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Implicit large eddy simulation of high-speed impinging jets

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Impinging jets are commonplace in industrial applications, including mixing and spraying, where flow steadiness is desirable. In the aerospace industry, rocket launches represent a critical phase during which jet instabilities can lead to payload damage and loss of flight control. The dynamic process is characterized by a supersonic jet impinging onto a flat surface, which produces complex fluid dynamic phenomena that are dominated by the intrecate shockwave structure of the jet [1-2].

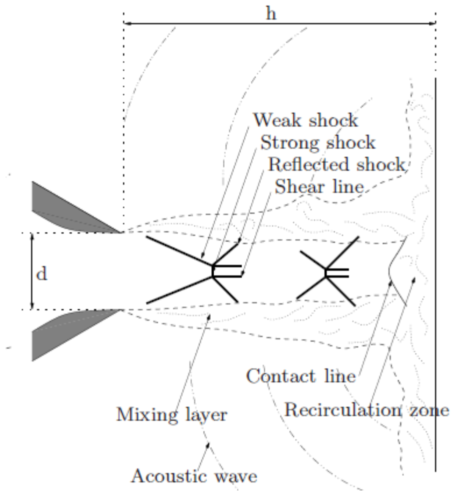

Figure 1: Complex flow dynamic structure of an impinging jet

Typical parameters involved in the flow configuration are: the Nozzle Pressure Ratio (NPR) as the difference between the ambient and nozzle pressure, the Reynolds number (RE) and the impingement distance (h/d). Even though the mean solution is relatively well understood, the growing of unsteady instabilities in the shear layer at the nozzle gives rise to oscillations in the dominant flow structures, which are responsible of generating a series of discrete tones which travelling upstream perturbs again the shear layer completing a loop usually known as feedback model [3] (see Figure 1). Regrettable, the exact dynamic of this phenomena and the influence of the different parameters involved on it is still not well understood

In the present study the non-steady dynamics of a jet with h/d=4, NPR=3.2 is considered. This configuration has been thoughtfully studied experimentally by [4]. An Implicit Large Eddy Simulation methodology has been used in the computations. Although, LES simulations have demonstrated their ability to predict the behavior of weakly compressible turbulent flows [5]. LES applications to supersonic flows however remain to be validated [6].
The present study seeks to understand the mechanisms leading to the appearance of instabilities in impinging jets. In the longer term, it is hoped that flow control guidelines will emerge from these types of studies.

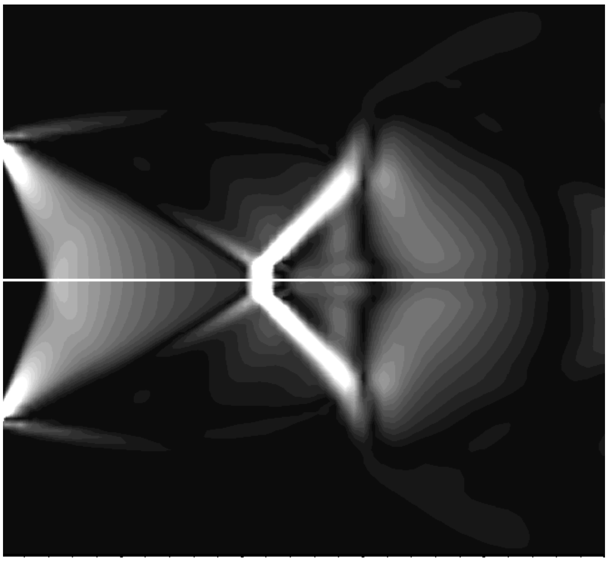

Figure 2: Density profiles in an impinging jet simulation.

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