Abstract

The interaction between fluid injectors and the detonation chamber is critical in a Rotating Detonation Engine (RDE). Of particular interest, injector response time relative to the detonation period is a limiting factor in sustaining detonation. Fuel/air injectors must be designed correctly to maintain proper injector response time and to sustain continuous rotating detonation behavior. The design depends on several variables: injector length and diameter, plenum length, diameter, & design pressure, detonation chamber pressure, mass flow rates, temperatures, and detonation properties influenced by equivalence ratio. This study develops a quasi-one-dimensional Eilmer based computational fluid dynamics (CFD) tool, which models the behavior of discrete cylindrical injectors. A single injector design for a typical hydrogen-air engine was developed as a base model to demonstrate the utility and potential of the tool. Dimensions were fixed, hydrogen was chosen as the working fluid, and a periodic pressure function was applied as a boundary condition at the plane between the injector and the detonation chamber. This periodic pressure function is intended to replicate the effects of a rotating detonation wave passing over the injector with an amplitude, frequency, and decay rate characterized by the chemistry and physics of the expected detonation. Several cases with varying pressure, frequency, and decay rates were run to exercise the tool and observe trends in data based on these variations. Pressure, temperature, velocity, density, mass flux, and momentum flux were all simulated at various points throughout the injector, with the point of particular interest being at the centerline at the injector exit. The gathered data are used to track the injector response time for each case, which would dictate whether a design can promote continuous detonation. Analysis and comparison of the data generated by the various cases with the base case indicates that the tool provides a good initial step for the injector design process.