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Transcritical Injection and Mixing of Conventional and Sustainable Aviation Fuels under Aeroengine-Relevant Conditions.

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Drop in Sustainable Aviation Fuels, together with the rise of overall pressure ratio engines, are central to near-term aviation decarbonization [1]. Yet, under transcritical conditions, it remains unclear how fuel properties govern mixing and how they should be represented numerically. We use a diffuse interface large eddy simulation framework [2] with real fluid thermodynamics based on the Peng Robinson equation of state [3] and multi-component transport [4] to study a single injector operating in aeronautical regimes. Fuel is injected into hot nitrogen at 60 bar with inlets matched on chemical power for conventional Jet A, the iso paraffinic ATJ SAF C1, and a 50% volumetric blend of the two. A pseudo-boiling [5] density threshold defines a thermodynamic liquid penetration length, and conditioned means quantify departures from adiabatic mixing lines [6]. Penetration magnitudes are similar across fuels. Turbulence attenuates and shifts the pseudo-boiling C_p peak toward higher temperature and slightly lower Y_{N_2}, which yields warmer conditioned trajectories and a shorter cold dense core for Jet A; the blend shows intermediate behaviour, while the ATJ fuel remains cooler downstream and mixes more slowly. These results indicate how thermophysical behaviour in the pseudo-boiling region controls transcritical mixing in aeronautical injectors.

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