Computational study of combustion in gas fired burners and flares: *Structure and emission of a turbulent jet flame in cross-flow*

M.S. Lawal, M. Fairweather, D. B. Ingham, L. Ma, M. Pourkashanian and A. Williams

Abstract

Quantifying the performance of flares in oilfields is difficult due to its dependence on a wide range of operating variables, such as wind speed, ' waste' gas composition and jet exit speed, to mention a few. Therefore, accurate measurement of emissions from gas flares still poses a significant challenge to all stake holders in the oil and gas industry. This study investigate the influence of changes in the velocity of the jet and the cross-flow on flame length, radiant fraction and emission index of pollutant species (NO_x, CO_2, CO and ratio of NO_2 / NO_x) of a jet flame in cross-flow. The flow configuration is of generic interest, and also practically relevant to flaring operation, and burners used in boilers and furnaces.

The flow field was computed using the Reynolds averaged Narvier-Stokes equations incorporating the realizable $k-\varepsilon$ turbulence closure. The combustion process is modelled based on the Eulerian particle flamelet model, while the heat loss by radiation is accounted for using the discrete ordinates method. Comparison of the predicted flame length and the trend of emission indices of the pollutant species with experimental data revealed good agreement for the range of jet-to-cross-flow momentum flux ratios investigated, namely, 10 – 800.

Issues associated with scaling-up of laboratory-scale to industrial scale flares is currently being investigated using more advanced turbulence models, such as the large eddy simulation, based on the input data from the CANMENT Energy and Technology Centre (CETC) Flare Test Facility, Ottawa, Canada. The information obtained from the numerical modelling is important in guiding industry, government and regulatory bodies towards an accurate estimation of the emissions from the burners operating in a cross-flow flow configuration. This is also an essential step towards optimizing burner tip design for cost effective and safe flaring operations with minimum impact on the environment.