Abstract

The rotating detonation engine (RDE) is widely considered one of the most promising and interesting areas of propulsion research due to its high levels of 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 low-pressure material injection. However, separated injectors has produced inhomogeneities in fuel-oxidizer mixtures that decrease the engine's overall propulsive and energy-producing capabilities. To enhance RDE performance through improving injection, 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 walled detonation channel and an open injector inlet and outlet, where existing injector geometries could be interchangeably tested. Several injection schemes, which varied by diameter, distance, and angle of injection, were tested to identify relationships between injector geometry and mixture homogeneity levels for maximizing efficiency. It was found that through the adjustment of angle and diameter of the existing axial-triplet scheme, the fuel-air mixture reached a homogeneity level 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 level of inhomogeneity within fuel-air mixtures was decreased by pursuing the improved model. The models presented could advance high-pressure, thrust-producing combustion systems for future rocketry and energy applications.

Keywords: rotating detonation engines, mixture characteristics, injection model, computational fluid dynamics, energy, propulsion.