IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Vehicles – Mechanical/Robotic/Thermal/Fluidic Systems (7)

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DESIGN OF AN INTEGRATED VEHICLE FLUID SYSTEM BASED ON ENERGY-FLUID MATCHING

Abstract

The integrated vehicle fluid (IVF) system integrates the functions of attitude control, electricity supply, and tank pressurization through the unified management of the high-specific-impulse cryogenic propellant of hydrogen and oxygen, which can significant reduce the system redundancy. In a typical IVF system, a small internal combustion engine (ICE) burns gas hydrogen and oxygen evaporated from tank and generates electricity to supply the vehicle equipment. The ICE provides necessary heat, liquid hydrogen and oxygen absorb the heat and convert to gas in hydrogen and oxygen heat exchangers (HEX). The gas hydrogen and oxygen are collected in accumulators and provide attitude control with hydrogen/oxygen thrusters. The gas in the accumulators are also used for self pressurization of tank. Applying IVF could significantly reduce the types of propellant of space transportation vehicle, which has great advantage in future in-orbit refueling era. In this paper, a design of an integrated vehicle fluid system is proposed based on on energy-fluid matching. The new system design has a couple of differences from previous IVF designs. Firstly, the ICE-burned gas hydrogen is taken from the evaporation waste of liquid hydrogen tank as usual, while the ICE-burned gas oxygen is supplied by the gas oxygen accumulator, which provides better control regulation capability of ICE power. The above design also suits the propellant filling technology of deep subcooling of liquid oxygen, where the evaporation in tank is extremely low. Secondly, a combined hydrogen-oxygen-coolant three-way HEX replaces the two separated hydrogen and oxygen HEX. Through two different heat exchange stage, the heat obtained from ICE could be flexibly distributed between hydrogen and oxygen, while the temperature of both fluid at the outlet of heat exchanger could be stably controlled at 150 K. The above temperature of 150 K has been considered as the optimum temperature of self pressurization in previous research. The system parameters and workflow of IVF is designed based on energy-fluid matching. The temperature, pressure, flow rate, heat, electricity of different modules must match with each other during five different operative mode of IVF. The design parameters and control logic of ICE and HEX is developed and the evolution of IVF system parameters during the whole vehicle mission are calculated.The calculation results in this paper show that by applying IVF the total weight of corresponding system can be reduced by 18 percent. The results might provide some guidance for the design of hydrogen/oxygen space transportation vehicle.