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Numerical Investigation of Dynamic Stall over a Wind Turbine Pitching Airfoil by Using OpenFOAM

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Abstract : Computations for two-dimensional flow past a stationary and harmonically pitching wind turbine airfoil at a moderate value of Reynolds number (400000) are carried out by progressively increasing the angle of attack for stationary airfoil and at fixed pitching frequencies for rotary one. The incompressible Navier-Stokes equations in conjunction with Unsteady Reynolds Average Navier-Stokes (URANS) equations for turbulence modeling are solved by OpenFOAM package to investigate the aerodynamic phenomena occurred at stationary and pitching conditions on a NACA 6-series wind turbine airfoil. The aim of this study is to enhance the accuracy of numerical simulation in predicting the aerodynamic behavior of an oscillating airfoil in OpenFOAM. Hence, for turbulence modelling, k-ω-SST with low-Reynolds correction is employed to capture the unsteady phenomena occurred in stationary and oscillating motion of the airfoil. Using aerodynamic and pressure coefficients along with flow patterns, the unsteady aerodynamics at pre-, near-, and post-static stall regions are analyzed in harmonically pitching airfoil, and the results are validated with the corresponding experimental data possessed by the authors. The results indicate that implementing the mentioned turbulence model leads to accurate prediction of the angle of static stall for stationary airfoil and flow separation, dynamic stall phenomenon, and reattachment of the flow on the surface of airfoil for pitching one. Due to the geometry of the studied 6-series airfoil, the vortex on the upper surface of the airfoil during upstrokes is formed at the trailing edge. Therefore, the pattern flow obtained by our numerical simulations represents the formation and change of the trailing-edge vortex at near- and post-stall regions where this process determines the dynamic stall phenomenon.

Keywords : CFD, moderate Reynolds number, OpenFOAM, pitching oscillation, unsteady aerodynamics, wind turbine
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