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SCHIBZ – FUEL CELLS FOR MOVABLE APPLICATIONS

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Abstract – **This paper reports about the project *SchIBZ* which has the aim to develop and proof a diesel oil fueled fuel cell system for maritime application and transportable, temporary CHP applications. In several steps the process was developed, a small proof of concept plant build and a large demonstrator for commercial applications. The test plant was successfully operated for more than 1000h. The demonstrator will be tested for some ten months onboard a commercial vessel in international waters. The development was executed by a consortium of 6 companies and supported by the German federal ministry of transport.**

Index Terms – **SOFC, Diesel Fuel, maritime application, large power**

I. NOMENCLATURE

DNV GL	Det Norske Veritas – Germanischer Lloyd SE
HDW	Howaldwerke-Deutsche Werft GmbH
IMO	International Maritime Organisation
LUH	Leibniz University Hannover
M&P	Motion Control & Power Electronics GmbH
NIP	National Innovation Program Hydrogen and Fuel Cell Technology
OWI	Oel-Waerme-Institut GmbH
PMP	Project Management Professional
SchIBZ	SchiffsIntegration BrennstoffZelle
SOFC	Solid Oxide Fuel Cell
TKMS	ThyssenKrupp Marine Systems GmbH

II. INTRODUCTION

In 2008 the former Blohm + Voss GmbH, today TKMS, started to investigate options for cleaner, quieter and more efficient power generation for oceangoing vessels. Different engine configurations were studied. Additionally, based on the experiences of the sister company HDW GmbH, different fuel cell configurations were studied. The configurations included also different fuels.

After rating the features of all configurations the combination of low Sulphur diesel oil and high temperature fuel cells promised to be the best solution, although one with considerable development needs.

To execute this development TKMS sought for partners with the respective know how. Finally the consortium consists of TKMS, DNVGL, sunfire, OWI, M&P, LUH and the ship owner Braren. Additionally funding by the German government was applied for under the NIP. The project started officially June 2009 as part of a so called lighthouse initiative, named e4ships.

Actually, the large demonstrator is under construction and shall be set to work late this year.

III. DEFINING THE SYSTEM

From preliminary studies it is known, that liquid hydrocarbons can be processed to a methane and hydrogen containing fuel gas by certain catalysts. Therefore it is decided to use fuels according to EN590, since these offer well known handling and safety features and the highest volumetric energy content. Other requirements are:

- 500 kW_e
- ~50 % electrical efficiency
- Mean time between overhaul 20.000 h+
- wide operating range with high efficiency
- exhaust gas energy recovery
- comparable costs to an emission reduced diesel engine genset
- exhaust gas releasing without funnel
- capable to follow load changes a close as possible

The system has to have a high reliability and availability. To achieve this the number of moving components should be kept low.

A. Catalytic reforming

The first task of the project was to identify a catalyst which can process diesel fuel according to EN590. To perform this a small test reactor was built for testing of different materials with fuel from the next door petrol station in small scale. After several tests a catalyst was identified which proofed a high fuel processing capability at well-fitting process parameters [1].

Based on this catalyst the fuel processing section of the system was designed by using simulation methods. Special consideration was given to the recirculation. Goal was the realization of an adiabatic process.

B. Electric behavior

The second main requirement is that the power system can operate in an island mode without rotating generators. This requires power electronics to provide highly dynamic load changes and sufficient short circuit currents. The characteristic of fuel cells in turn favors smooth operation. This made it necessary to introduce an energy buffer as part of the system at the DC side.

Again utilizing simulation methods several configurations of LiIon-batteries were evaluated. They offer a good combination of energy density and power capability. Combinations with our storages are surely possible but will be investigated later. The simulations led to a configuration of multiple batteries which are not operated in parallel to prolong the lifetime.

C. Scalability

Since fuel cells are packed in stacks which have to be packed again to gain larger powers, the power output should be scalable to suite different needs in later applications.

This is realized by defining a base module, which will suite most of the spatial boundary conditions in maritime and onshore applications. By stacking these modules next to each other typical power outputs from 45 to 270kW can be realized per plant. Larger systems are possible depending on the available installation space dimensions.

IV. Construction and Test

After a proof of concept test with a $10kW_e$ class test rig the construction of a $50kW_e$ demonstration plant is actually performed. The plant will be mounted inside standard containers for easier handling. A land based test will start end of this year and the operation on board the *MS Forester* will follow up. This is a mid-size commercial vessel where the total electric energy demand is between 100 and $200kW_e$. So the demonstrator will provide a significant share to the board network and can be operated like a rotating generator. The onboard operation will take place at least till end of 2016 with an option of 2 additionally years.

Fig. 1. Installation of the demonstration plant aboard the *MS Forester*[TKMS]

V. Conclusion

After working on this project for more than 7 years, we found, that liquid hydrocarbons are a valid option for certain power needs, especially in transport applications. In combination with fuel cells as energy converter liquid hydrocarbons can be utilized clean and quiet in applications with large energy demands.

Furthermore it became obvious, that HT fuel cells, especially SOFC, are at a well advanced technology state but the manufacturers need better funding. The availability of stacks on the market is not sufficient in terms of competition. Additionally the suppliers should be willing to supply stacks or stack assemblies to integrators, since single MEAs cannot be handled by many integrators.

Finally, fuel cells should always be seen as part of an aggregate, which includes the electrical side. In conjunction with energy buffers fuel cells can alter electric distribution systems a lot and offer additional efficiency gains.

Acknowledgment

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