Self-Excited Oscillations of Two Opposing Planar Jets

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Abstract

Opposing planar jets are used in a variety of industrial applications, including the production of sheet steel,air/fuel mixing in combustion applications, in valves and piping systems, and in reactor geometries usedin the chemical industry. In some applications such flow can be problematic, due to intense self-excited flow oscillations which can act as a source of potential vibrations, and intense acoustic tones which can pose problems related to ergonomic restrictions related to noise.

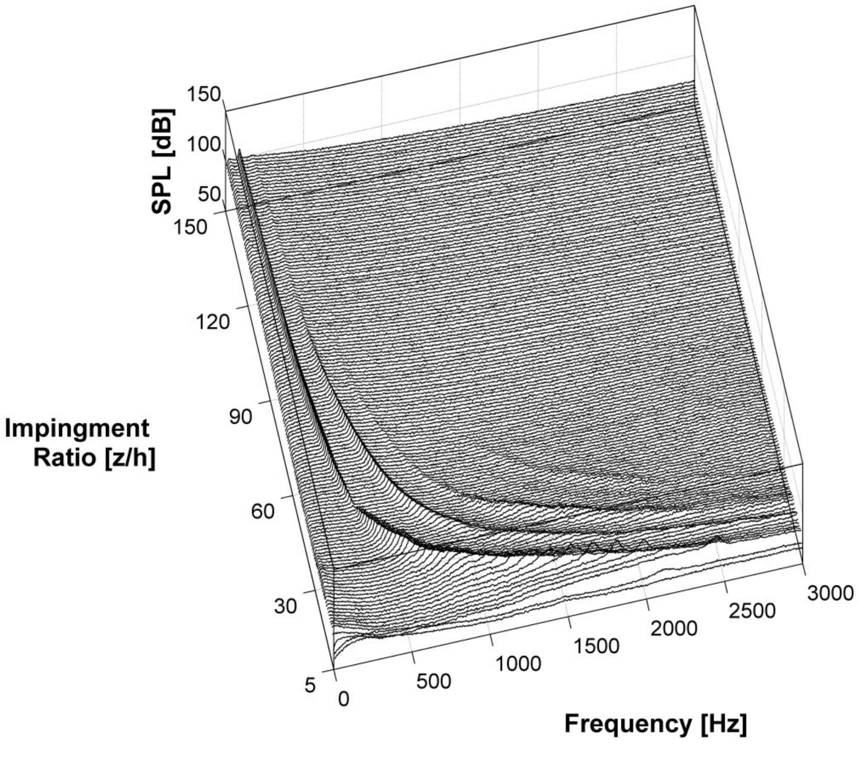

Figure1:Waterfall plot of aeroacoustic response of the opposing planar jet system for a flow velocity of U_0=225m/s and a jet thickness of h=2mm.

This paper willinvestigate self-excited behaviour of the opposing planar jet system for two opposing planar jets with an equal thickness of h=2 mm and at distance z apart, having nozzle aspect ratio of L/h=50, defined as the span of the nozzle, normalized by jet thickness.

An example of the self-excited response of the system is given in Figure 1 Showing the jets acoustic response at exit velocity of U_0=225 m/s & varying impingement ratio where $5 \leq z/h \leq 150$, intense acoustic tones are observed with a main peak frequency and a higher harmonic tone, peak frequency varies in an interesting behavior where the main peak frequency is inverse of the impingement distance.

The oscillating flow field has been obtained using phase-locked Particle Image Velocimetry (PIV) measurements to examine the development of the flow as a function of both varying impingement distance and flow velocity. Phase-locked PIV measurements use the periodic pressure signal obtained by a microphone in the acoustic near field to collect a series of measurements at a specified point in the phase of the flow oscillation, allowing for these measurements to averaged together to produce a single average flow field for that instant in the flow oscillation. By adding and manipulating a time delay, measurements can be obtained throughout the flow oscillation cycle, allowing for the reconstruction of the relatively high-frequency flow oscillation. Figure 2 shows an example of these measurements done at exit velocity of 200 m/s,where the two phase averaged velocity fields reveal a flapping motion of jets around the centerline in an anti-symmetric pattern, this occurs over a wide range of impingement ratios and exit velocities, where oscillations are robust in this kind of setup.

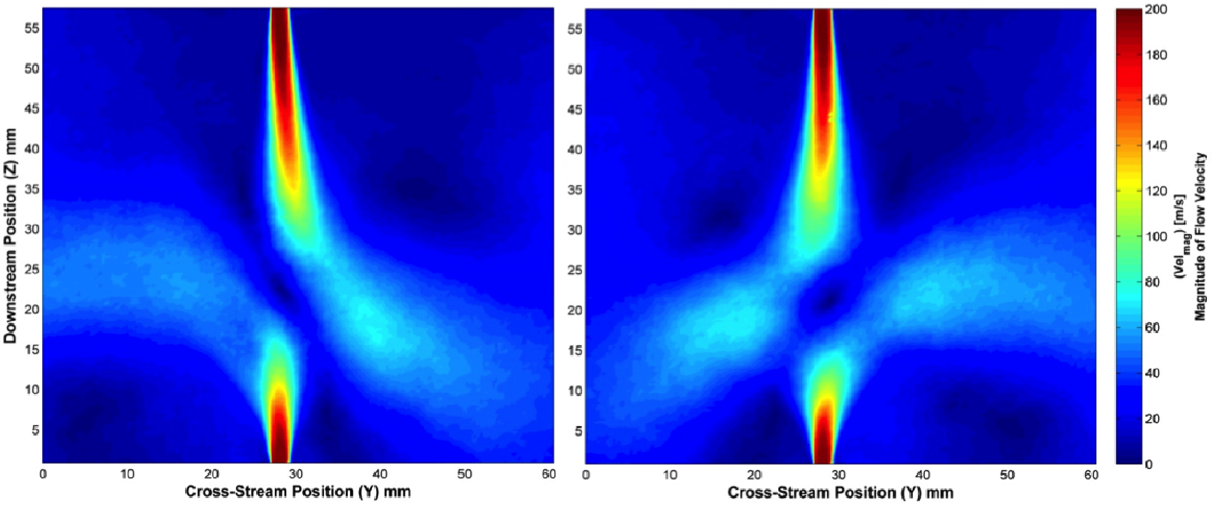

Figure2:Preliminary phase-averaged velocity fields showing the form of the flapping flow oscillation for the opposing planar jet system for a flow velocity of U_0=200 m/sand jet thickness of h=2mm (Add ϕ=0°, 180°) to the figures above) .

These measurements and analysis will be performed for a series of cases distributed over the large range of impingement ratio for which the self-excited flow oscillations occur at a single exit flow velocity of 250 m/s.

Further analysis of the flow fields will be performed to analyze the extent of the velocity fluctuations of the self-excited oscillation, including analysis of the vorticity field, identification of coherent flow structures, as well as the fluctuating velocity component in the stream-wise and cross-stream directions, this will uncover features of this oscillation phenomenon such as extent of flow oscillations and participation of coherent structures in this phenomenon, this will help in developing a model to predict the oscillation frequency in this flow.