Simulation de la gazéification de la biomasse pour la production d'hydrogène ou d'électricité sous Aspen plus et analyse énergétique et exergétique du procédé

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Abstract

The continuous rise in fossil fuel consumption and its associated environmental impacts have spurred significant research and development efforts toward renewable energy sources. Among these, biomass has emerged as a promising renewable alternative to help mitigate these challenges. Biomass gasification, a thermochemical conversion process, holds strong potential for the production of electricity and hydrogen. This thesis presents a thermodynamic analysis of biomass gasification integrated into a combined cycle, modeled using Aspen Plus software. An optimization strategy for hydrogen production is also developed, incorporating key catalytic processes such as tar catalytic cracking, steam methane reforming, and the water-gas shift reaction. The modeling approach is grounded in experimental data and takes into account both the formation and reduction of tar compounds. The results obtained in this study show that steam gasification produces the highest hydrogen yield than CO2 gasification. Key processes, such as tar catalytic cracking, steam methane reforming, and the water-gas shift reaction, were utilized to enhance hydrogen production. After optimization, the hydrogen production for the sand-CO_2 experiment increased from 1,9 to 35 g H_2/kg of biomass. With biochar and CO_2, production rose from 2,3 to 31 g H_2/kg, while the biochar and water vapor combination produced the highest yield, with an increase from 8 to 58,8 g H_2/kg of biomass. Among the various configurations studied, water vapor gasification and high-temperature pyrolysis stand out for producing the highest net electricity, reaching approximately 2,45 MW. In comparison, sand-CO_2 gasification generates around 1,90 MW, while the sand-biochar combination achieves about 1,5 MW.