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A Numerical Studies for Improving the Performance of Vertical Axis Wind Turbine by a Wind Power Tower

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Abstract : Recently, vertical axis wind turbines (VAWT) have been widely used to produce electricity even in urban. They have several merits such as low sound noise, easy installation of the generator and simple structure without yaw-control mechanism and so on. However, their blades are operated under the influence of the trailing vortices generated by the preceding blades. This phenomenon deteriorates its output power and makes difficulty predicting correctly its performance. In order to improve the performance of VAWT, wind power towers can be applied. Usually, the wind power tower can be constructed as a multi-story building to increase the frontal area of the wind stream. Hence, multiple sets of the VAWT can be installed within the wind power tower, and they can be operated at high elevation. Many different types of wind power tower can be used in the field. In this study, a wind power tower with circular column shape was applied, and the VAWT was installed at the center of the wind power tower. Seven guide walls were used as a strut between the floors of the wind power tower. These guide walls were utilized not only to increase the wind velocity within the wind power tower but also to adjust the wind direction for making a better working condition on the VAWT. Hence, some important design variables, such as the distance between the wind turbine and the guide wall, the outer diameter of the wind power tower, the direction of the guide wall against the wind direction, should be considered to enhance the output power on the VAWT. A numerical analysis was conducted to find the optimum dimension on design variables by using the computational fluid dynamics (CFD) among many prediction methods. The CFD could be an accurate prediction method compared with the stream-tube methods. In order to obtain the accurate results in the CFD, it needs the transient analysis and the full three-dimensional (3-D) computation. However, this full 3-D CFD could be hard to be a practical tool because it requires huge computation time. Therefore, the reduced computational domain is applied as a practical method. In this study, the computations were conducted in the reduced computational domain and they were compared with the experimental results in the literature. It was examined the mechanism of the difference between the experimental results and the computational results. The computed results showed this computational method could be an effective method in the design methodology using the optimization algorithm. After validation of the numerical method, the CFD on the wind power tower was conducted with the important design variables affecting the performance of VAWT. The results showed that the output power of the VAWT obtained using the wind power tower was increased compared to them obtained without the wind power tower. In addition, they showed that the increased output power on the wind turbine depended greatly on the dimension of the guide wall.

Keywords : CFD, performance, VAWT, wind power tower
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