Impact of Thermal Plasma on Biomass Particles for Entrained Flow Gasification

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Abstract: This study investigates the influence of thermal plasma on biomass particles for entrained flow gasification (EFG). A high-speed camera was used to capture the particle dynamics, while the plasma-treated particles were analyzed according to their properties. The results have already provided valuable input for the improved design of a plasma-assisted EFG, in terms of EFG burner design and reaction enhancement by plasma conditions.

1. Introduction

The utilization of thermal plasma for entrained flow gasification is expected to produce high-quality syngas with low tars and high hydrogen content [1-2]. This is ideal for use in further processes such as methanol synthesis [3]. Since the influence of thermal plasma on biomass particles has not yet been observed, it is important to investigate fundamental phenomena to increase the probability of success for upscaling.

2. Methods

A thermal plasma source with ≈ 1,75 kW of electrical power is used to treat biomass particles under thermal plasma conditions. In the current setup, nitrogen is used as plasma gas which is intended to represent the first two steps of particle gasification: First, drying and second, the release of volatiles. The biomass particles are dosed by an automated dosing system that ensures a constant flow of particles into the plasma zone. The interaction between the thermal plasma and the biomass particles is captured by a high-speed camera, which allows us to measure the velocity, acceleration and tracks of the particles. In addition, the plasma treated particles are collected and analyzed. Particle size distribution, elemental analysis, pore volume and structure were analyzed. The test rig in operation is shown in Fig.1.

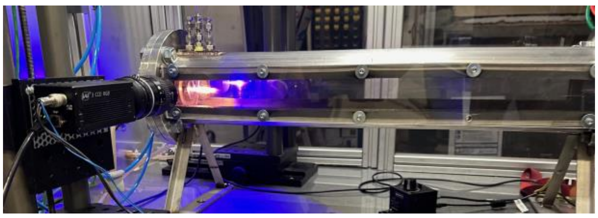

Fig. 1. Image of the horizontal test rig. Thermal plasma torch, camera, and backlight for imaging in operation.

3. Results and Discussion

Figure 2, A), shows the outlet nozzle of the thermal plasma torch. A closer look reveals injected biomass particles, some of which are already releasing gas, visible as white light. Figure 2, B) shows a histogram of the calculated particle velocity. The mean particle velocity was 10,35 $\frac{m}{s}$. As can be seen from the graph, a Gaussian distribution of particle velocity was observed. This was expected, as the measured particle size distribution also follows a Gaussian profile. 15,000 frames were analyzed and at total of 575 particle tracks were detected.

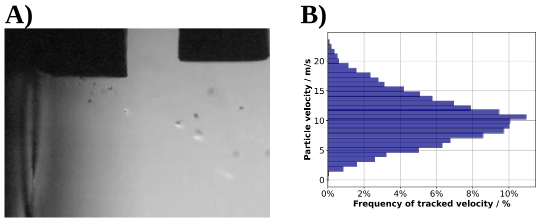

Fig. 2. **A)** High-Speed Camera, Phantom Camera – VEO 710, low shutter time, high frame rates. **B)** Velocity histogram, displaying the frequency of particles at a certain velocity.

Analysis of the particles by substance showed a significant change for particles between 10-100 µm, but almost no change for particles with approximately twice that diameter.

4. Conclusion

The findings have already provided crucial information for the implementation of thermal plasma in EFG and valuable insights for the simulation in CFD. The first results clearly show that particle size is one of the most relevant parameters for the interaction between thermal nitrogen plasma and biomass particles. Particles in the range of 100 µm tend to interact much more than particles with a maximum in their particle size distribution of around 250 µm.

Acknowledgement

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