Estimation of 1 Hz Distribution based on 10.min SCADA Data

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Summary
In time of digitalization, wind turbines are capable of tracking their individual load history via the installed Supervisory Control and Data Acquisition (SCADA) system. Currently, SCADA-Data are stored in by a 10 min based average and its maximum and minimum and its standard deviation in order to save storage and band width while neglecting the dynamic of the wind turbine. This publication presents a method of utilizing a distribution function such that the dynamic of the wind turbine can be included in the Damage Equivalent Load to predict the remaining life time.

1. Introduction

Wind energy is a key driver to achieve the renewable energy goals of 2050, to produce 80% of energy production by renewable sources. Simultaneous, wind energy should be competitive to other energy sources. One aspect of the competitiveness is proper maintenance. This requires to predict the remaining useful life of the wind turbine. By the means of the SCADA system, the historical loading of a wind turbine can be extracted. However, the 10 min based sampling neglects any dynamic in the system and therefore introduce an uncertainty into the determination of the damage equivalent load (DEL) [1]. The paper will present a method to redistribute the SCADA data for 1 Hz sampling by using two normal distributions.

2. Approach

Fig 1 shows a time series of the input torque of the CWD generic turbine [2]. It becomes clear that if only the mean load is considered the load history is not presented correctly. Also the case while considering the min and max of the signal, as those values do not occur that often.

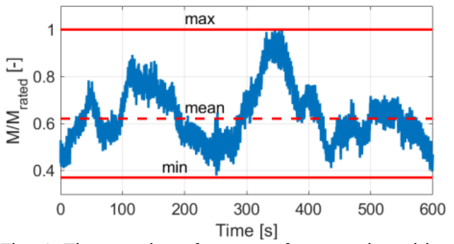

Fig. 1: Time series of torque of a generic turbine (blue line), min, max and mean of signal (red lines)

In order to estimate a distribution a single normal distribution can be used. A normal distribution is symmetrical around the mean signal. If the minimum and maximum are not equally spaced towards the mean signal, it could lead to an overshoot or underestimation of the extrema. In Fig. 2 the green distribution shows a normal distribution where a 3σ occurrence was used for the maximum value, leading to higher probability of the minimum value.

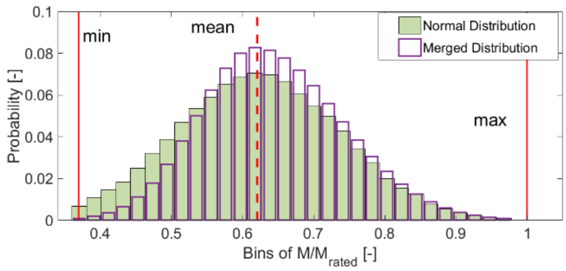

Fig. 2: Probability distributions based on the max, min and mean of the signal.

The author propose a distribution where two normal distributions are used. Each normal distribution uses a 3σ boundary for the maximum and minimum. Subsequently, the two distribution are merged at the mean value. Lastly, the distributions are scaled such that the sum of probabilities are equal to. In Fig. 2, it can be seen that the proposed method (purple line) has a better fitting at the extremes and the maximum probability.

3. Perspective

In the presentation a comparison with measured signals will be given to validate the shown approach

4. References

[1] H.B. Hendriks, Fatigue Equivalent Load Cycle Method, ECN-C–95-074
[2] A Werkmeister, R Schelenz, G Jacobs, Calculation of the design loads with SIMPACK, Simpack, User Meeting, Conference, 09-2015, Augsburg