Sensor-Based Structural Health Monitoring Associated with Finite Element Model Updating for Wind Turbines

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The worldwide demand for modern renewable energy systems is evident. In this context, onshore as well as offshore wind turbines take an exceptional position, around the world and particularly in Germany. This applies not only for current facilities but also for the next generation of wind turbines which are tremendously taller and larger than present ones.

In this context, the reliable lifetime or residual lifetime estimation of wind turbines plays a decisive role. Each year that definitely extends the service life of a wind turbine results in enormous economical as well as ecological earnings. To predict the remaining life time, accurately to a large extend, opens therefore new opportunities for the life cycle management and operation of wind energy converters. As a consequence, it is indispensible to identify potential deteriorations or degradations, and to know the structural condition of a wind turbine. Based upon this knowledge, the required maintenance activities can be initiated, on demand.

Within the talk, the prototype implementation of a sophisticated structural health monitoring concept for the reliable lifetime estimation of an onshore wind energy converter is elucidated. In this concept, the long-term sensor-based measurements, which are carried out continuously on a selected real world ENERCON E-40 wind turbine, are used for directly updating a previously validated finite element model. By that, the numerical model can be consulted as the matching counterpart of the individual real world states of the structure, and can serve as a reference platform for life cycle management. Prerequisite, however, is the availability of the following ingredients:

- Sensing system in terms of a weak point-oriented installation of multiple modern sensor components associated with data acquisition units (by wires or wirelessly), which connect to a remote high capacity computer system
- Remote high capacity computer system for controlled and failsafe data collection, data cleansing, data interrogation and data interpretation, where the data interpretation has to be based upon damage detection and damage localization (diagnosis) using signal analysis and system identification; the control hereby is best managed in terms of software agents acting as “watchdogs”.
- System identification capabilities and tools, where the inverse/identification problem is being transformed into an equivalent non-standard and simulation-based optimization problem that must be solved with the aid of derivative-free optimization strategies.
- Numerical methods for the solution of the (probabilistic) reliability analysis problems associated with deteriorations and damages (prognosis).

Due to the time limit given, the focus of the talk the will primarily be placed on the aspects of modern structural health monitoring associated with finite element model updating.