Sustainable hydrogen through decomposition of renewable ammonia: De-centralized supply applying micro-structured heat-exchangers and novel catalyst technology.

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Highlights

- Microchannel heat-exchanger developed for ammonia decomposition.
- Novel highly active catalyst formulation allows compact design
- Hydrogen purification through Pressure Swing Adsorption.
- Capacity designed to feed a 50 kW PEM fuel cell with purified hydrogen.

1. Introduction

Since more than 2 decades the energy division at Fraunhofer IMM focusses on the development of fuel processors for a multitude of fuels and increasing capacity [1]. The core technology are catalyst coated plate heat-exchangers, which allow a high degree of heat integration of the reactors, thus improving system efficiency. The current application utilizes (green) ammonia as feed for the hydrogen generation, which has gained substantial attention for a multitude of applications among them larger mobile (maritime [2]) but also stationary. Downstream purification of the hydrogen is achieved through pressure swing adsorption (PSA) before it is fed to a 50 kW fuel cell.

2. Methods

The catalyst development was carried out in micro-structured testing reactors as coatings applying FT-IR and μ-GC on-line analysis [3]. The prototype reactor was designed based upon prior experience in the laboratory scale [4] applying PROSIM process simulations, COMSOL fluidic simulations and a multiscale modelling approach for simulation of the reactor performance [5] before its construction and manufacturing process. The pilot scale ammonia fuel processor was operated at the current initial stage with PSA off-gas surrogate.

3. Results and discussion

Novel nickel-based catalyst technology, which shows superior stability and activity compared to e.g., ruthenium-based systems [3] was introduced as coating into the reactor, which is shown in Fig.1. The reactor technology has proven superior hydrogen production capacity in the first generation already when compared to alternative publications in the field [6]. The complete fuel processor is shown in Fig.2, which includes heat-exchangers and evaporators for feed conditioning and product cooling. The reactor achieved close to equilibrium conversion of the ammonia feed at an operation temperature of 700°C when operated with PSA off-gas surrogate at the initial level of testing.

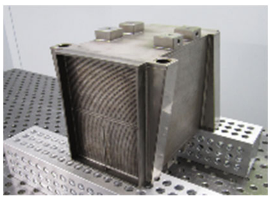

Figure 1. Ammonia cracking reactor with integrated afterburner as hydrogen supply for a 50 kW fuel cell.

Figure 2. Complete ammonia fuel processor.

4. Conclusions

The feasibility of de-centralized ammonia cracking through heat-integrated microstructured reactor technology has been proven in the 50 kW scale at high efficiency of 90%. The technology allows the operation of downstream high temperature fuel cells (SOFC), PEM fuel cells through PSA or alternative membrane separation but also the operation of internal combustion engines with partially converted Spaltgas. The off-heat of the SOFC, PSA off-gas, membrane separation retentate or engine off-gas can be used as heat source for the endothermic cracking in the heat-exchanger reactor.

References

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