Paper ID: 87398
oral

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IPB)

Author: Mr. Jan Erik Zeriadtke
DLR (German Aerospace Center), Germany

HYBRID ROCKET ENGINE NOZZLE DEFORMATION USING A LEVEL SET METHOD

Abstract

Nozzle erosion remains a significant challenge for the technology readiness level of hybrid rocket engines.To enable detailed flow analysis within the nozzle and general performance characterization, it is necessary to describe the three-dimensional nozzle geometry over the burn time. This work presents a novel method to simulate the time resolved nozzle geometry by using an implicit surface definition, the level-set method, and a common erosion rate model for ablative graphite. The surface is implicitly defined by a signed distance function in the flow field and structure. The erosion rate of the nozzle surface is calculated using CFD data and empirical correlations. These rates are used to deform the geometry by in a three-dimensional level set method. The level set equation is discretized using finite differences in time and discontinues Galerkin tetrahedron finite elements in space. The implementation using the open-source FEniCSx FEM environment is presented. To maintain the shape of the signed distance function, it has to be reinitialized periodically. For this purpose, a second PDE is implemented and solved similarly whenever the distance function becomes distorted. To validate the implementation, a variety of two- and three-dimensional test cases are presented, their convergence behaviour is shown. For practical meshes with up to five million nodes, parallel solving of the partial differential equations is shown to scale well. Finally, the resulting nozzle erosion simulation for the VISERION hybrid rocket engine is discussed.