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Modelling and Optimization of a Combined Sorption Enhanced Biomass Gasification with Hydrothermal Carbonization, Hot Gas Cleaning and Dielectric Barrier Discharge Plasma Reactor to Produce Pure H_2 and Methanol Synthesis

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Abstract : Concerns about energy security, energy prices, and climate change led scientific research towards sustainable solutions to fossil fuel as renewable energy sources coupled with hydrogen as an energy vector and carbon capture and conversion technologies. Among the technologies investigated in the last decades, biomass gasification acquired great interest owing to the possibility of obtaining low-cost and CO_2 negative emission hydrogen production from a large variety of everywhere available organic wastes. Upstream and downstream treatment were then studied in order to maximize hydrogen yield, reduce the content of organic and inorganic contaminants under the admissible levels for the technologies which are coupled with, capture, and convert carbon dioxide. However, studies which analyse a whole process made of all those technologies are still missing. In order to fill this lack, the present paper investigated the coexistence of hydrothermal carbonization (HTC), sorption enhance gasification (SEG), hot gas cleaning (HGC), and CO_2 conversion by dielectric barrier discharge (DBD) plasma reactor for H_2 production from biomass waste by means of Aspen Plus software. The proposed model aimed to identify and optimise the performance of the plant by varying operating parameters (such as temperature, CaO/biomass ratio, separation efficiency, etc.). The carbon footprint of the global plant is 2.3 kg CO_2/kg H_2, lower than the latest limit value imposed by the European Commission to consider hydrogen as “clean”, that was set to 3 kg CO_2/kg H_2. The hydrogen yield referred to the whole plant is 250 gH_2/kgBIOMASS.

Keywords : biomass gasification, hydrogen, aspen plus, sorption enhance gasification
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