Carbon2Chem®

Sustainable Methanol Production
Methanol Demonstration Plant Evaluation

Fraunhofer-Institute for Environmental, Safety and Energy Technology UMSICHT | Clariant Produkte (Deutschland) GmbH

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Objective

In phase 1 (2016-2020) a demonstration plant with a capacity of 50 l methanol per day, originally designed for conversion of pure CO_2 and H_2, was procured, installed at Fraunhofer UMSICHT in Oberhausen and successfully expanded for the utilization of gases containing CO and N_2 in addition. A fibre optical temperature probe on the reactor axis with 36 sample points was added to measure the temperature profile.

Strategy
Start-up and preparation for steel mill gases

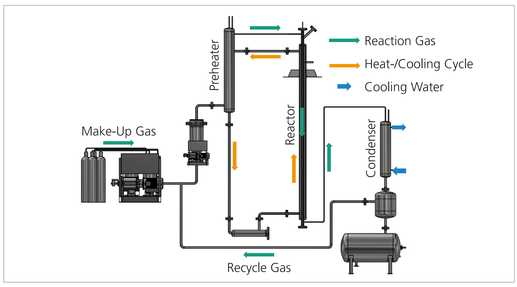
The plant in industrial set-up (single reactor tube with 6 m length and 34.3 mm inner diameter, with boiling water cooling jacket, recycle of unreacted gases and unchanged commercial catalyst) was commissioned and received all necessary permissions. The first step was to find out the operating window concerning make-up gas composition and flow rate as well as reactor temperature. All tests were performed in continuous operation (24/7) in three campaigns for five weeks each.

Solution process
Evaluation with bottle gases followed by relocation

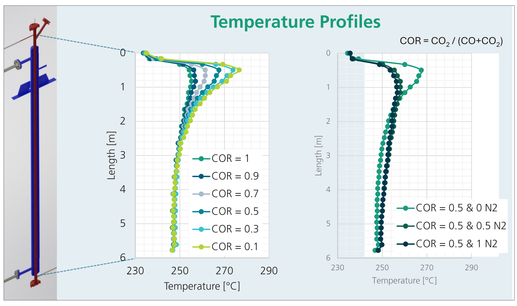
The make-up gas was initially composed of CO_2 and H_2 only with typical H_2 overspill. The share of CO in the carbon source was increased steadily up to 90 % and the stoichiometric number was kept constant. For equal shares of CO_2 and CO in the make-up gas, dilution with N_2 up to 50 % of carbon source was done to mimic the composition of blast furnace gas. The reactor temperature was varied from 245 °C down to 220 °C. Afterwards the container was relocated to Duisburg.

Results
Robust operation and successful relocation

Chemical equilibrium was achieved for nearly all conditions. The experiments showed the typical temperature profile with a hot spot in the upper part. With higher share of CO this hot spot occurs slightly earlier and is more pronounced. With N_2 dilution the profile was flattened even more. Variation of recycle ratio revealed shortcomings in the plant design, which was resolved by addition of a buffer tank. Finally, the plant was relocated to the technical center.



Process set-up with bottle gases to mimic different gas composition, reactor with recycle and boiling water cooling jacket.



Temperature profiles along reactor axis with 245 °C jacket temperature. Left: variation of CO share, right: N_2 dilution.

Methanol demonstration plant set-up at Carbon2Chem® technical center.

A KEY BUILDING BLOCK FOR THE CLIMATE PROTECTION

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