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SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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SOLID ROCKET MOTOR BALLISTIC SIMULATOR WITH NON-HOMOGENEOUS BURNING RATE DISTRIBUTION

Abstract

In Solid Rocket Motors (SRM) design the capability of modeling and predicting the ballistic behavior in all the operative conditions, from ignition transient to burn out, has always been very important in order to optimize design parameters and save development costs. Furthermore, the repeatability of the propulsive performances of a SRM has always constituted a common requirement by each designer or customer and, for this reason, the understanding and the diagnostics of instabilities or anomalous conditions surely represents a key aspect of this thematic. Local variations in propellant composition, air entrapments or surface imperfections can generate unexpected alterations in local burning rate (i.e. *Hump effect* or *BARF*) and consequently in pressure profiles. In order to reproduce these heterogeneities in the burning surface regression a three-dimensional simulation model has been developed at the II Faculty of Engineering of the University of Bologna, in collaboration with Avio Company, located in Colleferro (Rome). The algorithm has been realized mostly in Matlab code and represents the evolution of some previous two-dimensional versions, already tested on Small-Scale-Motors used in Avio for propellant characterization. It has been devised to be easily adaptable to a wide range of geometries and dimensions. Once acquired the motor configuration through a user-defined surface triangular mesh, the combustion process and the burning surface regression is simulated by the controlled movement of its vertices in relation to the local amount of burning rate and surface normal direction. The propellant behavior is locally characterized by predefined models which consider chamber pressure, surface temperature and grain composition variations. Then, a one-dimensional algorithm, developed in Avio and based on a finite-difference approach, provides the instantaneous distribution of pressure and the internal fluid-dynamics of combustion gases. In this way, knowing the burning surface evolution versus burnt web, and other motor characteristics, the pressure, mass flow rate and thrust can be calculated in function of the time. A preliminary validation phase has been completed on theoretical cases with homogeneous and non-homogeneous burning rate distributions, obtaining appreciable results in terms of volume and burning surface evolutions. Then, a new test campaign has been performed on the third-stage SRM of the Vega launcher manufactured by Avio, and the simulated results have been compared with its experimental firing test data.