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Vortex Formation vs. Aerodynamic Force Coefficient Variations for Rapidly-Pitching Flat Plates MICHAEL OL, KENNETH GRANLUND, U.S. Air Force Research Lab — We consider a flat plate in constant-rate (linear) pitch, from angle of attack $\alpha = 0^\circ$ to 90°, at a Reynolds number of 20,000. The motion is via a three-component electric rig fitted atop a water tunnel. Various smoothing transients at motion initiation and cessation are applied. Pitch pivot point is at the plate chordwise locations x/c = 0, 0.25, 0.5 and 0.75. Pitch rates range from $K = c\dot{\theta}/2U_\infty$ of 0.0025 through 1.0. Plate geometries include nominally 2D and aspect ratio 2.0; both have round edges. Lift, drag and pitching moment were measured directly with a force balance, while flowfield data included dye injection and PIV. For reduced frequencies $K < 0.05$, lift for the 2D plate followed the usual relation of $2\pi\alpha$, with stall delay in proportion to pitch rate, and stall behavior increasingly smoother as pitch rate increases. At higher K, acceleration or noncirculatory effects are manifest, with a rise in lift at low α, and a rise in drag at high α. Noncirculatory and circulatory effects are additive and the noncirculatory portion is well predicted by potential-flow methods. $K > 0.02$ evinces the formation of a leading edge vortex. Peak in lift correlates to the angle of attack where the leading edge vortex reaches maximum circulation and begins to shed. Lift and drag are seen to obey a scaling with pitch rate, for $K > 0.03$.

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