NEAR-FIELD RESPONSE OF AN AXISYMMETRIC JET TO TRANSVERSE ACOUSTIC FORCING

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Reacting flows in annular enclosures, such as combustion chambers in gas turbine engines, are subject to acoustic waves that inevitably interact with the primary flow [1]. In this study we consider a simplified case of a non-reacting axisymmetric jet subject to transverse acoustic forcing in the form of a standing wave. We perform high-speed stereoscopic particle image velocimetry (PIV) measurements in the near-field region of the jet to determine the effects of acoustic forcing on the turbulent structure. The jet is produced by issuing air ($\nu = 1.51 \times 10^{-5}$ m^{2}s^{-1}) from a convergent nozzle into a rectangular chamber. The convergent profile ensures a top-hat velocity profile at the nozzle exit, which produces a jet at $Re = 7300$, where $Re = u_e D/\nu$, $u_e = 11.0$ ms^{-1} is the nozzle-exit velocity of the jet and $D = 0.01$ m is the diameter of the nozzle. We perform PIV measurements at 5 locations: the pressure node, the pressure anti-node, and 3 equidistant positions in between the node and anti-node.

The frequency of the initial vortex formation from the Kelvin-Helmoltz instability is locked into the forcing frequency from the speakers ($f = 260$ hz). However, the structure of these initial vortices is noticeably different at the different nodal positions. In figure 1 we present the rms phase-averaged axial ($u_{\rm rms}$) and radial ($v_{\rm rms}$) velocities for the (*a*) pressure node and (*b*) anti-node. At the pressure node the centreline velocity $u_{\rm rms}$ is near zero because the pressure amplitude does not vary significantly at this position of the jet. Rather, the pressure gradient changes across the forcing cycle, which results in the jet being 'pushed' transversely by the pressure field. This is manifested by the non-zero radial velocity $v_{\rm rms}$ along the jet centreline. In contrast, the pressure anti-node position exhibits no radial velocity fluctuations at the centreline, but very strong axial fluctuations. The magnitude of the rms velocities at the shear layer ($r/D = \pm 0.5$) correspond with the nature of the initial vortex formation in the near-field, which is illustrated in the instantaneous vorticity fields shown in figure 1(*c*) and (*d*) for the node and anti-node, respectively. At the pressure node and anti-node the near-field vortical structure is anti-symmetric and symmetric, respectively. However, in between these points in the pressure field we observe a distinct asymmetry of the turbulent structure when subject to transverse acoustic forcing. We are currently performing tomographic PIV measurements to elucidate the instantaneous 3D vortical structures that correspond with these asymmetric pressure conditions.

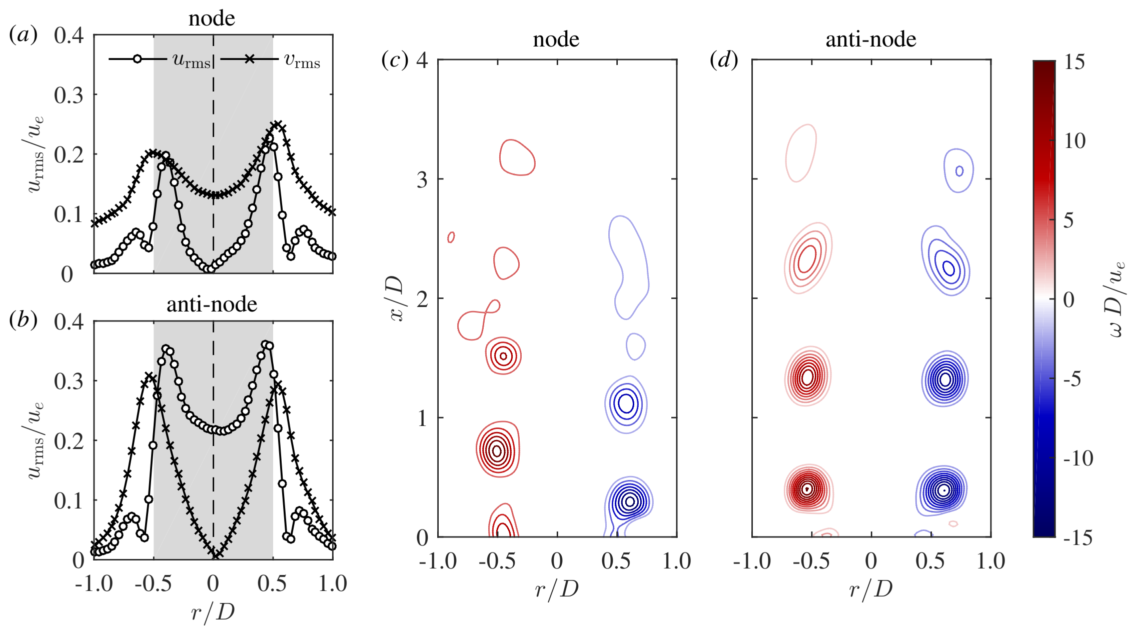

Figure 1. (*a*,*b*) Rms velocity profiles at the measured at the nozzle exit $x/D = 0$. (*c*,*d*) Examples of the instantaneous spanwise vorticity field for the node and anti-node, respectively.

References

[1] J. R. Dawson and N. A. Worth. Flame dynamics and unsteady heat release rate of self-excited azimuthal modes in an annular combustor. *Combustion and Flame*, **161**(10):2565–2578, 2014.