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C2Po1D-04: Experimental Investigation and Performance Evaluation of Catalysts-Filled Plate-Fin Heat Exchangers for Hydrogen Liquefaction

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Cryogenic hydrogen plate-fin heat exchangers (PFHXs) with continuous ortho-para hydrogen conversion are crucial for large-scale, efficient hydrogen liquefaction. However, most existing research relies on numerical methods, and detailed experimental data under cryogenic conditions remain scarce. To address this gap, experiments on catalysts-filled plate-fin heat exchangers (CPFHXs) were conducted within the temperature range of 40-80 K to obtain data on thermal-hydraulic-conversion performance. Based on these experimental results, correlations were derived and compared with numerical simulations. It was observed that when the space velocity is sufficiently low, the conversion efficiency approaches 100%, indicating that the outlet composition reaches equilibrium. However, the conversion efficiency decreases to 83.5% as the space velocity increases to 1.14 h^{-1}. Additionally, the inlet concentration and temperature significantly affect performance. Thermal performance improves under lower temperatures, with the j-factor reaching 0.070 when the inlet helium temperature is approximately 41.7 K. Notably, the numerical results for temperature and composition exhibited considerable deviations from the experimental data. More accurate correlations, derived from experimental data, were integrated into numerical simulations using CFD, improving the accuracy of performance predictions. These findings provide valuable insights for the design and optimization of CPFHXs.

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