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Modelling of a Steam Fluidized Bed Gasifier for Organic Waste Valorisation Within the LIFE-W2B Project

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Abstract

The integration of thermochemical and biological conversion technologies represents a promising pathway to maximise carbon recovery from organic waste streams while supporting renewable biomethane production. Within the LIFE-Waste to Biomethane (W2B) project, gasification is integrated with anaerobic digestion and photosynthetic upgrading processes, to produce biomethane and to enhance the valorisation of residual organic materials in waste management systems. The proposed demonstration facility includes a steam-assisted bubbling fluidized bed gasifier designed to process up to 50 kg h^{-1} organic feedstock dried by solar panels and having a moisture content up to 25%. The unit operates at 700–800 °C and produces a hydrogen-rich syngas that can be subsequently converted into biomethane through biological methanation processes. The feedstock consists of dried organic waste mixtures and residual biomass streams characterised by variable moisture content, organic composition and ash content, which may significantly affect gasification performance and syngas quality and therefore is tuned by solar drying processes. This study presents the development of an Aspen Plus® process model aimed at identifying the operating conditions that can maximise syngas production, carbon conversion efficiency and downstream biomethane generation potential. The modelling framework includes feedstock characterisation, drying, devolatilization, gasification reactions and syngas conditioning. Sensitivity analyses are performed to evaluate the influence of feedstock properties and operating conditions on syngas composition and process performance. Preliminary modelling results indicate that feedstock composition and gasifying agent configuration are among the most influential parameters affecting gasification performance. In particular, steam addition, together with feedstock moisture content, plays a dual role by promoting hydrogen formation through gasification and reforming reactions while simultaneously moderating reactor temperature. This effect may be beneficial, as it can help maintain the process within the optimal operating window of the selected gasification technology. However, excessive steam or moisture contents may adversely affect reactor temperature, gas yield, and syngas composition. Therefore, identifying the optimal combination of operating parameters for complex organic waste mixtures is essential to maximise syngas quality and support the efficiency of subsequent biological conversion

processes. The proposed modelling framework provides a tool for identifying optimal operating conditions capable of maximising carbon recovery and biomethane production potential within the LIFE-W2B concept. Future work will integrate process simulation results with biological methanation performance and environmental assessment activities in order to support the design and optimisation of integrated waste-to-biomethane systems.

Keywords: gasification, syngas, biomethane

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