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Stability in the boundary layer and wake of oscillating foils at moderate Reynolds numbers

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We modelled with RANS and LES different experiments of pitching foils at moderate Reynolds numbers (Re). We considered a $\pm 2^\circ$ sinusoidally pitching foil at $Re = 12\,000$, for a wide range of frequencies and compared with experiments [1-4]. We found that transition occurs in the wake and has a negligible effect on the unsteady forces. Similarly occurred for large amplitude oscillations and low Re, such as $Re = 1173$ [5]. In contrast, we found that if the pitch amplitude is large, transition occurs near the leading edge even at moderate Re conditions. For example, at $Re = 10\,000$, we increased the pitch linearly to 25°, then we maintained it constant for a short time and then linearly decreased to zero [6]. A large leading-edge vortex is formed and convected downstream, leading to large load fluctuations. Transition occurs within the leading-edge vortex and, hence, patches of turbulent flow convect downstream along the foil. We found that the correct identification of laminar and turbulent regions is critical to correctly compute the unsteady forces and, hence, this complex flow regime is a major challenge for numerical modelling.

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