Laboratoire Plasma et Conversion d'Energie

Convection velocity in HID lamp including acoustic resonance

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I. Motivation

Understand the interaction between acoustics resonances and the plasma instabilities.

2D axi-symmetric model used finites elements has been implemented in Comsol for a HID lamp operated at high frequency including the influence of acoustic velocity .

II. Model

a. Temperature

For to compute the temperature in the burner, we need three equations

1.Convection and Conduction equation:

$$\vec{\nabla}.(-\kappa\vec{\nabla}T) = Q - \rho C_p \vec{U}\cdot\vec{\nabla}T$$

2.Incompressible Navier-Stokes equation (convection velocity):

$$\rho(\vec{U}\cdot\vec{\nabla})\vec{U} = \nabla\left[-p\vec{I} + \eta\left(\vec{\nabla}U + (\vec{\nabla}\vec{U})^T\right)\right] + \vec{F}$$

3. Poisson's equation (electrical field):

$$\vec{\nabla}.(-\sigma\vec{\nabla}V) = 0$$

b. Acoustic Pressure

The modeling of acoustic resonances in the burner is performed by using the eigenfrequency analysis :

$$\vec{\nabla}.(-\frac{1}{\rho}\vec{\nabla}p) - \frac{\lambda_i p}{c_s^2\rho} = 0$$

c. Acoustic Amplitude

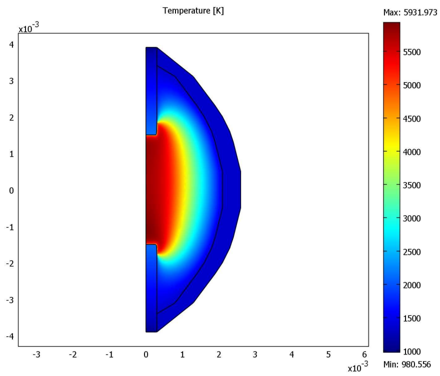
For to take into account losses to the walls and in the volume, we compute the amplitude of AR

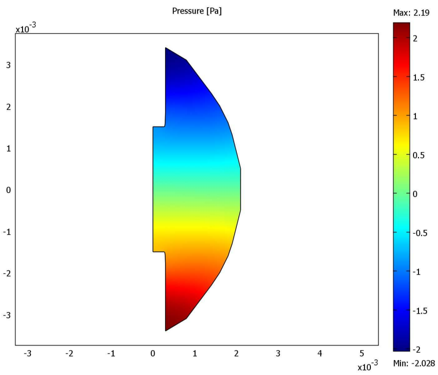
$$A_j(\omega) = i\frac{A_j\omega}{\omega^2 - \omega_j^{\,2} + i\dfrac{\omega\omega_j}{Q_j}}$$

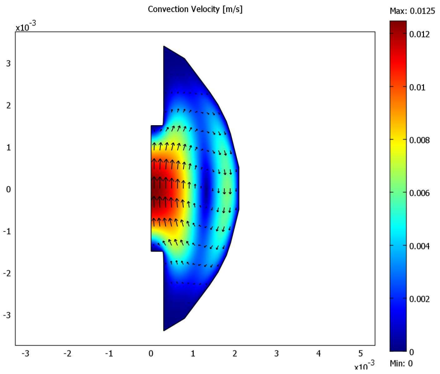
d. Streaming Acoustic

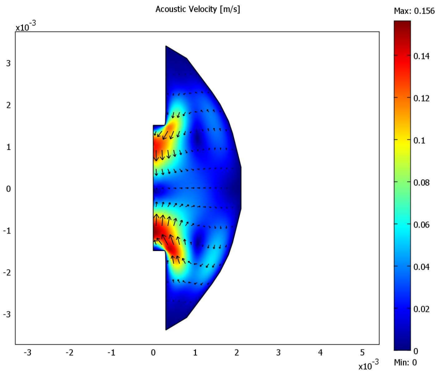
As a non-linear second order effect of the acoustic wave that has a time-averaged amplitude different to zero, a vortex acoustic flow develops in the burner and his force, for the direction of axis j, is written:

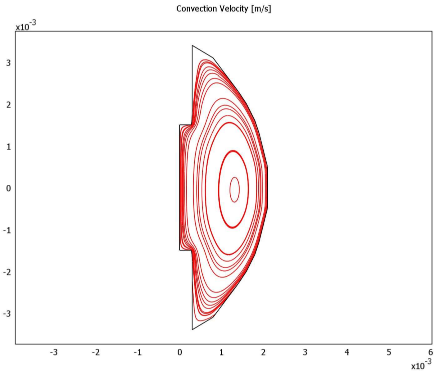
$$F_j = -\frac{\partial\overline{\rho v_i v_j}}{\partial x_i}$$

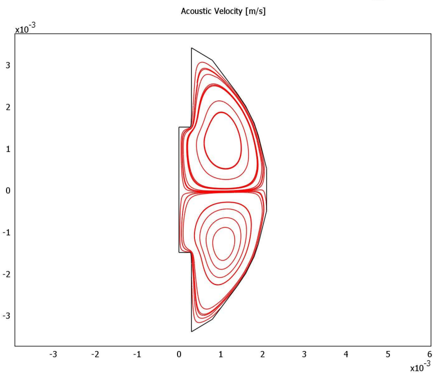




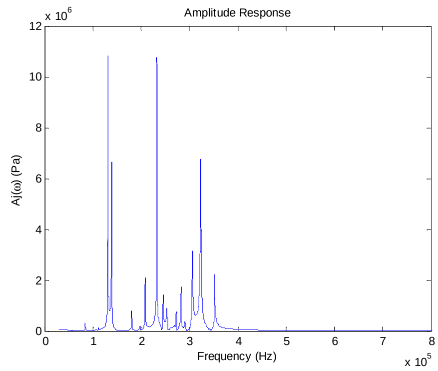








**For all figures, Pressure=40.10^5 [Pa] and Current=0.25 [A]*



III. Conclusion

The appearance of fluxes combining convection and acoustic streaming may be responsible for instabilities in HID lamp and it give us a beginning of explanation for the relation between the acoustic resonances and the arc instabilities.

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