Investigation on the Unsteady Aerodynamic Performance of the Airfoil Subjected to Heaving Motion

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Abstract:

This paper aims to investigate the unsteady flow characteristics of five different airfoils subjected to heaving motion by varying the thickness to chord ratio (t/c) approximately from 2% to 32% (multiples of 2). The influence of heave amplitude, heave frequency and mean angle of attack over the thrust force generation and propulsion efficiency of the airfoil is investigated at $Re < 1 \times 10^5$. Further, the flow field investigations were carried out to analyse the Leading Edge Vortex (LEV) formation and its convection over the suction side of the airfoil. A transition in the wake pattern from drag inducing to thrust producing is observed under certain conditions. It is observed that the flow separates at the leading edge by forming LEV on both suction and pressure side of the airfoil. As the flow past the trailing edge, these vortices convect downstream of the airfoil and form alternating pattern of coherent vortices in the wake region. With the increase in the number of cycles, these vortices interfere with the vortices shed in the previous cycle and affects the airfoil's propulsion efficiency. From the investigations, it is observed that, by controlling the system parameters, the adverse effects of the LEV can be minimised. Additionally, a remarkable variation in the instantaneous force coefficients (both qualitatively and quantitatively) is also observed with respect to the slight change in aforementioned parameters.

Keywords: heaving airfoil, vortex shedding, unsteady flow, wake pattern.