A TABULATED LARGE EDDY SIMULATIONS FRAMEWORK FOR COMPLEX FLOWS IN REALISTIC GEOMETRIES

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Abstract
The development of a reliable and accurate numerical framework to aid in the computation of turbulent reactive flows through Large Eddy Simulations (LES) is of the utmost importance in combustion chamber design. This paper proposes a numerical framework based on the OpenFOAM open-source environment, which allows the adoption of unstructured grids for the creation of realistic geometries. A tabulated chemistry (flamelet) approach is employed [1]: turbulent flamelets are generated before run-time and stored in tables to be addressed during the fluid dynamics computational process, leading to a highly efficient computation at run-time. This approach is implemented through the OpenSMOKE++ framework [2], which was modified and improved to allow for a variable number of inputs in the tables, so as to account for the physical characteristics of each case. In particular, non-adiabatic, real-gas, and thermodiffusive instability effects are among the physical processes that can be accounted for. The resulting LES framework is generated and adapted from an unsteady RANS (uRANS) framework [3].
In this contribution, the proposed framework is implemented in several applications, ranging from cold flows to premixed and diffusive flames. The canonical case of the Sydney burner [4] is simulated, presenting a non-premixed turbulent swirled flame at atmospheric pressure. A premixed jet flame is computed through the simulation of a Bunsen burner, characterized by grid generated turbulence. A reference flame for rocket applications is simulated in the TUMrig single injector chamber [5], defined by a non-premixed oxycombustion. The Ruiz case [6] is computed as a reference for mixing layers in real fluids. Finally, the capability of the framework is evaluated by comparing the results with the available experiments.

References
[1] N. Peters, Prog. Energy Combust. Sci. 10-3, 319-339 (1984)
[2] A. Cuoci et al., Comp. Phys. Commun. 192, 237-264 (2015)
[3] A. Remiddi et al., Proc. Combust. Inst (2022)
[4] P. A. M. Kalt et al., Proc. Combust. Inst. 29, 1913-1919 (2002)
[5] M. P. Celano et al., Progress in Propulsion Physics 8, 145-164 (2016)
[6] A. M. Ruiz et al., AIAA J. 54-5, 1445-1460 (2016)