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Numerical Study of Laminar Separation Bubble Over an Airfoil Using γ-ReθT SST Turbulence Model on Moderate Reynolds Number

Authors : Younes El Khchine

Abstract : A parametric study has been conducted to analyse the flow around S809 airfoil of a wind turbine in order to better understand the characteristics and effects of laminar separation bubble (LSB) on aerodynamic design for maximizing wind turbine efficiency. Numerical simulations were performed at low Reynolds numbers by solving the Unsteady Reynolds Averaged Navier-Stokes (URANS) equations based on C-type structural mesh and using the γ-Reθt turbulence model. A two-dimensional study was conducted for the chord Reynolds number of 1×105 and angles of attack (AoA) between 0 and 20.15 degrees. The simulation results obtained for the aerodynamic coefficients at various angles of attack (AoA) were compared with XFoil results. A sensitivity study was performed to examine the effects of Reynolds number and free-stream turbulence intensity on the location and length of the laminar separation bubble and the aerodynamic performances of wind turbines. The results show that increasing the Reynolds number leads to a delay in the laminar separation on the upper surface of the airfoil. The increase in Reynolds number leads to an accelerated transition process, and the turbulent reattachment point moves closer to the leading edge owing to an earlier reattachment of the turbulent shear layer. This leads to a considerable reduction in the length of the separation bubble as the Reynolds number is increased. The increase in the level of free-stream turbulence intensity leads to a decrease in separation bubble length and an increase in the lift coefficient while having negligible effects on the stall angle. When the AoA increased, the bubble on the suction airfoil surface was found to move upstream to the leading edge of the airfoil, causing earlier laminar separation.

Keywords : laminar separation bubble, turbulence intensity, s809 airfoil, transition model, Reynolds number
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