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Reacting Numerical Simulation of Axisymmetric Trapped Vortex Combustors for Methane, Propane and Hydrogen

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Abstract : The carbon footprint of the aviation sector in total measured 3.8% in 2017, and it is expected to triple by 2050. New combustion approaches and fuel types are necessary to prevent this. This paper will focus on using propane, methane, and hydrogen as fuel replacements for kerosene and implement a trapped vortex combustor design to increase efficiency. Reacting simulations were conducted for axisymmetric trapped vortex combustor to investigate the static pressure drop, combustion efficiency and pattern factor for various cavity aspect ratios for 0.3, 0.6 and 1 and air mass flow rates for 14 m/s, 28 m/s and 42 m/s. Propane, methane and hydrogen are used as alternative fuels. The combustion model was anchored based on swirl flame configuration with an emphasis on high fidelity of boundary conditions with favorable results of eddy dissipation model implementation. Reynolds Averaged Navier Stokes (RANS) k-ε model turbulence model for the validation effort was used for turbulence modelling. A grid independence study was conducted for the three-dimensional model to reduce computational time. Preliminary results for 24 m/s air mass flow rate provided a close temperature profile inside the cavity relative to the experimental study. The investigation will be carried out on the effect of air mass flow rates and cavity aspect ratio on the combustion efficiency, pattern factor and static pressure drop in the combustor. A comparison study among pure methane, propane and hydrogen will be conducted to investigate their suitability for trapped vortex combustors and conclude their advantages and disadvantages as a fuel replacement. Therefore, the study will be one of the milestones to achieving 2050 zero carbon emissions or reducing carbon emissions.

Keywords : computational fluid dynamics, aerodynamic, aerospace, propulsion, trapped vortex combustor
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