IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IPB)

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INFLUENCE OF DIFFERENT EQUATIONS OF STATE ON THE MIXING BEHAVIOR OF A TRANSCRITICAL SHEAR LAYER

Abstract

Numerical simulations of the flow field inside rocket combustion chambers are still challenging. Due to the high pressures and low temperatures of the injected propellants, real-gas effects must be considered. Close to the injector these effects heavily influence the mixing behavior of fuel and oxidizer. Due to the extreme conditions, few experimental measurements of such injectors exist. Alternatively, scale resolving simulations offer a detailed insight into the mixing process taking place in rocket combustors. Most studies employ simplified cubic Equations Of State (EOS), which are known to poorly approximate the thermodynamic state of the fluids under transcritical conditions. Moreover, they still lead to a significant increase in computational cost compared to ideal gas simulations. Thus, more accurate EOS are often not considered for scale resolving simulations. However, the influence of the chosen EOS on the resulting mixing field is still not well studied.

This study thus aims to analyze the influence of the EOS choice on the mixing behavior of transcritical shear layers as they appear in liquid rocket engines. The liquid oxygen gaseous hydrogen shear layer benchmark case from (Ruiz et al., AIAA Journal 54(5), pp.1445-1460) is simulated with different EOS. First, the novel solver is validated against existing reference solutions from the literature utilizing the Peng Robinson EOS. Afterward, the effects of different EOS on the mixing field are assessed and quantified. Different cubic EOS are considered. Furthermore, simulations with empirical Helmholz EOS are also performed to quantify the error associated with the simplified EOS.