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SCHAEFFLER TECHNOLOGIES GMBH & CO. KG, SCHWEINFURT

Virtual prototyping for wind turbine design

# Multi-Body Simulation Makes Wind Energy More Efficient

Rolling bearing supports in wind turbines are subjected to high, extremely alternating loads and a wide range of low and high speeds depending on the installation point. They are at the core of the drive train and therefore of the entire turbine. Accordingly, rolling bearing development takes account of the entire wind turbine system with the dependencies and interactions of its individual drive train components. Complex simulation programs enable engineers to test all components virtually prior to manufacturing and thus improve the reliability and cost-effectiveness of wind turbines for all load conditions.

In a joint development project, Schaeffler Group Industrial, wind turbine manufacturer Repower Systems AG and gearbox manufacturer Eickhoff Antriebstechnik GmbH have developed a systems simulation for calculating the dynamic operating loads for the drive train of wind turbines. The complex multi-body simulation model uses FEM calculations for optimizing the individual components of the drive train, their interactions as well as the entire turbine design as early as the development phase. This makes the design and operation of wind turbines significantly more reliable and cost-effective for all load conditions.

Load simulations are indispensable for the design of wind turbines. Although there are new types of turbines with, for example, alternative main bearing or gearbox concepts and increasing requirements for performance and reliability, extremely simplifying models have mostly been used for load simulations. They provide load time series for certain section variables only, and not for all components, as the basis for the design. Complex units, such as the gearbox with numerous dynamic components and their counter effects on the other parts of the drive train, are only regarded as a black box. This modeling does not adequately meet the requirements for gearboxes and thus a reliable design.

## Improving the in-depth understanding of systems

To come to a comprehensive understanding of the dynamic loads of the mechanical drive train components, the project partners brought their individual product and calculation expertise into the development of a complex multi-body simulation model (MBS model). The BEARINX® rolling bearing calculation software developed by the Schaeffler Group is the central program for quickly generating dynamic simulation models for complete gearboxes and visualizing the results. BEARINX® provides a particularly precise and reliable simulation of the drive train as it maps the behavior of shafts, gear teeth and bearings right up to the individual rolling contact. In conjunction with elastic simulations and FEM calculations for adjacent components and housings, BEARINX® achieves the highest modeling level.

In contrast to conventional simulation programs such as FLEX5® or BLADED®, hybrid FEM-MBS models include detailed sub-models of the rigidity matrices and masses for all elastic structural components such as frame, housing, planet carrier, gears and bearings. The BEARINX® rolling bearing calculation program first creates the gearbox model and subsequently the geometry, the arrangement of the gearbox elements, and the bearings used. A newly developed software family uses this BEARINX® model to create the multi-body simulation. Preprocessing program DynPre® generates the simulation model from the BEARINX® gearbox data and additional data about the geometry and material properties of the other turbine components (tower, rotor blades, generator etc.). This process is automated and therefore error-free, precise and particularly fast compared to other methods. The SAMCEF-MECANO program is used to create the actual multi-body simulation. Subsequently, the DynDP® program prepares the data for the analysis. The data is visualized in diagrams, films and 3D waterfall diagrams. The program enables the analysis of classed load time series as a prerequisite for calculating the rating life by taking the dynamics and interactions of the components into account. Loads can be evaluated at any point in time over the entire operating life. Even extreme load conditions, such as an emergency stop or short circuit, can be simulated and evaluated in detail. This applies for their effects on the overall system, the individual sub-systems and even the isolated rolling contact – always taking account of all dynamic conditions and effects.

Reliable design

The developed multi-body simulation model enables the integrated calculation of fatigue loads or extreme load conditions, such as emergency stop or short circuit, in unprecedented precision. This makes the design of the turbine significantly more reliable. The ability to analyze and asses design alternatives at an early stage provides security in the development process. The design can be changed early in the process, which significantly reduces development costs.

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Calculation model of the drive train
(Figure: Schaeffler Group)

• Press picture "0001637B.jpg"
Model created with DynDP® for visualizing the result: Dynamic load simulation from wind field to the individual contact in the rolling bearing.
(Figure: Schaeffler Group)

• Press picture "00015833.jpg"

(Figure: Schaeffler Group)

• Press picture "00006099.jpg"
The MBS program enables rating life calculations that take the dynamics and interactions of all components in the drive train into account.
(Figure: Schaeffler Group)

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