Numerical Investigation of Aerodynamic Characteristics of a New Wind Turbine During Its Design Stage

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ABSTRACT
Present work conducts computer simulations with the Computational Fluid Dynamic (CFD) software package Fluent as a modeling tool to explore aerodynamic characteristics of a new Wind Turbine named M1. In this research, the governing equations consisting of two-dimensional, steady and three-dimensional, time-dependent conservation of mass and momentum are solved. Both laminar and turbulent flow fields are solved. For the turbulent flow computation, the k-ε two-equation turbulent model is adopted. The three-dimensional, tapered and twisted M1 wind turbine blade used in this study employs a hybrid HH-10/HH-12 non-symmetrical airfoil in the design. The important aerodynamic properties, including pressure, torque, and aerodynamic power, are determined under broad ranges of wind speed and pitch angle. The results of the predictions can provide the designers with references for stress analyses as well as the input loading conditions for further areoelastic analysis.

Keywords : Computational Fluid Dynamic, aerodynamic, wind turbine, torque, aerodynamic power, pitch angle

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REFERENCES

【1】 Lab Report, "Optimizing Windmill Blade Efficiency".
【2】 牛山泉，三野正洋，「小型風車設計及製造」，能源科技。
【6】 Tao Xing and Fred Stern, "Simulation of Turbulent Flow around an Airfoil," The University of Iowa C. Maxwell Stanley Hydraulics Laboratory Iowa City, IA 52242-1585.
【8】 D. Afungchui, B. Kammoun, A. Chauvin, "Development of a Wind Turbine Blade Profile Analysis Code Based on the Singularities Method".
【9】 Andre Luiz Amarante Mesquita, Joao Paulo da Paz Sena, "Experimental Analysis or Airfoil for High Angle of Attack".
【10】 C. Lindenburg, "Aerodynamic Airfoil Coefficients at Large Angles of Attrak".
【11】 Izumi USHIYAMA, Toshihiko SHIMOTA, "An Experimental Study of the Two-Stage Wind Turbines," Mechanical Engineering Department, Ashikaga Institute of Technology 268-1 Omae-cho, Ashikaga-city, Tochigi-pref. JAPAN.
【13】 Earl P. N. Duque, Wayne Johnson, C. P. vanDam, Regina Cortes, Karen Yee, "Numerical Predictions of Wind Turbine Power and Aerodynamic Loads for the Nrel Phase II Combined Experiment Rotor".
【14】 L. J. Vermeer, "A Review of Wind Turbine Wake Research at Tudelft".
SIMPLER, and SIMPLEC Algorithms for the Treatment of the Pressure-Velocity Coupling in Steady Flow Problems," Numerical Heat Transfer,
Sons Ltd, 2002. 【27】 夏樹仁,「飛行工程概論」,全華科技圖書。