International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

Flame-Wall Interaction of Lean Hydrogen-Air Premixed Flames using Pointwise Adaptive Mesh Refinement

Umair Ahmed[1*], Stewart Cant[2]
*Lead presenter: umair.ahmed@newcastle.ac.uk
[1] Newcastle University, United Kingdom
[2] University of Cambridge, United Kingdom

Direct Numerical Simulation (DNS) of flame-wall interaction (FWI) requires high numerical accuracy due to the requirements of resolving a turbulent boundary layer as well as being able to resolve the reaction zone. Consequently, in DNS the friction Reynolds number is limited to relatively small values. Adaptive Mesh Refinement (AMR) becomes especially useful in providing adequate spatial resolution for the small–scale features in the near–wall region as well as the reaction zone. Considerable cost savings can be achieved by avoiding the need for fine mesh in regions away from the wall and also in regions of the flow with small temperature and density gradients. In the present work, the combustion DNS code HAMISH [1] has been used which employs pointwise AMR on a 3D cubic Cartesian mesh with Morton spatial indexing [2] and automatic parallel load balancing. The mass, momentum and energy equations are solved in a fully compressible formulation together with the balance equations for chemical species mass fractions. Detailed chemistry and molecular transport are included. A spatial reconstruction scheme based on a high–order finite–volume approach with good conservation properties is used [3]. Third–order explicit Runge–Kutta time stepping [4] is used with adaptive step control. The results from the AMR simulations are compared with the data obtained from the well established high–order finite difference DNS code SENGA2 [5]. The flow configuration simulated in this work is the Head–On Quenching of a premixed flame in a turbulent boundary layer. The wall friction Reynolds number, Re_τ, is set to a value of 150 for the purpose of comparison of results across different codes. In the current simulations lean hydrogen–air premixed flames with an equivalence ratio, ϕ, of 0.4 are investigated. Quantities such as the heat release rate, turbulent burning velocity, quenching distance, wall friction velocity and wall shear stress are extracted and compared.

References

[1] R.S. Cant, U. Ahmed, J. Fang, N. Chakraborty, G. Nivarti, C. Moulinec, D.R. Emerson, An unstructured adaptive mesh refinement approach for computational fluid dynamics of reacting flows, J. Comput. Phys. 468 (2022) 111480.

[2] G.M. Morton, A computer oriented geodetic data base and a new technique in file sequencing, IBM Tech. Report, 1966.

[3] L. Ivan, C.P.T. Groth, High–order solution-–adaptive central essentially non—oscillatory (CENO) method for viscous flows, J. Comput. Phys. 257 (2014) 830-–862.

[4] C.-W. Shu, S. Osher, Efficient implementation of essentially non– oscillatory shock-–capturing schemes, J. Comput. Phys. 77 (1988) 439–471.

[5] R.S. Cant, SENGA2 User Guide. CUED Report number CUED-THERMO-2012/04 (2nd ed.). (2013)