High temperature biomass gasification in an entrained flow reactor – Commissioning and first trials of a 100 kW test facility

Michael Kremling[1], Ludwig Briesemeister[1], Sebastian Fendt[1], Matthias Gaderer[2], Hartmut Spliethoff[13]

[1] Institute for Energy Systems, Technical University of Munich, 85747 Garching, Germany
[2] Regenerative Energy Systems, Technical University of Munich, 94315 Straubing, Germany
[3] ZAE Bayern, 85747 Garching, Germany

1. Introduction

The state of the art technology for thermochemical conversion of biomass to gas is fluidized bed gasification. The operation temperature of this process is limited to 950°C. This is why the concentration of tars in the product gas is high and an aftertreatment system is necessary. In a new approach an entrained flow gasifier – state of the art in industrial coal gasification plants – is used for thermochemical conversion at high temperatures (1000°C – 1500°C). Due to the high operation temperature the product gas is almost tar free and has only a little CH_4 content [1]. The product gas can be used directly for power generation (e.g. CHP, micro gas turbine, FC) or refined to SNG or BtL [2]. Another part of the new approach is the biomass pretreatment to make biomass useable for energy supply which is not energetically used until now and does not compete with agricultural food cultivation (e.g. straw, grass cut, agricultural residuals). Examples for pretreatment technologies are hydrothermal carbonization or torrefaction.

It is already theoretically shown that entrained flow gasification of biomass can be competitive to fluidized bed gasification [3].

2. Design of the test facility

The aim of this work is to investigate the high temperature gasification of pretreated biomass in an entrained flow gasifier. The focus lies on the optimization of the cold gas efficiency and the gas quality. Also the ash/slag behaviour inside the gasifier and the influence of the pretreatment parameters on the gasification are of interest. For these experimental investigations a 100 kW lab-scale test facility was designed, engineered and constructed. The gasifier is designed industrial-like but still flexible in operation. The main operating parameters are shown in table 1.

Table 1. Design and Operating Parameters of the test facility

Operation mode:	autothermal
Temperature:	up to 1500 °C
Pressure:	0 to 5 bar_g
Fuel input:	100 kW
Gasification agent:	air, O_2, H_2O, CO_2
Fuel feeding:	pneumatically
Operation without fuel refilling:	up to 10 h

The test facility consists of several subsystems like pressure vessel with refractory, dosing system for biomass and reaction gases, burner unit, water quench, gas analysis, product gas flare and others.

Figure 1 shows a cross section view of the gasifier. More details about design and engineering are described in [4].

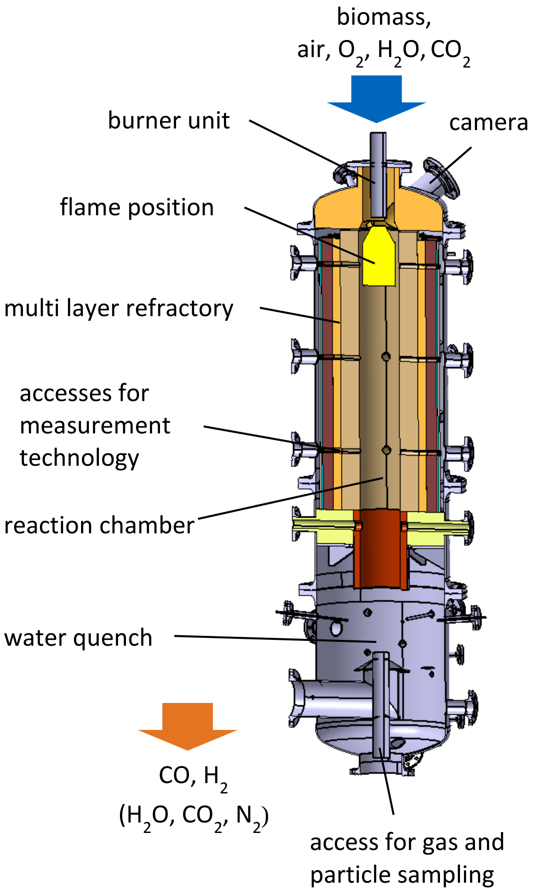

Figure 1. Cross section view of the gasifier

3. Commissioning

The test facility has an industrial PLC (Simatic S7), which controls all systems of the plant and logs the data.

After testing all sub systems separately the first heating up with a gas burner (84h with defined heating rates) was completed successfully. Maximum temperature reached 1500 °C.

The refractory contents electrical heaters for heating up the walls of the reaction chamber before starting the trials to reach a self-ignition of the biomass. The first test showed that the wall reached the expected temperature of 950 °C after 36 h.

The first trials in the gasification mode under realistic operation conditions were carry out with lignite. This fuel was used because it was available at the site, the behaviour is known and it has good properties for pneumatically conveying. The plant could be operated for almost 5 hours without interruption. The gasification agent was air, pressure was around 0.2 bar_g.

4. Outlook

In the next steps the operation with O_2 and pressure (up to 5 bar_g) has to be tested. The design of different burners continues. First significant results with biomass are expected to be available until the middle of 2015.

5. References

[1] C. Higman; M. Burgt. Gasification (2008)

[2] M. Kaltschmitt; H. Hartmann; H. Hofbauer. Energie aus Biomasse (2009)

[3] A. Tremel; D. Becherer; S. Fendt; M. Gaderer; H. Spliethoff. Performance of entrained flow and fluidised bed biomass gasifiers on different scale. in: Energy Conversion and Management 69 (2013) 95-106

[4] M. Kremling; L. Briesemeister; H. Spliethoff; M. Gaderer. High-Temperature Biomass Gasification in an Entrained Flow Reactor, in: Proceedings European Biomass Conference and Exhibition (2014)

6. Acknowledgment

The financial support from Federal Ministry of Food and Agriculture of Germany (FKZ: 2023911) is gratefully acknowledged.