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Experimental Investigation of Continuous Ortho-Para Hydrogen Conversion for Hydrogen Liquefaction within the Range of 40-80 K

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Ortho-para hydrogen catalytic conversion stands as a pivotal process in hydrogen liquefaction. Continuous conversion, the most energy-efficient, is realized by placing catalysts inside channels of heat exchangers. Experimental data is significant to reveal the underlying mechanism of thermal-flow-conversion process and optimize the conversion process, which is still lacking in the accessible literatures. In this investigation, a cryogenic experimental platform for heat exchangers with ortho-para hydrogen conversion is constructed where ortho-para hydrogen conversion coupled with heat transfer and flow is measured. The GM-cryocoolers are utilized as the cold source and helium acts as the refrigerant in heat exchangers tested. The hydrogen can be cooled to an impressive 36 K at an operating pressure of 2 MPa, sustained by a mass flow rate of 1 g/s (equivalent to 3.6 kg/h). A set of crossover tests are carried out regarding the heat exchanger parameters, the catalyst parameters, and the operating state of the fluids, and experimental correlations the catalyst-filled heat exchanger are proposed by measuring parameters such as temperature, pressure, flow rate, and para-hydrogen concentration. Furthermore, the mechanisms of flow and heat transfer coupled with catalytic conversion are elucidated. This study provides technical support for the design of continuous conversion heat exchangers.

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