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EXPERIMENTAL STUDY OF BORON IGNITION AND COMBUSTION IN CONVECTIVE FLOW

Abstract

Boron is a typical high-energy candidate for propellant formulations in the primary combustor of ducted rockets due to its potentially high energy release. The primary combustor burns and generates fuel-rich hot gas. Boron particles are heated in primary combustor, and then they are ignited with the hot air in the secondary combustor in which the induced ram-air and the fuel-rich hot gas mix and combust. All the present studies including models and experiments are in relatively static conditions. However, in typical secondary combustor, boron particles are in a convective environment at various Reynolds numbers. The fields around boron particles are no longer spherical symmetric. And the flow of the liquid oxide layer is affected by the relative velocity of the surrounding hot gas. So the production and consumption of the oxide layer may be changed. Moreover, flame shapes of boron particles in the combustion process may vary at different Reynolds numbers. And the burning rates corresponding to the convective environment will be different of those under relatively static conditions. Unfortunately, detailed experimental study and theoretical modeling of such cases are not available at present. In the present study, crystal boron lumps (purity of 99.99%), and spherical boron samples which are prepared by pressing micron crystal boron particles (purity of 99.99%) into spheres with diameters of 5-15mm for fixation convenience in the convective gas flow are ignited by xenon arc lamp and ethanol-oxygen combustion product. An experimental apparatus is designed including the ethanol-oxygen generator, the flow steadying section and the experimental section. The cross section of the experimental section is designed capaciously enough to reduce the boundary effect. The fixation location is situated about 540mm downstream of the nozzle exit of the ethanol-oxygen generator. The length is believed to be enough to steady the hot gas flow. A quartz window in the upside of the experimental section is designed for the auxiliary heat of the xenon arc lump and sometimes for recordings. The flame shapes of the boron ignition and combustion at various Reynolds numbers are recorded, and analyses are done for those cases. The results show that in high temperature gas flow, the ignition and combustion process of boron may be intensified at appropriative Reynolds numbers, but boron may extinguish at much higher Reynolds numbers. The work done can provide guidance to reveal the mechanism of boron particles ignition and combustion process in the secondary combustor of ducted rockets.