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VISCOPLASTIC THERMAL RATCHETING ANALYSIS OF THE REUSABLE ROCKET THRUST CHAMBER WALL

Abstract

Severe conditions of high temperature and pressure lead to cyclic accumulation of inelastic deformation on regenerative cooling thrust chamber wall during the reusable rocket engine operating. This phenomenon is known as thermal ratcheting, which influents the wall failure with low-cycle fatigue damage simultaneously. Uniaxial and thrust chamber wall ratcheting analyses employed Robinson's viscoplastic model with UVAE(uniformly valid asymptotic expansions) algorithm were completed in the paper. The isothermally uniaxial ratcheting behavior is more obvious with lower stress rate, higher mean stress and stress range, and the mean stress has stronger influence than the other two parameters. The thermal load plays more important role on the strain accumulating than the mechanical load in the thermal-mechanical coupled ratcheting analysis. Larger mean temperature and temperature range both accelerate the ratcheting behavior. Comparisons between the viscoplastic and elasto-plastic model analysis of the thrust chamber wall show that the former can demonstrate the softer state at the precooling and shut down phases and qualitatively replicated thermal ratcheting phenomenon appeared in the experimental cooling passage failure. As ignoring the thermal influence of coolant pressure on the heat transfer of thrust chamber wall, the strain accumulating more quickly under larger pressure load. With only hot run phase coolant pressure increasing, more obvious ratcheting phenomena will appear too.