EXPERIMENTAL AND COMPUTATIONAL STUDY OF LIFTED TURBULENT DIFFUSION FLAMES

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ABSTRACT Two lifted turbulent methane jet diffusion flames, one momentum dominated and the other one buoyancy dominated, have been experimentally and numerically investigated. Measurements were made for flame geometry (lift-off heights and flame heights), flame radiant fractions, post-flame NO_x emissions and in-flame local mean gas temperature and mean molar fractions of O_2, CO and CO_2. The calculations were performed using the FLUENT code. The main purpose of the present work is to investigate how an advanced commercial CFD code using state-of-the-art combustion models performs in the simulation of geometrically simple but physically complex flames. The realizable k-ε model was used for turbulence closure. Combustion was modelled using two different models: a partially premixed model, which combines a simple premixed flame model based on the solution of the transport equation for a progress variable with the laminar flamelet model for non-premixed flames, and the eddy dissipation concept. Radiation was accounted for using the discrete ordinates method and the weighted-sum-of-grey-gases model. The NO_x formation and emission was calculated in a post-processing stage. The results show that the structure of the buoyancy dominated flame is fairly well predicted, although the maximum temperature is overestimated. The predictions are less satisfactory for the momentum dominated flame. Both models predict the lift-off phenomenon, but do not reproduce the measured difference between the lift-off heights of the two flames. Neither the fraction of radiative heat loss nor the emission index of NO_x are satisfactorily predicted. The observed discrepancies may be related to the shortcomings of the models. The laminar flamelet model is able to accurately predict diffusion flames, but the extension to partially premixed flames by means of a progress variable is a relatively simple approximation, while the performance of the eddy dissipation concept in lifted flames has not been formerly demonstrated.