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3D IMAGING OF BURNING ALUMINUM PARTICLES IN SOLID PROPELLANT USING DIGITAL INLINE HOLOGRAPHY

Abstract

Aluminum powder particles has been used as metal additives in solid propellants since 1950's. The addition of aluminum powder can improve specific impulse, filling ratio and suppress high frequency combustion instability. The use of aluminum powder also has a negative impact that agglomerates formed by multiple Al particles will lead to a decrease in the combustion efficiency and two-phase flow losses. Therefore it is of great significance to carry out research on combustion mechanisms and regularity of aluminum particles. High speed camera with microscopic lenses is a commonly used device for aluminum combustion research which can obtain the droplet burning process and surface phenomena. However, in this method, only a few particles are located on the focal plane, and a large number of particles are blurred, which will lose a lot of useful data. In order to solve the problem that the high speed microscopic imaging suffers from a small depth of field and to obtain a fine dynamic combustion process of aluminum particles, high-speed digital inline holography (DIH) as a three-dimensional diagnostic tool is applied to record the combustion process of solid propellants. Digital in-line holography (DIH) is an optical technique which can obtain 3D information of particles through numerical reconstruction using a single camera. In this study, we use high speed digital holography to get the 3D positions, particle size and velocity of burning aluminum particles in solid propellant combustion field. The composite propellants used in the experiment are four-component, including Al(17 wt.%), AP(50 wt.%), RDX(10 wt.%) and HTPB(23 wt.%). Because solid propellants have different combustion states under different pressure atmospheres, the experiments are carried out under ambient pressure and 1MPa (nitrogen atmosphere) respectively. Through numerical reconstruction of the holograms, we obtain many dynamic behaviors of aluminum particles in the combustion field of the solid propellant, including the dynamic agglomeration of multiple particles on the burning surface, the dynamic combustion process of the agglomerates during it leaves the burning surface, the dynamic process of filigrees formation, the dynamic process of ejecting small agglomerates into the surrounding gases from burning aluminum particles and the dynamic process of single agglomerates break up into multiple agglomerates through explosion. Some results are compared with discoveries from high-speed imaging. From this study, the digital holography is expected to become a powerful experimental measurement tool for metalized solid propellants.