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A SCALED-DOWN STATIC TEST METHOD FOR SOLID ROCKET MOTORS.

Abstract

A scaled test method was developed to simulate not only combustion chamber conditions, but also realistic hoop stress, shear stress conditions in the casing, and web thickness and shear stress conditions in the propellant grain. This method was applied in a series of tests for an O-class solid rocket motor, the results of which are presented in this paper.

The need to perform scaled-down static motor tests exists predominantly for mid- to large-scale motors, for conservation of resources, safety reasons, and/or due to restrictions and regulations. Typically scaled-down static motor tests recreate conditions such as chamber temperature and pressure of the full-scale motor, but not conditions such as hoop stress and shear stress within the casing, web thickness and shear stress in the propellant grain during firing, performance of inhibitor and thermal liner for the entire duration of the burn, which then have to be reproduced using other testing techniques.

The so-called Single Grain Motor (SGM) test is a method that was developed to encompass all of the aforementioned tests in one. It was specifically designed for Bates-grain configurations, however it can also be adapted for any propellant grain shape/size solid rocket motor.

Such a test set-up will accurately reproduce key conditions and performance parameters of the full-scale motor, including the combustion chamber temperature and pressure, propellant regression rate, total burn time, motor specific impulse, heat transfer and insulation, hoop stress in motor casing, shear stress in motor bolts and retainer rings, igniter and pressure sensor interfaces. From these data, parameters such as thrust, total impulse, and mass flow can easily be calculated within a reasonable degree of accuracy. Additionally, SGM tests help streamline the process of manufacturing, assembly, and testing, and material supply, as well as obtaining a much more accurate estimation of the material and full assembly mass and dimensions. Thus, any faults in manufacturing, assembly, or exploitation can be adjusted accordingly at an earlier stage of the design process.

A series of SGM tests was conducted for an O-class (total impulse 30,000 Ns) Bates-grain configuration solid rocket motor. Their results were used in conducing a detailed design of the motor. Subsequently, the actual performance was analyzed and compared with the theoretical simulated performance. This paper details the results of these test campaigns, as well as the description of the test method in general and how it can be applied to other solid rocket motors.