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NUMERICAL ANALYSIS OF COMBUSTION AND REGENERATIVE COOLING IN LOX-METHANE ROCKET ENGINE

Abstract

In recent years, LOX-Methane propellant combination has attracted lot of attention because of its various advantages compared to typical LOX-Hydrogen rocket engines. ISRO is currently envisioning 10T class methane engine to replace existing propulsion system in its launch vehicles. Transcritical methane experience large thermodynamic and transport property variations at pseudo-critical temperature (near-critical fluid) which can significantly influence flow field and heat transfer characteristics. It is prerequisite to understand combustion and heat transfer characteristics of methane for future engine development. A numerical study is initiated to analyze combustion and regenerative cooling performance of methane in rocket engine elements. Combustion behavior and flame characteristics of LOX/Methane in typical shear co-axial injector have been investigated using non-adiabatic flamelet approach. Chemical kinetic mechanism (SKEL-16 species, 41 reactions) is incorporated to accommodate non-equilibrium effects by flame straining due to transcritical injection. Numerical methodology is validated with experimental results from RCM-3 (VO4) case of MASCOTTE cryogenic combustion facility[Singla et al. 2005]. A detailed parametric study is conducted to understand the role of varying velocity ratio (VR)and LOX post recess length. Initial studies reveal the role of high VR for better mixing and shorter flame length.

The thermo-fluid dynamic behavior of transcritical methane is investigated in rectangular regenerative channel subjected to asymmetric heating. The conservation equations are suitably solved to determine heat transfer characteristics and associated stratification effect of transcritical methane as it flows through channel across the critical point. Thermo-physical properties of methane in transcritical to supercritical regime are modeled utilizing Soave-Redlich-Kwong (SRK) equation of state. This numerical method is validated against experimental and numerical simulation data available in literature[Pizzarelli et al, (2012)79-87]. Various parameters such as flow direction, aspect ratio and surface roughness are investigated to understand their influence on heat transfer performance of regenerative cooling system. Results indicate the mitigation of heat transfer deterioration with above highlighted parameters.