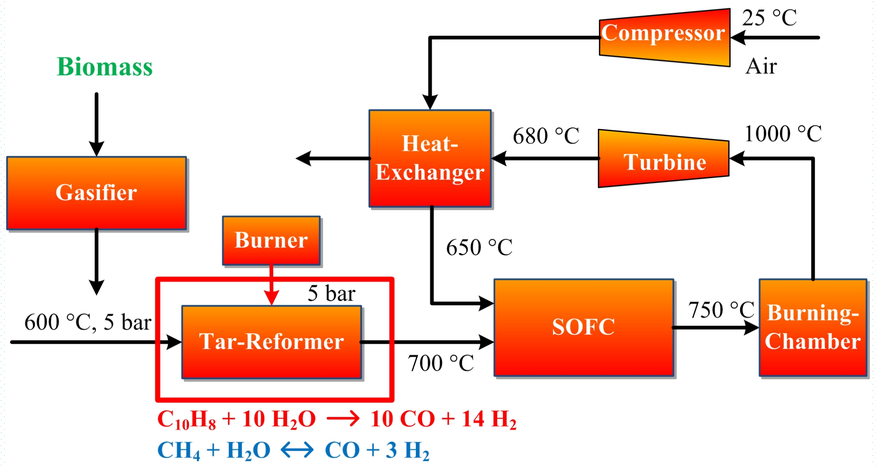
Institute of
Engineering Thermodynamics

Investigation of Catalytic steam Reforming of Tars and Methane from Pressurized Biomass Gasification Gas

Michael Speidel, Ralph-Uwe Dietrich, Antje Wörner

michael.speidel@dlr.de

Motivation

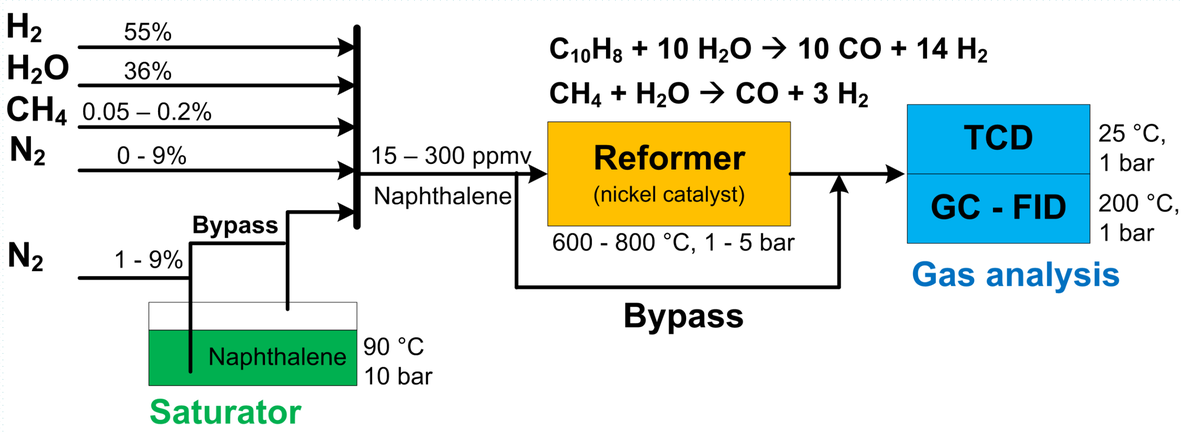


New concept to convert biomass into power in a hybrid system consisting of a SOFC and a gas turbine

Biomass conversion

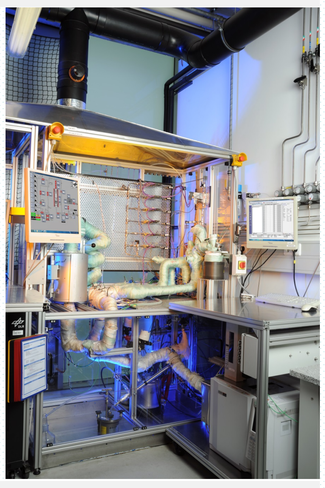
- *Power generation from pressurized gasification gas in a hybrid system of SOFC (Solide Oxide Fuel Cell) and gas turbine enables high electrical efficiencies (η_{el} = 39 %)*
- *Tars have to be removed from the gasification gas by conversion with steam in a tar reformer before conversion in the SOFC*
- *Parasitic methane conversion requires high heat input for the tar reformer*
- *At lower temperatures methane conversion is inhibited due to chemical equilibrium, thus reducing the heat input to the reformer*
- *Is it possible to convert tars at a pressure of 5 bara and temperatures lower than 700 °C?*
- *Is there a kinetic limitation of methane conversion?*

Simultaneous steam reforming of naphthalene and methane



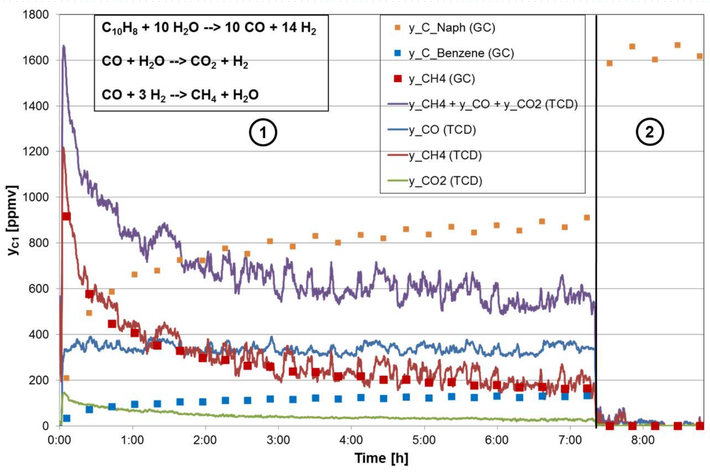
Test rig

- *Naphthalene ($C_{10}H_8$) is used as the model tar component in the synthetic gasification gas*
- *Steam reforming of naphthalene and methane is investigated over a nickel catalyst at temperatures of 600 °C – 800 °C and pressures up to 5 bara*



Preliminary Results

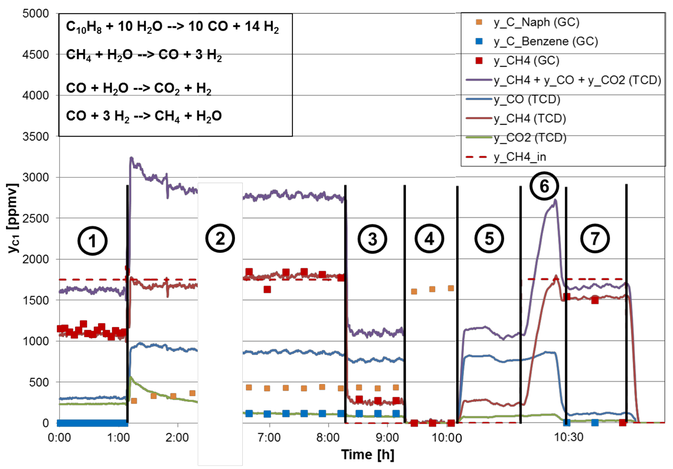
Steam reforming of naphthalene



- *Naphthalene is converted to CO and H_2, by-product is benzene*
- *Naphthalene conversion gets increasingly inhibited by coke formation*
- *Secondary reactions of CO (CO-Shift and methanation) get inhibited too*
- *Stationary only after hours*

Reforming of naphthalene at 5 bara and 650 °C; concentrations downstream (1) and upstream (2) of the reformer.

Combined reforming of naphthalene and methane



- *Methane conversion is inhibited by coke formation caused by naphthalene, even after turning off the naphthalene stream (compare part 1 before and part 7 after coke formation)*
- *Relative conversion of naphthalene (3, 4) is much higher than that of methane (7)*
- *Naphthalene conversion is not influenced by methane (2, 3)*

Reforming of methane (1, 1750 ppmv), naphthalene and methane (2, +160 ppmv), naphthalene (3), bypass naphthalene (4), naphthalene again (5=3), methane and naphthalene (6=2) and methane (7=1) at 5 bara and 700 °C.

Conclusions

- *Coke formation caused by naphthalene inhibits naphthalene conversion as well as methane conversion*
- *Sufficient tar conversion at stationary conditions, however, is possible (at 5 bara and temperatures down to 650 °C)*
- *Relative conversion of naphthalene is much higher than that of methane*
- *At temperatures < 700 °C methane conversion is limited due to chemical equilibrium and reaction kinetics; therefore heat input in the reformer is expected to be saved*

Outlook

- *Reaction kinetics of steam reforming of naphthalene and methane will be investigated at stationary conditions*
- *A Plug-Flow model of the tar reformer including the kinetics of the steam reforming reactions will be created*

Knowledge for Tomorrow

Wissen für Morgen

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