Analysis of Reduced Mechanisms for Premixed Combustion of Methane/Hydrogen/Propane/Air Flames in Geometrically Modified Combustor and Its Effects on Flame Properties

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Abstract : Combustion has been used for a long time as a means of energy extraction. However, in recent years, there has been a further increase in air pollution, through pollutants such as nitrogen oxides, acid etc. In order to solve this problem, there is a need to reduce carbon and nitrogen oxides through learn burning modifying combustors and fuel dilution. A numerical investigation has been done to investigate the effectiveness of several reduced mechanisms in terms of computational time and accuracy, for the combustion of the hydrocarbons/air or diluted with hydrogen in a micro combustor. The simulations were carried out using the ANSYS Fluent 19.1. To validate the results “PREMIX and CHEMKIN” codes were used to calculate 1D premixed flame based on the temperature, composition of burned and unburned gas mixtures. Numerical calculations were carried for several hydrocarbons by changing the equivalence ratios and adding small amounts of hydrogen into the fuel blends then analyzing the flammable limit, the reduction in NOx and CO emissions, then comparing it to experimental data. By solving the conservations equations, several global reduced mechanisms (2-9-12) were obtained. These reduced mechanisms were simulated on a 2D cylindrical tube with dimensions of 40 cm in length and 2.5 cm diameter. The mesh of the model included a proper fine quad mesh, within the first 7 cm of the tube and around the walls. By developing a proper boundary layer, several simulations were performed on hydrocarbon/air blends to visualize the flame characteristics than were compared with experimental data. Once the results were within acceptable range, the geometry of the combustor was modified through changing the length, diameter, adding hydrogen by volume, and changing the equivalence ratios from lean to rich in the fuel blends, the results on flame temperature, shape, velocity and concentrations of radicals and emissions were observed. It was determined that the reduced mechanisms provided results within an acceptable range. The variation of the inlet velocity and geometry of the tube lead to an increase of the temperature and CO2 emissions, highest temperatures were obtained in lean conditions (0.5-0.9) equivalence ratio. Addition of hydrogen blends into combustor fuel blends resulted in; reduction in CO and NOx emissions, expansion of the flammable limit, under the condition of having same laminar flow, and varying equivalence ratio with hydrogen additions. The production of NO is reduced because the combustion happens in a leaner state and helps in solving environmental problems.

Keywords : combustor, equivalence-ratio, hydrogenation, premixed flames
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