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RESEARCH AND DEVELOPMENT OF THE TURBOPUMP FOR A HYDROGEN PEROXIDE/KEROSENE ROCKET ENGINE WITH STAGED COMBUSTION CYCLE

Abstract

Compared with conventional propellant, hydrogen peroxide/kerosene has better density specific impulse, nontoxicis and non-polluted qualities although the general performance of this kind of propellent is slightly lower. It also has merits of longer storge period and lower operational cost than those cryogenic propellants. As the rocket propellant, its feature of non chemical reaction with air is more suitable for the reusable aerospace vehicle. In addition, its lower vapor pressure means lower inlet pressure requirement of turbopump which leads to lower oxidizer tank mass, and the high specific heat can simplify the whole cooling system. Due to the increased awareness about the envionmental protection in China, a program of hydrogen peroxide/kerosene rocket engine for high performance upper stages has been successfully carried out in recent years. However, there are more difficulties and even risks in the research and development of turbopump than other components of the rocket engine. The development approach and experiences of the turbopump assembly for a 35kN-thrust-class rocket engine with staged combustion cycle using hydrogen peroxide/kerosene are presented. Hydrogen peroxide has such features as catalytic decomposition effect, decomposing in the heat and exothermic decomposition effect. And the rocket engine with staged combustion cycle brings about the high operating pressure of turbine. Thus focuses of the design and research work are mainly on the solutions to above propellant and system problems. The turbopump's overall configuration, the cooling circuit and the blow-off scheme are particularly designed adaptable for the hydrogen peroxide propellant. Based on the investigation of compatibility between materials of pump and turbine with their working fluid, a set of practical measures as compatibility evaluation criteria, material selection and passivation process of pump parts is developed. Also as a result, the turbine material is determined. Furthermore, the operation tests of bearings and mechanical seals help to solve the problem of material adaptability to hydrogen peroxide. The high-speed turbopump assembly consists of fuel and oxidizer pumps, and a single-stage parpial admission turbine mounted on a common shaft. The hydrogen peroxide pump is a typical centrifugal impeller with an inducer, and the kerosene pump adopts the type of partial-flow impeller due to the low specific speed and rotor dynamics. The turbine with small pressure ratio and lower reaction meets the higher performance requirements. Finally, the results of the turbopump tests and engine hot-fire tests are analyzed, and the focus direction of further researches is put forward.