Proposition de sujet

Numerical investigation of plasma / flame interactions

This project is at the interface of Plasma and Combustion teams of the EM2C laboratory. Researchers from both fields will be involved in the PhD thesis management.

Flame ignition or extinction is the result of very complex interactions between combustion chemistry and turbulence. It has been recently observed in experimental studies [1,2] that the presence of a plasma discharge in the vicinity of reaction zones affects combustion. For instance, a discharge generated in a combustion chamber produces a pool of radicals. These highly reactive species strongly interact with combustion mechanisms, promoting the ignition of very lean mixtures. Such mixtures burning at lower temperature levels than usual stoichiometric mixtures, generate less nitric oxides which are strongly related to high temperatures. Unfortunately very lean mixtures are difficult to ignite in internal combustion engines (ICE). A plasma device could then be used to produce radicals and then to favour the ignition.

Interactions between turbulence and combustion are now well known by the scientific community and various modeling strategies using Reynolds Average Navier Stokes (RANS) [3] or Large Eddy Simulations (LES) [4] approaches are available. However the influence of a plasma discharge on the turbulent flame dynamics is not well understood. In the present study, we propose to perform a numerical experiment to understand the effects of plasma on flame ignition in a turbulent flow environment and to devise possible modeling routes.

For that purpose the Navier-Stokes solver YWC, developed at the EM2C laboratory, will be used. The code YWC is a direct numerical simulation code using complex chemistry, 6th order in space, 4th order in time.

The PhD candidate will select a numerical scheme able to perform multi-dimensional numerical simulations. In a first step, 0D simulations of closed reactors configurations will be conducted in order to understand the influence of plasma application on auto-ignition processes. Then, a 2-D simulation in a quiescent flow environment (at the initial condition, zero flow velocity is imposed) will be performed. This simulation step is important for validation purposes. The simulation will be compared to experiment data obtained at the EM2C laboratory by the plasma team. A 3-D simulation will then be performed. As the initial condition, a Homogenous Isotropic Turbulence is imposed. This simulation is expected to be representative of realistic engine conditions where turbulence, generated by piston motion, is present before ignition. This is also representative of Rapid Compression Machine conditions. The 3-D results will be analyzed in order to understand flame / turbulence / plasma interactions and to draw possible modeling routes.
References


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