EFFECT OF UNEQUAL FLAPPING FREQUENCIES ON FLOW STRUCTURES

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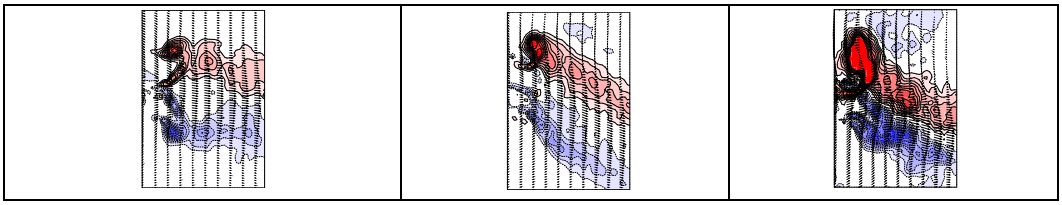
ABSTRACT: The generation of thrust by an oscillating airfoil is known for quite a long time as summarized by Jones et al. [1]. Although there are many experimental and numerical studies which investigate flapping airfoils, effects of unequal oscillating frequencies of pitching and plunging motions received little attention due to the complexity of the problem. Ol [2] briefly studied the oscillations of an SD7003 airfoil experimentally where pitch and plunge frequencies differ and observed that a separated leading edge vortex is formed every pitch period, unlike all prior tested pure plunge cases. Webb et al. [3] also considered the effects of unequal pitch and plunge motion of an SD7003 airfoil to model the gust response.

An experimental study was conducted in steady water flow to investigate the role of unequal frequency effects of a SD7003 airfoil which undergoes combined pitching and plunging motions with a phase angle of $\psi = \pi/2$ where pitch leads the plunge motion. The separated vorticity patterns from the trailing edge of the airfoil were recorded using Digital Particle Image Velocimetry (DPIV) technique for a Reynolds number range of $2500 \leq \mathrm{Re} \leq 13750$. The investigated cases are classified into five flow structure categories based on instantaneous and averaged vorticity patterns and velocity fields around and in the near-wake of the airfoil while the frequency of plunging motion, f_1, was kept the same as the frequency of pitching motion, f_2. Example cases for each category were then investigated for unequal pitching and plunging frequencies. Figure 1 shows the averaged vorticity and velocity patterns of four distinct instants of an oscillation cycle over 50 periods of motion for Category A1 for equal and unequal flapping frequencies.



(a) f_1=0.2 f_2=0.2 (b) f_1=0.2 f_2=0.4 (c) f_1=0.4 f_2=0.2

Fig. 1 Average velocity and vorticity profiles for equal and unequal plunging (f_1) and pitching (f_2) frequencies, for Category A1.

References

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