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THE THREE-DIMENSIONAL COMBUSTION FLAME OF MICRON ALUMINUM PARTICLES BASE ON COMPUTED TOMOGRAPHY OF CHEMILUMINESCENCE (CTC)

Abstract

Aluminum powder has been widely used in solid propellants, which can improve the specific impulse, loading ratio and damping the high frequency combustion instability. Much work had been study on the combustion characteristic of the aluminum particles by optical methods. Most of these optical methods were two-Dimensional (2D), which project the three-Dimensional (3D) combustion field onto a 2D plane and obtain by the high speed camera. However, due to the cumulative effect of projection direction, the 2D optical methods for temperature, component concentration and heat release measurement have large error. Therefore, in this paper, the technology of computed tomography chemiluminescence (CTC) is applied to the measurement of aluminum combustion, so as to obtain the structure of 3D micro combustion flame of aluminum particles near the solid propellant surface. Combined with dual wavelength temperature measurement technology, the temperature field distribution of 3D micro combustion flame is measured and analyzed. Nine imaging fiber bundles coupled with two High-CCD device cameras and two optical filters (700nm and 900nm) are used to acquire flame images simultaneously from nine different directions in a circular around the propellant combustion flame. The improved ART approach is used for the reconstruction of flame sections and the accuracy for different numbers of projections and angles are carried out in resolution. Simulation results are presented for the 3D reconstruction of the luminosity distribution of gas flame cross-sections and longitudinal-sections of gas flame. The experiment were carried out with AP/Al/HTPB propellant under 0.1MPa, the 3D morphology and of 3D temperature distribution of gas phase flame of aluminum particles (300μm) near the combustion surface was obtained, and the dynamic characteristics of 3D combustion flame of aluminum particles were analyzed. The results show that the three-dimensional flame dynamic process of solid propellant can be obtained by CTC. The dynamic evolution law of combustion flame difference of the same aluminum particle at different angles can be found by analysis, which can provide important data support for the establishment of aluminum combustion mechanism and combustion model.