SPACE PROPULSION SYMPOSIUM (C4)
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ESTIMATION OF FLIGHT SPECIFIC IMPULSE FOR SOLID PROPELLANT ROCKET MOTORS

Abstract

In general the specific impulse of a solid propellant rocket motor (SRM) is computed from static tests by measuring the thrust, integrating for total impulse and then dividing by the propellant weight to obtain the average specific impulse. However, this method is not considered accurate as static test involves flow separation effects, unburned propellant in the chamber that can burn at atmospheric pressure, unchoked flow conditions and other limitations. A new procedure is adopted to compute vacuum specific impulse from the measured sea level thrust of ground tested SRMs, which takes care of these ambiguities. This method is applied for two ground tests of a large solid rocket motor that are conducted recently. Various factors that affect the specific impulse are obtained from the ground test like: throat erosion law, combustion efficiency, thrust efficiency, and weight of the propellant burnt. Theoretical computations are made for the flight motors by utilizing the data obtained from the static tests.

In post flight analysis the average specific impulse is calculated through acceleration based trajectory reconstruction of the vehicle velocity by optimization methods. The specific impulse is computed using a model for the expelled mass, the ideal velocity equation and various velocity losses. It is observed that there is a difference of 0.3s to 1.3s between flight reconstruction and propulsion models. This paper presents the analysis that are carried out to understand these differences by considering various parameters like variation of throat erosion law, accuracy of pressure transducer, drag losses, variation in hump factor (thrust time profile) and other parameters. The purpose of the work is to consolidate the methodology for the analysis and reconstruction of the solid stage flight data, in order to characterize the scattering of the motor performance, reducing the uncertainties for the prediction methodologies for the future flights.