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FRAUNHOFER INSTITUTE FOR MICROENGINEERING AND MICROSYSTEMS IMM

1 *Reforming of natural gas / methane / biogas and electricity generation by fuel cell*
2 *CHP system with fuel cell and balance-of-plant*

IMM 50 kW NATURAL GAS BASED COMBINED HEAT & POWER PLANT

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Fraunhofer IMM has developed a reformer / fuel cell system with natural gas (methane) as energy carrier on a larger scale as stationary CHP system. The system has a number of advantages compared to combustion engine based CHP systems:

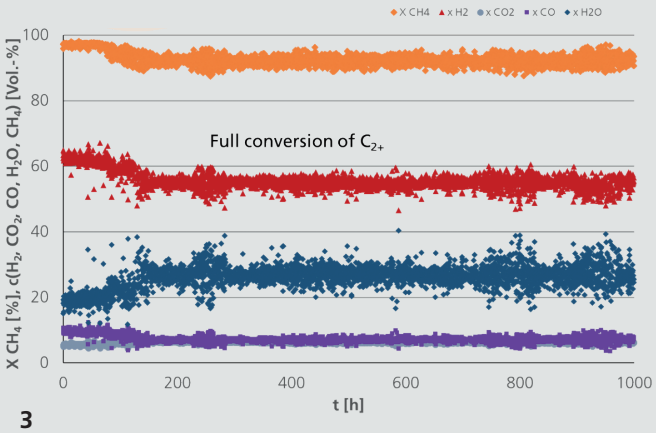
- Avoidance of pollutants such as nitrogen oxides through catalytic processes and of sulfur compounds through adsorption.
- Low maintenance requirements owing to largely avoiding moving parts.
- Reduction of the load dependency of the system efficiency compared to combustion engines.
- Compact and highly efficient by the application of microchannel plate heat exchanger technology.
- Highly dynamic operation possible through heat integration; optimal utilization of mass and heat flows.

Fossil natural gas or biogas can be processed now, but methane can also be produced from renewable sources in future (power to gas), from carbon dioxide of industrial processes or even from atmosphere.

Efficient and durable technology

IMM has developed a highly compact methane steam reformer and fuel processor components and installed all the remaining system components which are required:

- Fuel cell, balance-of-plant components and self-programmed control system were implemented.
- 200 temperature measurements in the fuel processor, 628 voltage measurements in the fuel cell; many other parameters of the demonstration system are monitored.
- PEM fuel cell technology was chosen because of its high reliability and durability.
- High overall efficiency of the combined heat and power unit > 95 %.
- Electrical efficiency 35 %.



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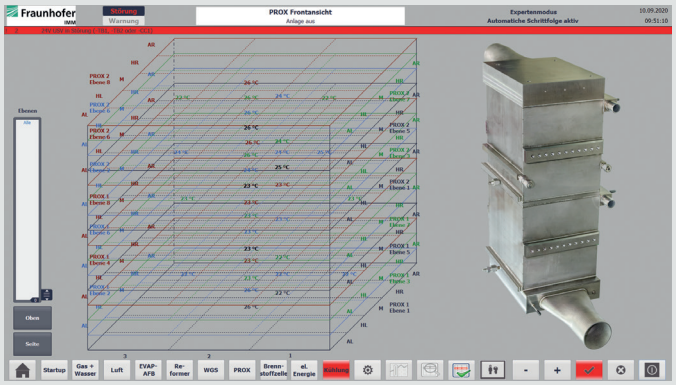

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- Conventional technology based on combustion engines achieves 70-95 % or 32-34 % at the optimal operating point - even if operated with hydrogen).
- Increased fuel cell efficiency in partial load (60 % at 20 % load, compared to 50 % at full load) allows efficient operation at partial load.

IMM methane steam reforming catalyst technology – tailor-made for the fuel

Benefit from 18 years' experience in reforming catalyst development for reforming, CO-clean-up and combustion:

- Robust catalyst, no pre-treatment necessary, no performance drop after longer shut-down.
- Catalyst technology is suited for natural gas and biogas and synthetic natural gas (from power to gas). This allows a seamless transition of natural gas based power generation towards future sustainability.
- Catalyst coating similar to automotive exhaust cleaning reduces catalyst demand further.
- Methane reforming is operated in the temperature range between 750-800 °C.
- Thermodynamic equilibrium dictates therefore the generation of significant amounts of carbon monoxide in the reformer.
- IMM has self-developed, highly active and robust water-gas shift catalyst technology available for the first stage of carbon monoxide removal (2).
- IMM has self-developed, highly active and robust preferential oxidation catalyst technology available for the second stage of carbon monoxide removal (fine clean-up down to below 10 ppm carbon monoxide).

The stability and robustness of our catalyst technology has been proven in the lab by excessive long term testing (see figure) and in practical operation in reactors of up to 50 kW scale.

IMM compact natural gas steam reformer reactor technology – tailor-made for the reaction

Benefit from 20 years experience in development of reformers for a large variety of fuels (methanol, ethanol, diesel and many others).

Conventional natural gas steam reformer reactors are fixed bed reactors, which are developed for large scale chemical processes. They have a number of drawbacks:

- The catalyst is not fully utilized and consequently even more catalyst is required compared to coated catalyst.
- The heat management is difficult, heat has to be introduced to drive the steam reforming reaction (realized by natural gas open flame combustion industrially).
- Substantial heat is contained in the fuel cell off-gas which can also not be utilized efficiently by the IMM integrated reactor design.
- Automotive monolith reactors are not suited for the steam reforming reaction.

All these issues are addressed by IMM compact reformer technology. The application of catalyst coatings in a plate heat exchanger allows optimum catalyst utilization and heat management through integrated fuel cell off-gas combustion The robustness of this technology has been proven in practical applications under conditions of start-up, stationary operation and load changes.

The application of catalyst coatings in plate heat exchangers for water-gas shift and preferential oxidation allows optimum catalyst utilization and heat management through integrated cooling functions.

Get your individual solution from us

Benefit from 18 years' experience in fuel processor development for stationary, mobile and portable applications.
Apart from the reformer, the fuel cell hydrogen supply requires devices for evaporation, heat exchangers, a reactor for water-gas shift and in case of low temperature PEM fuel cell technology a reactor for CO removal and other balance-of-plant. The whole assembly is named fuel processor.
On top of that, IMM has experience in putting the fuel cell into operation and in developing the control system which enables the fully automated operation of the fuel processor and the fuel cell.

The fuel processor design needs to be optimized for your specific application:

- the fuel cell type,
- the power range,
- the specific market requirements (achievable price and sales numbers) because fabrication techniques need to be chosen accordingly.

Talk to our experts to get the optimum solution for your system!

3 *Stability test of IMM self developed natural gas steam reforming catalyst*

4 *IMM self developed control system – 3D temperature monitoring*