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Training future mechanical, civil, electrionic engineers and computer scientists in SYStem Identification, Condition & Health Monitoring for a New Generation of WIND Turbines

Reporting

Project Information

SYSWIND

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Project closed

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Ireland

Final Report Summary - SYSWIND (Training future mechanical, civil, electrionic engineers and computer scientists in SYStem Identification, Condition & Health Monitoring for a New Generation of WIND Turbines)

Summary : EU FP7 Marie Curie ITN project - SYSWIND (Grant No. 238325)
Objectives
The primary goal of the project SYSWIND is to address the scientific challenges related to health monitoring, system identification and control of wind turbines to enhance their performance and the future prospects of wind energy. To reach this goal, the research carried out in SYSWIND has the following specific objectives to:
1. Develop new time-series and signal processing based identification techniques, which are suitable with uncertainties (both noise and model) and time varying situations.
2. Develop combined strategies based on high-low frequency signals and smart sensors to detect appropriate damage.
3. Develop WSN based protocol for health monitoring and control of wind turbines.
4. Develop multibody based efficient numerical models for system identification and for modelling damage in blades.

5. Identify aerodynamic loads on turbine during complex aerodynamic conditions.
6. Develop finite element (FE) based modelling of foundations to account for blade-tower coupling and soil-structure interaction.
7. Develop time-frequency based semi-active vibration control strategies using controllers and dampers to control tower/nacelle, blade vibrations under time varying parameters/conditions.
8. Develop semi-active control strategies for the stabilization of offshore turbines.
9. Develop fracture mechanics based model for damage in laminate composites for application to optimized design.

Overview of result

Growth in the European wind energy market has led to the manufacture of larger turbines (~ 7-10 MW). There are several challenges associated with these turbines, particularly offshore, e.g. vibrations/ damage of the flexible blades, mechanical drives/electric converters. These raise maintenance concerns and result in operational downtime, impacting on power systems and supply reliability. The SYSWIND network has trainned future engineers and scientists in truly multi-disciplinary and newly emerging scientific areas and technologies for next generation wind turbines. There are five research themes: new structural health monitoring (SHM), wireless sensor network (WSN), multi-body systems (including aerodynamics and geotechnics), semi-active vibration control and composite materials. Researchers in SYSWIND network consisting of a number of leading Universities, research labs and industries are leading the development of effective system identification, aeroelastic modelling, damage localization techniques and controllers with advanced algorithms.

“Global” structural identification of a full scale wind turbine under normal operating conditions has been considered via measured vibration data records. To achieve this, the SYSWIND researchers from University of Patras used vibration signals which were obtained from the tower of a wind turbine operating in a wind farm. Non-parametric and parametric output-only identification have been employed. For structural health monitoring of components of wind turbines, novelty detection method and time-frequency technique of empirical mode decomposition (EMD) has been used. Experimental data from a stiffened carbon fiber reinforced polymer plate has been analyzed and validated under incremental levels of impact damage. EMD has been used to examine common periodic gear tooth faults and intermittent gear tooth faults under transient loads such as those observed in wind turbine has been carried out by the researchers from the University of Sheffield a partner in SYSWIND. The focus of the researchers from Lac Engineering and Aalborg University is also on online detection of fault in offshore wind turbines with special reference to pitch offset.

Research on the analysis of 3D stall models for wind turbine blades using experimental has been led by Risø DTU as a part of the SYSWIND project. The empirical 3D stall models have been reviewed and applied to data from the MEXICO experiment. A comparison study between the models is carried out along with the predictions by advanced Computational Fluid Dynamics (CFD) analysis.

SYSWIND research network has also pioneering the technology on wireless sensing for wind turbine applications with research on adaptive sensing and on-board signal processing has been carried out at Trinity College Dublin. The wireless sensors will not only be able to acquire data but will also act as nodes for processing and transmitting information on the vibration characteristics and wind turbine conditions.

Researchers in Cagliari University of Cagliari from the SYSWIND network have developed finite element (FE) models for prediction of impact induced delamination in composite plates using cohesive elements.

Researchers in SYSWIND from Aalborg University are involved in the modelling of wind turbine as a multi-body system. Their model incorporates the rotor blades, nacelle, drive-train, tower and simplified model of

the generator. The model developed also includes the aerodynamics and turbulence (including the effect of blade rotation, i.e. rotational sampling). The reduced order model developed can be used for stochastic analysis/simulation and facilitate the development and design of new structural vibration controllers.
Research on vibration control of wind turbines led by Trinity College Dublin has resulted in the development of a smart blade with active/semi-active structural controllers for onshore/offshore turbines. The performances of semi-active frequency tracking algorithms and active control algorithms for control of vibrations in wind turbine blades have been tested under different loading and operating conditions. The implementation of these algorithms is expected to increase the life of the turbine components and improve the operational efficiency to generate power.
Impact
The system identification, health monitoring and control techniques developed for wind turbines will be useful for safe, efficient and reliable operations of wind turbine, particularly those deployed offshore. This will particularly assist in reducing the O&M costs and in turn reducing the cost of energy (COE) which is a key parameter in offshore renewable energy generation. In addition, the results of the project support the goal of minimizing the greenhouse emissions to abate climate change, will reduce the reliance on fossil fuel and increase the security of energy supply. Finally, the technologies developed will have a significant impact on the growth of offshore sector with a positive socio-economic effect of increasing job and employment markets.

For more information please visit the official website of SYSWIND project at www.syswind.eu or contact:
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