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INFLUENCE OF HYDROGEN AND OXYGEN SELF-PRESSURIZING TEMPERATURE ON HEAT TRANSFER OF PROPELLANT TANK

Abstract

Liquid hydrogen/oxygen has the highest specific impulse among chemical propellants, which can significantly improve the performance of space transportation system. For hydrogen and oxygen, self-pressurizing system can be adopted for tank pressurization to reduce the mass of system. Part of the liquid propellant is extracted from the tank, and heated and gasified by the engine before sent back to the tank to increase the pressure to the necessary value for the propulsion system. The self-pressurizing temperature is higher than the storage temperature of the tank, which will cause the loss of propellant. The loss of propellant is directly related to the total quantity of heat brought to the tank during pressurization. If the self-pressurizing temperature is low, the mass of gas required to achieve the pressurization effect of the specified volume of propellant is large. If the temperature is high, the mass of pressurized gas is small, but the heating effect of gas per unit mass is more significant. The total quantity of heat depends on both the density and the enthalpy difference, and they have opposite variation trend with temperature. Therefore, the effect of self-pressurizing temperature on the heat transfer of propellant tank might show a non-monotonic relationship. In this paper, the total quantity of heat brought to the tank at different self-pressurizing temperature is calculated and analyzed. The calculation results show that for hydrogen, the total quantity of heat decreases first and then increases with the increase of temperature at a certain pressure. There is a minimum of total quantity of heat. For the pressure within the range of 0.25 to 0.45 MPa, the temperature of the minimum heat is always around 150 K, with a deviation less than 2 K. For liquid oxygen, in the temperature range of 90 to 600 K, the total quantity of heat decreases monotonically with the increase of temperature with no minimum, which is mainly due to the fact that the decrease of density with temperature is greater than the increase of enthalpy difference with temperature. The above calculations imply that when the self-pressurizing temperature of liquid hydrogen is selected as 150 K, the total quantity of heat brought to the tank is the smallest, which is good for the storage of cryogenic propellant. These results might provide some guidance for the design of hydrogen/oxygen space transportation system.