Simulation of wind turbine drive trains in certification using SimPack

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Multi body simulation is fairly new in the still young wind energy industry. Though simulation is very important and designers have to rely on the results from the calculations because the long design life of 20 years sets a limit for the practicability of testing of the actual wind turbine.

Software codes like Bladed or Flex5 are well established to calculate loads for the verification of the general structural integrity of the wind turbine. These codes have their strong points in the investigation of the overall dynamic behaviour of the system. The analysis is usually limited to a small frequency range. The investigation of phenomena in a larger range of frequencies requires a more detailed representation of the system. That is where simulation software like SimPack comes in.

A wind turbines drive train is an integral and costly part of the wind turbine. Gearbox manufacturers, wind turbine manufacturers and certification bodies as Germanischer Lloyd Industrial Services GmbH, Renewables Certification (GL) put in much effort to realize a reliable drive train design. One aspect is the dynamic behaviour of the drive train. It plays a major role for the determination of the design loads and the verification of the machinery components.

Multi body simulation models are often used for the identification of eigenfrequencies and the dynamic behaviour of the drive train. The possible level of detail for such models ranges from simple torsional mass-spring-damper-systems with only a few rotational degrees of freedom to very complex systems containing flexible bodies and super-elements representing housings and foundations.

In many cases a simple model will provide sufficient insight into the dynamic behaviour of a complex system. For particular problems more detailed and complex models are necessary.

Since a few years the investigation of the dynamic behaviour of the drive train is part of the Type Certification of wind turbines. The Type Certification is the confirmation of compliance of a specific type of a wind turbine with defined requirements (e.g. guidelines, codes and standards). One important part of the Type Certification is a thorough design review (Design Assessment). The Certification procedure is based on the international standard IEC 61400-1 [1], [2] and/or GL's Guideline for the certification of wind turbines [3] and [4].

As one part of the Design Assessment an independent analyses of the dynamic drive train behaviour is carried out by GL. The necessary model data is extracted from technical drawings, CAD and FEM models.

Based on this information the multi body simulation model can be generated. Since the analysis of drive train dynamics was implemented in the Guidelines [3] and [4] SimPack is used for this task at GL.

Currently GL is finalising the revision of its guideline which will be published in April 2010 as GL 2010 [5]. Experience from various certification projects, research projects, discussions of GL and external experts and especially the technical committee with several experts from the wind industry resulted in a new revision including the state-of-the art in certification and the actual knowledge about turbine design.

In the upcoming guideline GL 2010 [5] an entire application-oriented appendix is dedicated to the analysis of drive train dynamics taking multi body systems as basis for the simulation.

Regarding the analysis of drive train dynamics using GL 2010 [5] may entail the following major updates:

- Torsional, axial and bending degrees of freedom need to be considered
- Simulation models with solely torsional degrees of freedom can be used if the calculation results are validated by measurements
- For particular problems simulation of a run up shall be carried out in time domain

In parts these new requirements are the results of current EU co-funded research projects that focus on the validation of simulation models by measurement. Together with wind turbine and gearbox manufacturers, research institutes and universities GL is part of the research project PROTEST. One task is the measurement on a drive train of a mega-watt class wind turbine. At the same time simulation models are build in SimPack in order to compare the results from simulation to measurements later on. More information can be found on the projects web site http://www.protest-fp7.eu.

In order to obtain a deeper insight of the dynamic behaviour of complex systems, e.g. the drive train of a wind turbine, the general tendency goes towards more complex and validated simulation models. Powerful and reliable simulation software is essential to achieve this aim.

[1] IEC 61400-1 “Wind turbine generator systems – Part 1: Safety requirements”, second edition February 1999.

[2] IEC 61400-1 “Wind turbines – Part 1: Design requirements”, third edition August 2005

[3] Germanischer Lloyd, Hamburg, Germany: “Guideline for the Certification of Offshore Wind Turbines”, Edition 2005.

[4] Germanischer Lloyd, Hamburg, Germany: “Guideline for Certification of Wind Turbines”, Edition 2003 with Supplement 2004.

[5] Germanischer Lloyd, Hamburg, Germany: “Guideline for Certification of Wind Turbines”, Edition 2010.

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