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Design and Commissioning of a Medium-Scale Hydrogen Liquefaction Plant

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This study presents the design and commissioning process of a medium-scale hydrogen liquefaction plant of 1.5 tons of liquid hydrogen per day (TPD), utilizing a Helium Brayton refrigeration cycle augmented with Liquefied nitrogen pre-cooling.

The design involved comprehensive simulation and analysis to optimize the plant's performance. The specific energy consumption (SEC) of the plant was calculated to be 18.2 kWh/kg LH2, with an exergy efficiency of 21.5%. An exergy analysis was performed to identify the processes within the plant that contribute most to exergy destruction. The analysis revealed that the compression process, expansion process, and heat transfer in the LN2 pre-cooling heat exchanger are the primary sources of exergy destruction sorted by the severity of the losses. These findings are crucial for understanding where improvements can be made to increase the overall efficiency of the plant.

The commissioning of the plant began with the conditioning of the system, which included purging, leak testing, and ensuring all components were properly aligned and functioning. Next, the control system was debugged to ensure that all automated processes and controls were functioning correctly. Then the plant was cooled down to lower than 20K for hydrogen liquefaction. Finally, performance tests were conducted, the measured hydrogen liquefaction rate is 1.59 tons per day, the specific energy consumption is 15.1 kWh/kg LH2, and the Para-hydrogen content in the liquid hydrogen output is 98%. The test results indicated that the plant's operational performance met the design specifications, suggesting that the design and commissioning processes were successful.

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