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Development of Membrane Reactor for Auto Thermal Reforming of Dimethyl Ether for Hydrogen Production

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Abstract : This research is devoted to developing a membrane reactor to flexibly meet the hydrogen demand of onboard fuel cells, which is an important part of green energy development. Among many renewable chemical products, dimethyl ether (DME) has the advantages of low reaction temperature (400 °C in this study), high hydrogen atom content, low toxicity, and easy preparation. Autothermal reforming, on the other hand, has a high hydrogen recovery rate and exhibits thermal neutrality during the reaction process, so the additional heat source in the hydrogen production process can be omitted. Therefore, the DME auto thermal reforming process was adopted in this study. To control the temperature of the reaction catalyst bed and hydrogen production rate, a Model Predictive Control (MPC) scheme was designed. Taking the above two variables as the control objectives, stable operation of the reformer can be achieved by controlling the flow rates of DME, steam, and high-purity air in real-time. To prevent catalyst poisoning in the fuel cell, the hydrogen needs to be purified to reduce the carbon monoxide content to below 50 ppm. Therefore, a Pd-Ag hydrogen semi-permeable membrane with a thickness of 3-5 μm was inserted into the auto thermal reactor, and the permeation efficiency of hydrogen was improved by steam purging on the permeation side. Finally, hydrogen with a purity of 99.99 was obtained.

Keywords : hydrogen production, auto thermal reforming, membrane, fuel cell
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