AVIS DE SOUTENANCE

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Présentée par

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Spécialité : Energies renouvelables

Sujet de la thèse : Study of integrated design and manufacture of a small wind turbine in the Moroccan context with certification type IEC 61400.

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Titre de la thèse : Study of integrated design and manufacture of a small wind turbine in the Moroccan context with certification type IEC 61400.

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Résumé de la thèse

The design process of a small wind turbine (rated power less than 50 kW or rotor swept area less than 200 m²) consists in defining optimum rotor blade geometry and a reliable mechanical power transmission system that will be able to extract maximum energy from the wind. The objective of the present work is to conduct an integrated design and analysis of a small wind turbine system under normal and extreme wind conditions. These design conditions are defined by the IEC standard for small wind turbines; IEC 61400-2 which was adopted as a reference during the selection process and the analysis of the turbine components. The IEC 61400-2 standard recommends using Simple Load Model (SLM) as a starting point for the design of a small wind turbine system. This model combines straightforward, and possibly simplistic, equations for the main loads with high safety factors. As its name implies, it is the simplest design methodology. However, the high safety factors associated with this model increases conservatism and leads to overdesigned structures. Due to the fact that the rotor blades of small wind turbines experience high numbers of fatigue cycles compared to large wind turbines, fatigue analysis was also included as a part of the design process in this study. The results of stress and fatigue analysis based on SLM showed that the main shaft of the wind turbine passes successfely all the load scenarios. However, the rotor blades failed fatigue analysis. This failure is due mainly to three reasons. The first reason is related to the rough approximation used by SLM and which consists in using one single bin to compute the number of fatigue cycles. This approach leads to an overestimation of the number of the fatigue cycles with a difference of 3.1E+9 cycles compared to the results obtained from other advanced tools such as FAST-Mlife codes and nCode Designlife composites. The second reason concerns the forces and moments on the blade during normal operation (load case A).
The associated stress level, that is used to calculate the fatigue damage factor, was determined based on the assumption that the wind speed during normal operation has a constant value of 10.5 m/s. The use of such a relatively high wind speed leads to an overestimate of the centrifugal loads and the bending moments on the blade during normal conditions. The third reason concerns the high safety factors that are imposed by IEC 61400-2 when full material characterization cannot be achieved, especially during early stages of the design process. This usually leads to heavy structure and affects the cost of the final blade design. Throughout this research project, we succeeded to build a prototype of an 11 kW small wind turbine by following the guidance of the IEC 61400-2 standard. Also, we concluded by suggesting revisions of both the design parameters and the partial safety factors that are used during the design process of the wind turbine components using SLM.

Keywords: Wind turbine; rotor blades; aerodynamic performance; stress analysis; SLM; fatigue analysis