Impact of Solidity on the Aerodynamic Performance of Vertical Axis Wind Turbine via 2D CFD Simulation

ABSTRACT

Research on vertical axis wind turbines (VAWTs) is receiving more attention due to their special characteristic of capturing omnidirectional wind flow. Unlike the horizontal axis wind turbine, the flow characteristic of VAWT is complex, especially in the downwind region. Solidity is one of the design parameters that will affect the wind turbine performance significantly where an optimum solidity provides a wide range of tip speed ratios while achieving a high coefficient of power. This paper presents the effects of the solidity of an H-Darrieus VAWT in terms of varying the number of blades and the chord length by using two-dimensional computational fluid dynamics simulations. The sliding mesh method and the k-ω SST turbulence model were selected to model the rotational motion of the NACA0021 airfoil VAWT. The reliability of the simulation was first validated with the data available in the literature where a good agreement is presented. In this study, the coefficient of torque, CT and coefficient of power, CP for various tip speed ratios (TSRs) were analysed at different VAWT solidity. The results show that when the VAWT solidity increases, the maximum CP increases up to an optimum point and shifts to a lower TSR, which links the aerodynamics performance and the vortices shedding on the blades. Also, it was noted that the self-starting ability of the rotor is highly affected by the solidity and is dependent on the initial starting orientation. The simulation results can serve as a reference in determining the solidity when designing a VAWT with a target TSR range.