Structural health monitoring based-maintenance optimization of wind turbine towers.

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Renewable energy development in the world is crucial, in order to tackle climate change and increasing energy demand. In fact, the reduction of emission of the greenhouse gases requires an increase in renewable energies. The European Union aims to reach the production of electricity from renewable energies to 27% in 2030. Wind energy is considered as the most promising and economically viable source of renewable energy. The Global Wind Energy Council (GWEC) predicts that the global annual growth rate of wind power will exceed 12% between 2013 and 2018. The European Wind Energy Association (EWEA) predicts with a central scenario that the installed capacity in Europe of wind power in 2020 can reach 192 GW, where it will be increased by 64% compared to 2013. In fact, the cumulative installed capacity of wind power in the European Union (EU) has increased from 47.8 gigawatts (GW) in the year 2006 to 153.7 GW at the end of 2016, representing annual growth of over 12% [1].

Wind power has increased significantly over the past years in several countries (China, US, Germany, etc.), supported by high private and public investments. Wind energy cost depends on the costs of their several components (turbine, steel tower and foundation, transport and installation, electrical infrastructure, maintenance operations, etc.). However, wind turbine failures breed enormous financial losses. Therefore, several maintenance actions (inspections, preventive maintenance, corrective maintenance) are usually applied to improve the reliability of their components and to avoid total failure of the wind turbine. One of the most significant costs of wind turbine farms is due to the maintenance actions, especially the cost due to corrective maintenance of the wind turbine components. Recent study has estimated the operation and maintenance costs of a wind project with twenty years lifetime can reach 10% to 15% of the overall energy generation cost or equivalently 75–90% of the initial investment [1], this share of maintenance costs can reach 25% to 30% at the end of the turbine lifetime.

Several maintenance strategies are developed in order to minimize overall maintenance costs. The condition-based maintenance is one promising strategy, especially when is combined with the Structural Health Monitoring (SHM) system. SHM is an emerging and innovative approach used for the monitoring and maintenance of structures throughout the lifetime [2]. It ensures structural integrity using non-destructive measurement techniques. The methods of SHM have come a long way in recent years due to the availability and accessibility of sensors, the development of new NDT techniques for damage detection (Non-Destructive Testing). Structural health monitoring-based maintenance optimization aims to include monitoring information, based on data acquisition and signals processing, into the maintenance planning, as the data adds information concerning the reliability.

This PhD academic research work aims to develop a general framework to minimize the operations maintenance costs by using the structural health monitoring system. In other hands, the SHM is used as an inspection method to predict the reliability of wind turbine components. In this work, we focus our study to the wind turbine tower, where the fatigue damage and crack propagation is one of the most critical failures of the tower. Vibration analysis and acoustic emissions are used to detect abnormal structural behaviour due to the occurrence of the damage. However, the structural performance predicted by the SHM is uncertain. A very common framework for modelling uncertain parameters is within probabilistic approaches leading to a probabilistic characterization of the structural response, However, other alternatives include non-probabilistic approaches, or interval methods can be investigated.

This Ph. D. work is the sequel of several preceding and ongoing theses realized in the same laboratory, where numerical models of the structural response of a wind turbine tower, blades and jacket are developed and used in the reliability-based optimization approaches.

References:

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