

Reconstruction of a wind turbine's endured load spectrum using a short-time load measurement and operational data

Authors: Dr. Christoph Heilmann (1), Anke Grunwald (1), Michael Melsheimer (1), Prof. Dr. Robert Liebich (2), René Kamieth (2)

Company: (1) BerlinWind GmbH, Bundesallee 61, 12161 Berlin, Tel.: +49 30 688 33 37 -40, -60, Fax: -69, Email: heilmann@berlinwind.com

Institution: (2) Technische Universität Berlin, FG Konstruktion & Produktzuverlässigkeit, Sekr. H66, Straße des 17. Juni 135, 10623 Berlin, Tel.: +49 30 314-23603, -22924, Fax: -26131

Abstract

Wind turbines (WT) are normally designed for a service life (SL) of 20 years. In Germany, over 1000 WT reach the end of the planned service life every year. Operators want to continue operation because wind speeds and energy yield were significantly below siting assumptions. For safety reasons, an assessment of the remaining SL is needed. WT guidelines propose an in-depth inspection and/or a site-related individually renewed calculation as methods.

However, the endured loads of an individual WT can only be realistically estimated based on direct load measurements. Therefore, the method described here proposes an individual short-time load measurement (several weeks) to correlate measured loads with operational data. Then, an estimation of the remaining SL is performed by reconstruction of the endured loads based on load measurement, operational data and available additional lifetime information including e.g. individual excess loads from rotor imbalances. The lifetime data amount influences the estimation uncertainty.

For the proposed method, a measurement system has been developed by BerlinWind GmbH, including a video-based calibration method for strain gauges. The system has been extensively tested at a small WT in urban conditions. For the evaluation of the measured data and the calculation of the remaining SL, a

software is in development at the TU Berlin, aiming at processing large amounts of data.

Exemplary evaluation of load measurements at Multi-MW WT prove the necessity of including individual load measurements at the WT in the estimation of its remaining SL to obtain reliable statements on safety and economic efficiency.

Keywords: Lifetime, fatigue, service life, load measurement, vibration, load reconstruction, load spectrum, service life extension, lifetime consumption, continued operation, balancing, imbalance, rotor dynamics, operational safety.

1 Introduction

A wind turbine (WT) is normally designed, tested and certified for a design life of 20 years [1, 2]. The design loads are validated by extensive prototype load measurements according to [7] for certification. 20 years is also the typical service life (SL) for the structure (tower and foundation) approved by the German building authorities according to [3].

In Germany, every year more than 1000 WTs reach the 20 years of SL and operators want to continue operation because wind conditions and energy yield in the past years were in the range of 20% below the siting assumptions. But before continuing operation to improve project economics, operational safety of the WT has to be assured. Moreover, unplanned costly component damages would reduce the economic benefit of service life extension.