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A FLAMELET PROGRESS-VARIABLE APPROACH FOR THE SIMULATION OF NON-PREMIXED FLAMES IN THE PRESENCE OF WEAK ELECTRIC FIELDS

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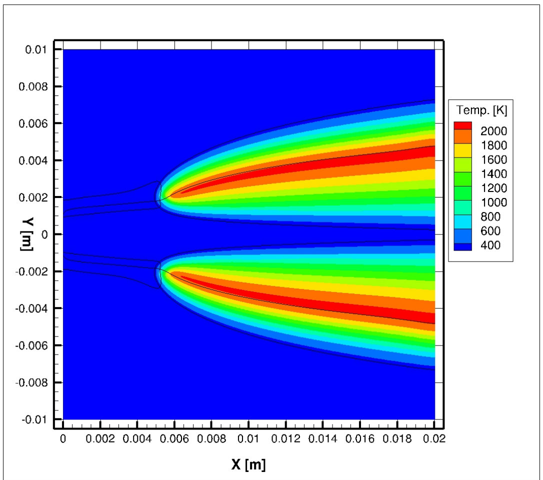
The development of complex flow control methods has a direct influence on the performance improvement of modern combustion chambers. In this context, applying an external electric field proved to be effective in increasing the extinction limits of both premixed and diffusive flames. Moreover, this control system seems very suitable for industrial applications because of the low complexity added to the combustion chamber and low power requirements.

In practice, the presence of the electric field promotes the separation of the cations and anions produced by the chemi-ionization of the flame, leading to a polarization of the fluid. This unbalance of charge present in the gas-mixture, together with the local electric field, changes the local momentum of the flow by means of the Coulomb's force. For this reason, the flame-front acts as an additional electrode absorbing most of the electric potential difference applied to the system.

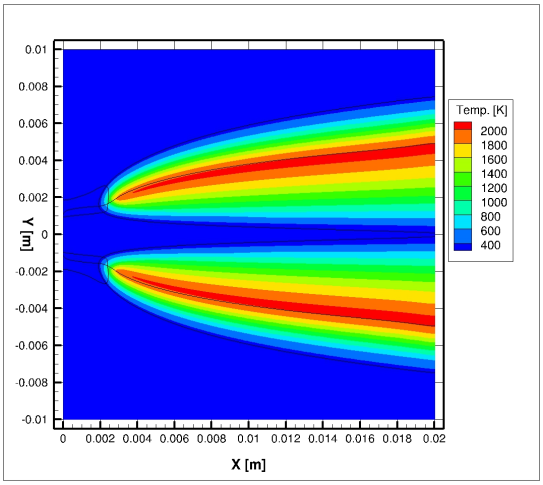
The aim of this work is to provide a model for simulating the effect of the electric field on a flame, based on the extensively tested flamelet progress-variable approach. It uses two scalars defined as linear combination of the anions and cations mass-fractions, respectively, along with the mixture fraction and progress-variable, to compute all the thermo-chemical quantities and the charge of the fluid. This approach allows one to use an arbitrary complex ionization mechanism without adding any computational complexity to the flow simulation.

The model has been coupled with a low-Mach number formulation of the Navier-Stokes equations and embedded in a massively parallel unstructured solver.

The capabilities of the proposed method will be presented discussing the simulations of a laminar flow in a two-dimensional non-premixed slot-burner considering several applied voltages. Two sets of results (see Figures 1-2) have been obtained using two different ionization mechanisms in order to show the flexibility of the proposed method.



Temperature contours with no imposed electric field



Temperature contours with 400 V imposed voltage