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Fatigue assessment and damage detection of wind turbine structures by continuous health monitoring

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Abstract

In order to maximize power production, wind turbines (WTs) are continuously emerging as bigger and taller structures, built in more challenging environments. This development however decreases the reliability of wind turbine (WT) infrastructures. In addition, the dynamic nature of the loads typical for WT structures result in an excessive number of stress cycles during their operation lifetime. This might significantly differ from the fatigue loading design assumptions, which is a determinant factor for limiting the design lifetime of WTs to a minimum target period of 20 years.

Installed Structural Health Monitoring (SHM) system on an operating WT structure provides invaluable insight to the structural performance and can contribute to early damage detection, thus eventually leading to reduced maintenance costs and extension of operation life time. In this paper, a four- year continuously recorded SHM data of an Enercon E40 - 500 kW type WT is utilized for assessing its consumed fatigue life time at a welded connection. The monitoring system was implemented on the WT located in Dortmund, Germany, as part of a DFG-funded research project with cooperation to Ruhr-University Bochum.

Keywords: Structural Health Monitoring, Wind turbine, Rain flow counting, Fatigue analysis

1 Introduction

Wind turbines are playing an essential role in the ongoing transition process towards clean energy sources. In the past decade there has been a steady increase of the wind generated power. In the European Union (EU), by the amount of power generation capacity, wind has already overtaken solar, fuel oil, nuclear, hydro and, in 2016, coal energy sources. Currently, wind energy is the second largest (after natural gas) source of power generation in EU, with a capacity of more than 150 GW [1]. The urge for higher power production resulted in taller and larger WTs, located in more challenging surroundings. This in turn resulted in exposure of WT structures to extreme loading conditions, which may affect their reliability.

In this context, continuous monitoring systems installed on operating WTs provide valuable structural performance information. Various sensors are installed on the structure to monitor selected structural parameters. Structural health monitoring strategies aim at delivering indices which are sensitive only to damage or other structural related changes (such as deterioration or changes in boundary condition), [2, 3].

In this paper, a WT located in Dortmund, Germany which is continuously monitored for the time span of four years (2010 to 2013) is considered. The monitoring campaign was undertaken as part of a DFG-funded research project with cooperation to Ruhr-University Bochum.

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