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PARAMETERS ANALYSIS OF NON-LINEAR COMBUSTION INSTABILITY BASE ON THE PULSED TRIGGER T-BURNER TECHNIQUE

Abstract

High-amplitude pressure oscillation in the combustion chambers of solid propellant rocket motors shows the nonlinear effect, including the mean pressure shift, the limit amplitude of the acoustic oscillation and the energy transfer between acoustic modes, which is usually called nonlinear combustion instability. These characteristics have the greatest destructive effect on the reliability and structural integrity of the system with the obvious undesirable vibration. The physical mechanism behind these phenomena is closely related to propellant combustion and nonlinear acoustic oscillation behavior; however, it has never been successfully established and still lacks relevant experimental data. Therefore, to fully understand the nonlinear combustion instability mechanism and carry out experimental research can effectively avoid or reduce combustion instability problem in the solid rocket motor. In this paper, the typical characteristic parameters of nonlinear combustion instability are measured based on the experimental technique of pulse-triggered T-burner, and the coupling relationship between propellant combustion characteristic and nonlinear acoustic oscillation is analyzed emphatically. Some different formulas of the composite propellants were adopted during the 30 pulsed T-burner firings. The operating pressure was set at about 7MPa and 10.5MPa, and the oscillation frequency was set at about 140Hz, 170Hz and 255Hz respectively, which are all the fundamental frequency of longitudinal acoustic mode in chamber. The results show that: First, the pulser trigger T-burner technology can measure the nonlinear instability parameters of the DC Shift, oscillation amplitude and the combustion characteristics of the propellant. Second, the different formulation propellants have the different combustion response characteristic, which have significant influences on the DC Shift and the limit oscillation amplitude. With the combustion response function increase, the DC Shift increases about 13.8-25.3%, and the initial limit amplitude increases about 24.5-55.5% under the different oscillation frequency with same pulser trigger pressure. Third, the DC Shift is proportional to the second order of the oscillation amplitude, and linear to the combustion response function, and the three parameters are closely coupled to each other. Finally, when the mean pressure shift over more than 5%, the energy transfer process will occurs between the acoustic modes, the high order longitudinal oscillation modes of the acoustic in the chamber are more likely to be excited, such as the second-order, third-order and higher orders, and the nonlinear combustion instability was more remarkable.