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Impact of the pressure level on a CH4/O2 diffusive flame in a single injector liquid rocket engine combustion chamber

Giulio PELENGHI[1], Thomas SCHMITT [2] , Nicolas ODIER[3], Annafederica URBANO[1,*]
*lead presenter: annafederica.urbano@isae-supaero.fr
1 Fédération ENAC ISAE-SUPAERO ONERA, Université de Toulouse, France.
2 Université Paris-Saclay, CNRS, CentraleSupélec, EM2C, Gif-sur-Yvette, France.
3 CERFACS, Toulouse, France

Thermoacoustic combustion instabilities can be one of the main problems for the development of liquid rocket engines (LRE) combustion chambers [1]. In the context of reusable engines, throttleability is an essential feature which is achieved lowering the operating pressure in the combustion chamber. This can lead to the transition from supercritical pressure (one phase) to subcritical pressure (multiple phase flow) in the combustion chamber. While they have been studied since decades, little is known about the response to acoustics of diffusive flames at high pressure in LRE typical conditions and on the impact that thermodynamic conditions can have of them. This is partly due to the difficulty in obtaining this information from experimental data and in validating computational solvers. The objective of the present work is to develop a numerical framework for compressible large eddy simulations capable of reproducing the behavior of a single injector combustion chamber from supercritical to subcritical conditions. A multi-fluid approach, implemented in the AVBP solver, is used [2]. The formalism allows to simulate both single, two-phase flows and the transcritical transition between conditions where interface exists or not. A single injector combustion chamber, reproducing the experimental chamber BKN [3] is simulated at both supercritical and subcritical conditions (see Fig.1). Comparisons with experimental data are carried out both on static average quantities and on dynamic quantities. Spectral analysis of pressure and heat release oscillations fields is shown to investigate the thermoacoustic coupling. The comparison with experimental data allows to illustrate the current modeling limitations and future needs for numerical developments. Eventually, the analysis of the results allows to observe the impact of pressure variation over the flame topology and on the overall dynamic behavior in the chamber.

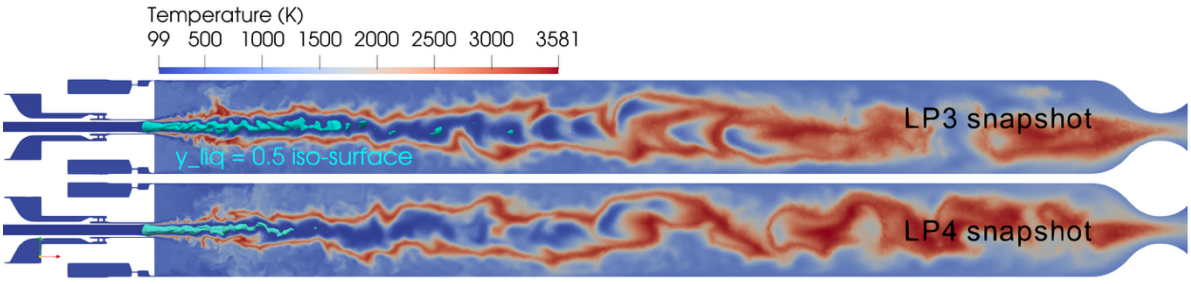

Figure 1: Temperature snapshots and liquid/vapour interface for the BKN simulation for two subcritical pressure load points.

References

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