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Investigations into the Efficiencies of Steam Conversion in Three Reactor Chemical Looping

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Abstract : This paper analyzes a three reactor chemical looping process for hydrogen production from natural gas, allowing for carbon dioxide capture through chemical looping technology. An oxygen carrier is circulated to separate carbon dioxide, to reduce steam for hydrogen production and to supply oxygen for combustion. In this study, the emphasis is placed on the steam conversion in the steam reactor by investigating the hydrogen efficiencies of the complete system at steam conversions of 15.8% and 50%. An Aspen Plus model was developed for a Three Reactor Chemical Looping process to study the effects of operational parameters on hydrogen production is investigated. Maximum hydrogen production was observed under stoichiometric conditions. Different conversions in the steam reactor, which was modelled as a Gibbs reactor, were found when Gibbs-identified products and user identified products were chosen. Simulations were performed for different oxygen carriers, which consist of an active metal oxide on an inert support material. For the same metal oxide mass flowrate, the fuel reactor temperature decreased for different support materials in the order: aluminum oxide (Al2O3) > magnesium aluminate (MgAl2O4) > zirconia (ZrO2). To achieve the same fuel reactor temperature for the same oxide mass flow rate, the inert mass fraction was found to be 0.825 for ZrO2, 0.7 for MgAl2O4 and 0.6 for Al2O3. The effect of poisoning of the oxygen carrier was also analyzed. With 3000 ppm sulfur-based impurities in the feed gas, the hydrogen product energy rate of the process were found to decrease by 0.4%.

Keywords : aspen plus, chemical looping combustion, inert support balls, oxygen carrier
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