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Hydrogen production from biomass using iron-based chemical looping technology: validation, optimization, and efficiency

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Abstract

To develop a new integrated system for co-production of electricity and hydrogen with CO_2 capture, a biomass steam gasification (BSG) process integrated with an iron-based chemical looping hydrogen production (CLHP) system and a combined heat and power (CHP) system is presented and simulated using Matlab and Aspen Plus. The raw wood (RW) and torrefied wood (TW) are used as the feedstock of the BSG process to produce RW- and TW-derived syngas, respectively. The CLHP system operates with solid circulation and adopts two countercurrent moving bed reactors where detailed kinetic models are validated by experimental data from the literature. The CHP system uses a combination of a heat recovery steam generator (HRSG) and a series of steam turbine (ST) cycles to enhance the electricity efficiency and the overall system efficiency. To address the maximum syngas conversion and hydrogen yield of the BSG-CLHP-CHP system, the optimal results show that steam velocity of the moving bed oxidizer is a crucial parameter, which should be operated at less than 15 cm s^{-1} for RW-derived syngas and 8.7 cm s^{-1} for TW-derived syngas. Overall, based on a comparison of the BSG-CLHP-CHP system performance in terms of hydrogen thermal efficiency, overall system efficiency, and hydrogen yield between RW and TW, the predictions suggest that TW is obviously superior to RW.

Keywords: Chemical looping technology; Moving bed reactor; Hydrogen production; Torrefied biomass; CO_2 capture; Process integration.