INVESTIGATION OF HEAT TRANSFER COEFFICIENT OF VERTICALLY HELICAL BUNDLE TUBE TYPE HEAT EXCHANGER FOR OXIDIZER DENSIFICATION

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Abstract: Cooled oxidizer, liquid oxygen, up to 86 K from the saturated temperature 90 K is supplied in replenishment to reduce boil-off after filling for Korea Launch Space Vehicle series. Decreasing oxidizer temperature is achieved by shell and tube type heat exchanger using 77 K liquid nitrogen as a cold side. It is one of the easiest ways to decrease oxidizer temperature without cooling the mechanical system as a cryocooler. An oxidizer is cooled as it flows into a tube side. The tube side of the heat exchanger is designed helically along the vertical direction and is immersed in a liquid nitrogen bath. A helically coiled vertical tube is volumetrically efficient and easy to control the outlet temperature of hot flow with handling a level of liquid nitrogen in a shell bath. The heat transfer coefficient is the most important in the design of a heat exchanger, and it is complicated to obtain the heat transfer coefficient on the outer tube wall. Nucleated boiling heat transfer of pool boiling occurs on the outer surface of the tube side in the shell side bath containing liquid nitrogen. However, bundle effect is also considered forced convection by bubble rising in bundle type heat exchanger.[1-3] The heat exchanger for generating subcooled oxidizer for the replenishment process is manufactured and installed in the oxidizer filling system of the second launch complex for Korea Launch Space Vehicle II in Naro space center located on Naro island of South Korea. In this study, the test results are analyzed, and the heat transfer coefficient considering the bundle effect is obtained in the bundle type heat exchanger under cryogenic liquids, liquid nitrogen, and liquid oxygen. The performance tests for examining heat transfer coefficient are conducted while applying a various range of mass flow rates of liquid oxygen and controlling the heat transfer area by changing the level of liquid nitrogen in the shell. The energy balance can obtain the heat transfer coefficient on the outer surface of the tube by comparing the total heat transfer amount calculated by the difference between the overall heat transfer coefficient and the change of inlet and outlet enthalpy. Since the outer heat transfer coefficient consists of nucleated boiling and forced convection, the forced convection heat transfer coefficient can be determined and confirmed to what extent the bundle effect is.

References:
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