Results of Propellant Mixing Variable Study Using Precise Pressure-Based Burn Rate Calculations

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Abstract

A designed experiment was conducted in which three mix processing variables (pre-curative addition mix temperature, pre-curative addition mixing time, and mixer speed) were varied to estimate their effects on within-mix propellant burn rate variability. The chosen discriminator for the experiment was the 2-inch diameter by 4-inch long (2x4) Center-Perforated (CP) ballistic evaluation motor. Motor nozzle throat diameters were sized to produce a common targeted chamber pressure. Initial data analysis did not show a statistically significant effect. Because propellant burn rate must be directly related to chamber pressure, a method was developed that showed statistically significant effects on chamber pressure (either maximum or average) by adjustments to the process settings. Burn rates were calculated from chamber pressures and these were then normalized to a common pressure for comparative purposes. The pressure-based method of burn rate determination showed significant reduction in error when compared to results obtained from the Brooks' modification of the propellant web-bisector burn rate determination method. Analysis of effects using burn rates calculated by the pressure-based method showed a significant correlation of within-mix burn rate dispersion to mixing duration and the quadratic of mixing duration. The findings were confirmed in a series of mixes that examined the effects of mixing time on burn rate variation, which yielded the same results.