Pneumatic conveying of biocoal from hydrothermal carbonization: An approach for small scale entrained-flow gasification

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1. Introduction

In a future energy system the utilization of domestic biomasses and residues will play an important role. An enlarged potential of biogenic fuels can be accessed by pre-treating these materials in order to produce a high-quality fuel.

A promising utilization path is the gasification of biocoal made by hydrothermal carbonization (HTC) in an entrained-flow gasifier [1][2]. Entrained-flow gasification is typically applied at large scale but it was shown that it can be competitive at smaller scale as well [3]. Efficiency and quality of the process depends heavily on the stability and continuity of the media supply. Therefore a reliable feeding system is required.

In this work a pneumatic conveying system is presented that is designed for a pilot plant (100 kW_{th}) gasifier [4]. The system is tested for its behaviour on different fuels and operation conditions. Variation on fluidization gas was performed and the consumption of carrier gas was measured.

2. Experimental set-up

The system basically consists of a pressure vessel that is connected to the gasifier via a conveyor pipe (CP1). A vacuum conveying system (LS1) is used to fill the vessel with fuel from a container. System pressure is controlled by two regulating valves. In the vessel bottom fluidizing gas is injected through a porous metal (FR4). Locally fluidized fuel is drawn off and pushed through the pipe. Fig. 1 shows a simplified P&ID of the system.

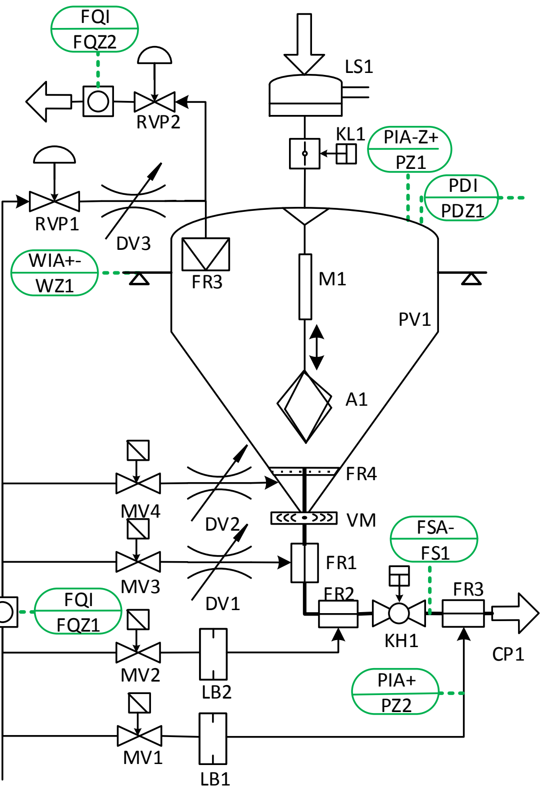

Figure 1. Simplified P&ID of the pneumatic conveying system

To avoid plugging additional gas is added by a metal frit (FR1) and increases the flow velocity. Interruption of conveying by plugging or instabilities is detected by a microwave detector (FS1).

Current feed rate is determined by weight measurement of the vessel and its time derivation. Carrier gas is determined by balancing the nitrogen in- and outlet measured by mass flow meters. In Tab.1 the basic design and operating parameters are summarized.

Table 1. Design and operating parameters of the conveying system

Parameter	Range
$\dot{m}_{coal}$ in kg/h	5…25
Coal bulk density in kg/m³	250…450
$p_{operation}$ in bar_g	0…5
V_{vessel} in m³	1

3. Experimental trials and results

Experimental trials and feedstock

Main purpose of the trials was to find stable working points without fluctuation of feed rate and to minimize the inert gas consumption for transportation. The latter can be evaluated by the solid-gas ration μ (1).

$$\mu = \frac{\dot{m}_s}{\dot{m}_g} \quad (1)$$

As feedstock two fossil coals and two HTC biocoals were tested with mean particle size as listed in Tab. 2.

Table 2. Mean particle size of fuels tested with the conveying system.

Fuel	HTC1	HTC2	Lign.	Bitum.
D50 in µm	54	153	57	20

Trials were performed varying feed rates, counter pressure, fluidization and additional gas. Two different conveyor pipes (inner diameters of 6 and 8 mm) were used with a pipeline length of 10 m.

Results

With the current set up biocoal with a mean particle size of 153 µm (HTC 2) could not be conveyed. This is probably due to the small pipe diameter attended by plugging. Other fuels in Tab2. could be steadily conveyed with additional support of a mechanical loosening system inside the vessel. The system consists of a pneumatically lifted and lowered anchor above the fluidized bed to avoid phenomena like channelling or formation of bridges.

Solid-gas ratio was 10-30 kg/kg. Necessary gas velocity for fluidization was in the range of 2-4 cm/s and the conveying velocity inside the pipe was 2-3 m/s.

4. Conclusions

With the system presented in this work the concept of pneumatic conveying for small-scale entrained-flow gasification could be proven. Different fuels with typical particle size distributions for entrained-flow processes could be conveyed steadily.

In particular the demonstration of the suitability for HTC coal as a rather new fuel type is of importance.

5. References

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6. Acknowledgement

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