Advanced combustion for aeronautics

Numerical Analysis of turbulent swirl-stabilized flame

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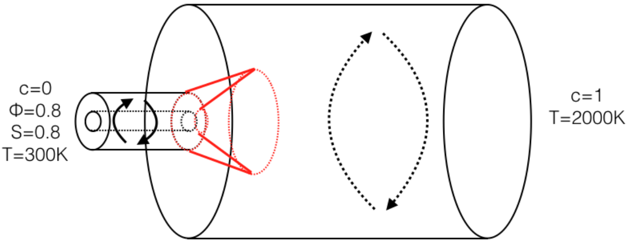
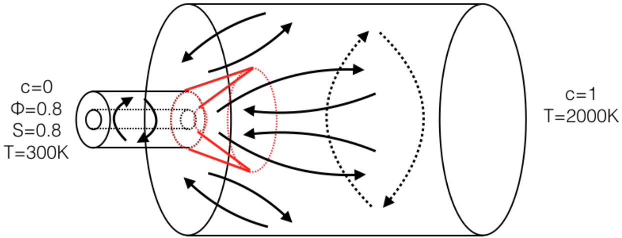
Numerical Study

The C-equation model for premixed combustion will now be put to use in order to **analyse the topology of a premixed turbulent CH_4 flame as a function of the inlet swirl number (S).**

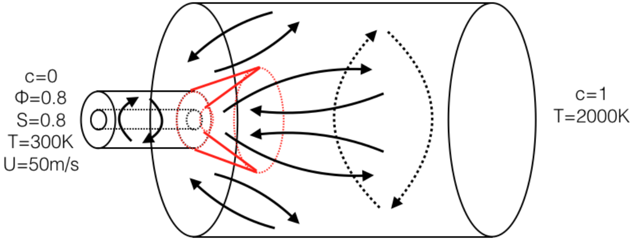


Numerical Study

In an homogeneous medium, the swirl number is defined as
$S = \dfrac{\int_{R_0}^{R_1} U V_\theta r dr}{\int_{R_0}^{R_1} U^2 r dr}$. If the rotational speed of the inflow increases compared to the bulk velocity, the Swirl number increases accordingly.



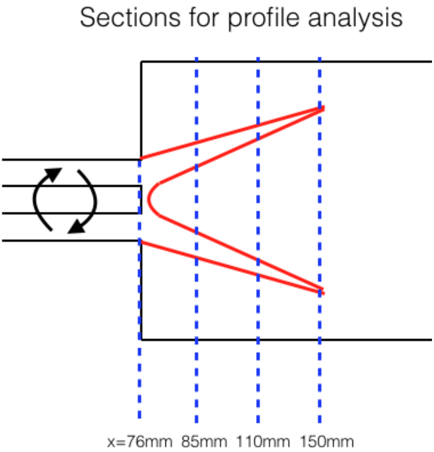
Numerical Study – work plan



All walls are no slip — heat fluxes at the walls are neglected

1. You will first run the reference case using the mesh at your disposal
2. You will analyze the flow topology in the reacting flow region

Numerical Study – cut sections for analysis



Variables to be analyzed are U_x, U_r, U_θ, U_{rms} and c or T.

Numerical Study

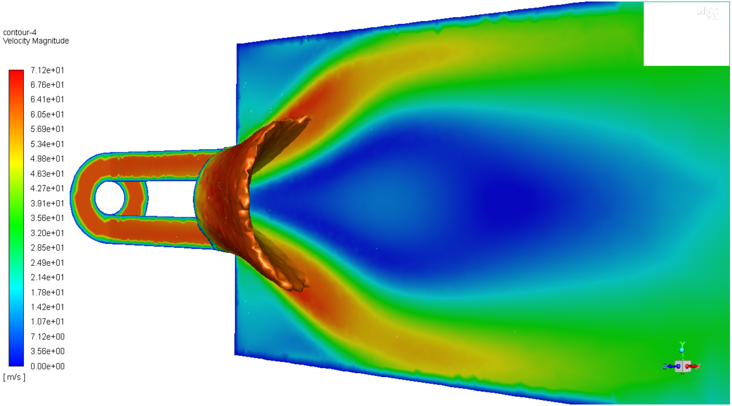


Figure 1 : Longitudinal cut colored by axial velocity. Iso-surface $c = 0.5$ colored by axial velocity.

Numerical Study – Analysis of the effect of stretch

For a given swirl number of your choice, you will analyze the effect of the stretch factor on the topology of the flame.
The effect of stretching on the flame is taken into account as a correction term such that

$$\overline{\dot{\omega}_c} - -- > \overline{\dot{\omega}_c} * G$$

$$\text{where } G = \frac{1}{2} erfc\left[-\sqrt{\frac{1}{2\sigma}}\left(ln\frac{\epsilon_{cr}}{\tilde{\epsilon}} + \frac{\sigma}{2}\right)\right]$$

$$\sigma = \mu_{str} ln\left(\frac{L}{\eta}\right)$$

$$\mu_{str} = 0.26$$

$$\epsilon_{cr} = 15\nu g_{cr}^2$$

where g_{cr} is the critical velocity gradient beyond which the flame blows off and σ is the r.m.s. of ϵ