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Computational Fluid Dynamics (CFD) Calculations of the Wind Turbine with an Adjustable Working Surface

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Abstract : This paper discusses the CFD simulation of a flow around a rotor of a Vertical Axis Wind Turbine. Numerical simulation, unlike experiments, enables us to validate project assumptions when it is designed and avoid a costly preparation of a model or a prototype for a bench test. CFD simulation enables us to compare characteristics of aerodynamic forces acting on rotor working surfaces and define operational parameters like torque or power generated by a turbine assembly. This research focused on the rotor with the blades capable of modifying their working surfaces, i.e. absorbing wind kinetic energy. The operation of this rotor is based on adjusting angular aperture α of the top and bottom parts of the blades mounted on an axis. If this angular aperture α increases, the working surface which absorbs wind kinetic energy also increases. The operation of turbines is characterized by parameters like the angular aperture of blades, power, torque, speed for a given wind speed. These parameters have an impact on the efficiency of assemblies. The distribution of forces acting on the working surfaces in our turbine changes according to the angular velocity of the rotor. Moreover, the resultant force from the force acting on an advancing blade and retreating blade should be as high as possible. This paper is part of the research to improve an efficiency of a rotor assembly. Therefore, using simulation, the courses of the above parameters were studied in three full rotations individually for each of the blades for three angular apertures of blade working surfaces, i.e. 30 °, 60 °, 90 °, at three wind speeds, i.e. 4 m / s, 6 m / s, 8 m / s and rotor speeds ranging from 100 to 500 rpm. Finally, there were created the characteristics of torque coefficients and power as a function of time for each blade separately and for the entire rotor. Accordingly, the correlation between the turbine rotor power as a function of wind speed for varied values of rotor rotational speed. By processing this data, the correlation between the power of the turbine rotor and its rotational speed for each of the angular aperture of the working surfaces was specified. Finally, the optimal values, i.e. of the highest output power for given wind speeds were read. The research results in receiving the basic characteristics of turbine rotor power as a function of wind speed for the three angular apertures of the blades. Given the nature of rotor operation, the growth in the output turbine can be estimated if angular aperture of the blades increases. The controlled adjustment of angle α enables a smooth adjustment of power generated by a turbine rotor. If wind speed is significant, this type of adjustment enables this output power to remain at the same level (by reducing angle α) with no risk of damaging a construction. This work has been financed by the Polish Ministry of Science and Higher Education.

Keywords : computational fluid dynamics, numerical analysis, renewable energy, wind turbine
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