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Assessment of phase-separation phenomena in LREs cryogenic flows

Authors

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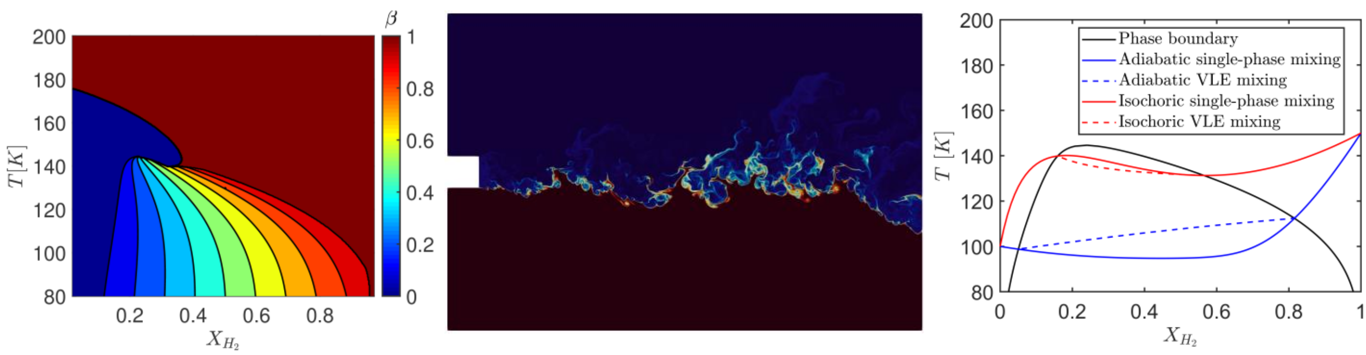
Abstract

Liquid Rocket engines (LREs) operate by injecting cryogenic propellants at elevated pressures, typically higher than the critical values of pure components and most combustion products. Thermodynamic states, comprising high pressures and cryogenic temperatures, are usually referred to as transcritical injection conditions. Transcritical injection trajectories entail several mixing-induced phenomena, one of which involves the elevation of the mixture critical point, which may result in locally subcritical states and phase separation effects [1,2], due to the non-ideal multi-component mixing. To describe and model these states, complex thermodynamic models are needed. A rather novel framework to account for these regimes, is the Vapor-Liquid-Equilibrium (VLE) concept [3,4], which features the introduction of a phase-fraction variable to describe the amount of vapor or liquid phase in the mixture. Thermodynamic properties are then consequently evaluated by weighting the liquid and gas phase contributions. Therefore, a VLE-thermodynamics model allows the quantitative description of multi-component mixture both in supercritical and in two-phase induced subcritical states. The present contribution aims to assess the relevance of a multi-phase induced regime under LREs relevant conditions in the context of large eddy simulations (LES) of practical interest. The impact of the phase-separation effects on the turbulent flow field is done by means of a numerical investigation at different resolution levels, of a 2-dimensional liquid-Oxygen gaseous-Hydrogen turbulent mixing layer, using an in-house solver based on OpenFOAM framework [5]. The following figures display preliminary results in terms of phase-fraction for a Hydrogen-Oxygen mixture (left panel); instantaneous density field of the mixing layer (center panel); Adiabatic and isochoric mixing line with and without the VLE model of the investigated case (right panel).



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