Evaluation of Simulation Strategies for Multipoint Injection Systems in Aero-Engines on the Example of a Liquid Jet in a Gaseous Crossflow

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Abstract

In an effort to reduce CO_2 and NO_X emissions of aeronautical engines, staged injection systems that allow optimizing lean combustion processes for different operating points are becoming more and more common. These systems employ multipoint injections where only the central part uses a classical hollow-cone fuel injection while for the second stage, a series of fuel jets are injected perpendicularly to the airflow. The present work evaluates the capability of different numerical strategies to simulate multipoint injectors. The evaluation is carried out using the test-case of a liquid jet in a gaseous crossflow for which experimental data are available. The gas phase is simulated using the LES solver AVBP, which has demonstrated its ability to predict unsteady reactive flows in complex geometries. For the liquid phase, a Euler-Lagrange method is used. Models in the Lagrangian solver include a Stokes law with Reynolds correction for drag as well as a Spalding-type model for evaporation, with two-way coupling between the gaseous and the dispersed phase. Primary and secondary breakup are not taken into account, as their role in realistic applications (outside the near-injector region) is limited. Instead, polydispersion at the injection is based on the size distribution in the fully developed spray available from measurement data. The impact of this lack of detail is analyzed by comparison to the experiment. Further analysis focuses on the spatial distribution of droplets downstream of the injection, as well as diameter distribution. It is shown that the degree of physical detail is sufficient to obtain a proper representation of the spray generated by a multipoint-type injector in the areas of interest for combustion.

Key words: spray, injection, liquid jet, crossflow, multipoint, aero engine

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