Abstract Submitted
for the DFD12 Meeting of
The American Physical Society

Thrust production of free-to-pivot plates at low Reynolds number KENNETH GRANLUND, MICHAEL OL, Air Force Research Labs, LUIS BERNAL, University of Michigan — As an abstraction of flapping-wing aerodynamics, rigid flat plates free-to-pivot at the leading edge between incidence angle limits of $\pm 45^\circ$ are considered in rectilinear as well as waving motion in a quiescent fluid. Thrust (lift) and resistive-force are measured, forming a hover Figure-of-Merit (FoM). The evolution of spatial retention of a leading edge vortex is tracked throughout the motion cycle, showing vortex formation shortly after the plate completes its rotation, and in some cases shedding of subsequent vortices after the initial leading edge vortex is ejected. Vortex evolution in rectilinear- vs. rotating and steady vs. accelerating motion is visualized with fluorescent dye illuminated by a laser light sheet at several spanwise stations along the leading edge. Experiments in water reveal a Reynolds number indifference in thrust and FoM for 8,000<Re<31,000 based on the maximum velocity of the leading edge. A study on aspect ratio from 3.4 to a nominally 2D-plate also shows an indifference in vortex shedding, force coefficients and FoM. The main operative parameter for aerodynamic coefficients is the stroke-to-chord ratio of the leading edge, with decay in both thrust production and FoM as the ratio approaches unity. Prescribed kinematics of varying phase lead/lag of the pitch- vs. stroke history from free-to-pivot cases shows the effect on attachment of the leading edge vortex and related thrust production and FoM. The effect on flow and force for several orders of magnitude lower Reynolds number are investigated by performing the experiment in varying mixtures of glycerin and water.

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Date submitted: 10 Aug 2012 Electronic form version 1.4