6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

The Identification of Turbulent Flame Topologies Using Computational Singular Perturbation

Dimitris M. Manias[1,2], Efstathios-Al. Tingas[1], Francisco E. Hernández Pérez[1] and Hong G. Im[1]

[1] Clean Combustion Research Center (CCRC), King Abdullah University of Science and Technology (KAUST), Thuwal-Jeddah, Saudi Arabia

[2] Department of Mechanics, School of Applied Mathematical and Physical Sciences, National Technical University of Athens (NTUA), 15780 Athens, Greece

Keywords: *CSP, extreme combustion, H_2/air turbulent flames, distributed reaction regime*

Understanding highly turbulent flames has been gaining a lot of practical interest recently, as the modern combustion devices are designed to operate at high-pressure, ultra-lean, low-temperature conditions. However, the processes that are involved in turbulent premixed combustion are considerably complex. Therefore, the investigation of the interaction between turbulent flow and premixed flame at extreme combustion conditions becomes more demanding. One of the additional challenges associated with highly turbulent premixed flames is the difficulties in identifying the turbulent flame topologies as the flame structures become severely corrugated or even disrupted by the small scale turbulent eddies.

To this end, the computational singular perturbation (CSP) [1], provide algorithmically a physical understanding of the system, without relying on the experience of the researcher. One of the major advantages of CSP is that it can identify locally the dominant processes and the most important species for the evolution of the system, thereby enhancing our physical understanding. Recently, a derived quantity referred to as the tangential stretching rate (TSR) [2] was found to be a comprehensive metric to represent various dynamical characteristics of a reactive-diffusive system.

In the present study the algorithmic tools of CSP and TSR are applied to turbulent flame analysis as a generalized way to distinguish physical and chemical behavior, by automatically identifying the key CSP modes and their time scales. In this context, the CSP/TSR approach and tools are used to compare turbulent hydrogen/air premixed flames at different combustion regimes, all of them previously generated [3] using three-dimensional (3D) DNS.

REFERENCES

[1] S. H. Lam, and D. A. Goussis, *Understanding complex chemical kinetics with computational singular perturbation*, *P. Combust. Inst.* Vol. **22**, pp. 931–941, 1989.

[2] M. Valorani, S. Paolucci, E. Martelli, T. Grenga, P. P. Ciottoli, *Dynamical system analysis of ignition phenomena using the tangential stretching rate concept*, *Combust. Flame* Vol. **162**, pp. 2963–2990, 2015.

[3] H. G. Im, P. G. Arias, S. Chaudhuri, H. A. Uranakara, *Direct numerical simulations of statistically stationary turbulent premixed flames*, *Combust. Sci. Technol.* Vol. **188**, pp. 1182–1198, 2016.