Simulation of Drivetrains on Wind Turbines within the Framework of Certification — with SIMPACK

Simulation with multi-body systems is relatively new in the emerging wind energy industry. Representative tests on a constructed model are practical only on a limited basis because of the long draft lifespan of 20 years. Realistic simulation is of paramount importance in product development.

Programs such as Bladed or Flex5 are well suited for calculating loads in order to verify the general stability of a wind power plant. These programs have their strengths in the investigation of the dynamic behavior of the overall system. However, the analysis is usually limited to a small range of frequencies. The investigation of phenomena in a larger range of frequencies requires a more detailed representation of the system. SIMPACK simulation software provides an excellent platform for this detailed model and analysis.

The drivetrain of a wind turbine is an integral and expensive assembly component of the plant. Manufacturers of transmissions, manufacturers of wind turbines and certification bodies (such as Germanischer Lloyd Industrial Services GmbH, Renewables Certification (GL)) engage in expansive efforts to put a reliable design into practice. One critical aspect of the design is the dynamic behavior of the drivetrain, which plays an important role in the determination of local loads and the physical integrity of the mechanical components.

MULTI-BODY SIMULATION MODELING

Multi-body simulation models are frequently used for the determination of natural frequencies and the investigation of the dynamic behavior of the drivetrain. The possible degrees of detail for such models range from simple mass shock absorber systems, with rotatory degrees of freedom, up to very complex systems with flexible bodies and super-elements for the consideration of the flexible housings and support structures.

Often a simple model provides sufficient information regarding the dynamic behavior of a complex dynamic system and helps with the investigation and understanding of dynamic phenomena. However, for special problems, more detailed and more complex models are necessary.

TYPE CERTIFICATION

For several years, the investigation of the dynamic behavior of the drivetrain has been part of the Type Certification of wind turbines. A type certification is the confirmation of conformity for adherence to fixed requirements (e. g., guidelines and standards) for certain types of wind turbine. An important component of a type certification is a thorough design assessment. The certification procedure is based on the international standard IEC 61400-1 [1], [2] and/or the GL guidelines for the certification of wind turbines [3], [4] and [5].

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COMPONENT OF THE DESIGN ASSESSMENT

As a component of the design assessment, an independent evaluation of the dynamic behavior of the drivetrain is conducted by GL. The necessary model data are derived from technical drawings, CAD and FEM models. On the basis of such information, a realistic representative multi-body simulation model can be prepared. SIMPACK is used by GL in order to investigate the dynamic behavior of the drivetrain.

In July 2010, the revision to guideline [4] was published as "GL 2010" [5]. Experiences from various certifications, research projects, discussions between GL and external experts and, above all, the technical specialized committee (with many specialists from the wind energy industry) have led to a new issuance which considers state-of-the-art knowledge regarding the development of wind turbines.

In the "GL 2010" guidelines [5], an entire application-oriented appendix is dedicated to the investigation of dynamic behavior of the drivetrain. The recommendations assume investigations with the use of multi-body simulation systems. The study of the dynamic behavior of the drivetrain on the basis of "GL 2010" will lead to the following changes:

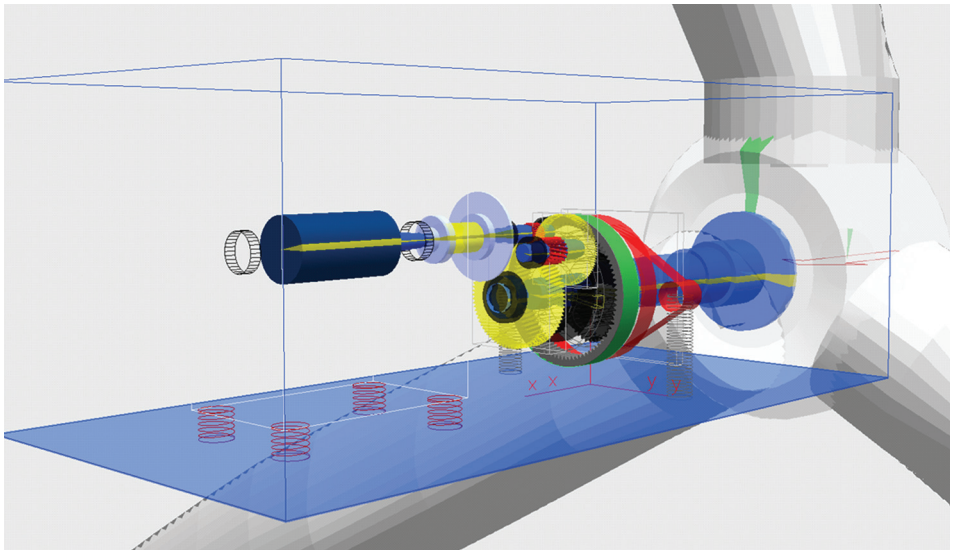


Fig. 1: 3D MBS model of wind turbine (including flexible blades, detailed drivetrain and generator)

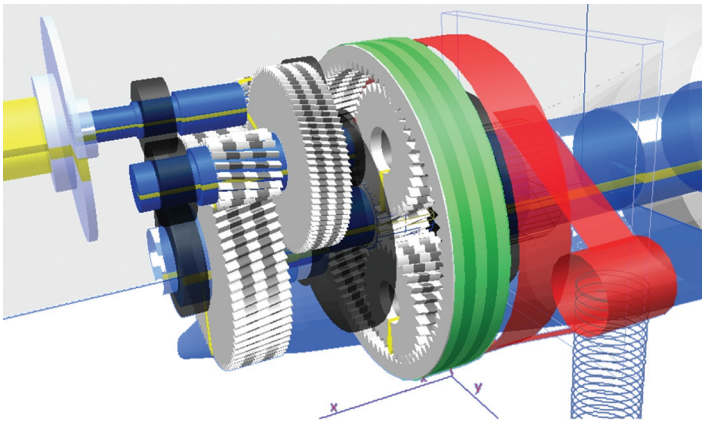


Fig. 2: Detailed SIMPACK model

- Torsion, bending and axial degrees of freedom must be considered.
- Simulation models with only rotational degrees of freedom can be used (if the calculation results are verified with measurements).
- For certain analyses, the simulation of a run-up must be conducted in the time domain.

In part, such new requirements are arising from current EU co-funded research projects that are concentrating on the validation of simulation models through measurement. Together with manufacturers of wind power plants and transmissions, research institutions and universities, GL is involved with the PROTEST research project.

One emphasis is the measurement of a drivetrain of a wind power plant of the megawatt class. At the same time, results arising from simulations with SIMPACK are compared with the measurement results. Further information is available at the Internet site for the project (see www.protest-fp7.eu).

CONCLUSION

In order to obtain a more in depth view of the dynamic behavior of complex systems (e.g., the drivetrain of a wind power plant), a clear trend to more complex and validated simulation models is imperative.
SIMPACK is high-performance and reliable simulation software is an important tool for achieving this goal.

INFORMATION

For more information about GL and renewables please see:
www.gl-group.com/GLRenewables

REFERENCES

[1] IEC IEC 61400-1 "Wind turbine generator systems – Part 1: Safety requirements", 1999. 2nd edition, February 1999.
[2] IEC 61400-1 "Wind turbines – Part 1: Design requirements", 3rd edition, August 2005.
[3] Germanischer Lloyd, Hamburg, Germany: "Guideline for the Certification of Offshore Wind Turbines", 2005 Edition.
[4] Germanischer Lloyd, Hamburg: "Guideline for the Certification of Wind Turbines", Edition 2003 with Supplement 2004.
[5] Germanischer Lloyd, Hamburg: "Guideline for the Certification of Wind Turbines", 2010 Edition.

SIMPACK Academy Events in 2010

MBS NUMERICS ACADEMY, 14.–16.09.2010, in Andechs, Southern Germany

Prof. Dr. Martin Arnold, Institute of Mathematics, Martin Luther University Halle-Wittenberg and Dr. Gerhard Hippmann, Solver Technology, SIMPACK AG

"Multi-Body System Numerics" aims to enable the calculation engineer to understand the capabilities and limits of numerical methods in multi-body dynamics. Elaborate presentation of the theoretical background is combined with software issues as well as practical examples and tips.

WIND TURBINE AND DRIVETRAIN ACADEMY, 05.–07.10.2010, in Gross Schwansee, Northern Germany

• Part 1: Dynamics and System Design of Wind Turbines, 05.–06.10.2010

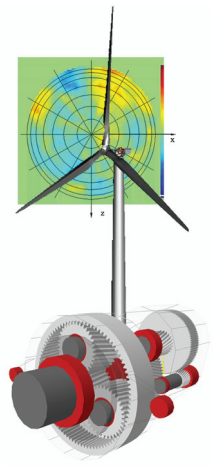
Prof. Martin Kühn, ForWind — University of Oldenburg and Stefan Hauptmann, University of Stuttgart

This course combines theoretical background with recent industrial experience to provide a comprehensive introduction to state-of-the-art wind turbine dynamics and design from a system´s view-point.

• Part 2: Design and Analysis of Drivetrains in Wind Turbines and Other Large Industrial Applications, 06.–07.10.2010

Prof. Berthold Schlecht and Thomas Rosenlöcher, Technical University of Dresden

This course covers the dimensioning and design of drivetrain systems and their components. In addition, the advantages and accuracy of multi-body simulation (MBS) will be shown.



For more information and registration please visit: www.SIMPACK.com/SIMPACK_academy.html