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Flow Simulations of Modified Diffuser Augmented Wind Turbine

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Abstract

Wind energy is second largest source of energy and it is the fastest growing renewable energy resource around the world. The main problem of using wind energy is the uncertainty of wind pattern. Low wind speeds result in less energy per unit volume of air passing through a turbine. This leads to higher electricity production cost from wind energy than from fossil fuels. In order for wind technology to compete with conventional sources of energy in terms of energy production costs, researchers are working on different ways to increase the energy density in wind. One of the most promising concepts in this field is the development of wind power augmentation systems. By the use of diffuser in the wind turbine, wind power augmentation system is also called as Diffuser Augmented Wind Turbine (DAWT). In DAWT the diffuser or flanged diffuser generates separation regions behind it, where low pressure regions appear to draw more wind through the rotors compared to a 'bare wind turbine'. The DAWTs are able to provide an opportunity to extract power from unstable low wind speeds. The main objective of this research is to propose new diffuser design for DAWT by introducing air vents and vortex generators. This study also investigates the effect of wind velocity and air pressure on proposed modified diffuser to develop the suitable diffuser for DAWT. The purpose of this modified diffuser is to create a low pressure region in the center of the diffuser to increase the inlet mass flow rate. Three modified designs were developed and simulated using Solidworks 3D computer aided design and computational fluid dynamics by ANSYS Fluent. Results showed up to 8.5594 m/s final wind velocity (2.14 times increment) over 4 m/s inlet velocity in modified Design 3 (Air vents with splitter). This modified diffuser Design 3 is based on the parameters: rotor diameter (D) = 500 mm, diffuser length (L) = 1000 mm, diffuser open angle (θ) = 12^o, flange size of 221.73 mm and inner splitter with 14^o open angle (α). This research proved that the flanged diffuser with inner splitter is effective to improve the performance of DAWT. Moreover, the new modified designs (air vents and vortex generator) are suitable to improve the diffuser performance significantly.

Keywords*:* DAWT, Diffuser with splitter, Air vents, Wind Velocity, CFD