PhD Advert Template

Project title: Numerical investigation of conjugate heat transfer during interaction of high-Hydrogen content flames with cooled walls using Direct Numerical Simulations

Project ID *(optional)*: *Please leave blank*

Accept all year-round applications

Funding information: Self-funded students only

Project description: Wall-bounded turbulent flows have been studied extensively under isothermal conditions and principally from the point of view of drag reduction. A relatively limited effort has been made to analyse the turbulent boundary layer in reacting flows. The expansion of gases induced by heat release due to chemical reactions significantly affects the velocity and heat transfer pattern within the turbulent reacting flow boundary layer, which can be very different from those obtained in turbulent isothermal wall-bounded flows. Understanding this behaviour for premixed flames involving high hydrogen content sustainable and e-fuels is pivotal to designing next-generation combustors to meet net-zero targets in propulsion and power generation sectors. The heat loss through the wall during flame-wall interaction can lead to flame quenching and can give rise to unburned fuel pockets. Heat loss and unburned fuels act to reduce the efficiency of propulsion and power generation devices and the heat transfer through the wall determines cooling load and temperature distribution in the wall ultimately determining the thermal fatigue of the combustor material. Thus, a thorough understanding of flame-wall interactions is essential for designing new-generation combustors including the conjugate heat transfer effects. In industry numerical simulations are often carried out using Reynolds Averaged Navier Stokes (RANS) and Large Eddy Simulations (LES) where the physical processes associated with length scales smaller than computational grid spacing needs to be approximated using turbulence models. However, the unavailability of reliable data for flame-wall interaction often compromises the predictive capability of these models and often the boundary layers involving turbulent reacting flows are modelled (inaccurately) using isothermal flow conditions. In the last decade or so, the availability of increased computer power has offered an important research avenue to investigate the effect by providing the means for Direct Numerical Simulations (DNS) where all the relevant turbulent length and time scales are adequately resolved. The purpose of this project is to carry out DNS of turbulent premixed flame-wall interaction including the effects of differential diffusion induced by light radicals (e.g. H and H2) high-hydrogen content premixed flames and conjugate heat transfer effects. This DNS data will subsequently be explicitly Reynolds averaged/ LES filtered to assess the performances of existing models with respect to the corresponding quantities extracted from DNS data. Based on this a-priori DNS analysis modifications to the existing models will be suggested and new models will be proposed wherever necessary.

The industrial partners will be kept involved during this project and they will attend the progress review meetings. We expect to publish project outcomes in reputed journals (eg Combustion and Flame, Physics of Fluids, Proceedings of the Combustion Institute) and conference proceedings (eg International Symposium on Combustion, European Combustion Meeting). The student will also have the opportunity to work with combustion groups at the University of Cambridge, as well as reputed combustion researchers in the USA, France and Germany.

The applicant for this project is expected to have a 1st class or 2:1 degree in Aerospace, Mechanical and Chemical Engineering, Applied Mathematics, or Applied Physics.

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Application enquires: *Prof. Nilanjan Chakraborty, Email:* *nilanjan.chakraborty@ncl.ac.uk* *, weblink:* [*https://www.ncl.ac.uk/engineering/staff/profile/nilanjanchakraborty.html*](https://www.ncl.ac.uk/engineering/staff/profile/nilanjanchakraborty.html)

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[ ]  other

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[ ]  cancer biology

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Computer Science

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Education

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Engineering

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Food Sciences

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Forensic and Archaeological Sciences

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Law

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Linguistics & Classics

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