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Direct-forcing immersed boundary modeling for dynamic stall in turbulent flow

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Abstract

Dynamic stall is a common physical phenomenon in a helicopter or a rotating fluid machinery. It can be considered as a uniform flow past a pitching airfoil. Dynamic stall occurs when its pitching angle exceeds a critical value. This study aims to establish a numerical model to simulate dynamic stall and the way to control dynamics stall. It is a typical fluid-structure interaction problem, so the direct-forcing immersed boundary method [1] is proposed to simulate the pitching airfoil in fluid flow. Turbulence is simulated by the Large Eddy Simulation (LES). Smagorinsky-Lilly sub-grid model is used to predict small eddy motion. The proposed numerical model was implemented by a hybrid parallel computing program and executed in Taiwania, the supercomputer at National Center for High-Performance Computing.

The proposed numerical model is validated by the comparison of drag and lift with Ohtake et al.'s experiment [2] for flow past a stationary airfoil at $\mathrm{Re} = 10^5$. Evolution of leading edge vortex (LEV) with respect to the pitching angle is visulaized. The variation of lift with respect to the angle of attack (AOA) in dynamic stall is captured by the numerical model.

References

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[2] T. Ohtake, Y. Nakae and T. Motohashi. 2007 Nonlinearity of the aerodynamic characteristics of NACA0012 aerofoil at low Reynolds numbers. *Journal of the Japan Society for Aeronautical and Space Sciences*, **55**, 439-445.