Vibration-based structural health monitoring of a wind turbine system. Part I: Resonance phenomenon

This paper is focused on a resonance phenomenon of a wind turbine system in 5 MW class, on the basis of dynamic signals acquired continuously from the tubular tower under normal operational conditions during two years. Firstly, technique specifications of the wind turbine system are introduced and a finite element model is developed to characterize the structural dynamic properties. The following part describes the continuous dynamic monitoring system integrated with an automated operational modal analysis procedure using the poly-reference Least Squares Complex Frequency domain (p-LSCF) method. Subsequently, variations and mutual relationships of environmental/operational factors such as vibration amplitude, temperature, wind speed, rotation speed of blades, pitch angle and nacelle direction are also presented. Finally, significant resonance is observed due to the fundamental frequency of the tower matching with the harmonic frequency induced by the rotation of three blades. As the rotation speed of rotor approaches to 8 rpm, the vibration amplitude of the tower increases significantly and the corresponding damping value decreases. With the further rising wind velocity, the rotation speed of blades stops increasing and the input energy just contribute to accumulate the vibration amplitude of tower. Such observation indicates the Sommerfeld effect that aggravates the resonance phenomenon. A vibration control device is necessary to minimize the excessive structural responses. A companion paper will further discuss the environmental/operational effects on dynamic properties of the wind turbine system under the operational conditions. (C) 2014 Elsevier Ltd. All rights reserved.