Towards fuel spray ignition in aircraft engine

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Abstract

In order to certify turbojet combustors, motorists need to ensure security criteria. One of them is the possibility to relight the combustor in case of in-flight extinction were the conditions are critical (low temperature and low pressure).
The most reliable and common ignition mode of air-breathing engines is electrical spark discharges. Heat deposition leads to the formation of an ignition kernel : the spark discharge deposites energy, and spherical flame expands in a small-scale way. The kernel then propagates in two different length scales : the kernel can first be transported into a recirculation zone and, finally, the whole chamber is ignited.
The certification of new combustors needs numerous and expensive ignition tests, for a wide range of conditions. For the preliminary phase, and in order to improve the design of industrial combustors, numerical tools are used. This is why accurate numerical models are needed to correctly reproduce the two-phase flow inside the combustion chambers before, during, and after the ignition process.

An ignition kernel model [1] has been developed and combined with a CFD code in two ways. Firstly, the ignition model is used to build the ignition probability map of a combustor. Secondly, a local ignition simulation is introduced as initial condition in an unsteady simulation to model the complete flame propagation.
These models are applied to numerical simulations for a mono-sector combustor, experimentally investigated on the MERCATO test-rig (ONERA-Mauzac). Velocity fields of the two-phase flow and the droplet size fields are provided by LDA and PDA measurements [2][3].

The unstructured reactive compressible code CEDRE is used, in which a lagrangian approach is developped to model spray [4][5]. The RANS and LES simulations are compared to the experimental measurements, and validated. More, the precessing vortex core, an hydrodynamic instability of the gas flow, is correctly captured by LES. From the two-phase mean flow field, the ignition model is first used to get an ignition probability map. Secondly, the local ignition simulation model is applied to instantaneous LES flow fields in order to get the ignition statistics. Results are then compared to the experimental statistics of the combustor for given localisation of the spark, and given operating conditions.

References:

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