EFFECT OF BURNER DIAMETER AND DILUENTS ON STRUCTURE AND STABILITY OF LAMINAR CO-FLOW DIFFUSION FLAMES OF DILUTED METHANE FUEL

Low calorific value gases (LCVG) have been a primary concern of environmental pollution as they are not easy to burn due to highly diluted fuel compositions. It is thus essential to understand the flame characteristics when these gases are burnt, especially under oxygen enhanced conditions. Although the study of stoichiometric flame lengths of laminar jet or co-flow diffusion flames has been a major topic of research in last few decades, mostly focusing on flames of either undiluted or slightly diluted fuel reacting with air. However, the flame characteristics under extremely diluted fuel conditions are not well-studied. Hence, a set of experiments and numerical simulations have been performed in the present work to study the flame lengths for a wide range of fuel and oxidizer dilutions using two different jet diameter burners (4 and 9 mm with identical volume flow rates). Both experimental and numerical results confirm that the 4 mm burner flame length is consistently higher than the 9 mm burner counterpart. This difference is attributed to the higher temperature of the 9 mm burner flame, which in turn is due to its lower conductive heat loss to the ambient. Several analytical models, available in the literature to predict the flame lengths, such as Roper, Li-Gordon-Williams (LGW), and Wang-Sunderland-Axelbaum (WSA), have also been analyzed and compared with the experimental data. A new analytical model is also proposed in this study by modifying the species diffusivity and flame temperature in WSA model. This revised model predicts the flame lengths better than the other analytical models, especially when the fuel stream is diluted.

Apart from the flame length, the understanding of lifted flame stabilization is important in the context of highly diluted flames as well. Laminar flames of highly diluted methane in a non-

premixed co-flow configuration have been studied experimentally and numerically for two different diameter burners (4 and 9-mm). Because the fuel is extremely diluted methane, an oxygen-enhanced oxidizer stream is expected to produce a stable anchored or lifted flame. Two different diluents, i.e., helium and nitrogen were used in the fuel stream, and the flame structure turned out to be notably different for these two cases. The nitrogen-diluted flames exhibited almost anchored nature. However, a helium-diluted flame could be stable at a lifted position despite having a less than unity Schmidt number (Sc). This difference is attributed to the difference in propagation speed between helium and nitrogen-diluted flames due to mixture fraction gradient, flame curvature and heat release impact. In comparison to nitrogen-diluted flames, helium-diluted flames can sustain at lower oxygen percentage due to a higher propagation speed. Apart from the difference in lift-off height, the nature of the flame length is also explored for flames with both the diluents. The structure of the flame – whether anchored or lifted – is also found to affect the variation of flame length with variation in oxygen percentage in the co-flow. A comparison between two different diameter burners is also investigated in terms of lift-off height and flame length. The 4-mm burner usually exhibits a higher lift-off than the 9-mm burner due to the higher jet velocity in the former case.