Allothermal gasification of biomass and lignite with integrated syngas cleaning for synthesis processes

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Motivation
Due to rising gas prices and the increasing dependency on natural gas imports, the production of substitute natural gas (SNG) is becoming a relevant option within the European Union. For the generation of SNG from biomass or lignite similar process steps are required. Especially steam gasification is favorable for synthesis processes since it produces a hydrogen rich syngas, which is preferable for synthesis processes. For decentralized applications a process line with low complexity is mandatory. The Heatpipe Reformer technology offers such a process [1]. Figure 1 shows the lab-scale (5 kW) coal-to-SNG process chain at the chair of energy process engineering at the University of Erlangen-Nuremberg, which is based on the Heatpipe Reformer technology.

Fig. 1: Lab-scale SNG process chain (5 kW) at EVT

Allothermal gasification
The lab scale gasifier produces a hydrogen rich pressurized syngas, which is nearly Nitrogen-free. Due to fluidized bed gasification at approx. 830°C the syngas still contains a high concentration of tar, which needs to be removed. While only reaching about 65 % removal efficiency with the lab scale tests stands, hardly removed. While only reaching about 65 % removal efficiency with the lab scale tests stands, the removal efficiency for H₂S and CS₂ exceeded the expected efficiencies. While more than 90 % removal efficiency for H₂S could be measured, thiophene was not affected by the scrubbing process. For an application for synthesis processes with sulfur sensitive catalysts guard beds for further desulfurization it could be applied for synthesis processes.

Fig. 2: Raw syngas composition for lignite and biomass steam gasification (T₁₈₀= 835°C, p = 5.2 bara, S/F = 5)

Fig. 3: SPE analysis of the raw syngas from lignite and biomass (T₁₈₀= 835°C, p = 5.2 bar, S/F = 5)

Integrated syngas cleaning
As proposed by Benson and Field sour gas components can be removed from the syngas stream at moderate temperatures with a relatively low energy demand. Using a 30 wt.% K₂CO₃ solution for the scrubbing process CO₂ and H₂S are removed from the raw syngas in the absorber column at 5 bara in the bench scale. The loaded solvent is let down in the desorber column at 5 bara in the bench scale. The loaded solvent is let down in the desorber column. Steam from the reboiler enhances the desorption of the sour gases. Light tar components like BTX are hardly removed. Only reaching about 65 % removal efficiency with the lab scale tests stands, the removal efficiency for H₂S and CS₂ exceeded the expected efficiencies. While more than 90 % removal efficiency for H₂S could be measured, thiophene was not affected by the scrubbing process. For an application for synthesis processes with sulfur sensitive catalysts guard beds for the removal of organic sulfur components are necessary. Off-gas treatment for the capture of H₂S or other high sulfur solid fuel types.

Fig. 4: Lignite syngas composition and sulfur concentration after gasifier and scrubber (T₁₈₀ = 835°C, p = 5.2 bara, S/F = 5)

Fig. 5: Lab-scale SNG process chain (5 kW) at EVT

Conclusion
With further adaptions the Benfield promises to be a suitable syngas cleaning process for decentralized applications. It represents a valid process for bulk sulfur removal and is capable of removing heavier tar components simultaneously. Combined with guard beds for further desulfurization it could be applied for synthesis processes.

Literature