Abstract

Boron-based fuels have remained attractive for solid fuel ramjet (SFRJ) and ducted rocket (SFDR) applications since long due to their potential to release high energy on combustion. However, boron's energetic potential has not been successfully harnessed even till date in any practical combustion system. As reported in literature, boron has its inherent problems during ignition and combustion due to native boron oxide (B_2O_3) coating around active core boron. In view of this, the present research focuses on utilizing boron particles embedded in paraffin-wax and HTPB in various proportions (weight %) as solid fuel. Various fuel combinations are studied here such as boron with paraffin-wax, boron with HTPB, and boron with HTPB along with metal additives (titanium, magnesium, and iron). Ti, Mg, and Fe particles have been used with boron-HTPB based solid fuel to enhance the burning of boron. A low-cost, rapid screening instrument called an opposed flow burner (OFB) is used to investigate the salient features of various boron-based solid fuels to understand the major performance parameters such as regression rate and burning efficiency. Gaseous oxygen is impinged on the solid fuel surface in OFB system. A range of oxygen mass flux has been considered while performing the experiments. High-speed videography and UV-VIS spectroscopy have been employed to realize the burning process of fuel samples. Emission spectra obtained from the experiments identify the gas-phase intermediate species (BO and BO_2) of boron ignition/combustion. The energy density of virgin solid fuel samples is evaluated using bomb calorimeter. In addition to that, several material characterization techniques such as FE-SEM, EDS, XRD, and TGA have also been applied on pre-and post-burn samples (ejected from the burning surface) to identify the physiochemical changes. The main objective of the present research is to understand the feasibility of boron-based solid fuels for hybrid gas generator in ducted rocket applications.

Keywords: Boron; Paraffin-wax; HTPB; Solid fuel; Opposed flow burner; Combustion; Regression rate; Burning efficiency; SFDR.