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NUMERICAL INVESTIGATION ON UNSTEADY AERODYNAMICS OF 2D AIRFOIL UNDER UNSTEADY CONDITION

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Vehicles like airplane, automobile and fluid machineries are operated under various conditions and they do not usually move at a constant speed. On the other hands, most of the wind tunnel tests or numerical simulations via Computational Fluid Dynamics (CFD) have been carried out for steady states, even though it is well known that the aerodynamic characteristics under unsteady speed condition is different from the one under constant speed condition. In order to realize higher performance, the unsteady characteristics should be considered at the design stage.

Vortex methods are grid-free numerical schemes. In the methods, vorticity distributions in the flow fields are represented by using discrete vortex elements and the motion and evolution of vorticity of each element are calculated at each time step. When compared to other computational schemes, vortex methods have advantages that unsteady distortion of vortical structures in turbulent flows is directly calculated without the numerical diffusion and the method can easily be applied to moving geometries. So the methods are appropriate methods for prediction of unsteady aerodynamical characteristics of moving bodies.

On unsteady aerodynamical characteristics, some pioneering works have already been carried out, Maresca et al. [1] experimentally investigated oscillating airfoils, but unsteady force could not be obtained. Fukuta and Yokoi [2] numerically and experimentally examined flow around in-line oscillating airfoil. The results showed that flow separation was developed from the unsteady effect.

In this study, as the first stage, unsteady aerodynamical effect of accelerated or decelerated two-dimensional airfoil (NACA0012) was numerically examined using a grid-free vortex method. The flow characteristics and aerodynamical forces were compared among various accelerated or decelerated conditions. The results showed that flow separation occurred under decelerated condition and the lift-drag ratio decreased as the decelerated velocity became high and increased as the accelerated velocity became high.

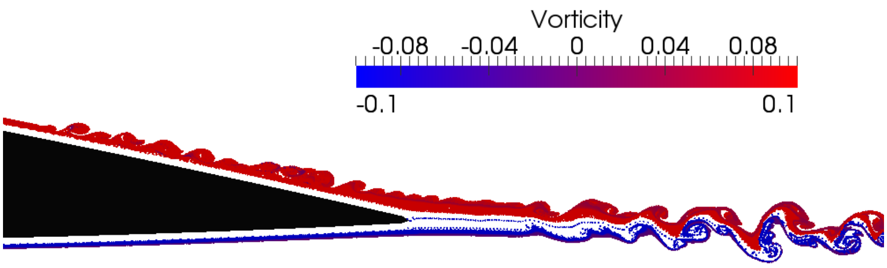

Fig1 . Flow pattern (decelerated case)

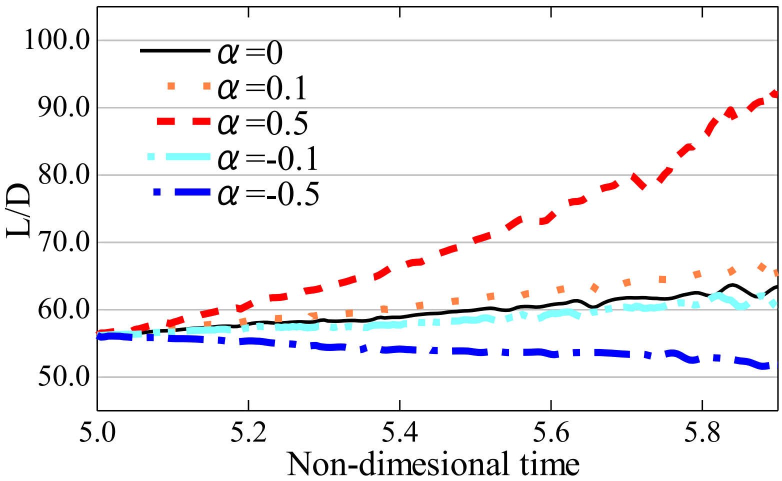

Fig2 . Time history of lift-drag ratio

As the next stage, 3D calculation of an airfoil at unsteady state will be carried out. Furthermore, the characteristics and aerodynamical forces of various motions including pitching motions will be investigated and results will be compared with the experimental data.

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