Mathematical Methods for Site Specific Remaining Life Prediction of Wind Turbines

Shadan Mozafari*[1]

[1]DTU Wind Energy – Denmark

Abstract

The cost of wind energy can be reduced by efficient inspections planning based on life assessment techniques and also using the right controlling plan for minimizing the damage occurrence in the components. Also damage occurrence in some of the failure modes does not cause significant changes in the system's behavior so failure prevention in early stages based on only condition monitoring is usually not possible. Besides these benefits of having an accurate model for life assessment, it would also allow for reduction of costs even in the design and manufacturing level.

The aim of the present project would be developing of a novel verifiable mathematical model for estimation of residual useful life of wind turbines, as a combination of stochastic and physical life estimation models to assess different limit states of a structure along with the probability of crossing pre-defined levels related to failure of the structure. Further uncertainties in the different inputs to life assessment procedure including loads, damage accumulation rules, simulation, etc. The main focus of the framework would be on fatigue as the main failure mechanism in wind turbine's components. Other limit states like serviceability and ultimate limit states would also be investigated in addition to fatigue and considering correlated effects. The framework would be verified through simulations of wind turbines by considering the wake effects in windfarms in order for the model to be applicable to wind turbines in the windfarms. The mathematical model would be general enough to be applicable to any component but its application on one or two components would be verified. For verification of the framework, wind turbine lifetime would be estimated based on multi-year simulations using HAWC2 software with site-specific environmental conditions within a wind farm in order to determine the residual useful lifetime (RUL) of the components and verify/rectify the framework developed in the first step. After verification, the model would be used along with suitable windfarm controlling schemes for different conditions in the windfarm with the objective of maintaining specific target lifetime for the wind turbine in each condition. The verified framework would be useful for making decisions on maintenance or life extension of WT's components in the windfarms.

All in all, the main predicted project outcomes are:

• A novel verified mathematical framework for assessing the remaining life of wind turbines' components considering multiple limit states.

• Utilization of available measured data from existing wind farms to predict the remaining life of WT's components using the developed framework.

*Speaker

• Application to wind farm controlling plans in different conditions using the developed framework with the goal of achieving a target lifetime.

Keywords: residual useful life, wind farm control, lifetime estimation, wind tubine life prediction