ADVANCEMENTS IN ELECTRICAL, ELECTRONIC AND AUTOMATION SYSTEMS IN TRANSPORTATION

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Abstract: Through our presentation we have tried to bring forward the stages of evolution and application of the advancement of technology in electronics, electrical and automation systems. With each stage we see the changes in performance and the efficiency of the system. With each upgrading stage of automation we have tried to analyse the effect of the technology in terms of environment, ease of working, accuracy, flexibility, etc. This advancement in technology has evidently proven that with every up gradation, the accidents, loss of human life and other catastrophes have been reduced significantly. At the same time, the job scope of the people has changed and also it has brought a major reform looking at the economic point of view thereby making it economically feasible and applicable.

Keywords: Hydrogen fuel-cell, Automated vehicles, Automated container terminals

1. Introduction:

Till now, the transportation sector is mainly using fossil fuel as a major source of energy though a small fraction is also contributed by batteries, fuel cells, etc.

One of the earliest application of electric driven (batteries) vehicle was in mid nineteenth century. The first known electric locomotive was built in 1837, in Scotland. It was powered by the galvanic cells (batteries).

Now-a-days, as a direct result of the vigourous rate of depletion of fossil fuels, the concept of the electric vehicles for transportation is being implemented widely. But what impact will the electric materials have on the environment after the entire potential will be exhausted? It will lead to the formation of E-waste in huge quantities which more or less will surely have a negative impact and at some point will have to be eventually decommissioned. With the advancement in technology, the hydrogen fuel-cell is proving to be a better alternative.

2. Advancement in Electrical Technology and Automation

A hydrogen fuel-cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through certain reactions. Fuel cells are different from most batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction. Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

Hydrogen + Oxygen = Electricity + Water Vapour

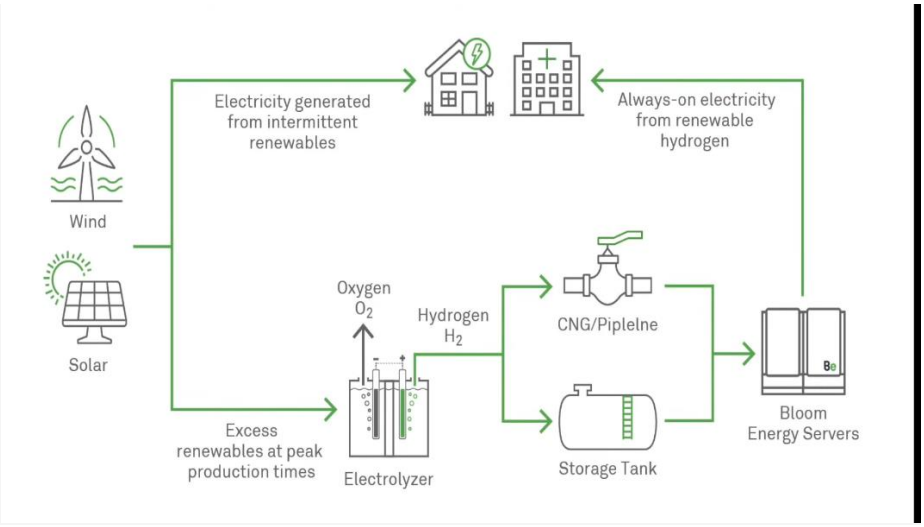
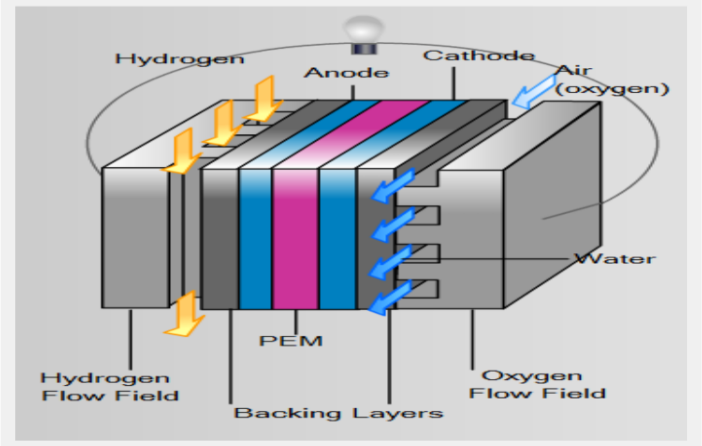


FIGURE 1. Application of hydrogen fuel cells



Cathode: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
Anode: $2H_2 \rightarrow 4H^+ + 4e^-$
Overall: $2H_2 + O_2 \rightarrow 2H_2O$

FIGURE 2. Working of the hydrogen fuel-cells

For automation to function accurately, the major requirements of the energy source should fulfill certain basic requirements:

- Continuous supply of energy
- Eco- friendly
- Should be available in adequate quantities
- Sustainable

Some of the advantages of the hydrogen fuel-cell are as follows:

- Zero emissions
- High level of energy efficiency
- Better fuel economy rating in vehicles
- Better consistency
- Flexibility in installation and operation
- Reduced demand for foreign oil
- Eliminates noise pollution, etc.

Because of the above advantages, the hydrogen fuel-cell can be used to supply the power to the equipments of various automation systems.

2.1 Automation:

The technique, method, or system of operating or controlling a process by highly automatic means, as by electronic devices, reducing human intervention to a minimum.

To reduce human deaths and accidents, we use automation to do the life threatening and dangerous jobs. Application of automation increases the accuracy in the dedicated areas thereby reducing the accidents and saving human lives, also reducing the costs and making the operations economical and safe**.**

For example: Earlier, during mooring operation, a large number of people have been injured due to the snapping of the mooring lines but with the current automated mooring systems, the job is done without physical involvement preventing the mishaps. Also the accuracy of the automated mooring systems is far greater than what it would be done by the crew and hence this accuracy is unaffected all the time and in all conditions (snowing, raining, windy).

2.1.1 Advanced Automation In Transportation

The current level of automation which has been applied in vehicles are:

- Auto start
- ABS (Anti-lock braking system)
- Auto adjusting headlights
- Automatic parking assist
- Traction control,
- Driver alert control
- Parking assist
- Auto transmission, etc.

Now automation has evolved to such an extent that we now have self-driving vehicles. Self-driving vehicles combine a variety of sensors to perceive their surroundings, such as radar, lidar, sonar, GPS, odometry and inertial measurement units. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

With involvement of automation, the overall performance and efficiency of the vehicles is increased manifold times. Automation is also playing a very crucial role in the developement of the smart vehicles. These vehicles are not only capable of operating on their own but also takes into consideration, the preferences of its passengers (Songs, Movies, Routes, etc.). These vehicles are also employed with artificial intelligence to a certain extent which makes the operation of automated systems even easier.

For Example: The sensor present on the dashboard of the car monitors the blinking frequency of the driver. As the driver tends to get sleepy, the sensor senses this and rings an alarm to alert the driver but inspite of this if the driver still doesn't get alerted, with the aid of artificial intelligence integrated in the control system of the car, the car gets parked automatically in the side lane without the driver's assistance.

So, with the current technology mentioned above if hydrogen fuel-cells are used as a primary energy source then the vehicle will have the attributes of both the above mentioned technology and the advantages of the hydrogen fuel-cell.

Currently, the leading automotive companies have leased and sold more than 6,500 FCV's (Fuel Cell Vehicles) and many of the world's automotive companies plan to produce their own FCV's in the next couple of years.

Fuel cell vehicles use hydrogen gas to power an electric motor. Unlike conventional vehicles which run on gasoline or diesel, fuel cell cars and trucks combine hydrogen and oxygen to produce electricity, which runs a motor. Since they're powered entirely by electricity, fuel cell vehicles are considered electric vehicles ("EVs")—but unlike other EVs, their range and refueling processes are comparable to conventional cars and trucks.

Producing the hydrogen itself can lead to pollution, including greenhouse gas emissions, but even when the fuel comes from one of the dirtiest sources of hydrogen, natural gas, today's early fuel cell cars and trucks can cut commissions by over 30 percent when compared with their gasoline-powered counterparts. Future renewable fuel standards—such as the requirements currently in place in California—could make hydrogen even cleaner.

2.2 SHIPS*:*

So, now coming to the shipping industry the main aim is to reduce the number of accidents by reducing the amount of the jobs to be done by the crew as most of the accidents occurring onboard are a direct consequence of a human error. A proven research says that human error accounts for approximately 80% of the accidents occurring onboard. This may happen due to a number of reasons such as long voyage lengths, fatigue, complacent nature of the crew, etc. Therefore, there is a very urgent need to reduce the workload on the seafarers. In order to achieve this objective, it has become very important to employ the newly developed, highly efficient automated techniques in ships.

Automation in the shipping industry has now evolved to such an extent that most of the systems onboard ships can be operated by automation, with a very little human supervision.

For example: Let us consider a main engine of a ship

Earlier, marine boilers were primarily installed on a ship for the propulsion plant, which used to run on steam (steam engine).Later the steam propelled engines were phased out and I.C engines (Internal Combustion) were introduced. Initially, these I.C engines were cam driven engines but later on these were replaced by intelligent engines or camshaftless engines.

Camshaftless engines are utilizing electronically controlled fuel injection and exhaust valve actuation systems. Research and development has advanced so that smart low speed-diesel engines are being installed in new ships.

The concept of the intelligent engine revolves around the idea that the engine is thinking for itself. The brain of the system is an electronic control system that analyzes the condition of the engine and the operation of the engine's system (The fuel injection, exhaust valve, cylinder lube oil and turbo charging system). Along with the control and timing needed to make the diesel run smoothly, the intelligent diesel goes beyond that by monitoring and evaluating the condition of the

engine, based on engine conditions the smart system can actively protect the engine from damage due to overload, lack of maintenance and maladjustment. The intelligent engine's finite control gives the bridge the ability to manually adjust more variables than the current camshaft system. Along with manual controls, operators can specifically design programs that optimize fuel economy, emission, turbo output, allowing for high performance under different loads.

The convenience of the camshaft is that not only does it keep the timing of the opening and closing valves and injecting fuel through its cams, it is also responsible for the mechanical force that is required to actually open and close the valves and power the port and helix fuel pump. The camshaftless intelligent system uses the rotation of the engine to power an axial piston pump that pressurizes a hydraulic oil system. The potential energy from the hydraulic pressure is directed by the electronically controlled servo system to drive InFI (Intelligent Fuel injection) and InVA (Intelligent Valve Actuation) systems.

The Intelligent, Camshaftless, diesel engines offer several potential improvements for marine diesel main engines. Variable electronically controlled timing of fuel injection and exhaust valves for lower specific fuel consumption and better performance parameters. The electronic controls also offer lower RPM for manoeuvring, including better astern and crash stop performance. With the smarter InFI (Intelligent Fuel injection) system the ship operator can more precisely control fuel consumption and improve emission characteristics. The highly integrated monitoring system allows for the potential of longer time between overhauls by equalizing the thermal load between cylinders.

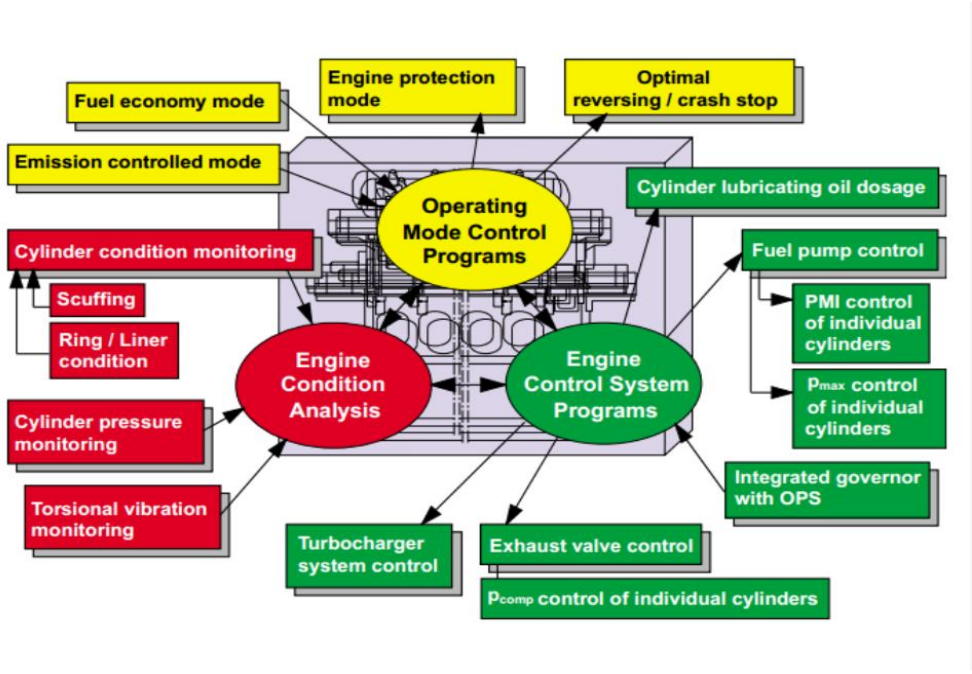


FIGURE 3. Block diagram of intelligent engine

Some of the other systems which use automation onboard ship are:

2.2.1 Automatic Navigation And Steering System

With the introduction of ECDIS (Electronic chart display and Information system), the traditional system of chart plotting has been phased out. Hence, the ECDIS has many advantages like: It is simple, reliable, and more accurate, real time update of charts is possible, grounding of the vessel can be prevented because of anti-grounding tool, the position of the vessel can be also plotted more accurately than it would have been plotted by employing the conventional methods of navigation and chart work.

2.2.2 Automated Main Engine:

Currently many efforts are being made to develop intelligent engines. With the help of automation, the efficiency of the engine has increased. Fuel is now burnt completely to produce the maximum output. Also, the emissions can be regulated and thereby make the engine run within the parameters specified by the international regulations.

2.2.3 Automatic Fire-Fighting Systems:

Automation has enabled us to prevent fire because the best way to fight a fire is to prevent it. Even if by chance, a fire takes place the fire-fighting system does the following functions: Raises the alarms which alerts the people, It is also capable of activating the extinguishing system.

2.2.4 Condition Monitoring, Maintenance & Inventory Management:

Automation has made it possible for us to calculate and compare the working parameters of the engine and helps us to determine the current working condition of the engine. Hence, the maintenance engineers can be helped by the automation systems to run the engine efficiently.

Similarly, based on the condition of the engine, the maintenance of the engine can be planned to prevent breakdown and stalling the operations of the engine.

Automation has made it easier to maintain a correct inventory of the spare parts which are required thereby reducing the wastage and cutting the cost to the company thereby making shipping more economical and profitable to the owner.

Looking at the future perspective, if hydrogen fuel-cells can be put to use instead of the conventional electrical power source, then the system can derive the advantages of the hydrogen fuel-cell thereby making the system better, efficient, reliable and eco-friendly on the electrically driven vessels.

The scope of automation was further widened when it was applied in the port based systems there by improving the logistics management and making the business more profitable.

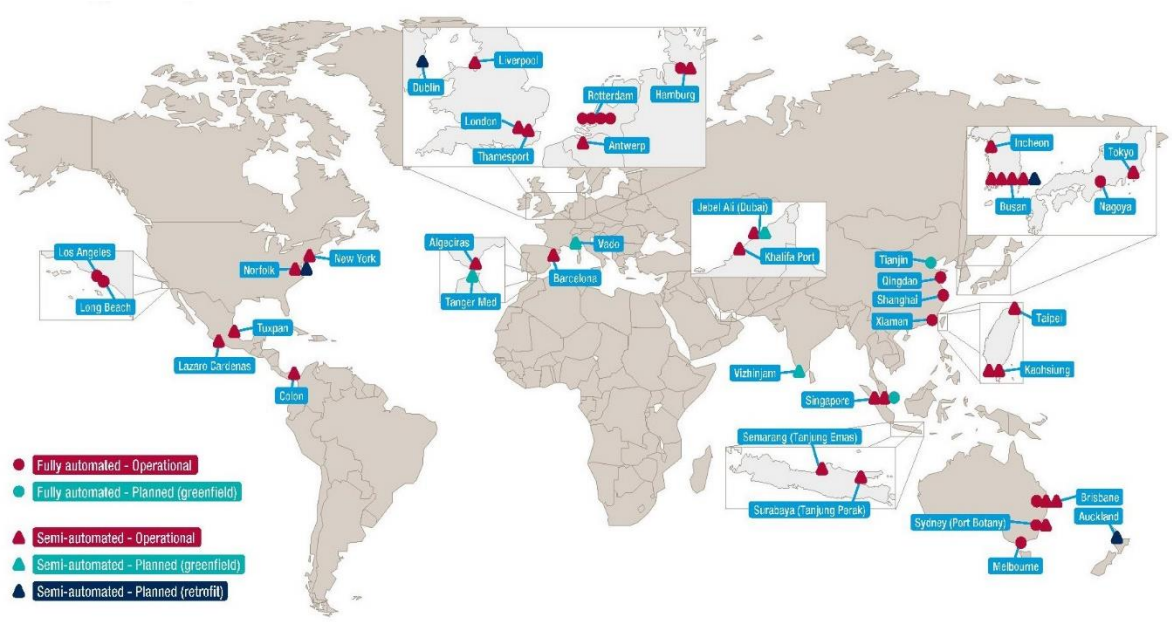


FIGURE 4. Existing and planned automated container terminals

2.3 Advantages Of Automated Terminals

The benefits are clear. Inefficiencies with port and carriers cost the industry as much as $17 billion a year and a fully automated terminal can reduce the number of workers required by at least 45%.

There's also the reduction of human errors and delays, and the fact that fully automated terminals are capable of providing 24/7 service - through the night, in complete darkness, and with no need for a caffeine or bathroom break.

2.4 Qingdao New Qian wan Container Terminal, Port of Qingdao

The Qingdao New Qian wan Container Terminal (QQCTN) at the Port of Qingdao is Asia's first fully automated terminal. Rather aptly, it's known to locals as 'ghost ship'.

"It's all controlled by artificial intelligence". "Through laser scanning and positioning, the program is able to locate the four corners of each container. It then accurately grabs them and puts them onto the driverless trucks. That's why it's able to work in complete darkness. These smart autopilot trucks, driven by electricity, have their routes and tasks under digital control. They even know when it's time to go for a recharge. Labor costs have been reduced by 70 percent because of this automatic terminal, while efficiency increased by 30 percent, because we can work at night. It used to take about 60 workers to unload a cargo ship, but the automatic port requires only nine. The automation has also changed it from a blue collar task into a white collar one. Workers used to operate the machines in sky-high cranes, but now much of the work has been left to a computer in the office. The 5.2 million TEU terminal now has two fully-automated berths across 660 meters of quay with seven STS cranes operated by remote control, 38 automated stacking cranes and 38 battery-powered automated guided vehicles. The three-year time-span significantly reduces the risk for investment, which makes it feasible to replicate in other cities.

With machines having taken over from berth to container yard, the humans can retreat to their control rooms and monitor them from there.

The terminal began operations in May 2017. In its first year, it handled close to 800,000 TEUs and serviced over 660 vessels. When operations started, it had an average loading efficiency of 26.1 containers per crane per hour. That figure has since increased to 33.1, which is reportedly 50% more than the average worldwide.

2.5 Yang Shan Deep Water Port, Port of Shanghai

It should come as no surprise that the world's largest fully automated port is at the world's busiest port - the Port of Shanghai. It's located on Yang Shan Island, just across Donghai Bridge, which was specially built to service the terminal.

Phase 4 of the Yang Shan Deep Water Port, covering 2.23 million square meters and 2,350 meters along the shoreline, began trial operations in December 2017.

FIGURE 5. Yang Shan Deep Water Port, Port of Shanghai

Once fully operational, the terminal will add seven additional berths to the port. It'll initially have a handling capacity of 4 million TEUs. But that is expected to be expanded to 6.3 million TEUs later, boosting the capacity of the Port of Shanghai to over 40 million TEUs per year.

Upon completion, the Yang Shan container port will be fully handled by 130 automated guided vehicles AGVs, the most in any single container terminal the world. Alongside them will be 26 bridge cranes, 120 rail-mounted gantry cranes, and just a handful of workers tucked away comfortably in a control room.

A fully automated container terminal involving a total investment of 14 billion Yuan ($2.15 billion) has started operating at Shanghai's Yang Shan Port.

Part of Shanghai Port-has been designed to handle a maximum of 6.3 million TEUs (20-foot equivalent unit), making it the largest automation port worldwide to date.

Its unique energy consumption structure should result in zero carbon dioxide or other emissions while allowing savings of up to 70 percent.

2.6 Economic Impacts:

Autonomous shipping holds the potential for providing numerous benefits to the maritime industry. One benefit is the reduction of human error that often plays a key role in the cause of accidents at sea. Some estimates have placed human error as the cause of marine accidents at 75 to 96 percent of cases. Additionally, after a review performed by Allianz Global Corporate & Specialty – an insurance company that provides different types of industrial insurance worldwide – of 15,000 marine liability insurance claims, it was determined that 75% of all the claims are due to human error.

The reasonable assumption is that autonomous, unmanned shipping vessels would be safer for human life, eliminating the risks faced by crews on the high seas that can potentially result in injury or death.

In addition to protecting human life, another potential benefit involves the enhanced productivity introduced through the reduction in fuel costs. It has been estimated that crew costs that include air-conditioning units, crew quarters, heavy ballast, and other amenities, along with the salaries of seamen can reach 10 to 44 percent of a ship owner's operating expenditure depending on the nature of the vessel. The reduction in weight due to the eliminating many of these items from the ship can amount to lesser fuel costs and more space for cargo.

As well, a potential improvement in logistics may be realized through the addition of designated lanes on the high seas for autonomous shipping which may contribute to a more efficient cargo transport system.

The possibility of a reduction in piracy incidents has been suggested as autonomous shipping increases, since the leverage often used in these incidents – the crew itself – has been removed. However, the potential also exists for piracy threats to increase since bandits on the high seas may work harder to compromise cyber security obstacles in order to gain access to these vessels.

3. Conclusion:

This presentation has showed us that with the evolving technology the accuracy of the systems has increased. The number of accident cases have been brought down there by bringing down the losses.

Also the systems have become more ecofriendly and the working conditions have become safer and business became more profitable.

Acknowledgement:

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