

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

P. Treiber, T. Schneider, M. Neubert, J. Karl

Chair of Energy Process Engineering (EVT), Friedrich-Alexander-Universität Erlangen-Nuremberg, Fuerther Str. 244f, D-90429 Nuremberg, peter.treiber@fau.de

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.

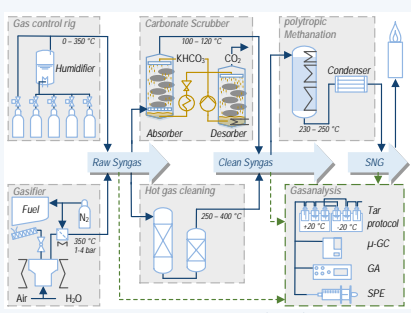


Fig. 1: Lab-scale SNG process chain (5 kW) at EVT

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 components and traces of sulfur species. Typical gas compositions are shown in Figure 2.

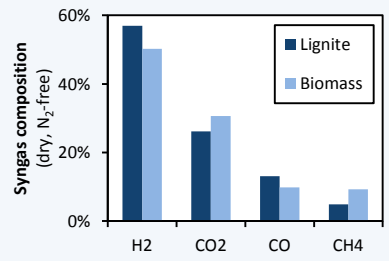


Fig. 2: Raw syngas composition for lignite and biomass steam gasification ($T_{FB} = 830^{\circ}\text{C}$, $p = 5.2 \text{ bar}_g$, $S/F = 5$)

Apart from the different C/H/O-ratio of these two fuel types it showed that lignite was mixed very well with the fluidized bed material. The normed biomass pellets however formed a layer of lighter coke pellets on top of the fluidized bed. Thus the heat transfer from the heated bed material to the biomass pellets was not comparable to the gasification of lignite particles.

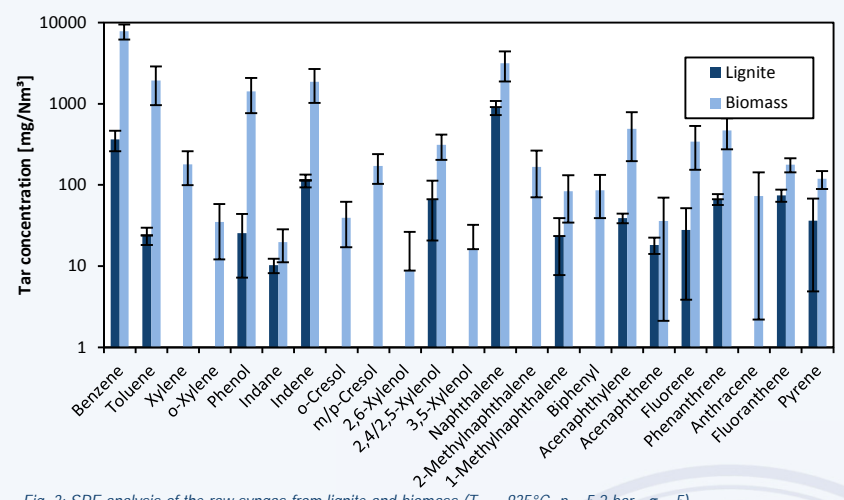


Fig. 3: SPE analysis of the raw syngas from lignite and biomass ($T_{FB} = 835^{\circ}\text{C}$, $p = 5.2 \text{ bar}_g$, $\sigma = 5$)

Figure 3 shows the measured tar components for lignite and biomass derived syngas.

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.-% K_2CO_3 solution for the scrubbing process CO_2 and H_2S are

Conclusion

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

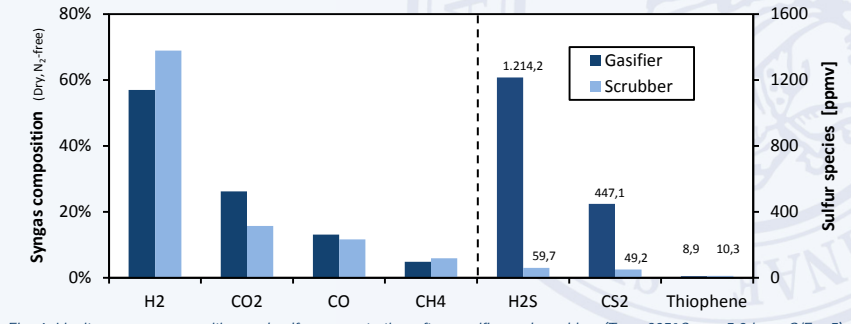


Fig. 4: Lignite syngas composition and sulfur concentration after gasifier and scrubber ($T_{FB} = 835^{\circ}\text{C}$, $p = 5.2 \text{ bar}_g$, $S/F = 5$)

removed from the raw syngas in the absorber column at 5 bar_a 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. While only reaching about 65 % removal efficiency with the lab scale tests stands, the removal efficiency for H_2S and CS_2 exceeded the expected efficiencies. While more than 90 % removal efficiency for H_2S 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 H_2S is primarily important for the application with lignite or other high sulfur solid fuel types.

Literature

- [1] J. Karl, "Biomass heat pipe reformer—design and performance of an indirectly heated steam gasifier," *Biomass Convers. Biorefinery*, vol. 4, no. 1, pp. 1–14, Oct. 2013.
- [2] H. E. Benson, J. H. Field, and R. M. Jimson, "CO₂ absorption: Employing hot potassium carbonate solutions," *Chem. Eng. Prog.; (United States)*, vol. 50, Jul. 1954.
- [3] H. E. Benson and J. H. Field, "Method for separating CO₂ and H₂S from gas mixtures," US Patent 2,886,405, 1956.



Contact:

Dipl.-Ing. Peter Treiber
Peter.Treiber@fau.de

Lehrstuhl für Energieverfahrenstechnik
Friedrich-Alexander-Universität Erlangen-Nürnberg
Fuerther Straße 244f, D-90429 Nuremberg, Germany
www.evt.tf.fau.de