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Author: Mr. Lihao Zheng
School of Astronautics, Beihang University, China

Dr. Nanjia Yu
School of Astronautics, Beihang University, China
Mr. Sihan Di
School of Astronautics, Beihang University, China
Mr. Haodong He
School of Astronautics, Beihang University, China
Dr. Chuang Zhou
China
Mr. Bowei Jiao
Beihang University (BUAA), China

FAULT SIMULATION STUDY OF FULL-FLOW STAGED COMBUSTION CYCLE ENGINE START-UP PROCESS

Abstract

Due to the harsh working environment, the liquid rocket engine is a sensitive and frequently malfunctioning part of the launch vehicle. The faults of the liquid rocket engine have the characteristics of rapid progression and strong destructiveness. The full-flow staged combustion cycle, as a staged combustion cycle with the highest combustion performance, has a complex engine structure including multiple rotary turbopump systems and numerous valves. These components are prone to failure during transient processes with drastic changes in state parameters. This study focuses on the start-up process of the liquid oxygen/methane full-flow staged combustion cycle engine. Based on the general simulation software AMEsim model library, a comprehensive simulation model of the engine system is constructed to simulate and analyze common faults during the start-up process, and to qualitatively analyze the characteristics of these faults. The simulation results show that a tank pressure fault has a relatively small impact on the system state and does not cause drastic fluctuations in system parameters. However, low tank pressure will decrease the starting speed and increase the load on the forced starting device. A minor leak in the upstream propellant pipeline will cause a decrease in combustion chamber pressure and an increase in the flow rate at the tank outlet. Furthermore, the closer the leak occurs to the main combustion chamber, the greater the impact of the same leak amount on the pressure in the main combustion chamber. Faults in the fuel pump and oxygen pump will both cause deviations in system parameters from the set values, with the oxygen pump failure having a greater impact on the system parameters due to the large proportion of mass flow rate supplied by the oxygen pump in the total propellant mass flow rate.