Numerical study of a bluff body stabilized lean premixed hydrogen flame using Artificially Thickened Flame model in OpenFOAM

R. Vadi*, A. Andreini
riccardo.vadi@unifi.it
*HTC Group, DIEF Department of Industrial Engineering, University of Florence, Italy

Abstract

In recent years, hydrogen has garnered significant attention due to its carbon-free nature, making it an appealing candidate for sustainable energy solutions. Its unique properties as an energy vector, such as high energy density and versatility across various applications, have further highlighted its potential in the transition to cleaner energy systems. It is important to characterise numerical models to expand knowledge in hydrogen combustion. In this study, the Thickened Flame Model [1] is implemented in the opensource software OpenFOAM v8. Thermal diffusion effects will also be investigated by integrating the Soret effect into the governing equations. A case study of a single sector hydrogen burner is selected. The test case will show the characteristics of hydrogen in terms of diffusion during the reactive process. Analysis of the atmospheric test bench operating with a lean, perfectly premixed, hydrogen-air flame stabilised on a conical bluff body [2] will be carried out. LES simulations are conducted in which the impact of modelling the interaction between the flame front and turbulence through the definition of efficiency function is analysed. The investigation is done by the qualitative comparison of the three-dimensional flame visualisation with the experimental test case. The quantitative one is conducted by comparing detailed Particle Image Velocimetry (PIV)/ OH-Planar Laser-Induced Fluorimetry (OH-PLIF) measurements, which allow the characterisation of the flame behaviour. The comparisons will make it possible to identify the optimal flame representation models among those selected.

Reference

[1] Colin, O., et al. "A thickened flame model for large eddy simulations of turbulent premixed combustion." *Physics of fluids* 12.7 (2000): 1843-1863.

[2] Yahou, Tarik, James R. Dawson, and Thierry Schuller. "Impact of chamber back pressure on the ignition dynamics of hydrogen enriched premixed flames." *Proceedings of the Combustion Institute* 39.4 (2023): 4641-4650.