Abstract

A study has been conducted that involved the modelling of gaseous oxygen – gaseous hydrogen propellants in a single element coaxial injector. The fluid flow domain and combustion dynamics were investigated to determine the key design parameters. The study investigated the optimisation of the key design parameters to improve the injector performance in terms of combustion length and combustion efficiency. The numerical model captured the complex chemical combustion interactions and gas mixture variations in the combustion chamber. Mixing in the numerical model was achieved by the shear layer development between the propellants. The flame anchored in the head end region, where the axial distance is less than 0.1m directly influence the combustion length which was used to evaluate the injector performance. High turbulence intensity was developed in the head end region while combustion products were routed to the combustion chamber wall. The turbulent eddy currents that were developed are responsible for the fluid motion and consequently energy transfer to enhance mixing and the combustion process. At the combustion chamber wall heat is transferred from the hot gas mixture to the wall. The species, temperature and velocity non-uniformity in the axial direction produces the various distributions that were used for model comparison. The modelling of the phenomenon poses challenges that include grid resolution, turbulence modelling, chemical kinetic modelling and wall boundary layer modelling: all of which influence the accuracy of the predicted heat flux. A base case numerical solution was developed and compared to a physical model result. It was found that the base case simulation compared well to the physical model and produced a 95% confidence interval with an error percentage of less than 5%. Using the base case results, further design optimisation was applied by variation in oxidiser post recess length and application of swirl directional flow. An improvement of combustion length of 21.7% was achieved when the base case momentum ratio simulated at a recess length was 30% of the oxidiser post inner diameter. Applying swirl flow at the base case momentum ratio by varying the oxidiser flow improved the combustion efficiency by 1.7% to achieve 98.2%. The swirl test case produced