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NUMERICAL EXPERIMENT OF FLOW AROUND AN IN LINE FORCED OSCILLATING SYMMETRICAL FOIL WITH ATTACK ANGLE IN A UNIFORM FLOW

H. FUKUTA[1,c], Y. YOKOI[2]

[1]Graduate student of Mechanical Engineering, National Defense Academy, Hashirimizu, Yokosuka, 2398686, Japan
[2]Department of Mechanical Engineering, National Defense Academy, Hashirimizu, Yokosuka, 2398686, Japan

[c]Corresponding author: Tel.: +81468413810; Fax: +81468445900; Email: em50019@nda.ac.jp

KEYWORDS:

Main subjects: flow visualization
Fluid: separation flow, flow around aerofoil
Visualization method(s): numerical simulation
Other keywords: in-line forced oscillation, fluid force, vortex method

ABSTRACT: In this study, a numerical simulation is performed as what obtains relative velocity fluctuation by oscillating an object with comparatively large amplitude in the direction of flow. Follow pattern and instantaneous fluid force around an In-line forced oscillating symmetrical aerofoil (NACA0012) with attack angles of 0, 5 and 15 degrees which has each different characteristic in the stationary state are investigated using a vortex method at the Reynolds number Re=4.05×10^5 based on the main flow velocity U=20m/s, in ranges of the oscillation amplitude ratio 2a/c=0.5,1.0,1.5 and 2.0 and the oscillation frequency ratio f/f_K=0.25,0.5,1.0 and 2.0 (here, a :half-amplitude of oscillation, c :chord-length, f :oscillation frequency, f_K :natural Karman vortex shedding frequency from a stationary aerofoil with the attack angle of 90 degrees). The results of calculation about attack angles of 0 and 5 degrees which doesn't produce the flow separation at the stationary state is as follows. In the case of attack angle of 0 degree, although the aspect of flow around aerofoil seems to be a stationary situation with the exception of the case that a pair of vortices occurs on the surface of the pressure side and suction side at the f/f_K=2.0 and 2a/c=2.0, the lift coefficient is changed by oscillation as shown in Fig. 1. In the case of attack angle of 5 degrees, as shown in Fig. 2, the flow separation on the surface of aerofoil is produced even if the movement speed of aerofoil is in the range which does not exceed main flow velocity U. The relation of generating of separation and a variation of the relative flow velocity is investigated. Here, the maximum of the relative flow velocity is u_{max}=2πaf, and defined the velocity ratio as u_{max}/U. The flow separation is observed at the value of velocity ratio u_{max}/U more than or equal to 0.5. The other side, the aspect of flow around aerofoil with attack angle of 15 degrees which produces flow separation at the stationary state doesn't become calm but become more complicated by influence of oscillation. In addition, the case of attack angle of 3 degrees is investigated in order to clarify the relationship between the generation of flow separation and the velocity ratio u_{max}/U in a variation of attack angle. The result which observed the flow separation at the u_{max}/U=0.9 is added to other attack angle's results and shown as Fig. 3.

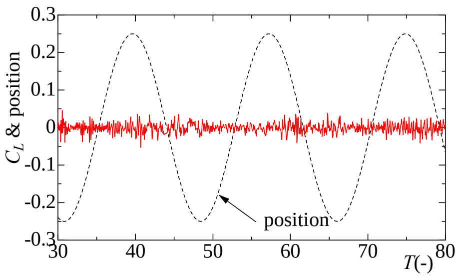

Fig. 1 Time histories of lift coefficient in f/f_K=0.5, 2a/c=0.5 and foil position in attack angle of 0 degree

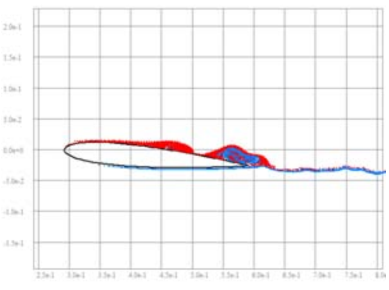

Fig. 2 Flow aspects around the bottom dead center of an oscillating foil in the case of u_{max}/U=0.713 in attack angle of 5 degrees

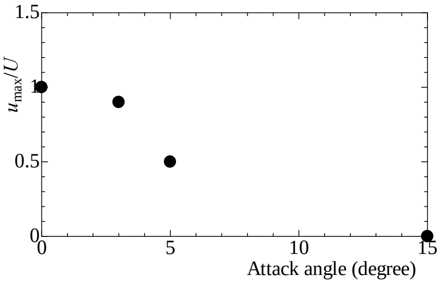

Fig. 3 Variation of u_{max}/U of generating separation with attack angle