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Large Eddy Simulation of Oscillating NACA0012 Airfoil

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ABSTRACT

This work analyzes the flow over an oscillating NACA 0012 airfoil. The motivation for this study is related to modeling the flow over a blade of a vertical axis wind turbine. For such blades, the angle of attack oscillates as the blades rotate and is a function of the azimuthal angle. This behavior can be simplified by oscillating the airfoil at the same frequency around zero angle of attack. Accurately modeling this flow is crucial for the next step of the project, which involves controlling the boundary layer flow by installing micro blowers near the leading edge of the airfoil. These micro blowers may be able to increase the efficiency of the wind turbine.

Initial work performed using the Reynolds-Averaged Navier-Stokes (RANS) method showed that the hysteresis of the lift coefficient was not well captured compared to experimental data. By using a Large Eddy Simulation (LES) approach, the simulation of the flow was more accurate, and some critical features, such as the sudden drop in the lift coefficient at the maximum angle of attack, were obtained.

The results presented are associated with a flow over a NACA 0012 airfoil at a Reynolds number of 1 million. The free stream velocity is 24.914 m/s, and the reduced frequency is 0.15. The angle of attack ranges from 5 to 25 degrees. Two LES meshes are used: the first mesh has 2.3 million elements with 6 cells in the spanwise direction, and the second mesh has 3.8 million elements. For the first mesh, two different timesteps are used: 5760 timesteps per cycle and 11520 timesteps per cycle, with a maximum of 30 iterations per timestep. For the finer mesh, 11520 timesteps per cycle are used. The Y+ for the finer mesh, at different angles of attack, ranges from 1 to 5. The size of the mesh of the first element on the surface and in the boundary layer is also discussed.

The lift coefficient and drag coefficient for cycles from 4 to 10 are compared between the three simulations (two LES and one RANS) and also compared with experimental data. Results clearly show that the LES approach available in STAR-CCM+ is appropriate for accurately capturing this type of flow. Future work will analyze the benefit of micro blowers using the LES method described above.