Numerical modelling of combustion stability prediction in a dual mode ramjet with a cavity flameholder

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Abstract
The renewed interest of the aeronautics industry in hypersonic propulsion systems led to a relaunch in dual mode ramjets (DMR) research. These engines operate at sensitive inlet conditions and must be combined with low-speed propulsion systems such as turbojets. The transition between supersonic and hypersonic regime shows an oscillating behavior as the combustion shifts from subsonic to supersonic. Recent studies use hydrogen as a fuel given its high specific impulse. The most common engines use either a strut injection or cavity-based ones. Nevertheless, the experimental campaigns of these propulsion systems are quite expensive and difficult to reproduce, thus limited to reduced-scale test facilities. Computational Fluid Dynamics (CFD) represents a viable alternative to emulate the behavior of such engines. Still, where cold flow simulations can precisely predict the air passing through the DMR, the combustion process and stabilization is difficult to study numerically. In this initiative, the Partially Stirred Reactor (PaSR) model seems promising in describing the interactions between the chemistry and turbulence as it showed its ability in describing combustion in different regimes. This work aims at implementing the PaSR model in DMR to assess the stability of the combustion process so as its limits. To this end, 2D and 3D RANS simulations are performed on a jet in crossflow with cavity flameholder using Ansys Fluent. The effects of inlet stagnation temperature and equivalence ratio on the flame stability and changes in backpressure in the isolator are assessed in this work. Finally, the PaSR model is compared to the other reactor-based model, namely the Eddy Dissipation Concept (EDC) model. The results of the simulations are validated with the available experimental data.