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C3Or2A-05: Onboard cryogenic propellant subcooler for launch vehicles using Joule-Thomson Device

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Subcooling of cryogenic propellant offers significant advantages for launch vehicles. By densifying the propellant, the propellant tank can be made compact. In addition, onboard subcooling of the cryogenic propellant in the tank efficiently achieves the required NPSH for the rocket turbopump. This means that the amount of venting gas from the tank to cool the propellant and the amount of tank pressurizing gas, such as helium, can be reduced. Therefore, the onboard subcooler is especially advantageous for upper stages. In this study, a cryogenic propellant subcooler consisting of a Joule-Thomson orifice and a heat exchanger was developed. A sub-scale test was conducted using liquid nitrogen as the working fluid, and subcooled liquid nitrogen was successfully obtained. By evaluating the thermal efficiency, the optimum diameter of the Joule-Thomson orifice was found. Considering a practical application of the subcooler for the upper stage propulsion system, the present method proved to have less weight penalty compared to the conventional vent/press operation.

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