Development of a Supercritical Diesel Reformer in a Hybrid Fuel Cell System

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Introduction

In the next decades diesel fuel will remain the preferred logistic fuel for NATO forces. For reasons of logistic support and stealthness of military operations, the use of fuel cells for power generation is an attractive solution. Moreover, in comparison to diesel-generators fuel cells offer higher efficiency and lower emissions of NO_x, PM (particulate matter) and CO_2. The use of diesel fuel in fuel cell systems requires (pre)reforming of diesel into a hydrogen or methane rich gas. However, catalytic reforming of diesel fuel causes either deactivation of catalysts or formation of coke due to sulphur content and aromatic compounds in the diesel fuel. To this end an alternative process for reforming of diesel fuel is investigated, gasification of diesel in supercritical water.

In order to improve the dynamic response to load changes a battery is added to the system design, resulting in a fuel cell – battery hybrid system.

The aims of this project are development of a supercritical diesel reformer and optimisation of the hybrid fuel cell system design.

Project description

To investigate the process performance an experimental set-up of a supercritical water gasification reformer is designed and built. In supercritical water, diesel is converted into a hydrogen-rich gas, at a temperature of approximately 650°C and a pressure of 300 bara without any catalysts. After cooling down, a gas/water separator and gas clean-up, the hydrogen-rich gas can be used in a fuel cell. The liquid phase will be recycled into the reactor. Experiments and modeling have shown the optimal conditions for conversion of diesel in supercritical water. To optimise hybrid system design, performance and control a dynamic simulation model is developed.

Results

The results of experiments with maritime diesel fuel are promising, a carbon conversion up to 85% and an energy conversion up to 92% have been obtained. A kinetic model of the process is being developed.

In order to optimize hybrid system design, performance and control, a dynamic simulation model is developed. System studies have been carried out in order to assess various combinations of the supercritical reformer with fuel cells. An optimal system with regard to simplicity and efficiency seems a combination of the supercritical reformer with a solid oxide fuel cell. Overall system efficiency (LHV) of more than 42% is calculated when using diesel as fuel. The efficiency can be further increased when the solid oxide fuel cell will be integrated with a simple cycle gas turbine. This makes the technology interesting in various military applications, in the range from 10 kW (APU) to 1 MW (hotel load on board of naval ships).

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