

Reactor concepts for synthetic natural gas production from CO₂

BL2F Summer school

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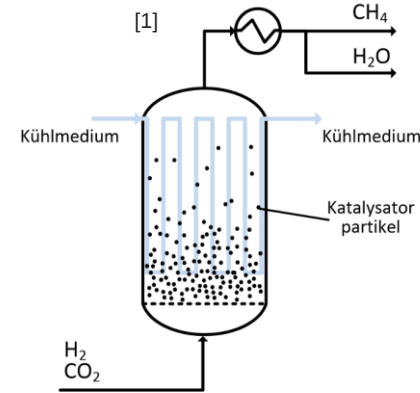
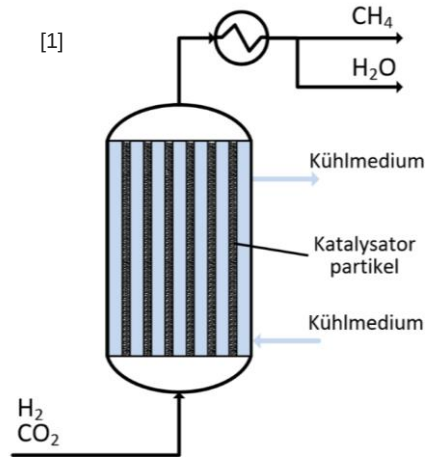
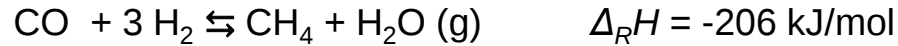
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Catalytic methanation

Reactions



Reactor concepts

- Fixed-bed reactor
 - Adiabatic or polytropic
- Fluidized-bed reactor
- (Micro-)structured reactors
- Slurry bubble column reactor

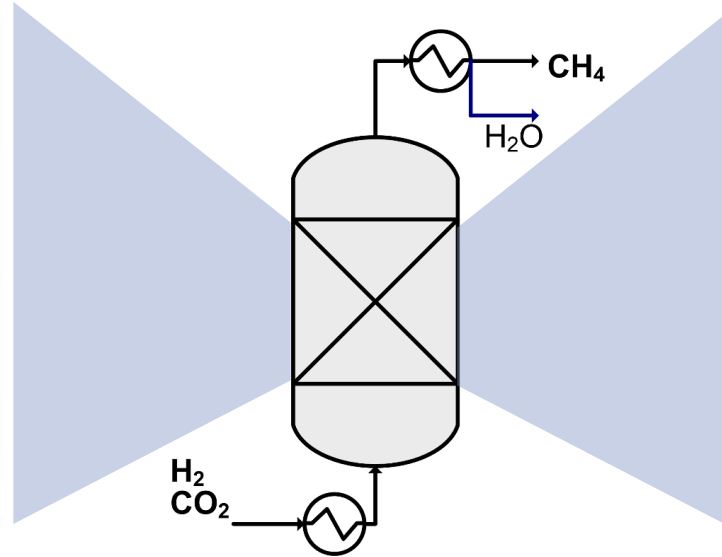
[1] Graf, Frank; SCHOOF, RENE; ZDRALLEK, MARKUS (2020): POWER-TO-GAS;GRUNDLAGEN KONZEPTE LOSUNGEN. [S.I.]: VULKAN-VERLAG GMBH.

Catalytic methanation at the Engler-Bunte-Institut

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Honeycomb
Reactor



$p_{\text{abs}} = 5 - 20 \text{ bar}$; $T = 240 - 320 \text{ }^{\circ}\text{C}$

Commercial Nickel catalyst

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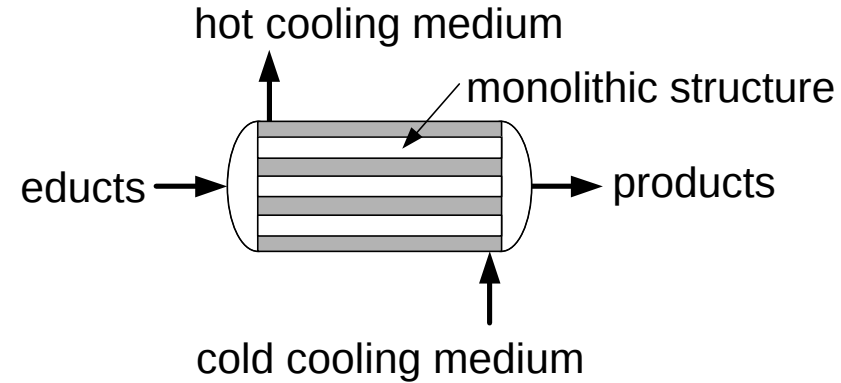
Slurry Bubble
Column Reactor

Honeycomb methanation

Advantages

- Defined temperature profiles
- Good handling and Scale-Up capabilities
- Economic reactor design for small and big plants

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Challenges

- Efficient axial and radial heat removal
- Load flexibility
- Catalyst deposition
- High CO₂ conversion

Catalytic Methanation in Falkenhagen, DE



- Plant size: 1 MW (electric power of electrolysis unit)
- CO₂ from bioethanol production
- Wind power for hydrogen production
- Injection directly into the gas transport grid

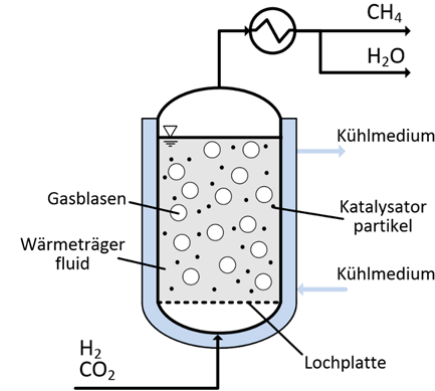
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Three-phase methanation

Concept

- (solid) catalyst ($< 100 \mu\text{m}$) is suspended in a (liquid) heat transfer fluid and fluidized by (gaseous) educts
- Efficient temperature control enables highly dynamic load changes

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Lab scale plant

- Investigation of reaction kinetics in a Continuous stirred-tank reactor (CSTR)
 - Mass transport resistance and hydrodynamics can be neglected
- $T < 400 \text{ }^{\circ}\text{C}$ and $p_{\text{abs}} < 40 \text{ bar}$
- Gas phase analysis (IR/TCD) and liquid sampling

Three-phase methanation in the SBCR (E Lab)

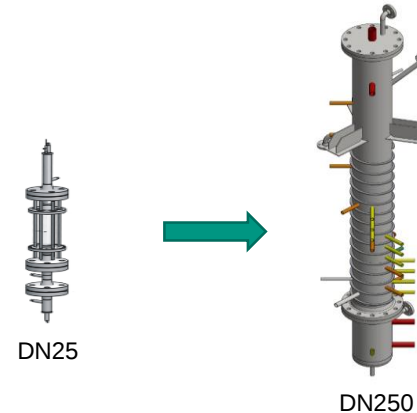
Methanation plant

- 10 m³/h (NTP) CH₄ output
- $p = 5 - 20 \text{ bar}$, $T = 240 - 320 \text{ °C}$
- Feed: CO₂/H₂ or Bioliq[®]-Syngas
- Avoidance of wall influences

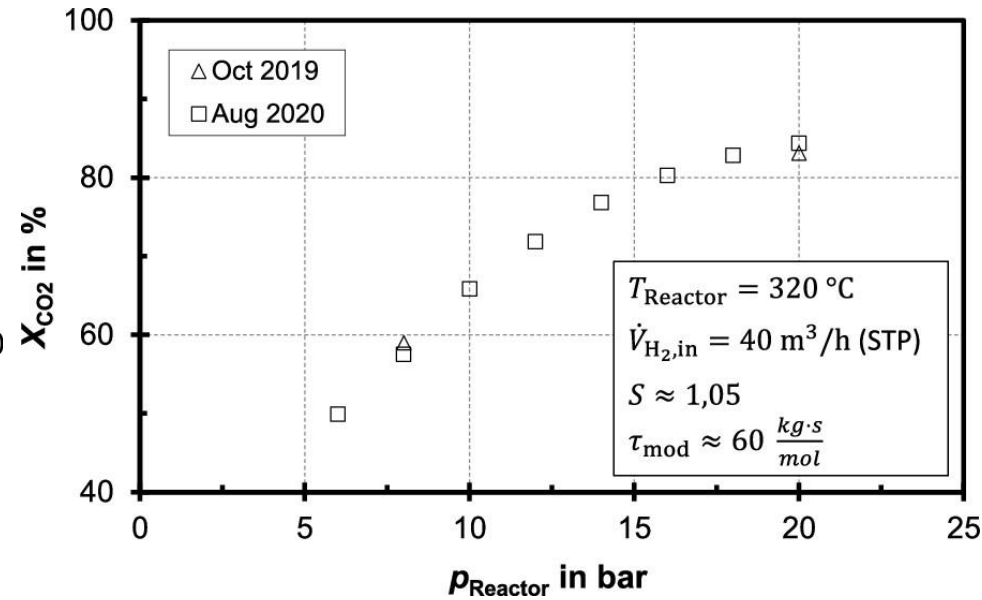
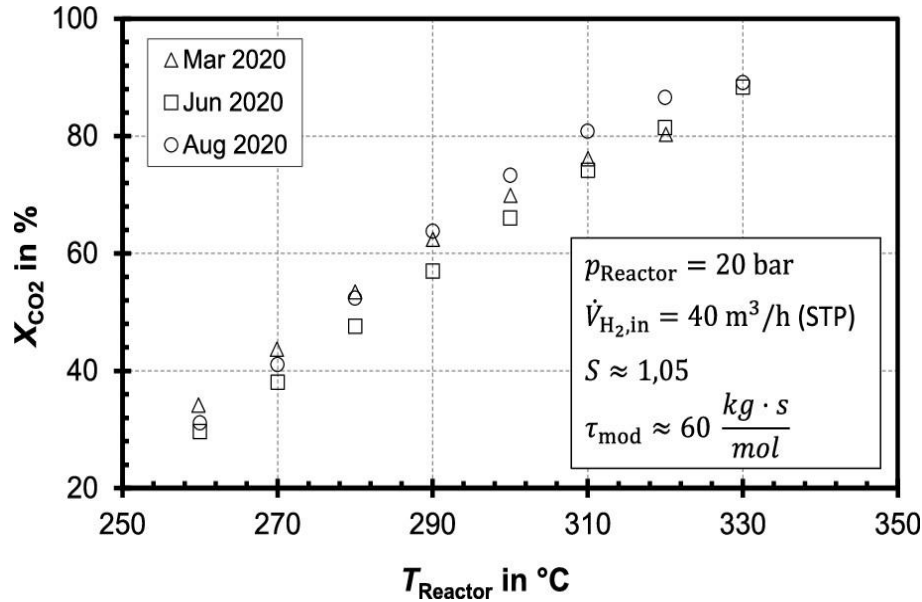
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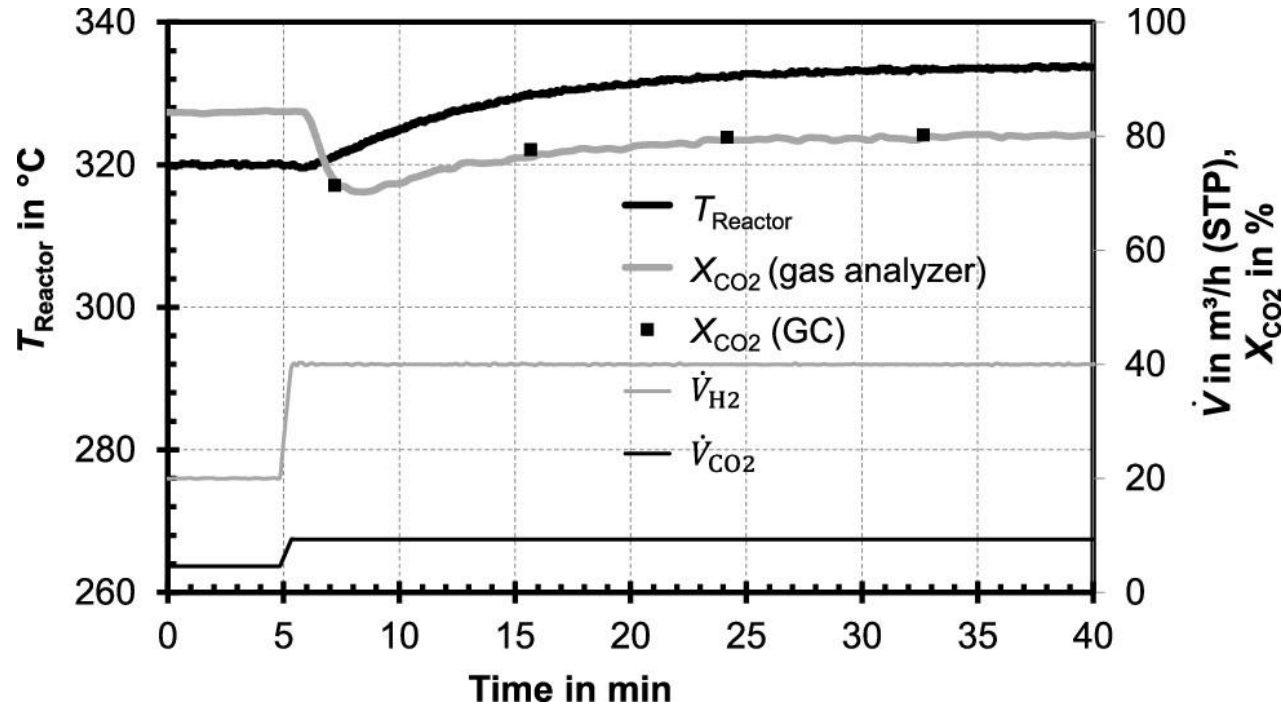


Stationary operation – T & p dependency (E Lab)



Sauerschell, Simon, Siegfried Bajohr, and Thomas Kolb. "Methanation Pilot Plant with a Slurry Bubble Column Reactor: Setup and First Experimental Results." *Energy & Fuels* 36.13 (2022): 7166-7176.

Dynamic operation via load changes (E Lab)



Sauerschell, Simon, Siegfried Bajohr, and Thomas Kolb. "Methanation Pilot Plant with a Slurry Bubble Column Reactor: Setup and First Experimental Results." *Energy & Fuels* 36.13 (2022): 7166-7176.

Thank you for your attention!

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