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Three-dimensional Floquet stability analysis of the wake in cylinder arrays

Three-dimensional stability of the periodic wake of tightly packed rotated and inline cylinder arrays is investigated for $60 \leq Re \leq 270$. Results are compared with existing numerical and experimental studies for an isolated cylinder. Numerical Floquet analysis shows that the two-dimensional wakes of the rotated and inline arrays with spacing $P/D = 1.5$ become unstable at $Re_c = 64 \pm 0.5$ and $Re_c = 132 \pm 1$ respectively. Two-dimensional vortex shedding flow is unlikely in practice for such flows. The dominant spanwise wavelength is $\lambda/D = 0.9 \pm 0.1$ for the rotated array at $Re = 100$ and $\lambda/D = 3.0 \pm 0.1$ for the inline array at $Re = 200$. Three-dimensional simulations show excellent agreement with the Floquet analysis for the rotated case, and reasonable agreement for the inline case. The instability mechanism appears to be similar to Mode A for an isolated cylinder, although the structure of the three-dimensional vorticity is different due to the spatial periodicity of the flow. Unlike the isolated cylinder, both array flows are unstable as $\lambda \to \infty$ (like a thin shear layer). This is the first investigation of three-dimensional wake instability in cylinder arrays, a problem of significant practical and theoretical interest.