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INVESTIGATION OF THRUST OSCILLATIONS IN LARGE SEGMENTED SOLID ROCKET MOTORS DURING GROUND TESTS

Abstract

Thrust oscillations, induced due to the vortex driven pressure oscillations inside the combustion chamber of large segmented Solid Rocket Motors (SRM), has been an important and widely discussed topic among space community for more than 30 years now. Thrust oscillations with significant dynamic loads often reduce the payload mass capacity and launcher usability, and therefore their reduction and control becomes an important objective. All the large SRM's like Space Shuttle RSRM, Titan SRMU, Ariane 5 MPS, ETM-03, and Ares DM-1 have been reported for pressure oscillations in ground tests and even during flights. The recent ground tests of the S200 motor, the strap-on boosters for the three staged GSLV Mark III vehicle, also revealed the presence of oscillations in its pressure and thrust. This paper briefly discusses the physical mechanism behind the pressure oscillations and its applicability to the S200 Motor. Further, it elaborates on the findings of the oscillation measurements carried out during S200 Motor static tests. The data processing techniques and related evaluation methodologies are also discussed. Interestingly, the transformation of the pressure oscillations into thrust (the ratio of thrust oscillation to pressure oscillation) appears to be highly non-linear and changes with the burn time. Though numerical simulations, cold-flow experiments and subscale firings have been proven to give substantially fair description of these pressure oscillations, the full scale firing of the rocket motors have been always of wide interest. However, evaluation of the dynamic thrust during full scale firings is a challenging task in view of test stand structural interactions. Different in-situ experiments were performed to understand and characterize the test stand dynamics. Subsequently, by refining the measured static test data, a thrust oscillation forcing function and the profile of pressure and oscillations that is expected for S200 solid motors during the burn time were generated. Probable reasons for variation in the magnitude of thrust oscillations between the two ground tests have also been proposed. These results are useful in further studies of launch vehicle response and the requirement for employing Thrust Oscillation Isolation System etc. This paper contains details like: 1) Data acquisition and recording 2) Dynamic charactarisation of static test stand 3) Theoretical estimation of Thrust oscillations 4)Analysis of thrust and pressure data.