Tolani Maritime Institute

in association with

The Institute of Marine Engineers (India), Pune Branch

and

The Institution of Engineers (India), Pune Local Centre

proudly presents All India Seminar

TRANSTECH'21

28th to 30th April 2021

PROCEEDINGS

TOLANI
Maritime Institute

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MESSAGE

Adapting to the times, this year Transtech '21 "Efficient Shipping on Clean Oceans" is being presented on a virtual platform. Congratulations to the team who have painstakingly made this event possible despite all odds, for the sole and ultimate purpose of keeping live our quest for knowledge and continued professional development.

Although the shipping industry has come a long way in the manufacturing of efficient ships and maintaining the oceans clean, there is scope for much more. The use of cleaner and alternate fuels come at a cost and significant technical difficulties. How can we further optimize hull forms to reduce fuel consumption? While we need to protect our vessels from corrosion by improving on our coatings, we also need to protect the oceans from our paints. Is it possible to reach levels of zero emissions? Technology has evolved rapidly in the last couple decades; the Fourth Industrial Revolution has shipping in its sights. In what ways can we incorporate into our industry artificial intelligence (AI), robotics, the Internet of Things (IoT), 3D printing, genetic engineering, quantum computing, and other technologies? Transtech '21 will address such challenges and give us a platform to discuss the industry's continued search for better solutions.

All the best to the participants and as always a special thank you to our guest speakers who contribute invaluably to the success of our seminar.

Dr. Sujata Naik
Chairperson,
Governing Council
Tolani Maritime Institute, Pune

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MESSAGE

I feel delighted that Tolani Maritime Institute is again organizing TRANSTECH, which has provided a platform to the budding engineers from Maritime Training Institutes and other Engineering Colleges to showcase their talent and churn out new ideas for the future of the maritime sector. Transtech '21 will be conducted online due to the prevailing pandemic. We are in the 13th year of our celebration of excellence, and what could be a better theme than "Efficient Shipping on Clean Oceans" for Transtech '21? This topic is appropriate for protecting our oceans. India is collaborating with other countries to develop clean and healthy oceans, sustainable use of ocean resources and growth in the blue economy.

Transtech, over the last decade, has dealt with innovative topics and brought many students from different academic institutions across the country to come together and share their ideas. These ideas have evolved in technical paper presentations, demonstrating models and interaction with experts from the industry.

The rock-steady support from the two prestigious professional bodies, namely The Institution of Engineers (India), Pune Local Centre and The Institute of Marine Engineers (India) Pune Branch, is praiseworthy and multiplies the importance of the event.

I am sure Transtech'21 will allow our cadets and teachers to interact with the speakers from the industry and students from various colleges online.

I take this opportunity to extend my best wishes to Prof Anirudh Kumar and his organizing team for successfully organizing Transtech' 21.
Let us come together, think together and grow together!

Capt. Krishnamurthy Iyer
Principal, Tolani Maritime Institute

The Institution of Engineers (India)

(Established: 1920 - Incorporated by Royal Charter:1935)

"A Century of service to the Nation"

PUNE LOCAL CENTRE

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It is a matter of immense pleasure to note that Tolani Maritime Institute, Induri in association with The Institution of Engineers (India), Pune Local Centre and The Institute of Marine Engineers (India), Pune Branch is organizing Annual Seminar for Students "TRANSTECH-21" on the theme "**Efficient Shipping in Clean Oceans**" during April 28-30, 2021.

Shipping is a vital cog in the world's trade machine. Ships offer the best option, when it comes down to shifting material around the planet, particularly bulk transport of ore, coal, oil and cereals for which there is no alternative. Shipping already accounts for nearly 4.5% of the world's greenhouse gas emissions and, as the volume of global trade continues to grow, this proportion is also set to rise. According to the UN, annual emissions from the world's merchant fleets exceeds 1.2 billion tonnes of CO_2, twice that of the aviation sector. This is now a growing concern for many governments seeking to take steps to reduce not only CO_2 emissions but also other environmental impacts such as waste contamination. As a result, people are turning to the concept of Clean Shipping and the benefits that it can potentially provide.

Switching to low-sulfur fuel, Use of LNG fuel for propulsion, Implementation of an exhaust scrubber system, applying the best anti-fouling hull paint, use of proper waste heat recovery system and exhaust gas re-circulation system etc. are some of the measures which can be implemented to achieve Clean shipping.

I am confident that the during the seminar numerous emerging technologies will be discussed which will be helpful in creating tangible understanding so as to achieve Efficient Shipping.

I wish the Seminar a grand success and extend my greetings to all concerned.

With Best Wishes

(Prof. K K Ghosh)

The Institute of Marine Engineers (India)

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Shri Bhalchandra Chandakkar
Chairman
Pune Branch
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Institute of Marine Engineers (India) Pune Branch is proud to be associated with Tolani Maritime Institute along with The Institution of Engineers (India), Maharashtra State Centre for hosting “Transtech 2021” as a part of its Annual Event.

Transtech 2021 is now a well known national common platform for Engineering students in all fields to present technical papers on various topics of interest and also encouraging them to do research work and empowering them with thinking ability. This will help the students to exchange ideas on latest technical developments in various disciplines.

The theme : "Efficient Shipping on Clean Oceans" will help the students in getting a better understanding of present day changed circumstances and solutions to be sought to make life better at sea and also give the students the right direction in their pursuit of knowledge of the subject.In times of COVID it seems like we are stuck in a time warp with a complete turnaround for Work and living the LIFE, while shipping has still delivered the necessities to keep the wheels turning. Studying from home has been a challenge all through the year, but am sure, we all will come out as winners.

I wish the seminar a grand success and my greetings and compliments to all the organizing team.

Bhalchandra Chandakkar
Chairman
The Institute of Marine Engineers (India)
Pune Branch

Tolani Maritime Institute, Pune, in association with The Institute of Marine Engineers, Pune Branch and The Institution of Engineers, Pune Local Centre proudly presents All India Seminar

TRANSTECH 2021

28 to 30 April, 2021

"Efficient Shipping on Clean Oceans"

PROGRAMME SCHEDULE

Day 1, Wednesday, 28th April 2021

Time	Activities
0945	Chief Guest joins
0945-0950	*Saraswati Vandana*
0950-0955	Welcome of Chief Guest
0955-1000	Welcome address by *Capt. Krishnamurthy Iyer*, Principal, TMI
1000-1010	*Corporate Video*
1010-1015	Introduction to Transtech by *Mr. Anirudh Kumar*, Convener, Transtech-21
1015-1025	Video on Transtech -2021
1025-1030	Address by *Mr. Bhalchandra Chandakkar*, Chairman, Institute of Marine Engineers (I), Pune Branch.
1030-1035	Address by *Prof K.K. Ghosh*, Chairman IEI Pune Local Centre.
1035-1045	(a) Introduction of Chief Guest & Key Note Speaker *Dr. Ketan Kotecha* by *Capt. Indranath Banerjee* (b) Online release of '***Transtech-2021 Proceedings***' & '***TMI Technical Bulletin***' by the Chief Guest
1045-1130	Inaugural speech by the *Dr. Ketan Kotecha on* ' 'AI for All"
1130-1135	Vote of Thanks by *Dr. Sanjeet Kanungo*, Vice Principal-ME, TMI
1135-1145	Introduction of Judges: *Mr Arvind Kumar, Mr Anand Thakoor & Mr Shailendra Kumar*
1145-1305	**Technical Session I - (4 papers)** – [Session Chair – Dr Sanjay Dabadgaonkar]

Day 2, Thursday, 29th April 2021

Time	Activities
0930	Guest Speaker *Capt. Gajanan Karnjikar* - joins
0930-0935	Welcome of Guest Speaker
0935-0945	Corporate Video
0945-0950	Welcome address by *Capt. Krishnamurthy Iyer*, Principal, TMI
0950-1000	Video on Transtech -2021
1000-1040	(a) Introduction of Guest Speaker *Capt. Gajanan Karnjikar* by *Capt Kevin Mascarenhas* (b) Technical talk by Capt. Gajanan Karnjikar *on* 'Blue Economy'
1040-1200	**Technical Session II - (4 papers) -** [Session Chair – Dr Sudhir Sindagi]
1200-1320	**Technical Session III - (4 papers)** – [Session Chair – Dr Anjali Deshpande]
1320-1325	Vote of Thanks by *Capt Indranath Banerji*

Day 3, Friday, 30th April 2021

Time	Activities
0930	Chief Guest and Guest Speakers Joins
0930-0935	Welcome of Chief Guest & the Key Note Speakers
0935-0945	Corporate Video
0945-0950	Welcome Speech by *Capt. Krishnamurthy Iyer*, Principal, TMI
0950-0955	Video on Transtech 2021
0955-1125	**Online Exhibition Session of Models -** Online relay of pre-recorded videos on Technical Models made followed by question answer
1125-1205	(a) Introduction of Key Note Speaker Dr. Sanjay E. Talole by *Capt Kevin Mascarenhas* (b) Technical *talk by* Dr. Sanjay E. Talole *on "Disturbance Estimation and Rejection based Control of Marine Vessels"*

1205-1245	(a) Introduction of Chief Guest ' Dr Gopinath Chandroth ' by *Capt Indranath Banarji* (b) Speech by Chief Guest on "*Marine Accident Investigation"*
1245-1330	Valedictory Function *(Anchored by Capt Indranath Banarji)* 1245 Conference Summary by *Dr. Dhiren Dave* 1250 Address by *Judges* 1255 *Prize Announcement / Distribution by Chief Guest / Guest Speakers*
1330-1335	Vote of Thanks by *Capt. Manoj Hirkane*, Vice Principal-NS, TMI

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Papers

Models

ALTERNATIVE FUEL – PREDICTED ISSUES AND SOLUTIONS

By: Cadet Ashpreet Singh[a]

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Abstract: With changing times, Maritime industry also underwent modifications, and the process is still going on. This paper aims to bring out one such modification which is related to Fuel. The paper will focus on the GHG emissions by the Maritime sector with the current type of fuel i.e. HFO& MDO to run the ships. It will also bring out the possibilities of the types of alternatives which can be used and discuss in detail about their viability and environment-friendliness. The final opinion of the topic along with a scenario of future will be at the concluding part of this writing.

Key words: Alternative fuel, Environment friendly, GHG emissions, Renewable energy

1.Introduction

We all have heard this famous adage "Without ships and the men manning those ships, half of the world would Freeze, and other half would starve". This clearly states that Maritime sector is the oldest and one of the most indispensable networks of this world. As we have stepped into 21stcentury, a century which is a victim to Global Warming, it is our utmost duty to upgrade our technologies and minimize the emission from our ships. As per the 4th GHG Report by IMO, the greenhouse gas emission from Maritime Industry rose about 10% from 2012 to 2018. The international consortium of research institutes that compiled IMO Report predicted that the emissions would increase up to 50% until 2050. The figures are alarming and Maritime sector will be and is also being presently targeted by International bodies who have adopted Paris Agreement under UNFCCC. IMO is under immense pressure to cut down GHG emissions to come in the bracket of Paris Climate Change Agreement. In January 2020, IMO has enacted regulations to lower the sulphur content from 3.5% to 0.5%. These regulations require ship operators either to use high-cost low sulphur HFO or look for alternatives. Hence, there is a dire need to reduce the carbon footprint, keeping in mind the cost effectiveness, availability, reliability and modifications to be done to adopt a different fuel for the ships.

Fig 1: Pollution by ships using HFO/MDO

Brief Report on Possible Alternatives

A detailed study has been carried out regarding the viable alternatives and information has been compiled. The references for this study have been listed at the end of this paper.

LNG (Liquefied Natural Gas)

This fuel is produced by lowering the temperature of hydrocarbon to -160^0 Celsius. This liquefies the methane present in natural gas and makes it suitable for its application at atmospheric pressure. This fuel has clear cut advantage over HFO in terms of SO_X , NO_X emissions and particulate matter. The GHG Index of this fuel is also low as compared to the fuel used presently. However, the release of unburned methane could reduce the benefit of LNG as CH_4 has 25-30 times greenhouse effect than CO_2. As per IMO's 4^{th} GHG report, methane emissions drastically increased to 151% over the period studied. The main reason for this was methane slip or unburned methane released through LNG powered ships. The ship makers are continuously devising methods to avoid methane slips and have got a little success in the field. The greatest resistance of LNG being adopted globally is cost of retrofitting and bunkering facilities. Also, ship owners felt that competitive prices in the market may not ensure its smooth sailing.

However, the fuel has gained popularity. The reason being EU announcing sulphur **c**ap of 0.5% from 3.5% on MFOs and so an incentive to owners who are switching to LNG Powered ships. The Emission Control Areas (ECAs), namely Baltic Sea, North Sea, North American ECA and most of the American and Canadian Coast are also in favour of LNG as a less contaminant vehicle.

Hence, the demand for LNG-fuelled ships is rising and below given figure shows the statistics of the same.

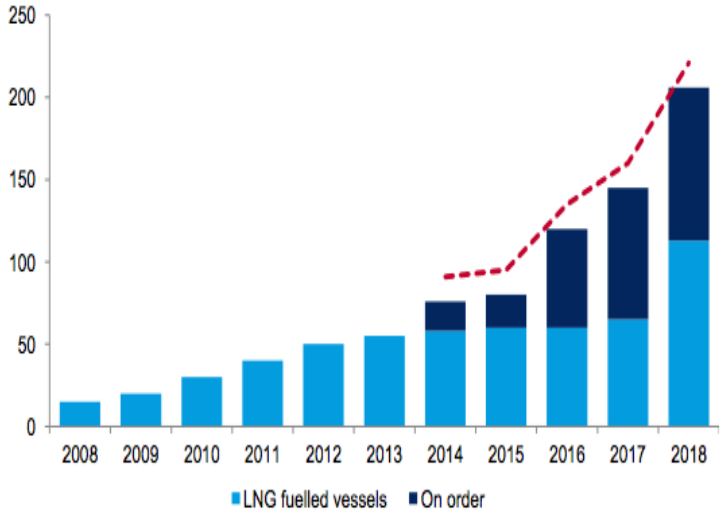

Fig2: Increase in LNG-Fuelled Vessels

Biofuels

This Fuel is derived from Biomass. Biomass can be used to produce to produce alcohol-based fuels such as Ethanol, Liquefied Biogas (LBG) or Biodiesel etc. This fuel is the most Technological – ready to be used by Shipping Industry as LNG requires costly retro-fitting and low sulphur HFO is costly. But Biofuels have their issues too. As per the study by Forbes, the demand of biofuels will begin a debate to grow crops for food or fuel production and this will eventually lead to inflation in food prices. High water consumption and excessive use of fertilisers to grow crops will lead to excessive nitrogen as contaminant for environment. It is also estimated that this fuel will not be able to meet supply-demand cycle of this Industry.

However, if Biofuels are made flexible to mix with conventional fossil fuels and can be made to run combustion engines, the carbon footprint as well as cost can come down. The calculations show that Biofuels can only meet

20-30% of Shipping's requirement and hence to ensure that a functioning Bioeconomy emerges, coordination of entire shipping chain is needed.

Ship Electrification and Hydrogen

Ship electrification is a fuel which can proudly give us zero emission. This alternative has showed promising results in shorter transits. We can add batteries almost everywhere on ships and they can reap us good benefits. But the issue concerning this is weighted batteries and lack of charging stations for longer transits.

Another opportunity to electrify ships is "Fuel Cells". They utilize liquefied hydrogen as fuel and through electro chemical process, produce electricity till the time fuel i.e. Hydrogen is available. They are better than simple batteries since the longer transits of ships are benefitted. Electric propulsion gives us more manoeuvrability and more power and efficiency to the engine.

But, on the other hand, there are limitations also. The first is that conventional lithium-ion batteries pose safety at risk as they use electrolytes. If the components degrade, they may heat up the battery leading to severe consequences. If we see Fuel cells, then as we all know, Hydrogen requires much more space, so we need tanks with large quantity. This will reduce the amount of cargo being loaded and eventually it is not beneficial for Ship owners. And costs are expected to rise as hydrogen is not readily available in the atmosphere.

Nuclear Propulsion

The most controversial alternative but its application cannot be questioned. Most of the people will argue about its misuse and the answer to it is low-enriched nuclear fuel which is not fit to make weapons. This fuel can be used for longer transits as massive amount of energy is generated. But, till date only four merchant cargo ships have been fuelled by nuclear drive. The main reason is radiation accident due to which every port is apprehensive of calling them for cargo operations. But this fuel has proved its worth for Ice-breaker ships which refuel after years once they set their sail and engines are immensely powerful to finish their primary task.

Thus, operating this fuel in merchant fleet needs fool proof strategy as accidents such as general cargo ship Mutsu, now RV Mirai in which a lot of resistance was generated due to a possible leak of gamma rays and neutrons, still keeps this fuel distanced from Merchant fleet. But the technology is changing rapidly, and the figure may change after 2030 as Thorium reactors which are safer are being tested and they may bring a revolution in safety practices.

Renewable Energy

The concept for green shipping is now becoming a concern for ship-owners and ship builders. There is always a possibility for application of Wind and Solar Energy as a fuel for ships. In 1970s and 80s, rigid sails on cargo ships proved to reduce fuel consumption. Also, wind turbines on ships can generate electrical power and propel the ships. Still, a lot of advancement related to expensive wind turbines, noise pollution created by them etc.

This sum up to technological immaturity for this alternative.

One more discovery was of Application of Magnus Effect to propel the ships. The machinery used is known as ROTOR SAILS.

It is used to propel ship and is mounted with its axis vertical. When the wind blows, the Magnus effect creates a forward thrust, thus driving the vessel forward.

Fig 3 ROTOR Sails installed on Maersk Pelican (8.2% fuel savings were accounted)

Solar Energy has reduced fuel consumptions on ferries and small boats. But on merchant ships, the fuel saved through solar energy is very less and hence, it is not commercially viable to use solar power.

The hybrid engines which have both alternatives and also some fuel can be viable. In case of ROTOR sails, the engine can be throttled back when there is adequate wind speed and so fuel is saved.

Liquid and Gaseous Fuels

There are some fuels on which vessel cannot solely rely on but if hybridisation capability is achieved, they are significant too. The fuels like LPG and DME can be used if initial ignition processes are carried out by primary fuel and then in the open ocean, they can play a role. LPG has a vast network, so refuelling is not a tedious task, but it lowers the efficiency of engine. But work needs to be done to explore DME as a fuel due to its lower viscosity, combustion enthalpy and modulus of elasticity which leads to longer injection period, leakage in fuel pipes and greater compression pump respectively.

The Future Scenario

The alternative fuel is the need of hour and so we all should keep on striving until we achieve our aim i.e. to cut down GHG emissions and maintain efficiency as well as safety simultaneously. With regard to the alternatives listed above, I feel each of them have its pros and cons.

In today's times, LNG looks as the most viable replacement of HFO only if the problem of methane slip is resolved by making engines more environment efficient as CH_4 emissions are far more dangerous than CO_2. Nuclear propulsion is very far from being adopted and will continue to work for some icebreaker ships. The acceptance of Biofuels will be subject to their production and availability in coming years. Ship electrification will continue to be utilized for shorter voyages and Fuel cells (Hydrogen) requires more study. Renewable Energy, particularly wind and solar energy look as a more secure potential source which will be highlighted soon.

The crux of all these is Hybrid Engines. Even if Renewable energy comes into play, the ships will need a reserve of HFO and cannot fully depend on the ROTOR sails and same is the case with other alternative fuels. Also, International support is required in order to bring down the prices of expensive technologies such as dual-fuel engines, ROTOR sails etc.

2. Conclusion

The introduction of alternatives in any Industry takes time. The time taken is accounted for research and exploring so as to develop the technology to extract the best out of it.

The majority of these alternatives will come into play in either regions with excessive restriction on emissions or regions with a sufficient fuel supply along with developed infrastructure.

All the above written fuels have the potential but surely, introducing new technology will be viewed distantly from ship owner's view and hence, international and cohesive support is much needed to bring a change in this Industry.

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Authors acknowledge the guidance received from Faculty of our Institute

ALTERNATIVE FUELS

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Abstract: This paper look at an alternative fuel for shipping. The goal is to produce hydrogen from the water. Hydrogen can be produced by methods such as electrolysis, thermolysis, steam reforming and various others methods; it is also an abundant chemical species which can be used to produce more efficient and friendly energy. However hydrogen energy fuel is harder to store, and although it is an abundant species, it could be expensive to extract pure hydrogen.

1.Introduction

Maritime transport accounts for over 80% of world trade by volume and for approximately 3% of global greenhouse gas emissions, while it is also a contributor of air pollution. In order to reduce the impact of maritime transport on climate change and on the environment, a number of fuel efficiency measures, have to be adopted, including the introduction of **ALTERNATIVE FUELS**. The immediate effect of introducing alternative fuels will be a strong reduction in SOx and NOx. Both the demand for low sulphur fuels (as per latest regulation) and as well as the need for reduced GHG emissions can be addressed by the introduction of alternative fuels.

1.1(a)Hydrogen as Alternative Fuel

Nowadays ships use heavy oil as fuel. Ships contain boiler and diesel engine for propulsion and electricity production. As we know the fuel which we are using is very limited and after sometime it will be exhausted. We have to seek for such fuels which will replace them also solve the problem of global warming and pollution. So, do we have such matter present? Yes, the answer is water. The whole idea is how we can utilize the one of the most abundant matter on earth as a in the large marine industry. Now we know that water molecule H_2O has two atoms of hydrogen and one atom of oxygen. Hydrogen is one of the most excellent fuel used in different fields of the world. What we have to do is to develop a system which will be able to continuously produce hydrogen from water and then use it as a fuel in the engine of a ship.

Combustive Properties of Hydrogen

Wide range of flammability: 4% to 75% at 25°C

Low ignition energy: 0.02 mJ

Small quenching distance: 0.064 cm

High auto ignition temperature: 585 °C

High octane number: 130

High flame Speed
high Diffusivity
very low density

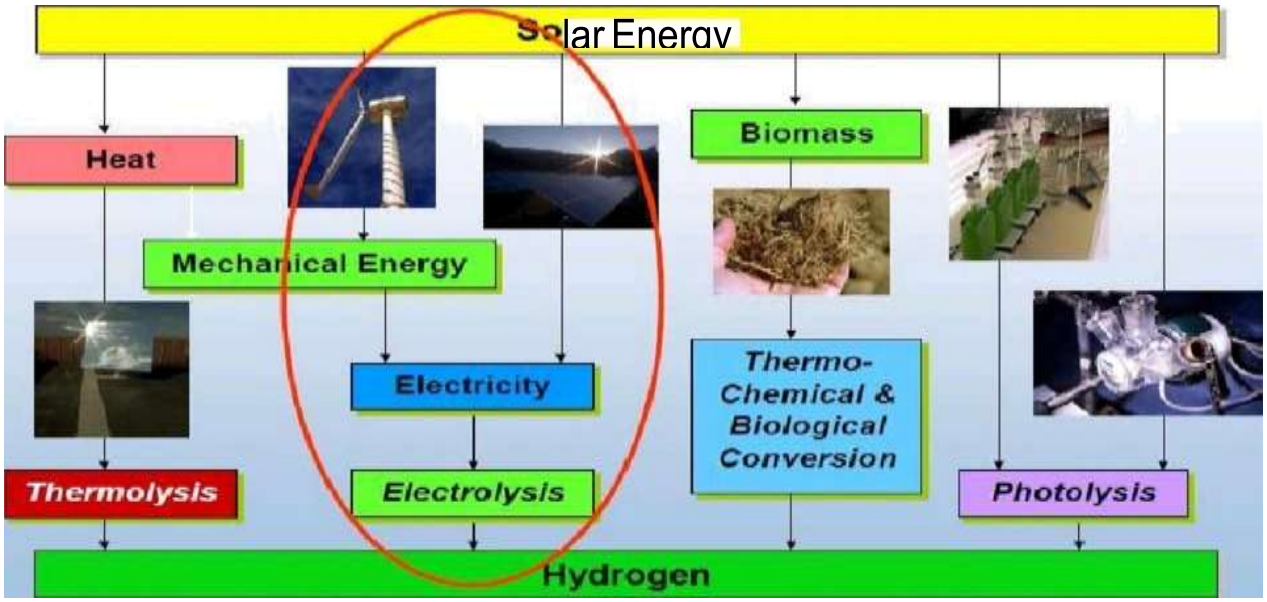
Hydrogen flames are very pale blue and are almost invisible in daylight due to the absence of soot

Higher calorific value: 141,790 KJ/Kg.

Method of producing Hydrogen

Some common methods are;

- Bio-catalyzed electrolysis
- steam reforming
- From coal
- Electrolysis
- Thermolysis
- Photocatalytic water splitting
- Fermentative hydrogen production



Sustainable path of Hydrogen

The basic idea of this system is given below: Hydrogen is an excellent fuel with huge calorific value of 141860 kj/kg. Also, its combustion again produces water which is essential for life. Now we have to separate the hydrogen and oxygen from water. So, for that we have to do the electrolysis of the water. As we know the breaking of water molecules into hydrogen and oxygen by passing electricity through water is electrolysis. Now the question is from where we can get such amount of electricity because if we use the electricity from conventional sources then the system could becomeinefficient. So here we will use non-conventional source of energy to produce that electricity. The problem of electricity in ship can be easily solved. We will generate electricity to initiate electrolysis from solar cells and wind Mills installed in ship. This will provide us with sufficient amount of energy so that we can initiate electrolysis process. Now once electrolysis gets started, we will get hydrogen and oxygen which will be collected separately in two chambers. One is hydrogen chamber and another one is oxygen chamber. Now the hydrogen chamber will be cooled continuously because hydrogen is highly inflammable and explosive gas. Now we will not liquefy hydrogen. We will keep hydrogen at highpressure and cooled.

This high pressurized hydrogen now will be used as fuelby two ways: The hydrogen is sent to the combustion chamber withhigh pressurized air and the combustion will take place there by sparking. Due to the combustion high pressure and high temperature steam will be produced because the burning of hydrogen is explosive. This high-pressure steam will be sent to set of turbines that can be used to produce electricity, for propulsion of ship, for driving themotors, pumps etc. Once work done the energy extracted the fresh water will be used for different purpose in ship or can be sent back to the electrolyzer with some modifications.

The second way is the use of hydrogen in internal combustion engine. The hydrogen is sent to the engine where it will ignite and due to which the Piston willmove and thus can be used for propulsion of ship.

Some theoretical calculation

Consider 1 kg of water,

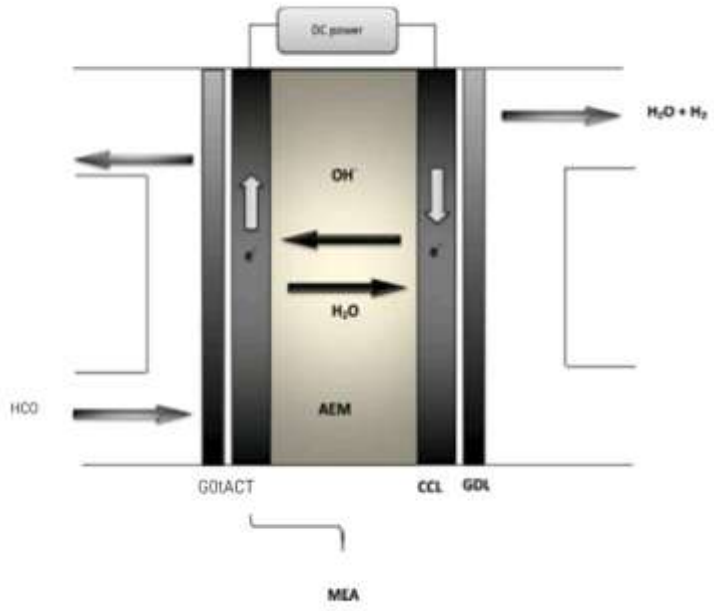
The dissociation energy of 1 mole of water= 241.8 KJ
The dissociation energy of 1 kg of water= 241.8*55.55=13431.99 KJ
Energy produced from combustion of hydrogen produced from 1 Kg of water =0.002*55.55*141860= 15760 KJ

But in practical there are many other losses which causethe reduction in efficiency. But still its efficiency is muchmore than any present power generation system.

Anion Exchange Membrane Electrolyzer

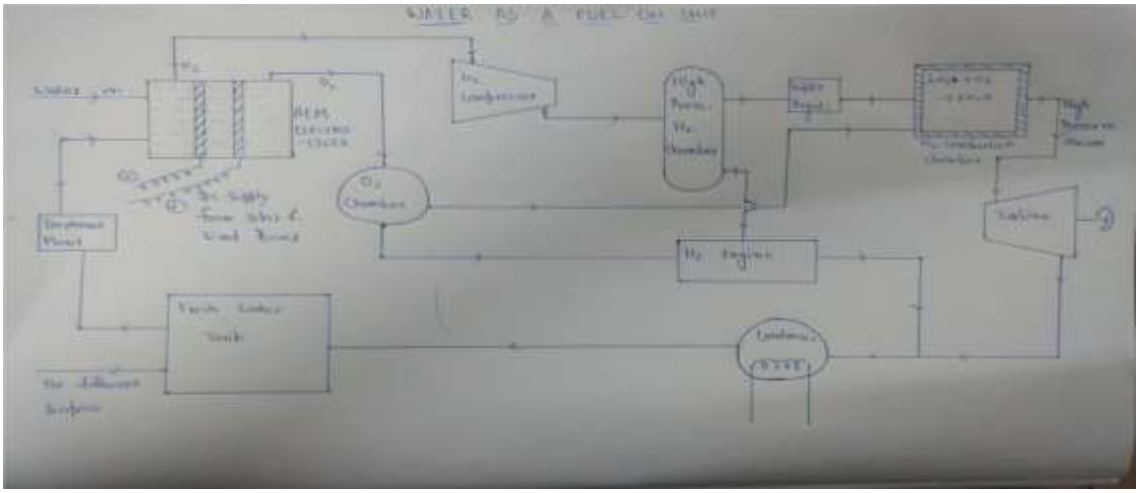
The most important part of our whole system is electrolyzer. We are going to use the anion membrane exchange (AEM) electrolyzer. It has an ALKALINE SOLID POLYMERIC MEMBRANE between the electrodes whichwill efficiently produce hydrogen and oxygen continuously even if the solar power or wind power is less. Its cost is also low. It can directly send hydrogen at30 bar pressure. It is simple efficient economic.

Now coming on the working its simple when the electricity is passed. Hydrogen gas is produced at cathode and the oxygen gas is produced at anode. Fromthere the gases are supplied to their respective chambers.



Hydrogen Storage and Transport

The hydrogen is a fuel with humongous calorific value. Itsignition temperature is 500 degree Celsius. Hydrogen is explosive gas so it becomes very important to handle hydrogen with care. We will use fiber reinforced polymer(FRP) pipes to transport the gaseous hydrogen insulated with sorbothane. As we already mention we will not liquefy the hydrogen this will save energy. We will only compress hydrogen and store it in composite tanks such of carbon fiber with the polymer liner fiber reinforced thermoplastic. Such type of tanks can handle pressure upto 700 bars. The compression will require 2.1% of total energy production.



Combustion of Hydrogen

$$2H_2 + O_2 \longrightarrow 2H_2O \qquad (1)$$

The hydrogen is an excellent fuel with calorific value of 141860kj/kg. Its combustion is explosive and produces high temperature and high-pressure steam. The shocks ofthe explosions will be controlled by sorbothane. The high pressurized steam can be sent to turbines for energy production, propulsion, and running pumps compressors etc.

The hydrogen can be burnt inside an internal combustionengine and be used for propulsion.

The exhaust is high temperature steam can be used for different purposes in ship. At the end all the steam from turbine engine gets condensed as fresh water and be usedwhere it is desired**.**

Advantages

- The first and foremost advantage and that is going tobe a need in future for running machinery is the rapidly decreasing fuel oil reserves. After few decades we will be left with no fuel oil!! What then? This is the best alternative for producing high amount of energy for the huge structure like ships because we cannot run the whole ship on electricity produce by solar power, we must need something else and this is the solution.

- The second advantage is that the inlet is water and exhaust is water. Water is abundant in nature in seacan be used after treatment. The exhaust is water sono harmful emission of gases which will help in fighting against pollution.

- There will no problem in waste disposal of fuel.

- It is better than the nuclear power because nuclearpower is more risky and also not good for environment. Radioactive waste will cause great threat to nature and marine life.

- Another huge advantage is on ships on deck we have space to install solar panels and wind mill andthe power input which we are giving is totally renewable solar and wind energy which is free of cost and endless so automatically the efficiency willincrease tremendously and the question that moreenergy input required to break water than it will produce on hydrogen combustion will be solved totally.

- It will save any future fuel cost of the ship.

Disadvantages and Solutions

- The main disadvantage of the system which is spoken many times is about efficiency of the systembut good news!! As already said the only input is in the form of solar energy and wind energy which arefree and endless so we have made our input free.

- The second question which is raised time to time isthat COST. But its one-time installation cost is high but it will make the whole fuel consumption cost infuture zero which I think is incomparable. So yes,in long term it is economic.

- It is risky and requires lots of maintenance. Yes, it isrisky but it is worth taking the risk because we haveto seek for the other source of energy in future andthis is the future. ALSO, IT IS MUCH SAFER THAN THE NUCLEAR-POWERED SYSTEM THE OTHER ALTERNATIVE. The maintenance will be required more, man power require more which will create more job opportunities and thus also a good thing.

- **A difficulty for hydrogen is its energy density. The energy density per unit volume of hydrogen at any practicable pressure is significantly less than that of traditional fuel sources, although the energy density per unit fuel mass is higher. If hydrogen is used as a marine fuel, large quantities of hydrogen will be needed to be stored onboard the ship. The two most promising techniques for now are compressed hydrogen in a pressure vessel or liquid hydrogen.**

- Compressed hydrogen is a storage form where hydrogen gas is kept under pressures to increase the storage density. Compressed hydrogen is stored in tanks at 350 bar and 700 bar. Hydrogen is liquified by reducing its temperature to -253°C, similar to liquified natural gas (LNG) which is stored at -162°C. there is an efficiency loss of 12.79% due to the cooling of the hydrogen.

2. Conclusion

The idea to use water as a fuel in the ships can be revolutionary in marine field. It will create more clean energy. The energy which is everlasting. It will create theemployment. It will save us from the future threat of ending fuel oil reserves and pollution. It will save the whole cost of fuel consumption and marine life will be safe hands.

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ALTERNATE MARINE FUELS

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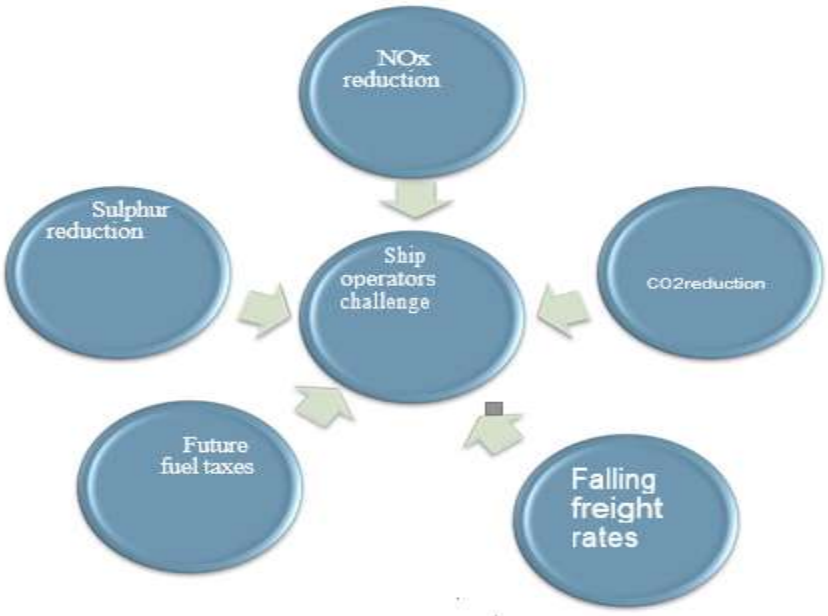
1.Introduction

- The IMO decision to limit the sulphur content of ship fuel from 1 January 2020 to 0.5% worldwide.
- Recently adopted resolution to reduce greenhouse gas (GHG) emissions by 50% by 2050, will change the future mix of ship fuels dramatically.
- The combined amount of heavy fuel oil (HFO) and marine gas oil (MGO) consumed by ships accounts for no more than 25% of total global diesel fuel and petrol production (2016).
- This is roughly equivalent to the amount of energy consumed using liquefied natural gas (LNG), which stands at 24%. However, LNG represents only a small portion (approx.. 10%) of the overall gas market.
- DNV GL has issued a new white paper assessing a range of alternative fuels and technologies.
- "Alternative fuels and technologies for greener shipping", the paper examines the cost, availability, regulatory challenges and environmental benefits of alternative fuels and technologies.

1.1(a)Marine Fuel Challenges

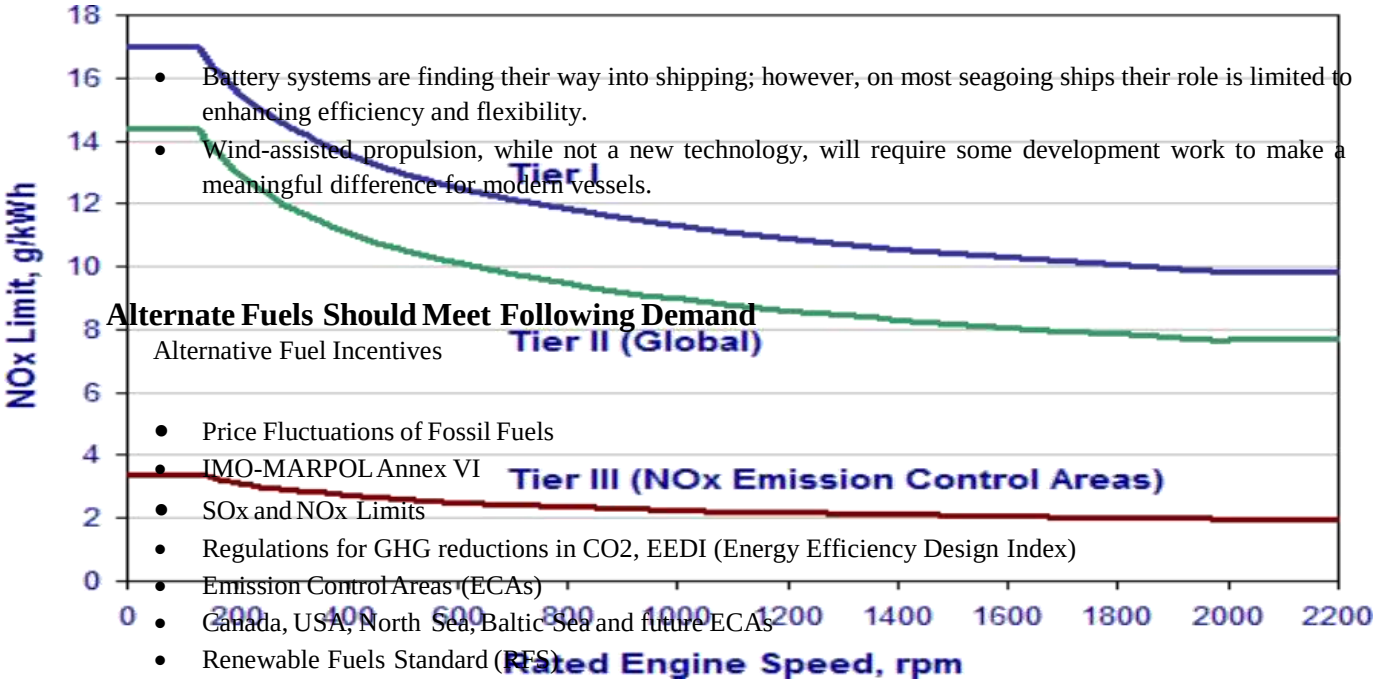


NOx Limit Timelines

- After 1 Jan 2011 Marine Diesel Engines must comply with Tier II Standards
- Tier III Marine Diesel Engines for ships constructed on or after 1 January 2016 and operating in designated NOx ECAs

New Technologies and alternatives Fules

- Among the proposed alternative fuels for shipping, DNV GL has identified LNG, LPG, Methanol, Biofuel and Hydrogen as the most promising solutions.
- The classification society believes battery systems, fuel cells and wind-assisted propulsion to offer potential for ship applications.
- Fuel cell systems for ships are under development but will take time to reach a level of maturity sufficient for substituting main engines.



- Battery systems are finding their way into shipping; however, on most seagoing ships their role is limited to enhancing efficiency and flexibility.
- Wind-assisted propulsion, while not a new technology, will require some development work to make a meaningful difference for modern vessels.

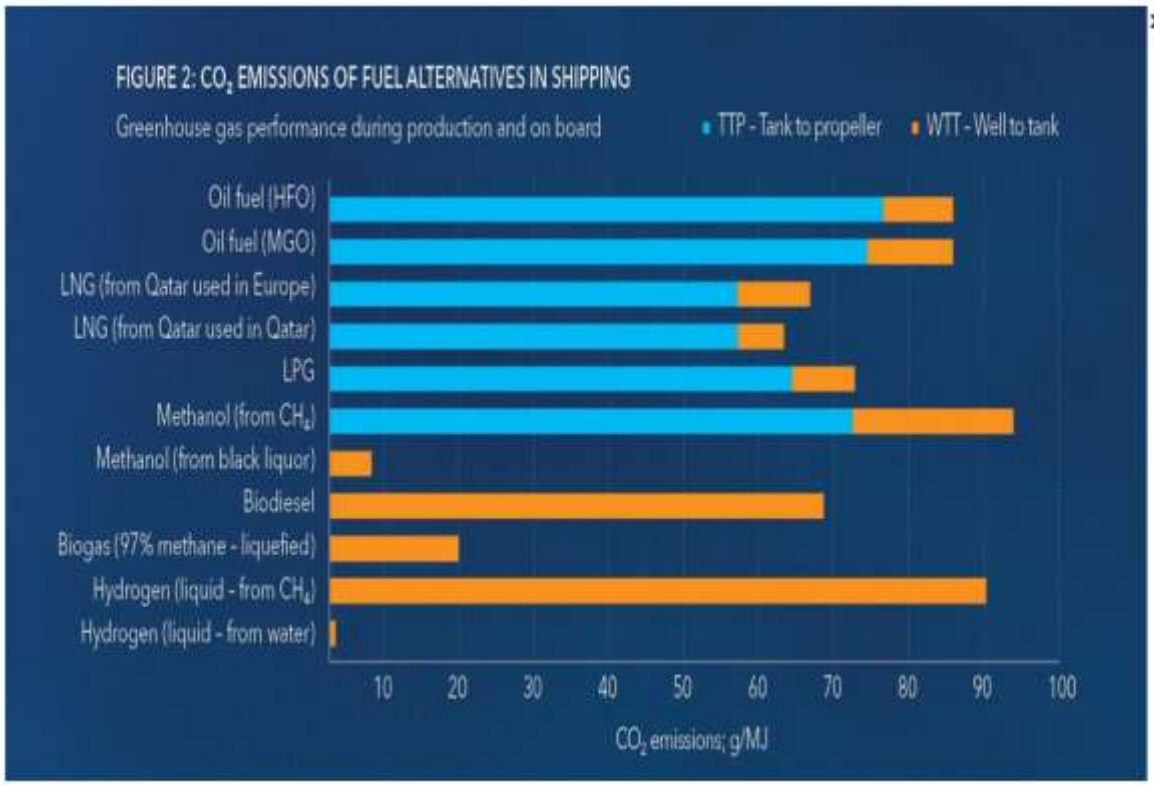
Alternate Fuels Should Meet Following Demand

Alternative Fuel Incentives

- Price Fluctuations of Fossil Fuels
- IMO-MARPOL Annex VI
- SOx and NOx Limits
- Regulations for GHG reductions in CO2, EEDI (Energy Efficiency Design Index)
- Emission Control Areas (ECAs)
- Canada, USA, North Sea, Baltic Sea and future ECAs
- Renewable Fuels Standard (RFS)
- Global Fuel Sulfur limits
- No Engine or Fuel System Modifications
- Drop in Liquid Fuel
- Lowers Emissions
- Competitively priced
- Available worldwide or regionally for bunkering
- Can mix with current fuels
- No degradation of Engine performance

CO_2 Emissions Of Alternate Fuels

- When it comes to CO_2 emissions, LNG is the fossil fuel producing the lowest amounts.
- However, the release of unburned methane (so called methane slip) could reduce the benefit over HFO and MGO in certain engine types. Methane (CH4) has 25 to 30 times the greenhouse gas effect of CO2.
- Nevertheless, engine manufacturers claim that the tank-to-propeller (TTP) CO_2-equivalent emissions of Otto-cycle dual-fuel (DF) and pure gas engines are lower than those of oil-fuelled engines.
- If produced from renewable energy or biomass the carbon footprints of methanol and hydrogen can be significantly lower than those of HFO and MGO.



The Greenhouse Gas Challenge

- The cleanest fuel is hydrogen produced using renewable energy.
- Liquefied hydrogen could be used in future shipping applications.
- However, because of its very low energy density it requires large storage volumes, which may prevent hydrogen from being used directly in international deep-sea shipping.
- In a sustainable energy world where the entire energy demand is covered by renewable, CO_2-free sources, hydrogen and CO2 will be the basic ingredients for fuel production, most likely in the form of methane or diesel-like fuels produced in a Sabatier/Fischer-Tropsch process.
- LNG has already overcome the hurdles of international legislation, and methanol and biofuels will follow suit very soon.
- It will be a while before LPG and hydrogen are covered by appropriate new regulations within the IMO IGF Code as well.
- The existing and upcoming environmental restrictions can be met by all alternative fuels using existing technology.
- The IMO target is to reduce GHG emissions by 50% by 2050 is ambitious and will likely require widespread uptake of zero-carbon fuels and further energy efficiency enhancements.
- Fuel cells can use all available alternative fuels and achieve efficiencies comparable to, or better than, those of current propulsion systems.
- Fuel cell technology for ships is still in its infancy.
- Wind-assisted propulsion could potentially reduce fuel consumption, especially when used for slow ships, but the business case remains difficult.
- Batteries as a means of storing energy can be considered as an alternative fuel source in the widest sense.
- In deep-sea shipping, batteries alone are not an adequate substitute for combustible energy sources.
- Finally, with low-sulphur and alternative fuels becoming more widely available, the well-known combined-cycle gas and steam turbine technology as used in the PERFECt Ship project represents a viable alternative for high-power ship propulsion systems.

1.2(b)HydrogenAs Fuel

Two types of hydrogen fuel use for ships need to be considered.

- Hydrogen (dual fuel) internal combustion engines can burn hydrogen with very low GHG emissions (MGO is used as pilot fuel).
- Fuel cell systems on the other hand use an electro-chemical reaction to generate electricity.
- The efficiency of fuel cells is relatively high, at around 45%, compared to internal combustion engines (roughly 20%).
- For the time being the use of an internal combustion engine seems to be more interesting compared to a fuel cell in a marine environment because of the following reasons:
- No fundamental changes required to the main engine.
- When no hydrogen can be supplied, the engines run on MGO.
- If something fails in the hydrogen system, the system switches to pure MGO combustion.
- Co-combustion has almost no effect on the maintenance schedule.

Issues to consider with fuel cells:

- Salty environment of shipping and the large movements (up to 40° of banking) is probably too challenging for

fuel cells.

- At high constant power output, the fuel cells have less efficiency compared to the co-combustion concept.
- Fuel cells produce electrical energy, but we need mechanical energy for the propulsion. The need for power electronics will make it very expensive.

Biofuels

I. Biodiesel (FAME)
II. Algae Fuels (not yet available)
III. Hydrogenation-Derived Renewable Diesel (HDRD) Methanol
IV. Dimethyl-Ether (DME)
V. Bio Crude /9Pyrolysis oil)

- Biofuels are a possible alternative marine fuel because they have low GHG emissions over the well to propeller path and at the same time have low sulphur levels to comply with existing sulphur regulation.
- One of the challenges are the volumes that are required to supply the shipping sector.
- A single very large ship may consume the annual production from a single medium sized biofuel facility e.g.100 mio. Liters.

Advantages

- Lower SOx Emissions
- Safe to use, Environmentally friendly
- Commercially available
- Cost Competitive
- Can be blended or used as neat fuel
- Produced to ASTM and EU Specifications
- Advanced Biofuel
- Marine engines certified to burn biodiesel

Disadvantages

- Low Temperature Operation (High Cloud Point)
- Fuel system and engine compatibility
- Storage limitations affects fuel stability(Duration)
- Can clog fuel filters whem first used -Solvent action loosens deposists, etc.

- Price fluctations depending on feedstock
- Not readily available to marine market.

Methanol

- Methanol is a safe, cost effective, globally available marine fuel.
- With the growing demand for cleaner marine fuel, methanol is an alternative for ships that helps the shipping industry meet increasingly strict emissions regulations.
- Methanol significantly reduces emissions of sulphur oxides (Sox), nitrogen oxides (NOx) and particulate matter and with the ability to be produced from renewable sources, offers a pathway to meeting future emissions regulations without further shipowner investment.

LNG

- From all alternative fuels, lng as fuel is now a proven and a available reduced fuel even though it has some risk factors.
- It is extremely important to analyze and safety evaluate fire and explosion risk of LNG ships. It is necessary for the proper functioning of these machines.
- Liquefied natural gas is liquid fluid basically composed of methane, containing traces of ethane, propane, nitrogen or other components usually present in natural gas as well, the density of which is 447 kg/m^3
- LNG is produced by purifying natural gas and supercooling. At atmospheric pressure methane becomes liquid at -162°C.LNG therefore is a cryogenic liwuid. The process is known as liquefication.
- Natural gas is cooled below its boiling point, removing most of the compounds found in the fuel, the remaining gas is primarily methane with small amounts of other hydrocarbons.
- LNG as a fuel shows a large energy to volume ratio.
- LNG combustion is characterized by low levels of productions of CO2, Sox, NOx and particulate matter in comparison to conventional fuels. To reduce the emission of Sox into the Sulphur content of heavy fuels oils used for marine propulsion will be restricted in the near future.
- Natural gas process has been reduced the last years due to introduction of shale gas in the US market. This is the reason that LPG has improved it competitiveness to HFO, especially on ECA's areas.

Properties Of LNG

- LNG is simply natural gas that has been cooled to its liquid state at atmospheric pressure at 260°F
- Currently imported as LNG is commonly 95%-97% methane, with the reminder a combustion of ethane, propane, and other heavier gases.
- LNG is transported at ambient pressures.
- LNG vapour which reduces the gas into a practical size for transportation and storage reduces the volume that the gas occupies more than 600 times.
- LNG is considered a flammable liquid.

- LNG vapour is colorless, odorless and non-toxic.
- LNG vapour typically appears as a visible white cloud, because its cold temperature condenses water vapour present in the atmosphere.

Advantages OF LNG

- Most likely improved revenue.
- Increased number of passenger and crew cabins.
- Improved environmental footprint.
- Energy efficiency may be increased by installing flow-improving.
- Additional open deck spaces.
- Reduction of main engine maintenance hours.
- Cheaper lubricants.
- Cleaner engine rooms.
- No soot on decks- less cleaning and wash water needed.
- No need for exhaust cleaning devices or catalytic reactor.
- Slightly lower noise level in engine room.

Disadvantages OF LNG

- Design and retrofit cost compared to distillates.
- Time required for ship to be taken out of service for the retrofit operations.
- Bunkering challenges.
- Statutory challenges
- LNG fuel cost pricing challenges.
- LNG infrastructure challenges.
- More tank space required to accommodate enough LNG to cover all the itineraries
- Onshore bunkering logistics are still under developments.
- Rules still under development.
- More sophisticated fuel equipment is required

Hybrid Marine Oil Fuel

- ExxonMobil Premium HDME 50, a heavy distillate marine fuel, is specially designed to help marine operators comply with the 0.10 per cent sulphur cap introduced in the ECA zones. ExxonMobil premium HDME 50 fuel helps engineers to safely and efficiently operate their main and auxiliary engines and boilers. It has the performance benefits associated with both marine gas oil (MGO) and heavy fuel oil(HFO)
- A low sulphur content associated with MGO
- The higher flashpoint and lower volatility properties typically found in HPO

- The properties of ExxonMobil Premium HDME 50 fuel allow marine operators to simultaneously comply with the ECA sulphur cap
- Reduce the risk of engine and boiler damage.

Storage

ExxonMobil Premium HDME 50 fuel should always be stored in a heated tank. Prior to transfer, it should be heated to enable pumping. ExxonMobil Premium HDME 50 fuel will have a cleaning effect on the storage tank and is likely to carry any existing fuel oil residues/sludge that are present in the tank, having built up over time. These residues may be picked up in filters further down the fuel treatment process. This is more likely during the initial use of the fuel.

Treatment

ExxonMobil Premium HDME 50 fuel should be processed in a similar way to an HFO; it should be purified prior to use in main an auxiliary engine. Operators should check that their purifiers are correctly set up for the viscosity of this new fuel. Care should be taken while commingling ExxonMobil Premium HDME 50 fuel with HFO to avoid any issues that may occur during the cleaning effect on any residues in the settling and service tanks. These residues may carry through and be picked up in the fuel filters.

Combustion

The fuel should be heated to the appropriate temperature to achieve the correct injection viscosity according to the engine builder guidelines.

Engine Lubrication

Operators should follow their OEM-recommended guidelines for the appropriate lubricants to be used with their engines. ExxonMobil Premium HDME 50 produced currently at Antwerp refineries, is a residual fuel with very low content of sulphur. This product was already tested on medium speed and low speed engines, but only at manufacturers sites and not on sea-trails. This fuel has a high pour point and it is paraffinic, requiring storage temperature between 30-40˚C. Even if HDME 50 has a very low content of Al + Si, is still necessary to treat it in purifiers/separators and filters at less than 60 microns, with fuel inlet temperature of 60-70 C for a proper injection. If it is mixed with other fuels, there is a risk to loose its properties, especially in case of a big difference between the viscosity and density of the subjected fuels. Chemical comparison of the heavy fuel oil with HDME 50 cannot be easily done due to very different compositions of these types of fuels. For example cetane index is not applicable for HDME 50, the product being clear, opaque and green color, originated from distillation processes.

Blending Component

METHANOL+ LONG HYDROCARBON CHAIN + SPECIAL SECRET ADDITIVES

Application

- For vessels running in a 0.10% sulphur ECA complaint environment.
- A pour point closer HFO means that the product is to be stored in heated tanks and treated in heated fuel systems.
- When sulfur levels over 1.00% are present, comingling 10% -15% or greater with low sulfur HFO may result in asphaltene precipitation due to the reduced solvency action of the product. Since it is impossible to identify all crude sources from previous fuels bunkered operators should take a cautious approach and limit comingling of ExxonMobil Premium HDME 50 and existing low sulfur HFO to 2% or less.
- Cetane Index is not an applicable measure of ExxonMobil Premium HDME 50 ignition qualities and CCAI is used instead. Likewise, the product is not clear and bright but green / brown in color. This coloration is due to the refining and processing of the fuel and is not an indication of residual product in the fuel.

Typical Properties

Kinematic Viscosity	
cSt @50°C	30-45
Density @15 Ckg/m^3	900-915
Cetane Index	N/A
CCAI	795-810
Sulphur Content, mass %	<0.10
Flash point, °C	>70
Hydrogen Sulfide, mg/kg	<1
Acid number, mg KOH/g	<0.1
Total Sediment- existent mass %	<0.01
Total sediment- aged mass %	0.01
Oxidation Stability, mass%	<0.01
Carbon Residue, mass%	<0.30
Pour Point, °C	6-12
Appearance	Brown/ green, opaque
Water, vol%	0.05
Ash, mass %	<0.01

HFRR lubricity, microns	<320
Vanadium, mg/kg	<1
Sodium, mg/kg	<1
Al + Si, mg/kg	<5
Ca, mg/kg	<1
Zn, mg/kg	<1

2.Conclusion

- Compliance with emission and fuel sulfur limits are forcing changes in the marine fuel mix.
- Fossil fuels are seen as dominate through 2020 with transition to mostly distillate fuel.
- Biofuels do not seem to be a strong alternative with their limited availability and cost.
- Natural Gas as LNG is viable alternative propulsion fuel for ships.
- Has been demonstrated and is in use on vessels on fixed and coastal trade routes
- Appearing in new builds and conversions with LNG fuel systems and gas engines
- Development of a global LNG bunkering system is critical to the expansion of LNG as a fuel for the large ships that travel on international routes
- Exhaust scrubbers are viable alternative to using lower sulfur fuels
- Shown effective in marine installations.
- March 2014 Wartsila has 45 ships contracted for total of 94 Exhaust Gas Scrubbers.
- Other Vendors (Alpha-Laval, Clean Marine) have sold and installed scrubbers.
- Exhaust Gas Cleaning Association Reports about 160 sold by all vendors – Mostly for new builds.
- Compliance with the new emission requirements will raise construction and operating costs for ship owners.
- NOx compliance in 2016 for new ships in ECAs will be achieved with after treatment devices to reduce NOx emissions.
- Ships with gas fired engines may comply without NOx after treatment of note is lack of a low-cost fuel to replace HFO.

HULL FORM OPTIMIZATION

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Abstract: A technique for enhancing of body structures concerning their hydrodynamic presentation in quiet and unpleasant water is introduced. The strategy depends on an underlying enhancement of a parent frame structure for seakeeping and the improvement of the subsequent ideal body structure for quiet water obstruction. In the initial segment of the method, variant structure structures varying from a parent in the fundamental measurements as well as in at least one body structure boundaries, for example, CWP, LCF, CB, LCB, KB, CP are automatically generated and their sea keeping characteristics assessed. At the point when suitable reaches for the principal qualities and boundaries of the frame structure being scrutinized are recommended, a proper streamlining method is utilized to acquire the variation with the best seakeeping conduct. The weighted amount of the full estimations of chose transport reactions for various boat rates and headings in standard waves frames the goal work. Hooke and Jeeves Algorithm is utilized to achieve the optimization. The methodology brings about a bunch of patterns in regards to the proposed varieties of the chose frame structure boundaries, inside the predetermined imperatives. These patterns are then applied on the parent structure to determine a streamlined body structure with reasonable lines. Subsequently this frame structure can be privately changed to improve its quiet water opposition or, as it ought to be done, its impetus characteristics. The materialness of the technique is exhibited in two cases: a regular reefer transport and a maritime destroyer. Scaled models of the parent and the upgraded structure structures have been tried for quiet water obstruction and seakeeping. In the two cases the legitimacy of the technique is illustrated.

1.Introduction

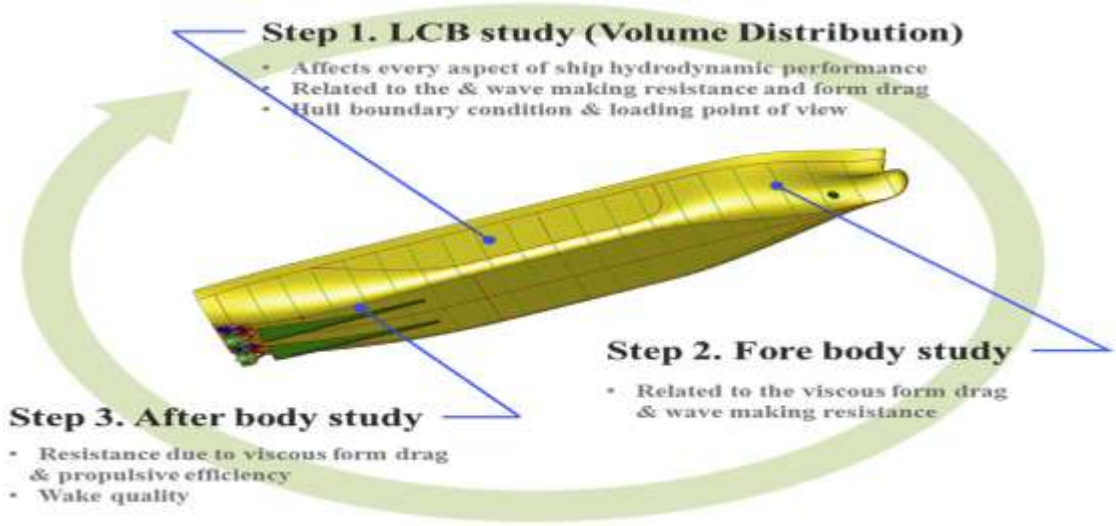
As natural guidelines have been become more rigid, the interest for LNG-filled vessel is expanding as option in contrast to regular fossil-energized ones. In accordance with this pattern, it is important to research a SLBV (Small scope LNG Bunkering Vessel) that provisions LNG fuel to LNG-filled boats. Furthermore, it is realized that the LNG freight limit of the SLBV is around 5,000 m3 e8,000 m3 . In spite of the interest for the SLBV, the distributed exploration is restricted. The idea concentrate for the SLBV configuration was led in UBC (University of British Columbia) with transport proprietor, characterization. They examined the driving assessment, the electrical frameworks, the channeling framework, the HVAC framework and the definite investigation of the existence cycle cost just as the profit from speculation (Zargham et al., 2016). A few Korean shipyards like SHI (Samsung Heavy Industries), HMD (Hyundai Mipo Dockyard), HHIC (Hanjin Heavy Industries and Construction) and STX have a history of building the SLBV. It tends to be seen that the SLBV has generally lower L/B proportion and bigger Cb (Block Coefficient) than those of ordinary LNG (Kim and Lee, 2005). Also, different sorts for the drive framework are applied to the SLBV because of the significance of mobility for the bunkering. Ordinary drive framework for the SLBV is the blend of CPP (Controllable Pitch Propeller) and high lift rudder or uncommon propulsor like an azimuth engine. As per the impetus framework, the plan requirement for course of action is resolved and thus, the body structure plan of the SLBV is likewise influenced. In this investigation, we might want to recommend the plan course of the SLBV including its particular fundamental specifics and unique impetus framework. The consequences of this investigation had been applied to the boat working at SHI

Hull Form Description

The body structure ought to be depicted in satisfactory detail for seakeeping counts, however in a straightforward way to take into account the programmed age of the numerous variations needed by the enhancement conspire. Accordingly, the structure is viewed as known whether the accompanying attributes are determined: the primary measurements LBP, B and T, the sectional region bend S(x), the waterline bend B(x), the longitudinal profile bend Z(x) and the bend of the longitudinal appropriation of the centroid of the boat segments KB(x), Athanassoulis and Loukakis (1985).
From these curves, all necessary ship design parameters can be derived i.e., Δ, CB, CP, CM, CVP, CWP, LCB, LCF, KB etc.

Hull Form Variants.

The initial phase in the enhancement interaction is to determine an improved body structure as for seakeeping execution. Since the changes important for seakeeping allude chiefly to worldwide frame structure boundaries, variations of the parent body structure are consequently produced. In this regard the strategy proposed by Lackenby (1950) is utilized, reasonably stretched out to oblige waterlines and sectional territory bends of any shape. A vital element of the code is that it considers the autonomous fluctuation of any of the accompanying six structure boundaries: CWP, LCF, CB, LCB, CM and KB. Along these lines, variation sets of structure boundaries contrasting in one boundary just can be created and by progressive uses of the technique, recommended sets of frame structure boundaries can be gotten. Albeit these arrangements of frame structure boundaries don't really relate to a viable faired lined body structure, they give direction to the alteration of a parent body structure or to the age of a body structure by Computer-Aided Ship Hull Design (CASHD) systems, as for example those proposed by Pigounakis (1997), Harries (1998), and Bloor and Wilson (1999). Comparable techniques are right now encapsulated in business CAD programming as TRIBON M2 (Kockums, 2002) or AUTOSHIP 7.1 (Autoship System Corp., 1999).



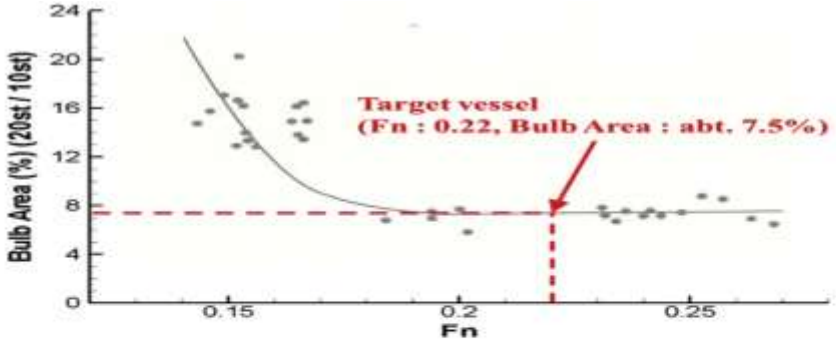
Study for optimum LCB position

The examination on the LCB position, one of the fundamental specifics, was done firstly. It was accepted that the estimations of length, shaft, draft and Cb are fixed and dictated by outer conditions like load limit, port impediment and steering of a boat.

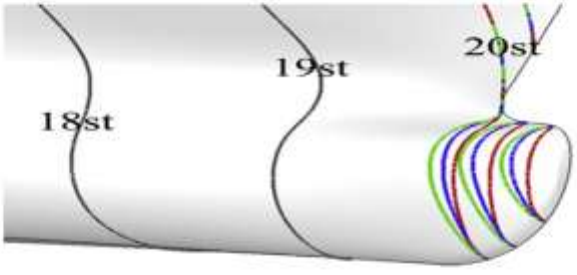
There are three runs of the mill techniques for choosing an ideal LCB position as follows:

(1) Statistics

(2) Partially parametric frame plan
(3) CNP (Conventional Non-Parametric) structure plan



(a) Optimum bulbous bow area by using the statistics data



(b) Bulb shape change

Fig. 9. Study of the bulbous bow section area (at Fn ¼ 0.223)

Study for optimum fore-body design

One of the plan focuses for front body configuration is to limit wave making opposition. For this reason, the bulb segment territory study was done like Fig. 9 (a). The territory proportion begins from 7.5% in light of the fact that the ideal bulb region proportion is suggested that esteem at twentieth. as per the past examination. As shown Fig. 9 (b) and (c), the bow wave top was decreased as the bulb region is expanded. However, when the bulb territory proportion is bigger than 10%, the bow wave top didn't diminish any longer and the second wave top was delivered. At long last, the ideal bulb zone was resolved as 10%.

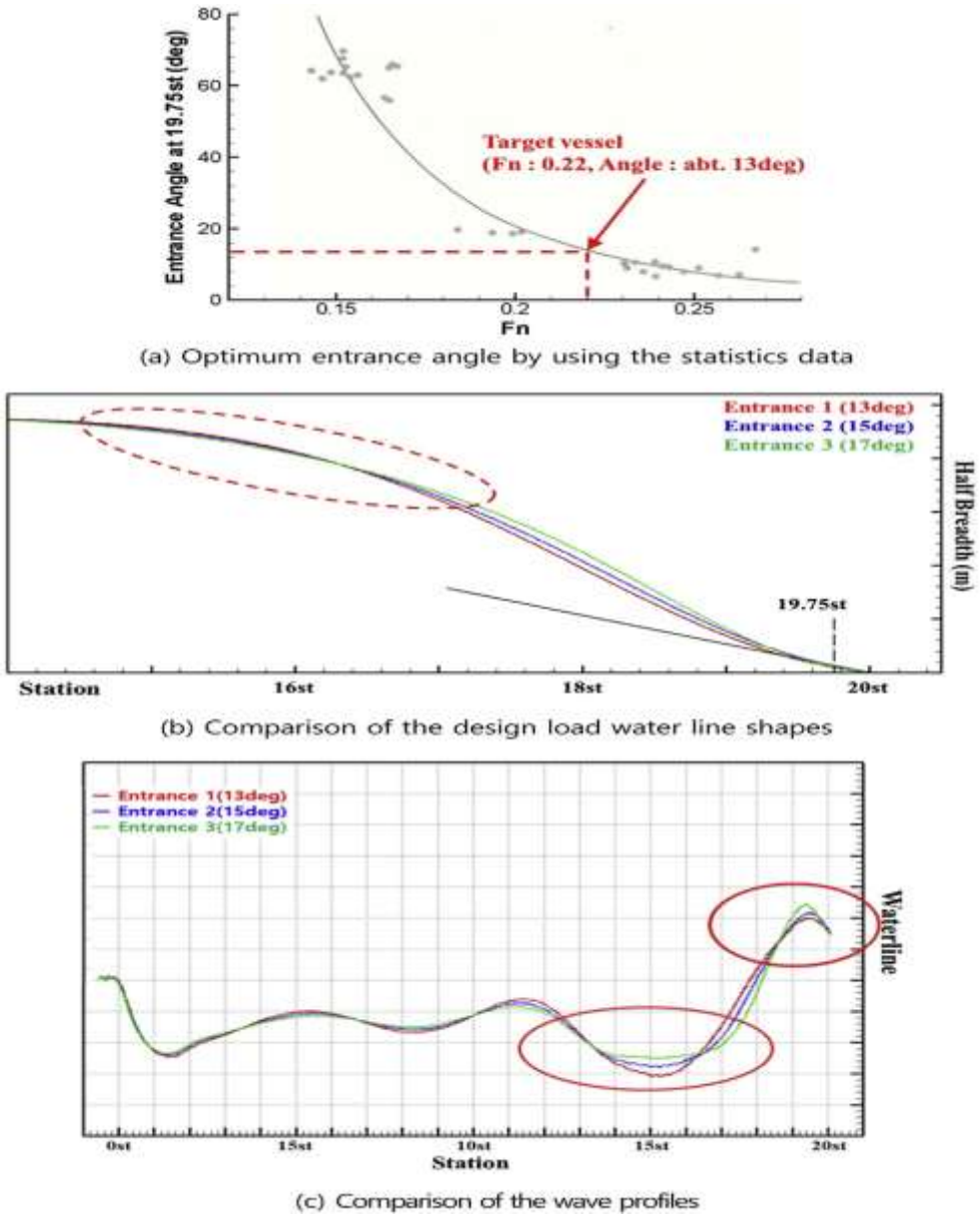
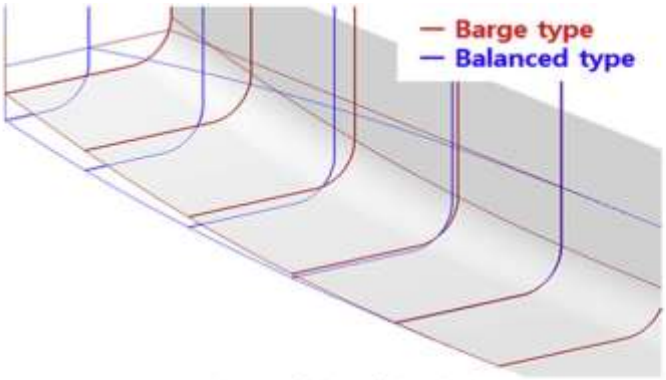


Fig. 1. Study of the entrance angle optimization (at Fn ¼ 0.223).

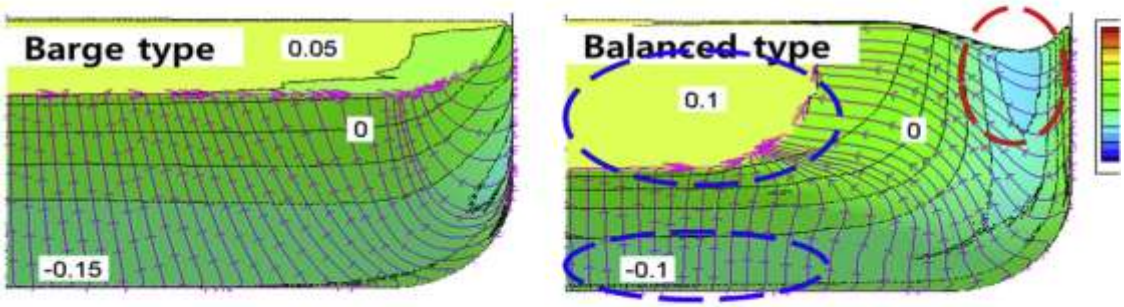
Then, a passageway point identified with shoulder wave obstruction was inspected. As demonstrated in Fig.1(a), the passageway point at around 19.75st. was expanded from 13deg which is resolved from the past examination As the passage point is expanded, the bow wave top was additionally expanded. Notwithstanding, the greatness of wave empty around shoulder was alleviated. The point around shoulder

zone in the red circle appeared in Fig. 1 (b) is generally diminished as the passageway point is expanded. The size of bow wave top has a typically enormous impact on wave opposition in traditional LNGc. Be that as it may, since the objective vessel on this examination has a low L/B proportion and enormous Cb, wave empty around the shoulder was unequivocally created in a wide reach. Along these lines, it is more successful to limit wave empty around the shoulder than to limit bow wave top as demonstrated in Fig.1 (c).

Study for optimum aft-body design



(a) Comparison of the aft-body shapes



(b) Comparison of the pressure distribution

Fig. 2. Comparison of the aft-body (at Fn ¼ 0.223).

The SLBV is fitted with azimuth engines, for the most part. Hence, the harsh ought not be in a harsh bulb structure. The investigation on an ideal state of toward the back body, as demonstrated in Fig.2 (a), was completed into two classes: a freight boat type producing butt cheek flow and a reasonable sort

creating consolidated butt cheek and waterline flow. The estimations of Cb and transom region were kept. As demonstrated in Fig.2(b), the negative pressing factor was dispersed at side locale of the reasonable kind in the red circle since waterline flow is produced. Notwithstanding, the pressing factor recuperation region was extended in the blue circle. The explanation is that the difference in harsh profile's curve on the decent kind is generally more modest than that of the canal boat type. The vortex shedding strength at the transom region in the fair sort was diminished more than with the goal that the pressing factor recuperation of the transom zone is expanded. Thusly, the obstruction of the toward the back body with the fair kind was about 10% not exactly that of the canal boat type. Hence, the decent sort was received as the base shape. The reasonable structure type, as introduced in Fig.3 (a), was modified to fulfill some plan requirements. The stern frame structure is additionally investigated to enhance the harsh profile, which was a vital factor for pressure recuperation of rearward body as demonstrated in fig(c)

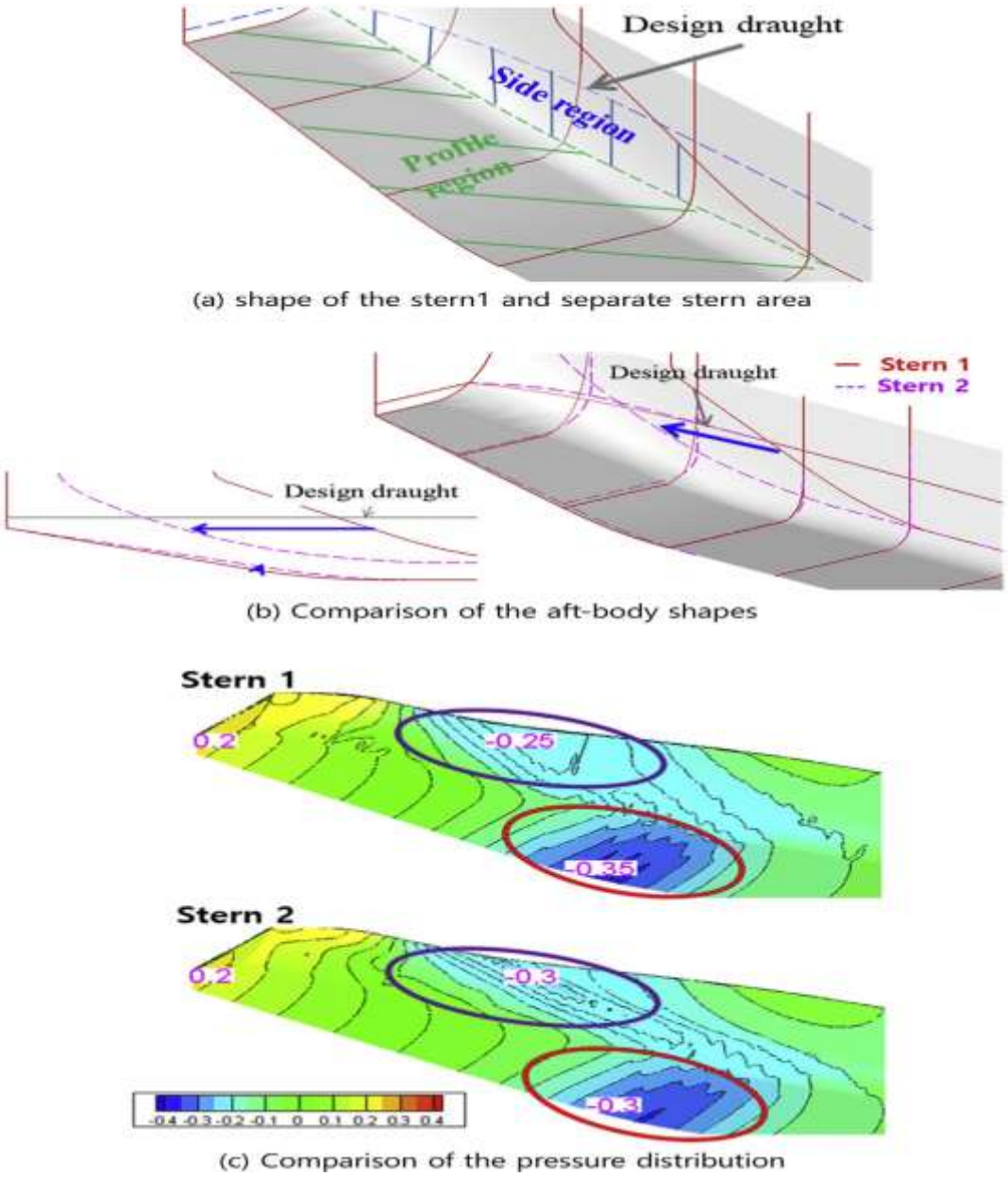


Fig. 3. 1st design concept for aft-body (at Fn ¼ 0.223)

Right off the bat, the arch of the harsh profile was streamlined to move the volume from profile locale to side area, introduced as the harsh 2 in Fig.2 (b). The pressing factor recuperation was improved as demonstrated in the red circle, yet the negative pressing factor territory was expanded as demonstrated in the purple circle from Fig.2 (c). Thus, the absolute opposition was expanded about 4% from Stern 1. The

explanation is that since the profile district is generally more extensive than the side area, the situation of side digression is unnecessarily moved to the harsh the longitudinal way as shown Fig.2 (b).

Also, the bend of the harsh profile was enhanced by expanding the transom submersion, introduced as the harsh 3 in Fig.3 (a). As shown Fig.3 (b), the pressing factor recuperation around the base region was improved as demonstrated in the red circle on the grounds that the curve of the harsh profile was completely decreased. The increment of the negative pressing factor territory around the side district in the harsh 2 isn't instigated as demonstrated in the purple circle since this plan idea prompts retaining the difference in volume at the profile area. Notwithstanding, the pressing factor recuperation around the transom zone turns out to be more regrettable as demonstrated in the blue circle on the grounds that solid flow partition was initiated at the transom locale coming about because of expanding transom drenching under the water as demonstrated in Fig.3

(b). Therefore, the complete obstruction was expanded about 3% contrasted with Stern 1. Ultimately, the bend of the harsh profile was advanced with raised bend shape introduced as the harsh 4 in Fig.4 (a). This ideal plan

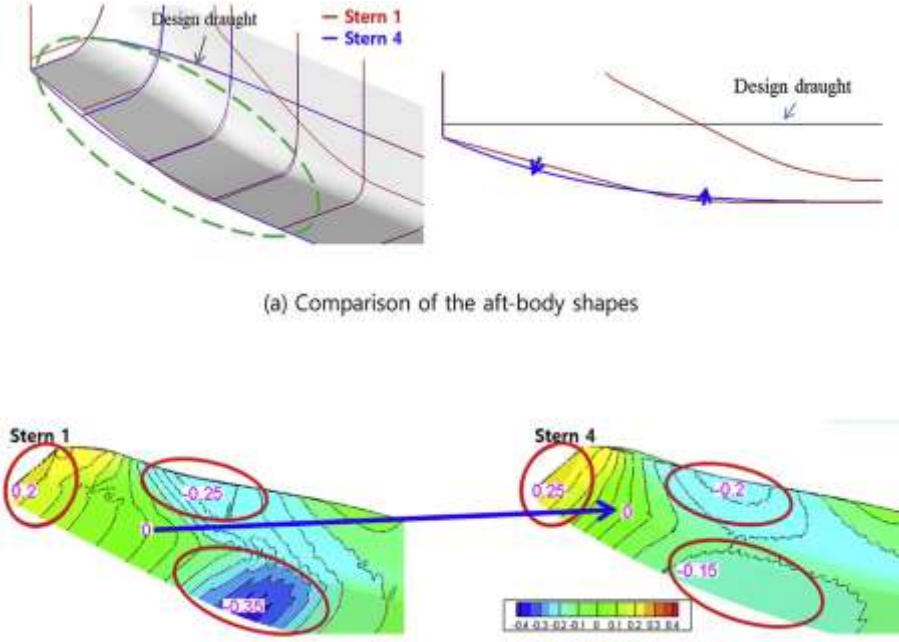


Fig. 4. Final design concept for aft-body (at Fn ¼ 0.223).

has the most improved pressing factor recuperation as demonstrated in the red circle in Fig.4 (b) since this plan idea doesn't change the transom inundation and position of side digression as demonstrated in Fig.4 (b). The complete obstruction was diminished about 5% from Stern 1 thus, the ideal plan course of the rearward body is to expand the pressing factor re-covery by changing the curve of harsh profile and configuration load water line just as the region and inundation of the transom submerged.

Hull Form Optimization Technique for Minimum Wave

Resistance

Artificial Neural Networks (ANN) method is presented as an advancement apparatus in limiting wave opposition of a boat's body. In the current examination, ANN strategy is executed along with a computational stream solver dependent on low-Froude number hypothesis, which uses source-board technique with Dawson's calculation. The current procedure is applied to the toward the back structure streamlining of a sailboat for least wave obstruction. The resultant ideal structure is contrasted with deference with the wave obstruction qualities with those of the first structure just as with those of the ideal structure got then again by utilizing quadratic programming with flimsy boat hypothesis. It is seen that the utilization of ANN method for frame structure advancement, albeit still at its beginning phases of improvement, can be perceptibly fruitful and promising.

The handling components in an ANN work simultaneously and all in all in an equal and dispersed style. ANNs have exceptionally close binds with improvement, and the ties are showed in two perspectives. On one hand, learning calculations have been created dependent on enhancement strategies to prepare ANNs to play out various demonstrating errands. The well known back propagation calculations (Feed Forward ANNs), for instance, are basically founded on slope drop strategy. Then again some ANN structures have especially created for taking care of different enhancement issues (Recurrent ANNs).

Hopfield and Tank initialized a significant part of the impulse for the Recurrent ANN ways to deal with enhancement. In their original work, Hopfield and Tank utilized the constant Hopfield organizations (Hopfield, 1982) for taking care of combinatorial enhancement issues (for instance, the mobile sales rep issue) (Hopfield and Tank, 1985) and straight programming issues (Tank &Hopfield, 1986).

First and foremost, it presents an immediate utilization of Artificial Neural Networks (ANN) procedure in structure enhancement. This has demonstrated to give certain benefits, for example, directional quest for the ideal plan just as a nearly quicker improvement technique with large number of targets. Also, it investigates the specific benefit given by this method that permits the Authors to redesign their past approach, which is given in Danisman et al. (2001a) and (2001b) in view of slight boat hypothesis, and to make a correlation between the two streamlining approaches utilizing the dainty boat hypothesis from one viewpoint and low-Froude number hypothesis (for example Dawson based) on the other. The proposed new enhancement method is applied uniquely to the rearward type of a medium speed sailboat to diminish wave obstruction just as to decrease the neighborhood wave heights because of changes in the toward the back calculation.

OBJECTIVE FUNCTION AND THE NUMERICAL FLOW SOLVER

Definition of Objective Function

Wave opposition is to be upgraded with the goal that a potential stream solver is utilized for this reason. For this situation, target capacity may not be communicated by an unequivocal structure like y f (x1, x2 ,. , xn) in which x1, x2,… ,xn address straightforwardly body structure boundaries or counterbalances as it is utilized in Michell's necessary. This verifiable numerical association between wave obstruction and body structure requires a mathematical instrument which connects the aftereffects of mathematical stream solver to the advancement code and thusly assists with deciding the attainable headings throughout numerical programming Fake Neural Networks approach is considered here to encourage the method between mathematical stream solver and numerical programming. ANNs are end up being ready to track down a utilitarian connection between a bunch of control factors and reaction esteems. On the off chance that there is sufficient number of sets of plan factors and comparing reactions, ANN can get familiar with the connection between them which in this way characterizes an unequivocal recipe for the goal work. In this examination, plan factors are picked as various boat half breadths, which addresses the body structure calculation in the streamlining locale. Comparing reactions can be chosen as wave obstruction, most extreme wave tallness, huge wave stature, and so forth At least one of these outcomes can be utilized to characterize target work.

Imperatives in The Optimization Procedure

Forcing plan imperatives in a streamlining interaction can forestall the methodology winds up with an undesirable, unimportant arrangement. Those requirements for a boat frame structure might be;

- Upper and lower limits for half breadths
- Displacement
- Waterplane territory
- Fairness rules for the improvement area.

Mathematical Flow Solver Used in the Evaluation of Objective Function.

To assess the goal work (for example wave opposition, huge wave stature, most extreme wave tallness, and so on) a stream solver, which depends on Dawson's (1977) calculation is utilized. As indicated by the current calculation Rankine source dissemination is made absurd, which are utilized to address the wetted surface zone (WSA) of the boat structure under the stacked water line (LWL) just as a segment of the free surface around the body. Impermeability condition is applied at the WSA of the boat, while at the free surface joined linearized free surface conditions are forced. The free surface condition utilized in the wave opposition code is equivalent to proposed by Dawson:

$$\nabla\Phi \cdot \nabla[-(\nabla\Phi)^2 + \nabla\Phi \cdot \nabla\phi] + \frac{1}{2}\nabla\phi \cdot \nabla(\nabla\Phi)^2 + g\phi_z = 0$$

where the velocity potential is taken as the sum of;

$$\phi = \Phi + \varphi$$

ϕ fulfills the Laplace's condition, □ indicates the twofold model potential and □ signifies annoyance potential because of the free surface impacts. The separation of the speeds in (1) along the smoothes out is performed by Dawson's 4-point in reverse separation conspire, which guarantees the radiation condition mathematically. In the current examination, a definitive wave obstruction estimation is finished by the pressing factor combination over the WSA under the LWL.Optimization Using Quadratic Programming with Thin-Ship Theory To show the upsides of the ANN based improvement strategy, it is chosen to contrast and another option and grounded enhancement technique, which depends on quadratic programming with imbalance imperatives and slender boat hypothesis, given by Goren and Calisal (1988). Momentarily, in this technique, the complete obstruction of the vessel, which is thought to be the amount of frictional opposition and wave making opposition, is taken as the goal work. The detailing of the frictional obstruction, which depends on the ITTC-1957 equation, and that of the wave-production opposition dependent on the Michel's slim boat hypothesis are diminished to quadratic structures as capacity of the cross over frame balance utilizing Hsiung's tent capacity approach, Hsiung (1981). The target work is then limited utilizing the quadratic programming dependent on Wolfe's Algorithm under the arrangement of given plan limitations.

IN THIS SYSTEM, IN VIEW OF THE PREVIOUS INVOLVEMENT IN MONO-BODIES (FOR EXAMPLE GOREN AND CALISAL (1988)) AND AS OF LATE WITH SAILBOATS (FOR EXAMPLE DANISMAN ET AL (2001A)), IT IS CHOSEN TO WAY TO DEAL WITH THE STREAMLINING AT TWO STAGES:

IN THE ABOVE STREAMLINING, THE ADVANCEMENT SPEED IS VIEWED AS 18 BUNCHES (FN = 0.5). ALBEIT THE FRAME DISPERSING ITSELF MAY DRAMATICALLY AFFECT THE OBSTRUCTION WITHOUT ADJUSTING EACH DEMI-BODY, THIS BOUNDARY IS LIKEWISE KEPT STEADY. THE SUBTLETIES OF THIS ADVANCEMENT CAN BE FOUND IN DANISMAN ET AL (2001B).

OPTIMIZATION USING ANN BASED METHOD

Prior to the application of this method, a practical decision is taken for the region of the optimization on the hull surface. This is because the earlier exercise with the alternative optimization method has indicated that considerable contribution to the wave- making resistance comes from the aft-shoulder waves. Therefore, it is decided to apply the ANN based optimization to the aft region of the demi-hulls by imposing the similar design constraints applied in the previous method

DISCUSSION OF COMPARATIVE RESULTS

Figure unmistakably shows that both enhancement strategies give roughly 10% addition in wave making obstruction as for the first frame structure. It is likewise intriguing to take note of that the enhanced structure acquired from the ANN based strategy has an awry toward the back body areas as opposed to the symmetric one got from the intelligent quadratic programming technique with flimsy boat hypothesis utilizing source-sink circulation on the middle plane.

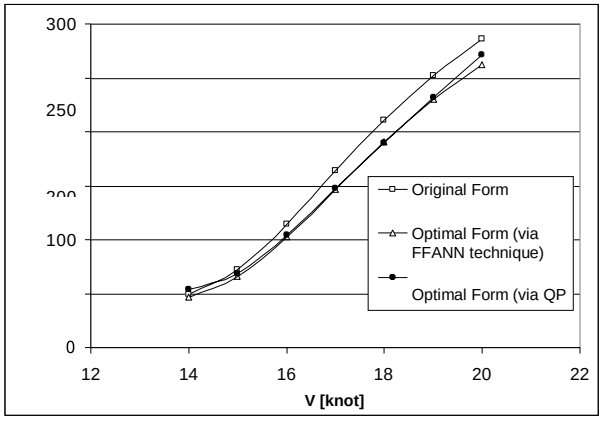


Figure 5. Computed wave resistance comparison of original and optimal forms

3.Conclusion

It was led to enhance the presentation of the SLBV which has a lower L/B proportion and bigger Cb than those of customary LNG. The enhancement study was acted in three areas: LCB, Fore-body and Aft-body. As needs be, this examination presents the ideal plan bearing for the SLBV.

(1) The ideal LCB's position was thought of and analyzed utilizing three distinct techniques. It is presumed that, because of its extraordinary specifics of the objective vessel, it is unseemly to foresee the ideal LCB's position utilizing measurements or the Lackenby change strategy. Nonetheless, the ideal LCB's position ought to be acquired by traditional non-parametric body configuration thinking about the qualities of body structure. Specifically, dissimilar to regular LNGc, the rearward body on the objective vessel can be essentially planned with four lines being addressed.

(2)A investigation on the enhancement of bulb shape and passage plot for front body was performed. It demonstrates that the advancement of the shoulder wave is more compelling than the decrease of bow wave top, which is notable as broad way to deal with center or quick speed vessels. The explanation is that the objective vessel has moderately enormous volume appropriation in shoulder district because of its low L/B proportion and huge Cb. Consequently, serious shoulder wave in that locale is basically produced and straightforwardly influences toward the back body without changing equal part.

An examination on the enhancement of harsh profile, one of the significant plan boundaries, was done dependent on rearward body with a decent structure type. Albeit the fair frame type creating complex flow by joining butt cheek flow and waterline flow, the obstruction was less than that on scow type. Also, the raised kind profile on toward the back body is significantly more viable to expand the pressing factor recuperation and lessen to opposition instead of the volume change of body side and transom.

In light of the frame structure improvement, subsequently, the all out EHP of final body structure was diminished 9.5% from the underlying body structure in this examination.

In this technique, in light of the previous involvement in mono-structures (for example Goren and Calisal (1988)) and as of late with sailboats (for example Danisman et al (2001a)), it is chosen to way to deal with the enhancement at two stages:

In the above streamlining, the improvement speed is viewed as 18 bunches (Fn = 0.5). Albeit the structure separating itself may dramatically affect the opposition without adjusting each demi-body, this boundary is likewise kept steady. The subtleties of this enhancement can be found in Danisman et al (2001b).

Acknowledgement

We would like to express our sincere gratitude to our Vice Principal C/E Tejinder Pal Singh Bhamra , our faculty advisor C/E. Chilukuri Maheshwar and HOD C/E. Yogesh Chonka our faculty advisor C/E. Chilukuri Maheshwar and HOD C/E. Yogesh Chonkar for providing their invaluable guidance , comments and suggestions throughout the course of this project.

Through this technical paper, we have learnt about how focus on the optimization work has been made to minimize the wave resistance , but in future , the applications will be extended to cover optimization towards improved performance of the stern flows and improved seakeeping properties.

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3 IN 1 MIRACLE PAINT COATING FOR EFFICIENT SHIPPING WITH MAJOR EMPHASIS ON MARINE BIOFOULING

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Abstract: It will be an understatement to say that today's economy is depended on the massive yet very crucial shipping industry. Though there are many ways of transportation but none are as widespread and more reliable. There is a perception that cargo transport by ship is low in air pollutants, because for equal weight and distance it is the most efficient transport method. However, because sea shipment accounts for far most annual tonnage and the distances are often large, shipping's emissions are globally substantial. This factor also works in favour as even a small reduction in pollutant level of individual components of this industry will make a greater as well as more substantial effect on the overall picture. This paper discusses how a simple coating with three different application can reduce three major problems and help in countering pollution thereby making the shipping industry even more environmentally reliable.

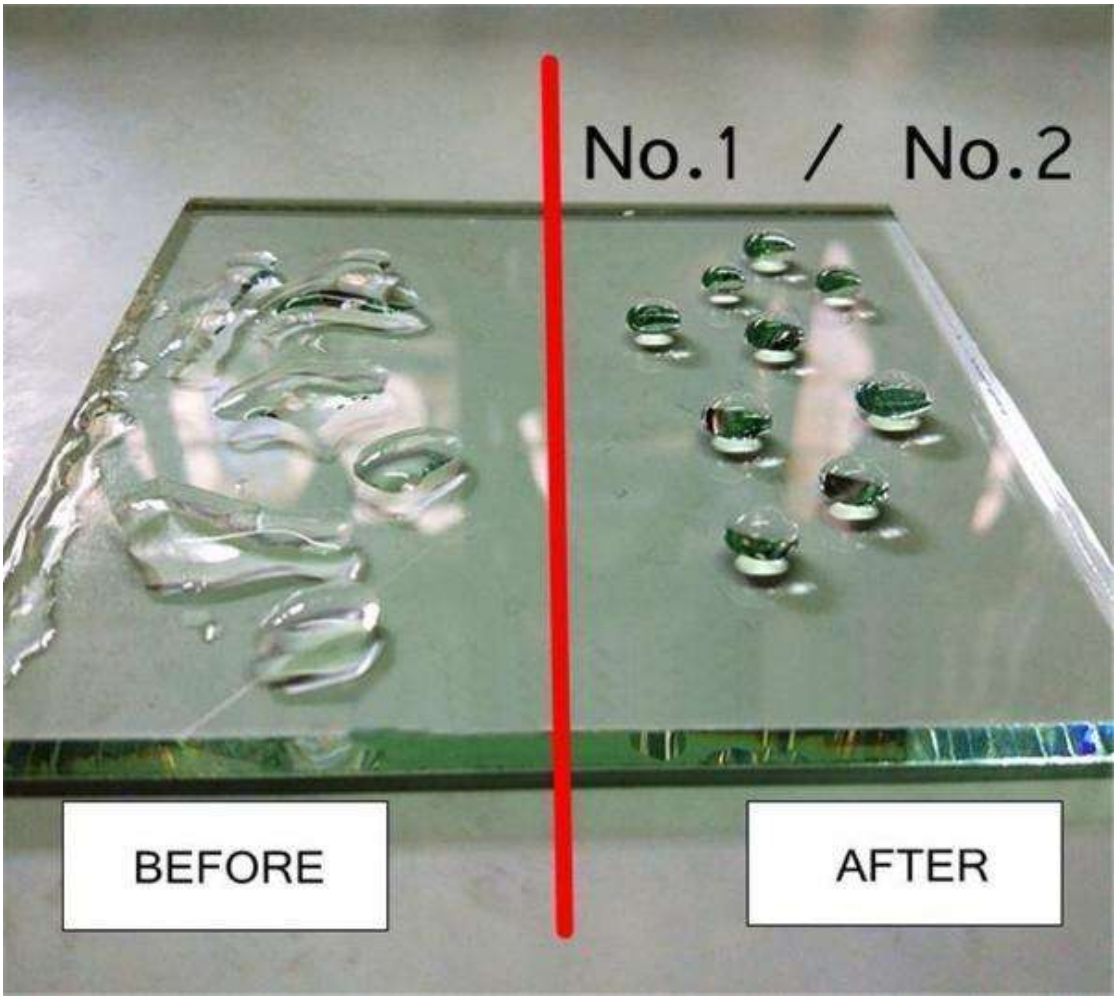
Keywords: superhydrophobic coatings, marine biofouling, biocompatible polydimethylsiloxane.

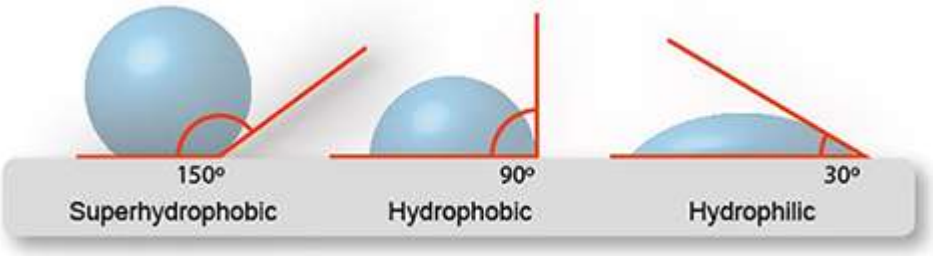
1.Introduction:

In the past few years, the topic of environmental degradation has been brought into the limelight of the global stage for the greater good. The shipping industry has not been devoid of these trends and there have been calls to make the industry more green and environmentally reliable. Though the concept of coating the marine vessels is not new and has been in practice almost as early as man began to ride the waves, but the idea has not been benefitted by the new advances in science and technology that has come with the advent of the information age. The conventional coatings are bulky, toxic and only focus on managing corrosion. It is about time we focus on this aspect of ship management and improve the elements our ships are being coated with, managing to meet more than one goals and thereby not only increasing efficiency but also benefitting the biosphere we dwell in.

Super hydrophobic material to make the vessel more hydrodynamic:

Superhydrophobic coatings are made up of a thin highly hydrophobic layer capable of repelling water, it is made up of materials with super/ultra-hydrophobic capable of repelling up to 100 % water droplets coming in contact with it. A coating with thus properties will not only increase the overall hydrodynamic qualities of the ship but also contribute by reducing the overall fuel consumption. Some of the most commonly used materials used to prepare such superhydrophobic coatings are biocompatible polydimethylsiloxane and carnauba wax. The materials are so readily available that with proper guidance a superhydrophobic coating can be prepared at home.





Marine biofouling:

Ships travel from one corner of this planet to another traversing oceans and in the process it through millions of specific ecosystems part of the grand marine life thriving on this planet, this leads to what is now known as marine biofouling. The intrusion of invasive aquatic species to new environments by ships is now identified as a major threat to the world's oceans. These species, traveling on ships' ballast water or on their hulls, are able to survive, establishing a reproductive population in the host environment.

Effects of marine biofouling: This newly discovered yet ignored phenomenon has led to a spectrum of problems ranging from marine bio diversity to hull degradation. This problem has become more evident the last decades, as shipping traffic in the oceans has increased greatly. It leads to destructive consequences as the marine biodiversity suffers and has even led to drastic economic instability for countries that depend on the coastal and marine environment, such as tourism, aquaculture and fisheries. Biofouling causes a deposit of marine life on the hull of the ship that negatively affects the performance, it may lead decrease of speed by up to 10%, something that in turn may require even a 40%increase in fuel to counterbalance. Therefore, marine biofouling is a problem that causes economic, biological and as much as 40% decrease in overall ship efficiency. Examples of marine biofouling:

Fig. The deposited marine life can be evidently seen, this alien surface causes massive increase in resistance.

Problem statement: Marine biofouling is not a well-known problem that is responsible for a wide variety of problems for the shipping industry as well as the global economy and environment. The few coatings that have been introduced are Harmful to the environment and are bulky as well as expensive in application.

2.Main work:

The IMO had announced a regulatory update that declares that by 1st January 2008 all ships must have an antifouling coating, this proves that how important yet new this problem is concerning the legacy of a thousand-year-old industry. The coating we have worked on is a superhydrophobic foul release coating utilising the chemical properties of hydrophobic material in ratio depending upon these various factors cost, area, thickness, longevity as the overall conditions is not same. It is a low energy coating that enables the easy release of the marine life, makes the hull superhydrophobic thereby making it more hydrodynamic and prevents rust like conventional coatings at an overall cheaper price. The microscopic layer of the coating sticks efficiently on the outer hull of the vessel with an angle of 152 degrees and more creating an extremely water repellent surface, furthermore consists of completely natural or non-harmful synthesized/derived substances like biocompatible polydimethylsiloxane in major ratio. This layer works to drastically reduce the contact drag of water with the surface of the hull greatly increasing the overall hydro dynamics of the vessel. Furthermore, this superhydrophobic layer stops the growth of alien and uninvited marine life growth as well as deposition on the outer hull stopping marine biofouling and creation of a rough surface by said entities.

3.Conclusion:

It is widely accepted now after a thorough research that Bio Marine fouling is responsible for a plethora of major problems spanning across multitudes of industry including shipping. Norms are already in place to ensure every sea going vessel is equipped to combat the same. Thus, a coating combating this problem as well as rusting and improving efficiency by as much as 40% might come as one of the best ways to combat and control this problem.

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ZERO EMISSION TECHNOLOGY- FUEL CELL

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Abstract: The need for technological development to reduce the impact of air pollution caused by ships has been strongly emphasized by the world, including the International Maritime Organisation (IMO). There are many kinds of research regarding various alternative fuels and their operation underway all over the world. One of these alternative fuels is hydrogen. Hydrogen has high energy content per weight and when burnt gives Zero Emission. Hydrogen can be burnt on board a ship with the help of a Solid Oxide Fuel Cell (SOFC) and a battery. Hydrogen can be stored onboard in a Liquid Hydrogen (LH_2) tank which would be a double-walled vacuum insulated with a high-grade stainless-steel liner. This LH_2 can be obtained through shore storage facilities.

The LH_2 will be drawn from the storage tanks and sent to the fuel cell where the energy conversion occurs and we receive electrical energy which gets stored in the battery. This electrical energy will be used to propel the ship through a propeller with an e-motor.

Keywords: Liquid Hydrogen, Fuel Cell, SOFC, Electrolysis, Zero emission.

1.Introduction:

Maritime transport is the backbone of international trade and the global economy. 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 which is a heavy sludge petroleum-based fuel that emits compounds of Sulphur, Nitrogen and Carbon. On average Bulk carrier emit 440 million metric tonnes of CO_2, while container ships emit 140 million tonnes of CO2.

1.1 Background

In 2015, the "Third IMO greenhouse gas Study," conducted by the International Maritime Organization (IMO), reported that air pollutants emitted from ships in 2012 accounted for 13% of NOx, 12% of SOx, and 2.6% of CO_2 in terms of global atmospheric pollutant emissions. The International Council on Clean Transport (ICCT), a world environmental non-profit organization, has analysed and forecasted the pollutant emissions from

ships from 1990 to 2050, and reported that the NOx and SOx emitted from ships are expected to extend to 30% and 20%, respectively, of all global pollutant emissions. These study results support the view that the long-term effects of atmospheric pollutants caused by ships are foreseen to become more severe, considering the trend of accelerating global trade in the longer term. There's a necessity to develop technology for reducing pollutant emissions from ships.
With the planet becoming conscious about reducing the carbon footprint The Marine Environment Protection Committee (MEPC) in the International Maritime Organization (IMO) has discussed the switch to cleaner fuels

and their availability. In such context hydrogen as a marine fuel may be a viable option in achieving Zero Emission.

1.2 Relevance of HFC

Hydrogen fuel, compared to heavy oil fuel, is environmentally-friendly, which produces zero-emission because it wastes only clean water. It reacts with oxygen gas within a cell that converts chemical potential energy into electrical energy. The system is widely called HFCs which can generate low-carbon heat and electricity while avoiding environmental impacts faced by other low-carbon technologies (Dodds et al., 2015). Technology maturity and commercial viability of HFCs are enough, and therefore the level of technologies is continuously improving for several applications. for instance, as for transport sectors, HFCs are already being employed in many applications like cars, forklifts, emergency backup systems and light-duty trucks, among others.

1.3 Drawbacks

In terms of environmental advantages compared to other fuels or systems, the shipping industry should consider applying HFCs to commercial vessels; however, there seem to be some challenging issues for progress in the application of HFCs to ships, i.e., technical and practical problems, cost reductions and infrastructure for supplying hydrogen.

1) The technical and practical problems associated with HFCs on board are existing vibrations that will affect HFCs in dynamic situations which are found in transportation areas. Vibrations may contribute to exacerbating defects like pinholes, cracks, and delamination, which result in performance degradation and lack of durability (Ahmeda, Banana, Zua & Bazylak, 2011). Moreover, storage of hydrogen was limited onboard due to the shortage of space, which led to short time running.

2) It is crucial to contending with costs for the aim of the commodification of HFCs. it is widely accepted that specific materials incorporated into tanks or catalysts are normally expensive. This problem can be seen in the automobile industry as well. Toyota's “Mirai”, as an example, costs approximately £60,000, which is around

twice as much as the standard-sized cars of Toyota (Lilly, 2017). mass production of HFCs would offer economies of scale which will result in decreased cost; however, it's not currently become a reality. Moreover, the not only capital cost of fuel cells, but also hydrogen price should be taken into consideration. the price would be designed to keep up the equilibrium between demand and supply; thus, it's harsh to predict the price. it would depend upon production cost, supply cost, market value, and demand, storage cost, distribution cost, competing, non-energy markets for biomass (Demirbas, 2017). to commercialize ships with HFCs, cost-effectiveness is important for the shipping industry, compared to a different alternative fuel like LNG marine fuel.

3) the supply of hydrogen might be one of the issues. at the moment, though ships with HFCs are produced, they can't be freely operated at sea due to a lack of supply fuel infrastructure. However, HFCs suppliers are unwilling to pay the capital cost of hydrogen fuel stations unless demand and supply for commercial shipping with HFCs are well developed. Furthermore, shipping companies also are unwilling to invest in ships with HFCs unless hydrogen bunkering is sufficiently prepared. this is often known as the "chicken-and-egg" dilemma, which occurs within the automobile industry (Salomon, 2016). Toyota tried to simultaneously solve this issue with the introduction of the hydrogen-powered, "Mirai", and keeps trying to produce it today (Muller, 2014). to build hydrogen fuel stations at the port, the enormous cost would be necessary. This means that not just one player, but also all the relevant players should make efforts. to build them together.

2] Hydrogen as a marine fuel

Hydrogen as marine fuel faces some significant obstacles like lack of reliability or high cost. However, compared to some other proposed alternative fuels, like LNG, methanol and biodiesel, hydrogen has some advantages as a marine fuel.

1) Hydrogen is superior to other alternative fuels from an environmental perspective. DNV GL investigates that CO2 emission of LNG from the tank to the propeller is more than 55 g/Mega Joule (MJ), and if using methanol from CH4, it's more than 70 g/MJ, whereas one of hydrogen it is zero in shipping, an equivalent as biodiesel (DNV GL, 2018). Moreover, as for NOx emission, the emission of hydrogen is below 20%, compared to HFO-fueled Tier II diesel engines which are employed as a baseline (100%). This value is sufficient to comply with Tier III NOx limits (DNV GL, 2018). Therefore, hydrogen is the cleanest fuel produced by using RE.

2) The energy content of the fuel is much higher than that of other fuels. according to the European Commission (EC), the energy content of hydrogen is 120 MJ/kg, which is around 3 times above that of other cleaner fuels, as shown in Figure 2. Thus, high energy efficiency can be achieved by utilizing hydrogen as fuel (EC, 2017).

3) Hydrogen could be considered as an alternative fuel because technologies and network regarding production, storage, transportation of hydrogen have already been matured (Oesterholt, 2018). As a result,

there would be regardless of practical use so that the commercial viability of hydrogen as marine fuel might be only a matter of time.

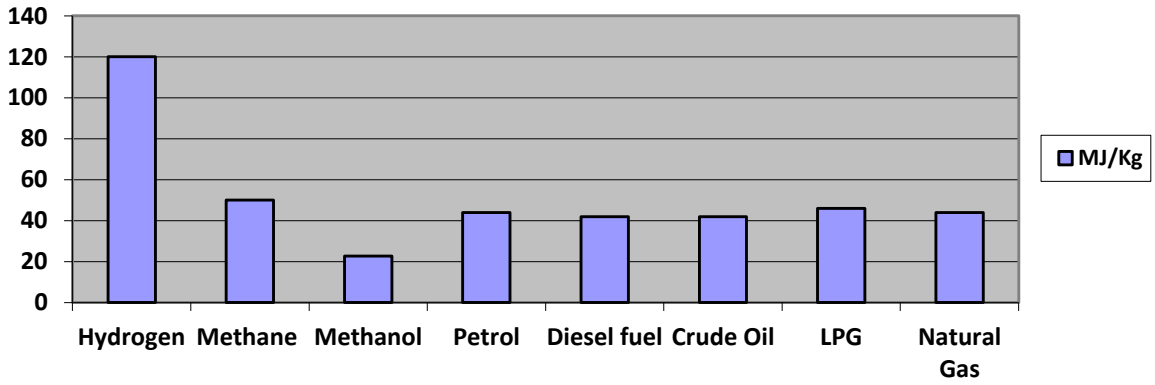

Figure 1: Energy Consumption Graph

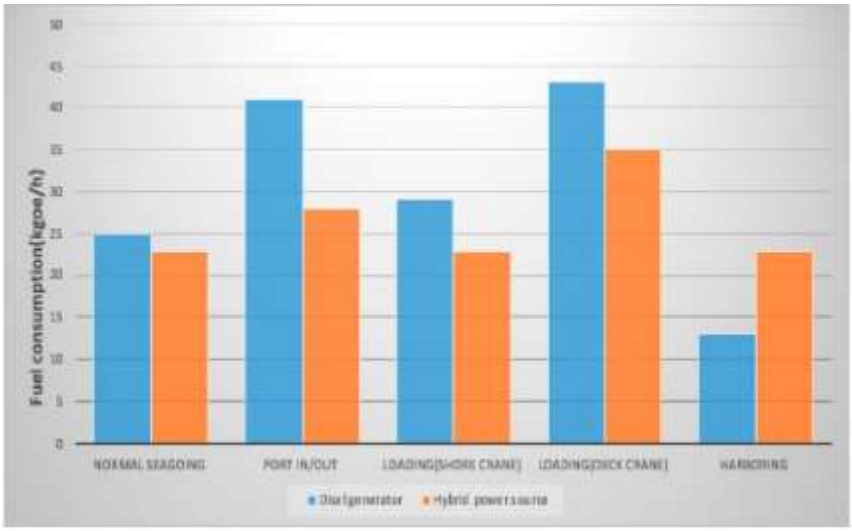

Figure 2: Fuel consumption in each operating mode of the 40 k DWT bulk carrier. [1]

2.2 Cost

Although hydrogen has some advantages in the practical use of hydrogen, the cost of hydrogen is significantly large. As shown in Figure 2, the price of natural gas and hydrogen presents €1.103/kg and €9.5/kg respectively (EC, 2017). the reason why the price of hydrogen is extremely higher is that the infrastructure for hydrogen production, transportation and distribution is required. due to the low

volumetric energy density comparatively, hydrogen must be controlled and managed under a high pressure to liquefy at very low temperature (IEA, 2005). This process is very expensive compared to natural gas.

1) Hydrogen has an advantage of the energy content of fuels and energy efficiency so that running costs in utilizing hydrogen for customers can be cheaper than one in other cleaner fuel. EC estimates that the hydrogen price (€) per 100 km, combined with the fuel cost of hydrogen, is 4.275, which is less than LNG and biogas (EC, 2017). In terms of running cost, hydrogen is a cost-competitive energy source.

2) Hydrogen demand will progressively increase based on the assumption that the market share of hydrogen-fueled vehicles will grow (Drennen & Schoenung, 2015). Thanks to the increase in its demand, the price of hydrogen may go down in the future. National Renewable Energy Laboratory (NREL) estimates that hydrogen fuel prices may fall by $2/kg in the range from 2020 to 2025 (Californifuel cell partnership, 2018). Transport cost could be reduced by $2.46/GJ in the range from 2025 to 2035 (Drennen & Schoenung, 2015). Availability of low-cost materials and economy of scale can help to decrease production, distribution and transport cost, which results in lower hydrogen price.

3) The fossil fuel price historically fluctuates. According to the Institute of Energy Economics (IEE), Japan, the LNG price follows the lead of the crude oil price track, and therefore the price in 2016 was $7.23/MBtu, which is less than half of the price of more than $15/MBtu, as shown in Figure 3 (IEE, 2017). This is because OPEC member's decision for a production cut of oil, politics, supply and demand balance and long-term contract affecting the oil price (Lioudis, 2018; Rogoff, 2016; EIA, 2018). Further, LNG prices are typically affected by their long-term contracts that are linked to crude oil or petroleum product prices (EIA, 2015). Therefore, in the future, the fossil fuel price might be above that of hydrogen. [2]

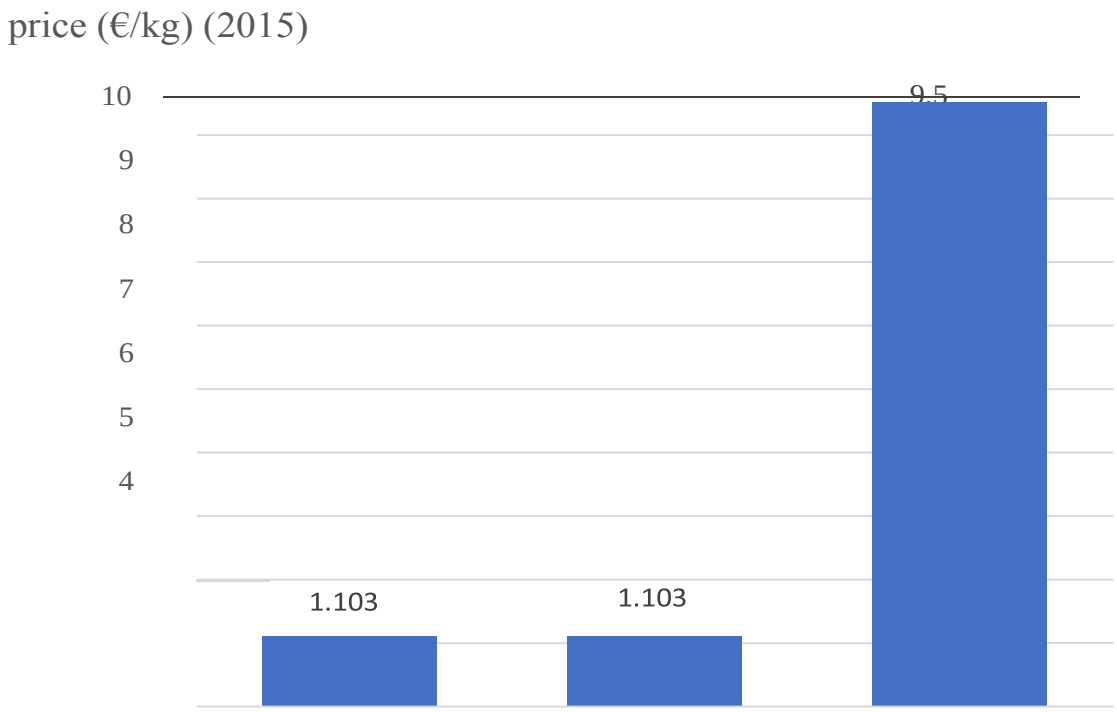

Figure 3. A price comparison between Natural gas, Biogas and Hydrogen (Source: EC, 2017)

2.3] SOFC (Solid Oxide Fuel Cell)

Solid Oxide fuel cell SOFC is an electrochemical conversion device that produces electricity directly from oxidizing a fuel. Fuel cells are characterized by their electrolyte material, the SOFC features a solid oxide or a ceramic material.

SOFC can be operated at a high temperature between 500- 1000°C. A porous ceramic material is used in the electrolytes. SOFC uses a nickel-base alloy because the anode, and normally, lanthanum strontium manganite is employed within the cathode. SOFCs have been generally used in large scale power production onshore, with capacities up to 10 Mega-Watt (MW). Several projects have been demonstrated regarding SOFCs as maritime application, including the Methapu, Felicitas and SchIBZ projects (Tronstad et al., 2017). The emission from SOFC is ZERO since hydrogen is used as fuel. The reactions that happen in the SOFC are the following:

Fuel cell reactions

Anode reaction:

$$2H_2 + 2O_2\text{-} \rightarrow 2H_2O + 4e^-$$

Cathode reaction:

$$O_2 + 4e^- \rightarrow 2O_2^-$$

Total reaction for fuel cell:

$$2H_2 + O_2 \rightarrow 2H_2O$$

The efficiency of SOFC could be as high as 85% or higher if a heat recovery system can be applied. There are two kinds of SOFCs, i.e. planar and tubular. The tubular SOFC is more stable in terms of thermal cycling, whereas the planar SOFC is recognized because of the more suitable design due to high energy density (Tronstad et al., 2017). Combing SOFCs with a battery will reduce thermal strain and achieve a more flexible operation. The current progress in the development of SOFC will contribute to a longer life with more than 50,000 hours, which may make them improve operational flexibility and lead to reducing investment costs to below 2,000 $/kW by between 2025 to 2035 (IEA, 2015).[2]

PARAMETERS	SOFC

Temperature (Degree Celsius)	600-700
Electricity Efficiency (%)	60-85
Module Power Level (KW)	200
Lifetime (hrs)	20,000 – 40,000
Sensitivity to fuel impurities	Low
Emissions	Zero

Table 1: Different parameter of SOFC

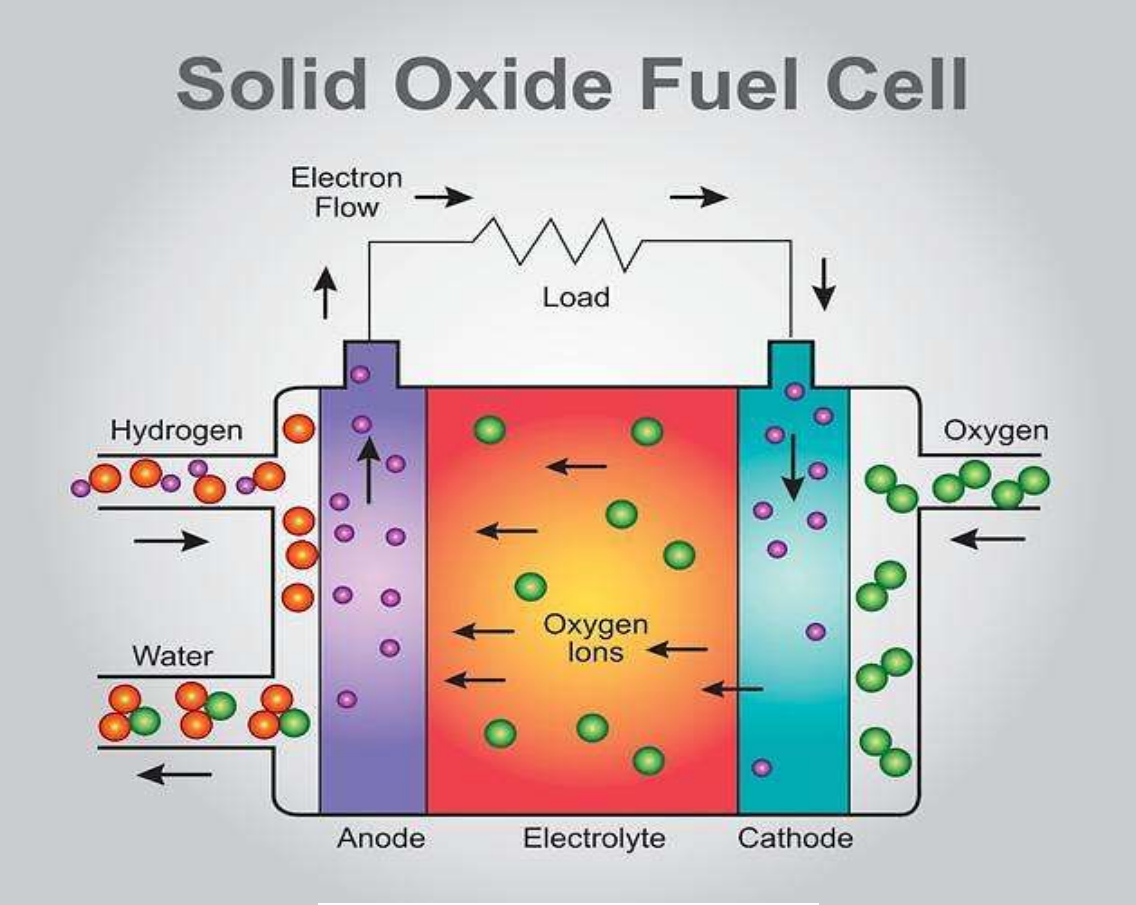

Figure 4: Diagram of solid oxide fuel cell(sofc).

2.4] Energy Storage System (ESS):

The energy storage system **is** that the electricity storage device, which uses electricity within the battery generated by the fuel cell stored. As shown in Figure 5, it is composed of a secondary battery and power conditioning system (PCS). Figure 5. Basic diagram for the energy storage system (ESS). A lead-acid battery was used for the ESS in the testbed, and it was built using the bidirectional connection system, of which the specifications are listed in Table 7. The PCS has functions for checking the state of charging (SOC) of batteries

in real-time and controlling the temperature, current, and voltage to enable the system to be operated stably. It also has functions for surge protection, automated prevention of overcharging/overload, overvoltage alarms, and overvoltage prevention.

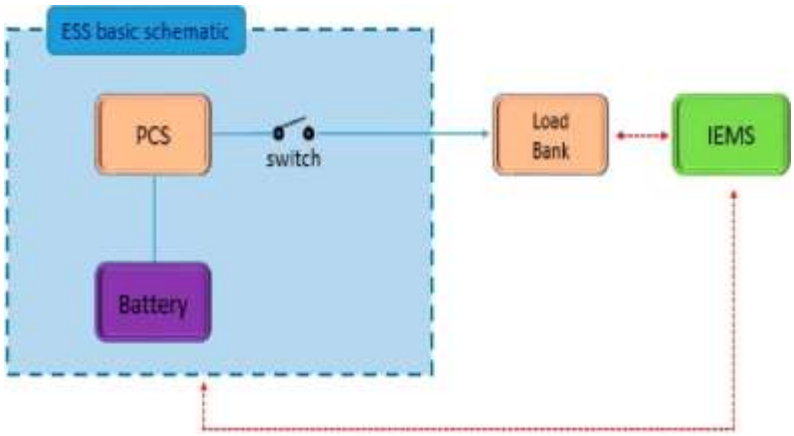

Figure 5: Basic diagram for the energy storage system (ESS).

3] Storage and handling of hydrogen fuel

An important think about selecting the shipping fuel for the long term is the ease at which it can be brought on board and handled on the ship. In the next section, we will evaluate the selected storage forms based on their bunkering ease and onboard use. With compressed and liquid hydrogen there are already several projects underway that investigate the possibilities of hydrogen bunker facilities.

With compressed Hydrogen there are 2 difficulties, firstly the storage in the gas cylinders results in rather low weight and volume densities of the overall system, hence which in turn will require large parts of the ship's deck and its hold to be used for the storage of the cylinders. Secondly, the other issue is the slow fuelling/bunkering time that is inherent in transporting a low-density gas. Therefore, if compressed hydrogen is to be used then a standard 20- or 40- foot container could be used to store the fuel, which can then be loaded on a ship. These are referred to as cassette type fuel systems. This system is an innovative design as the ships are already accustomed to the handling of a TEU container.

On the other hand, Liquid Hydrogen has been extensively being used for powering vehicles. Liquid hydrogen can be stored onboard in a double-walled vacuum insulated tank having a 304 stainless steel liner. Refuelling a ship with LH2 is similar to LNG bunkering. LH2 can be stored in the dockside H2 station as is being done in Hamburg, Germany. Or LH2 can be brought to a ship through a bunker barge.

These tanks can be stored in the uppermost deck of the ship which is in contact with the atmosphere. The reason for this is to ensure that in the event of a leakage the hydrogen fuel vent and evaporate into the atmosphere because of its lighter density.

Figure 6: Bunkering of LH_2

2.Conclusion:

As International Organisations around the world commit their resources to a greener future it is imperative that the shipping industry also follow suit. While international environmental regulations for the shipping industry have been increasingly tightened, ship owners will be required to invest in Zero Emission technologies. In such conditions, hydrogen fuel and FCs are one pathway through which zero-emissions could be achieved. Hydrogen fuel when burnt through a SOFC discharges clean water thus proving its environment-friendliness. From the economic point of view research on fuel cell technologies are still in its early stages of commercialization due to high costs. Governments can play a role to help accelerate the development and deployment of HFCs by establishing energy and economic policies to develop projects and funding. Hydrogen is fuel for the future, as the reserves of crude oil get exhausted and its price begins to soar, HFCs can be the go-to fuel for the coming generations of ships.

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GREEN TECHNOLOGY

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Abstract: This paper presents the efforts in encouraging green technology for maritime development from the perspective of higher education in marine technology. Discussion is commenced by observing the general trend of industry from the past centuries up to these days, especially in the scope of ship technology. Emphasis is given in the value-chain of ship technology, covering the initial process of ship design, construction, operation and to the end of ship lifetime which call for the ship recycling process. Several points in the attempts to introduce innovative green technologies are put forward, accompanied by the understanding on principles of green engineering. Some aspects of safety are also highlighted to correlate marine operation and the port infrastructure as an integrated system, and the possible impacts to environment.

Keywords: maritime development, green technology, innovation, safety

1. Introduction:

The threats posed by shipping are not spread evenly across the oceans, but rather concentrated in busy shipping lanes and ports. The main damage is caused by mainly due to release of oil and chemicals: through accidental spills and operational discharges and air pollution through emission of sulphur dioxide, nitrogen oxides, and carbon dioxide.

Also, diesel fuel costs continue to rise with implementation of low-sulfur limits, making power generation more expensive for ships. In the past, up to the late of 19th century, our understanding on maritime activities might be limited only to the sector related to seafaring and shipping or transporting goods through the seas and oceans within the frame work of international trading. However, since the beginning of the 20th century and especially after the end of World War II, the scope of maritime activities has grown very rapidly in parallel to the advancement technology and industry. nowadays we sees various type of merchant ships, such as modern general cargo ship, passenger and cruise ships, oil tankers, container ships, bulk carriers, chemical tankers, LPG carriers, and LNG carriers.

Various sources have put forward the definition of green technology, in which generally may be described as the technology developed and used in such a way so that it does not violate environment and at the same time it conserves natural resources. Further the green technology would improve production processes, productivity and efficiency, use

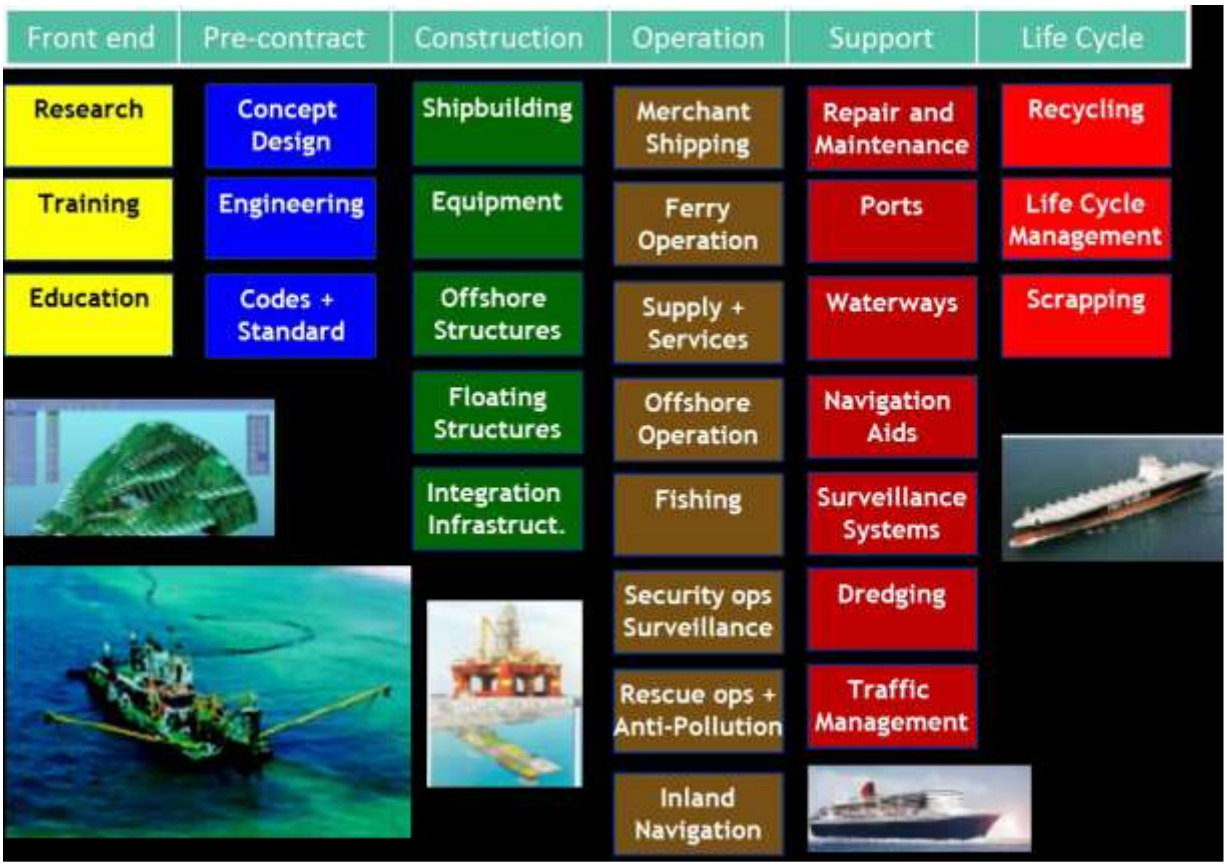
of raw materials or energy and reduces waste as, waste or pollution. The green technology should also gradually implemented in the field of maritime development.

2. Green Marine Industry

Generally maritime development may be described in term of shipbuilding industry, starting from the early 19th century centered in Europe and the USA, where the primary products are wooden sailing ships evolved into wooden steam ships and then iron steam ships. In this era the ships were designed mainly for carrying passenger, general cargo and as surface warships. By 1860 and 1880s the first oil tankers were built and then put into operation. Since then the advancement of shipbuilding industry went very rapidly, especially after the WW II. Hence nowadays we sees various type of merchant ships, such as modern general cargo ship, passenger and cruise ships, oil tankers, container ships, bulk carriers, chemical tankers, LPG carriers, and LNG carriers. In addition to these, expansion in marine operations, especially due to the need in offshore oil and gas exploration and exploitation, has led to the development of various service vessels

In order to comprehend further the nature of marine technology development it may be best illustrated in relation to the value-chain of ship technology as depicted in Figure 4. The technology development will involve, firstly the front-

end activities, namely education, training and research, followed by the second pre-contract activities covering concept design and engineering design which should meet certain codes and standards. Next to this is the construction of the product in the shipyard, which requires provision of equipments and integration of various components and systems. After the completion, the ship will be put into operation in accordance with the purpose, ranging from merchant, military and special services. During the lifetime operation of ships, a wide range of support infrastructures and facilities are needed to assure safe operation is achievable. These includes the periodic repair and maintenance, ports, waterways and navigation aids, dredging, surveillance systems, and traffic management. The last part of the value-chain is the end of ship lifetime. Eventually nowadays this aspect has been seriously considered due to the impact to environment.



Hence IMO in 2003 published a Guidelines on Ship Recycling; where every ship is mandatory to have a "Green Passport" containing information regarding the inventory of material in ships' structure, systems, and equipment that may be hazardous to health and the environment.

Examples of efforts carried out by ITS as an institution responsible in higher degree education on marine technology to contribute in the development of green technology are, among others, the design and building of solar boats and the design and building of bamboo boats, as shown in Figure 5 and 6. The principles in developing new products for green technology covers:

a. Involvement of lecturers, students, researchers, partners from industry, government and other stakeholders. The involvement of student is considered as one of the primary points, namely as early as possible establishing awareness to young generation on the importance of green technology. Further it also reflects an effort in encouraging the students to augment their expertise and practical skills, which will be important for them when it comes the time to work in industries;

b. Comprehensive research on the aspect of product design, including renewable materials, systems, costing and impacts.

c. Exposures the prototypes and products to wider community, nationally and internationally to extend the networking for further collaboration. This is utmost important for students, whenever possible they participate in international competition, so as they could soundly interact with young generation from different countries to initiate a further cooperations for the future; and

d. Preparing to meet the trend in the third industrial revolution , especially in the area of manufacturing. All sorts of goods, eg. ship parts, could be manufactured by “printed out” using 3-D printers, in what is being termed “additive manufacturing,” distinguishing it from the “subtractive manufacturing,” which involves cutting down and pairing off materials and then attaching them together. 3-D entrepreneurs are particularly bullish about additive manufacturing, because the process requires as little as 10 percent of the raw material expended in traditional manufacturing and uses less energy than conventional factory production, thus greatly reducing the cost.

Fig- The design, building, trial and international competition for ITS Batharasurya solar boat

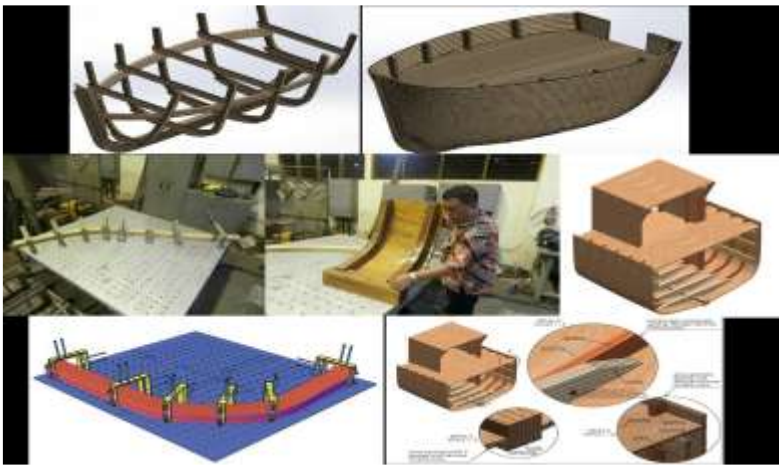


Fig: -Construction of wooden boats

The existence of timber for the production fishing vessels is increasingly scarce and expensive. Wood scarcity has been caused by intensive illegal timber logging and inappropriate reforestation program. Currently, the ship industry began to switch to Fiberglass Reinforce Plastic (FRP) as material for fishing vessels. However, use of this material is not in line with the principles of Green Marine Industry, because this material contains toxic and the waste produced is not environmentally friendly. It is therefore necessary to find alternative materials that are more environmentally friendly and can replace wood for shipbuilding materials.

Laminated bamboo is one of the environmentally friendly alternative materials for the production of ships. Laminated bamboo can replace solid wood as the main material of the ship. Based on the results of research on bamboo laminate that has been done, this material is technically and economically feasible to use the main material of the ship. The advantages of bamboo laminated are:

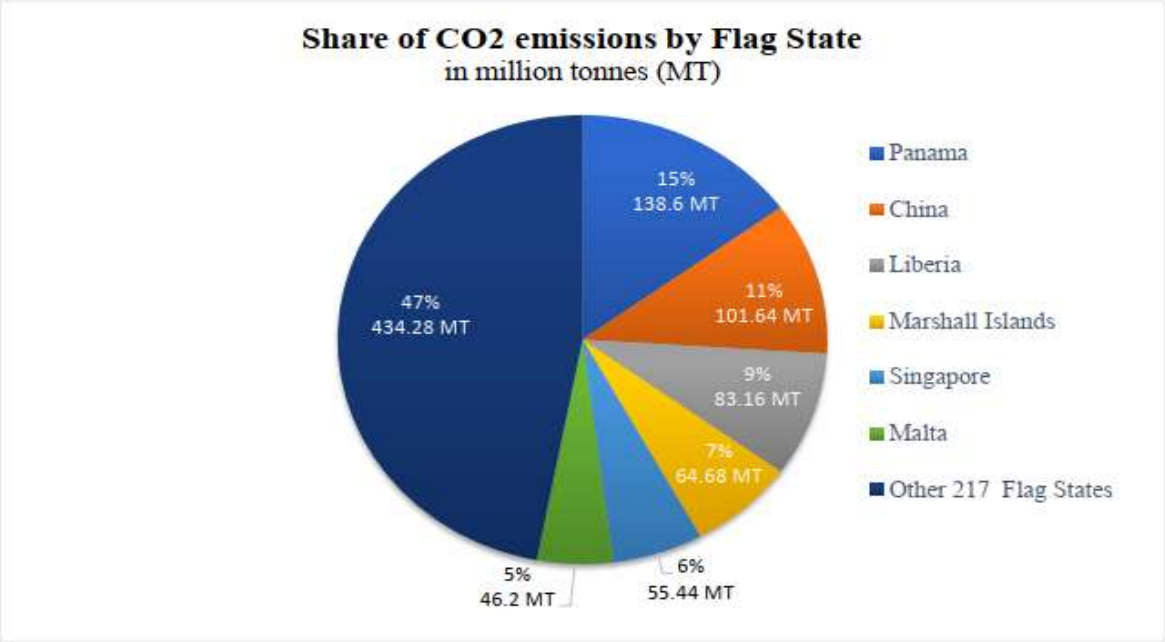
Available in large quantity;

- The bamboo harvest period is relatively much shorter compared to the wood (4-5 years vs 20-30 years);
- The strength of bamboo laminated is some 1.5 times higher than the solid wood (construction lighter);
- The price of bamboo laminated could reach as low as 30% of the price of solid wood (more economical);
- Bamboo is environmentally friendly and sustainable.

The principle in manufacturing of laminated bamboo as alternative material used for vessel construction are as follows. The first step is to make slats of bamboo with certain sizes of thickness and width. Then the bamboo slats are laminated by way of a brick pile with polyamide epoxy adhesive. Laminates which are already in the stacked bricks composition are then pressed utilizing a special clamp in accordance with the size and shape of the ship's construction. Size of the stack the stack size is made in accordance to the size and shape of the wooden boat construction, based on the design. Formation of laminated bamboo can be adapted to the shape of the straight structural component of the vessel (beams, keels, girders, etc.) and curved structures (frames). Curve-shaped structures are made using a special tool by bending the stacked slates according to the curve profile, then arranged, glued and clamped by a special brace. Factually

bamboo laminate can be applied to all parts of ship structures, namely the keel, frames, shells, deck beams, girders and components of the superstructures.

3. Green Ships



Concerns and issues related to green ships emerged initially early in 1970s. This is followed by the official documentation when IMO organized the International Convention for the Prevention of Pollution from Ships (MARPOL). This was the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years. It is reasonable to remind us all on the annexes which have been included in the MARPOL Consolidated Edition 2011, as follows:

 Annexes I and II address, respectively, vessel-source oil pollution and pollution from the bulk carriage by sea of noxious liquid substances.

 Annex III is concerned with marine pollutants carried in packaged form and much work has been done to ensure consistency in the classification of marine pollutants through a harmonized approach with IMO's International Maritime Goods Code and also taking account of new scientific knowledge.

 Annex IV addresses sewage discharges into the sea. The latest amendments to this Annex has been set to enter into force on 1 January of 2013 and designate the Baltic Sea as the first Special Area to benefit from a general prohibition of sewage discharges, with strictly controlled exemptions for passenger and cruise ships.

 Annex V regulates the disposal of ship-generated garbage and has been completely revised. The amendments has been set to enter into force also on 1 January 2013 and introduce a general prohibition of the discharge of all garbage – under the currently applicable Annex the discharge of plastics has been subject to a total, globally applicable ban. The revised Annex does however permit exceptional discharges for food waste, cargo residues, animal carcasses and cleaning agents or additives, yet these will be subject to additional requirements being fulfilled and the discarded items not being harmful to the marine environment.

 Annex VI addresses global climate change concerns by prohibiting ships' emissions of ozone-depleting substances. Having been adopted by an IMO diplomatic conference in 1997, Annex VI did not enter into force until 2005. Further reductions of air pollutants were subsequently introduced in 2008 amendments and in 2011 a formidable milestone was reached with the adoption of new amendments pertaining to ships' energy efficiencies aimed at limiting and reducing greenhouse gas emissions through technical and operational measures. These concern the Energy Efficiency Design Index (EEDI), for mandatory application to new buildings, and the Ship Energy Efficiency Management Plan (SEEMP), which is mandatory for both new and existing ships

A response to the latest IMO regulations contained in the annexes as afore mentioned, various shipping companies worldwide have then prepared for the implementation. An example of a comprehensive plan for implementation has been demonstrated by Carnival Corporation & PLC, a global cruise company and one of the largest vacation companies in the world. Carnival Corporation & PLC is investing in a broad range of voluntary energy reduction initiatives that meet or surpass the requirements of current laws and regulations Reducing fuel and driving energy efficiency takes multimillion-dollar investments and a multipronged strategy that includes:

1. Designing Company Ships for Greater Efficiencies

Effective fuel conservation starts with efficient ship design. Engine design has a major impact on efficiency and resultant emissions. Carnival Corporation & PLC actively participates in the Working Groups at the International Maritime Organization (IMO) that have and are continuing to develop efficiency regulations and standards that affect the cruise industry. When this company build new ships, consideration is given to implementing fuel conservation-related design strategies including:

- optimizing hull design and coating systems to minimize drag;
- selecting fuel-efficient combustion equipment;
- installing equipment to use waste heat; and
- installing energy-efficient on-board equipment, including lighting.

2. Maintaining Company Vessels

Carnival Corporation & PLC continuously refurbishes and updates vessels to make them more efficient and to reduce fuel consumption and air emissions. The company are achieving some key energy reductions through:

- optimizing diesel generator use at sea and in port;
- managing use of evaporators
- using fluorescent and LED lighting
- utilizing automatic heating ventilation and air-conditioning (HVAC) control systems
- changing chiller additives
- applying silicone-based anti-fouling marine hull coatings
- cleaning propellers and hulls periodically
- optimizing plant energy consumption
- increasing use of waste heat from engine exhaust for fresh water production and steam generation
- using vessel shore power installations ("cold ironing") where available.

3. Minimizing Fuel Use and Engine Emissions

To reduce the environmental footprint and our fuel costs from operating our ships' diesel-electric and diesel power plants, the company implement measures that are based on existing IMO regulations. These measures include developing a ship-specific SEEMP for each vessel. SEEMP became mandatory for all ships of 400 gross tonnage and above starting on 1 January 2013. The company also examine ways to increase energy efficiency through fuel homogenizers, which improve combustion and reduce fuel consumption. In addition, the company optimize the use of diesel generators on board to improve efficiency, and the use of waste heat generated by the ships' engines to heat water instead of relying on the ships' boilers. The company reduce the power required by engine room ventilation fans, through use of variable-frequency fan-drive motors and related pressure and temperature control systems.

4. Implementing Other Energy-Saving Initiatives

Carnival Corporation & PLC is introducing other energy-saving measures, including:

- designing more fuel-efficient itineraries;
- using voyage optimization tools;
- increasing energy use awareness through education and training of guests and crew;
- developing the ability to use alternative fuels; and
- researching and developing emissions-reduction technologies.

4. Green Ports

Ports are the entry gates of the ships loading and discharging all commodities. The traffic of oceangoing ships, tugs and pilotage boats, and cargo handling activities alongside berth and within the terminal area are the source of soil, water and air pollution. Port State control are entitled to take fuel samples in order to verify the fuel onboard. They are also entitled to pursue a more active role by using boats or even drones, which are now considered by few states, assess vessel's smokestack plumes to identify possible violations. Port authorities will almost certainly also require sight of a vessel's engine log books, bridge log books, the fuel oil changeover procedure, bunker delivery notes, the oil record book and sounding tables. Green technologies offering support for more environmentally port and terminal operations are increasingly accessible and economically viable. Electric vehicles, gas-fuelled cranes, highly efficient LED lightings.
The wave of imposing environmentally faces considerable rationalism, as environmentally-friendly operations could be viewed as a burden only. The following examples may serve as a sign towards an optimism.

First example: Terminal of Teluk Lamong, at Port of Tanjung Priok, Surabaya, which was inaugurated May 2015. PT Pelabuhan Indonesia III set an ambitious plan to build a modern and environmentally-friendly port. In this first stage, the terminal operates a berth of 1,200-meter length for its three terminals, international and domestic container terminals, and dry bulk terminal. The Terminal Teluk Lamong is equipped with advanced facilities such as shore-to-shore crane (STS), combined terminal trailer (CTT) dan straddle carriers (SC). The terminal aims to be the first green terminal in Indonesia. All equipment is powered by electric, except CTT and SC by environmentally-friendly fuel of EURO4 standard.

Fig: -Port of Tanjung Priok

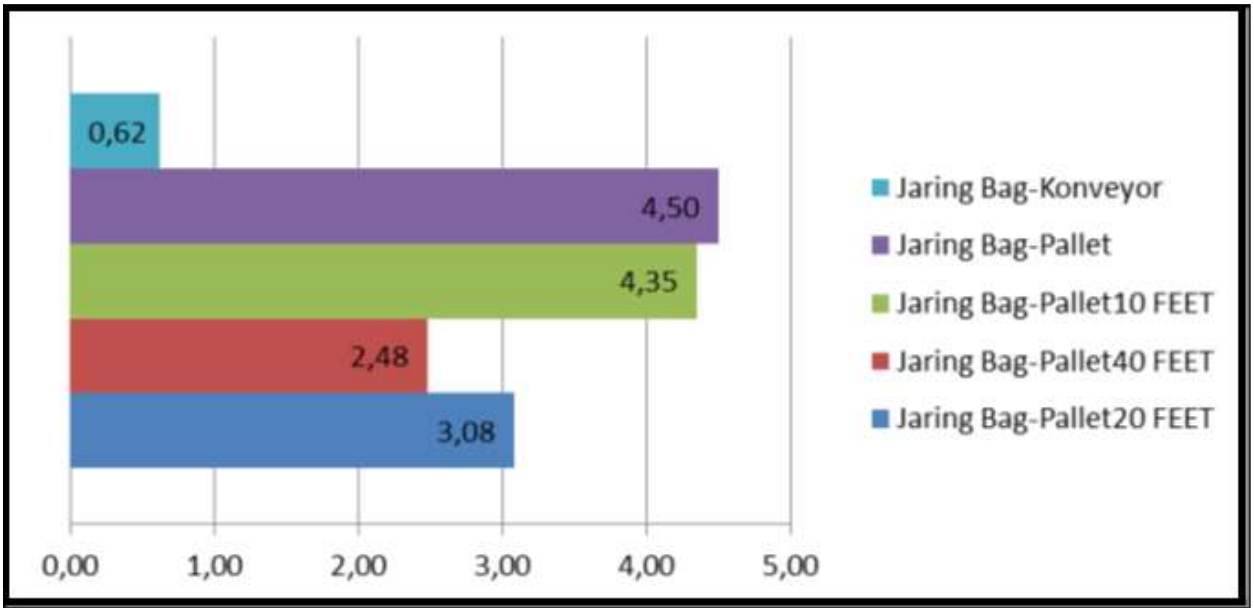


Fig: - Benefit-cost ratios of possible options for cement handlings

5. Marine Transportation Safety

The analysis of marine traffic safety in the sea of transportation is very important to enhance navigational safety. Currently, Maritime safety for green ship is the best issue in the world. IMO has recommended Formal Safety Assessment (FSA) methodology to enhance maritime safety. Various measures to enhance navigational safety and environmental protection in the sea has been proposed by the three littoral States and adopted by the IMO. The measures adopted by the IMO in the sea include the following: Sea lanes and Traffic Separation Schemes, vessel Traffic Systems, mandatory ship reporting system and routing measures such as under keel clearance requirements and deep-water routes. In the other hand, regulation 19 of SOLAS Chapter V - Carriage requirements for ship borne navigational systems and equipment - sets out navigational equipment to be carried on board ships, according to ship type. In 2002 IMO adopted a new requirement (as part of a revised new chapter V) for all ships to carry AIS capable

of providing information about the ship to other ships and to coastal authorities automatically. In this case, an AIS is implemented for formal safety assessment under the International Regulations for Preventing Collisions at Sea 1972 (COLREG) guidelines. In this context, AIS implemented as source of data and input for the FSA.

According to the IMO, the FSA is a rational and systematic process for assessing the risks associated with any sphere of activity, and for evaluating the costs and benefits of different options for reducing those risks. The FSA is also a formal and integrated approach to assessment. The purpose of applying this method is to use the five-step procedure of the FSA to make an overall analysis and enhance maritime safety. The five-step procedures of FSA which includes:

1) hazard identification
2) risk assessment
3) establishes safety measure
4) cost-benefit assessment
5) recommendation for decision making. The FSA is a tool designed to assist maritime regulators in the process of improving and deriving new rules and regulations

6. Conclusion

Reviewing on to a number of facts presented and further discussed in this paper, it can then put forward some concluding remarks as follows:

- The development of the maritime industry increased gradually in the 19th century and then rapidly since after the WW II;
- The rapid development occurred with the discovery of new technologies, particularly in the ship industry;
- Rapid development of maritime industries has resulted in adverse impact on the environment, therefore the IMO has set a number of regulations demanding maritime operations to implement green technology;
- Various attempts were then made by the industries, companies and research institutions, including higher educations in developing and implementing green technology to support maritime development in the future; and
- Safety aspects of the operation and port infrastructure also deserves attention in term of green technology for the future maritime development

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LIFE CYCLE ANALYSIS OF A SHIP

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Abstract: This paper represents the life cycle analysis in shipping industry which hasn't been explored earlier because of the complexity in this sector. Life cycle analysis in different fields has proven to work successfully in reducing environmental impact and saving both capital and human resources. In this paper we extensively discuss shipping industry impact on environment from the beginning to the end. Hence, this paper aims to provide a systematic and environmentally friendly shipping sector ecosystem.

Keywords: Life cycle analysis, shipbuilding, ship breaking, ship environmental impact

1.Introduction

1.1(a)Life cycle Analysis

Life Cycle Analysis (LCA) also known as "cradle to-grave" can be defined as the proper analysis of the environmental impacts on products or services during their entire life cycle. Over the last few decades, we have witnessed unprecedented environmental changes like increased earth temperature, rise in seawater level, and untimely natural calamities. An increase in greenhouse gases has threatened to change our mother nature and increased consumption of chemicals has created a hole in the ozone. Now, with the advancement in science, the mass is more aware than before. Almost every year, new resolutions are passed by the UN to examine the humans' effect on nature. Societies are now conscious of the need to radically decrease waste streams from production, consumption, and scrapping of a product.

Need of LCA

Life Cycle Analysis (LCA) of a product is used to highlight the energy consumption and minimize environmental impact of the product from its start to its end. LCA is a very useful tool for companies as it can help them to cut the

cost for production and manufacture products which are biodegradable. Company management can take useful assessment and information from their LCA reports too.

LCA in Shipping Industry

LCA in maritime sector is not explored as it should be. Shipping companies can save millions of dollars by just slightly changing their orthodox way of ship building or scrapping. Ships should be constructed, run and

scrapped in a way that their environmental impact and energy consumption should be rational. In LCA ship design, construction, outfitting, operation, maintenance & repair and ship scrapping is considered.

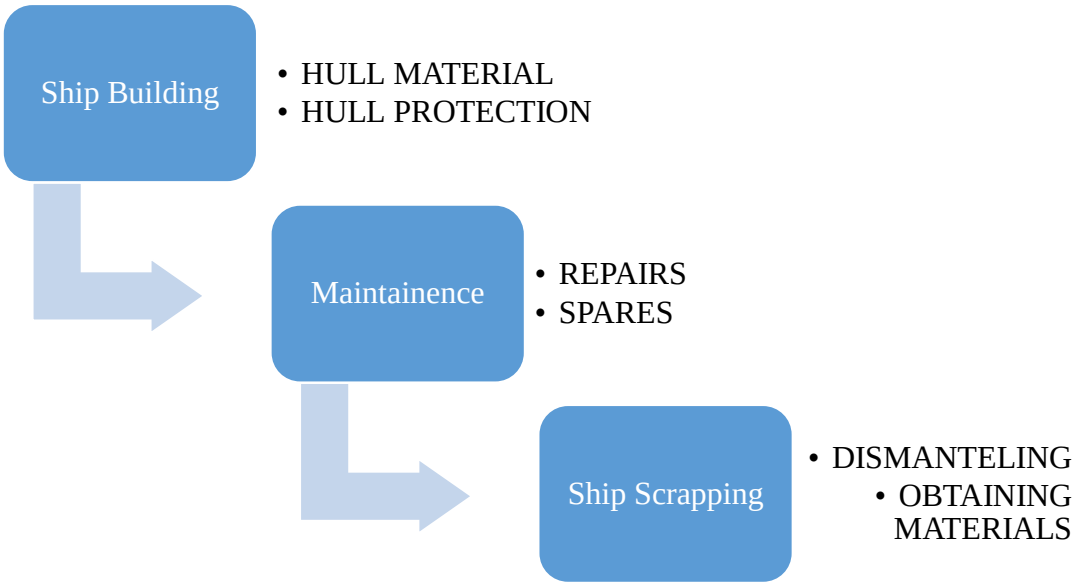

Figure (1): -Ship life cycle

Ship Building

Ship building as the name suggests is building up the ship from raw material. It sounds easy but it is really long and complex process. Ships take 6-7 months to be brought on seas. Shipbuilding process comprises of various sub process.

Ship-owners give vision to the ship building yard about their future ship. The size, complexity and purpose are known forehand. Ship-owners want to maximise their invested capital by keeping future prospects in mind. With the help of naval architecture, they propose a plan which meet all the above mentioned.

Craftsmen cut the sheets of metal for various parts. But now these large-scale machines are used which can cut more complicated design with more precision. Blueprint of the model is provided by naval architecture to the yard workers

and cutting bending of metal sheets starts. Ship hull has bents which are carefully bended by craftsmen either by hammering or heating it.

Constructing a ship in one go is really hard task for yard so to save time various parts of the ship are constructed and assembled together in a shipyard. With the help of a crane, the engineers install and joint all of the assembled blocks in the correct order on the building berth. It should be fixed at the correct position. A little mistake in fixing of assembled blocks can cause ship to be warped. Serious technical knowledge and high labour as the assembling blocks weight around 150 tons is required.

After the process of assembling, the paint process begins. The main role of painting is to prevent ship from corrosion and rusting issues. The standard of painting is strengthened nowadays for complying with environmental issues; thus it is considered one of the most important process.

Launching is the next process and it implies floating the ship in sea for the first time. The building berth inclines towards sea and the ship simply slide on it and float on the sea.In the outfitting process, the hull gets equipped with all the necessary equipment i.e., pipes, engine, interiors and electric wire etc. The ship gets moored at quay and the remaining construction starts.

In trial process, the entire performance test such as vessel speed is checked and get confirmed if the owner is satisfied with it. All the operation checks and function test of apparatus is also checked to see its maximum efficiency. The last process of ship building is when the ship leaves the shipyard and starts a sail.

FIGURE (2): -SHIP BUILDING PROCESS.

Ship Maintenance and Running

Most of the ships have to be maintained to avoid any disaster. For this after every five-year dry-docking is performed for repairing the hull and repainting it with anti-fouling paints. It has been recorded that with time emission by the ships also increases.

55 percent of total emission by shipping industry is generated by the big three namely bulk carriers; oil tankers and container ships. Due to covid 19 pandemic around 60 percent of world fleet was idle hence 1 percent drop in emission was observed in year 2020 mainly due to fall in cruise ship industry.

Apart from pollution, toxic ballast water, waste from human and anti-fouling paint is killing the marine life. Pollution kills over a million seabirds and one hundred thousand sea mammals every year and coastal nation's economy which is dependent on sea grass meadows, mudflats, and wetlands are losing critical resources when aquatic vegetation dies off.

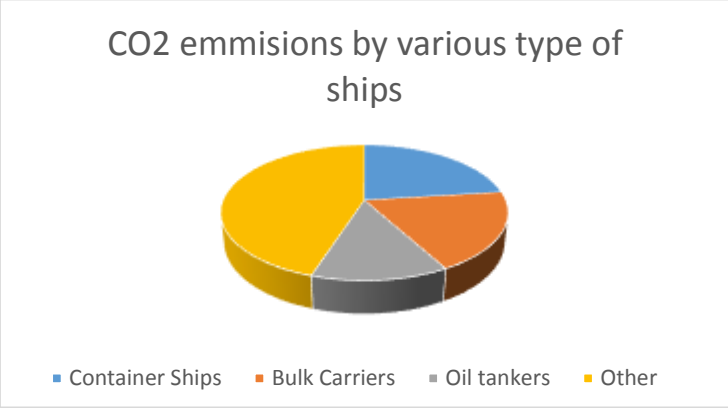

Figure (3): –The big three namely bulk carriers, container and il tankers produces 55% of emissions

Ship Recycling

Ship breaking is defined as taking apart of ship in order to get metal from its parts and to sell its parts in scrap. Ships are made up of huge amount of steel and its scraped metal is sold in LWT to different steel mills. The metal is cut into smaller pieces and sold to the companies/brokers. They usually melt the metal pieces and process it as per needed things.

Old ships were built before there was any ban on treacherous material. This put thousands of recycling worker's life in peril. In the last decade only around 400 workers lost their life. Ships are not designed or constructed keeping in mind the needs and demands of recyclers, they are built according to its buyers which wants it to be prudent and cost efficient.

During 2016 recession, the fright dropped reduced significantly. That was the year when the greatest number of ships was broken down. UAE and Greece were the biggest dumpers and about 90 % of these ships were broken in

Indian subcontinent. Due to strict environmental laws and labour regulations ship breaking industry is vanished from developed world. It left the developing nations to the corner of the market. Major countries which are in this sector are India, Bangladesh, China, Pakistan and Turkey.

Most of these dumped ships contain many hazardous materials like asbestos, PCBs and heavy metals. But most of ship recycling yard located in subcontinent doesn't have proper infrastructure to deal with. Ship breaking industry administer sustainable environment since it recycles huge amount of ferrous and nonferrous metals. Unfortunately, these unhealthy practice over shades its positive effect.

IMO adopted Hong Kong convention in 2009, to tackle this situation. Ship recycling process can be improved by firstly improving design of ships and secondly providing a green recycling environment.

The main aim of designing ships for recycling is to make most of it and to reduce the hazards caused by it. Documentation of hazardous material present onboard makes it easy for recyclers and also mariners to make them aware about what are they dealing with. This is also stated in Hong Kong Convention 2009 according to (Lloyd's Register, 2011).

Substance	Origin	Harm
Asbestos	Engine room	Lung cancer and asbestosis
Polychlorinated biphenyls	Cable insulation, capacitors etc.	Carcinogenic, bio accumulative diseases
Ozone depleting substances	Blowing agent for insulation of LNG carriers, extinguishing agent	Environmental harm
Organotin compounds	Anti fouling paint	Neurotoxin effects
Heavy metals	In paint and lamps	affect nervous system
Oil and fuel	Engine room	May result in fire and explosion

Figure (4): -Shows hazardous material present on board

Shipping Industry's Environmental Impact

If shipping industry was a country, it would be the sixth most polluting country in the world. Fifteen container ships produce more CO_2 emissions as compared to 50 million sedan cars. The main reason for this is that ships run on a very low-grade fuel while in its counterpart cars run on refined petrol or diesel. Still ships have less carbon emission per tonnage of cargo. Emissions and impact of ships is a hard topic to study as most of the time ships are in vast ocean. Ships also generate NO_x and SO_x in a large quantity both proven cause for acid rain. Applying rules and regulation on cars and trucks is easy but for ship it's a really hectic task as multiple barriers like flag of the ship, owner and company operating it all are different parties residing in different corner of the world.

Statistics says that Shipping industry produce 2.2 percent of global greenhouse gases and 2.1 percent of world's CO_2 emissions According to the International Council on Clean Transportation (ICCT), an independent environmental research organisation, international shipping industries produce 812 million tonnes of carbon dioxide in 2015.

The International Maritime Organization is continuously pushing commercial liners to improve and creating stricter environmental laws. Sulphur content in 2020 was set at as low as 0.5 % but these regulations are hard to implement as marine diesel engines runs on heavy fuel which results in pollution. Changing these engines requires immense capital and brains. All of these regulations are contained in the Convention on Marine Pollution (MARPOL), Annex VI, which sets the regulations for Air Pollution in the Maritime Industry.

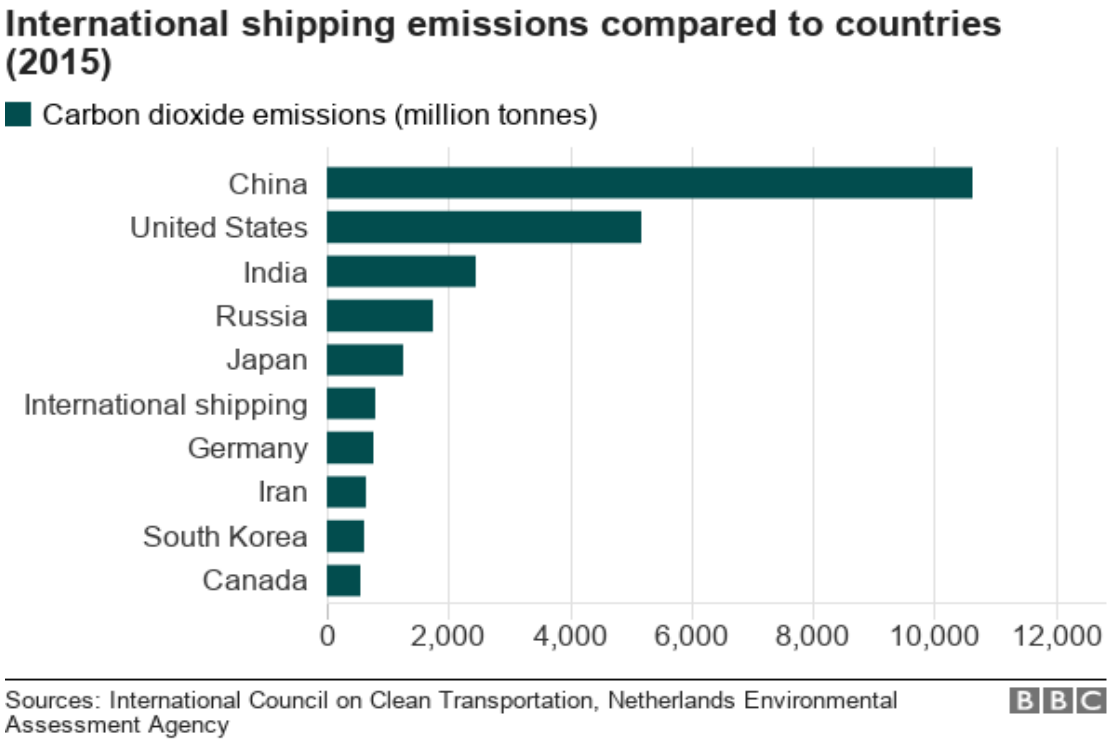

Figure (5): - Comparing Ships Emission with Countries Emissions.

Emissions of CO2 are by far the largest while ships are in sea but a considerable amount is also generated while building and recycling it. According to data a Panamax type ship produces 1 million tons of co2 emissions.

The ship building stage shows that Hull sub system produces more pollution as compared to its machinery sub system. Approximately 30 percent of co-emission from ship is produced during building and dismantling.

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Global CO2 emission	31959	32,153	31,822	33,661	34,726	34,968	35,672	36,084	36,062
International shipping	881	916	858	773	853	805	801	813	812
Domestic shipping	133	139	75	83	110	87	73	78	78
Fishing	86	80	44	58	58	51	36	39	42
Total shipping % of global	1100 3.5%	1,135 3.5%	977 3.1%	914 2.7%	1,021 2.9%	942 2.6%	910 2.5%	930 2.6%	932 2.6%

Figure (6): - Shipping CO2 emissions to global CO2 emissions.

Recommendations

Government and various associations related to shipyards and scrapping yards should provide cost assessments to pollution prevention projects and make them available for the marine industry. Military shipyards should share vital pollution related lessons to private counterparts. Almost no post contact has been established by the two which is now needed to be changed. Good faith efforts to ensure safety for workers and seafarers should be continued.

Recently in 2019 the government of India has introduced the recycling of ships act, which needs to be implemented more effectively and efficiently. This act was long awaited as India was a signatory of Hong Kong convention, after long wait it was introduced in parliament and was put into immediate effect. This bill is applicable to all ships listed in India or entered to its port except any warship operated by government. It defines what is recycling of ship means and prohibits the use of hazardous material in manufacturing of ship. Every year two hundred workers die in shipbuilding and ship scrapping yards. Proper PPE equipment absence in yards and inadequate training is the reason. Government has introduced new scrapping policy to standardise this scrapping industry but a long road needs to be travelled to accomplish it.

2.Conclusions

LCA method when applied on our marine industry aimed to reduce the use of hazardous material and helps us to emphasis more on its alternatives. This LCA is an ongoing process and in future will surely create a framework for which shipping companies can look on to decrease hazardous environmental impact of ships. No doubt that investing in LCA will surely benefit not only our marine sector but also our society.

Environment hazards and condition of workers undermines the noble cause of recycling and shipbuilding. There is a critical need of plan which will make it cost proficient and furthermore environment friendly.

Naval architectures now have to redesign the ships accordingly Implementation of measures like mentioned in Recycling of ship act 2019 should be applied on field not in papers alone. Severe assessment at yards by the concerned officers can save numerous lives.

Acknowledgements

We would like to thank our **HOD- IMU MPC, Mr. Hare Ram Hare Sir** for guiding us in making of this paper. We would also like to thank our **Professor. Mr. Shashank Bani Sir** for suggesting us to go forward with this subtheme.

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MAGNUS ROTORS FOR GREATER STABILITY AND MANOEUVRABILITY OF SHIP

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Abstract: Magnus force generated by rotating cylinders has been an important area of research for decades. The interest arises from the various applications which the generated lift provides according to the orientation of cylinders on different fluids. This paper explains the possibility of using the lift generated by a rotating cylinder under water attached to the hull. The lift generated can be used to stabilize the ship during rough weather. Given the orientation of cylinders and the lift generated, it can also be used for turning the vessel sharply i.e. as a turning force. As the technology of using magnus force generated by crosswinds and magnus force stabilizers are already being adapted by leading shipping companies and the world's increasing motive to move towards a safer future with the use of Renewable Energy, the use of magnus force as an auxiliary system for stabilization and maneuvering can be a boon.

Keywords: Magnus Force, Lift, Stabilizers, Emergency maneuvering, Automation, Navigation

1.INTRODUCTION

The concept of using rotating cylinders underwater was an untapped area for commercialization. It has space for advanced technologies to emerge out and is already catching up the trend with handful of companies designing the first rotors. This paper will describe the technology to use the magnus force on the spinning cylinders attached to the ship's hull and the use the same for stabilizing the ship and also as an additional turning force source. The idea is

derived from the functioning of Flettner Rotors which harness cross-winds to generate force which propel the ship. The rather common aspect is the use of magnus force to decrease the dependence on orthodox technologies, and move towards more effective and greener ones. With this paper a 'versatile' Magnus force rotor capable of solving problems such as stability and emergency turning is explained and can be used for the basis for future developments.

Theory of magnus force:

It is believed that the effect of magnus force was first explained by sir Isaac Newton during a tennis match in Cambridge college. Later it was described in detail in 1852 by Heinrich Magnus. The Magnus effect uses principles from Bernoulli's equation. Bernoulli's equation states that if the velocity of a moving fluid is increased, the pressure must decrease. When a cylinder rotates in a moving fluid it experiences a lift. This happens due to the pressure differential that arise mainly on the upper and lower portions of the cylinder. The pressure differential arises due to the velocity difference which takes place, as the fluid near the surface of the cylinder gets dragged in the direction of the spin at one side and in the opposite direction at the other side. The portion where the fluid flow direction matches the spin direction of the cylinder, leads to low pressure area and vice-versa. The result of which fluid exerts a force towards the low-pressure area and hence the lift arises perpendicular to the flow of the fluid.

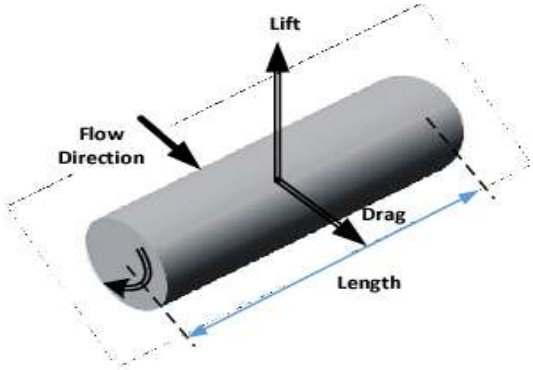

Figure (1)

The magnus force depends on the angular velocity of the cylinder, velocity of fluid flow, dimensions of the cylinder. The lift force on the cylinder is given by kutta-joukowski theorem.

$L = \rho v G$

Where L is the lift per unit length along the cylinder, ρ is the density of the fluid, V is the free stream velocity and G is the vortex strength. G is given by

$G = 2.0 r \pi V_r$

Where r is the radius of cross-section of cylinder, Vr is the velocity of tangential velocity of cylinder given by

$V_r = 2 r \pi S$

Where s is the spin of the cylinder

This formula is derived under number of assumptions and can give a basic idea of the amount of lift which can be produced.

The lift force can also be calculated directly by a given CL of a cylinder.

$F_L = ½ . \rho A V_2 C_L$

Where F_L is the lift force, V is the flow velocity, A is the projected area, CL is the lift coefficient of the cylinder.

The other major force which is generated is the drag force. It can be calculated by the following formula,

F_D=½. $\rho A V_2 C_D$

Where CD denotes coefficient of drag, V is the flow velocity, A is the projected area.

Design and implementation:

The design and position of the cylinders should be such that the fluid flow can produce maximum lift. The aim to stabilize the vessel can be achieved effectively by placing the cylinders on port and starboard sides of the hull.The cylinders will be turned by variable speed electric motors and the orientation will be achieved by hydraulic controls. The rotors are fitted in a mechanism which doesn't restrict the degrees of motion. This is a necessary condition for effective working. Research done by L.R. P Sosa and J. Ooms [1] hasshown the lift coefficient is directly proportional to the aspect ratio and velocity ratio of the cylinder(rotor).

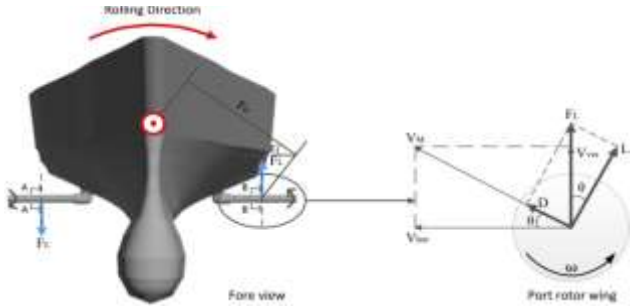

Figure (2)

As end plates on cylindrical rotors under cross-flow of air, increase the generated lift to a great extent as found by Prandt.The same can be implemented under water to verify its practical effectiveness. While this design can increase drag too.

The direction and velocity of fluid flow (i.e. - water), lift generated, drag generated can be calculated and fed to an automated control system by sensors to automate the control of the rotors. The orientation of rotors is controlled by hydraulic systems.

The control system of the rotors can use backstepping method with sliding mode controlling method .Usingmagnus rotors for stabilization and maneuvering requires rotors to be placed at intervals from stern to bow. The length and number of rotors will depend on the magnitude of force and moment required for adequate functioning. The rotors are mainly installed on the bow and stern part of the keel below the design water level (DWL). Rotors are also installed in pairs across the beam of the ship.

Calculations:

For a model rotor the dimensions and the operating conditions can be the following:

Length: 0.60 m

Radius: 0.04 m

Projected area: 0.15 m^2

Maximum lift coefficient: 8(approximately)

Drag coefficient: 0.5

Velocity of flow: 5 m/s

Density of sea water: 1027 kg/m^3

Lift force per Rotor (F_L): 15400 newtons

Drag force per rotor (F_D):962.8 newtons

The lift force generated above is enough for effective operation of a ship of length 85-100 metres. It must be noted that the above force is generated by a single rotor. There are generally 4-8 rotors working together as per circumstances.

The moment produced by each rotor can be calculated by the product of the above force to the working lever distance.

From the above calculations, the drag force is around 6% of the lift force. The Drag force can be minimized by making the rotor cross-section more tapered (approaching an elliptical shape). This design reduces the coefficient of drag by a huge amount.

The maximum lift coefficient is considered for calculation which is approximately equal to the aspect ratio of the rotor. Similarly, other variables can be adjusted according to the operating conditions for the calculation of magnus lift generated. When upscaling, the length and diameter of the rotor can be increased.

Roll stabilizing analysis:

The rotors are installed on both the sides of the hull and are fitted in slots in the hull where it can be kept retracted. The concept is well used in the RAKE design by Rotorswing To attain roll attenuation the rotors on both the sides rotate in opposite direction according to the direction of roll. The moment produced by the rotors is substantial and can decrease the roll to a minimum. At higher speeds,drag can take toll on the effectiveness and thus can be retracted when necessary. The arrangement below can be installed with a slot as shown in the diagram. This is a conceptwhich can be used and further enhanced to allow the rotor to operate in all the directions of motion.

Figure (3)

The roll attenuation is best at low speed and is proved by the analysis done by L.R. P Sosa and J. Ooms [1] on the model ship at 14 knots. Even at idle condition the swinging motion along with rotation of the magnus rotors produce greater rolling attenuation compared to fins.

Turning force analysis:

The picture below explains that, if the orientation and spin is changed the direction of lift force (Fmag) generated is changed. Aligning the rotors as per stream flow direction, we can generate turning force that will help to maneuver the ship. This feature or concept of designing the rotors to produce enough force for turning the ship, makes it immensely 'versatile' rather than being a rotor only for stabilization. The tuning force generated (TF) depends directly on the dimensions of the rotors, velocity of the fluid flow.

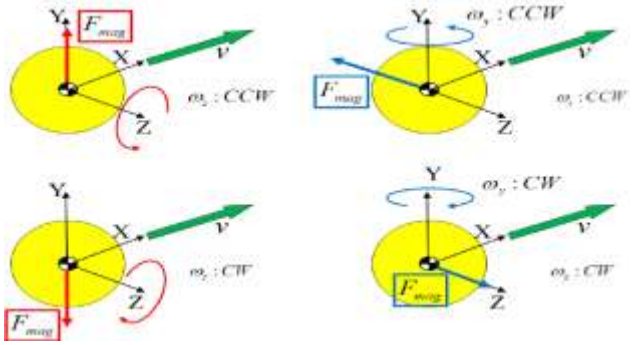

Figure (4)

The magnus rotors for inducing turning force will have to installed at both bow and stern where each of them provides counter-moments to maneuver the ship. This can be very useful and lifesaving at times of emergency maneuvering.

Merits:

The rotors have certain merits in its design than fins which make them a better choice in many useful applications. The merits of using magnus rotors are discussed below:

- Longer lever arm so stabilizing moment is more than fins.
- The total force generated can be used on roll damping unlike fins which has force components not contributing to roll attenuation.
- Less drag when not in use and can be retracted easily.
- Higher efficiency at low speeds.
- Flexibility on the positioning of the rotors
- High lift coefficient than fins.
- Can be used for various applications not just rolling attenuation.

Demerits:

As for every technology, magnus rotors also have disadvantages which need to be attenuated with the help of better design. Following are the demerits:

- Uses large electric power.
- Complex mechanical system to automate.
- With increase in length of ship, the power required and dimensions of the rotor for effective functioning increases drastically.

2.Conclusion:

According to the above findings and conditions, the magnus rotors should ideally perform the stabilization and maneuvering at the most effective way. As this research paper will be followed by CFD analysis, there will be certain manufacturing changes and contradictions to the ideality of the device. Making and embracing changes in the design will provide a better understanding of the science behind the practical implementation of the project. Nevertheless, this project will serve its motive of providing a highly efficient auxiliary system for stabilization and maneuvering for ships.

The results of this paper summarize that magnus rotors are more effective at low speeds and produces greater roll attenuation than fins. The rotors take less space and can be retracted very easily, providing the greater ease of access. These rotors can effectively decrease the response time during maneuvering. While the greatest achievement of this technology is by making vessels less prone to accidents and hence save resources.

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ADVANCEMENTS OF SENSOR TECHNOLOGIES IN SHIPPING

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Abstract: This paper is a brief analysis of the evolution of sensing technologies in the shipping industry in lieu of the rising trend of pollution free oceans and cheaper yet efficient working of ship. Detection and measurement of certain parameters like fuel viscosity, shaft torque, and oily water discharge directly contributing to the ship's running efficiency which is done via different modification of sensors are analysed and evaluated on the basis of accuracy and performance. Also various sensor options were experimented with to detect and hence control SO_x and NO_x emissions in simulated environments. The findings are recorded for future considerations.

Keywords: Sensors Montoing Advancements Efficient Clean.

1.Introduction

Sensors- A basic understanding.

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. We are surrounded by sensors all round us- our cell phones use **tactical sensors** (touch), computer mouse uses **optical sensors** and hence goes the list. Similar to our body which has 5 senses (smell, touch, sight, taste and smell) which work together to perform properly similarly machines have been fitted with sensors like temperature, pressure, level sensors for it to perform required task properly and to aid inspector in monitoring well-being of machinery. Also, like our bodies, these sensors get modified as the database of reactions to unique circumstances expands. Shipping Industry and Sensor advancement are going hand in hand for efficient operation of ship on oceans. The sensors aid in control and monitoring the emissions of pollutant gases, oily water discharge, ballast water management which are must for clean oceans. Various advancements in navigation technology like RADAR, ECDIS, ECHO SOUNDER, Auto Pilot etc helps in preventing the accidental pollution and aids in safe navigation. On the other side in ships engine department sensors help in monitoring machineries health, working hours, overload, temperature, lubricating oil level, viscosity, air-fuel ratio, shaft torque etc… and directly effects the efficiency of the running condition.

1.1(a) ODMCS- Oil Discharge Monitoring and Control System.

Earlier an inspection glass fitted in the overboard discharge pipe of the oil/water discharge and illumination by a light bulb fitted at glass exterior opposite the viewer permitted sighting of flow. The discharge was shut down at slightest oil carry over, but poor light and oily deposit accumulation at glass interior caused observational errors. However, the basic functionality of the ODMCS has remained the same. A more sophisticated approach using

photocells (monitoring bilge or ballast water passing through a sample chamber by a strong light shining directly through it and on to a photo-cell) was established. Light intensity decreased with increasing oil-in-water content therefore this light's effect on the photo-cell compared with that of direct light on the reference cell could be registered on a meter calibrated to show oil content.

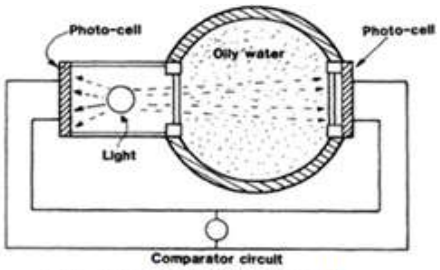

fig. Direct light photocell

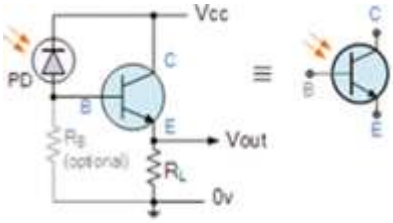

fig. circuit of photocell

Another approach is to register **light scattered** by oil particles dispersed in the water by the sampling pumps. Light reflected or scattered by any oil particles in the flow illuminates the scattered light window. This light when compared with the source light increases to a maximum and then decreases with increasing oil content of the flow. However, these designs allow only for the scattered beams and not the reflected ones due to oil globules.

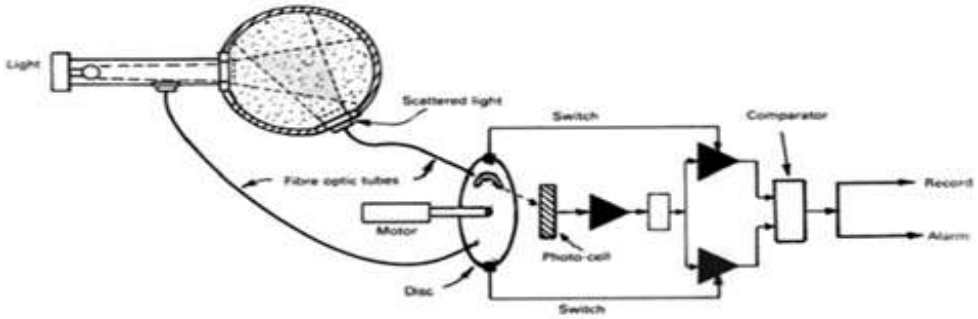

fig. Scattered light photocell

The latest and most accurate ODMCS using **infrared as a light source** for the detecting cell in the skid assembly in accordance with IMO Resolution **MEPC.108(49)** is the Mark 6 Oilcon® which discriminates between oil and other contaminants such as mud, rust or entrained air. The system is based on the unique multiple scattering principle which resulted in unprecedented levels of accuracy, reliability and cost efficiency of installation and ownership, unlike any other similar systems such as the JOWA ODME.

2.Main Work

A near infrared diode operated in the pulsed mode for low average power dissipation but high intensity signal is processed and transmitted via an intrinsically safe communication cable from the detector cell to the Electro Pneumatic unit (EPU), where the detection signals are used to compute the oil levels present in the sample passing through the detector cell. The light leaves the detector cell via **three** windows (direct beam, scattered beam and reflected beam) and along fibre optic cables to the **optical receivers**. The signals from the direct and scatter detectors are used to

compute the oil concentration, whilst the reflected signal is used to compute other contaminant levels present in the sample passing through the detector cell. Flow rate of sample water is detected by a **magnetic flow sensor.** Output is also sent to the computing unit along with a LED feedback signal.

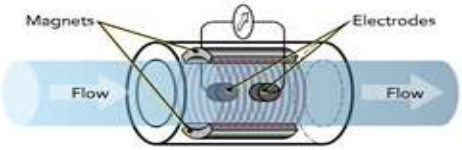

fig. magnetic sensor

In the **flow meter** the water flow through the orifice plate causes a pressure difference across the plate which is converted into a mA signal and transmitted to the **Zener Barrier module** inside the EPU by the dP/I transmitter, further converting electrical control signals from the computer unit to pneumatic (preferably a **P200 P/I transducer**) or electrical supply signals for ODME functions. Thereon the output signals to **MCU** are oil content of ballast water in ppm, rate of discharge of ballast water in tonnes per hour, and the ship's GPS input, speed in knots and overboard valve position. Finally it computes and records the instantaneous rate of discharged oil in litres per nautical mile, total quantity of oil discharged into the sea on each voyage and controls the ship's overboard discharge system.

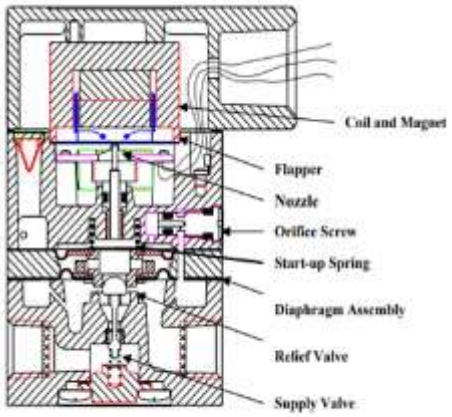

fig. Voice coil flapper design

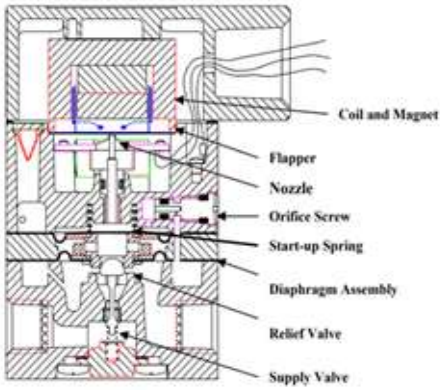

fig. piezo-electric actuator flapper design

2.1(a) Torque Measurement

Indirect measurement of torque is done by means of **strain gauges(fig1).** Generally, the active part of the sensors is about 2-10 mm2. The elements are located on the shaft axis in such a way that the resistance of the elements increases, if the axis is subjected to tensile forces. However low-to-moderate rotating speeds provide impactful measurements. At higher rotating speeds or heavy-duty applications that deal with dust, dirt, extremes of temperatures, and vibration, the reliability and accuracy of torque output may get compromised.

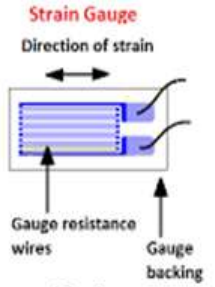

Fig. 1

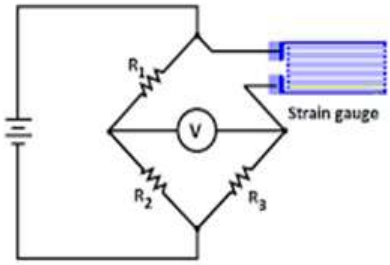

Fig. 2

fig. Torque sensor (strain gauge)

LEMAG offers shaft twist measurement by means of **induction sensors** that measure displacement. 2 **precision sensors** are mounted opposite to the electrical arms. The data measured are transmitted by radio waves from the shaft to a stationary unit. However, the sensor sensitivity is **about 18.2 mV/Nm**. The non-repeatability, non-linear and hysteresis error being about 2.3%, 3.3%, and 2.6% respectively, better designs were opted.

Fig 2. Position of induction sensors

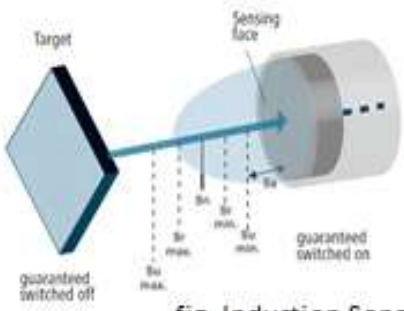

fig. Induction Sensor

The firm **GREX** method includes 2 identical **magnetic bands** mounted on the shaft at a certain length and they **measure the phase displacement** as shaft torque occurs. **2 magnetic sensors** at 0.8 – 1.6 mm from the shaft where easy to install three-dimensional adjustable arms generate **128-628 impulses per revolution of shafts.** The microprocessor in the transmitter measures the delay - s_0, s_1, s_2, …s_n, between the impulses caused by the shaft twist. The accuracy of the digital measurement is very high with a resolution of 100 nanoseconds (ns) with an error of less than 1 %. A major disadvantage of this system is the fact that it is not suitable for measurement of torque under the stopped condition. **VAF** offers the **T sense** where 2 rings mounted on the shaft, spaced 250 mm apart, the displacement between which is determined on **the principle of optical measurement** providing extreme accuracy of the **optical sensor** (within nanometre range) with possibility for analysis of torsional vibration. For experimental research a new, microprocessor-based telemetry system for real time shaft power measurement is being employed. 3 different propulsion units were selected for detailed investigation. The details of the investigation are given in Table 1.

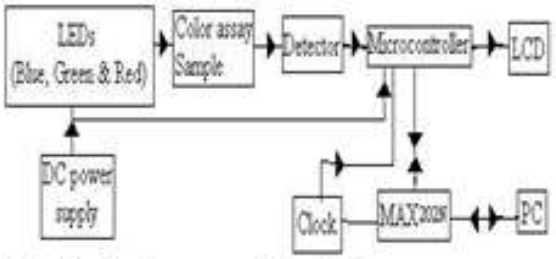

fig. Optical sensor block dia.

fig. Animation of optical sensor

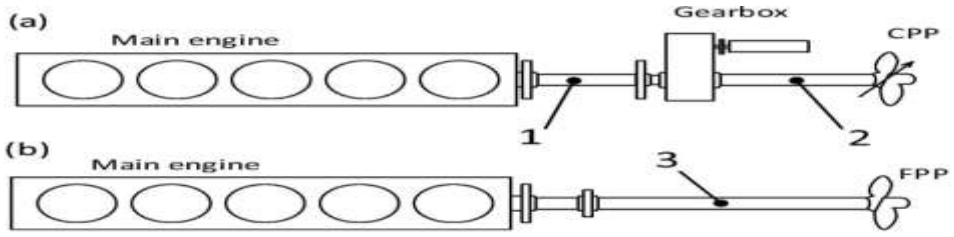

Fig 1

2.1Table

No	Propulsion location	Propulsion type	Engine model	Sensor location (acc. Fig. 1)	Nominal power/torque/speed
I	Ro-Pax ship, port side	Indirect, CPP	Sulzer 8ZAL40S	2	5760 kW/ 332.5 kN·m/ 165.4 rpm
II	Ro-Pax ship, starboard side	Indirect, CPP	Sulzer 8ZAL40S	2	5760 kW/ 332.5 kN·m/ 165.4 rpm
III	MUS lab.	Direct, water brake	Sulzer 6AL20/24	3	397 kW/ 5.265 kN·m/ 720 rpm

fig. table 1

2.2(b) Viscosity Indicator

Primitive viscometer designs entailed a cup with a calibrated hole in the bottom measuring the time for liquid flow hence quantifying kinematic viscosity (measured on board). Modern devices work by imparting a magnetic force on a piston or using a heavy piston and measuring the speed whereas others rotate a cylinder inside a coaxial sleeve and measure the drag force on it. Commonly used is where a fixed quantity of oil is forced through a capillary (narrow bore) tube the flow of which is such that the difference in pressure readings taken before and after it is related to the oil viscosity. A **differential pressure gauge** is calibrated to read viscosity and the pressure values are used to operate the heater control to maintain some set viscosity value. However, the rate of strain could not be manipulated in a continuous manner, normal stress differences and dynamic measurements were not possible.

Latest modifications (around 2003) include **micro acoustic sensors** for on-board automotive oil-condition sensors. A viscosity sensor can be realized with micro acoustic devices utilizing **shear-polarized oscillations**. For liquid sensing, special wave-types are used in order to avoid unwanted radiation losses due to the excitation of compressional waves in the liquid. Around 2012 emerged **Suspended Micro channel Resonators** (SMRs) i.e., **resonant mass sensors** containing liquid within the mechanical structure, therefore minimizing damping associated with the fluidic viscous

drag. For viscosity measurements in a low viscosity regime (<10 mPa s) they use two measurement schemes, namely the quality factor (Q-factor) and the vibration amplitude monitoring of the SMR running in a closed loop feedback. By comparing, the obtained results demonstrate that the SMR can measure the fluid viscosity with high precision and even real-time monitoring of the viscosity change is possible with the amplitude-based measurement scheme.

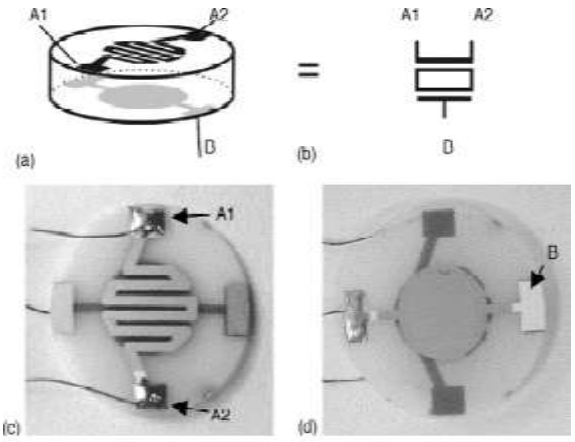

fig. Micro acoustic sensors

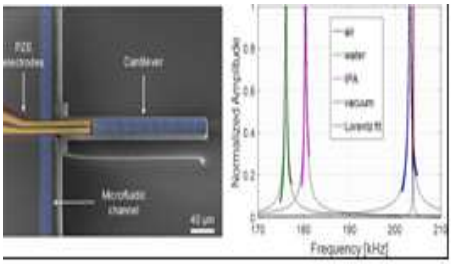

fig. SMR

Nowadays **ViscoSense®2** uses their **patented measuring principle** based on the torsional vibration of a pendulum in liquid. The measured damping of this **piezo-driven vibration** is directly related to the viscosity. A **built-in temperature sensor** is used for temperature measurement, located near the viscosity sensor. It measures inline the actual dynamic viscosity of a large range of liquids. The measurement is insensitive to unwanted external influences. Low velocity, flow direction and pulsations have no effect on the sensor operation.

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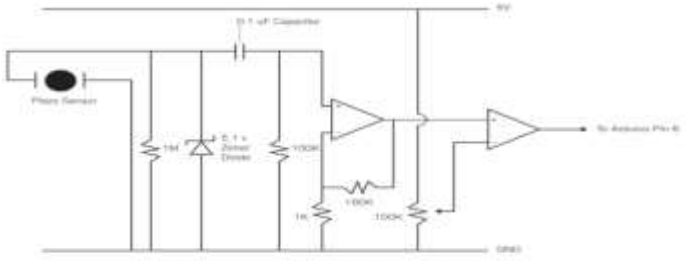

fig. Piezo sensor for vibration detection

fig. Viscosity in line analyzer

2.3(c) SO_x and NO_x Sniffers

Emissions from the ship's engine like CO_2, NO_x, SO_x, etc are needed to be monitored, to ensure that regulations are being followed. After implementation of Sulphur Cap 2020, the rule limits the sulphur in the fuel oil used on board ships, operating outside designated emission control areas to 0.50% m/m (mass by mass) - a significant reduction from the previous limit of 3.5%. Within specific designated emission control areas, the limits were already stricter (0.10%).

This new limit was made compulsory following an amendment to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). The IMO MARPOL regulations limit the sulphur content in fuel oil. This means ships must use fuel oil which is inherently low enough in sulphur, or install an appropriate exhaust gas scrubber, in order to meet IMO requirements. Earlier the Port State Control authorities used to check the sulphur content in the fuel by checking the lab analysis report of recent bunker and Bunker delivery note. As lots of ship owners have switched to scrubbers, they can use High Sulphur content Heavy Fuel Oil. Since scrubbers can be used to reduce the output of SO_x in exhaust by washing it by sea water, so monitoring SO_x in exhaust cannot be done by traditional method i.e. by checking the sulphur content in fuel oil. Thus to detect these emissions newer technologies are introduced to aid PORT STATE Inspectors for detection of violators.

High-tech help:

1. **Optical measurement** of the ship's exhaust plume- Solar light is reflected on the ocean, and it is reflecting up into sensors in telescopes which are mounted on an aircraft. From this, we can monitor the ratio of SO_2 to CO_2."
2. The more close-up tools for checking ships are '**sniffers**' sensors that come into contact with the exhaust itself. These sensors can be mounted on aircraft or, placed under bridges. Authorities in different parts of world recently began flying sensor-equipped drones into ships' plumes.

Operation of sensors in UAV

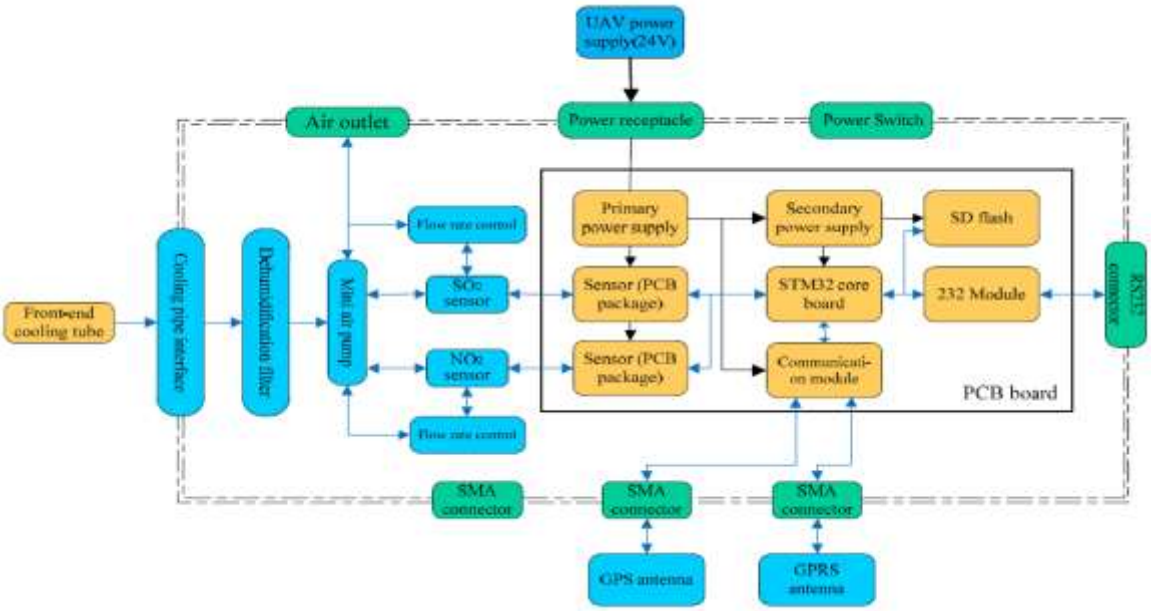

fig. Operational circuit of Sox and NOx sensor fitted on UAV.

As soon as the the UAV approaches a plume, the mini air-pump in the UAV extracts gas in the front-end cooling pipe (Figure) of the pod for cooling. Water vapour and particulate matter generated by cooling are then filtered through the dehumidification filter module to improve the accuracy of subsequent gas monitoring and the working life of the equipment. The flow rate control module of the air pump improves the cooling efficiency and reliability of the

equipment. According to the actual temperature of tail gas sampling after cooling, the air extraction speed of micro air pump can be controlled to stabilize the temperature of tail gas after cooling. The sensors detect the processed gas through sampling module and send gas concentration data to the main control processing module through the communication port. In present study, mainly SO_x and NO_x in the plume are measured. **The sensors of SO_x and NO_x are based on electrochemical principle**. The accuracy is **± 5%** (full range), the response time is **<1s**; non-linearity is no more than **± 1%**, and the power dissipation is **<1.0**. Finally, the measurement data is sent out by GPRS antenna. In addition, a **STM32 chip** is used as the main control chip, and two levels of power supply conversion provide power for the pod.

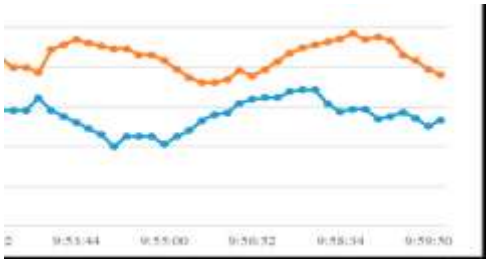

Figure. Measurement concentrations (ppm) of SO_2 (blue solid line) and NO_2 (orange solid line) in ship plumes during field testing of the rotary unmanned aerial vehicle: (**a**) plume 1, 09:52 to 09:59. While the investments and time required to monitor these emissions might sound challenging, it is minor in comparison to the benefits that clean shipping can bring in for the industry as a whole.

Lambda Sensors

It is essentially a potentiometric solid electrolyte concentration cell ("Nernst cells"). It measures the oxygen activity towards an outside air reference or in novel embodiments towards an internal pumped reference. An experiment was conducted to understand whether the classic **lambda sensor** can be operated also as a NO_x sensor. The **thimble-type lambda sensors** were mounted in a furnace in order to simulate a hot exhaust pipe. The temperature of the sensor was determined by comparing the heater resistance with respect to different external parameters. First simulated condition was such that $\mathbf{T_{furnace} = T_{sensor}}$. Thereby, the relation $\mathbf{R_{heater} = f(T_{sensor})}$ could be established. Second condition established the dependency $\mathbf{R_{heater} = f(U_{heater})}$. Due to the fact that the same heater resistance correlated with the same temperature of the sensor, a direct dependency $T_{sensor} = f(_{Uheater})$ between these parameters could be evaluated.

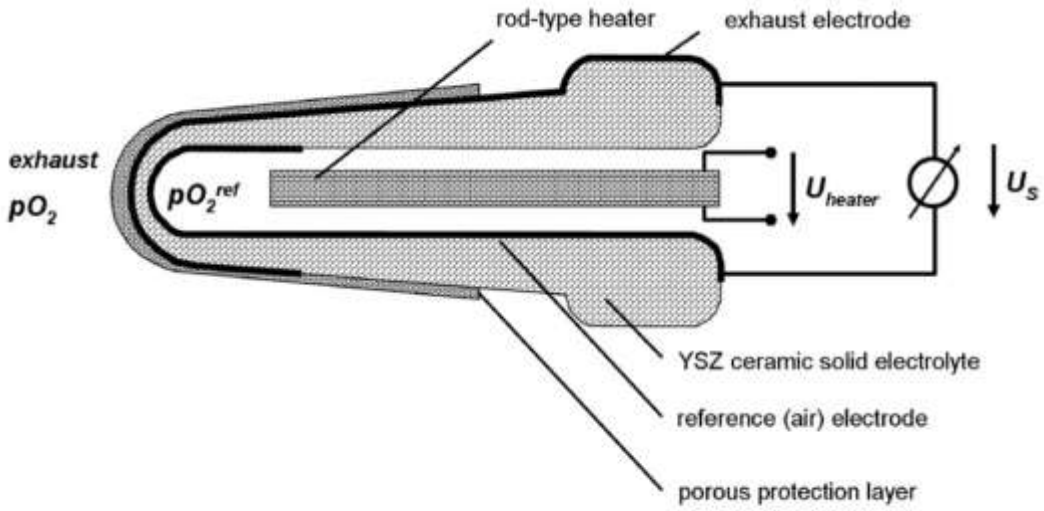

Fig. 1. Schematic depiction of a thimble-type lambda sensor.

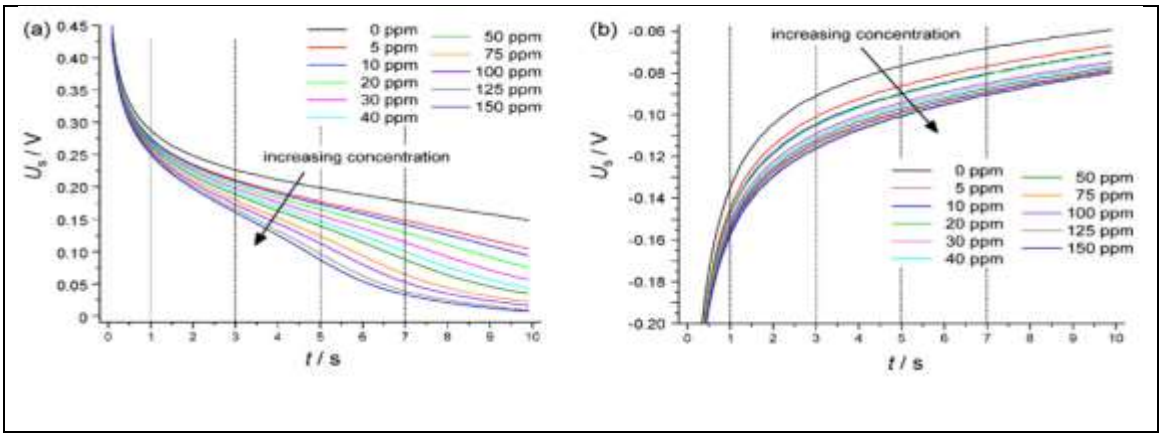

Figure 3. Time behaviour of the sensor voltage during the discharge phase at changing NO concentrations. (a) Left side: after a positive pulse of 2.5 V and 100 Ms. (b) Right side: after a negative pulse of 2.5 V and 100 Ms.

The discharge curves show a strong and monotonic dependency on the concentration of NO for both positive (Fig. 3a) and negative (Fig. 3b) pulses. The curve is not only shifted with changing concentrations, but shows additional changes in the overall shape, which are more evident for the positive pulse. A clear response to NO can be observed even at the lowest investigated concentration level of 5 ppm and the detection limit can be assumed to be in the range of 1 ppm. Nevertheless, a further shift of the discharge curves is evident at NO concentrations up to 150 ppm and, therefore, the detection of NO is possible over at least two decades of concentrations.

Further Expected Advancements

An UK-based Ricardo Energy & Environment, for example, has developed a novel way to use data from the Automatic Identification System (AIS) trackers that all ships carry. Coupling ships' locations and speed with parameters like engine power and fuel consumption rate, the company can create a composite view of carbon emissions in a given area. Soon satellites might join the monitoring effort as well. The European Space Agency's Sentinel 5 satellite has already proven its ability to measure the amount of NO_x in shipping lanes. Now the EU has asked the agency to design a satellite specifically for the macro-monitoring of CO_2. The hope is that the new, carbon-tracking bird will be in orbit sometime in the 2020s, proving yet another tool for checking the health of the plane.

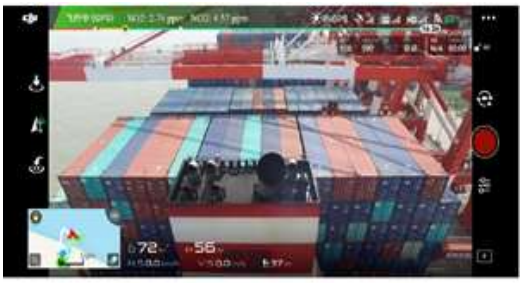

fig. View at drone display

Fig. 4. Decoupling capacitors on AFE and ISB boards with sensors

2.4(d) Ballast Water Testing Methodology

The Ballast Water Management Convention is a treaty 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 which came into force from 8 September 2017, stating 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 to prevent the spread of invasive species as well as potentially harmful pathogens. There are two ballast water management standards (D-1 and D-2).

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 200m 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. **D-2** standard specifies that ships can only discharge ballast water that meets the specified criteria. Methods Used for testing: -

Pulsed Amplifier Modulated Fluorometry (PAM): This measures **fluorometric character** of a particle where Chlorophyll fluorescence originates. Principle of counting pulse amplified modulation is based on selective increasing fluorescent signals measured by intensive, but very short pulses of measuring light. It can be taken into consideration for the final selection of potential detection method of unwanted micro-organism detection.

FIGURE- Ballast-Check 2 is configured for detecting chlorophyll fluorescence from live algal cells. Light from the fluorometer is absorbed by algae, which causes the cells to fluoresce. Fluorescence emitted by the cells is detected, quantified, and displayed as a digital number estimating the abundance of algae in the sample as cells/ml for 10-50-micron sized cells. The Ballast-Check 2 has a set threshold value of **10 cells per ml**. When the measured Abundance of algae is greater than or equal to the set threshold, this indicates a high risk that algae may be in gross exceedance of the discharge standard.

Flow Cytometry: This allows easy recognition of the different groups in the sample and quantification of their abundance as well as their **optical properties** (size, pigment). Scanning of 10,000 scans per second is one of the advantages of this tool. The flow cytometer could be fixed on ships, under water and on moorings, and should allow a high level of autonomous operation combined with high speed and high throughput. Results of flow cytometry measuring have shown the possibility of using flow cytometry for detection of micro-organisms **size less than 10 µm**.

Fluoroscein Diacetate Hydrolysis (FDA) and Adenosine Triphosphate (ATP): The analysis and detection of microorganisms in ballast water is a measure of the total energy of life in a sample of treated ballast water or direct microscopic observation to enumerate viable organisms ≥10 and <50 µm in minimum dimension. Enzymes FDA (Fluorine Diacetate) are like ATP, produced and secreted from living organisms and measurable indicators of living biomass in a sample of ballast water.

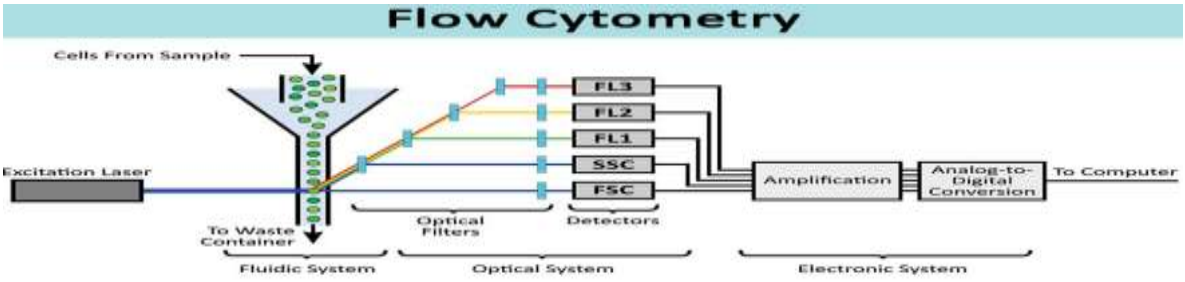

Figure: Schematic of a common flow cytometer, illustrating the fluidic, optical, and electronic systems.

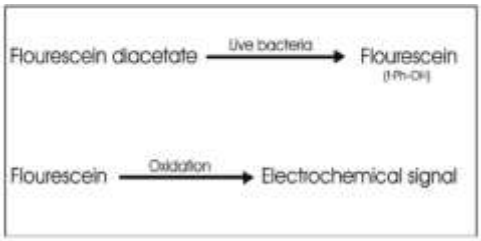

FIG:-Illustration of the hydrolysis of fluorescein diacetate to fluorescein by cellular esterases.

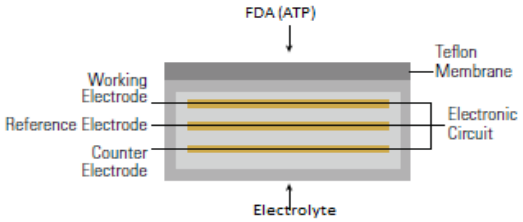

fig. typical elecrochemical sensor

3.Observations

Observations pertaining to role of different types of sensors in increased efficiency and emission control of ships have been stated above, corresponding to the various experiments involving torque measurements, SO_x & NO_x sniffers and BMS.

4.Conclusion

It is safe to summarise that as corporate giants are realizing the importance of a greener initiative, efforts to make more efficient ships on top of cleaner waterways are rising. To meet such demands onboard sensor technology is constantly reinventing itself. Sophistication of sensors will continue as the regulating bodies keep on implementing stricter rules and shipping companies try to reduce their expenses while abiding said regulations. Eventhough most modern sensors are highly accurate and cost effective, personnel training in these technologies are still not efficiently conducted**.**

Acknowledgements

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DIGI SHIPPING

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Abstract: Few of the digitalized technologies has been discussed in our paper. They are:

1. IoT adoption enabling better ship and fleet operations:

Using IoT devices and sensor systems across your fleet helps you gain a competitive edge, by enabling you to harness the full potential of data for more effective operations and decision-making.

2. Artificial intelligence optimising decision-making and safety:

Artificial intelligence has many potential applications in the maritime industry, e.g., optimising business processes, voyage planning and vessel maintenance.

3. Robotics for complex tasks in complex environments:

As ship operations are becoming ever more complex and sophisticated, robots are increasingly being used to support and perform tasks. According to the Global Marine Trends 2030 report, new types of robots for shipping will have advanced functions.

4. Drone technology:

Replacing the need for human inspections, routine maintenance can be monitored remotely in real-time by surveyors, providing instant feedback to the vessel or offshore Superintendent. This, in turn, reduces costs, increases efficiency and significantly reduces the risk to human life during essential maintenance.

1. Introduction

The shipping industry has a long history and is the foundation of the today's civilization which is still growing in a very fast rate. To cope up with this shipping companies are shifting towards digitalization.

- In shipping, digitalization and the use of data has had a huge impact. Ships have become sophisticated sensor hubs and data generators, producing and transmitting information from anywhere, often in real time. At the same time, advances in satellite communications are improving connectivity, allowing for massive increases in the volumes of data transferred at ever-lower cost.

2.Main Work

1.1 Technologies discussed

a) Internet of Things (IoT)

b) Artificial intelligence
c) Robotics
d) Drone Technology

2.1(a) What is Internet of Things (IoT)?

- Internet of Things (IoT) is an ecosystem of connected physical objects that are accessible through the internet. The 'thing' in IoT could be a person with a heart monitor or an automobile with built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.
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➢ **Benefits of IOT in shipping**

1. *Cargo Tracking*: End-to-end supply chain solutions with location, security, status, and settlement data of cargo for customers, clients, shippers, ports and landline partners.
2. *Online Booking*: Instant self-serve booking, as opposed to waiting hours for a confirmation.
3. *Container ROI*: Increased container utilization.
4. *Automatic Settlement*: Online payments and automatic settlements based on IoT triggers. For example, cargo was delivered to a client loading dock with no damage sensor alerts such as water, humidity, etc.
5. *Smart Ports*: Rotterdam, Europe's largest port, will host connected ships by 2025. Sensors will collect, process and analyse real-time data to check availability of berths and other data points such as weather, tide, clearance heights, etc. This collection and curation of robust data sets will allow more efficient communications and decision-making to realize operating cost reductions.
6. *Lowering operating and capital costs:* IoT solutions like mobility, asset tracking, ship capacity automation, berthing + loading analytics, environmental monitoring, smart metering and ecosystem predictive insights greatly reduce (or eliminate) manual tracking and human-error while increasing productivity, efficiency, and cost reductions.
7. *Condition of cargo:* IoT enables data-rich, event triggered alerts and tracking of numerous metrics (temperature, humidity, velocity, altitude, light, vibration, wetness/dryness, etc.) to ensure cargo is transported and delivered as agreed.

2.1(b) Artificial Intelligence

- Artificial intelligence (AI) is wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence.

  Artificial intelligence generally falls under two broad categories:

- 1.Narrow AI: Sometimes referred to as "Weak AI," this kind of artificial intelligence operates within a limited context and is a simulation of human intelligence.

- 2.Artificial General Intelligence (AGI): AGI, sometimes referred to as "Strong AI," is the kind of artificial intelligence we see in the movies, like the robots from *Westworld* or Data from *Star Trek: The Next Generation*. AGI is a machine with general intelligence and, much like a human being, it can apply that intelligence to solve any problem.

➢ **Applications of AI**

1. Automated processes at shipping terminals
2. Reducing Fuel Consumption
3. Image recognition systems
4. Navigation systems
5. Unmanned vessels

Companies presently using AI technology

- SailRouter uses AI-based cloud application that helps ship owners to reduce fuel consumption and maintenance costs.
- VesselBot uses AI-based digital chartering marketplace for the bulk maritime industry.
- Mitsui O.S.K. Lines Ltd. and its subsidiary MOL Information Systems is also using Big Data related to ocean shipping which develops the capability of data analysis of economics and maritime affairs and forecasts the ocean shipping market and bunker prices with greater accuracy.
- Sea Machines Robotics builds autonomous control and remote command systems to upgrade the operation of commercial vessels. Sea Machines recently with Maersk also installed an AI-powered situational awareness technology to their new ice-class container vessels.
- Rolls-Royce also pulled off an AI-based autonomous voyage through passenger vessel, a state-run car ferry that avoided obstacles on a 1-mile route and docked automatically. These AI-based systems in vessel help the ship perform easily in rough winter weather, handling snow and strong winds.

2.1(c) Robotics

- Industries around the world are now showing more interest in robotics because it represents the key to future medicine, warfare, better economy, and well-being. Even maritime industry is not untouched from the robotization. With the introduction of a variety of new robotic technologies, the day is not far when robots will carry out several important jobs both at sea and on shore.
- We will discuss on some of the robotic technology of the shipping industry namely:

1. Fire Fighter Robots
2. Hull Cleaning Robots
3. Anti-Piracy Robots

1.Firefighting robots

- Shipboard Autonomous Fire Fighting Robot (SAFFiR), developed by Naval Research Laboratory in collaboration with Virginia Tech and other US universities, is an autonomous humanoid robot capable of

detecting and suppressing shipboard fires and working shoulder to shoulder with human firefighters using advanced sensors.

In the case of fire on ships, these robots would perform tasks such as:

1. turning valves
2. picking up and dragging fire hoses
3. putting water on fire

The robots can respond to gesture and commands, and its sensor package includes a camera and gas sensor. IR and UV camera help it to see through the smoke and detect the source of excess heat respectively

2.Hull cleaning robots

- An innovative hull cleaning robot namely “Hull BUG” has been developed by Sea Robotics and funded by U.S. Navy Office of Naval Research (ONR) to tackle this issue.

Fig: - Hull Bug

- The Robotic Hull Bio-inspired Underwater Grooming tool (Hull BUG), is a small autonomous vehicle weighing 30 to 40 kg. It uses four wheels and attaches itself to the underside of ships, using a negative pressure device that creates a vortex between the BUG and the hull. It crawls on the hull surface and performs frequent grooming (light cleaning of fouling films). Sensors provide obstacle avoidance, path cleaning, and navigational capabilities. A fluorometer lets the robot detect biofilm and then it uses rotary brushes or water-jets to scrub the fouling film off.

3.Anti-piracy robots

- Recon Scout throwbot developed by Recon Robotics, is an anti-piracy robot which will fight against maritime piracy.

- The dumbbell-sized robot can be fired from cannon within 5 seconds and can survive throws up to 120 feet. Its magnetic wheels help it to crawl on the ship's hull before it reaches the deck. It can be controlled by joystick from the nearby command centre. The robots can keep eye on piracy activities using its cameras that can see even in darkness using infrared camera.

Fig: - Recon Scout Throwbot

2.1(d) Drone Technology

- An unmanned aerial vehicle (UAV) is an aircraft without a human pilot on board and a type of unmanned vehicle which include a UAV, a ground-based controller, and a system of communications between the two. The use of drones and unmanned aerial vehicles (UAVs) is currently a hot topic for the maritime industry.
- The maritime industry has steadily welcomed the technology to avoid when possible humans inside enclosed spaces. The idea is, during an inspection, to replace current techniques that require crew, surveyors or independent inspectors to enter dangerous and potentially hazardous tanks with routine remote UAV inspection. This significantly reduces risk to human life during essential maintenance, reduces costs, and increases efficiency.
- Inspections and surveys
- UAVs can be used to carry out external surveys of cargo and ballast tanks, as well as tall structures on deck. Meanwhile, remotely-operated vehicles, such as the Deep Trekker remotely operated vehicle (ROV), can be dispensed at sea to carry out inspections of hulls to check for damage and the impact of invasive aquatic species.
- Drones are able to carry out survey tasks quickly and efficiency, preventing expensive and time-consuming workarounds for surveyors.

4. Conclusion

1. The digital evolution in shipping industry will not come to an end yet and will continue to shape the industries future in every aspect.
2. Advantages of digitalization being:
3. A reduced margin of error
4. Multichannel sales
5. Effective connection with customers
6. To be at the forefront of the market.

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THEORIZING THE BASIC FRAMEWORK OF MACHINE LEARNING INCLUDING THE CAPABILITIES, APPLICATIONS AND LIMITATIONS IN MARITIME INDUSTRY.

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Abstract: Evolution of the shipping industry from manned to autonomous and smart ships is the topical theme, today. This can be achieved by incorporating digitalization, machine learning and artificial intelligence along with the current shipping model. Our paper aims at throwing light on the implementation of Machine Learning in the Maritime Industry with algorithms that monitor and control the ship's systems, provide predictive maintenance and develop optimum routes and charts for navigation etc. Our research follows a qualitative and case study approach for improving situation awareness, supporting a number of ship operations and functions.

Keywords: System Integration, Internet of Things, Machine Learning, Algorithm.

1. Introduction

Since the beginning of the 21st century, we have been experiencing a digital transformation that has affected all aspects of our lives. The machinery and technology that we use in our daily lives are getting smarter and automated day by day. The world has already witnessed three industrial revolutions, which brought huge leaps in industrial processes, resulting in significantly higher productivity. The first revolution improved efficiency through the use of hydro-power, increased use of steam power, and the development of machine tools. Electricity and mass production through the use of assembly lines come along in the second. And the third and most recent revolution further accelerated automation and digitalization.

Although some areas of the economy will see fast and disruptive changes, others like shipping industries will change slowly and steadily at a more evolutionary pace. In either case, there is no going back.

This transition from manned ships to autonomous ships can be achieved by integrating technologies such as IoT (Internet of Things), AI (Artificial Intelligence) and ML (Machine Learning) within the current model of the shipping industry.

This incorporation presents us with new models that can improve efficiency of transportation and also provide us with valuable data and research that will pave the way for completely autonomous ships in the future.

The ship board machinery works continuously, generating millions of data points every second. The ultimate objective of the industry should be to utilize all this data to gain visibility into the equipment's health and optimize overall functioning and hence making shipping more efficient.

Our paper aims at discussing the basic framework and possibilities, applications and limitations of adopting machine learning in the shipping industry.

Our paper is structured as follows:

Section 1- Discusses digital technologies such as System Integration, Machine Learning and IoT.

Section 2- Discusses implementation of ML in the engine room through Multivariate Regression Model and Cognitive Anomaly Detection and Prediction.

Section 3- Discusses the scope of implementing ML in navigation.

Section 4- Concludes the paper

2. Main work

2.1. Understanding the Components of Automation

2.1.1. System Integration, IoT and Sensor Technology

System integration is a discipline that combines processes and procedures from sensors and sub-systems for the purpose of developing large-scale complex systems that involve hardware and software.

IoT technology, namely sensors, actuators, or processors are embedded in vessels' technical systems, constituting the Internet of Ships and Sea Services. Embedded software platforms integrate and manage the increasingly automated functions of ship. IoT is basically an interconnected network of sensors, actuators and processors that enables us to collect data autonomously from different systems namely engine monitoring and control system, navigational control system and communications systems, provide this data to the processors and then carry back the commands of the processor and remotely actuate these commands.

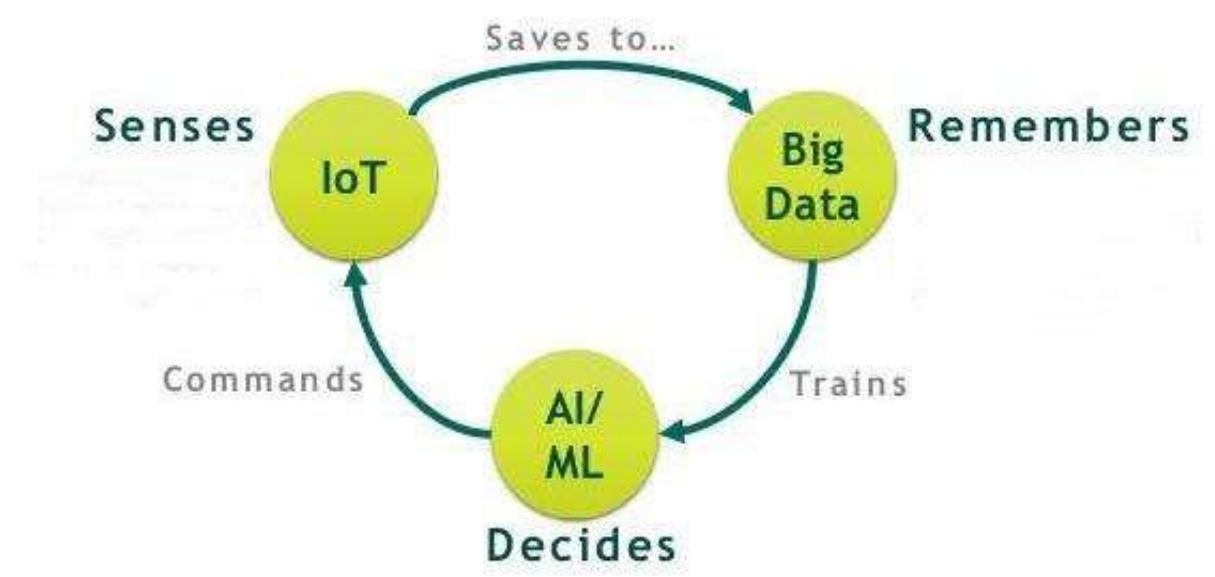

Fig 1*: Linking IoT, ML & Big Data*

2.1.2. Machine Learning:

Machine Learning is a way of implementing Artificial Intelligence using statistical learning algorithms to build systems that have the ability to automatically learn and improve from experiences without being explicitly programmed. In simple terms, ML is a technique of parsing data, learning from that data and then applying what they have learned to make an informed decision.

ML algorithms can be broadly classified into three categories based on the method used for training the system.

Supervised Learning:

In supervised learning we have input variables (x) and an output variable (Y) and we use an algorithm to learn the mapping from input to output. It takes a known set of input dataset and its known responses to the data (output) to learn the regression/classification model. A learning algorithm then trains a model to generate a prediction for the response to new data or the test datasets.

UNSUPERVISED LEARNING:

UNSUPERVISED LEARNING IS USED WHEN WE DO NOT HAVE LABELED DATA. ITS MAIN FOCUS IS TO LEARN MORE ABOUT THE DATA BY INFERRING PATTERNS IN THE DATA SET WITHOUT

REFERENCE TO THE KNOWN OUTPUTS. IT IS CALLED UNSUPERVISED BECAUSE THE ALGORITHMS ARE LEFT ON THEIR OWN TO GROUP THE UNSORTED INFORMATION BY FINDING SIMILARITIES, DIFFERENCES AND PATTERNS IN THE DATA. UNSUPERVISED LEARNING IS MOSTLY PERFORMED AS A PART OF EXPLORATORY DATA ANALYSIS.

REINFORCEMENT LEARNING:
REINFORCEMENT LEARNING CAN BE EXPLAINED AS LEARNING BY CONTINUOUSLY INTERACTING WITH THE ENVIRONMENT. IT IS A TYPE OF MACHINE LEARNING ALGORITHM IN WHICH AN AGENT LEARNS FROM AN INTERACTIVE ENVIRONMENT IN A TRIAL-AND-ERROR WAY BY CONTINUOUSLY USING FEEDBACK FROM ITS PREVIOUS ACTIONS AND EXPERIENCES.
ML IS ESPECIALLY APPLICABLE WITH A DATA SET CONTAINING A COMPLEX NONLINEAR FEATURE SPACE, THE ADVANTAGE BEING THE ABILITY OF THE ALGORITHMS TO IDENTIFY COMPLEX PATTERNS IN A HYPERSPACE WITH NO PRIOR KNOWLEDGE OR DATA CLASSIFICATION.

2.2. Implementation

There are a wide variety of algorithms and scope for implementing ML on ships.

Here we are describing a few ML models and how they can be implemented on-board ships to get the desired results and discussing the possible scopes.

2.2.1. Suggested Models for Engine Room

a) **Multivariate regression model –**

Multivariate Regression is a supervised machine learning algorithm involving multiple data variables for analysis. A Multivariate regression is an extension of multiple regression with one dependent variable and multiple independent variables. Based on the number of independent variables, we try to predict the output. Multivariate regression tries to find out a formula that can explain how factors in variables respond simultaneously to changes in others.

This model can be integrated into the ship's autonomous system to find out how the engine room input energy requirement responds to change in multiple independent variables.

The ship systems can be divided into modules -

- Integrated bridge system
- Advanced sensor module

- Engine monitoring and control system [EMCS]
- Engine automation system
- Engine Efficiency System [EES]
- Navigation control and monitoring system [NCMS]
- Waste heat recovery system
- Key performance indicator system [KPI]
- Maintenance and Repair scheduling system [MRS]

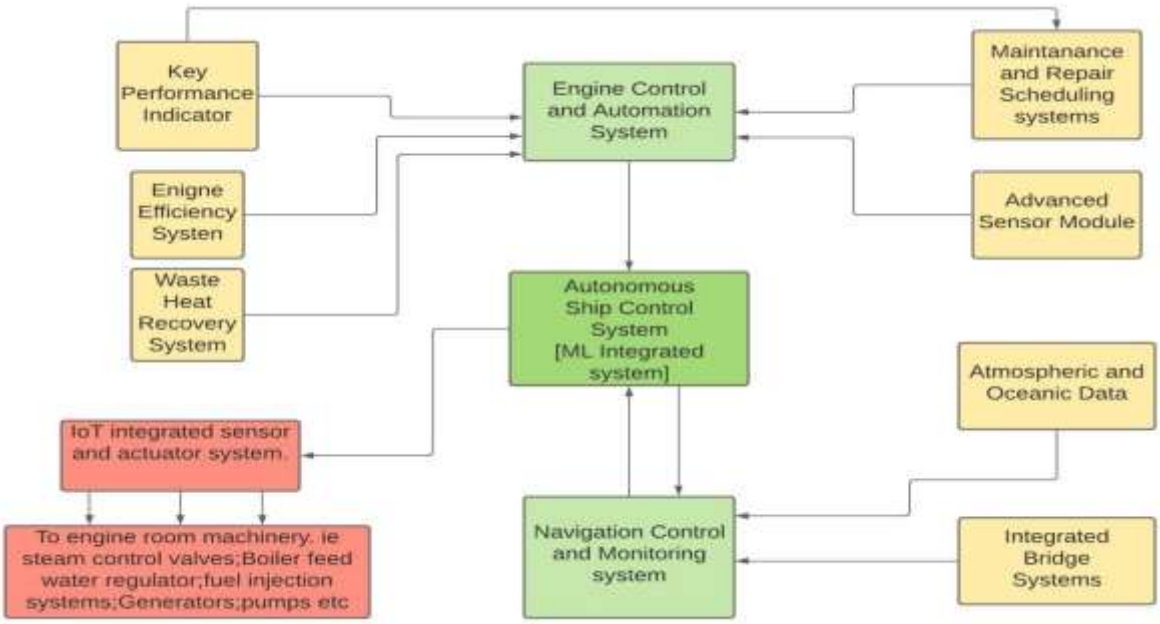

Fig 2: Flowchart- Ship System Modules

Data variables for analysis are collected from system modules -

- Key performance indicator system - Contains pre fed values of variables for maximum efficiency of individual components as given by the manufacturers guidelines. [e.g.- rpm of pump at which it gives maximum overall pump efficiency]
- Engine monitoring and control system - this gives instantaneous values of engine room variables and collects real time information of changing variables.
- Waste heat recovery system - gives information about main engine jacket water cooling outlet temperatures, condenser steam inlet temperature, electrical generators and compressors.

Based on the above input data the Multivariate regression model will create an algorithm on its own that will describe how the dependent variable [i.e., energy requirements. E.g., SFOC, boiler furnace temperatures etc.] will change with changes in independent system variables.

The algorithm then uses a regression model that updates system independent variables and repeats itself until it converges to the true regression function which then sets engine parameters to suitable values to provide maximum overall engine room efficiency.

At normal operation the AEMC system gets input from the Engine Efficiency System (EES) and follows the recommendations from the EES as long as these do not conflict with commands from the NCMS.

The system offers a load sharing application that will ensure that electricity producers run optimally. The load sharing algorithm will automatically dictate which auxiliary systems run to keep the total SFOC as low as possible and seek to even running hours as much as possible. It will take into account the electrical need of the ships systems and run the diesel generators and WHR as efficiently as possible in terms of fuel consumption.

b) Cognitive Anomaly Detection and Prediction (CADP)

CADP is a model incorporating ML developed by Progress DataRPM. DataRPM's patented Cognitive Predictive Maintenance (CPM) platform is a first-of-its-kind solution, making the process of Cognitive Anomaly Detection and Prediction provides a framework for multi-sensor time series data. It employs Meta Learning that uses machine learning to analyze sensor data from every machine to find patterns and anomalies in data and identify influencing factors and predictors to automate anomaly detection. This enables the system to make predictive maintenance a reality. The framework is designed for unsupervised detection of anomalies.

The Meta-Learning powered solution is credited with consistently delivering greater than 80% accuracy in asset failure prediction in 1/30th the time and resources, delivering over 30% in cost savings. This model is currently used in number of industries and systems such as

HVAC Systems, Automotive Assembly Line, Health Care Device Manufacturing, Tele-communication, Cable & Electronics Power Grids.

Some current applications of CAPD:

- Prevent Breakdowns in Connected Cars
- Predict Quality Issues on Assembly-Line
- Predict Part Failures & Breakdowns of Cars
- Predict Failures of Industrial Washing Machines
- Predict Quality Issues & Identify Data Gaps
- Predict Failures & Detect Efficiency Predictors

The scope and benefits of implementing CADP into the marine field are immense and have not been explored yet. With the development of digitalized and automated ships, CADP can be integrated in future ships to help save time

and money using engine room machinery data to diagnose and correct chronic failure points in the machinery and overall plant by predicting catastrophic failures of components, and hence avoid total breakdown and save billions of dollars.

The CADP solution will collect data from the IoT developed system modules and then automatically run multiple machine learning experiments to find patterns and anomalies of various system parameters. Using this, it creates an ensemble of predictive models that provide information about components that are about to fail and need maintenance, and the result is a complete closed looped system that is descriptive and predictive in nature.

Advantage of implementing CADP on ship:

- Improvise routine maintenance schedules by prioritizing based on system anomaly detection.
- Increase overall machinery lifespan by anticipating impending disasters and prevent them from occurring.
- Discover underlying machinery failure patterns and be prepared for future contingencies.
- Minimize disruptions and prevent unplanned machine downtime.
- Enhance machine utilization.
- Reduction in spare part inventory on ship.

2.2.2. Scope in Navigation

Navigation shows potential for AI use in shipping and a number of systems are currently in development. Some use elements of image recognition and tracking software, alongside machine learning and IoT connectivity.

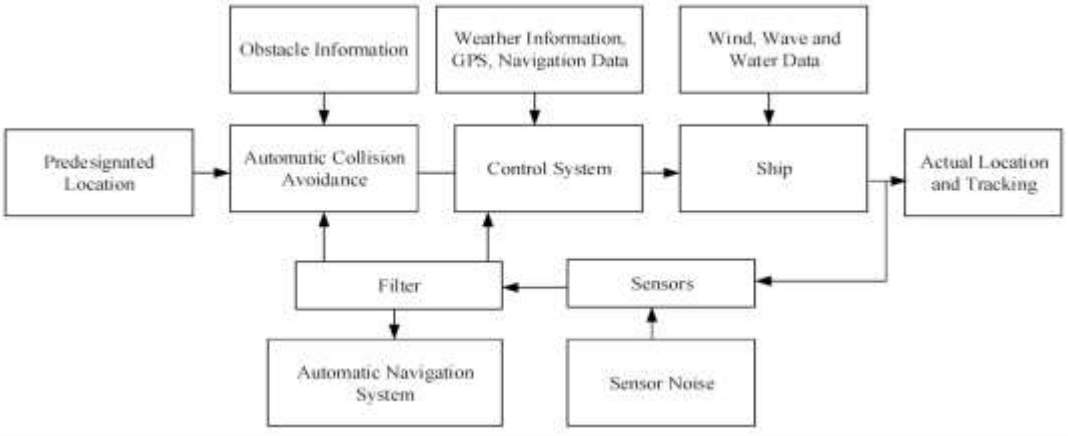

Fig 3

- Voyage optimization: Machine learning will be applicable to improve voyage optimization such as operating fuel efficiency, minimizing crew load work, improving voyage estimates, calculating optimum RPM profile, ship speed controlling, course planning etc. Constant collection of voyage-impacting data and predictive analysis will ensure that vessels are always sailing at the recommended speed, avoiding port delays and bad weather.

- Optimize SFOC: Machine learning can be used to build an optimal route and speed for the vessel based on the analyzing of data from the vessel [trim, tonnage, draught etc.] and external factors [weather conditions, water current directions]. This allows us to reduce the fuel consumption due to the voyage and ship conditions.

- Sustainability of transportation: The researches can be focused on environmental regulations, green technology and energy efficiency by adopting machine learning techniques with a view to presenting practical solutions.

- Controlling freight rates: It provides more efficient and safe cargo capacity utilization which is capable of offering more realistic rates for cargo.

- Maritime security improvement: Machine learning techniques can be used such as agent-based techniques for evaluating, understanding, detecting, anticipating and preventing piracy or kidnap or other potential hazards related with security.

- Aid in designing future fully autonomous ships: Throughout the lifetime of the ship, data related to engine parameters, fuel consumption, maintenance and repair works etc are collected and stored which can be then provided to ship designers and manufacturers for designing more efficient, sustainable and autonomous ships.

2.2.3. Current Situation of Automation

The shipping industry is growing in confidence at AI technology's capacity to run processes in container terminals and expects it to play a big role in operations in the near future. In a survey by Navis, 83% of respondents expect to increase their investment in AI technologies within the next three years. A large proportion of participants also agreed that AI could be involved in automating processes at terminals, such as container handling equipment assignments (81%), decking systems (81%), recommended actions (69%), predicting gate volumes (59%), and stowage of vessels (52%).

In September 2018, Stena Line introduced AI-assistance to its first vessel: The Stena Scandinavica, which is now running the technology as a pilot study. The Stena Fuel Pilot AI software is able to predict the most economical route in terms of fuel consumption. Factors such as weather, currents, and other variations potential problems are taken into account and then the most efficient route is recommended.

The company has a set target of cutting fuel consumption and carbon emissions by 2.5% per annum. Of Stena's total running costs, 20% is spent on fuel. By the end of 2020, Stena Line plans to install the AI software on 38 of its vessels

throughout Europe. One of the most complex factors to predict is water currents, which Stena hopes to make possible by refining the AI technology. Stena's ultimate ambition for AI is to create a system so precise that the captain can use it to plan routes in total confidence.

Kawasaki Kisen Kaisha (K Line) has started a project to research into AI's capabilities to improve the quality of shipping services. The research is being carried out in collaboration with fellow Japanese organisations Hiroshima University, Marubeni Corporation and the National Institute of Maritime, Port and Aviation Technology (MPAT). The project will use predictive models for maritime logistics and market conditions.

Next year, Stena Line is rolling out an AI platform to cut fuel consumption on its fleet of ships.

The Chinese company developed the graphic recognition engine by combining AI deep-learning technology with MOL's extensive maritime experience. The system automatically collects image data, which MOL intends to use to refine the precision of the technology. The system has been tested this year onboard MOL's passenger line cruise ship, Nippon Maru. MOL plans to try the solution on other vessels as the company explores the development of autonomous smart ships.

Orca AI is one such AI navigation platform being developed. The company's solution combines sensors and cameras with deep learning algorithms. It is able to locate and track other vessels on the water and take action to avoid collisions. Meanwhile, Wartsila subsidiary Transas' Navi-Planner is an AI platform that uses machine learning to optimize voyage planning. Safe navigation routes are automatically created according to the latest charts and environmental information available. It records any near-misses and other incidents that occur during voyages. The system will also be able to adjust routes and speeds to ensure arrivals take place on schedule

2.2.4. Limitation

- Cyber threat
- Misreporting of data can cause concerns, as it may lead to incorrect analysis and inappropriate decision-making.
- Slowdown in investment in big data analytics due to existing challenges.
- Lack of big data-skilled workforce / Skills shortage

3. Conclusions

The shipping world is constantly changing and upgrading. Digitalization and automation is at an all-time high. Fully autonomous and ML system integrated ships will help us create a sustainable and a more efficient shipping model for the future. There are innumerous ML algorithms and models through which this technology can be incorporated into the current shipping model. After our research and study on such models we found that the Multivariate Regression

Model can be used to give optimum values of engine system parameters to manage the engine room energy requirements efficiently. Industries have already developed various ML models and are utilizing them to improve manufacturing and working efficiency. After researching about such current ML models that are already in use in industries other than shipping, we came across CADP. Cognitive Anomaly Detection and Prediction makes predictive maintenance a reality and gives information about possible machinery failure and can immensely help to optimize ships maintenance schedule and reduce unplanned machine down time. We also discussed how ML algorithms and data processing can make navigation more efficient and sustainable. The scope and benefits of using ML integrated autonomous systems into shipping is very wide and under development.

Considering the fact that developing laws, regulations and international instruments is a long and time-consuming process, while technology continues to advance at an exponential rate. We need to avoid regulatory gaps; it is important for today's policymakers and regulators to remember that they must be prepared for tomorrow's technologies. Policymakers and international organizations need to facilitate the interoperability of data-driven processes in international shipping and trade and within the ships' systems. More research needs to be done and ship manufacturers and owners should start integrating digitalization and ML with the current shipping model and take steps towards autonomous and smart shipping models. As time passes the integrated systems will collect and process more data and the algorithms will keep getting smarter day by day.

Acknowledgement

We would like to thank Tolani Maritime Institute for providing us the platform to present a technical paper on such a diverse topic that is of great importance and is still scarcely treaded upon. We are glad to be able to grab this opportunity and take full advantage of it.

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Technical Write-ups for Models

SHIP AUTOMATIC MOORING CONTROL SYSTEM

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OBJECTIVE

The following are the objectives of our proposed model: -

1. To completely automate the process of mooring.
2. To minimise the risk involved in mooring and berthing operations by minimising human intervention required for the same.
3. To accurately provide the correct amount of tensioning force to the mooring ropes, thus intelligently preventing their whipping or parting.
4. To make the ship completely independent and self-sufficient during mooring, by eliminating the need of a mooring boat or port staff.

PRINCIPLE/ CONCEPT

Our model is broadly based on Artificial Intelligence and Internet of Things (IoT). We plan to replace traditional mooring, involving throwing of heaving lines to a jetty or buoy, with artificial intelligence-based cranes that would perform the same operations, with greater accuracy. With our proposed model, we aim to smoothen and simplify the critical operation of mooring by using cranes, programmed to move in a pre-defined and set pattern. The crane comprises of 4 programmable servo motors, that can be made to move intelligently, to move the crane arm to pre-decided places

Furthermore, the crane arm would also have a magnetic piece attached to it. This is due to the fact that the crane arm would first be programmed to move towards an additional arm which would also be attached to a magnetic piece, connected to a loop of the mooring rope. The crane would then proceed to place this mooring rope loop over the bollard, tighten it by wrapping it around the bollard, giving it just the required amount of tensioning rope. These series of processes would sequentially be performed on their own, all by virtue of the Arduino chips, programmed to drive the motors in such a way, so as to achieve the above-mentioned results.

EQUIPMENT WITH SPECIFICATION USED FOR MODEL

1. Arduino UnoR3
2. Servo Control Robotic Arm (Wooden)
3. Servo Motors – 9 g – (4 units)
4. USB Cable for Arduino
5. 6 V Battery Holder
6. M-M & M-F Jumper wires
7. Bollard structure
8. 7 mm Diameter Nylon Rope

Test Equipment for Experiment

1. Measuring Tape
2. Stopwatch

DESCRIPTION OF OPERATION/EXPERIMENT/PROJECT

Berthing and mooring are critical operations, being performed on ships since days beyond recall. These operations demand a great deal of expertise by both the ship's crew and the authorities at the port. They require effective and clear communication, teamwork and co-operation between the ship's crew and the port authorities. The individuals employed in mooring need to be highly skilled and trained, to carry out berthing safely and successfully. Traditional mooring Is done via making an approach to the jetty at a 25-degree angle, reversing the direction of the engine to get the stern to the required position to align the ship, and finally stopping the engine well before as it moves for some headway. Most ships, keeping aside a few, still use manual mooring, where heaving lines, tied to mooring lines are thrown to the jetty or quay. People are especially vulnerable in the snapback zone and near the bight of the rope.

With our proposed model, we plan to minimize the risk involved in these operations, by absolutely minimizing the need for human intervention and expertise.

We plan to completely automate the mooring procedure, and make the ship self-sufficient for the same. We have designed a system where in an Arduino controlled crane, fitted on the ship, would have a magnetic strip, that would automatically go to a mooring loop attached with an iron piece, pick the loop up and drop it on the bollard. The Arduino would be programmed to go to the exact location of the mooring loop and wrap it around precisely on the bollard. This procedure is repeated for all the lines, namely - the spring lines, headlines, breast lines and stern lines.

This eliminates the need of throwing the rope at all, and also the risk of standing in the vicinity of the dangerous regions concerned with manual mooring. It also eliminates the need of hiring a mooring boat, thus saving money for the company.

It is a faster, easier and more reliable process than using the method of berthing with traditional mooring ropes. Furthermore, it makes mooring even easier in polar regions and icy weather. It also has the added benefit to provide accurately, only the required amount of tensioning force for the given angle and position. It would reduce the manpower and human skill required, and would in general just smoothen the entire process of berthing a vessel.

PROCEDURE

MECHANICAL PROCEDURES:

We began our project, by first constructing the servo controlled robotic arm. We made use of a hard plywood board, 3mm in thickness. We cut out slender, rectangular pieces, for the assembly of the crane part of the robotic arm. We further cut out bigger rectangular pieces, in order to make the base, on which the crane would rest. We also cut out two square rectangular pieces with slots in between, for the servo motors to be inserted.

Then, 2 small arms were intricately cut in the shape resembling that of a gear, to which the servo motor was to be coupled. These two arms together constitute the 'gripper' of the robotic arm, the part which would grip the mooring rope.

Proceeding further, we cut out four mounts, which were slender rectangular pieces, slightly bigger than the arms of the crane. Over these mounts, the entire structure is supposed to sit.

The above constructed parts were then assembled with one another using nuts and bolts, forming hinges at the desired places. The four servo motors were then installed in the respective slots – two for the cranes, and two for the gripper arms.

Moving on, we used a soft plywood board, of 8 mm thickness, to construct the ship's structure. The entire assembled crane, was then placed on the deck of the ship.

PROGRAMMING AND AI BASED PROCEDURES

In order to control the movement of the four servo motors installed in the servo controlled robotic arm, we made use of a programmable Arduino UNO chip. We wrote a special programme on a software, and programmed the chip to move in a pre-decided manner, as required for the mooring operation described earlier. The four motors thus have four degrees of freedom.
The Arduino UNO chip interacts with the servo motors by making use of jumper wires.

WORKING

The model is based on artificial intelligence and IoT. The model essentially makes the ship independent and self-sufficient during berthing and mooring operations. With the model we are putting forth, we are presenting a procedure where a servo controlled robotic arm, installed with four servo motors, capable of having four degrees of freedom, would essentially pick up a loop of mooring wire from the deck of the ship, and would proceed to place it on the bollard ofthe jetty/dock.

This is made possible with the help of a special programme written specifically for this operation, where the Arduino UNO chip would govern the four servo motors to move in a pre-calculated pattern, so as to not only accurately place the loop on the bollard accurately, but also give the required amount of tensioning force to the rope, thus minimising the chance of snapping. The Arduino UNO chip also requires a 5V battery for its power supply, and is made to interact with the four servo motors using jumper wires.

QUANTIFICATION OF MODEL/PROJECT

1. Torque: 2.5 Kg/cm
2. Operating speed: 0.1s/60degrees
3. Rotation: 0 degrees – 180 degrees

4. Operating Voltage: +5V
5. Maximum Height: 48cms
6. Maximum Range: 31 cm
7. Weight of Motor: 9 grams

TESTS/EXPERIMENTS WERE CARRIED OUT ON MODEL/PROJECT AS FOLLOWS

Test 1:

1. A measured amount of load (weight of rope) was intentionally put over Robotic Arm Crane.
2. Two coordinates were fixed, named A & B.
3. Readings were taken for time taken for the crane to move from A to B and thereafter the speed was found out.
4. For every new reading, the weight of rope was varied, keeping the distance between A & B constant.
5. The average speed from the three readings was calculated.

Observation table:

Table No. 1

Sr. No	Distance between Point A & B (cm)	Weight of rope (grams)	Time (sec)	Speed (cm/sec)
1.	15	25	22	**0.6818**
2.	15	50	26	**0.5769**
3.	15	75	31	**0.4838**

Results: ***While testing the robotic arm, it was found that by increasing the weight of rope the time taken by the robotic arm to move from point A to point B increased.***

Test 2

1. A measured amount of load (weight of rope) was intentionally put over Robotic Arm Crane.
2. Weight of rope was fixed for an entire test.
3. Readings were taken for time taken for the crane to move from A to B and thereafter the speed was found out.
4. For every new reading, the distance between A & B was varied, keeping the weight of rope constant.
5. The average speed from the three readings was calculated.

Observation table:

Table No. 2

Sr. No	Distance between Point A & B (cm)	Weight of rope (grams)	Time (sec)	Speed (cm/sec)
1.	10	25	20	**0.5000**

2.	15	25	24	**0.6250**
3.	20	25	29	**0.6896**

Results: ***It was also found out via experiments, that by increasing the distance between point A and point B, the crane took more time as compared to when points A and B were nearer keeping the weight of rope constant.***

ACCIDENTS RELATED TO MOORING LINES

Mooring stations are considered to be one of the most dangerous places to work at, on ships. Statistics show that a ballpark figure of 53% cases of injuries and casualties onboard are linked to working at mooring stations. This includes snapping of ropes due to high tension, improper working of drum bitts, and trapping of operator in ropes.

Real life incidents

CASE 1: A Hong Kong registered bulk carrier vessel saw the unfortunate accident of a crew member dying after being hit by a mooring rope. During the mooring operation, the spring lines got struck in the front fender, were subject to a tensioning force more than they could withstand and eventually snapped and hit the Ordinary Seaman.

Reasons:

- Failure in identification of the poor arrangement of lines due to an obstruction.
- Poor communication between the mooring team and Bridge.

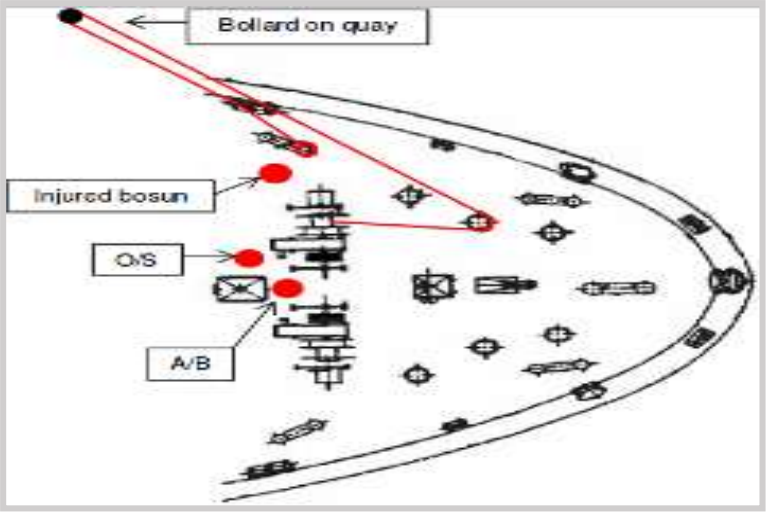

Figure 7, Credits: maritimeaccidents.org

CASE 2: During the berthing of a Hong Kong registered ship at a container terminal in Kobe, Japan, a mooring rope on board the vessel parted. The unfortunate snapping of the rope hit and killed two seamen who were engaged in the mooring operation.

Reasons:

- Rope got tangled into the side bend and when tensioned, it snapped.
- Degradation of the rope due to rubbing and chaffing on the side bend, leading to reduced strength, thus making it more susceptible to breaking

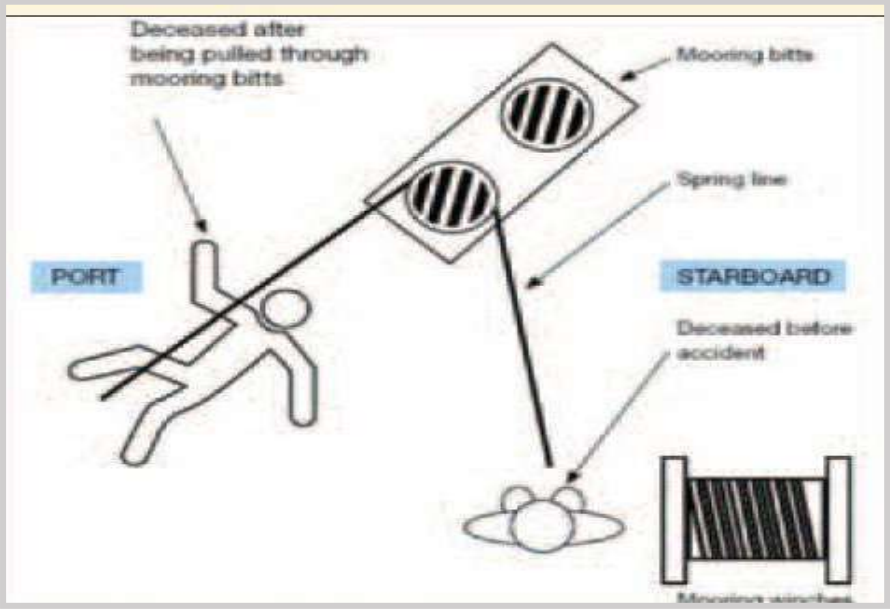

Figure 2, Credits: Nautinist.org

CASE 3. At the time of mooring of a cargo vessel, one set of the mooring lines snapped away from the cargo barge's bollard and hit the monkey island of the tugboat. Due to the impact causes due to the snapping of the mooring lines, the tugboat lost control and suffered damage.

Reasons:

- Incorrect mooring line angle.
- Poor and deteriorating condition of bollard.
- Unnecessary extra slack from tug results in slipping off line.

Figure 3, Credits: IMCA-int.com

Figure 4, Credits: IMCA-int.com

CASE 4: While positioning a merchant ship alongside the jetty, while the spring lines were being wrapped around the bollard, one of the forward spring-lines failed. The rope, which was made of high-modulus polyethylene (HMPE), failed in-board close to the roller pedestal that led the rope from the winch at a 90° angle to the roller. The energy stored due to excessive tension resulted in snapping of the line.

Reasons:

- Rope failed due to overloading.

- Wear and reduced strength are the chief factors that caused the rope to snap.

Figure 5, Credits: gcaptain.com

CASE 5: In the month of May, 2017, a second officer on a bulk carrier got injured due to a severe mooring accident. The vessel was berthing at the port and the spring line whipped and hit the deck officer, who was involved in the operation.

Reasons:

- The line was trapped between rubber fender and port structure and the mooring crew was unaware of this.
- As the pilot gave an order to position the vessel, the mooring team started tightening the rope. The Second Officer leaned in to check the rope, and as the line was trapped between the fender and the port structure, it bounced back and hit the deck officer on the chin, catching him off guard.

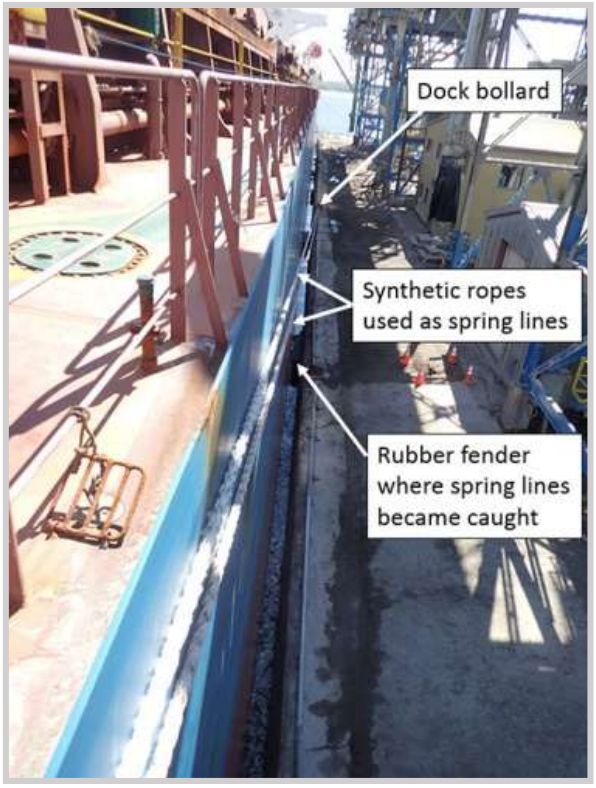

Figure 6, Credits: Transportation safety board of Canada

CONCLUSION/INFERENCE

After conducting trials, it was ascertained that the model satisfies the purpose it was designed for.

1. Due to the automatic mode of operation, human interruption is minimal and hence the risk involved is minimized.
2. Faster mooring operations can be achieved due to the high precision of the servo controlled robotic arm system. During the case of an emergency mooring/ unmooring this could prove to be of great importance
3. By placing lines directly on bollard, the interaction of the line with sea water or fresh water is reduced, thus resulting in lesser wear and even reducing the maintenance requirements.
4. An Integrated system of mooring crane and rope winch can be developed and used in the future to achieve better performance and to nullify the risk involved to precious human life on board as well as on shore.

SCOPE FOR FURTHER STUDIES

The loss of life during the mooring accidents demands a very sophisticated, feasible and safe countermeasure to reduce the involvement of crew during mooring operations. The automatic mooring system can be used with modifications in future to yield better results.

Modifications for future:

1. Mounting a camera on crane to provide clear vision and efficient monitoring from bridge.

2. Automatic bollard positioning system by using photo sensors which will guide the crane to place the line at the bollard with a light emitting diode. This will ensure precision even during rough weather, foggy conditions etc.
3. An Integrated system of mooring rope winch and crane will limit human interference to the monitoring positions only.
4. A programmable system of rope tension measuring system and an alarm system can predict the undesired increase in tension in rope near the breaking / snapping point. This system can automatically act to reduce the tension by allowing more line to be drawn from winch. The Tension measuring system is developed by a company called ***Gigasense*** to measure the tension in wires and ropes, and their technology seems especially promising for the scope of our model.

FIGURES/PHOTOGRAPHS

Figure 7: Actual Model - Side View

Figure 8: Actual Model - Top View

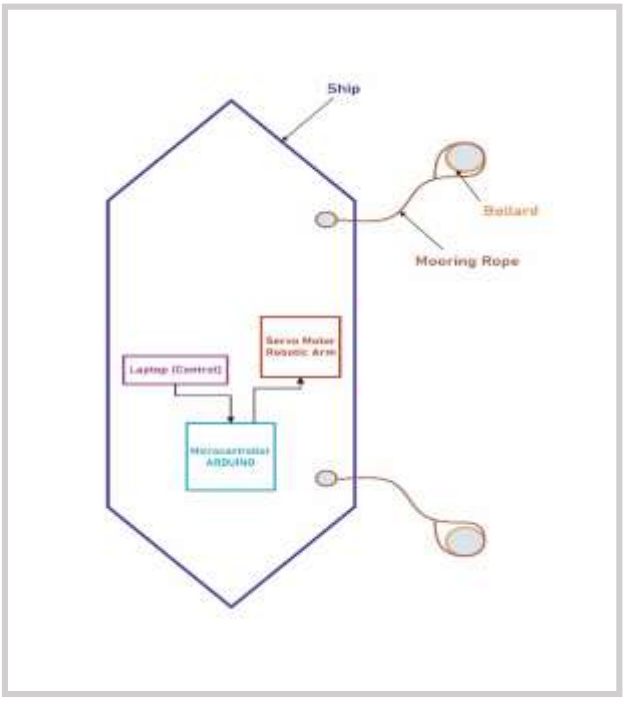

Figure 9: Diagrammatic Representation

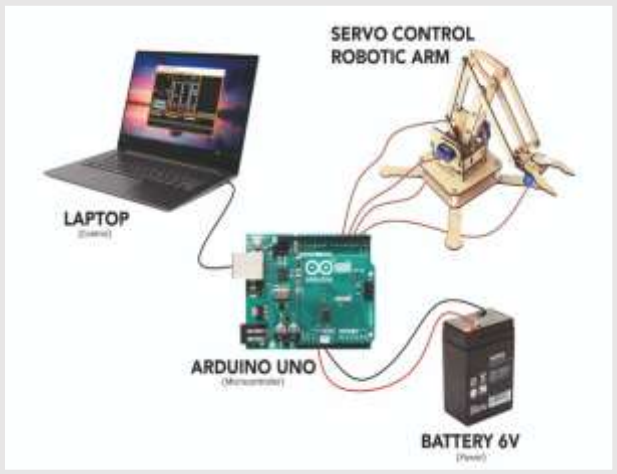

Figure 10: Circuit Diagram

Figure 11: Diagrammatic Representation of soft model using computer based LUMION8.5 software

Figure 12: Diagrammatic Representation of soft model using computer based LUMION8.5 software

References:
[1] www.arduino.com /Library/Device Contr
[2] www.allaboutelectronics/ Projects
[3] Maritime accident report 2014- Danish Maritime accidents investigation board.
[4] www.gigasense/gigasense rope tension meter.

FIRE EXTINGUISHER DRONE AND SENSOR

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ABSTRACT: In recent times, Fire has turned out to be one of the major hazards on the ongoing vessels, as it gives great damage to the vessel and also a huge dent in the profit of the shipping corporations. several methods had been introduced in order to extinguish the fire but drone is one of the most efficient way of extinguishing the fire, since it can be used in any part of the vessel to quench the fire.

This drone contains a pressure sensor and a temperature sensor. When it is taken close to the fire it senses the temperature and if the readings are within the permissible range, then a signal will be sent to the receiver unit i.e. connected to the dropping mechanism and it will drop the fire extinguisher ball which is attached to it.
sensors are the most important equipment onboard since most of the machines are monitored using these sensors. schlepping and maintaining of these sensors could be minimised, as in this detailed study we have shown that by using the same components we can reassemble various sensors.
This article describes the study of fire extinguisher drone and the working of different sensors using the same equipment's.

INTRODUCTION:

1. To extinguish the fire within a short period, since fire is a major hazard it could cause intense damage to the lives on board as well as it would give huge dent in the profit of the shipping company.
2. To use different sensors with the help of the same equipment.

Usage of drone in the maritime field:

The drone market in the US is subjected to a rapid growth, where the value of drone activity raised from 40 million dollars in 2012 to 1 billion dollars in 2017 and is expected that by 2026, commercial drones will impact the country's GDP (gross domestic product) with up to 46 billion dollars. Nowadays, the usage of drone for fire emergency situations around the world becomes a key element for reducing of response time, increase safety for people, assets and rescuers, improve effectiveness on repression operations and bring savings on intervention costs.[1]

Initiating stating problem:

How can drones bring benefits to emergency management and particularly in fire emergencies?
To develop a more focused problem formulation, in order to facilitate the limitation of the present initiating stating problem, the analysis is built on the following steps:

- Describe the problem by identifying and ranking different stakeholders related to the scope and the initiating stating problem
- Describe what an emergency is and different phases in an emergency

• Identify a relevant organization that is acting in the field of fire emergencies and describe the type of services that they perform

• Analyze the problem by doing a thorough literature review on the state of the art •

Conclude with key research objectives for the present thesis.

Drone risk identification:

From the analysis of the interviews, one conclusion that can be drawn is that there is a need to look at how the drone itself can become a possible risk if used in any of the three phases of emergency management cycle (preparedness, response and recovery). For this purpose, a Bow-Tie model is constructed to serve as a method to illustrate what are the factors that must be considered for safe operations and develop procedures and rules within the company, according to it. The bow-tie model is a graphical risk analysis tool that identifies, prevents, controls and mitigates the causes and consequences of an hazardous event by forming a logical relationship between them. It can be considered to be a combination of the thinking of a fault tree that analyzes causes and an event tree that analyzes consequences, but the bow-tie model focuses more on identifying 32 barriers for both sides. It serves more as a qualitative risk analysis method, while Fault Tree Analysis and Event Tree Analysis allow for

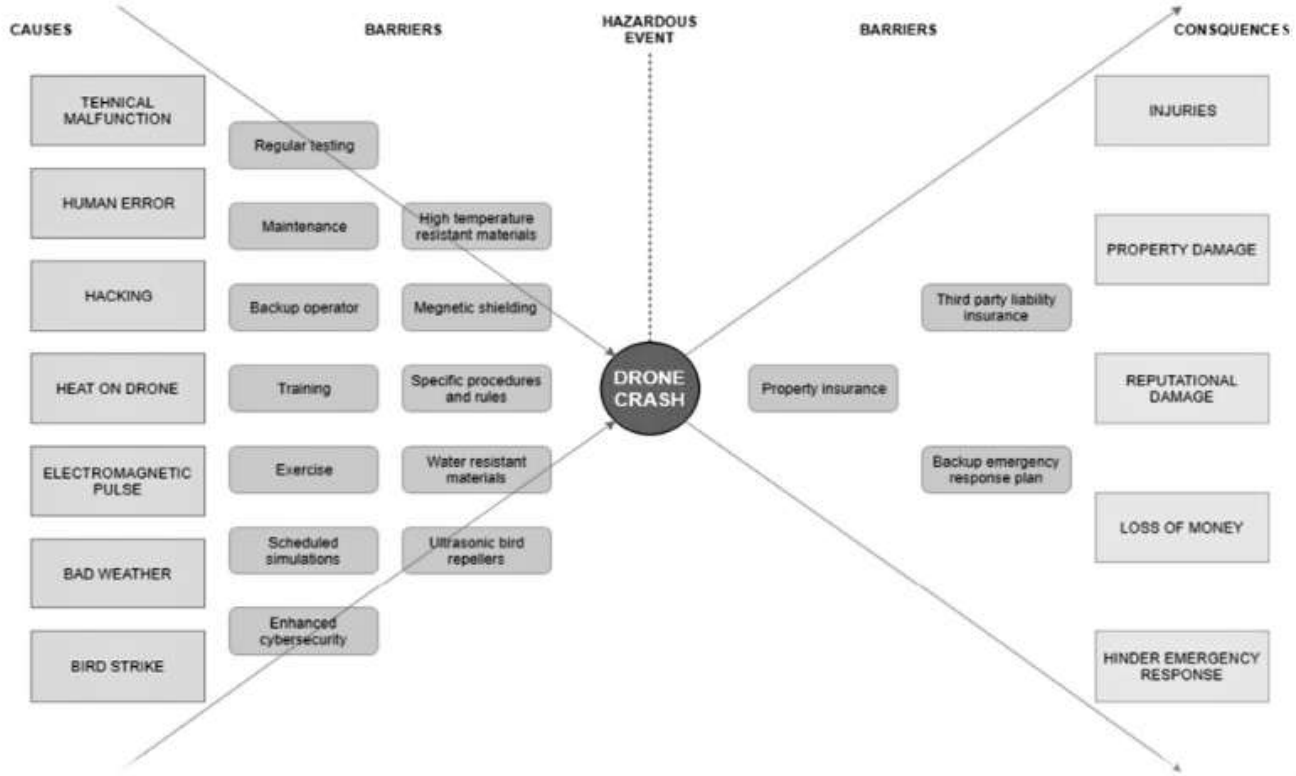

FIG-1 DRONE RISK

quantification of probabilities. It is a strong method to illustrate a brief risk picture as it is simple to understand, focuses on barriers and does not require a high level of expertise, but lacks in complexity.[2]

Development in drone extinguisher:

This prototype describes a hex copter able to carry payloads that are capable to extinguish fires in a ten square meter area. The drone was built from different components: flight and motor controllers, motors, transmitter and receiver (RC TGY-I6 [2]), battery and propellers, wireless transmitter and receiver linked to GPS, as well as a dispenser actioned by a servomotor to release payload. 40. The drone is controlled via DJI NAZA M-Lite flight controller [3] and weights 7 kg including 2 extinguisher bombs which weight 3 kg together. The developers also tested the drone in various experiments and concluded that the size of the propellers has to be 8inches because they offer better stability. The prototype is a low-cost solution that proposes not only video feed capabilities, but also interaction with the fire.[4]

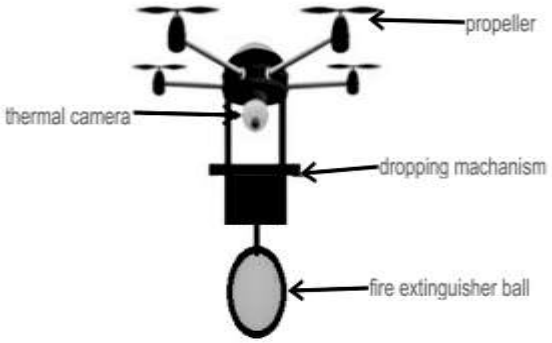

FIG 2- FIRE EXTINGUISHER DRONE

ACTUAL DRONE:

YUNEEC Tornado H920 Hexa-Copter

The Tornado H920 Hexa-Copter from Yuneec is a six-rotor aerial platform optimized for flying a Panasonic GH4 camera. To support the camera, it works with the separately available GB603 gimbal, which serves to stabilize the camera while allowing it to move independently of the aircraft. The Tornado's landing gear retracts to allow an unfettered 360° view as the camera pans. A 5.8 GHz SD video downlink system is provided, and the included ST24 transmitter features an integrated 7" Android device for live monitoring and OSD telemetry display.

This Tornado bundle comes ready-to-fly and includes a pre-bound transmitter, two flight batteries, a dual-battery charger, and an aluminium case.

- Works with GB603 gimbal for Panasonic GH4 camera.
- Carbon fiber frame
- Retractable landing gear
- Fail-safe folding arms
- Return-to-home and auto landing capabilities
- One motor failure survivability
- GPS antenna
- Compass
- Air pressure sensor [5]

FIG 3- YUNEEC Tornado H920 Hexa-Copter

WORKING PRINCIPLE:

I. FIRE EXTINGUSHER DRONE:

Working of machanism:

The fire extinguisher drone consists of a receiver unit. The receiver unit carries a LED for the indication that the drone and mechanism are on, it also carries a motor and it is powered by a 4.7V lithium-ion battery. When the receiver receives the signal the motor connected to the receiver unit rotates and the pin which it attached to the motor will move back and the ball which is supported on the pic will fall. We can even use a rack and pinion mechanism to drop the ball. In the fig 4,we could see when the pinion rotates the rack will move and the thread which is on the rack will fall.

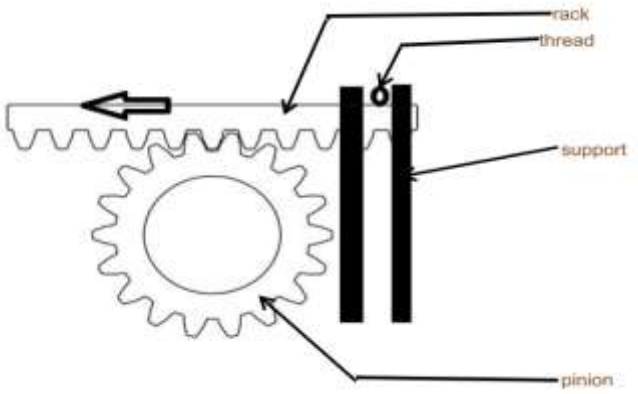

FIG 4- DROPPING MACHANISM

Complete Working:

Whenever the fire hazard takes place on board it should be extinguished within a short period. As a result, it could damage the vessel, cargoes, and crew members on board if it hasn't been extinguished. A fire extinguisher drone can be used on the vessel which will carry a fire extinguisher ball (consists of 90% of dry extinguish powder- ammonium phosphate mono). That ball will be held and carried out by using a drone, which will be dropped in the place of the hazard to extinguish the fire. As soon as the ball drops on the fire it explodes within seconds and hence it will spread the dry ammonium powder all over the surface and which will quench the blaze. The ball will explode only to spread the dry ammonium powder and it will not lead to damaging any of the vessel gears around it. "Yuneec H920 Tornado Drone" can be used because it has a carrying capacity of 1.7kg, thus it can easily carry the ball and the dropping mechanism.

II. Sensor:

We have a variety of sensors onboard and we are going to use the same equipment's which are Arduino UNO, breadboard, jumper wires, LED, and buzzer for all the sensors. Here we are going to show the working of infra ray sensor as fire detector, sonar as vibration detector, flow detector to get the flow velocity, and gas detector.

Eqipments:

- **Breadboard:**

  The purpose of the breadboard is to make quick electrical connections between components- like resistors, LEDs, capacitors, etc- so that you can test your circuit before permanently soldering it together. Breadboards have many small sockets on them, and some groups of sockets are electrically connected to each other.[6]

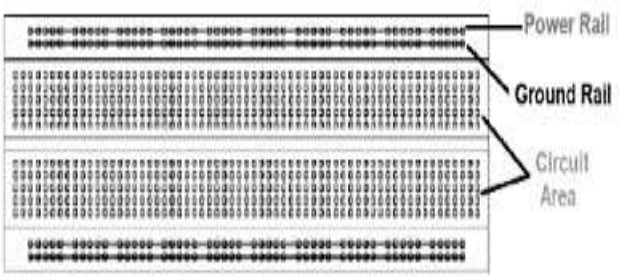

FIG 5- BREADBOARD

- **LED and BUZZER:**

LED:

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. Light is produced when the particles that carry the current (known as electrons and holes) combine together within the semiconductor material. Since light is generated within the solid semiconductor material, LEDs are described as

solid-state devices. The term solid-state lighting, which also encompasses organic LEDs (OLEDs), distinguishes this lighting technology from other sources that use heated filaments (incandescent and tungsten halogen lamps) or gas discharge (fluorescent lamps).[7]

BUZZER:

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.[8]

- **Arduino uno:**

  The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P

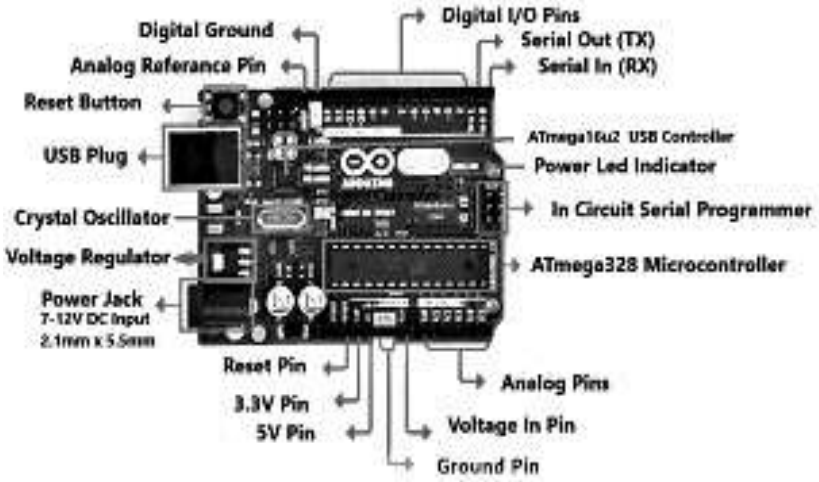

FIG 6- Arduino uno

Microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. [9]

Different sensors with working:

- **Sonar sensor (as vibration detector)**

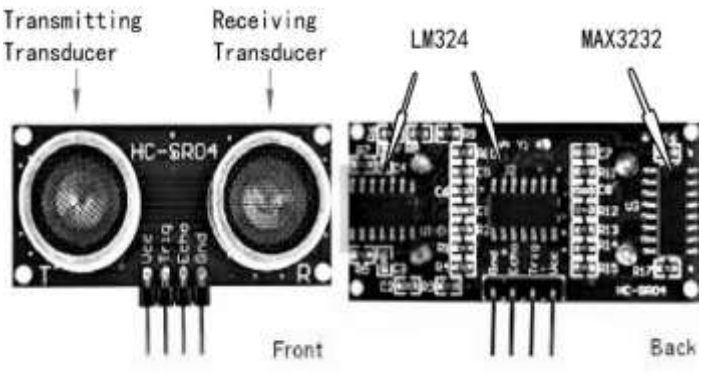

FIG 7- Sonar sensor

Principle:

Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating the distance based on the time required. This is similar to how radar measures the time it takes a radio wave to return after hitting an object. [10]

Working:

Here the distance can be used to detect the vibration. If the machines are vibrating within a certain limit the sonar sensor will emit the signal hence the alarm will not ring, but when the machine is vibrating more than the certain limit which means it will have more displacement and hence the sonar sensor will send a signal which is detected by the Arduino and that will start the alarm.

Circuit diagram

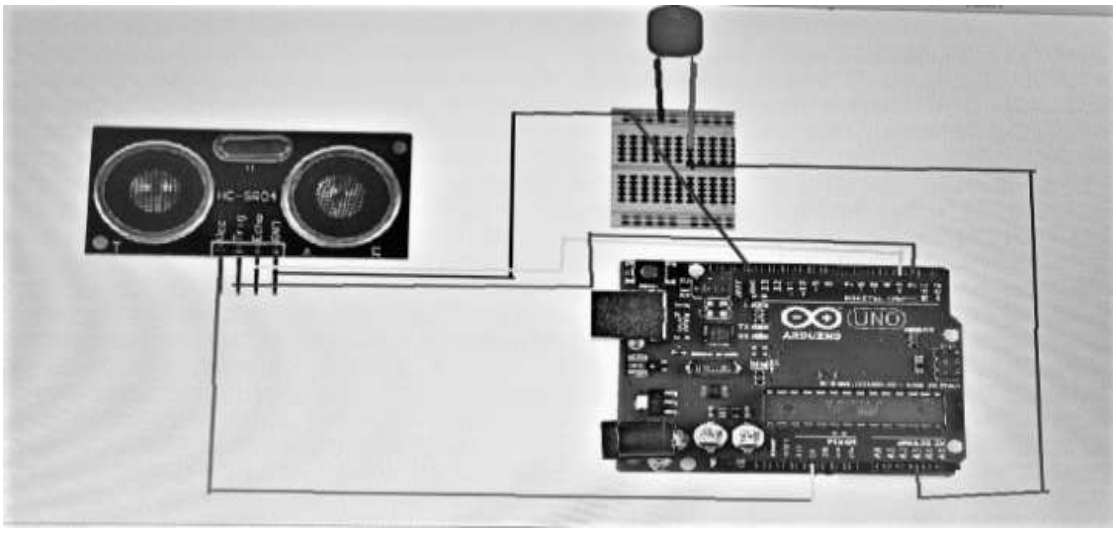

FIG 8-CIRCUIT FOR VIBRATION DETECTOR

❖ Gas detector (MQ-2):

Principle:

The MQ-2 Gas sensor can detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO, and even methane. The module version of this sensor comes with a Digital Pin which makes this sensor operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin is also TTL driven and works on 5V and hence can be used with most common microcontrollers. [11]

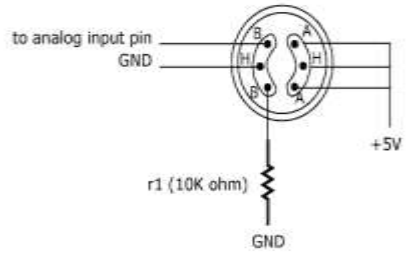

FIG 9-Gas-Detector(MQ 2)

Working:

When the gas is not detected the sensor will not send the signal and the green led will glowing here, but when the gas detects here the sensor will send a signal to the Arduino uno and that will glow the red led and start the alarm.

Circuit diagram:

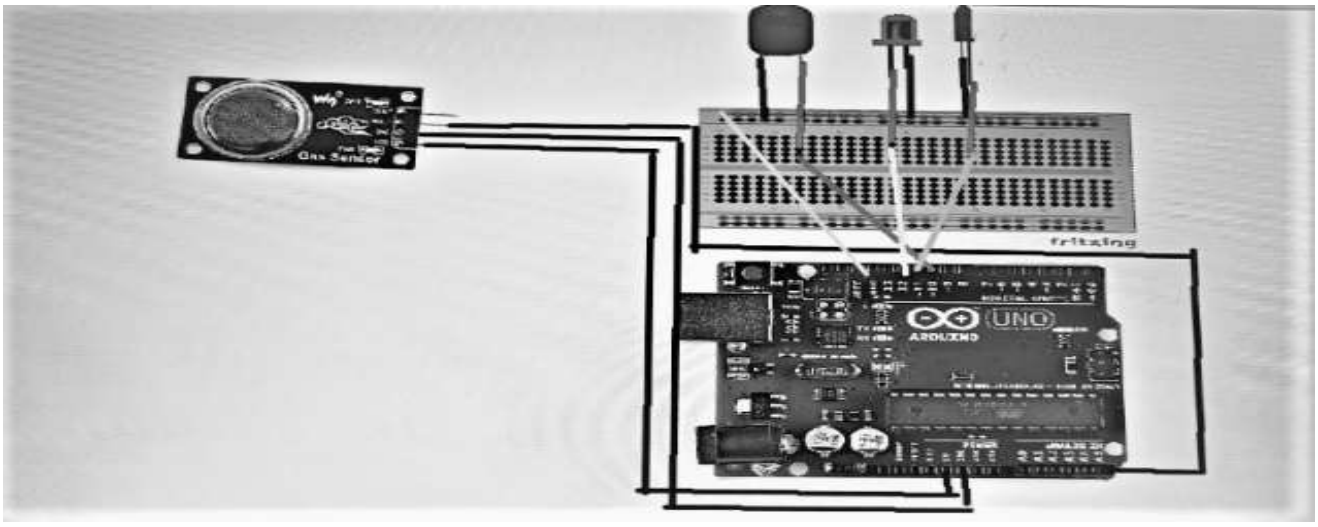

FIG 10- CIRCUIT FOR GAS DETECTOR

❖ Infrared sensor (fire detector):

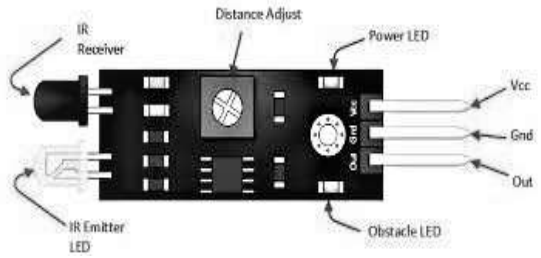

FIG 11-INFRARED SENSOR

Principle:

IR sensor is an electronic device, that emits light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation.[12]

Working:

When the fire is not detected the sensor will not send the signal and the green led will glowing here, but when the fire detects here the sensor will send a signal to the Arduino uno and that will glow the red led and start the alarm.

Circuit diagram:

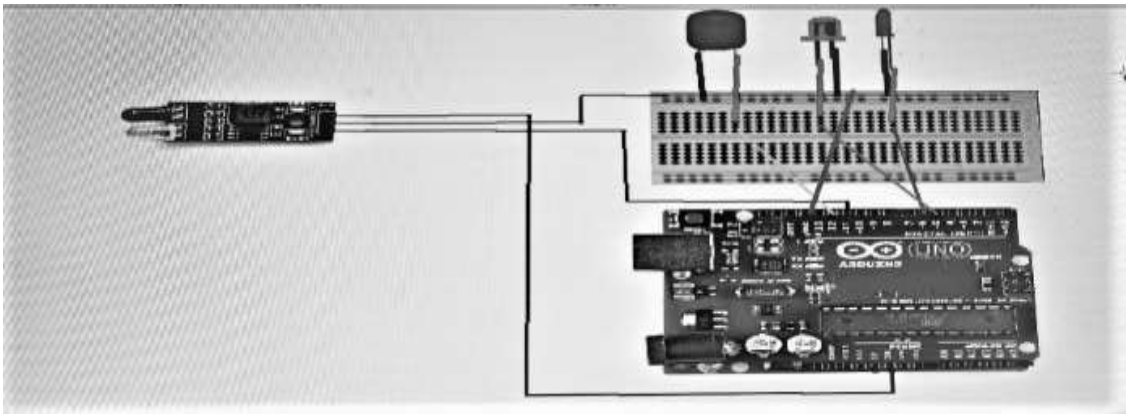

FIG 12-CIRCUIT FOR FIRE DETECTOR

- **Flow detector:**

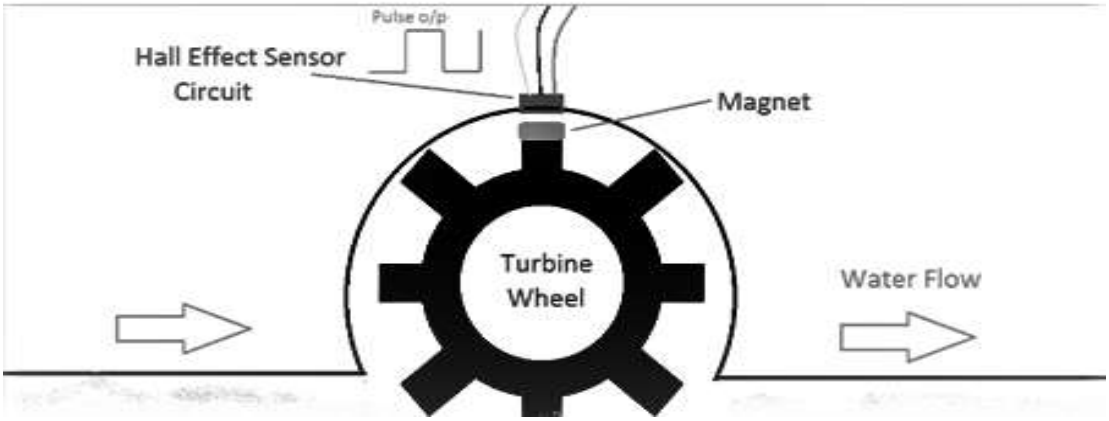

FIG 13-FLOW DETECTOR

Principle:

To monitor the amount of water being supplied and used, the rate of flow of water has to be measured. Water flow sensors are used for this purpose. Water flow sensors are installed at the water source or pipes to measure the rate of flow of water and calculate the amount of water flowed through the pipe. The rate of flow of water is measured as liters per hour or cubic meters.[13]

Working:

The water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a hall effect sensor is present the sense and measure the water flow.

When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect t sensor. Thus, the rate of flow of water can be measured.

Circuit diagram:

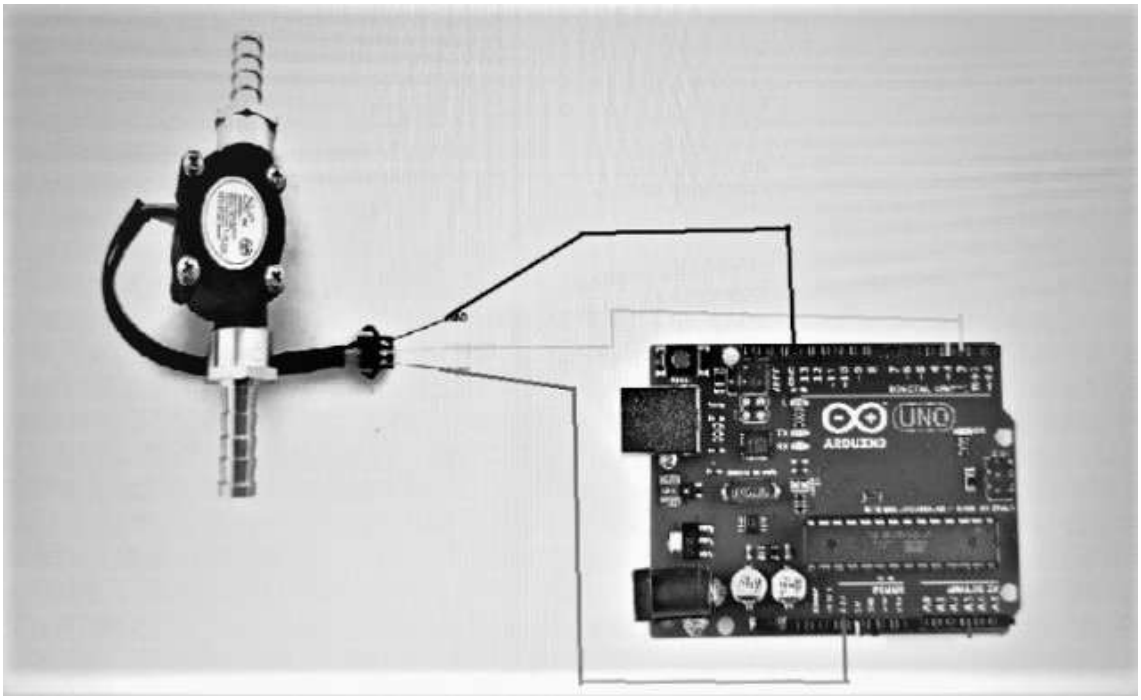

FIG 14-CIRCUIT FOR FLOW DETECTOR

Arduino Code for All Sensors:

a) Infrared sensor:

```
const int buzzerPin = 12;
const int flamePin = 11;
int Flame = HIGH;
int redled = 5;
int greenled = 6;
void setup()
{  pinMode(buzzerPin, OUTPUT);
  pinMode(redled, OUTPUT);
  pinMode(greenled, OUTPUT);

  pinMode(flamePin, INPUT);
  Serial.begin(9600);
}
void loop()
{ Flame = digitalRead(flamePin);
  if (Flame== LOW)
```

```
  { Serial.println("ATD9940648217;"); // ATDxxxxxxxxxx; semicolon should be at the last ;AT command that follows
UART protocol;
    digitalWrite(buzzerPin, HIGH);
    digitalWrite(redled, HIGH);
    digitalWrite(greenled, LOW);
       Serial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
     delay(1000);  // Delay of 1 second
     Serial.println("AT+CMGS=\"+919940648217\"\r"); // Replace x with mobile number
     Serial.println("FIRE IN THE HOUSE");// The SMS text you want to send
     Serial.println((char)26);// ASCII code of CTRL+Z for saying the end of sms to  the module
     //delay(100);
 } else
  {  digitalWrite(buzzerPin, LOW);
    digitalWrite(greenled, HIGH);
    digitalWrite(redled, LOW);
  }
}
```

b) Gas detector:

```
int redLed = 2;
int greenLed = 3;
int buzzer = 7;
int smokeA0 = A5;
// Your threshold value
int sensorThres = 400;

void setup() {
  pinMode(redLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(smokeA0, INPUT);
  Serial.begin(9600);
}

void loop() {
  int analogSensor = analogRead(smokeA0);

  Serial.print("Pin A0: ");
  Serial.println(analogSensor);
  // Checks if it has reached the threshold value
  if (analogSensor > sensorThres)
  {
    digitalWrite(redLed, HIGH);
    digitalWrite(greenLed, LOW);
    tone(buzzer, 3000, 300);
  }
  else
  {
    digitalWrite(redLed, LOW);
```

```
   digitalWrite(greenLed, HIGH);
   noTone(buzzer);
  }
 delay(100);
}
```

c) Sonar sensor:

```
#define pingPin 9       //trig pin of sr04
#define echoPin 10

void setup() {
  Serial.begin(9600); // Starting Serial Terminal
  pinMode(pingPin,OUTPUT);
  pinMode(echoPin,INPUT);
  pinMode(12,OUTPUT);   //pin12 is used as GND pin  for buzzer since arduino nano has only two GND
pins
  pinMode(11,OUTPUT);   //pin A3 provides the output on buzzer
}
void loop() {
  long duration, cm;
 digitalWrite(12, LOW);   //Buzzer GND is always low
  //send a signal at ping pin at an interval of 0.002 seconds to check for an object
  digitalWrite(pingPin, LOW);
  delayMicroseconds(2);
  digitalWrite(pingPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(pingPin, LOW);
duration = pulseIn(echoPin, HIGH);  //check time using pulseIn function
   cm = microsecondsToCentimeters(duration);   //functin call to find distance

 /* Serial.print(cm);
  Serial.print("cm");
  Serial.println();
  delay(100);

  for debugging
  */   if (cm<5&&cm>4.5)
                    {analogWrite(11,255);
                     delay(1000);
                     analogWrite(11,0);
                     delay(1000); }    //sound buzzer every second if obstacle distance is between 20-30cm.
    else if (cm<4.5&&cm>4) {analogWrite(11,255);
                     delay(500);
                     analogWrite(11,0);
                     delay(500); }   //sound buzzer every 0.5 seconds if obstacle distance is between 10-20cm.


  else if (cm<4&&cm>0)  {analogWrite(11,255);
                     delay(100);
```

```
                    analogWrite(11,0);
                    delay(100); }    //sound buzzer every 0.1 seconds if obstacle distance is between 10cm.
  else
  analogWrite(11,0); //do not sound the buzzer
}                 //function to return distance in cm from microseconds long microseconds To Centimeters(long
microseconds)
 { return microseconds / 29 / 2;
}
```

d) **Flow detector**:

```
volatile int flow_frequency; // Measures flow sensor pulses
unsigned int l_hour; // Calculated litres/hour
unsigned char flowsensor = 2; // Sensor Input
unsigned long currentTime;
unsigned long cloopTime;
void flow () // Interrupt function
{ flow_frequency++; }
void setup()
{
  pinMode(flowsensor, INPUT);
  digitalWrite(flowsensor, HIGH); // Optional Internal Pull-Up
  Serial.begin(9600);
  attachInterrupt(0, flow, RISING); // Setup Interrupt
  sei(); // Enable interrupts
  currentTime = millis();
  cloopTime = currentTime;
}
void loop ()
{
  currentTime = millis();
  // Every second, calculate and print litres/hour
  if(currentTime >= (cloopTime + 1000))
  {
    cloopTime = currentTime; // Updates cloopTime
    // Pulse frequency (Hz) = 7.5Q, Q is flow rate in L/min.
    l_hour = (flow_frequency * 60 / 7.5); // (Pulse frequency x 60 min) / 7.5Q = flowrate in L/hour
    flow_frequency = 0; // Reset Counter
    Serial.print(l_hour, DEC); // Print litres/hour
    Serial.println(" L/hour");
  }
}
```

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PROJECT NAME- SENSES

MAIN THEME – EFFICIENT SHIPPING ON CLEAN OCEANS

SUB-THEME – ADVANCEMENTS OF SENSOR TECHNOLOGIES IN SHIPPING

BY

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INTRODUCTION

Automation and Modern Technology have paved a way towards having efficient and cleaner vessels. Our group will be working on how the advancements of sensor technologies have contributed widely to improving the shipping industry.

CONCEPT

We will be mounting sensors in one of the tank in a vessel. The basic function of the sensor will be to measure the fluid level in a tank. The sensor can be used in bunker tanks, ballast tanks and in cargo storage tanks. The sensors are mounted in such a way that they can measure the fluid level of the tank even during the time of Rolling and Pitching. Having the sensors in this arrangement makes them detect various parameters like level and in turn the overall stability, any leakages can be detected immediately. The accurate level detection at each instant make the sensors widely useful and effective.

WORKING PRINCIPLE

Arduino helps in segmenting code into functions allows a programmer to create modular pieces of code that perform a defined task and then return to the area of code from which the function was "called". The typical case for creating a function is when one needs to perform the same action multiple times in a program. We have mounted sensor in a small model that is operated with the help of Arduino. The large scale implication of the model is to measure the fluid level in a tank at any instant.

COMPONENTS OF THE CIRCUIT-

1. Arduino Nano
2. ESP866 XL (Wi-Fi module)
3. Ultrasonic Sensor
4. 5V Buzzer
5. Transistor BC547x1
6. 330 Ohms resister
7. Led (Reel + Green)
8. Male-Female jumper wires.
9. Female-Female jumper wires.
10. Bread Board.
11. AMS 1117-3.3.
12. Laptop Supply or 5V (1A) Battery

MAKING OF THE CIRCUIT

Step 1: Now after the programming of Arduino and Wi-Fi module we will solder it on board.

Step 2: Solder the Arduino on board.

Step 3: Solder the resistor and LED's as shown in figure.

Step 4: Solder the resistor with transistor on same board that we have to connect later with buzzer using jumper wires.

Step 5: Now, fit the ultrasonic sensor which is used to detect the water level, fix it above the tank using jumper wires.

Step 6: Connect the pins with Arduino as shown in figure.

Step 7: Solder the Wi-Fi module on other board connecting it with the Arduino Nano and AMS1117 as shown in figure.

Step 8: Once all connections are done check the jumper wire and connection properly.

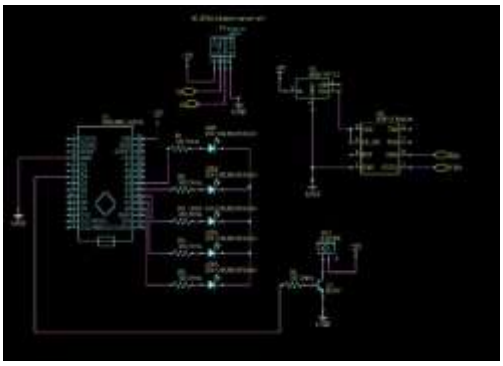

Fig a. Circuit diagram of the sensor

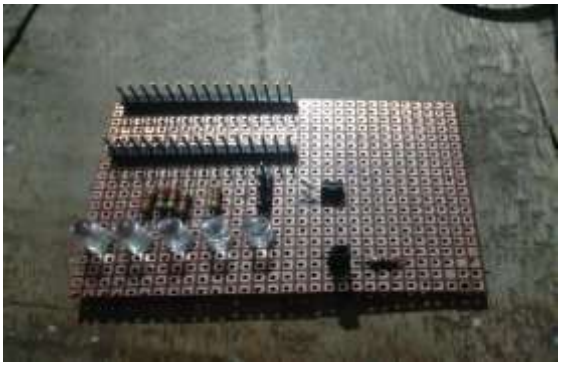

Fig b. The soldered circuit **MAKING OF THE VESSEL**

Materials:

- 4 mm thick plywood
- 0.5 inch nails
- Hot glue
- Epoxy resin (For waterproofing)

Principle Dimensions of the model vessel

LOA: 56 cm

Moulded depth: 11 cm

Moulded breadth: 9.2 cm

For the vessel we started with making the keel by taking the diagram as a visual reference. All the parts were hand cut using a junior handsaw and then nailed and glued as per requirement. After the assembly was complete the vessel was smoothed using different grades of sand paper and then finally coated with epoxy resin. Finally the tank was fitted around the mid-ship and the circuit was carefully placed inside the vessel.

Fig c. The vessel on which the sensor will be mounted

APPLICATIONS

Sensors have played a vital role in the advancement of the shipping industry. This sensor can be widely used to measure the fluid level in a tank. With this sensor coming into play, instantaneous water level can be measured and leakages and ruptures can be detected very easily.

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RIGID HIGH WING COMPOSITE SAILS FOR PROPULSION OF COMMERCIAL VESSEL

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Abstract- To definitely decrease the fuel oil utilization of an enormous vendor vessel, the use of sea wind power ought to be considered as a possibility for the primary drive force of the vessel. The new idea of "engine helped cruising transport" is proposed as an incredible eco-transport towards a low-carbon society. High rigid sails are fitted on the upper deck of the vessel. The hard sail has a sickle wing area, and additionally has a vertically adaptive reefing instrument and a self-turning instrument to meet the breeze course. The streamlined cooperation of the wing line sail framework is completed with a full scale CFD recreation. Moreover, a case concentrate on the impact of "engine helped cruising transport" in the genuine ocean was done and over half of drive energy is obtained from the sea wind power in normal.

Keywords- Wind propulsion, wingsail, Energy Saving, Sailing Vessel, CFD.

I. INTRODUCTION

To advance toward the period of a low-carbon society, it is important to radically lessen CO2 discharges from huge maritime dealer vessels that are consuming fossil oil. Consequently, a difference in fuel hotspot for transport drive is totally required for the up and coming age of trader vessels. The applicants would be driven by wind, thermal power, energy units, battery, bio-fuel, CCS (carbon-dioxide catch and capacity), and so on From the perspective of maintainability and free energy costs, it is clear that sea wind power is the best answer for drive moderate speed vehicles, like an exceptionally huge shipper vessel.

For decreasing the fuel oil utilization of a vessel, it is recommendable and surprisingly imperative to utilize wind power adrift.

The Shin Aitoku Maru (figure) was one such early modern vessels to be fitted with the JAMDA-NKK wing sails in 1980.(Endo et al 1982)

Fig. 2 shows a fishing trawler named Maartje Theadora with skysails developed by SkySails GmbH & Co. KG, a Hamburg-based company. It showed a 10% reduction in annual consumption of fuel. (©SkySails)

FIGURE 1. Shin Aitoku Maru(Photo: MK)

FIGURE 2. Maartje Theadora with Skysail (©SkySails)

II. ENGINE ASSISTED SAILING VESSEL

The idea of a "engine helped/assisted cruising transport" is required for a low-carbon society. The breeze fuelled trader vessel for a fuel oil decrease by over half is the idea of a "engine helped cruising transport" is required for a low-carbon society. The breeze controlled trader vessel for a fuel oil decrease by over half is proposed in this paper. (Ouchi, K. and Uzawa, K. 2011)

FIGURE 3. Concept picture of a motor assisted sailing vessel Credits : (B9 Energy Group)

A. Wing Sails

Wing sails create more prominent power and give simpler control than some other sort of sail in presence and are getting into more extensive use where their present plans are pertinent. With their higher effectiveness and better

taking care of in outfitting accessible breeze for impetus, wing-cruised boats, given comparative hullforms, are quicker and more flexibility and are, therefore, overwhelming the field versus their delicate cruised rivals.

FIGURE 4. NACA 6412 with extrusion for the wing sail design (top), Wingsail design with dimensions (bottom).

B. Rigid High Wing Sail

The vessel will be fitted with unbending wing sails which can be turned 360° to meet the breeze heading and reefed telescopically by a mechanical gadgets within the sail. The kind of sail that will be used is shown in the figure below from "Rotatable Telescopic Wingsail" by Jose Mandolo Delfin Jalandoni, 2013.

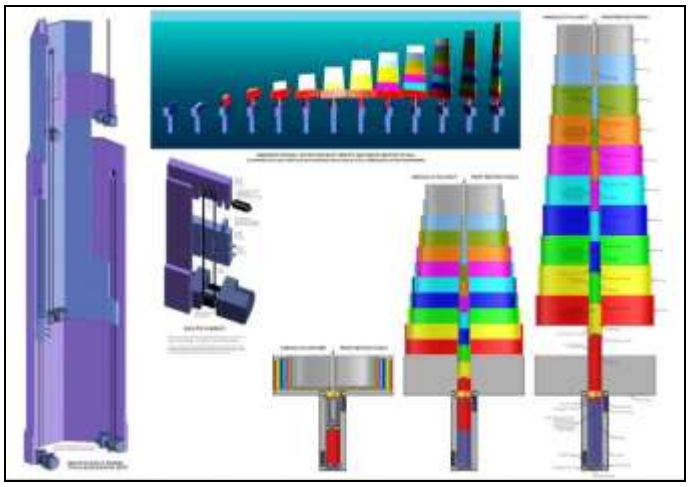

FIGURE 5. "Rotatable Telescopic Wingsail" by Jose Mandolo Delfin Jalandoni, 2013

We have made a modification here to the model.The immense inflexible sail is thought of to be made of Carbon Fiber Reinforced Polymer, progressed carbon composite material, in view of its daintiness and superb strength. In any case, the adaptive sliding pole is chosen to be of high tractable steel on the grounds that the cost of CFRP composite is very costly. These hard wing sails can withstand a drag upto 800 KN when a wind with V=30m/s is flowing. The weight is assumed to be 100 tonnes. (Ouchi, K. and Uzawa, K. 2011)

1. Advantages of using Telescopic Rigid Wing Sails:

- The sails can be brought down during a storm.
- Drag can be reduced by lowering the wings when travelling against wind.
- No obstructions while moving cargo in ships like freighters with boom crane.
- The wingsails can be easily retrofitted in merchant vessels

C. Efficiency of Rigid High Wing Sail

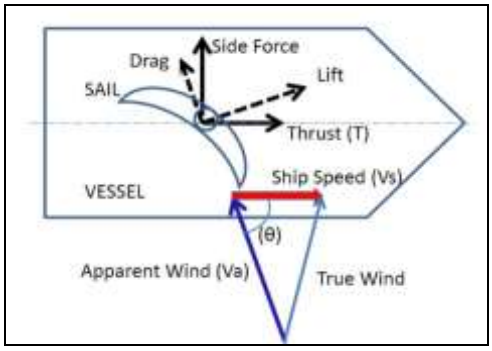

FIGURE 6. Forces acting on a wingsail (Ouchi, K. and Uzawa, K. 2011)

$$T = 0.5 \cdot \rho a \cdot Va^{\wedge}2 \cdot A \cdot Cx \qquad (1)$$

Where:
Density of the air: ρa (kg・s/m4)
Apparent Wind Speed: Va (m/s), shown in Fig. 6
Area of wing sail: A (m2)
Thrust coefficient: Cx (Variable Parameter according to the Apparent Wind Angle θ)

1. CFD simulation and prediction

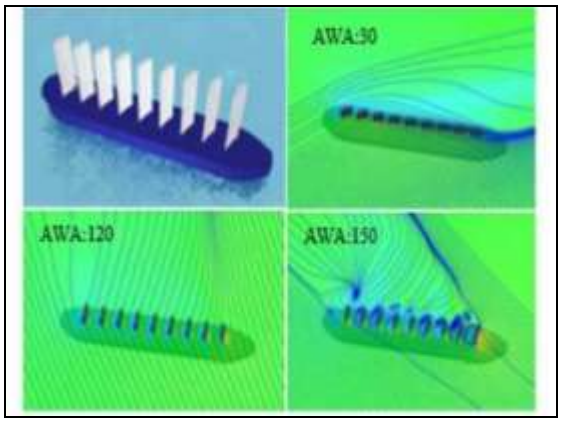

FIGURE 7. CFD simulations of modelled ship with wingsails at varying AWA (Atkinson, G. 2017)

The Apparent Wind Angle (AWA) was differed from 30 to 165. The stream representation around the 9 wing sails at AWA=30, 120 and 150 are appeared in Figure 7. The wing sail points were changed in accordance with augment the all out push power furthermore, as demonstrated in the figure, the communication between wing sails is the central issue for this. It likewise shows the push power appropriation on each wing sail at AWA=30, 120 also, 150. Because of the solid association at AWA=30, the push power appropriation shows the top at the bleeding edge wing sail and diminishes towards the hindmost one.

TABLE 1. Wind, Thrust, Power and Vessel's Speed (Ouchi, K. and Uzawa, K. 2011)

Va m/s	T ton・f	Tt ton・f	EHP KW	BHP KW	Fn $Vs/\sqrt{Lg}$	Vs kt
4.0	2	14	334	463	0.047	4.9
6.0	3	30	1,126	1,564	0.070	7.4
8.0	6	54	2,669	3,707	0.093	9.8
10.0	9	84	5,213	7,241	0.116	12.3
12.0	14	122	9,008	12,512	0.140	14.7
14.0	18	165	14,305	19,868	0.163	17.2
16.0	24	216	21,353	29,657	0.186	19.6

Where,

Tt- Total Thrust, EHP- Effective Horsepower, BHP- Brake Horsepower, Fn- Froude number, Vs- Vessel speed

From the above table, we can see that a wind of 12 m/s can drive a cape size vessel at 14 knots without engine.

III. CASE STUDY

A reproduction of wind energy using proportion of the vessel was completed in a genuine journey in the pacific exchange wind territory of Hawaii Islands Ouchi, K. and Uzawa, K. (2011), shown in figure 8.

FIGURE 8. The Area of Actual Sea Simulation(Ouchi & Uzawa 2009)

Characteristics of the wind in this region- The wind direct is east or north east and the average speed is 8.1 m/s. [] The ship journeys northward or southward without altering the course. The ship is completely driven by the engine and propellow when moving against the wind (Ouchi & Uzawa 2009).

TABLE 2. Wind Energy Utilizing Ratio

Power (MW)	JAN		APR		AUG		NOV	
Vs (kt)	14	-14	14	-14	14	-14	14	-14
BHP (MW)	16	16	16	16	16	16	16	16
W	0	0	0	0	0	0	0	0
SW	0	0.1	0	0	0	0	0	0
S	0	0.1	0	0	0	0	0	0
SE	0.1	0.4	0	0	0	0.1	0	0.2
E	4.4	7.6	3.7	6.4	1.7	2.9	4	6.8
NE	1.2	4.4	2.8	9.2	2.9	11.2	2	7.1
N	0	0	0	0	0	0.1	0	0
NW	0	0	0	0	0	0	0	0
Total (MW)	5.8	12.7	6.5	15.6	4.6	14.3	6.1	14.2
Utilizing Ratio (%)	36	80	41	97	29	89	38	89

This table shows the wind energy utilisation ratio when the ship is moving at a fixed speed of 14 knots as discussed above while calculating the forward thrust using equation (1). The outcomes are huge: normal ratio at northward is 36％, southward is 89%, and all out average proportion is 64%.

From the above study we can easily draw a parallel that more than 50% fuel energy can be saved by employing wind energy in the Pacific Trade Wind Region. (Ouchi, K. and Uzawa, K. 2011)

III. CONCLUSION

A wingsail is proposed for establishment on a Trader vessel. It is tracked down that a lot of fuel can be saved utilizing this economical fuel source. The advantage of utilizing this innovation is twofold: it will limit the air contamination and it is utilizing environmentally friendly power energy. These sails are made of CFRP and are installed telescopically with 360 degrees rotation. The avoidance and stress computation on the sails is done and it is perceived that the framework is sensible and prudent for an exceptionally huge merchant ships. While calculating the Forward Thrust using equation (1), we see that the ship moves with a velocity of 14 knots without the help of the propellor. The calculations can be applied to a cape size bulker. CFD reproduction on the stream field of nine wing sail framework is done, and all out push of the vessel is assessed in instance of upwind, abeam and down wind. It has been proposed that critical force from such gigantic sails can decline fuel oil utilization definitely by practically over half in ideal locales. Therefore, based on the above mentioned facts, circumstances and statistics, it can be concluded that High Rigid Wing sails are a good alternate source of propulsion of vessels.

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ANTI PIRACY SYSTEM IN PORT CONTROLLED SHIP

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Abstract: This model is based on the theme 'Advancement in Sensor Technology in Shipping'. As we know that soon we are going to have crewless ships running all around the globe. SVAN (Safer Vessel with Autonomous Ferry) collaboration of Rolls Royce and Finferries have successfully demonstrated fully autonomous ship. They have achieved by using artificial intelligence, advanced sensors, autonomous navigation and many more. But, the safety of the goods carried by the vessel is rarely mentioned. Piracy is still practised at sea. We cannot ignore piracy at sea in search of automation in shipping industry. Graph of number of pirate attack from year 2010 to2020 is given in Fig.1. Crewless ship would be a golden opportunity for pirates to do their work fearlessly. Considering the great danger of piracy in crewless ship this model is made. This anti-piracy system will prevent the attack of pirates in autonomous ship and will make the goods carried by autonomous vessels safe at sea.

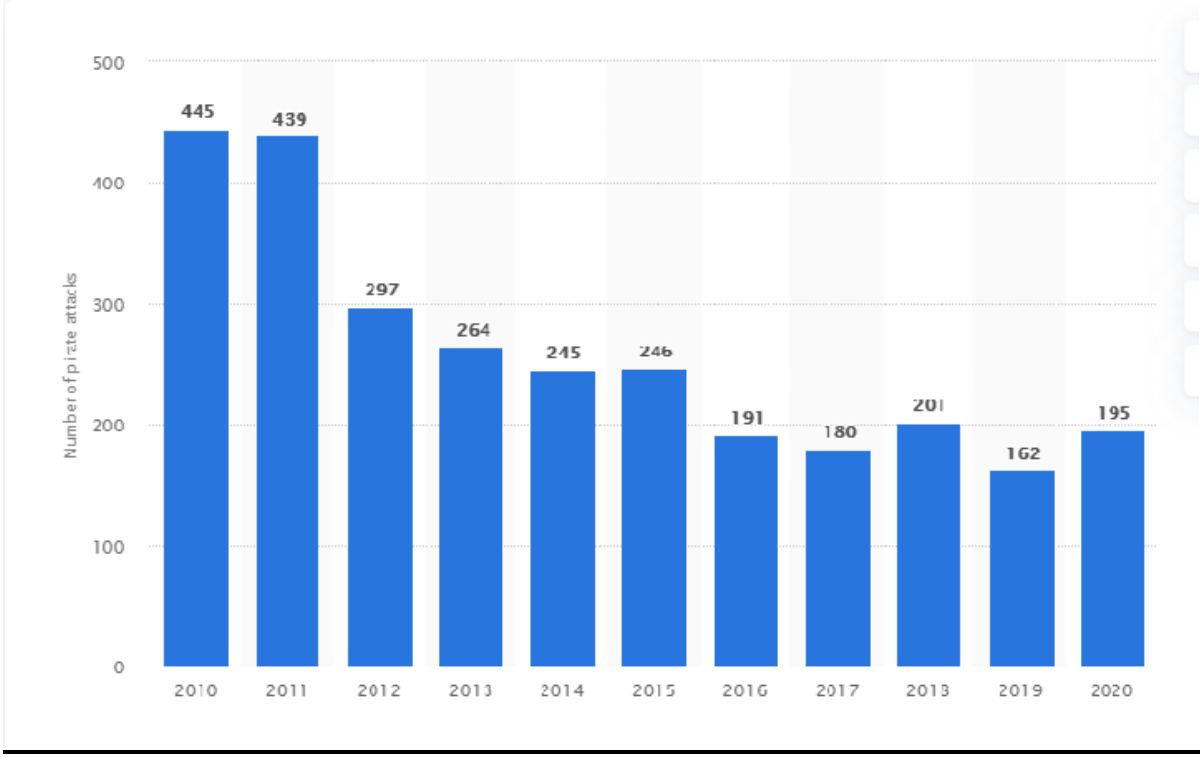

Fig.1: Number of pirate attack from year 2010 to2020

1.Introduction

The command will be given from port to the ship through transmitter and reciever module and machines in the ship will work according to the command sent from port.

The anti-piracy system will consist of ultrasonic sensor, arduino uno(microcontroller), and water cannon.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, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.The ultrasonic sensor and water canon will be controlled by Arduino uno.

Many ultrasonic sensors and water canons will be attached in the freeboard of the ship at a certain level as shown in Fig.2. The ultrasonic sensor will detect if any solid object is near the ship or not. The readings of the ultrasonic sensor will be seen from the port. The sensor will show a constant distance i.e. maximum range of the sensor when no solid object is in front of it. If the reading changes then we will get to know that a boat is near the ship. The sensor will give us the distance between the pirate's boat and our ship. A 'water cannon on distance' will be set on the ultrasonic sensor that if the distance between pirate's boat and our ship becomes less than water cannon on distance then the water cannon below the sensor will turn on and throw high pressure water to the pirate's boat.It will turn off if the distance between pirate's boat and our ship becomes grater than water cannon on distance. This will prevent coming of any solid object such as pirate's boat to come near the ship from any direction. The water cannon on distance can be controlled from port.We can reduce the 'water cannon on distance' if the ship is passing througeh a narrow canal. It can also be turned off when the ship is near any port. If any non piracy boat wants to come near the ship such as tug boat then it would need to take the permit from the ship's company. If it gets the permit then the sensors can be turned off for some time. The water canon will throw seawater when turned on as it can be used unlimiteadly and it will also not affect marine life. This will prevent pirates to come near the crewless ship, so the goods will be carried safely in the sea.

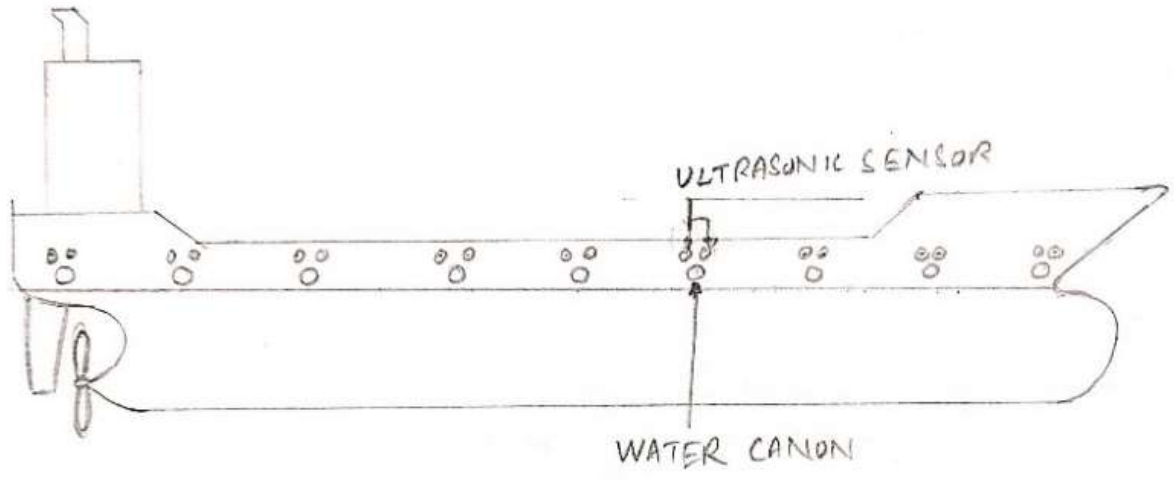

Fig.2: Ultrasonic sensors and water cannon attached in freeboard

Working Principle:

The ship is wirelessly connected to port by transmitter and receiver module. The controller at port will be used for running the ship. Ultrasonic sensor is used to detect pirate's boat near the ship.The readings of the ultrasonic sensor will be continiously monitored in the port.If any pirate's boat comes too near of the ship water cannon will throw high pressure water to the pirate's boat which will prevent them to enter the ship.

Materials Used:

- **Arduino uno R3:**

Fig.3: Arduino uno R3

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

- **Motor Driver Shield:**

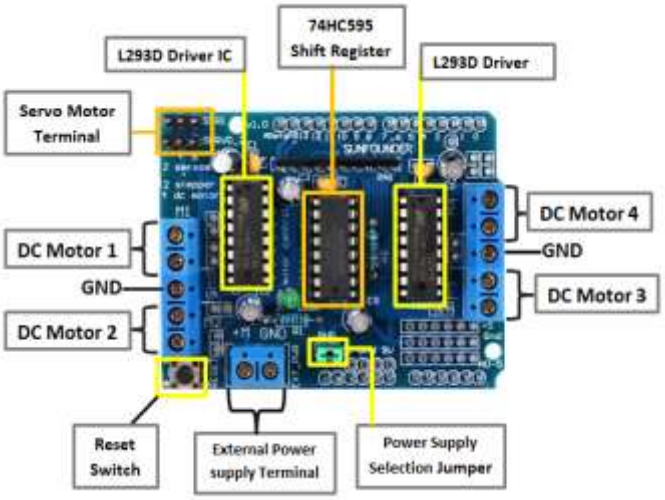

Fig.4: Motor Driver Shield

The Motor Shield is a driver module for motors that allows you to use Arduino to control the working speed and direction of the motor. Based on the Dual Full-Bridge Drive Chip L298, it is able to drive two DC motors or a step motor. The Motor Shield can either be powered by Arduino directly or by an external 6V~15V power supply via the terminal input. This module can be used for the development of micro robots and intelligent vehicles, etc.

- **Relay Module:**

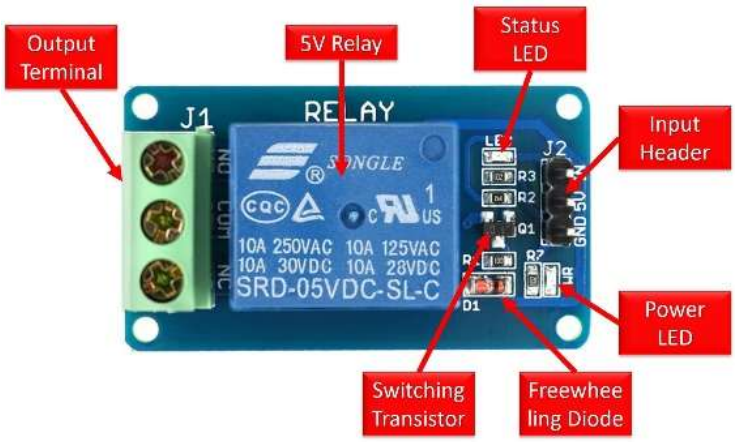

Fig.5: Relay Module

The relay is the device that open or closes the contacts to cause the operation of the other electric control. It detects the intolerable or undesirable condition with an assigned area and gives the commands to the circuit breaker to disconnect the affected area. Thus protects the system from damage.

Working Principle:

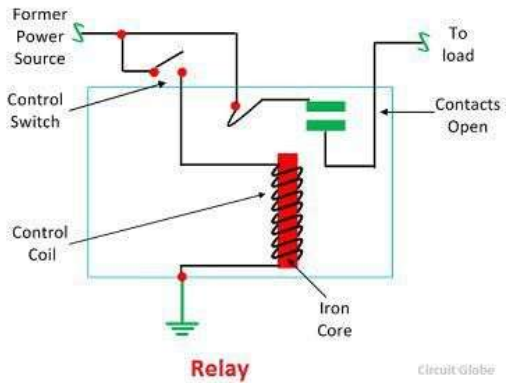

Fig.6: Working Principle of Relay Module

It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energises the electromagnetic field which produces the temporary magnetic field.

This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high power relay has two contacts for opening the switch.

The inner section of the relay is shown in the figure. It has an iron core which is wound by a control coil. The power supply is given to the coil through the contacts of the load and the control switch. The current flows through the coil produces the magnetic field around it.

Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load. If the contact is already closed, then it moves oppositely and hence open the contacts.

- **Bluetooth Module HC05:**

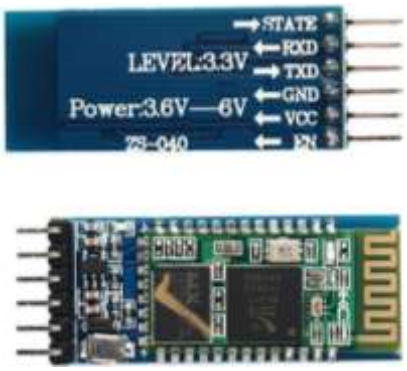

Fig.7: HC-05 Bluetooth Module

HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. ... HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

- **Ultrasonic Sensor:**

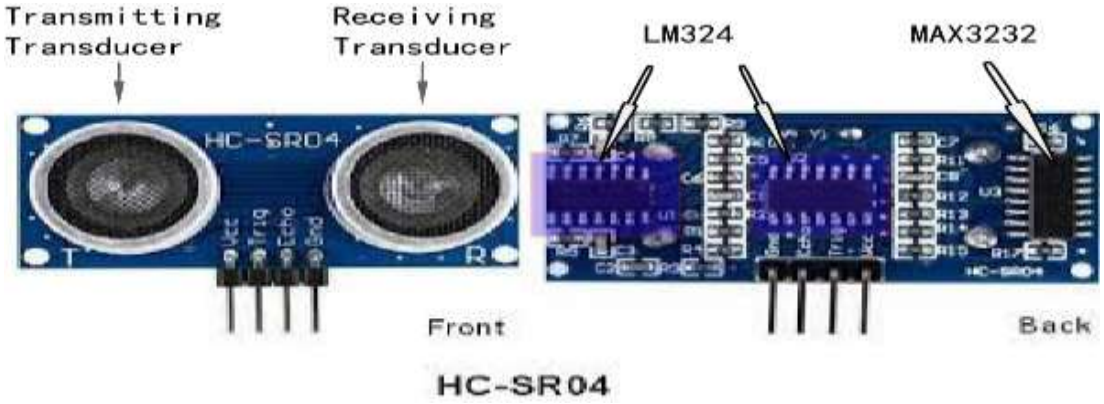

Fig.8: ultrasonic sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is **D = ½ T x C** (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second).

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, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.

- **Water Pump AC:**

Fig.9: Water Pump

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into hydraulic energy. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.[1]

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, and come in many sizes, from microscopic for use in medical applications, to large industrial pumps.

Working Principle

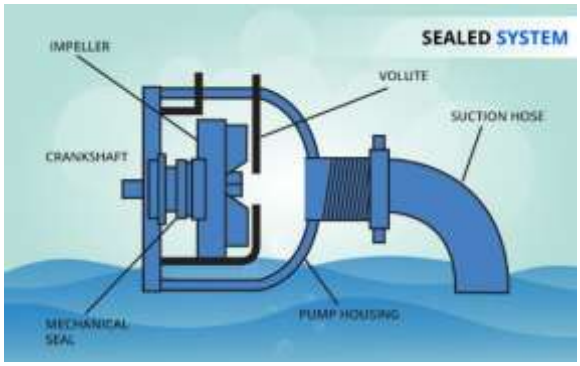

Fig.10: Working Principle

All pumps use basic forces of nature to move a liquid. As the moving pump part (impeller, vane, piston diaphragm,etc.) begins to move, air is pushed out of the way. The movement of air creates a partial vacuum (low pressure) which can be filled up by more air, or in the case of water pumps, water.

- **DC Motor 9v:**

Fig.11: DC motor

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

- **Jumper Wires:**

Fig.12: jump wire

A jump wire (also known as jumper, jumper wire, jumper cable, DuPont wire or cable) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.[1]Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

- **Adapter 5v:**

Fig.13: 5V Adapter

An AC-to-DC power supply adapts electricity from household mains voltage (either 120 or 230 volts AC) to low-voltage DC suitable for powering consumer electronics. Small, detached power supplies for consumer electronics are called AC adapters, or variously power bricks, wall warts, or chargers.

Circuit Diagram:

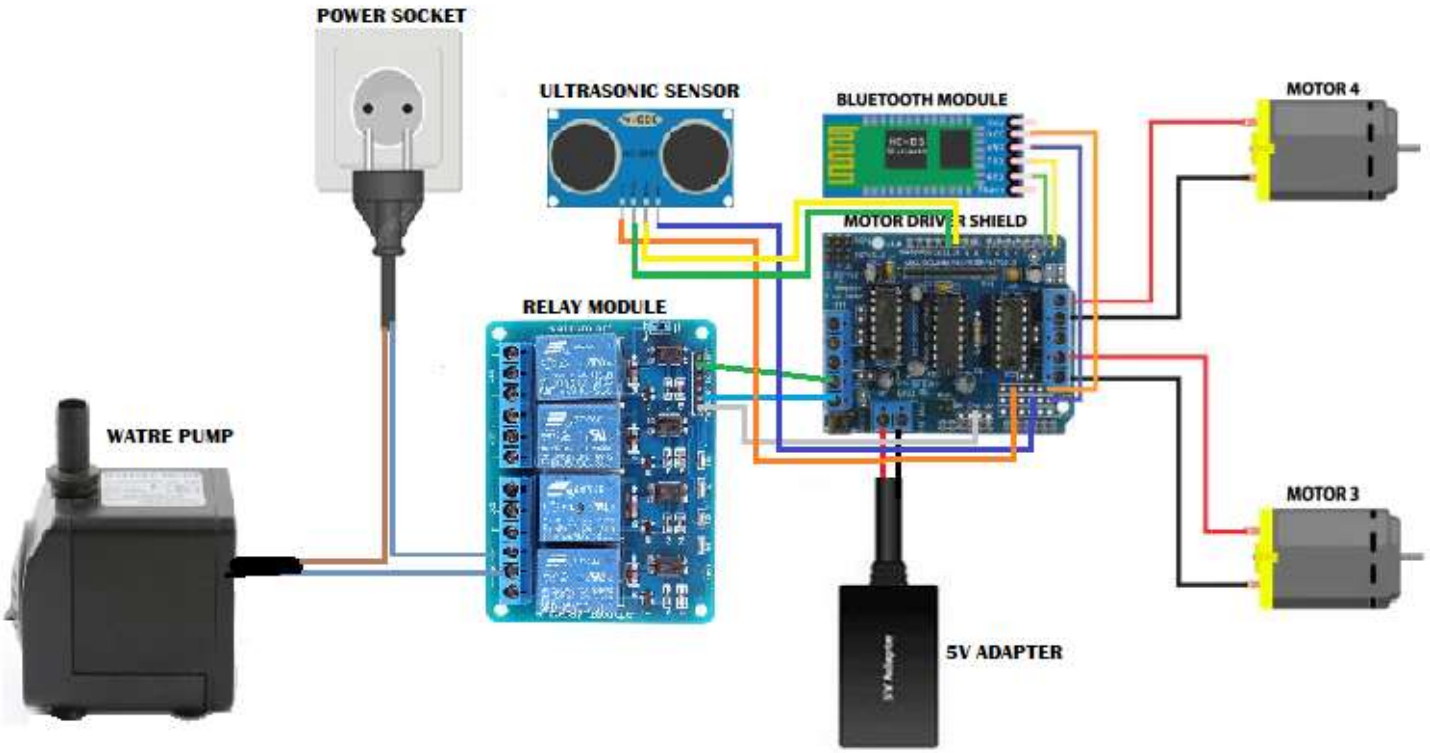

Fig.14: Complete Circuit Diagram of Anti-piracy system on port controlled ship

Arduino Code:

```
#include <AFMotor.h>

AF_DCMotor motor1(3);
AF_DCMotor motor2(4);

AF_DCMotor motor3(2);

const int trigPin = 10;
const int echoPin = 11;

long duration;
int distance;
int safetyDistance;
```

```
char command;
 void setup()

{
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Serial.begin(9600);
}

void loop(){

digitalWrite(trigPin, LOW);
delayMicroseconds(2);

digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);

distance= duration*0.034/2;

safetyDistance = distance;
if (safetyDistance <= 20)
{
 pumpon();
}
if (safetyDistance=0)
{
 pumpoff();
}
else
{
 pumpoff();
}

Serial.print("Distance: ");
Serial.println(distance);
if(Serial.available() > 0){
command = Serial.read();
Stop();
switch(command){
```

```
case 'F':
propelercw();
break;
case 'B':
propeleracw();
break;
case 'L':
rudderleft();
break;
case 'R':
rudderright();
break;
}
}
}

void propelercw()
{
motor1.setSpeed(255);
motor1.run(FORWARD);
motor2.setSpeed(0);
motor2.run(RELEASE);
}

void propeleracw()
{
motor1.setSpeed(255);
motor1.run(BACKWARD);
motor2.setSpeed(0);
motor2.run(RELEASE);
}

void rudderleft()
{
motor1.setSpeed(0);
motor1.run(RELEASE);
motor2.setSpeed(255);
motor2.run(FORWARD);
}

void rudderright()
{
motor1.setSpeed(0);
```

```
motor1.run(RELEASE);
motor2.setSpeed(255);
motor2.run(BACKWARD);
}

void Stop()
{
motor1.setSpeed(0);
motor2.run(RELEASE);
motor2.setSpeed(0);
motor2.run(RELEASE);
}
void pumpon()
{
  motor3.setSpeed(255);
  motor3.run(FORWARD);
}
void pumpoff()
{ motor3.setSpeed(0);
  motor3.run(RELEASE);
}
```

2.Conclusion:

As the transmitter and receiver module works within a range so practically the ship will be wirelessly connected to port by gsm module and satellite phone as it does not have any range so we can get connection between port and the ship from anywhere in the world. Advanced sensors will be used with good range and heavy duty water cannons will be used in the automated ship. GPS module will be also installed in the ship for navigation purpose.

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