Plasma Pyrolysis

A-124

Integration of a free-burning plasma arc into a fluidized bed gasification system.

R. Schimpke[1,2], V. Kuznetsov[1], M. Gräbner[1,2,3], P. Pieterse[4], D. Uhrlandt[4]
[1]TU Bergakademie Freiberg, Institute of Energy Process Engineering and Chemical Engineering (IEC), Freiberg, Germany, [2]TU Bergakademie Freiberg, Center for Efficient High Temperature Processes and Materials Conversion, Freiberg, Germany, [3]Fraunhofer Institute for Ceramic Technologies and Systems (IKTS), ivision Energy and Process Engineering – Circular Carbon Technologies, Freiberg, Germany, [4]Leibniz Institute for Plasma Science and Technology Greifswald e.V., Process and Energy Technology, Greifswald, Germany

Syngas production from secondary feedstock by means of plasma-assisted gasification covers a wide field of technologies with different development states from lab-scale to industrial scale [Kuz2026]. This contribution presents the development and integration of a DC plasma arc system into the COORVED pilot-scale plant to make this fluidized bed gasifier ready for allothermal sewage sludge gasification along with high-value syngas production. The whole work was conducted within the framework of the PhosCOOR project with its primary objective of achieving strongly reducing conditions and high temperatures by means of electricity integration independent of the gasification agent composition, whereas reaction conditions are provided that favor phosphorus release into the gas phase.

The integration of a free-burning arc [Pie2025] required overcoming several technical challenges, including the selection of suitable electrodes, mitigation of electrode erosion and oxidation, and the design of adjustable electrode positioning. A robust power supply capable of handling extreme voltage fluctuations and rapid load changes was established. The plasma arc system was successfully incorporated into the existing plant control infrastructure, enabling stable arc operation at power inputs of 15–20 kW while enhancing operational flexibility and process control.

Experimental campaigns included a systematical comparison of autothermal, hydrogenating, and allothermal (plasma-assisted) gasification modes. The feasibility of stable plasma-assisted operation over extended periods was demonstrated, with stationary conditions achieved for multiple balancing time frames. The results demonstrate the successful development of a new plasma-enhanced fluidized bed gasification principle. Results reveal that plasma-assisted gasification enables high syngas qualities with CO_2 concentrations down to 2 vol.-% even for low quality feedstocks. Key performance indicators like carbon conversion rates of > 95 wt.-% and cold gas efficiencies of > 85 % highlight the potential of plasma-assisted gasification. The results underline the potential of plasma technology to decouple process temperature from gasification agent composition, opening new avenues for process optimization and contribute to resource circularity and sustainable waste management.

References:

[Kuz2026] Kuznetsov, V.A., Gräbner, M., Schimpke, R., Uhrlandt, D., Richter, A. , (2026), Systematic evaluation of gasifiers driven by the high-enthalpy plasma supply, Fuel, 138538
[Pie2025] Pieterse, P., Gonzalez, D., Najam, A., Schimpke, R., Gräbner, M., Uhrlandt, (2025), Towards plasma-enhanced gasification: Investigating free-burning carbon arcs in molecular gas mixtures, Plasma Physics and Technology, 52-55, 12