

Structural Health Monitoring of Offshore Wind Turbines

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Observed settlements of the grout connections between the wind turbine and the monopile foundation have been experienced at over 60% of Europe's offshore wind farms including Vattenfall's offshore wind farm at Horns Reef. That gave rise to the idea of an improved condition monitoring of fatigue loads and to develop a Load Observer Tool in close cooperation with Vattenfall and the mayor objective of this project is **to develop a tool to estimate the remaining lifetime**.

PROBLEM STATEMENT AND METHOD

In this project, well-known methods from system identification, state estimation and fatigue analysis are applied in an innovative approach for application in condition monitoring.

A Wind Turbine Generator (WTG) Load Observer model, representing the wind turbine response, is formulated to determine the loads. In this reduced t-order aero-elastic model, standard available SCADA signals are used to estimate rotor averaged wind speed and the rotor thrust force online. In 10-min blocks estimated wind and thrust force signals are post-processed into a mean wind speed and an equivalent fatigue force applying a standard rainflow counting method. Corresponding, prior calculated, mean wind speed dependent distributions of equivalent fatigue thrust force and probability of occurrence are updated for each 10-min sequence and applied for updating a lifetime fatigue load estimate.

DISCUSSION

Only the low frequent response can be captured by the WTG Load Observer model based on the standard available SCADA signals. Therefore acceleration measurements are needed to capture the dynamic response of the wind turbine response caused by the rotor (1P effect), the blades passing the tower (3P effect for a 3-bladed wind turbine) and waves at offshore locations. The Kalman filter is needed and implemented to process this signal. Combining the information the right thrust force can be estimated.

POTENTIAL/OUTLOOK

Having knowledge about the remaining lifetime loads the condition of the grouting can be predicted by the Load Observer Tool. By continuously monitoring the experienced loads and an extrapolation of these loads, valuable information about critical components can be obtained and damages avoided. Further, scheduling of inspections and maintenance can be optimised, turbine life time prolonged and structural optimisation performed. Also, bad performance due to not considered aero-elastic phenomena or unsuitable controller settings can be pointed out. All these benefits represent a huge value for a wind operator as Vattenfall.