COMPUTATIONAL STUDIES OF INSECT-SIZED FLAPPING WINGS IN INCLINED STROKE PLANE UNDER THE INFLUENCE OF TEMPORALLY VARYING SHEAR INFLOW

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Abstract

2D computational studies on the effects of temporally varying shear inflow condition on forces generated by an insect-sized flapping wing in the inclined stroke plane have been carried out for Re = 150. Temporally varying shear inflow condition was represented by a combination of a mean wind speed term, a temporally fluctuating velocity term and a spatial velocity gradient term. The mathematical form followed the expression Here, U_G is the gusty inflow velocity in m/s, U_∞ is mean free stream velocity in m/s, U_g is the amplitude of the temporally sinusoidal velocity fluctuation in m/s, V_{grad} is the linear velocity gradient along the Y-axis in m/s per m, U_w is the root mean square average of the flapping cycle velocity of the wing in m/s, f_g is the frequency of the temporally sinusoidal velocity fluctuation in Hz, f_w is the wing's flapping frequency in Hz, y is dimension along Y-axis in m and t is time in second. For the present studies $U_g/U_w = 1$ and $f_g/f_w = 0.1$ were chosen. Five cases with linear velocity gradient ratio along the Y-axis, $V_{grad}/U_w = \pm 5, \pm 2.5$ and 0 were considered. Findings were analyzed by plots of instantaneous and cycle-averaged force coefficients, phase space plots, global recurrence plots and windowed recurrence quantification analysis. Numerical investigations revealed that negative V_{grad}/U_w induced a considerable increase in vertical force and marginal decrease in the horizontal force. Positive V_{grad}/U_w induced a marginal increment in horizontal force but caused a substantial decrement in vertical force.

Keywords: MAV, NAV, PAV, Flapping Wings, Inclined Stroke Plane, Temporally Varying Shear Inflow, Global Recurrence Plots, Windowed Recurrence Quantification Analysis