Minimizing Fuel-Oxidizer Mixture Inhomogeneities in Rotating Detonation Engines

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The rotating detonation engine (RDE) is widely considered one of the most promising and interesting areas of propulsion research due to its high energy output and thermal efficiency. The current use of separated fuel and oxidizer injectors, which aid in detonation wave combustion and propagation, prevent the interference of high detonation wave pressures with material injection. However, this injection scheme has produced inhomogeneities in the fuel-oxidizer mixture that decrease the engine's overall propulsive and energy-producing capabilities. A standardized, 2-dimensional computational domain was developed in Ansys Fluent, with the aim of developing a more effective injection strategy. The simulation featured a closed detonation channel and an open injector inlet to interchangeably test existing injection geometries. Several injection schemes, which varied by diameter, distance, and angle of injection, were tested to evaluate the most effective existing injection geometry. These variables were then altered to determine relationships between injector structure and mixture homogeneity levels, applied in developing a novel, more effective injection scheme. It was found that through the adjustment of angle and diameter of the existing axial-triplet scheme, fuel-air mixtures reached homogeneity levels of 99.2%. Using a novel and strategic approach, this model demonstrates the improvement of multiphase, non-reacting fluid flows and high-pressure material injection without the use of high-fidelity models. Through the iterative adjustment of injection-specific variables in the RDE, the fuel-air mixture inhomogeneities were reduced by pursuing the improved model, and could advance high-pressure, thrust-producing combustion systems for future rocketry and energy applications.