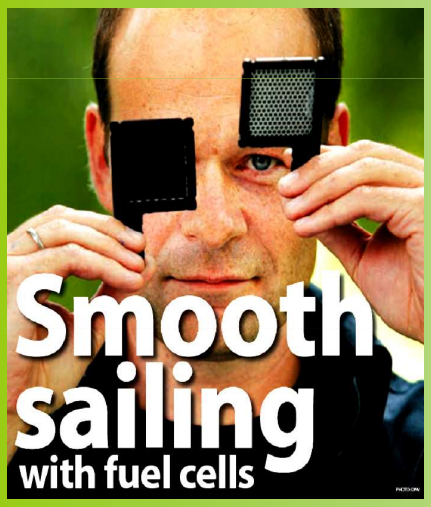
FUEL CELLS IN MARINE TRANSPORTATION

PODARA N. ELEFTHERIA



ABSTRACT

Lately, fuel cell systems are deriving greater concern in the fields of electricity generation. The marine transportation sector requires ample amounts of energy, therefore greatly contributing to the consumption of fossil fuels. The technology of fuel cell turns out to be promising for marine applications but due to the novelty of the technology and its consequent limitations ,its use in the fields of shipping industry is presently absent. The target of the present dissertation is the identification of the most suitable fuel cell system to be used for propulsion and electric generation on a merchant ship.

BACKGROUND

Due to the fact that the days of abundant and inexpensive petroleum are driving to an end and taking into account the environmental issues, other forms of energy devices must be developed. Such kind of alternative energy device is a fuel cell. Latterly, fuel cell systems are acquiring greater interest in the fields of electricity generation as well as in other energy consuming areas such as land transportation. Sattler (2000,p.62) acknowledges that fuel cells are able to provide the following operational requirements for marine applications: propulsion; emergency power supply; generation of electric energy for ship's network or sometimes a combination of the previous usages. Georgescu and Mamut, (2006,p.49), also in their study discuss the possible architecture of a ship as far as reforming, distribution systems and hydrogen storages are concerned. They also claim that despite these problems fuel cells for maritime propulsion are better, cleaner and more efficient than other propulsion systems.

Unfortunately, even though the application of fuel cell systems has been studied for many years, the usage of such systems for marine applications is limited. Adams (1990,p.182) emphasizes that the main reasons why the technology of fuel cells has not been developed are: the new development and higher procurement costs than diesel generators (approximately three times for procurement); the need for d.c to a.c conversion for auxiliaries; the need to demonstrate the ability to reform diesel fuel into gases suitable for use with fuel cells; and finally possible obstacles in the operation of reformers and fuel cells.

Sattler (2000,p.63) states that the operation of pure hydrogen and air PEM fuel cells is equiprobable to be curtailed to vessels carrying hydrogen as cargo, due to the fact that the low volumetric energy density demands very bulky fuel tanks and in addition to this safety precautions are also essential. Adamson (2005,p.1) also observes that the market of fuel cell technology has not received the requisite attention, that as many believe it worth.

On the other hand, nowadays, the increasing demands for investments in renewable resources have brought about the need of applying such systems in marine vessels. The advantages of replacing diesel generators with fuel cells systems are seen to be: cost; signatures; efficiency; size and weight; strength of the system; start up time and dynamics; ARM(Availability, Reliability, Maintenance) development status; safety; environmental/emissions. In addition to this, Krcum, Gudelj and Juric,(2004,pp.491-194), explain that the naval industry has been concerned with the efficiency, safety and a lower environmental impact from shipping and conclude that fuel cells can provide the solution to these issues. They also observe that the fuel cell system consumes 25% less fuel.

Many studies have been carried out for the usage of fuel cells in different type of applications such as for navy military applications, for passenger ships and submarines.

Fuel cells can work with different type of fuels. Some of them are: Liquefied natural gas (LNG) ;Hydrogen;Methanol;J.P5 fuel.

The matter of the fact is that, hydrogen needs bulky storage tanks. Many researchers have befuddled by trying to conceptualize a solution. The solution that many researchers result in is the reforming of the existing marine fuel into a hydrogen rich-gas suitable for fuel cells. Kickulies (2005,p.12) explains the maritime projects which took place at HDW concerning current fuel cells and the way fuels can be reformed. Krummrich et al (2006,p.500), illustrate a similar but more explanatory investigation, the DESIRE project, which demonstrates how the reforming of F76 diesel fuel into a hydrogen rich gas would be used in PEM fuel cell.

For the subject project a type of fuel cell must be proposed. In order to choose, a comparison among all types of fuel cells must be done. Alkaner and Zhou,(2006,p.188) carried out a life cycle assessment of MCFC plant for maritime use, which is compared to a common diesel engine which operates as an auxiliary power generating unit. The study shows that the construction of MCFC affects significantly to environmental impact compared to that of diesel engines. Finally, the modeling and the simulation of many fuel cell systems have engaged many researchers.

PROJECT DESCRIPTION

This project is a study about the feasibility of applying a fuel cell system in a merchant ship in order to satisfy the requirements for propulsion and electric power generation.

In the first part, the theoretical background of the fuel cell technology will be thoroughly investigated. Afterwards, the identification of the most suitable fuel cell will be presented as long as a comparison among the types of fuel cells has been surpassed. Next step is the delimitation of the auxiliary machinery and systems required to be installed onboard the vessel. In addition, a comparison through different types of corresponding bunkering fuels such as diesel oil, hydrogen, natural gas (LNG), methanol will be carried out in order to select the most suitable for the designed system. What is more, the required modifications in the ship fuel storage and the treatment systems, will be documented. Furthermore, the cost of the whole installation will be estimated. In addition, the proposed fuel cell system installation will be compared to a conventional ship propulsion plant installation. Finally, conclusions will be extracted as far as the economical feasibility and the effective applicability for applying such system in merchant ships.

EXPECTED OUTCOMES

The major components of the particular project are presented as following:

Identification of the most suitable fuel cell in order to provide propulsion and electrical generation to a merchant ship.

Delimitation of the auxiliary machinery and systems required to be installed onboard the vessel for the proper function of the proposed fuel cell system.

Selection of the most suitable corresponding fuel.

The required modifications in the ship fuel storage and the treatment systems, will be documented.

The cost of the whole installation as well as the running costs will be estimated.

And finally, results will be provided concerned the economical feasibility and the effective applicability for applying such system in merchant ships.

AIMS & OBJECTIVES

The aim of the current project is the study of the implementation of a fuel cell system in a merchant ship in order to conform to the requirements for propulsion and electric power generation and the comparison with a conventional power plant.

In order to accomplish this aim, a set of objectives has been implanted, as follow:

A review of the available fuel cell technologies and their applications.

The identification of the most suitable fuel cell to satisfy the requirements for propulsion and electric power generation.

The auxiliary machinery and system components required for the proper function of the system .

The specifications for the corresponding fuel will be documented .

An economic feasibility will be presented.

Finally, the proposed fuel cell system will be compared to a typical ship plant.

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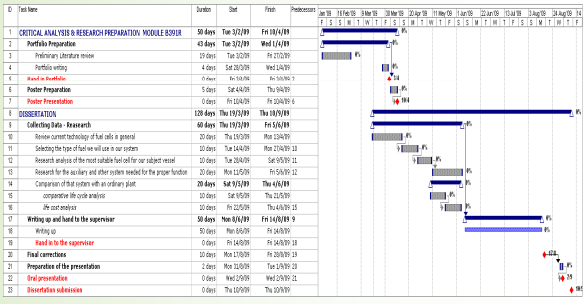

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