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ULTRASONIC MEASUREMENT OF SOLID FUEL REGRESSION RATE OF A HYBRID SLAB MOTOR

Abstract

Instantaneous solid fuel regression rate is important for hybrid rocket motor design and performance prediction. Ultrasonic pulse-echo system is a well-developed method to measure time-related regression rate, but the accuracy of the system is largely dependent on sonic velocity of the fuel, which is related to local pressure and temperature. To derive accurate transient regression rate of different types of fuel, effects of pressure and temperature on sonic velocity was examined and was taken into account in the following firing test results. A specialized hybrid slab motor with a quartz glass window and thermal couples was designed. A 300mm-long, 80mm-wide and 25mm-thick slab fuel was attached to the upper wall of the chamber with ultrasonic transducer outside the wall. One of the side walls was equipped with a quartz window, through which temperature distribution was recorded roughly by a thermal infrared imager and a high speed photography metrical system to give a general description of the diffusion flame. The other side wall was inserted with thermal couples to record temperature distribution and to calibrate the thermal infrared imager. The pressure effect of pure HTPB, metallized HTPB, PMMA and PE on sonic velocity was measured at different pressure by blocking the exit of the nozzle and pressurizing the chamber with nitrogen. The temperature effect of different fuels on sonic velocity was confirmed by standard blocks of fuels at different temperature in an oven in non-burning condition. According to the results, sonic velocity of solid fuels under firing condition was calculated by measured bulk pressure and simulated temperature profile in the fuel during firing tests. Results of regression rate of hybrid slab motor firings were then calibrated by the corrected sonic velocity and compared to images taken by high speed photography metrical system.