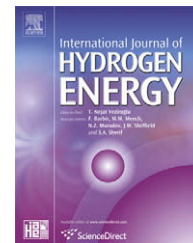


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MCFC-based marine APU: Comparison between conventional ATR and cracking coupled with SR integrated inside the stack pressurized vessel

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ABSTRACT

In the present work the implementation of MCFCs as auxiliary power units on-board large vessels, such as cruising, passengers or commercial, ships was investigated. The MCFC stack was designed to supply 500 kW_e and was fed with diesel oil undergoing a reforming process. The system modelling of the plant was performed in steady-state and aimed at assessing the power efficiency for different reforming strategies, process configurations and constituting items thermal integrations. The code Matlab/Simulink was used to this end. Two major fuel processing strategies were examined: “auto-thermal reforming” and “inside vessel steam reforming”. The latter consisted of a pre-reforming unit in which the liquid fuel underwent a catalytic cracking in mild conditions; subsequently, the resulting gas mixture made of light hydrocarbons was mixed with steam and fed into a steam reformer inside the MCFC stack vessel, where conversion to syngas occurred. Due to the high temperature (650 °C) exothermic level of MCFC, the stack was compatible with a syngas steam reforming production thermally self sustained. This allowed to increase the global electrical efficiency from 32.7% (for the ATR-based system) up to 44.6%. The process was then designed aiming at increasing the overall efficiency by thermally integrating the outlet flue gases with the pre-heating section. This led to efficiencies equal to 39.1% and 50.6% for the “auto-thermal reforming” and “inside vessel steam reforming”, respectively. Finally, the process was upgraded from an auxiliary power unit (APU) to a combined heat and power unit (CHP), since the residual heat in the flue gases was recovered for heating purposes (sanitary water production) and the demineralised water recirculation was implemented to reduce the water make-up and the process environmental footprint.

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1. Introduction

A clear trend towards the design and installation of integrated electric propulsion systems in ships has emerged in the last few years [1–3]. Most of the cruise ships employ diesel engines

to produce propulsion and diesel based generators for the hotel power for ships, as illustrated in Table 1 [1,4,5] with problems mainly linked with environmental protection: maritime transport accounts for about 3% of global petroleum consumption but contributes 14% of NO_x and 16% of SO_x.

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