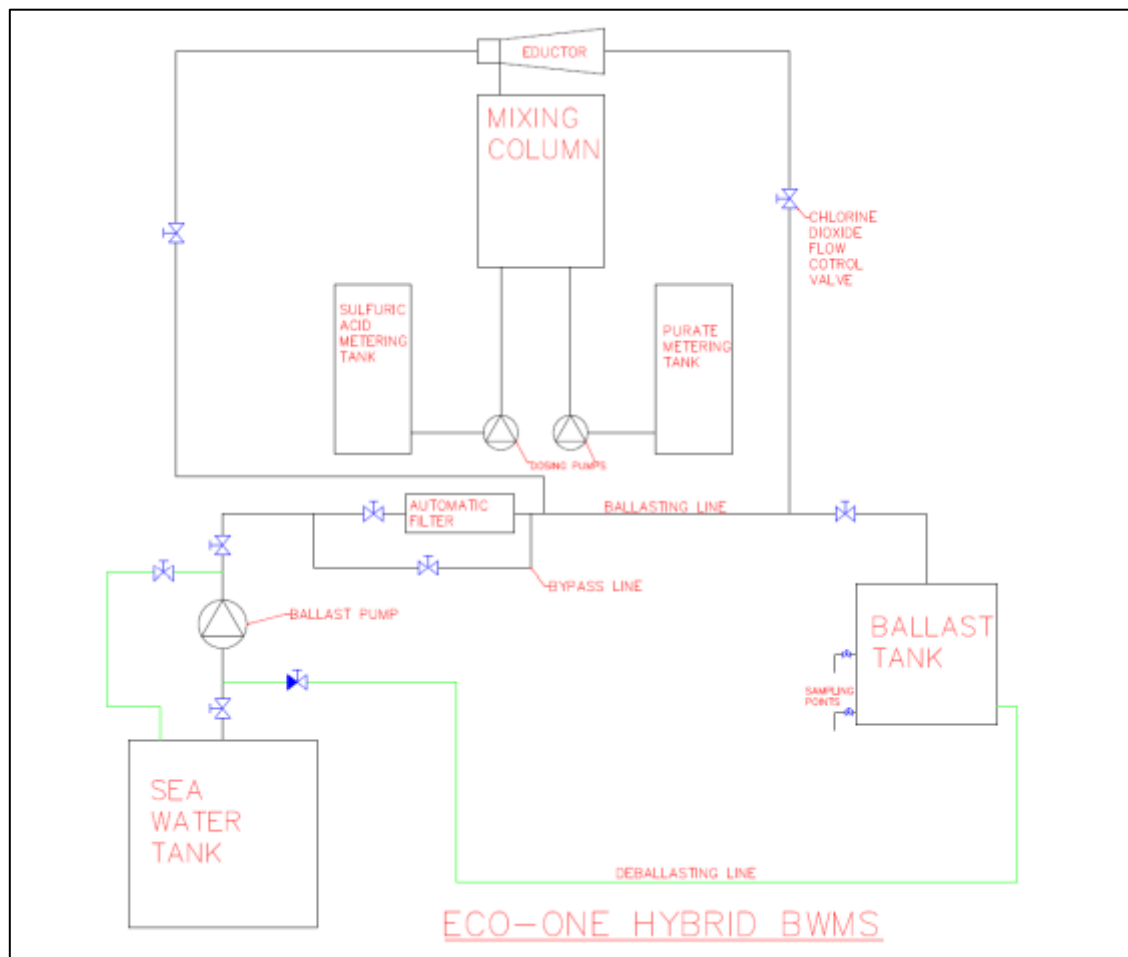


FIG 1: Eco-One Ballast water treatment system

VI. OPERATION

To demonstrate the ballasting operation, first we open/close required valves. Then start the dosing pumps so that mixing column has sufficient amount of disinfecting agent. Then ballast pump is started. One tapping from main ballast line goes to the venturi and provides the motive fluid. The disinfecting agent is then transferred from mixing column into the injection quill through the venturi. The injection quill in the ballast line injects the disinfecting agent into the ballast water. Once operation is complete, all pumps are shut off and appropriate valves closed/opened. Before de-ballasting is to be carried out, two samples from the ballast tank are to be taken to check for chlorine content in the ballast water. The content should be below the

MADC value. For de-ballasting, appropriate valves are to be opened/closed to set the line and then ballast pump is started. Once de-ballasting is done, shut the ballast pump.

VII. RESULTS

Treated ballast water is held in ballast tanks for a minimum of 24 hours for complete disinfection, also for ballast tanks where sampling of ballast water to be discharged is not possible the minimum holding time is 48 hrs. Before de-ballasting ClO₂ residual must be below 0.2 mg/L (ppm) which is the MADDC. The time required to achieve Maximum Allowed Discharge Concentration (MADC) depends on the quality of water used for ballasting and may vary upto 72 hours in some cases. To test for MADDC two samples are to be taken from each ballast tank, one sample from around the middle of the tank and one from near the bottom of tank. The water is tested with analytical device supplied by the manufacturer.

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Hydrogen Fuel Cell

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I. ABSTRACT:

A working model based on fuel cell and its construction. The model depicts the construction, outlook and first experiences on the use of fuel cell systems on board ship with hydrogen as fuel, giving a by-product of electricity and water, this electricity can be used for propulsion eliminating SO_x and NO_x and giving zero emissions. Constructional view on how one can eliminate various machineries such as purifier, tanks, bilges, sumps and auxiliary engines too leaving more space in the ship which can be commercially beneficial is explained.

II. OBJECTIVE:

Using hydrogen fuel cell with zero carbon emissions as energy source in ship by replacing IC engines and eliminating the use of fossil fuels onboard for a sustainable shipping.

III. INTRODUCTION:

With 90% of worldwide trade taking place by sea, the shipping industry is a huge participant in the world's economy but also a sizable contributor to global GHG emissions. The shipping industry accounts for approximately 3% of the world's GHG emissions with a worldwide commercial fleet of more than 90,000 ships. Shipping's share of air pollution is becoming significant, and the urge to reduce shipping emissions has increased. International legislation at the IMO governing the reduction of SO_x and NO_x emissions from shipping is being enforced. One possible solution will be the use of fuel cell systems for auxiliary power or even main propulsion.

Types of Fuel Cells

The Polymer Electrolyte Membrane (PEM) Fuel Cell Phosphoric Acid Fuel Cell

1. Solid Oxide Fuel Cell
2. Alkaline Fuel Cell
3. Direct methanol fuel cells

4. Molten Carbonate Fuel Cell

IV. CONCEPT:

A fuel cell uses the chemical energy of hydrogen or other fuels to produce electricity. Using hydrogen as the fuel, the by products are electricity, water, and heat. Fuel cells are unique in terms of the variety of their potential applications; they can provide power for systems as large as a 100GT merchant vessel in maritime sector. Fuel cells have lower or zero emissions compared to combustion engines and are quiet during operation.

V. WORKING PRINCIPLE:

Fuel cells work like batteries, but they do not run down or need recharging. They produce electricity and heat as long as fuel (hydrogen) is supplied. A fuel cell consists of two electrodes, a negative electrode (or anode) and a positive electrode (or cathode) sandwiched around an electrolyte. A fuel, such as hydrogen, is fed to the anode, and oxygen is fed to the cathode. In a hydrogen fuel cell, a catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. The protons migrate through the electrolyte to the cathode, where they unite with oxygen and the electrons to produce water and heat.

VI. DETAILED DIAGRAM:

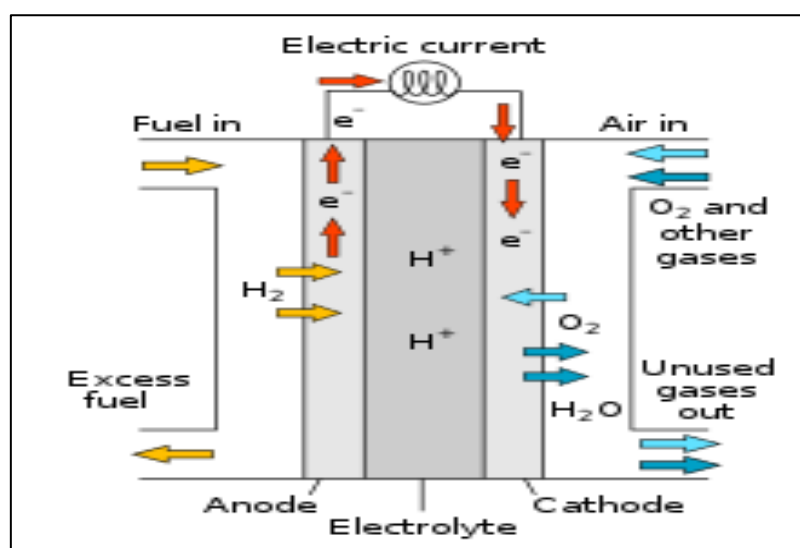
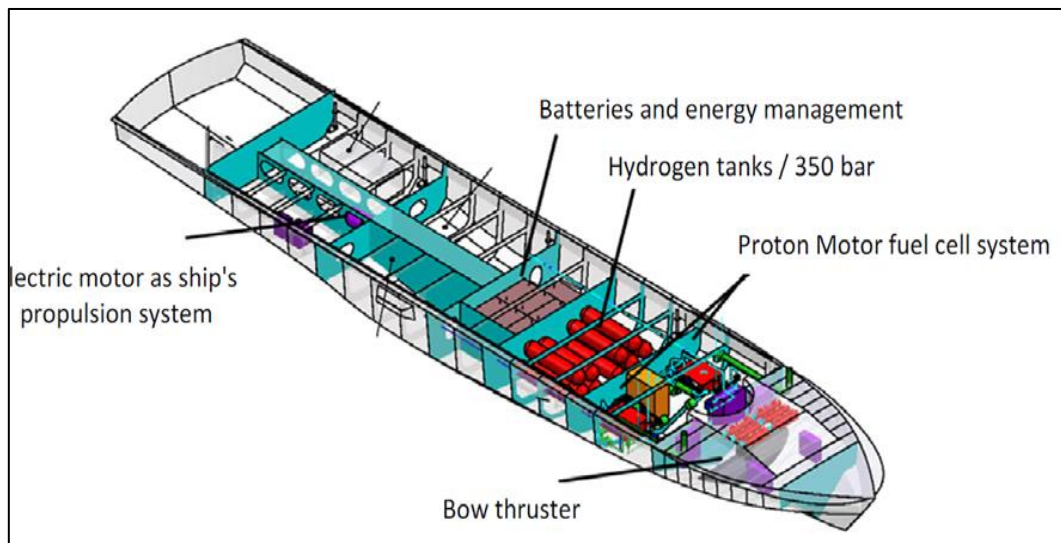


Fig. Fuel Cell

VII. CONSTRUCTION:



VIII. RESULTS (TABLES/GRAPHS)

Technology	Relative cost	Module Power levels (kW)	Lifetime	Tolerance for cycling	Fuel	Maturity	Size	Sensitivity to fuel impurities	Emissions	Safety Aspects	Efficiency
Alkaline fuel cell (AFC)	Low	Up to 500 kW	Moderate	Good	High purity hydrogen	High, experience from several applications including one ship	Small	High	No	Hydrogen	50-60 % (electrical)
Phosphoric acid fuel cell (PAFC)	Moderate	100-400 kW	Excellent	Moderate	LNG, Methanol, Diesel, Hydrogen	High, extensive experience from several applications	Large	Medium	CO ₂ and low levels of NO _x if carbon fuel is used.	High temperature (up to 200 C), Hydrogen and CO in reforming unit	40 % (electrical) 80 % (with heat recovery)
Molten carbonate fuel cell (MCFC)	High	Up to 500 kW	Good	Low	LNG, Methanol, Diesel, Hydrogen	High, extensive experience from several applications including ships	Large	Low	CO ₂ and low levels of NO _x if carbon fuel is used.	High temperature (600-700 C), Hydrogen and CO in cell from internal reforming	50 % (electrical) 85 % (with heat recovery)
Solid oxide fuel cell (SOFC)	High	20-60 kW	Moderate	Low	LNG, Methanol, Diesel, Hydrogen	Moderate, experience from several applications including ships	Medium	Low	CO ₂ and low levels of NO _x if carbon fuel is used.	High temperature (600-700 C), Hydrogen and CO in cell from internal reforming	60 % (electrical) 85 % (with heat recovery)
Proton Exchange Membrane fuel cell (PEMFC)	Low	Up to 120 kW	Moderate	Good	Hydrogen	High, extensive experience from several applications including ships	Small	Medium	No	Hydrogen	50-60 % (electrical)
High Temperature PEM fuel cell (HT-PEMFC)	Moderate	Up to 30 kW	Unknown	Good	LNG, Methanol, Diesel, Hydrogen	Low, experience some applications including ships	Small	Low	CO ₂ and low levels of NO _x if carbon fuel is used.	High temperature (up to 200 C), Hydrogen and CO in reforming unit	50-60 % (electrical)
Direct methanol fuel cell (DMFC)	Moderate	Up to 5 kW	Moderate	Good	Methanol	Under development	Small	Low	CO ₂	Methanol	20 % (electrical)

IX. CONCLUSION:

Hydrogen fuel cells are a promising alternative to current marine fuels. Fuel cells convert the chemical energy of hydrogen into electrical and thermal energy. This clean energy is then used to power ships' propulsion or auxiliary power systems – without generating greenhouse gas (GHG) emissions which shows a sustainable shipping.

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- Article: <https://doi.org/10.1039/D0EE01545H>

Onboard Power Generation And Distribution With Blackout Demonstration

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I. ABSTRACT:

Emergency generators are an important safety component of any vessel, especially cargo ships. In the event of a power failure, an emergency generator can provide power to critical systems, such as steering, navigation, and communication equipment, ensuring the safety of the crew and vessel. Therefore, it is essential to ensure the safe and reliable operation of emergency generators. This technical paper outlines the safety measures that lead to and must be taken for the safe operation of emergency generators on cargo ships.

II. OBJECTIVE:

The objective is to provide an overview of the safety measures that required to ensure the proper operation of emergency generators on cargo ships. It discusses the concept, working principle, safety measures, and SOLAS requirements in cargo ships.

III. INTRODUCTION:

Cargo ships rely heavily on electrical power supply to operate their machinery and equipment. However, power failures can occur due to various reasons, such as technical faults, rough weather, or even sabotage. In such situations, an emergency generator on-board the ship can be a lifesaver, providing electrical power supply to critical systems and equipment until the primary power source is restored.

An emergency generator is a backup power source that is designed to provide electrical power in the event of power failure. It is typically smaller than the primary power source and is used only during emergencies. Emergency generators can be powered by diesel or other fuel sources. They are usually located in a separate room on the ship, away from the main engine room, in a compartment above the waterline, along with the emergency switchboard. This dedicated compartment should have access to the main deck.

The importance of emergency generators in cargo ships cannot be overstated, as power failures can be life-threatening in some situations, such as during rough weather or in the case of

medical emergencies. Therefore, it is crucial to ensure that emergency generators are always operational and ready to operate properly in case of an emergency.

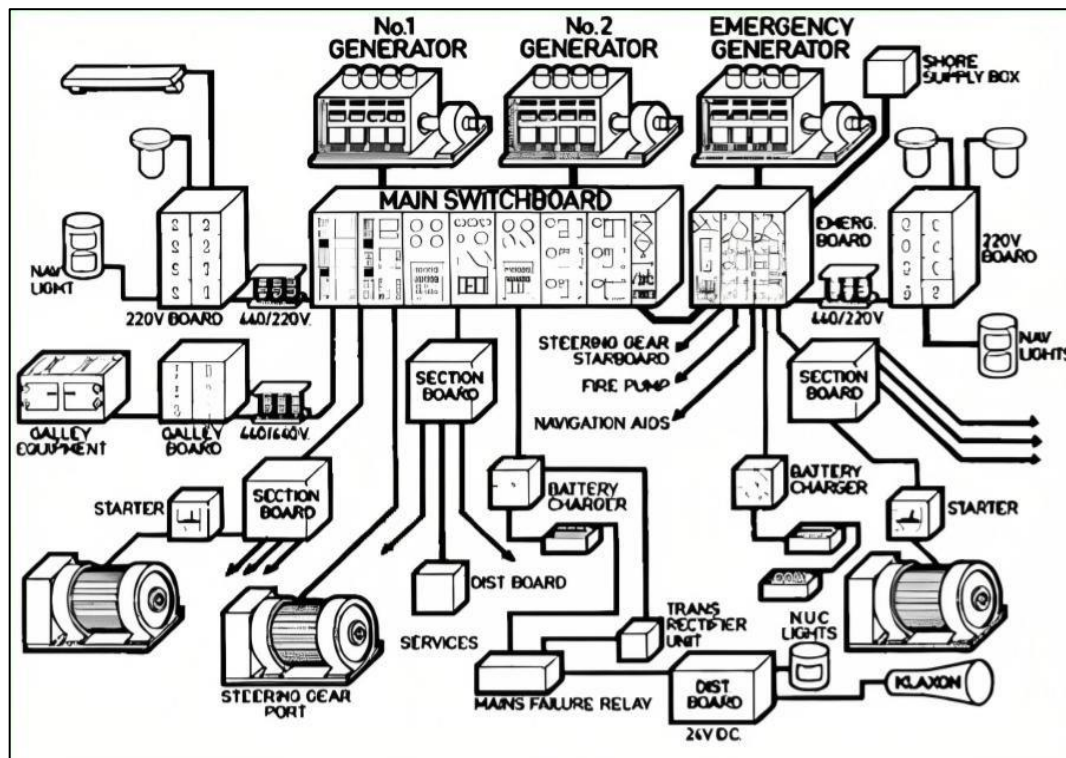


Figure 2 - A Ship's Typical Electrical Distribution System

In this context, regular testing and maintenance of the emergency generator system is critical to ensure its reliability and readiness. Also, the emergency generator system must comply with relevant regulations and standards, such as the Safety of Life at Sea (SOLAS) requirements, to ensure its safety and effectiveness.

In this project, we will demonstrate the actual setup of a ship's power generation and distribution system. This includes showcasing the emergency generator and its critical role in providing backup power in case of a power failure.

There are various reasons why the prime mover of an emergency generator, typically a diesel engine, may fail. These reasons can include mechanical problems, insufficient fuel, engine starter motor faulty or lubrication issue, and electrical malfunctions such as a faulty changeover relay, timer, starter motor's battery, or Emergency Generator's Control Panel PCB.

It is important to note that as per SOLAS regulations, in the event of a complete failure of all main generators, the emergency generator must start and come online within **45 seconds**. This emphasizes the critical nature of the emergency generator's role in ensuring the safety and

operation of the ship's systems, particularly during critical situations such as bad weather or emergencies at sea.

IV. CONCEPT:

The concept of an emergency generator in a cargo ship is straightforward - it is a backup power source that provides electrical power during an electrical power failure.

Emergency generators in cargo ships are typically designed to support critical systems and equipment that are necessary for the safe operation of the ship and the well-being of its crew. Some of the equipment and the systems that the emergency generators can support includes:

- 1) **Navigation systems:** Navigation systems, such as GPS, radar, and radio communication, are critical for the safe operation of the ship. In the event of an electrical power failure, the emergency generator can provide power to these systems to ensure that the ship stays on course and can communicate with other vessels and shore stations.
- 2) **Lighting:** Emergency lighting is essential during an electrical power failure to ensure that the crew can move around the ship safely. The emergency generator can provide power to emergency lighting systems, such as escape route lighting and critical area lighting.
- 3) **Communication systems:** Communication systems, such as the ship's public address system, intercoms, and emergency telephone systems, are crucial for the safety and well-being of the crew. The emergency generator can provide power to these systems to ensure that the crew can communicate with each other during an emergency.
- 4) **Life support systems:** Life support systems, such as the ship's fire detection and suppression systems, ventilation systems, and emergency pumps, are critical for the safety of the crew and the ship. The emergency generator can provide power to these systems to ensure that they continue to operate during an electrical power failure.
- 5) **Medical equipment:** In the event of a medical emergency, the ship's medical equipment, such as the defibrillator and other life-saving equipment, require electrical power to function. The emergency generator can provide power to these systems to ensure that the crew receives the medical care they need.

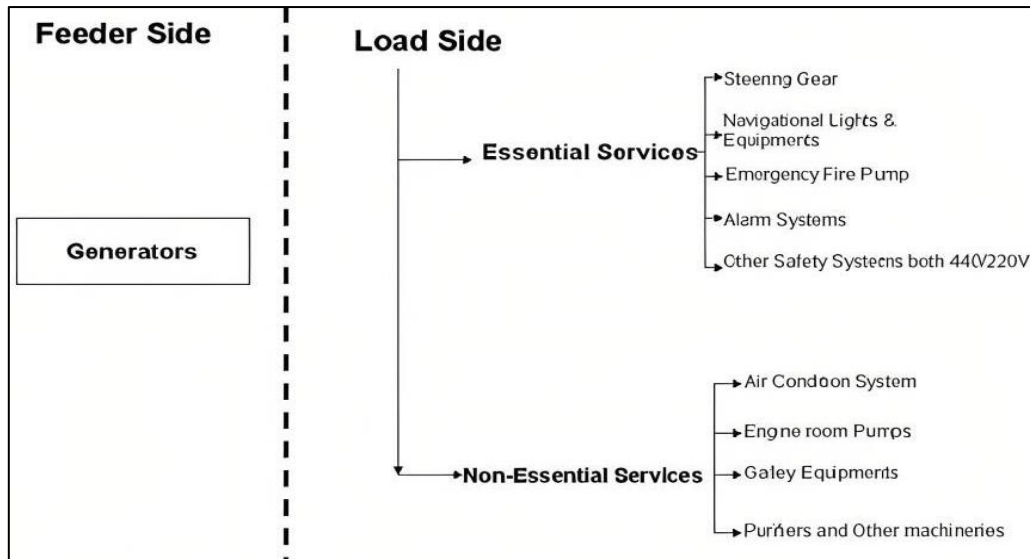


Figure 3 Power distribution arrangement Essential and Non-Essential services

V. WORKING PRINCIPLE:

The project demonstrates the actual functioning of the generator systems on board, including the configuration of the main generator and the emergency generator. Due to specific reasons, the running generator can fail and stop supplying power to the emergency busbar. At this moment, the emergency generator in our project starts automatically using a timer and relays and continues to supply power to the emergency busbar. It is essential to ensure the satisfactory working of the emergency generator as critical bridge equipment and emergency machinery, such as emergency fire pumps, steering gear systems, etc., rely on it for power.

Furthermore, two real-time situations have been incorporated into this setup. The first situation shows the emergency generator not starting, which could occur due to various reasons, such as a malfunctioning timer or relay. The second situation shows the emergency generator starting but not supplying power to the emergency busbar, which could be due to a fault in the generator's transfer switch or voltage regulator. By simulating these scenarios, the project aims to provide a realistic and comprehensive understanding of the workings of the generator systems on board and the importance of ensuring their proper functioning in emergency situations.

Auto changeover to an emergency generator during a blackout is a technical process that involves the use of an automatic transfer switch (ATS) to transfer the load from the main power supply to the emergency generator. The ATS is a device that detects any interruption or failure in the main power supply and automatically transfers the load to the emergency generator.

The auto changeover system typically consists of the following components:

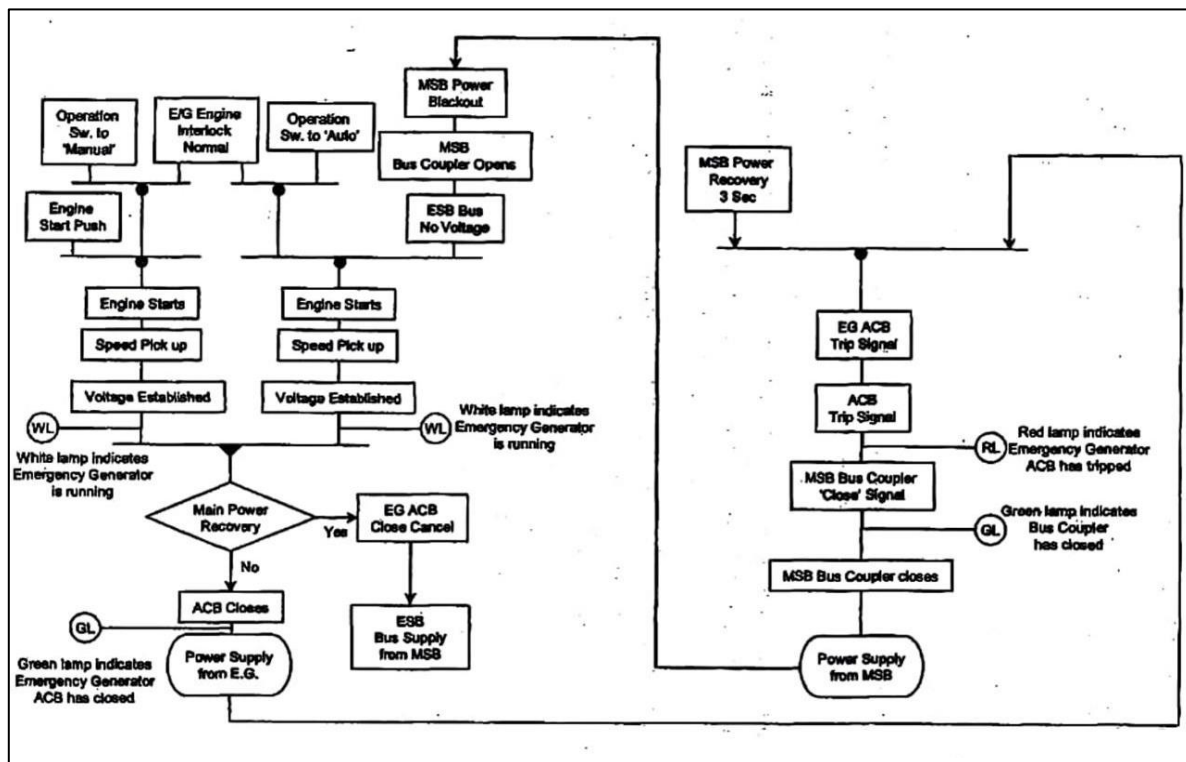


Figure 4 – An Emergency Generator’s Manual and Automatic Starting Flow Chart

- Automatic Transfer Switch (ATS): The ATS is a device that detects any interruption or failure in the main power supply and automatically transfers the load to the emergency generator.
- Control Panel: The control panel is the brain of the auto changeover system. It receives signals from the ATS and controls the opening and closing of the power contactors.
- Power Contactors: The power contactors are the switching devices that open and close the main power supply and emergency generator supply.
- Sensing Devices: The sensing devices monitor the main power supply and the emergency generator supply and confirm that the emergency generator is running and supplying power before transferring the load.

During normal operation, the ATS is set to the main power supply, and the power contactors are closed, supplying power to the critical systems and equipment on board the ship. When there is an interruption or failure in the main power supply, the ATS detects the fault and signals the control panel to open the power contactors for the main power supply and close the power contactors for the emergency generator. The sensing devices confirm that the emergency generator is running and supplying power before transferring the load.

Once the main power supply is restored, the ATS detects the return of power and signals the control panel to open the power contactors for the emergency generator and close the power contactors for the main power supply. The auto changeover system then reverts to the normal operation mode, ready for the next emergency.

Testing and trying out emergency generators in cargo ships is a critical process to ensure their reliability and readiness in case of a power failure. Here are some steps that can be taken to test and try out emergency generators on cargo ships:

1. **Conduct a visual inspection:** Before starting the generator, conduct a visual inspection of the generator and its surroundings to ensure that there are no signs of damage or loose connections.
2. **Check the fuel supply:** Ensure that the fuel tank is adequately filled and that the fuel supply valves are open.
3. **Start the generator:** Once the generator is ready, start it and let it run for a few minutes to ensure that it is functioning correctly.
4. **Monitor the generator:** During the trial run, monitor the generator's performance, including its speed, frequency, and voltage output. Also, ensure that the generator's safety features are functioning correctly, such as automatic shutdown if oil pressure is too low or if the generator overheats.
5. **Test the load capacity:** After the generator has been running for a few minutes, connect a load to test the generator's capacity. Gradually increase the load to the generator's maximum capacity, and monitor the generator's performance.
6. **Shut down the generator:** Once the trial run is complete, shut down the generator and conduct a post-operation inspection to check for any signs of damage or leaks.
7. **Record and document the test results:** It is crucial to record and document the generator's test results, including any issues, corrective actions taken, and maintenance performed. This information is necessary to ensure that the generator is safe and reliable for future use.

It is important to note that testing and trying out emergency generators should be done according to the manufacturer's recommendations and any relevant regulations or standards, such as the SOLAS requirements. Additionally, it is recommended to conduct regular testing and maintenance to ensure that the emergency generator is always ready to function correctly in case of an emergency.

VI. DETAILED DIAGRAM:

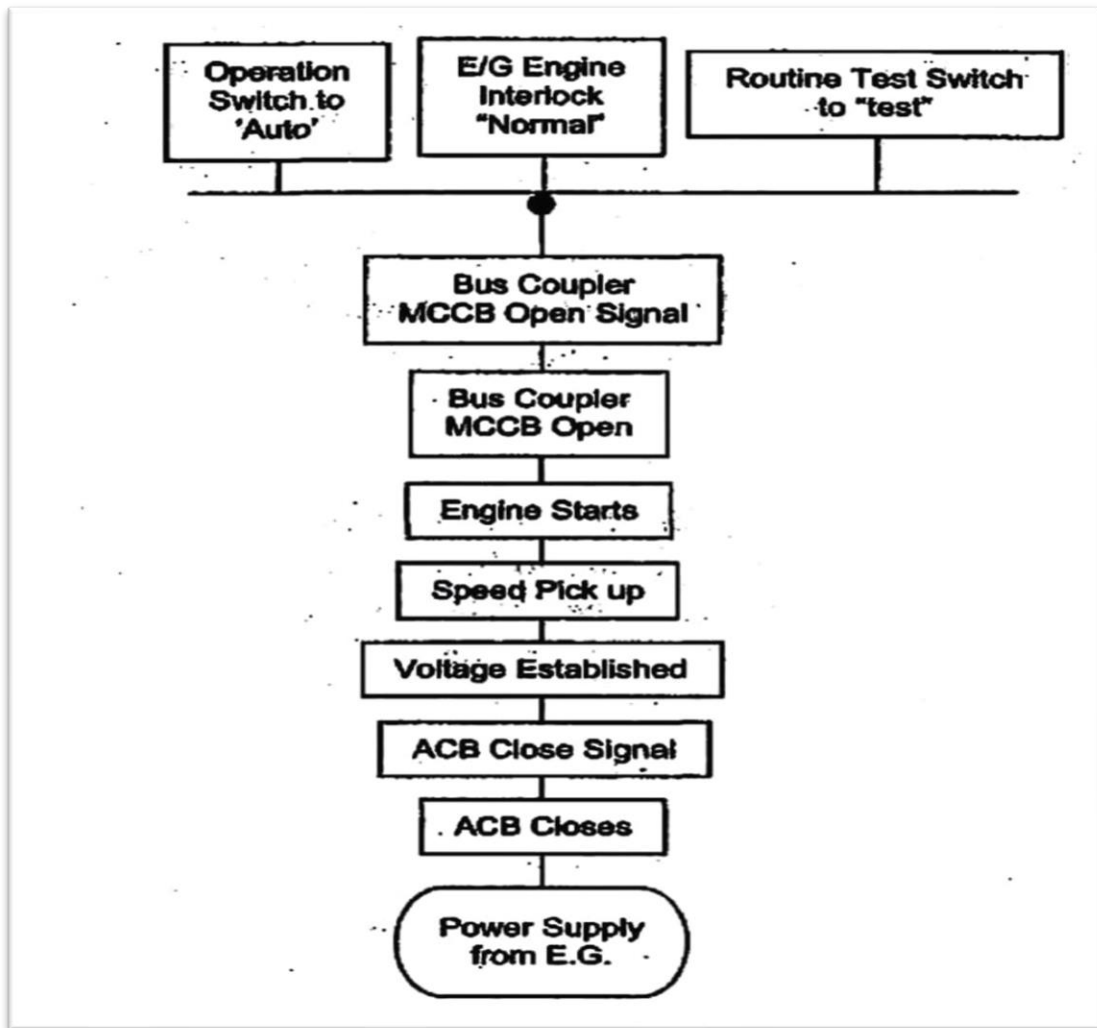


Figure 5 – Emergency Generator's Routine Testing flow chart

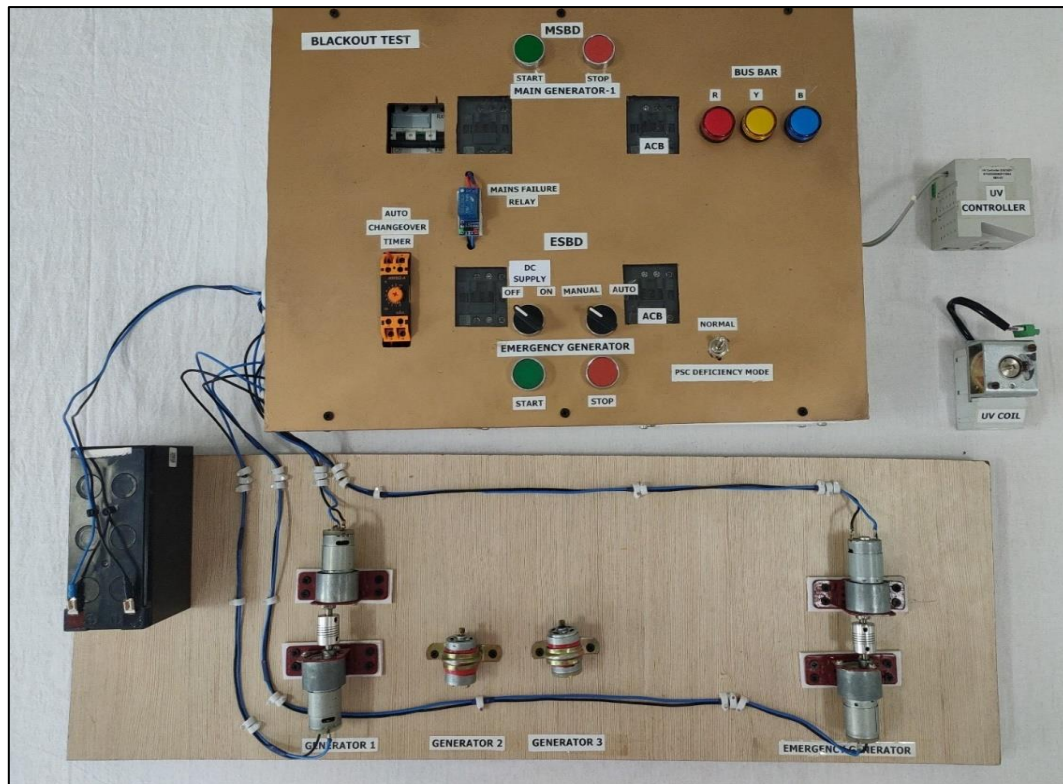


Figure 6 – Working Model of Onboard Power Generation and Distribution with Blackout Demonstration

VII. CONCLUSION:

The safety of emergency generators on cargo ships is essential for the safety and efficiency of the vessel and crew. Proper installation, maintenance, and testing of emergency generators are crucial to ensure their reliable and safe operation in case of a power failure. Therefore, it is important to adhere to the safety measures outlined in this technical paper to prevent accidents and ensure the timely and safe delivery of cargo.

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Patient Monitoring Systems for Hospitals

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I. ABSTRACT:

Due to the emergence of the new corona virus, health care is now of paramount relevance in every country. In this new era of technology, man has become a working machine that works like a robot 24 hours a day, seven days a week to acquire two meals. In this fast-paced world, he has forgotten to focus on the most important aspect of life: his health. Thus, one of the most essential uses of IoT is the health monitoring system. In India, about a quarter of the population dies as a result of a broken health-care system, in which doctors see patients in the morning, evening, or alternate shifts in most hospitals. What happens if a patient's health becomes critical in the meantime or if a doctor is unavailable to treat them? The solution is that a patient may lose his or her life. To avert this critical circumstance, we propose a practical embedded system device that continuously checks the health of patients. The pulse rate, vital signs, and saline liquid level of the patient are all monitored by this device (if any). Knowledge and communication technologies aid in the development of a digital revolution. For integrating various physical devices with networks, an IOT area unit has been identified.

II. OBJECTIVE:

This will give control of constant patient monitoring and patient data directly in the hands of hospital staff. Specifically made to target hospitals with large non ICU wards, as well as where constant monitoring is necessary. The device will monitor some of the vitals of patient constantly.

III. INTRODUCTION:

This system is used to continually measure the values of critical physiological parameters in patients such as blood pressure, body temperature, ECG, EMG, heart rate, and so on. Using bio-sensors, this device detects the patient's numerous parameters. A biosensor is a chemical sensing device that combines a biologically generated recognition entity with a transducer to allow for the quantitative development of a complex biochemical parameter. A system is a method in which a doctor continuously monitors one individual in a very remote location, in way over one parameter at a time. The soundness of the human heart is shown by the heartbeat. It aids in determining the state of a patient's circulatory system. The muscles receive oxygen-rich blood from the human heart. Except for tissues, it transports cell waste. Pulse rate varies in response to the need for muscles to expel carbonic acid gas and absorb element changes that occur during toil or sleep. This heart beat monitoring device allows the United States of America to calculate stomach beats per minute and compare them to normal heart beats; this information will only be used to track heart illness. Body temperature is also a common indicator of overall health.

IV. CONCEPT:

Using a single microcontroller interfaced with two sensors including heartbeat detection sensor through which we can calculate oxygen level too. Also, a temperature sensor , through which we can send the required information to pc through bluetooth/Wi-Fi ,this will directly provide message to doctors by using necessary program,the message which can displayed is the values of the necessary health condition of the patient

V. WORKING PRINCIPLE:

These sensors were designed and interfaced to the ATmega16 microcontroller to monitor medical characteristics like as pressure, pulse, and temperature. This microcontroller includes an ADC that converts analogue signals from sensors to digital signals. Wearable sensors such as pulse monitors and pedometers are increasingly popular. Many products are already on the market, such as Vivo metrics' Life shirt, Body Media's Body Watching System, and Nike's Apple iPod Sports Kit, which allows for personal feedback monitoring of performance during activity periods. The heartbeat detector is a simple way to monitor how well your heart is working. The flow of blood through Finger is monitored by this detector. The amount of blood in the finger fluctuates over time as the heart forces blood through the blood arteries within it.

When a finger is placed on the heart beat detector, a digital output of the heart beat is displayed. It has a brilliant red crystal rectifier that works well and a light weight detector. Because the most light should pass unfold in the finger and be recognised by the detector, the crystal rectifier must be extremely bright. The finger becomes somewhat more opaque as the centre pumps a pulse of blood through the blood arteries, allowing less light to reach the sensors. The detector signal changes with each heartbeat. This change is translated into an electrical pulse.

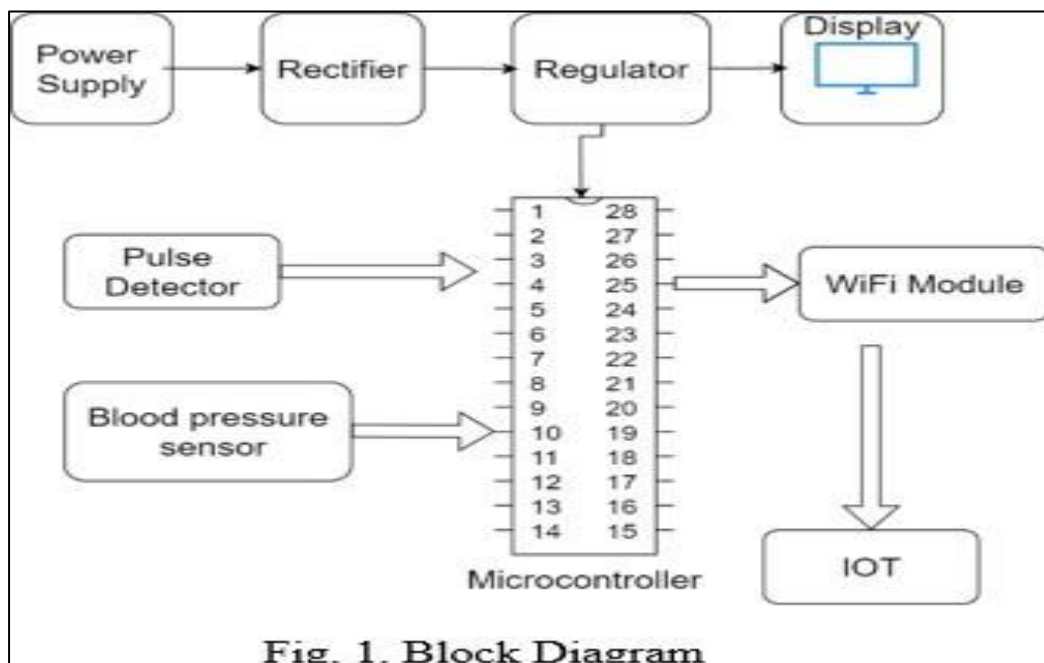


Fig. 1. Block Diagram

This digital output will be connected to a microcontroller, which will display the BPM rate. An electronic device that outputs a +5V logic level signal amplifies and triggers this signal. A light emitting diode that blinks with each heartbeat also indicates the output. The planned approach has a significant advantage: including ambient sensors that collect context data can aid in medical knowledge analysis. When a patient is participating in sports, medical measures such as heart rate and oxygen saturation must be taken regardless of whether the patient is sleeping or not. It's estimated that seventy percent of all illnesses might be avoided with proper screening.

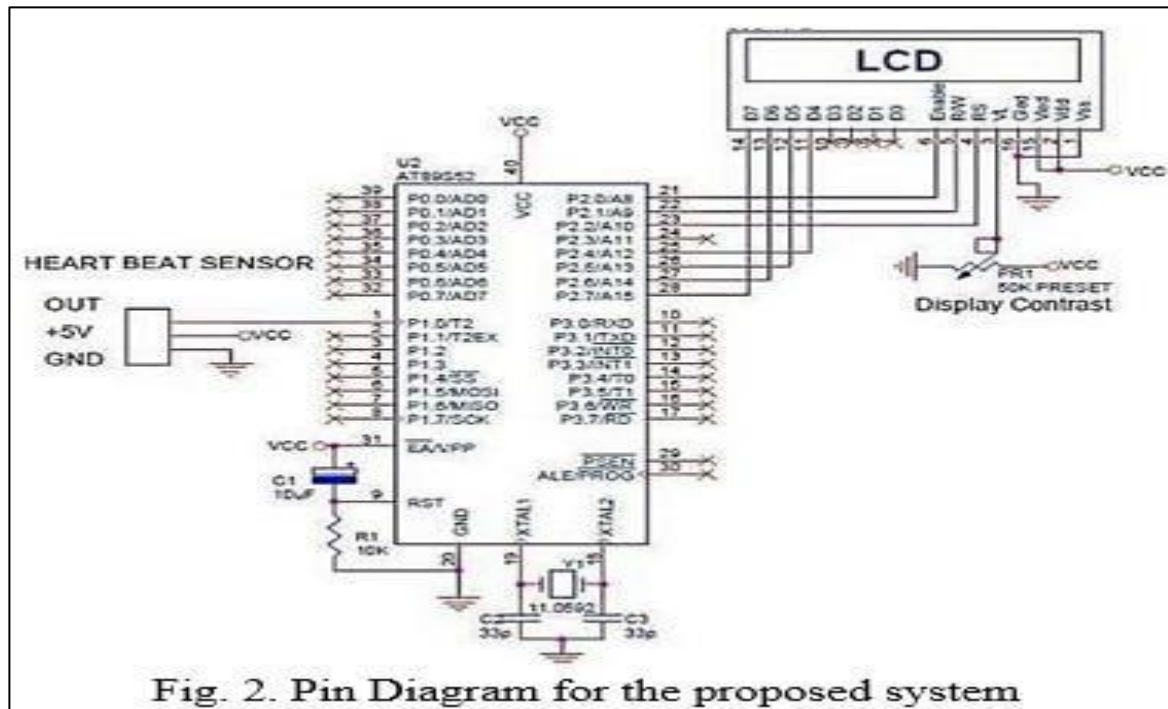


Fig. 2. Pin Diagram for the proposed system

If metrics were implemented, prices for treatments and pharmaceuticals may fall dramatically. Temperature sensors, humidity sensors, and, in the event of an emergency, smoke detector alert signals are among the environmental sensors. It is critical to include specific conditions sensors such as smoke detectors so that the attending medical professional can explain the acceptable course of action.

VI. RESULTS:

The microcontroller initially provides the digital values of sensed parameters. If the specified values are below a certain threshold, the microcontroller will frequently send the output victimization transmitter (CC2500) from the native web site to the remote monitoring site. At the same time, the output is saved to the memory card for long-term storage. On the remote viewing website, values are received by the receiver (CC2500), which sends the output to the linear unit, which then translates the serial data into USB data, which is displayed at the Nurse Management Station. The outcome is displayed on a graphical user interface screen since it is saved in information for future use, and the doctor will see it on his or her mobile victimization web.

VII. CONCLUSION:

With effective use of patient monitoring system, diagnosis can be made faster and transport time can be used to analyze situation

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Bluetooth Controlled Car with Arduino

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I. ABSTRACT:

A remote-controlled vehicle is any mobile machine controlled by means that are physically not connected with the origin external to the machine.

In this project, we make use of Bluetooth technology to control our machine car. We do not call this a robot as this device does not have any sensors. Thereby, senseless robots are machines.

The project aims are to design a Bluetooth control Arduino car and write a program into the Arduino microprocessor. Arduino car contains an Arduino microcontroller with basic mobility features. In this project, we make use of Bluetooth technology to control our machine car.

After doing this we can only say that we have been able to create as per our goal described. The device can be controlled by any smart device with android. The major reason for using a Bluetooth-based tech is that we can change the remote anytime – mobile phones, tablets, and laptops and physical barriers like walls or doors do not affect the car controls.

II. OBJECTIVE:

Bluetooth Control cars can be a helping hand for the cripples, or for the ones who want to drive but are unable due to many physical disabilities, where human life is at risk, we can use it from a very distance as it is fully wireless.

III. INTRODUCTION:

Wireless or Bluetooth control cars are developed to make our day-to-day life easy and simpler. Today for striving in this modern era it is necessary to use modern technology to simplify our day-to-day activities. Thousands of people die because of driving vehicles. If it can be remote-controlled, we will be able to save thousands of lives. The drone started a revolution in this regard. Bluetooth-controlled cars can be a revolutionary project for our upcoming future. It can be used for low-range mobile surveillance devices, (military Applications where no human intervention will be needed), Assistive devices (like wheelchairs), home automation, etc. It is aimed to bring a huge ground-breaking change in society by overcoming the hurdles we are facing today. Driverless cars are providing mobility to many people who cannot drive which is an added advantage to commuters who wish to use cars on daily basis. Bluetooth control cars are the gadget of the future.

IV. CONCEPT:

The main processing unit consists of Arduino UNO to perform specified operations. Arduino UNO board is used as the main microprocessor of the device. It will run and will control the movement of the vehicle using the motor driver who will control the wheels. The Programs are compiled using Arduino IDE and then the sketch is uploaded to the board using a pc and a USB cable. Speed variations can be achieved by making slight changes to the sketch. It is based on a 4-wheel drive platform integrated with an ultra-sonic sensor to avoid obstacles and line tracer sensors. It also has an infra-red remote controller for the manual steering of the vehicle. The car is upgradable and can replace, upgrade, and expand the input sensors and add other functionality by adding other modules.

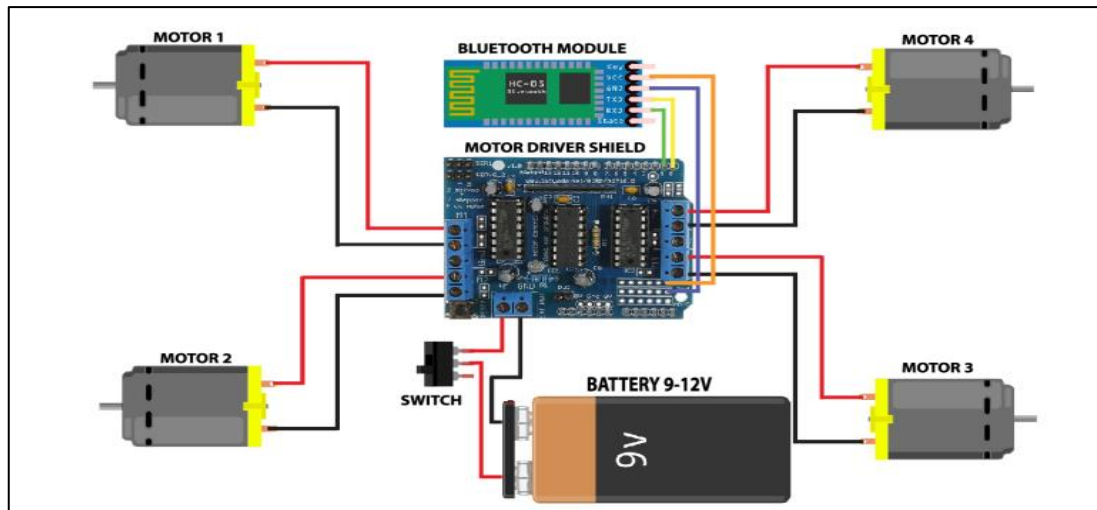
V. WORKING PRINCIPLE:

Assemble the robot, make the necessary connections, and upload the code to Arduino. If you understood the HC-05 Bluetooth Module tutorial, then understanding the Bluetooth Controlled Robot project is very easy. First, in the Android App, I have used 5 keys as Forward, Reverse, Left, Right and Stop. The corresponding data associated with each key is as follows:

- Forward – 1
- Reverse – 2
- Left – 3
- Right – 4
- Stop – 5

When a key is pressed, the corresponding data is transmitted to the Bluetooth Module from the Phone over Bluetooth Communication. In the Arduino code, the Arduino UNO receives any of this data from the Bluetooth Module (as per the key pressed) and performs a simple switch case operation, where each case associated with appropriate instructions to the Motor Driver Input Pins. For example, if 'Forward' key is pressed in the Android Phone, then '1' is transmitted. Arduino will then make IN1 and IN3 as HIGH and IN2 and IN4 as LOW to achieve a forward motion. Similarly, other keys correspond to appropriate setting of IN1 – IN4 pins.

DETAILED DIAGRAM:



VI. RESULTS:

The prototype is created using 4 DC motors driven by an H-bridge with dual output, connecting the two left wheels and the two right ones to its outputs. The car is remotely controlled either by Bluetooth an app or by infrared. Some extra functionalities can be added to the software.

VII. CONCLUSION:

This project consists of a basic prototype of a Bluetooth control car above stated. The prototype car can recognize commands from users and can turn the car left, right, and stop with great accuracy. It can be further improved by using different sensors like ultrasonic or infrared and with various levels of coding.

Our Bluetooth control car has a range of 10-20 meter with the mobile Bluetooth controlling system. The range mostly depends on the receiver's transmission level.

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Micro Bubble Drag Reduction a Model Based Analysis & Innovation

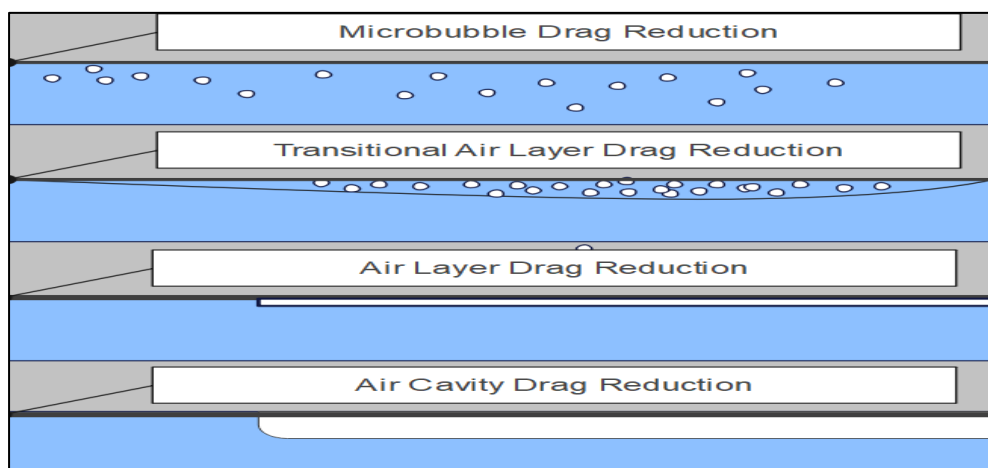
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I. ABSTRACT:

Innovation in the field of Transportation and energy-efficient systems is one of the significant necessities to reach the zero carbon emissions goals by the end of this century. One of the ways to increase efficiency and reduce the resistance in the Transportation of Cargo is the Lubrication of Microbubbles under the hull of vessels, also known as (Micro Bubble Drag Reduction). A model is made by our team and reduction calculations were made B.Tech ME, Second Year Tolani Maritime Institute,

II. OBJECTIVE:

The marine field is a vast region of Engineering and Technology, from the old day human-propelled vessels to the modern-day Man B&W 2-stroke dual-fuel engines. The Industry has advanced to such a level that much research and simulation must be done to install a new system. This technical paper explains the Micro Bubble Drag Reduction system through a model-based analysis. The change in ships' hull resistance with and without air injection is calculated. The model-based analysis is referenced through a Froude's model testing on hull resistance but measured through distance and time reference. According to Froude, the ratio of the large ship to the smaller model is the square root of the original proportion of the large vessel. Paper will lead to the working principle of the lubrication system. The machinery which is installed to make this system work. The minimum speed at which a vessel should be propelled to take the most efficiency out of this system. Content here also will include an innovative idea of using the LNG vessel's exhaust gases to lubricate the hull. The paper will give information on porous plates used to inject the air under the hull and the pipes used to transfer the compressed air under the hull, including the positions where to inject the air and the orientation of the nozzles—explaining the structure material and the area covered by the system under the hull.



**Figure 1:- Different type of Air Reduction injection types surface water contact
BLACK line is plate.**

III. INTRODUCTION :

The reason to choose the MBDR method from the four systems above is that the system provides enough control with the drag reduction. MBDR is also a system that takes less volume or does not occupy more space. The air lubrication system tries to attain a thin sheet of air bubbles under the vessel's hull. Due to this, the fuel needed for the main machine will be cut off to some extent, and hence it will reduce carbon emissions.

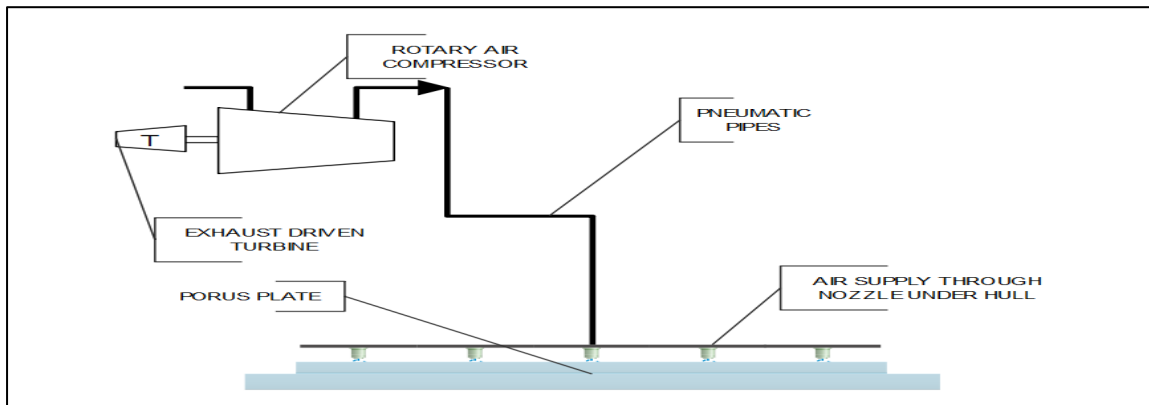


Figure 2:- Line Diagram of the Air System which is driven through the exhaust gases of the main engine.

IV. MODEL BASED ANALYSIS/WORKING PRINCIPAL :

This model-based analysis calculated the time for the Model to travel a 50-meter distance. This was done using a Compressor and a DC 18 V power supply with stone, which is made of Porous Concrete and generates microbubbles. The air bubble needs to be injected to all be equal in size. If the injected bubbles are not similar, different-sized beads will create various buoyant forces at different levels. The stability of the ship will affect hugely if the buoyant force is not acted similarly in every vertical Z direction concerning XY plane.



Figure 3:- Mild steel ship model



Figure 4:- Compressor coupled with a 12 volts DC motor.

This motor is DC rated with high Torque which generated the air to inject it at the depth of 10 cm under the hull the output of the compressor was connected with a pneumatic air transfer pipe and sent to the nozzle by drilling a hole of 5 mm on the hull.

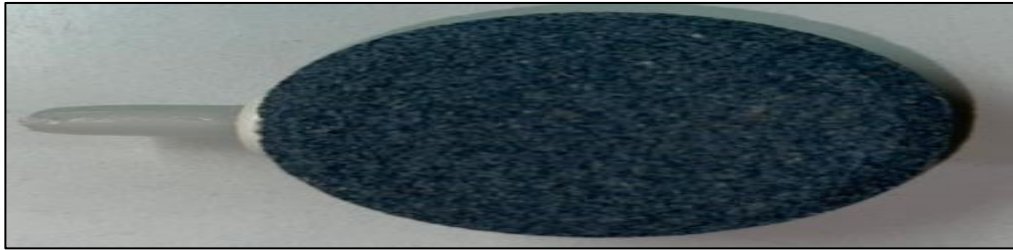


Figure 5:- Porous Concrete Injector plate which generates Microbubbles.

The output of the compressor was connected with a pneumatic air transfer pipe and sent to the nozzle by drilling a hole of 5 mm on the hull. The concrete particles are stuck with each other with the help of adhesive, making them porous. The air passing through the pipe in a pretty free flow will be made into tiny bubbles when passed through the porous rock and hence turned small. Abrasives particles when added to adhesive make a strong bond which can handle high pressure outputs.

The images below represent the different patterns of the flow of air bubbles with their structure.

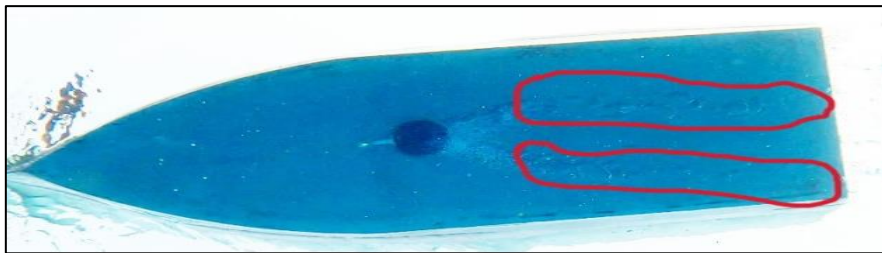


Figure 6:- Bubbles Separated too near the hull.

The image above shows that the bubbles are separated too early, and hence the microbubble effect of air lubrication is attained but can be referred as giant bubbles which can give different types of upward forces according to the bubble size. To compensate for this effect, we need to reduce the inlet pressure and increase the inlet flow, which will allow the injector plate to function properly

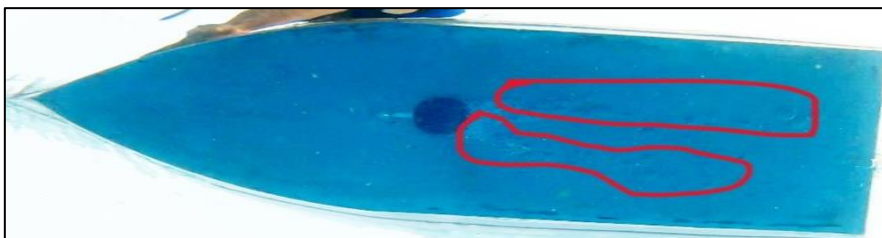


Figure 7:- Rate of air inlet is too less and hence the microbubbles aren't created.

Above is the condition where the injection pressure, as well as the quantity of the air injection, is significantly less. If these are the stagnation conditions, then it is hard to achieve the drag reduction, and in some cases, it may increase the resistance

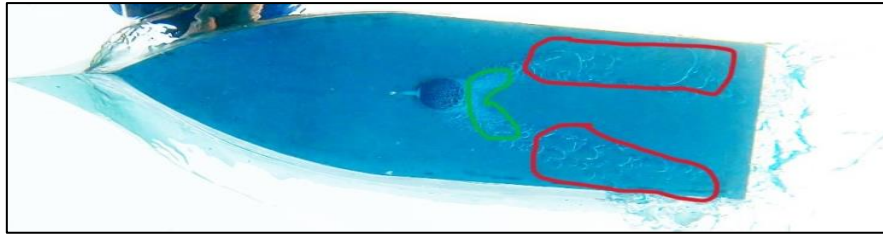


Figure 8:- Green Part shows High Density small bubbles Red part shows Piling Up effect.

The aim is to get high-density microbubbles injected; when this high-density microbubble piles up together and the piled-up bubbles also pile up, they create an air cavity, and the cavity has the potential to give vibrations to the hull. The injector plates should be placed so that the microbubbles are high-density and more petite in radius and should not pile up. They must be dragged till the end of the hull and only must be escaped the aft of the vessel.

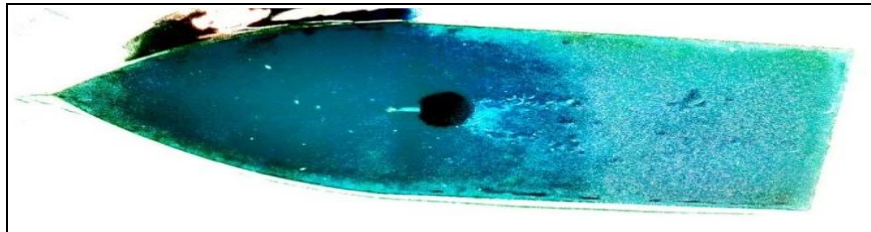


Figure 9:- Area near nozzle plate is piled up when the air goes towards the end of the hull it separated and shows almost perfect hull lubrications (The above image has been edited for the visibility of the microbubbles)

Equally distributed microbubble air injection is the perfect type of microbubble air injection. The condition can lead to the maximum hull drag reduction possible. The area near the nozzle in the above image is inside the condition where the air bubbles are in huge quantity, and this point will stay the same till the ship is at constant velocity. Once the velocity is increased, the bubbles need to be injected with a higher pressure and higher flow rate. Some of the bubbles in the above image are huge at the centre of the hull, but this will not affect the drag as they are covered with a vast amount of microbubbles to compensate the large volume bubble.

V. CALCULATIONS/RESULTS:

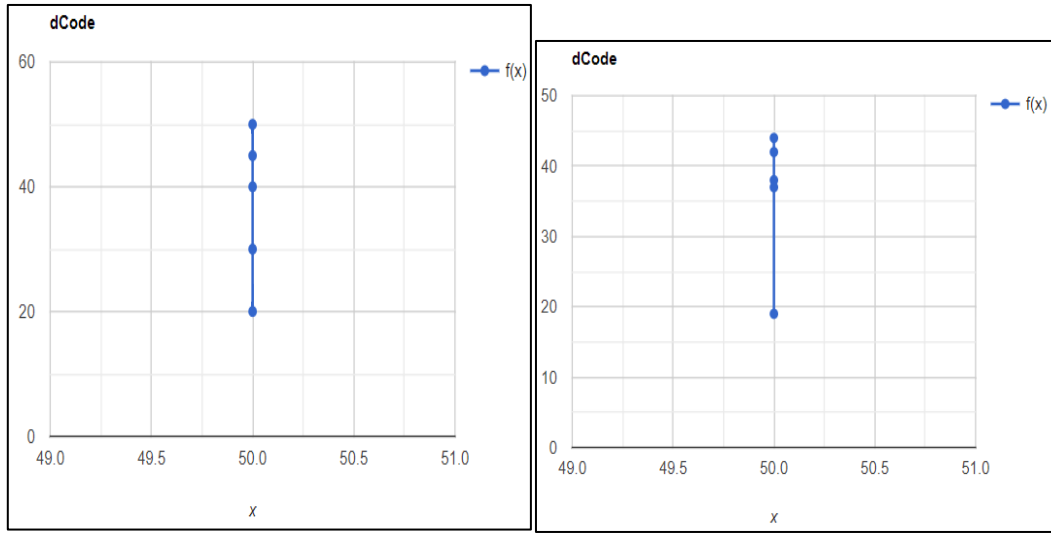
The ship was made to move with the constant pulling force of a motor with a radius of the pulley to be 3 mm. The motor is DC powered with 18 Volts, and the distance was 50 meters. This process was done with and without an air lubrication system installed. The draft is 7 cm. The table below shows the readings of time distance and the air inlet pressure

Sr no	Distance	Time required	Pulling force (Regulated motor with different rpm)
1	50 meters	50 seconds	0
2	50 meters	45 seconds	0
3	50 meters	40 seconds	0
4	50 meters	30 seconds	0
5	50 meters	20 seconds	0

Table 1:-Readings without air inlet

Sr no	Distance	Time required	Air Pressure
1	50 meters	48 seconds	1.3 bar
2	50 meters	39 seconds	1.3 bar
3	50 meters	32 seconds	1.3 bar
4	50 meters	28 seconds	1.3 bar
5	50 meters	19 seconds	1.3 bar

Table 2:-Readings with the air inlet with the same 5 motor stages and pressure of 1.3bar



The graph on the left shows the time and distance at particular speeds without air lubrication and the distance on right shows the time and distance at the same pulling force but with the air lubrication. According to the readings it is proved that the air lubrication is effective with the speed limit of 1.11 meter per second to 1.66 meter per second the air lubrication is not that useful for the operational conditions at speed less than 1.1m/s and more than 1.6m/s.

The drag reduction with the speed and distance calculations can be measured and is given at the table below.

Speed	%Reduction
1m/s	4%
1.1m/s	14%
1.25m/s	20%
1.66m/s	7%
2.5 m/s	5%

Table 3:- % reduction in time taken to cover same distance.

These are the reduction found on the model-based speed distance analysis, not the ship hull drag resistance calculation. Hence, these readings are apparent to have some error percentages. However, with this analysis, we can prove that air lubrication can reduce drag at a smaller scale where the waves are made to be ignored, and the air resistance is. Achieving 20 percent drag reduction is a challenging task. This can be only possible in model structures as they are

lightweight and with a lower draft and a much smoother surface compared to the vessel's hull. Now moving to the case where the vessels are injected with air bubbles instead of this small model, they are equipped with a bulbous structure bow with a huge surface area to encounter air resistance and rusting, which increases the friction of the hull with all these conditions calculated the MBDR system can promise to achieve a drag reduction of 10 to 7 percent in case of the average merchant ship.

Air Discharge Position :

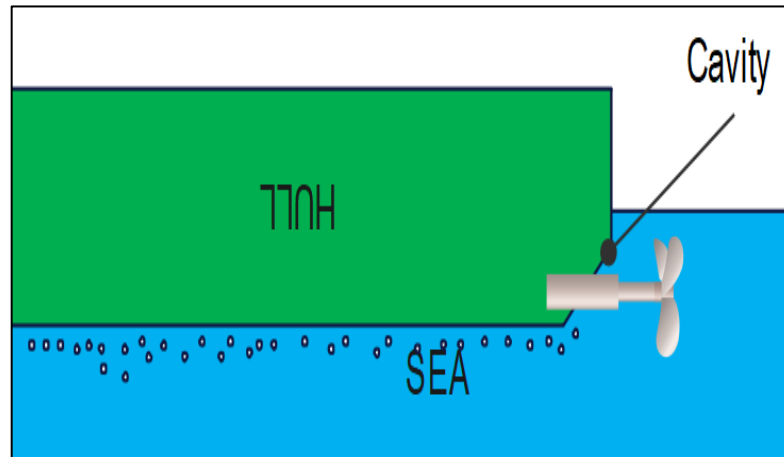


Figure 10:- Cavity For the air bubble to escape.

When the bubbles travel below the hull, they are pretty good in their micro nature, but once they reach the end, they should be sent to air, so they do not come in contact with the propeller. Suppose they are in contact with the propeller. In that case, they may cause cavitation in the propeller, which will highly reduce the pushing force of the propeller and result in significantly lesser efficiency.

VI. CONCLUSION:

Concluding this paper, the microbubble drag reduction method is a valuable method to reduce drag reduction; the different types of injections and the air bubble structure were explained. When where and how much to inject the air pressure was given in the paper, the drag reduction was measured with the function of speed distance and time notations. It was observed to range between a maximum of 20 percent at the velocity of 1.23m/s and a lease of 4 percent at 1m/s. The graph was noted between distance and time. The images of the underwater hull show the different types of cavitations. Model-based analysis was performed, and as a result, the MBDR system is quite efficient. The paper went through the installation location of the system. The boiler flue gases generated the power required to drive the compressor in our paper by placing a turbine in between the boiler generating tubes which has a temperature range of 945* Celsius to 340* Celsius coupled with an alternator, and this can provide the compressor enough power to compress the air. This system of injecting microbubbles has already been used by the company named Silverstream Technologies and is implemented by the company on a majority of Gas carriers and cruise liners to reduce carbon emissions; microbubble drag reduction is already operational in the maritime field also the MAN B&W WHRS waste heat recovery system is the efficient engine which can be used for the ships fitted with microbubble air lubrication.

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5. The figures are made by the AUTHOR using Wonder share E draw Max Application.
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Cargo Hold Cleaning Robot

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I. ABSTRACT :

Future is all about robots, robot can perform tasks where humans cannot, Robots have huge applications in military and industrial area for lifting heavy weights, for accurate placements, for repeating the same task number of times, where human are not efficient.

Generally, robot is a mix of electronic, electrical and mechanical engineering and can do the tasks automatically on its own or under the supervision of humans.

Cargo Holds of dry/liquid bulk carriers require a certain degree of cleaning when changing cargo. Such cleaning is time-consuming and at times, a hazardous task for the crew, which can be performed mainly while in port. The risk of not being sufficiently clean can be a big influencing factor. A consistently high cleaning is required. So, this model 'cargo hold cleaning robot' focuses on reducing the cleaning time, increasing safety, reducing risk, and cleaning while in open water using latest technology such as internet of things (IOT), artificial intelligence (AI), sensor technology, etc.

II. OBJECTIVE :

The objective of this model is to:

- Restrict the entry of crew in enclosed place such as cargo hold to reduce loss of life and increase safety at sea.
- Make cargo hold cleaning operation easy.
- Reduce cargo hold cleaning time.

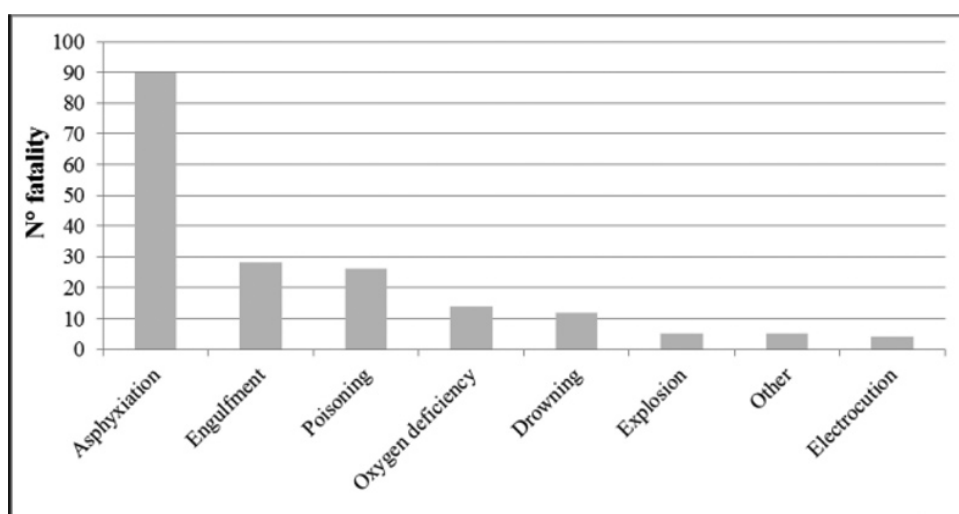


Fig.1: NIOSH accidents classification based on causes and number of fatalities occurred in confined space.

III. INTRODUCTION:

Enclosed spaces exist on ships of all types and sizes and the animation highlights different scenarios that could lead to the tragic loss of life in areas on ships where oxygen levels are depleted. Despite the safety requirements described in SOLAS Regulation XI-1/7, all Group Clubs continue to see fatalities caused by oxygen depletion in confined or enclosed spaces on ships. Too many lives are lost unnecessarily when seafarers or shore-based personnel enter enclosed spaces on board ships.

The International Group has undertaken research into fatalities arising from enclosed spaces during the period of 2015 to 2020. Of the 83 deaths that occurred in enclosed spaces, 53% of deaths were due to oxygen depletion and over 60% of the incidents were located in the cargo hold.

There have been a total of 145 in the past 20 years, and alarmingly 28 in the past 16 months. We know that maritime workers are generally aware of the risks associated with entry into confined spaces, but they may not be aware of the details and extent of the varied dangers posed by forest products, coal, iron ore, grains, gases and other cargo. As such, ITF emphasized it is not enough for a worker to rely on opening the hatches for 30 minutes and hoping for the best, or to do the best they can to protect themselves on their own. It is also not enough for workers to take all available precautions but sometimes still be caught without sufficient protection by pockets of gases and lack of oxygen.

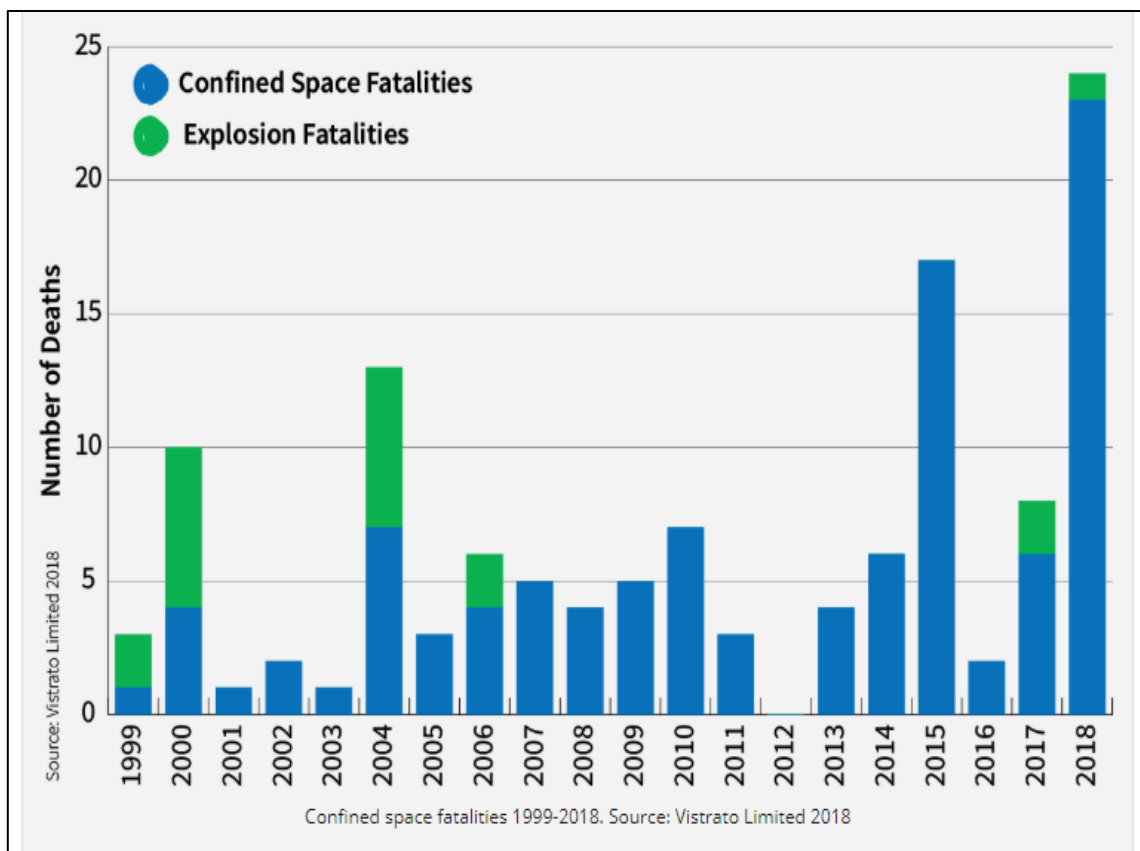


Fig.2: Confined space fatalities 1999-2018. Source: Vistrato Limited 2018

IV. CONCEPT:

This model focuses on effective cargo hold cleaning operation by using a robot. The robot is made using arduino uno, bluetooth module, gear motors, motor driver, water pump, nozzle, camera module, gas sensor, etc.

The robot has two rear wheels and a forward caster wheel. It enables the robot to move in different directions. A water pump and a nozzle is installed in the robot. The nozzle can rotate about x-axis as well as y-axis. A gas sensor is installed to detect presence of harmful gases in the cargo hold. A camera module is installed in the front of the robot for live video monitoring of the cleaning operation. The robot has two operation mode which are manual mode and auto mode. In manual mode the robot is remotely controlled and cleaning operation is continuously monitored. In auto mode the robot automatically runs in the cargo hold and performs washing. The robot is secured using a rope and it is lowered down into cargo hold using that rope. After cleaning operation, the robot is picked up from cargo hold using the rope. Once a cargo hold is cleaned the robot can be lowered down into another cargo hold, or more number of robots can be used for faster cargo hold cleaning.



Fig.3: Cargo hold cleaning concept model

V. WORKING PRINCIPLE:

Cargo hold cleaning depends on the type of cargo which was carried previously. If it was a dirty cargo such as coal, sulphur or products which may react with another cargo the tanks need to be cleaned thoroughly with chemicals and water. Care needs to be taken for not using water if the cargo has the tendency to react with it. Some cargo such as cement, coal etc needs to be shovelled first. Such cargo will leave a thin layer on the cargo hold surface which needs to be clean by use of chemicals. Once the chemical cleaning is done the hold is washed with sea water. Clean cargo such as grains, corns, etc, the hold can be directly washed using seawater without the use of chemicals.

Depending upon the previously carried cargo the robot will perform the cargo hold cleaning operation under the surveillance of deck officers.

VI. DIAGRAM:

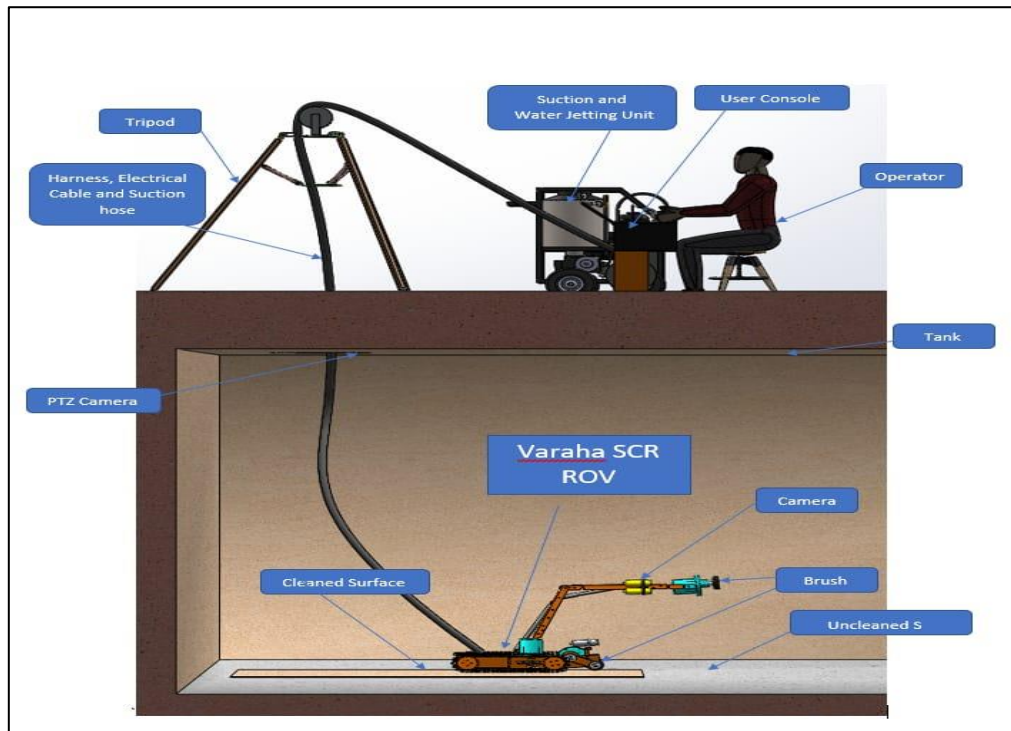


Fig.4: Manual mode cleaning operation

VII. CONCLUSION:

The cargo hold cleaning robot is an innovative method of cargo hold cleaning. It makes cargo hold cleaning operation more efficient, fast and safe. The robot is not only used for cargo hold cleaning purpose but it can also be used for fire-fighting purpose. The robot can be sent to extinguish fire where humans cannot reach. With smoke sensors and live video monitoring fire-fighting becomes safer and easier. The wide range of application of this robot in maritime industry makes this robot a good product for ship owners.

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Piracy Prevention Robot

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I. ABSTRACT:

An anti-piracy robot for ships could potentially be developed to help protect ships from pirate attacks. However, such a robot would require careful consideration of its design, capabilities, and limitations. One possible approach for an anti-piracy robot could be to create an autonomous vessel that can patrol around the ship, equipped with cameras, radar, and other sensors to detect potential pirate activity. It could also be equipped with non-lethal weapons such as net launchers or other contraptions to deter pirates from approaching the ship. However, there are several challenges and limitations to consider when designing such a robot. For example, it may be difficult to create a robot that can accurately detect pirate activity and distinguish it from other sea traffic or natural phenomena. It may also be challenging to ensure that the robot is able to navigate safely in different weather conditions and handle unexpected obstacles.

II. KEYWORDS:

ROV, live video monitoring, net launcher, underwater bot, GPS tracker

III. INTRODUCTION:

A piracy prevention robot for ships would need to have several features and capabilities to effectively deter and respond to piracy threats. Here are some potential features:

1. Surveillance capabilities: The robot would need to be equipped with cameras, radar, and other sensors to monitor the ship and surrounding waters for any signs of pirate activity.
2. Navigation and communication systems: The robot would need to be able to communicate with the ship's crew and navigate the ship to avoid pirate attacks.
3. Defensive measures: The robot would need to be able to deploy defensive measures such as water cannons, smoke screens, or even non-lethal weapons like rubber bullets or stun guns.
4. Alarm systems: The robot would need to be able to alert the crew and authorities if it detects any pirate activity.
5. Remote control: The robot would need to be remotely controlled by the ship's crew or authorities to ensure that it responds appropriately to any threats.

6. Durability: The robot would need to be able to withstand harsh marine environments and potential attacks from pirates.
7. Autonomous capabilities: Ideally, the robot would be able to operate autonomously, without the need for constant human intervention.

Overall, a piracy prevention robot for ships would need to be a versatile and capable machine that can effectively respond to piracy threats and keep the crew and ship safe.

In our project model, we will be focusing on the autonomous capabilities and the ability to deter any sort of piracy that a ship can be inflicted with as early as possible without any risk and casualties.

IV. CONCEPT:

The purpose of the model is to stop the propeller of the pirate ship and prevent them from pursuing the merchant vessel. The model uses Arduino UNO and Arduino Nano modules, Bluetooth module, ESP 32 camera module, Neo-6M GPS module among other key components.

To stop the propeller, a net is launched by the robot to latch onto the rotating propeller of the pirate vessel. The propeller gets entangled in the high-strength net, momentarily seizing it and making the pirate vessel unable to pursue the merchant ship.

The robot is completely unmanned and is controlled by a wireless controller with a camera fitted in it for live monitoring of events.

The robot has three primary launching mechanisms:

- Hose launcher- The hose launcher launches a hose which latches and secures the robot to the pirate ship. It reduces the power required to keep up with the pirate vessel and be in extremely close proximity to the target in the scenario that the robot is found out by the pirates.
- Net launcher- Once the robot is secured onto the pirate ship and it has correctly positioned itself near the propeller of the pirate vessel, it launches a high-strength net directed on the propeller of the pirate vessel via a powerful ballistic launcher.
- GPS tracking contraption- A contraption equipped with a GPS tracker is attached to the pirate vessel so that we are notified and are updated of the location of the pirate vessel in real time. This location and tracking of the target is then sent to nearest navy and coast-guards in case of any distress.

The robot moves underwater from ship to target which makes it harder to notice and is less susceptible to being compromised during the entire operation.

V. WORKING PRINCIPLE:

To actualize the ideas behind the model we plan to make a device that has the potential to protect and keep any eye on the activities of the pirates without an upfront confrontation which might endanger the lives involved and to prevent them from getting on board by stopping them.

Once an unidentified boat is identified and is under suspicion that can be a potential threat to merchant ship comes in the detection range of 100mts, the device is launched into the sea to patrol the underwater perimeter and go nearby the unidentified boat.

If the boat is identified as a pirate vessel, the device gets activated and is equipped with radio control. The device launched from the merchant ship then approaches the pirate ship. It is controlled by a remote operator to precisely manoeuvre and target the pirate's ship. Once it is attached with the pirates' boat it is easier to manoeuvre the device. The robot uses its launching mechanism to stop the pirate ships' propeller, seizing it and rendering it unable to manoeuvre effectively.

It is also equipped with a camera module and inbuilt GPS to keep track of them. In case any mishap happens due to an altercation, this GPS module is programmed to send distress signal to the nearest navy or guards to keep track of the route of the pirates when they fall back.

By following this working principle, the model can effectively and prematurely prevent piracy on merchant ships by quickly detecting and neutralizing potential threats before they can cause harm to the ship and its crew.

VI. CONCLUSION:

As this is a proposed model, it is built with financial constraints. Overall, the development of an anti-piracy robot for ships is a complex task that would require a multidisciplinary approach involving experts in robotics, navigation, security, and international law. While such a robot could potentially be a useful tool in the fight against piracy, it would need to be carefully designed, tested, and regulated to ensure its effectiveness and ethical use.

Another consideration is the legal and ethical implications of using robots as a means of self-defence against piracy. International laws and regulations would need to be carefully studied and followed to ensure that the use of such robots does not violate any rules or laws.

VII. ACKNOWLEDGEMENT:

We would like to thank Tolani Maritime Institute, Induri, for providing us with an opportunity to do a research model on PIRACY PREVENTION ROBOT. We would like to express our sincere gratitude to our teachers, seniors and batch mates for their constant guidance and encouragement in carrying out this research project.

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Ship Collision Prevention System

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ABSTRACT:

With the increasing demand for transportation worldwide, maritime transportation has witnessed a great development in the past few years. At the same time, shipping traffic has become more and more intensive. The safety of ships has become the primary concern of the shipping industry. As technology continues to evolve, more new technologies and tools are used to improve the safety of maritime transportation. However, ship accidents still occur from time to time. Figure 1 shows the causes of accidents to ships. The International Maritime Organization (IMO) report points out that more than 80 percent of maritime accidents are caused by human factors. Ship collision accident is a major threat to the safety of maritime navigation, which may cause serious casualties, economic losses and marine environmental pollution, etc. Therefore, to reduce the navigational risk and casualties caused by human factors, it is very necessary to improve the ability of autonomous navigation and autonomous collision avoidance of ships. In this model, in order to solve the problem of collision of ships, the ship collision prevention system is made based on sensor technologies for intelligent transport system and behaviour based safety for improved maritime operation.

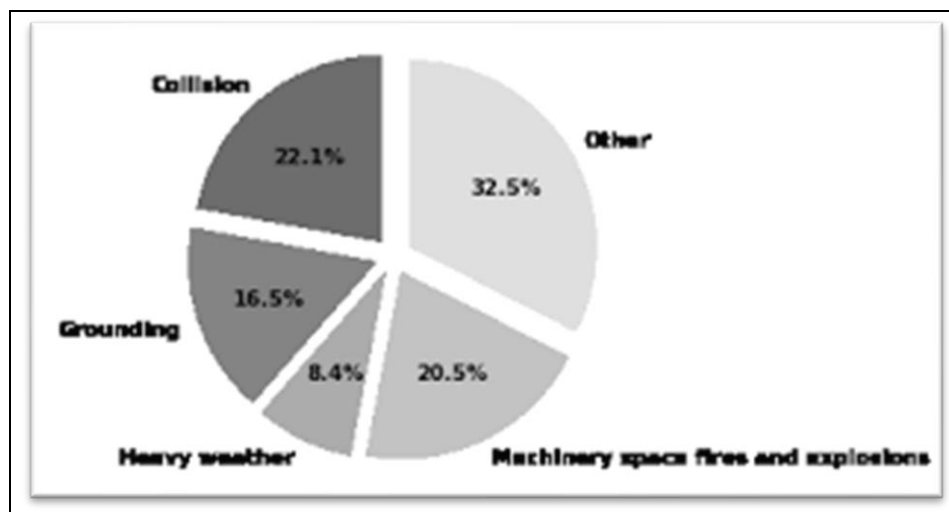


Fig. 1. Cause of accidents to ship

OBJECTIVE:

The objective of this model is to design an innovative concept to prevent ship to ship collision and improve maritime safety.

INTRODUCTION:

Ship collision is the name given to the physical impact that occurs between two ships resulting in a damaging accident.

Ship collisions are of particular importance in marine accidents. Some reasons for the latter are:

- The loss of human life.
- The environmental impact of oil spills, especially where large tanker ships are involved.
- Financial consequences to local communities close to the accident.
- The financial consequences to ship owners, due to ship loss or penalties.
- Damage to coastal or off-shore infrastructure, for example collision with bridges.

As sea lanes are getting more congested and ship speeds higher, there is a good possibility that a ship may experience an important accident during her lifetime.

Water traffic has become increasingly busy with the rapid development of the shipping industry in recent years, which has led to an increased risk to individuals and society in terms of various aspects, especially ship-ship collision accidents. Higher speeds may cause larger operational loads, like slamming, or excessively severe loads, for example during a collision. Denser sea routes increase the probability of an accident—in particular a collision—involving ships or ships and shore or offshore structures.

Almost 27% of ship collisions occur near coasts and 22% at narrow channels.^[2] This is due to disregarding best practices and regulations by navigation officers and masters. In addition, the IMO guidelines for voyage planning are not always followed. Violations usually occur when inadequate safe speed, overtaking or miscommunication with the pilot.

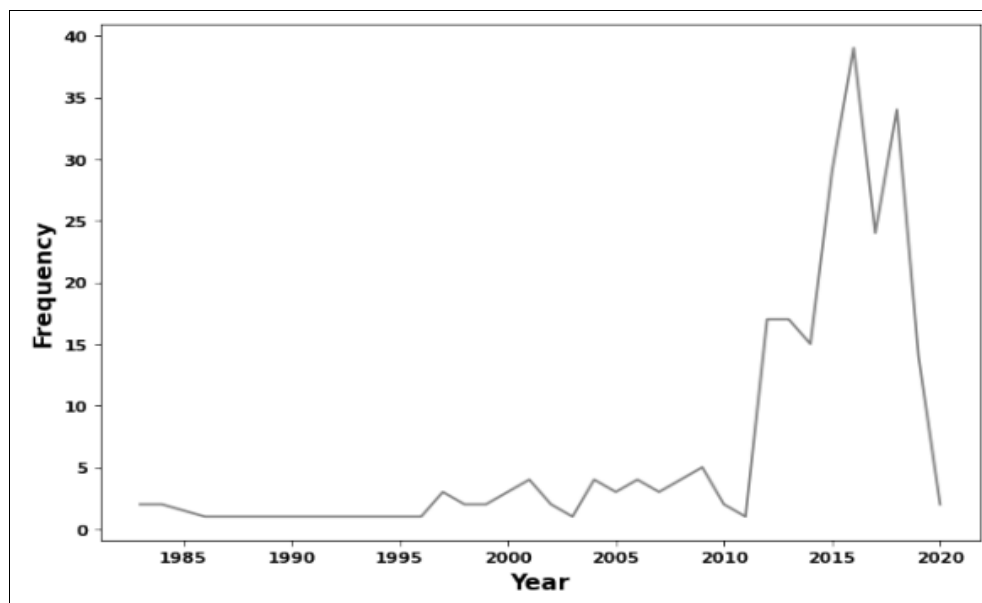


Fig2. Timeline for the total number of accidents for the period 1983–2020

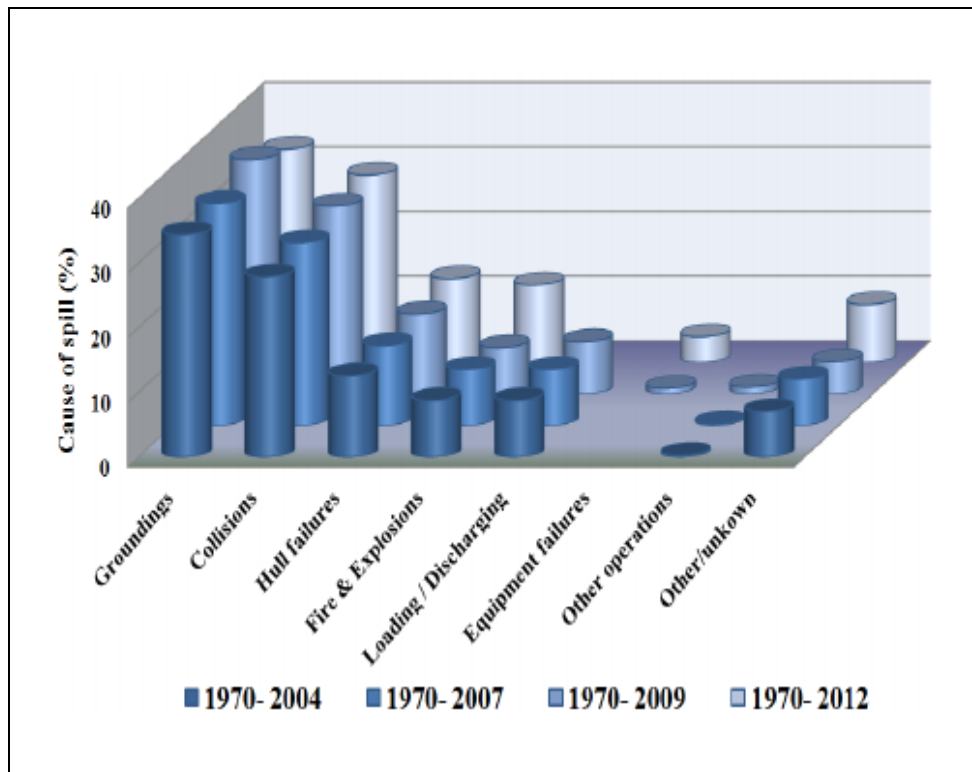


Fig.3: Causes of oil spill

CONCEPT:

There are several different types of maritime collisions, including:

- Side collisions – when a vessel is struck on the side by another vessel.
- Bow-on collisions – when two vessels strike each other head-on.
- Stern collisions – when one vessel runs into the back of another.

In most of the cases of collision between two ships, one ship collides from fore end. The fore end is most vulnerable to damage in case of collision. But other sections of the ship also have the probability of collision. So, this model focuses on prevention of collision at fore end as well as other sections of the ship.

This model is made using ultrasonic sensor, arduino and air blower. An ultrasonic sensor is fitted in the front of the ship. A inflatable air bag is fitted in the bulbous bow and forward shear of the ship. The ultrasonic sensor detects any ship approaching towards the ship. If the approaching ship comes near to the ship then alarm comes, if it comes too close then the inflatable air bag inflates, hence avoids metal to metal contact and minimises structural deformation. The water area around the ship are divided into three regions, as shown in Fig.3 Those are safe area, potential collision area and forbidden area. There is no danger to the ship when approaching ship is safe area. Once the approaching vessel enters the potential collision area an alarm turns on which also indicates from which side the vessel is approaching. When the approaching vessel enters the forbidden area the inflatable airbag inflates and prevents the collision. The airbag inflates only in the area where collision is about to occur.

This inflatable air bag and ultrasonic module is installed in all over the freeboard of the ship to prevent collision from any side of the ship.

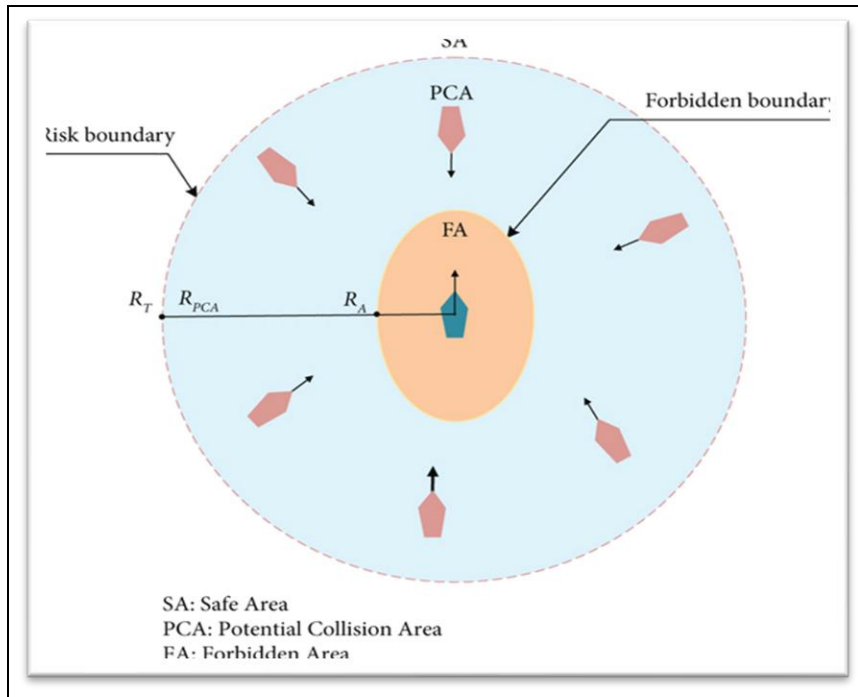


Fig.4: Division of water area around the ship

WORKING PRINCIPLE:

This model works on the principle of pressure is inversely proportional to area. At the time of collision the area of contact increases by inflation of air bag in the collision area of both the ships. This reduces the pressure which minimises the structural deformation of both the ships. The inflatable air bag not only reduces the pressure by increasing the area of contact but also gives a cushioning effect which further reduces the impact of the approaching ship at the time of collision. To detect a ship approaching ultrasonic sensor is used. It works on the principle of when an electrical pulse of high voltage is applied to the ultrasonic transducer it vibrates across a specific spectrum of frequencies and generates a burst of sound waves. Whenever any obstacle comes ahead of the ultrasonic sensor the sound waves will reflect back in the form of echo and generates an electric pulse. It calculates the time taken between sending sound waves and receiving echo. The echo patterns will be compared with the patterns of sound waves to determine detected signal's condition.

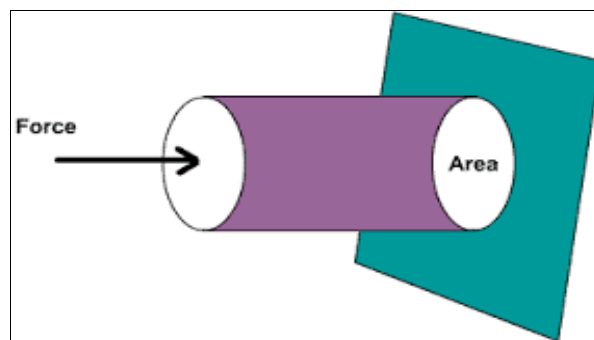


Fig.5: Pressure= Force/Area

DETAILED DIAGRAM:

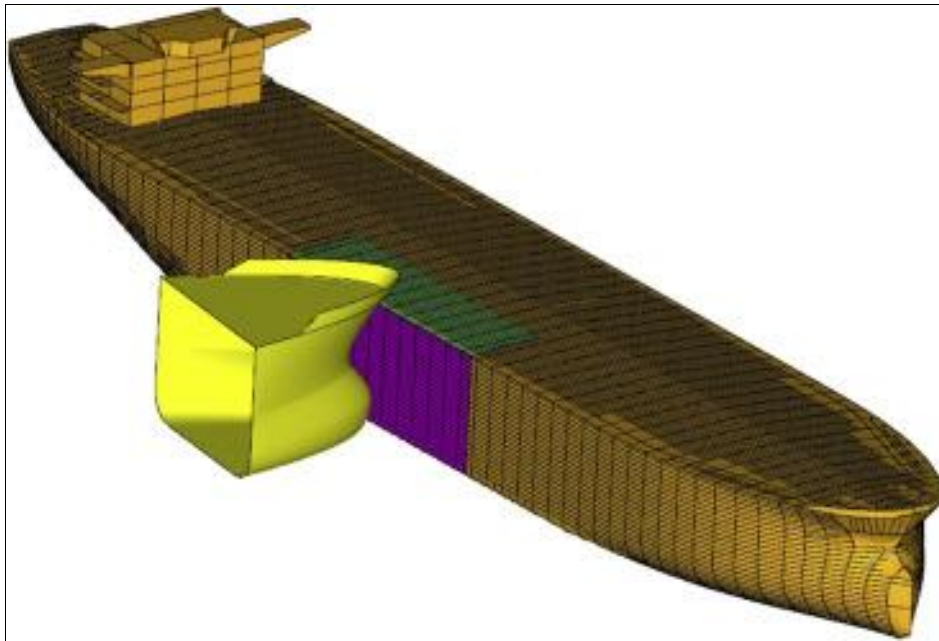


Fig.6: Ship to ship collision without collision prevention system

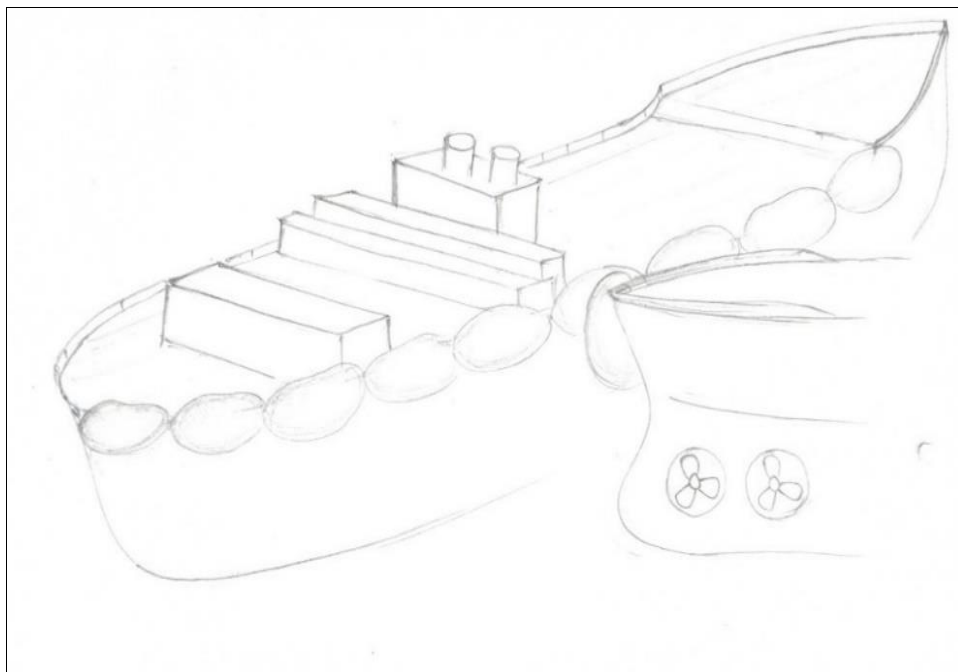


Fig.7: Ship to ship collision with collision prevention system

CONCLUSION:

Ship collision contributes to a great percentage in accidents in shipping industry. The main contribution of this paper is to present a real-time collision prevention model. The collision prevention system effectively minimises the structural deformations of the ships in case of any ship to ship collision. Thus, it reduces the probability of life loss, economic loss and oil spillage hence, improves maritime safety.

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