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Prediction and understanding of the Boundary Layer Flashback in a perfectly premixed academic burner operating with pure hydrogen

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The availability of a model able to provide quantitative information about the onset of the flashback occurrence in a Gas Turbine (GT) premixer can be crucial for the development of the next generation engines, required to operate with higher and higher hydrogen content in the fuel [1,2]. In this context, Computational Fluid Dynamics combustion models are asked to become a valid tool to support design decisions despite the inclusion of some peculiarities of hydrogen combustions are still missing in the current literature, above all the modelling of thermo-diffusive instabilities and their interaction with turbulence at relevant GT conditions [3,4]. As a first development step, in this study a perfectly premixed unconfined burner from Delft University [5] is simulated through the Thickened Flame Model (TFM) [6]. The focus is concentrated on the conditions where pure hydrogen is employed. Additionally, despite the Bunsen-like burner operates at ambient conditions, the selected equivalence ratio of 0.5 is in line with industrial applications. Two procedures have been used to trigger the flashback, both using Large-Eddy simulation and both starting from a stable flame position located outside the quartz burner. The first one replicates the experimental procedure: the bulk velocity of the mixture is decreased until the boundary-layer flashback happens. In the second one the equivalence ratio is increased until the same condition. The numerical model, relying on a *wall-resolving* approach, is able to predict the onset of the flashback with a satisfactory accuracy. Basing on that, a dedicated post-processing of the solution is performed to gain useful information on the conditions leading to the flashback. In particular, both the Particle Image Velocimetry (PIV) and the chemiluminescence from the test campaign are used to verify the accuracy of the TFM in predicting the dominant mechanism responsible for the flashback and shed some light on the interaction between the flame propagations and the velocity field when such phenomenon occurs.

References

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