Investigation on the Combustion Characteristics of NH_3/CH_4 Premixed Swirling Flame at Various Reynolds Numbers

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Abstract

Enhancing the combustion characteristics of ammonia-containing fuels is key to enabling widespread utilization of ammonia as an energy source. In order to explore the combustion characteristics of NH_3/CH_4 premixed flames in radial swirl combustion chamber at different inlet Reynolds numbers (*Re*), a series of experiments and large eddy simulation studies were conducted, with *Re*=14000-38000. The volumetric flow ratio of NH_3 to CH_4 was fixed at 7:3, and the equivalence ratio of the premixed flame was fixed at 0.85. Experimental observations indicate that when the inlet *Re* exceeds 14000, stable premixed turbulent flames appear in the combustion chamber. As the *Re* increases, the flame becomes more stable. To further investigate the influence of *Re* on combustion characteristics, detailed Large Eddy Simulations (LES) were performed using the Dynamic Thickened Flame (DTF) combustion model for different *Re*. Three conclusions can be obtained: (1) As the inlet *Re* increases, the temperature and heat release rate inside the combustion chamber increase, and the flame structure images captured in experiments and the instantaneous flame images from LES both indicate fuel begins to burn steadily at the exit of the swirl burner nozzle, contributing to the stabilization of the flame; (2) Under the same swirling conditions, increasing the inlet *Re* results in similar inner recirculation zone (IRZ), outer recirculation zone (ORZ), and turbulence intensity in the combustion chamber. The mass recirculation rate varies continuously along the axial direction, with stronger recirculation in the outer recirculation zone at lower *Re* and stronger recirculation in the inner recirculation zone at higher *Re*; (3) As the velocity increases, the residence time of the fuel in the combustion chamber gradually decreased, NO generated on the flame surface is swiftly transported downstream into the combustion chamber. Both experimental and LES results showed that NO emissions at the outlet of the combustion chamber increased with the increase of the inlet Reynolds number.

Keywords

NH_3/CH_4 Premixed Combustion, Flame Stability, Nitric Oxide Emission, Reynolds Number Effect, Large Eddy Simulation, Turbulence Intensity, Recirculation Zone