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NUMERICAL MODELLING OF SUPERCRITICAL COMBUSTION IN LOX-METHANE MULTI-ELEMENT CHAMBER

Abstract

In recent years, LOX-Methane propellant combination has attracted lot of attention because of its various advantages compared to typical LOX-hydrogen/kerosene rocket engines. Medium to high thrust class methane engines are envisioned to replace existing propulsion system in launch vehicles. It is prerequisite to understand combustion characteristics of methane for future engine development. The present work is focussed on numerical modelling of supercritical combustion in a multiple shear coaxial injector element combustion chamber. A typical liquid rocket engine operates at high pressures which are generally above the critical pressure of propellants, where thermodynamic properties of propellant deviate from ideal behaviour.

In order to account for real gas effects Soave- Redlich-Kwong (SRK) real gas equation of state (EOS) is employed. A non-premixed non-adiabatic steady flamelet model is invoked considering the non-equilibrium effects of flame straining due to transcritical injection in turbulent combustion. A 21 species, 84 reaction ARM-19 mechanism is incorporated into the flamelet model to calculate non-equilibrium/scalar dissipation rate. Assumed shaped PDF is used for turbulence/chemistry interaction. A finite volume based methodology is used to solve Favre averaged Navier Stokes equations with SST k-model for the turbulence closure.

A validated methodology is developed based on Mascotte chamber RCM-3 (V04) test. A comparative study using two combustion models, i.e. detailed chemistry based Eddy Dissipation Concept (EDC) and flamelet based non-premixed model was carried out. The study showed that, flamelet based combustion model is computationally less expensive and suitable for modelling supercritical combustion. Numerical results showed good agreement with literature result from Kim et al. RCM-3 (V04) test case. The developed methodology is applied on full scale 120 element shear coaxial LOX/Methane thrust chamber to understand combustion and associated flame characteristics. The predictive ability of combustion modelling will be employed to enhance combustion efficiency by appropriately varying the geometric or injection condition for Lox-methane propulsion system