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VISCOPLASTIC AND ELASTO-PLASTIC THERMAL-STRUCTURE ANALYSIS OF THE REUSABLE ROCKET THRUST CHAMBER

Abstract

As one of the critical components of the reusable rocket engine, the thrust chamber is designed to operate in severe conditions of elevated temperature and pressure for improving the engine performance. At these elevated temperatures, in turn, the thrust chamber wall experiences significant inelastic strains. For an accurate estimation of the chamber life and to predict their progressive deformation with the number of loading cycles, a realistic stress-strain analysis must be made. Unified viscoplastic analyses provide realistic descriptions of high-temperature inelastic behavior of materials, in which all inelastic strains (e.g. creep, plastic, relaxation, and their interactions) are accounted for as a single, time-dependent quantity. Comparisons between the viscoplastic and elasto-plastic model on demonstrating the uniaxial cyclic test and structural analysis of thrust chamber wall were completed in the paper. Firstly, Excellent agreement of the viscoplastic analysis result with the experimental data under strain controlled cyclic load confirms the correct finite element implementation of Robinson's model, which also excels in simulating the isothermally uniaxial ratcheting and leads to a more realistic life assessment as concerning ratcheting behavior. For the analysis of thrust chamber, resulted from softer state simulation with Robinson's model, the viscoplastic curve turnings are smoother than the elasto-plastic one. What's more, the elastic responses of the two curves are similar, but large difference appears in the plastic phase. In addition, under the cyclic loadings, thermal ratcheting phenomenon of the thrust chamber wall is simulated by the viscoplastic model, while the inelastic strain could not accumulate as the number of cycles increases with the elasto-plastic model. As the first cycle in stress-strain loops is not stable enough, the loop after 2 cycles is recommended for the life prediction parameters.