Flow around an oscillating airfoil with and without a wavy-leading edge

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The flow around an oscillating airfoil with a wavy-leading edge was studied using an extended PIV technique in a low speed wind tunnel. The basic airfoil (without a wavy-leading edge) was NACA0015 with a chord length of c = 100mm (Fig1a). The wavy-leading edge airfoil was made based on the basic wing. The leading edge of the wavy wing was made into a wave form. The wave length was 0.33c and the amplitude of the wave was 0.075c (Fig.1b). The wings were driven to be a pitch oscillation by a crank-mechanism, which controlled by a digital motor. The pitch oscillations of the wings were harmonic form with frequencies of 3Hz and 6Hz, respectively. The corresponding reduced frequencies were $\kappa(= fc/U_\infty)$= 0.06 and 0.12. To snap the arbitrary correlated flow velocity between the pitch oscillation and the flow, an extended PIV was developed based on a dSPACE 1103 system and LaVision standard PIV system. The streamwise flow fields on the lifting surface of the wings were recorded using the extended PIV technique. More than 500 records for each pitch angle were averaged to obtain the raw velocity of the flow. The wings had an initial angle of attack of 10 degree, was defined as the balance position. The maximum pitch amplitude was 10 degree so that the pitch angle was ranged from -10 to 10 degree. The Reynolds number defined by the chord length was fixed at 30000.

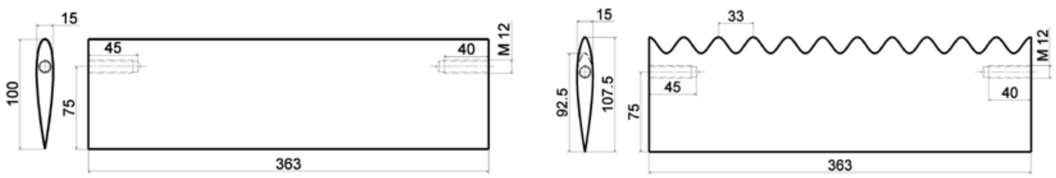

Figure 1 the wing shape: a) basic wing: NACA0015; b) wavy wing.

Figure 2&3 present the vorticty and streamline around the basic wing and the wavy wing, respectively. The profile shown in Fig3 was at a wave crest in the middle span of the wavy wing. As the wing moved up from the balance position, a vortex was formed near by the leading edge for the basic wing (see Fig2a, b and c). The vortex became more and more strong and moved from the leading edge to the wing tail. As the wing came back the balance position the vortex totally shed off from the wing tail. The vortex caused the pressure on the lifting surface varied with the pitch oscillation. It might lead the wing motion to be unsteady. For the wavy wing, however, such vortex would never occur during the whole cycle of the pitch oscillation. The wavy leading edge depressed the vortex formation.

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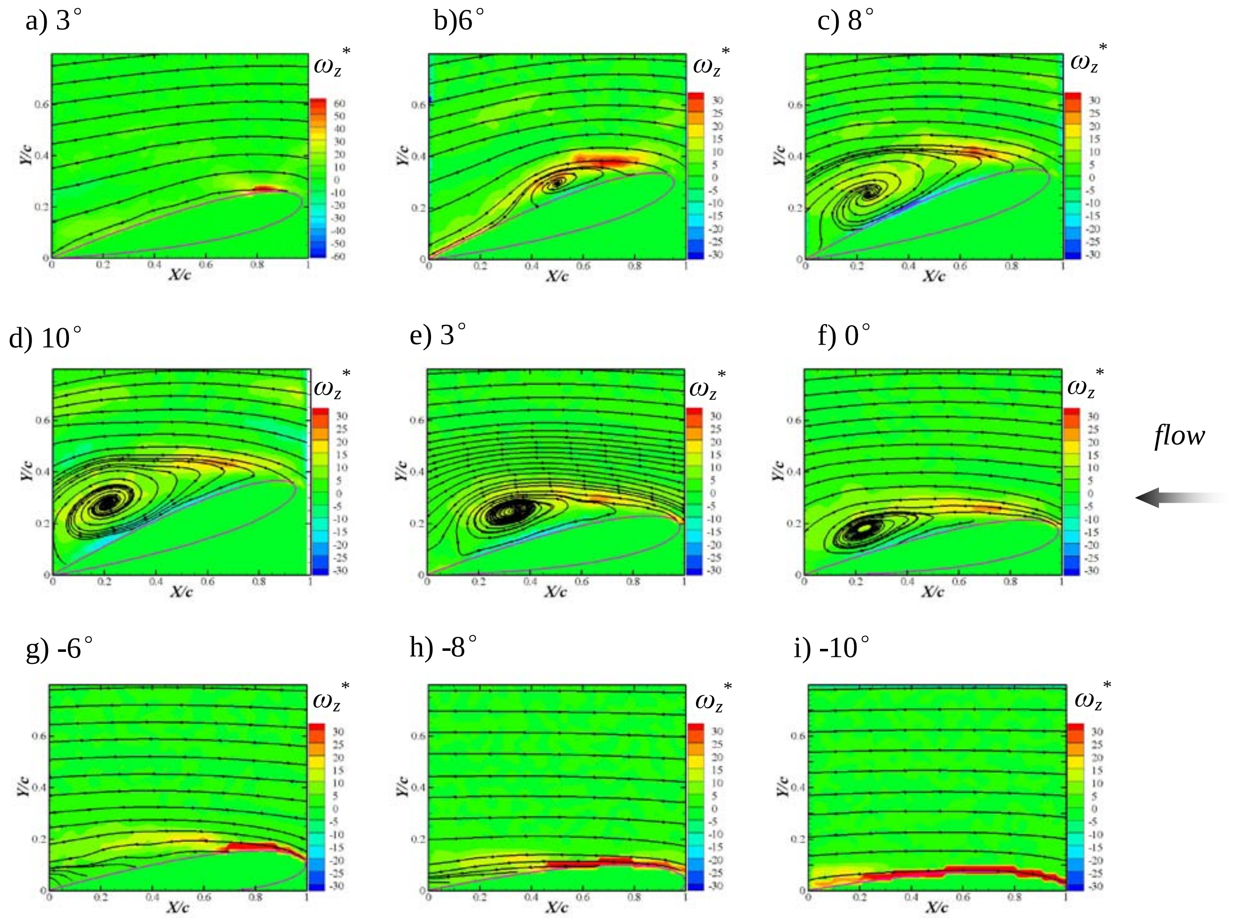

Figure 2 Vorticity and streamline of the flow around the basic wing in an oscillation cycle, κ = 0.06.

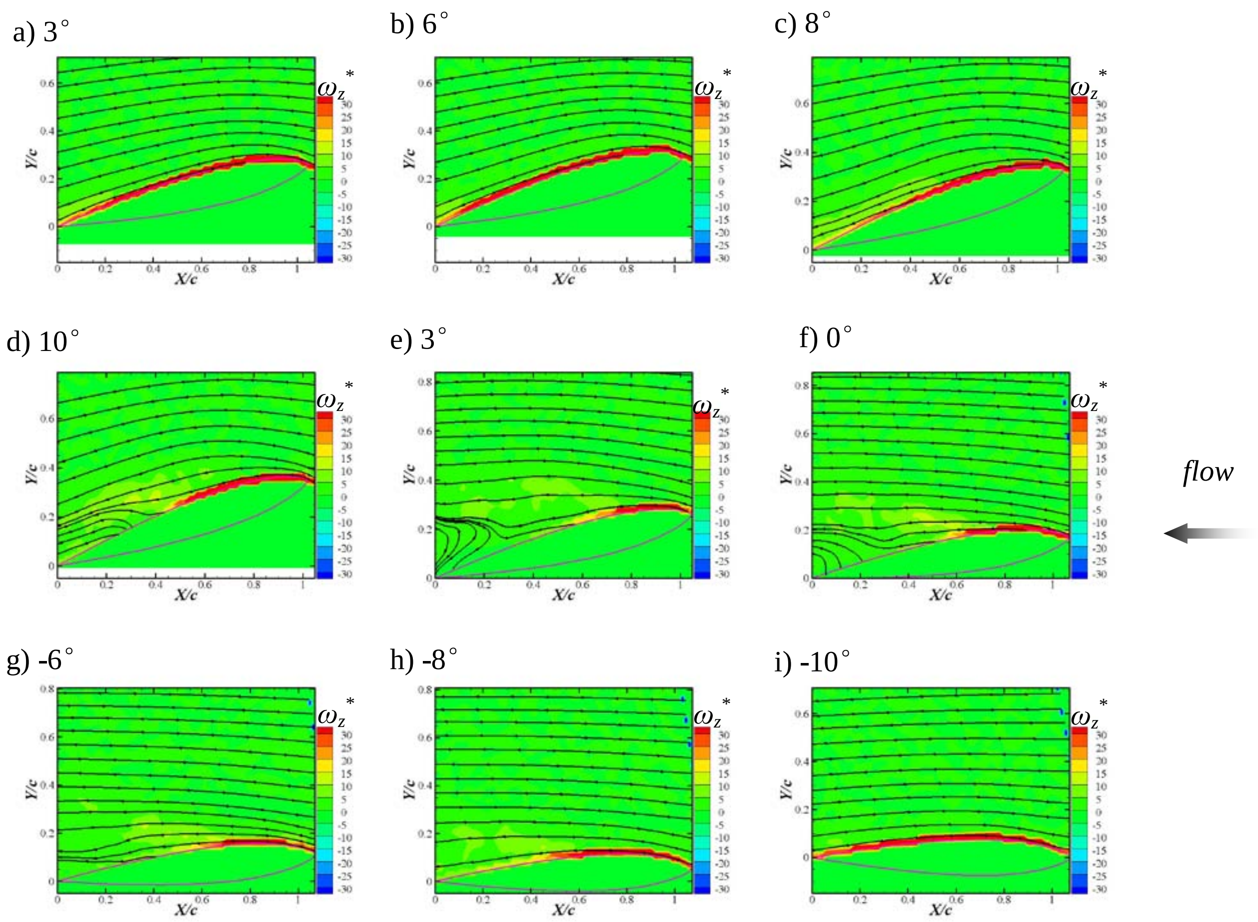

Figure 3 Vorticity and streamline of the flow around the wavy wing in an oscillation cycle, κ = 0.06.