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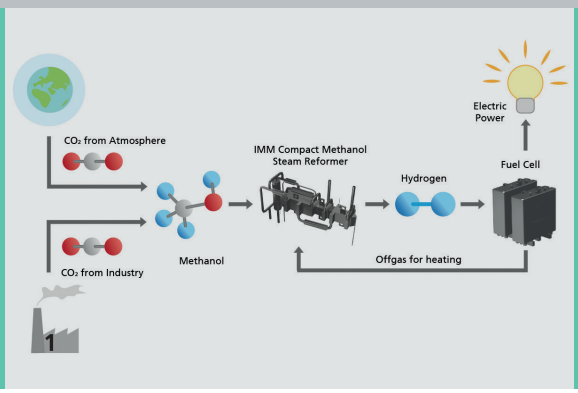

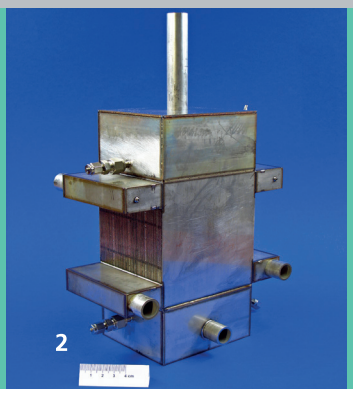

1 *Utilization of methanol as hydrogen supply for fuel cells - sustainable and compact*

2 *IMM compact methanol steam reformer produces enough hydrogen to power a 6.5 kW fuel cell*

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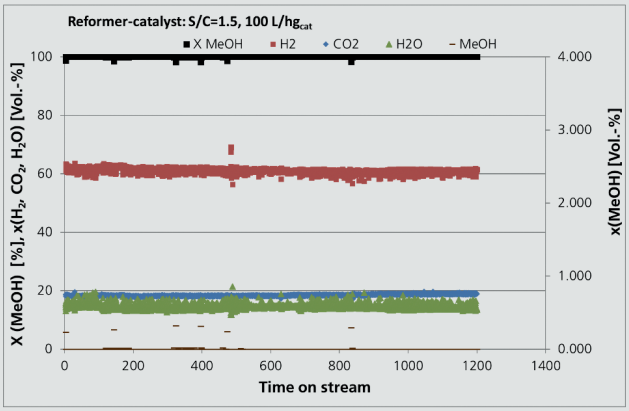
IMM COMPACT METHANOL REFORMER – HYDROGEN SUPPLY FOR MOBILITY

Mobile fuel cell applications require compact and simple hydrogen supply considering also the still limited availability of compressed hydrogen. For many portable and mobile applications, methanol is a viable alternative to compressed hydrogen owing to its higher power density and easy transportation. Methanol can be produced from renewable sources, but also from carbon dioxide from industrial processes such as cement fabrication or even from the atmosphere.
Its conversion to hydrogen (named reforming) is easiest compared to many other alcohol or hydrocarbon fuels, which require much higher operating temperature of the reforming process.
The hydrogen content of reformed methanol (reformate) is with 75 % (dry basis) highest of all fuels.
The reformate is then fed to a fuel cell (possible are high and low temperature PEM fuel cells) which produce electric power.

Catalyst coated reformer

IMM has developed a highly compact methanol reformer which has several advantages compared to conventional technology, which originate from our unique catalyst and reactor technology:

- Robust catalyst, no pre-treatment necessary, no performance drop after longer shut-down.
- Higher activity compared to conventional technology allows minimum catalyst demand (and cost).
- Catalyst coating similar to automotive exhaust cleaning reduces catalyst demand further.
- Stable catalyst operation at partial load allows system modulation.
- Plate heat exchanger technology allows optimum heat integration and system efficiency.



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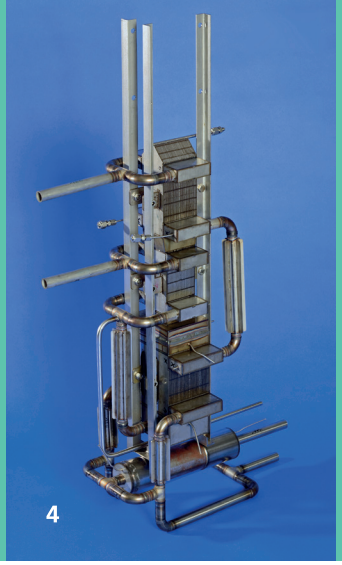

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3 Long term stability test of IMM self-developed and patented methanol reforming catalyst
4 IMM compact methanol fuel processor includes fuel supply and exhaust gas utilization

- Reactor fabrication similar to automotive high pressure heat exchangers or fuel cell metallic bipolar plates.
- Cheap fabrication steps: Embossing, screen printing and laser welding allow cost reduction for product ramp-up.

IMM unique methanol steam reforming catalyst technology - tailormade for the fuel

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

Commercial methanol steam reforming catalysts had been developed for industrial methanol synthesis and are little suited for decentralized reforming (reverse process).

- They require operation at temperatures below 300 °C, which makes the reaction too slow and consequently the catalyst demand high and reactors rather bulky.
- They are also sensitive to air exposure.
- They generate carbon monoxide excessively at partial load.

All these obstacles are overcome by innovative IMM self developed and patented catalyst technology, which follows a completely different route of the reforming reaction [1], [2]. Its stability and robustness has been proven in the lab by excessive long term testing (see figure) and in practical operation in reactors of up to 20 kW scale. Since its invention a decade ago, the catalyst was continusly improved.

IMM compact methanol steam reformer reactor technology - tailormade for the reaction

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

Conventional methanol steam reformer reactors are fixed bed reactors, which are developed for large scale chemical processes. They have a number of draw-backs:

- They suffer from catalyst attrition especially in mobile applications.
- 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.
- Substantial heat is contained in the fuel cell off-gas which can also not be utilized efficiently.
- 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 [3] .

Benefit from 18 years experience in fuel processor development for stationary, mobile (aviation, maritime, ground transport) and portable applications. Apart from the reformer, the fuel cell hydrogen supply requires devices for evaporation, 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. IMM has developed compact and highly integrated high-performance components for that. The fuel processor design needs to be optimized for your specific application:

- the fuel cell type,
- the power range,
- the specific environment,
- 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!

References

[1] Wichert, M. et al. Kinetic Investigations of the Steam Reforming of Methanol …. Chem. Eng. Sci. 2016, 155, 201.
[2] Men, Y. et al.Methanol steam reforming over bimetallic Pd-In/Al2O3 catalysts … Appl. Catal. A 2010, 380, 15.
[3] Kolb, G. Design and Operation of a Compact Micro-channel 5 kW Methanol Steam Reformer … Chem. Eng. J. 2012, 207-208, 388.