Hydrogen production by ammonia cracking: Catalyst, reactor and system development

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Since more than 20 years one of the focal topics at Fraunhofer IMM is the development of fuel processors for a large variety of fuels [1]. Catalyst coated plate heat-exchangers are utilized, which allow a high degree of heat integration of the reactors, which improve the system efficiency. The current system design utilizes ammonia as feed for the hydrogen generation, which is an ideal fuel for a number of applications among them larger mobile (maritime) but also stationary. A downstream pressure swing adsorption (PSA) system is foreseen to purify the geneated hydrogen before it is fed to a 50 kW fuel cell.

Through the heat integration of e.g. PSA off-gas can be utilized to supply the ammonia cracking reaction and the feed evaporation with energy, which increases the overall system efficiency considerably.

The core part of the fuel processor is a cracking reactor with integrated PSA off-gas combustion, which utilizes self-developed, non-noble metal based catalyst technology for ammonia cracking, which has the highest activity (0.2 mol H_2/g_{cat} min at 650 °C reaction temperature). reported in open literature to-date according to the knowledge of the authors. The extremely high activity of the catalyst and the application of catalyst coatings which allow very high catalyst utilization generate high reactor productivity at moderate catalyst cost. A productivity of 0.9 $L_{H2}/(s\ L_{reactor})$ was already achieved in the first generation protoype [2]. This is according to Badakhsh et al [3] the second highest productivity ever reported in open literature for ammonia cracking reactors.

The cracking product contains some unconverted ammonia, which requires removal owing to the very low tolerance of LT-PEM fuel cells of less than 1 ppm. This is achieved through the PSA unit, which also separates the nitrogen product. The feed of the oxidation reaction which is performed in the burner compartment of the cracking reactor is utilized for feed evaporation and superheating in other plate heat-exchangers, which increases the overall efficiency even more.

Fig.1 shows a CAD model of the cracking reactor, which has been designed for 25 kg/h ammonia feed. The start-up of the system is achieved through heating with electricity.

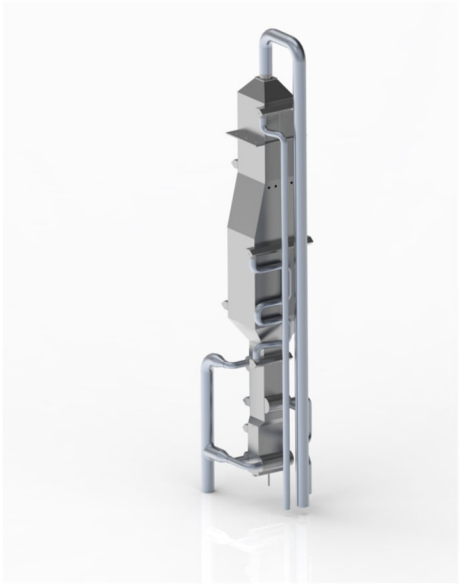

Figure 1. *CAD model of the ammonia cracking reactor for 25 kg/h ammonia feed*

Results from catalyst testing and operation of the entire ammonia cracking system, which is foreseen to supply a LT-PEM fuel cell of 50 kW electrical power output.

References

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