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Experiments on the instabilities of a swirling jet

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Abstract

Instabilities present in a free-swirling jet in the Reynolds number range from 20,000 to 60,000 and a nominal swirl number of 0.5 are studied experimentally, using smoke visualization and hot-wire anemometry. Flow visualization photographs show vortex breakdown at the core and rolling up of the shear layer around the jet into weak, irregular, large scale organized structures. When forced by acoustic excitation these structures become energetic and periodic. Axisymmetric and helical instability waves in the Strouhal number range 0.75 to 1.5 are excited and their evolution along the axial direction are measured from velocity spectra and ensemble averaged measurements. Compared to a nonswirling jet, the overall growth of the instability waves are considerably smaller, and vortex pairing is suppressed in a swirling jet. However, the overall spread and mass entrainment rates are higher in the latter.

Measurements of the mean velocity components and turbulence fluctuations show that the vortex breakdown affects the axial velocity distribution and rapidly replaces the potential core with a large amount of turbulence. Upon interacting with the vortex breakdown, the shear layer along the jet periphery loses its organized structure and, in general, "random turbulence" follows.

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