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DEVELOPMENT OF A CONSISTENT BURN RATE DETERMINATION METHODOLOGY FOR BALLISTIC EVALUATION MOTOR

Abstract

Propellant burn rate is the major contributing input parameter for the accurate performance prediction of solid rocket motor (SRM) in addition to various other input parameters such as nozzle throat diameter, propellant mass, burn rate scale factor, throat erosion rate and correction factors for mid-web anomaly, propellant characteristic velocity and thrust coefficients. Testing of small motors (ballistic evaluation motors - BEM) is the most practiced procedure for the burn rate determination of solid propellant. Even though the BEMs are cast along with main motor using same propellant, the measured burn rates mostly need a scale factor to match the main motor performance. This burn rate scale factor will be different for different type of motor even if the propellant is the same and depends on the size of the main motor, the casting processes etc.

The BEM used is of 1m long, 200mm diameter with radially burning 10-lobed star ported grain of propellant mass 42kg. The BEM grains are cast separately as cartridge grains with a 2mm thick outer rubber insulation and fired in a metal motor case at a desired pressure by using a graphite nozzle of appropriate opening. The burn rate is evaluated as the ratio of minimum web thickness to the burn-time. Burn-time is the point of sharp drop of pressure of the motor at which propellant web reaches the insulation of the motor. The accuracy of the burn rate calculated depends on the accuracy of the web measurements and precision of burn-time selection. A variation of 0.3mm in the web dimension or 25ms in the burn-time can result in 0.5 percentage error in the estimated burn rate. Among these two parameters, accurate web measurement value can be obtained with a vernier callipers but determination of burn time is ambiguous because the pressure fall at burn time is not sharp for most of BEM tests.

The paper describes a methodology based on locating a point close to the sharp pressure drop region of the dimensionless pressure-time curve as the burn time at which the curve has a pre-fixed negative slope. The advantage of the method is that it can be easily programmed and the burn time can be determined automatically by feeding the pressure-time history of the motor. Large number of BEM analysis indicated that the results are accurate and the computed burn rates gives accurate performance history of main motors with consistent scale factors.