Plasma-assisted Entrained Flow Gasification of Torrefied Wood in a Pilot-Scale Gasifier

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Abstract: This study evaluates the influence of different operation parameters on a plasma-assisted entrained flow gasification process. The experiments are carried out on a pilot-scale entrained flow gasifier using torrefied wood as feedstock. The gasifier is equipped with a thermal steam plasma torch, capable of delivering up to 50 kW_{el} of power.

1. Introduction

Entrained flow gasification has gained prominence as an advanced technology for converting carbonaceous feedstocks into valuable syngas, which can be utilized energetically or for chemical synthesis. In recent years, the feedstock for gasification has shifted from fossil fuels like coal to more sustainable sources like biomass and residues, leading to a deterioration in fuel properties. Simultaneously, there is an increasing demand for syngas quality as the focus moves away from energetic use towards utilization for syntheses like Fischer-Tropsch [1]. Introducing plasma into the gasification process addresses these contradictory trends, as previous studies have demonstrated that plasma utilization enhances syngas quality and reduces tar formation [2].

2. Methods

The experiments are performed in a conventional pilot-scale entrained flow gasifier (figure 1) with a fuel input of around 100 kW_{th}, retrofitted with a plasma torch. The torch generates a thermal steam plasma with up to 50 kW_{el} power. The newly designed burner unit is installed at the top of the reactor, allowing the plasma to flow coaxially with the feedstock into the reaction chamber. The feedstock, torrefied wood with a higher heating value of around 20 MJ/kg, is milled and sieved to a particle size below 300 µm. Using nitrogen as a carrier gas, a pneumatic dense feeding system transports the particles into the gasifier. In addition to the plasma gas, a secondary gasification agent (air, oxygen, steam, or CO_2) can be added to the reaction chamber. A full water quench at the bottom of the reactor rapidly cools the gas before it exits the gasifier. A particle filter removes the fly ash and other particles before a flare safely burns the product gas.

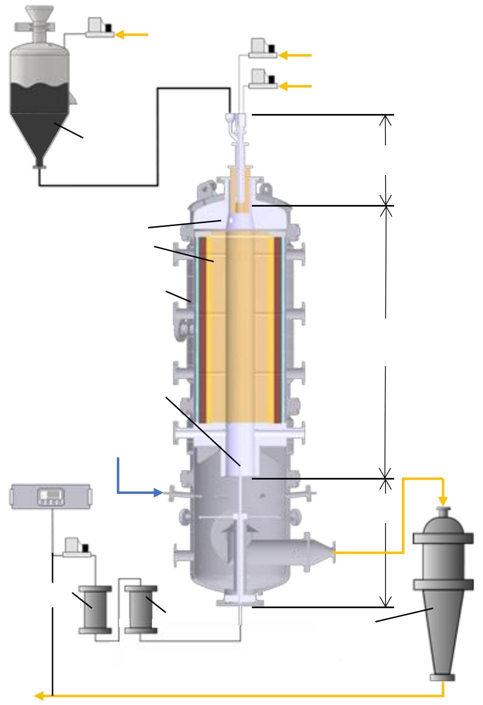

Fig. 1. Scheme of the entrained flow gasifier

3. Results and Discussion

The influence of various process parameters, such as different carbon-to-oxygen ratios and plasma-to-fuel ratios, are investigated. The influence of these parameters on the process is evaluated by using key performance indicators. The wall temperature of the refractory lining along the length of the reaction chamber is measured, as well as the gas composition right before the quenching zone. Additionally, the cold gas efficiency and carbon conversion efficiency are calculated.

4. Conclusion

This research provides valuable insights into the potential benefits and challenges of utilizing plasma in an entrained flow gasification. Our findings offer a foundation for future developments in sustainable and efficient gasification technologies and aim to inform decision-makers and researchers about the influence of critical process parameters on its performance.

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