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DEVELOPMENT OF THE QUASI-3D MODEL FOR THE GRAIN BURNBACK ANALYSIS OF SRM'S

Abstract

To date performing the grain burnback analysis of 3D grain designs has been a computationally time-consuming task. Consequently, this fact complicates the preliminary design due to the long time required to simulate each case. Indeed, the aim of this phase is to find rapidly the initial grain configuration, which is then improved and optimized with more accurate calculations in the following design steps. This way, in recent years many efforts have been carried out towards finding faster 3D grain burnback analysis techniques.

This project presents the development of a numerical code aimed to simulate the grain burnback analysis and predict the performance of a solid rocket motor (SRM). On the one side, the Level Set Method (LSM) has been applied to calculate the grain burnback evolution of 2D and 3D grain configurations introduced by the user as an input. In addition, in order to implement the 3D grain burnback analysis, an innovative approach called Quasi-3D model has been developed towards reducing the computational time. The Quasi-3D approach consists of modeling the 3D grain burning surface through few 2D reference cross-sections, which are propagated using the LSM in 2D. Then, the 3D surface is reconstructed by interpolating the grain shape between the reference cross-sections. Precisely, the 3D grain burning surface is generated in two steps: reconstruction of the zero level set of each reference cross-section and triangulation between the points of each cross-section to form the 3D surface. On the other side, in order to calculate the performance of the SRM, the internal ballistics simulation uses 0D-unsteady and 1D quasi-steady flow models found from the literature.

The numerical code has been validated studying the NAWC motors No. 6 and No. 13. The comparison of the simulation results against the experimental data and other simulation tools shows a good agreement. Therefore, the quasi-3D model represents a successful trade-off between simulation time and accuracy, though it is faster than the 3D LSM but not as precise. Hence, the Quasi-3D model is a suitable tool for the preliminary design phase of a SRM.