Numerical analysis of the aerodynamic and geometric relationship of a vertical axis wind turbine

ABSTRACT

The demand for wind energy has a high potential as an alternative energy source. Vertical axis wind turbine (VAWT) has good developmental potential for unfavourable wind conditions, especially in urban areas, such as low wind speed. This paper aims to conduct a comprehensive numerical analysis of the two-dimensional H-Darrieus VAWT to understand the VAWT's performance with different solidities. The VAWTs were subjected to low and ultra-low Reynolds number conditions with various tip speed ratio (TSR) values. The numerical investigation was conducted using ANSYS Fluent software using high-fidelity Computational Fluid Dynamics (CFD) technology. Based on previous studies' experiences and data, different computational settings in CFD simulation were employed. The geometric parameters of the study were validated against published simulation and experimental data to ensure the accuracy of the simulation results obtained in this study. The CFD simulation results demonstrated that only a high solidity turbine (σ = 1.20) at a low TSR of 2.0 and a low solidity turbine (σ = 0.60) at a moderately high TSR of 2.5 could generate the optimal quantity of energy since instantaneous moment coefficient lies in the positive region while operating under low Re 75000. In contrast, some turbine configurations produced negative Cm at specific operational TSR ranges when the rotor was subjected to low Re (15000) and ultra-low Re (5000 and 9000). According to the results, the negative instantaneous moment and power coefficients meant that the wind turbine could not be optimally configured due to insufficient power converted from the wind's kinetic energy.