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Characterization of biogenic synthesis gases for direct utilization in industrial burners for the substitution of fossil fuels in process heat

Christian Wondra, Peter Treiber, Jürgen Karl

Chair of Energy Process Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg, Fürther Str. 244f, 90429 Nürnberg

Motivation

One fifth of the final energy demand in Germany is attributable to the production of process heat in industry, which continues to be generated mainly from fossil fuels, especially natural gas. In order to achieve CO_2 neutrality, it is important to develop new and innovative concepts in this area. In this context, the use of biomass and biogenic residues has the advantage that they can be utilized in a CO_2-neutral manner and, in addition to green hydrogen, lead to climate-neutral process heat generation. Solid fuel firing systems cannot be used everywhere, because the control cannot be implemented sufficiently quickly and flexibly and the necessary adiabatic combustion temperatures cannot be achieved. Biogenic synthesis gases from gasification, on the other hand, can be used with minor modifications in existing burners and furnace systems, which means that the substitution of fossil fuels can be realized with minor modifications.

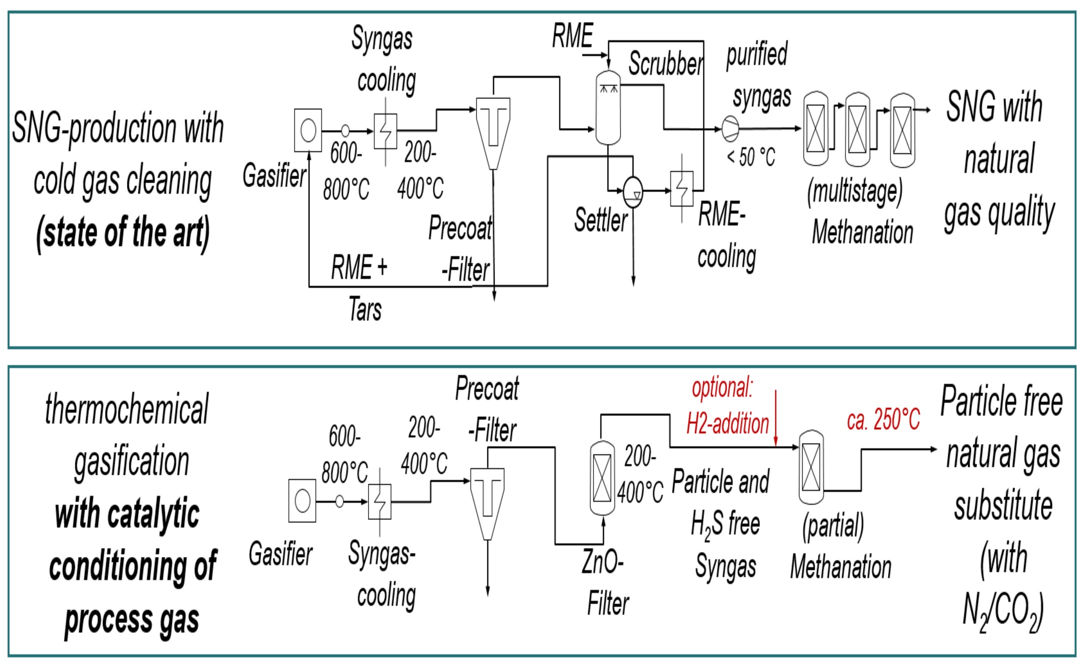


Fig. 1: State of the Art SNG-Production versus catalytic conditioning of syngas.

Direct utilization of biogenic synthesis gases

Substitute natural gas (SNG), which is produced during the thermo-chemical gasification of biomass, is very well suited for use in industry. For this purpose, however, the raw synthesis gas produced must be upgraded to applicable natural gas standards using various upgrading steps and a multi-stage methanation process. For many industrial processes, the technically complex and cost-intensive purification to natural gas quality is not necessary. Instead, hot gas purification and partial methanation can already produce a product gas that can be directly utilized in modified gas burners.

The project KonditorGas

In order to provide plant manufacturers and operators with the motivation to realize these processes, the process chain is demonstrated on a semi-industrial scale. On the one hand, the raw gas from autothermal air gasification and, on the other hand, the raw gas from allothermal steam gasification are used. By means of hot gas purification and partial methanation, the gas qualities are adapted for use in so-called FLOX burners to ensure stable and smooth burner operation. For the adaptation of the burners, a characterization of the synthesis gases is necessary. This involves analyzing the various gas compositions and the tar load of the resulting process gases, as well as determining the burner- and safety-specific properties such as ignition limits and laminar flame velocities, which are determined with the aid of a specially designed test rig.

Test rig for flame speed

The optical angle method is used to determine the flame speed, for which a code was programmed using MATLAB that automatically evaluates the data. First, the image is grayed and the intensity of the individual pixels is determined. The flame is then segmented by means of binarization before the angle is determined and the flame speed calculated.

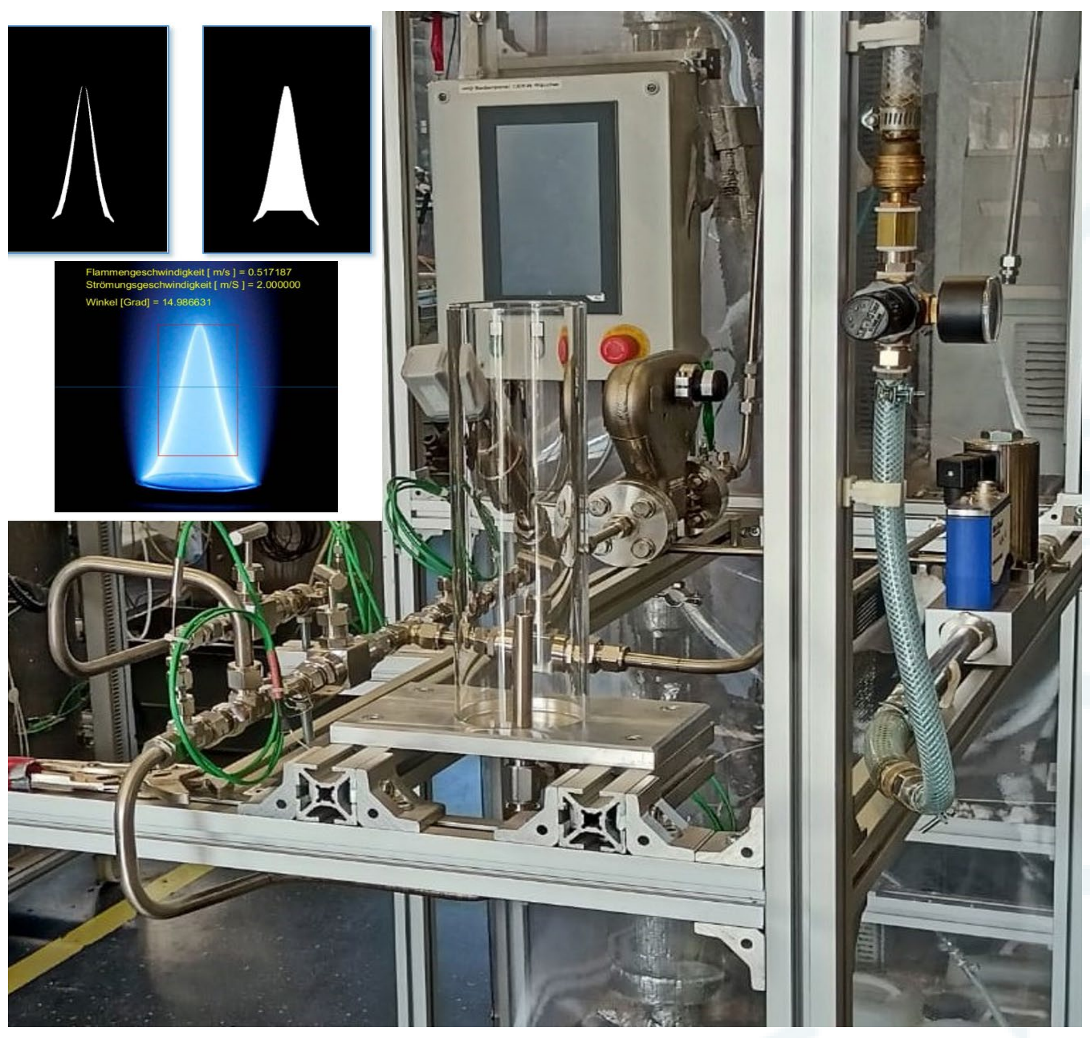


Fig. 2: Test rig as well as the binarization and segmentation of a flame image.

The determination of the ignition limits is integrated into the test rig design by using a modified tube method. A glow wire is installed in the glass cylinder over which the gas mixture flows. The area is detected with a thermal imaging camera to detect temperature differences and determine the ignitable gas mixtures.

Characterization of the allothermal synthesis gases

A 5 kW fluidized bed gasifier is available for the allothermal generation of the synthesis gas, which can be operated up to a reactor pressure of 5.2 bara. The first series of tests were carried out at 1.5 bara. The steam number σ, which describes the stoichiometric ratio of water vapor to fuel, and the temperature of the fluidized bed were also varied.

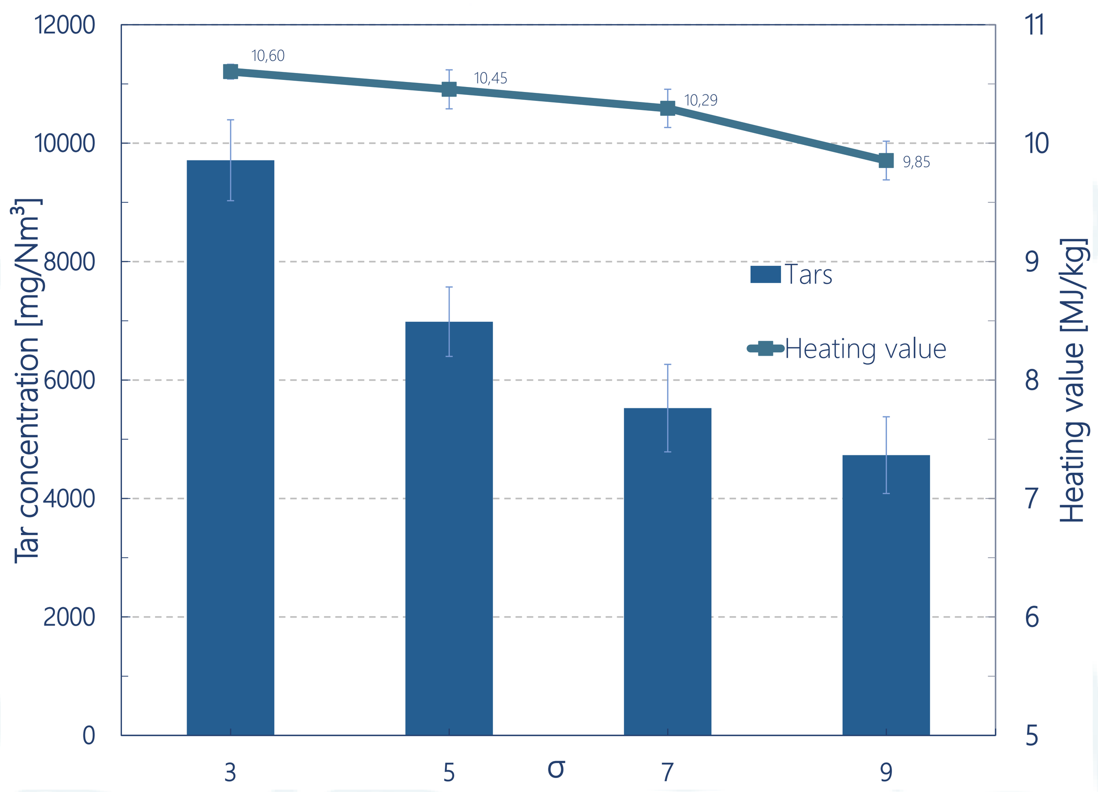


Abb. 3: Tar concentration and heating value of the allothermic synthesis gas as a function of the stoichiometric steam ratio σ

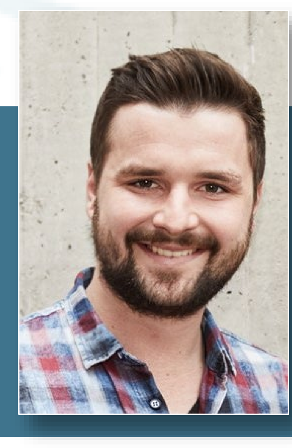
The results show that at higher steam excess, the tar content decreases sharply, while the calorific value does not change much.

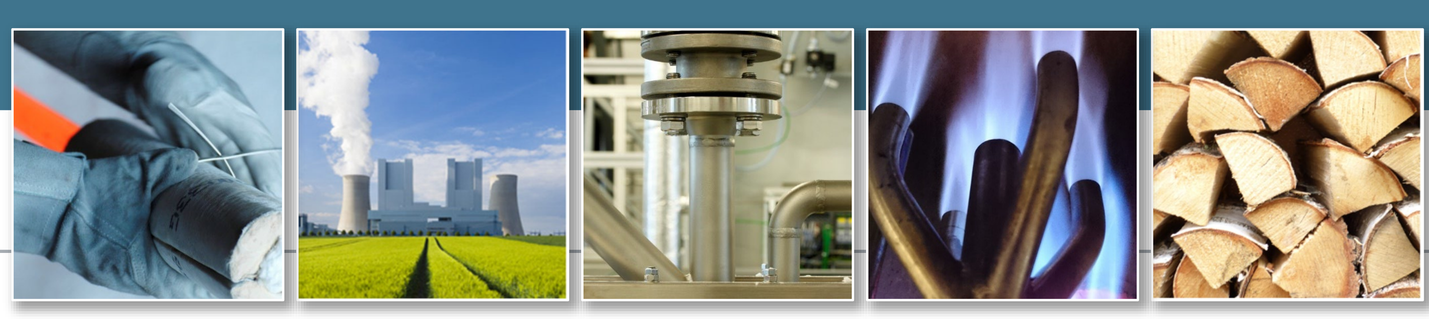
Conclusion

In the KonditorGas project, two innovative process chains are being realized on a (semi-) industrial scale for the direct utilization of biogenic synthesis gases to generate process heat. The first characterization tests show promising results, so that a high calorific synthesis gas with low tar load can be produced. In further tests, the laminar flame speed as well as the ignition limits will be determined to ensure safe operation of the FLOX burner.

Chair of Energy Process Engineering
Prof. Dr.-Ing. Jürgen Karl, Prof. Dr. Katharina Herkendell

Christian Wondra M. Sc.
+49 (0)911 530 99399
Christian.Wondra@fau.de





Friedrich-Alexander Universität Erlangen-Nürnberg
Fürther Straße 244f, 90429 Nürnberg

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