Design of Small Horizontal Axis Wind Turbine for Low Wind Speed Rural Applications

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Abstract

In this study, a 2 kW small scale horizontal axis wind turbine with a rotor radius of 1.8 m and a Tip Speed Ratio (λ) of 6 was designed to work at low wind speed for rural applications. Aerodynamic analysis was performed on 10 airfoils, *viz* Aquila, BW-3, E387, FX63-137, NACA0012, NASA LS-0413, RG-15, S1223, SD7080 and SG6043 using QBlade software. These airfoils were used to analyze lift coefficient (C_L) and lift to drag ratio (C_L/C_D), with different angles of attack (α) and compared with one another. From the analyzed results, SD7080 airfoil was found to be the best due to its wide and maximum lift to drag ratio of 46.30 for the angle of attack (α) of 5^o and comparatively high power production at low wind speed operation. It showed a high soft stall behaviour in the α range of 4-9^o. The blades were specifically designed for various airfoils by applying Blade Element Momentum Theory (BEMT). The power coefficient (Cp) of the selected airfoils varied according to the values of tip speed ratio (λ). From the results, it was detected that the SD7080 airfoil blade has an optimum power coefficient of Cp = 0.34, at λ = 6 for Reynolds number (Re) = 81712. SD7080 airfoil blade was analysed for different Re values of 30642, 40856, 51070, 61284, 71498 and 81712 in comparison with tip speed ratio and power coefficient. A considerably high power coefficient of 0.29 was produced when Re as low as 40856 at λ = 6. Therefore, from the numerical simulation, it was found that SD7080 was the most suitable airfoil to start producing considerably high power under low wind speed applications.

Keywords: Small horizontal axis wind turbine, BEMT, numerical simulation, QBlade software.