Aiming To Achieve Zero Emissions From Ships

- Hare Ram Hare

Introduction

The world is on the brink of collapse with increase in the carbon emission and melting polar ice caps. We are almost near extinction with the average temperature rise around 7°C till 2100. As mankind is driving towards future, there is more importance being given to green practices with changing government policies.

Maritime sector has also developed various regulations and conventions to lower the emissions and new concept of "Zero Emissions", was derived.

Recent trends in shipping show a huge inclination towards stripping-off emissions to lowest values possible. We know that the standard fuel cycles are not much efficient even with the various improvisations made over. Fuel cells have proven to be efficient power sources over the last decade with maximum efficiency up to 82% which is almost twice of the standard engine cycles. There have been sincere efforts by automobile industries with hybrid vehicles coming into the picture, now it is time for hybrid vessels too.

Vessels can be run using hydrogen power plants with an effective analysis of the total outcomes of using hydrogen as a fuel in terms of profits to the owner and also to the environment. Economic viability of any change is the most important consideration in the industry, inherent with all other requirements all standards and conventions can be abided which are mainly concerned to environment with almost least equipment onboard.

Hydrogen as a fuel:

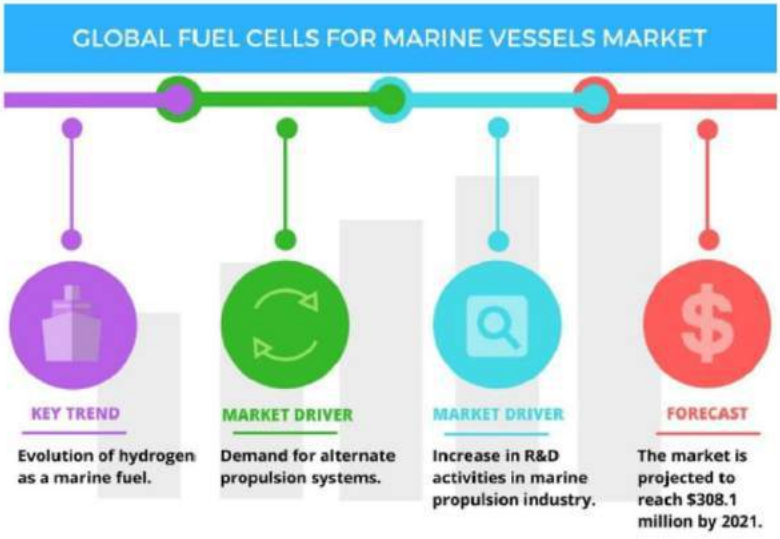
Some research shows that the maximum conversion efficiency of fuel cells is limited to the Carnot efficiency. The oretical efficiency of fuel cell may exceed that of the Carnot cycle for the same temperature range. The lowest value of maximum efficiency is found to be 79.3, 75.7, 82.1 % of hydrogen-oxygen, hydrogen-air, methane-air fuel cells respectively. By increasing the stoichiometric coefficient of air, the efficiencies of both hydrogen-air and methane air fuel cells monotonically increase and they approach 100 % limit at a stoichiometric coefficient of 7.2 and 9.8 respectively.

A fuel cell system running on hydrogen can be compact and light-weight and have no major moving parts. Because fuel cells have no moving parts and do not involve combustion in ideal conditions they can achieve **99.999%** of reliability.

There are many types of the fuel cells so the efficiencies vary, but most are between **40-60% energy efficient**. However, if the excess vapor produced in the fuel cell is used up the efficiency can rise up to **85%.** Significantly more than that of the coal fired power plants that are only **1/3** times efficient. Assuming production at scale fuel cell can save up to **20-40%** on energy costs when used in cogeneration systems. A fuel cell power plant running on hydrogen as a source would produce **1 ounce of pollution (other than CO_2) for every 1000KWh of energy**. Fuel cells also produce **97% less nitrogen oxide emissions** compared to coal fired power plants. Solitary such program is operating in **Stuart Island in Washington state.** Solar panels power an electrolyzer, which makes hydrogen. The hydrogen is stored at 500 US gallon (1900L) tanks at200 PSI and runs a Relion fuel cell to provide full electric backup to off grid residence.

Production of hydrogen on a large scale:

There are 6 different methods of



production of hydrogen on a large scale.

- Steam Methane reforming (SMR)
- SMR using hydrogen as a fuel in the furnace (SMR+)
- Auto thermal reforming (ATR)
- Partial Oxidation (POX)
- Electrolysis

Requirements for powering ships with hydrogen:

- Electric Propulsion systems.
- Hydrogen storage Tanks
- Compatible piping systems Electric Propulsion System:

Electric propulsion system would look like below. The electricity produced from the fuel cell generator would be used to drive the propellers. Output equivalent to a 2 stroke diesel engine can be achieved.

Recent Developments & possibilities

In recent conditions, the cost of production, manufacture and dispensing of hydrogen is comparatively much higher when compared to that of the fossil fuels. But, what if the hydrogen needed to run the fuel cells is produced onboard itself?

Yes, there is process to break water into its principle components with the use of sunlight. This photo electrochemical method is still in the R&D stage. Once we are able to produce hydrogen on a large scale onboard there is no need of fueling stations plus in addition there would be a large cut own in the fuel costs which would benefit the ship owners a lot. All the ship needs are sufficient water onboard & sunlight to run. The vessels in future will become self-sufficient.

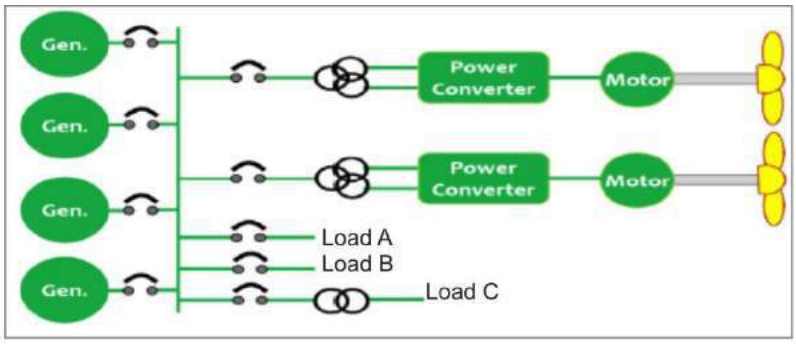
Scottish shipyard Ferguson Marine has successfully led a European consortium —known as HySeas III — in a bid for EU funding to develop the world's first hydrogen-fuelled commercial ROPAX ferry.

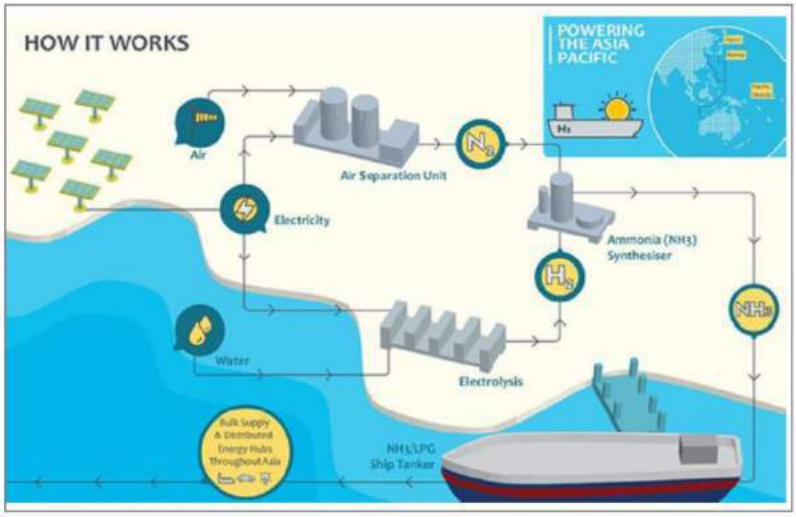
Hydrogen fuel cells have a long track record of supplying efficient, clean power for a wide range of applications, including forklifts, emergency backup systems, and vehicles. An analysis by Sandia and DOE showed that due to fluctuating loads in maritime auxiliary power applications, a hydrogen fuel cell, which follows the load, is more energy efficient than a diesel engine. A hydrogen fuel cell only supplies power when it is needed.

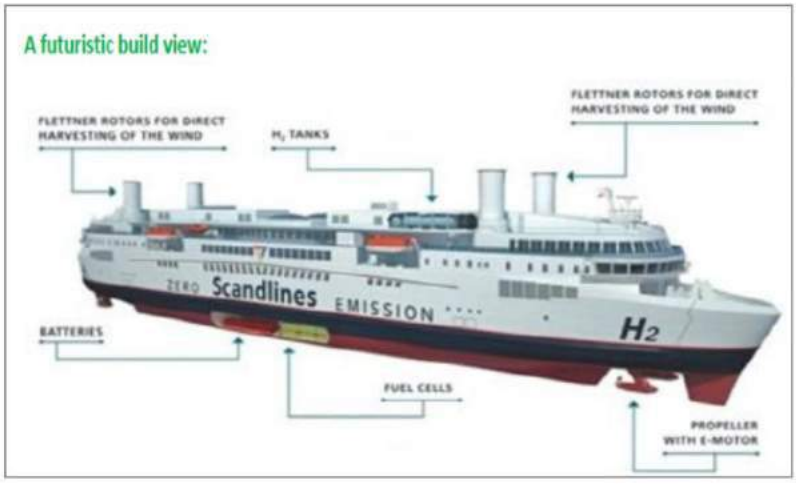
Hydrogenics Corp. designed and manufactured a containerized 100-kilowatt hydrogen fuel cell unit, which includes the fuel cell engine, a hydrogen storage system, and power-conversion equipment. Built into a standard shipping container, the unit has an outward appearance and functionality similar to maritime diesel generators that are currently in use.

Viking cruises (Norway) has joined the ranks of companies working to introduce fuel cell technology.

Major commercial ports can produce daily emissions equal to those of half a million cars or more. To combat these environmental impacts, many US ports have begun to adopt green practices. Hydrogen fuel cells have the potential to meet the electrical demands of vessels in ports, as well as supply power for other port uses, such as yard trucks, forklifts, and other







materials-handling specialty equipment. If implemented, hydrogen fuel cells, which produce zero pollutant emissions and no greenhouse gases at the point of use, can reduce the overall amount of diesel or other maritime fuel used.

Conclusions:

- The major concern regarding hydrogen run ships is its economic viability. But with the research and developments in the production of hydrogen the costs have now become considerably low. But still not equivalent to be as cheap as gasoline or HFO.
- Considering the life cycle benefits of the vessels with the systems onboard the profits are guaranteed but the ship owner must have the guts to invest in such a high capital cost project.
- In the current conditions a lot of improvements are needed but soon with such rate of technological progress, in the upcoming decade or 5-year span project will be suitably viable.
- The storage cost of hydrogen above the ground is also a major challenge to overcome.
- The systems prove far more efficient than the conventional diesel generators.
- Less use of auxiliaries and lesser maintenance required for the systems with very low downtime.
- More cargo accommodation space available since the system has a simplified layout and weighs lighter than conventional diesel engine systems.
- The water vapor produced as a leftover product can be used for various purposes onboard.

Note:

The full version of paper is available; parties interested can contact the authors

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