

Vortex Wandering and Coherent Dynamics in Flap Side Edge Noise

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The vortex dynamics and noise generation mechanisms of a high-lift wing are investigated by utilizing the flap side edge gap as a control parameter. Experiments were conducted on a 30P30N model at $Re_c = 1.3 \times 10^6$ using stereo particle image velocimetry, unsteady surface pressure measurements, and a phased microphone array. The primary effect of the change in gap width is to modulate the strength of the secondary vortex and its hydrodynamic interactions downstream. When there is no gap, a weak secondary vortex entrains into the primary vortex, causing coherent co-wandering and elevated low-frequency noise. In contrast, a strong secondary vortex formed in the presence of a gap resists merging, preserving the primary vortex's downstream coherence and shifting acoustic sources to higher frequencies. In both cases, the primary noise generation mechanism is the scrubbing of the primary vortex on the suction side edge during the vortex cross-over event. Crucially, cross-correlation analysis isolates a specific dipole-like surface-normal wandering motion as the primary hydrodynamic driver of surface pressure fluctuations.