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SYSTEM ANALYSIS OF FEED SYSTEM COUPLED COMBUSTION STABILITY IN LIQUID ROCKET ENGINES

Abstract

In order to study the longitudinal acoustic combustion instability in the liquid rocket engine scale test system, frequency domain models are established, which consider gas choking boundary conditions. The models include distribution parameter pipeline model, throttle orifice model, open swirl injector model, secondary injection model, and manifold volume model in the liquid feed system, sensitive time-delay combustion model and distributed parameter gas flow model in oxidizer-rich gas generator. The impedance characteristics of the generator inlet are analyzed under the flow disturbance of liquid oxygen and kerosene. It is found that the superposition of entropy waves makes the first-order longitudinal acoustic frequency of the generator relative to the disturbance of liquid oxygen and kerosene flow slightly different, and it is offset from the theoretical value. The admittance characteristics of the outlet of the liquid oxygen and kerosene feed system are analyzed under the chamber pressure disturbance. The open swirl injector dynamic model reduces the admittance amplitude of the feed system, and has a greater impact on the medium and high frequency than the low frequency. As the diameter of the pipeline increases, the flexibility increases, and the admittance increases as a whole. As the impedance of the throttle orifice increases, the local characteristics of the feed system are more obvious, and the effect of preventing the chamber pressure pulsation from propagating to the upstream of the feed system is stronger. According to control engineering theory, the amplitude-frequency response and phase-frequency response of the open-loop transfer function are obtained, and the stability of the closed-loop system is analyzed using the logarithmic frequency stability criterion. Adjusting the position of the throttle orifice and the length of the pipeline can make the higher frequency response of the local feed system stagger with the first-order longitudinal acoustic frequency of the generator to avoid resonance. When the pipe diameter is reduced, the flexibility is reduced, which can reduce the admittance amplitude of the feed system and improve the stability. In summary, for the problem of combustion instability coupled with the feed system, the system stability can be improved by changing the parameters of the throttle orifice and pipeline in the feed system.