Fraunhofer IMM

Fraunhofer Institute for Microengineering and Microsystems IMM

Mobile and stationary energy supply: Reformer technology for hydrogen carriers

Power-to-Gas – Methanation of carbon dioxide in IMM compact microstructured reactors

The exploitation of renewables requires reliable and efficient storage systems to deal with their intermittent availability. Storage through the conversion of carbon dioxide from biogas plants into methane is an option with distinct advantages:

- high flexibility in end-use
- long-term storage
- clean combustion

Furthermore, methane as an energy carrier can take full advantage of well-established natural gas distribution infrastructure. However, the conversion of carbon dioxide and hydrogen into methane, i.e. methanation, still faces technical challenges that have to be adequately addressed relating to:

- quick response for a highly dynamic operation
- efficient heat management for the strongly exothermic methanation reaction
- development of sulphur-resistant and highly selective catalysts

Plate-heat exchangers coated with catalysts

While conventional methanation plants mainly rely on two-step fixed-bed reactor technology, Fraunhofer IMM has successfully applied its well established micro-structured reactor approach to develop a novel process to face the new challenges in the transition towards a low carbon economy. A two-stage catalytic methanation process applying catalyst coated microchannel reactors was conceived by design for carbon dioxide from biogas plants.

In the first step of the IMM methanation process, carbon dioxide is partially converted in a monolithic reactor coated with a high-temperature resistant catalyst. Afterwards, the remaining carbon dioxide reacts in an oil-cooled heat-plate-exchanger reactor operated at a much lower temperature.

This configuration leads to a decreasing temperature profile and a high conversion ratio, i.e. higher than 97 % under a decentralised-fuel production scenario that simultaneously takes advantage of the existing natural gas distribution infrastructure and local sources of carbon dioxide. The results generated on the pilot scale are encouraging as the scaling-up is considered feasible for capacities in which carbon dioxide is available.

IMM methanation catalyst technology – robust and tailor-made for dynamic operation

Benefit from 18 years of IMM experience in catalyst development for gas-phase reactions.

At the core of this development is the use of a novel catalyst formulations. Long-term testing at a laboratory scale has demonstrated their high selectivity and stability and strong resistance to the presence of traces of sulphur-based compounds commonly found in raw and upgraded biogas.

A proprietary catalyst is employed in the first process stage. Long-term testing proved the suitability of the IMM catalyst under harsh temperature operating conditions. Experiments under changing inlet feed-gas composition proved the practical applicability under dynamic regimes of operation.

The outstanding characteristics of the new catalyst formulation and the stability of this two-stage process enable the production of regenerative methane that can be directly injected into the natural gas network. This makes the IMM methanation concept suitable for a flexible and decentralised energy supply.

IMM compact methanation reactor technology – tailor-made for the reaction

Benefit from 20 years of IMM experience in developing reactors for fuel processing, combustion, fuel synthesis and much more.

Fixed-bed reactors experience a number of disadvantages for proper methanation. These include the poor use of catalysts and the generation of hot spots in the reactor bed, which can damage both the catalyst and the reactor itself.

IMM compact methanation reactor technology overcomes these limitations. The robustness of the plate-heat exchanger reactor technology has been proven in practical applications under start-up, stationary operation, and load changes for various applications.

In addition to ensuring the proper functioning of the catalysts and high carbon dioxide conversion, the integrated heat removal allows the utilisation of the energy released during methanation. The integration and subsequent use of this heat in district heating systems, for instance, make possible the even more efficient use of resources and a direct reduction in the consumption of fossil fuels, nowadays widely used for heating in almost all conventional district systems.

IMM techniques for methanation reactor construction – tailor-made for customer requirements

Benefit from 18 years of IMM experience in modular chemical plant development for a variety of applications!

The construction of the plate-heat-exchanger reactor can be performed by cheap-fabrication techniques such as roll embossing for micro-channel plate manufacturing, catalyst coating by screen printing and reactor sealing by laser welding. The design and construction of the monolithic reactor can rely on techniques originally implemented for automotive exhaust cleaning.

The compact design of both methanation reactors allows the modularisation of the whole process and its installation in containers. The set-up of methanation modular plants facilitates installation, monitoring, maintenance, subsequent operation, and coupling with the corresponding carbon dioxide sources.

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