SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (2) (5)

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VISCO-PLASTIC CYCLIC STRESS ANALYSIS OF A SEMI-CRYOGENIC ENGINE THRUST CHAMBER

Abstract

Indian Space Research Organisation is developing a high thrust semi cryogenic engine for a heavy lift launch vehicle. The engine is to be reused several times and hence the thrust chamber is designed accordingly. The chamber is of double walled construction wherein the inner wall made of a special Cu-Cr-Zr-Ti alloy is brazed to the outer wall made of a high strength stainless steel. For initial hot tests of the engine, a truncated thrust chamber is envisaged in which the inner wall of throat segment is made in two parts which are joined together by electron beam welding. The cyclic life of this engine is decided by plastic strains developed in the copper to copper EB weld when subjected to high pressure and thermal loads during multiple cycles of engine operation.

The cyclic life of the thrust chamber is evaluated through a comprehensive finite element modelling and cyclic stress analysis using ANSYS (Version 15.0) code. Rate dependent behavior of the copper alloy in welded condition is studied by undertaking a detailed program involving experimental investigations and material modeling. The well known Perzyna visco-plastic model is employed for predicting rate dependent behavior of the material.

Perzyna parameters for the copper alloy are evaluated from high temperature tension tests conducted on EB welded specimens in an INSTRON 8862 electromechanical UTM, at different strain rates. This model is combined with the Chaboche nonlinear kinematic hardening plasticity model and Voce nonlinear isotropic hardening model to simulate cyclic hardening behavior of the material during repeated hot tests of the engine. This material model combination is used to determine the stress and strain state at the throat to arrive at the cyclic life of the chamber.