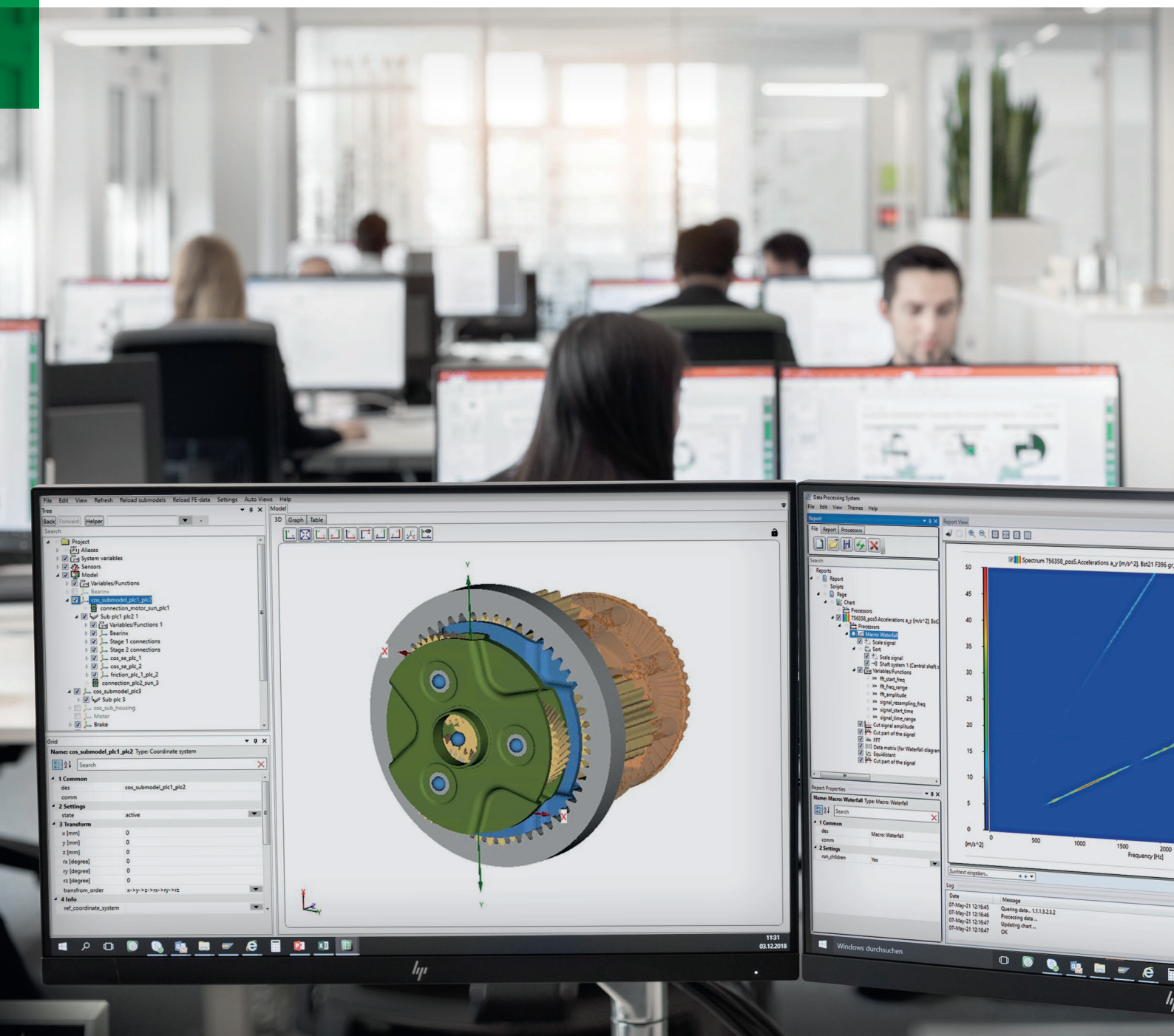
SCHAEFFLER

We pioneer motion

Simpla

Dynamic system simulation with rolling bearing expertise



Bearinx Simulation Suite – The perfect tools for systems with rolling bearings

Thanks to its state-of-the-art simulation programs, Schaeffler offers the best possible support in the product development process – from the dynamic simulation of an entire drive train, through to the detailed simulation of contact conditions inside rolling bearings. The Bearinx Simulation Suite includes CAE tools that are perfectly suited to the specific requirements of the design.

Simpla

Simpla – system simulation with rolling bearing expertise

As part of the Bearinx Simulation Suite, Simpla provides support in the creation, control, and analysis of complex mechanical system simulations, e. g. wind turbines, in order to help analyze and optimize their dynamic behavior. The focus here is on the interactions between our products and the customer's design. Simpla uses numerous interfaces to combine expertise from software developed inhouse such as Bearinx and commercial programs such as Abaqus, Simpack, and Samcef.
This enables a wide range of simulation methods to be combined with each other.

Bearinx

Bearinx – bearing design with an understanding of systems

Bearinx allows complete gearboxes and linear guidance systems to be modeled and calculated with all the relevant data regarding elasticity, contact rigidity,and environmental influences. The results provided also include loads and the displacement and deformation of all the components. Additional parameters such as rating life, safety factors, pressure curves, and friction vaues are calculated for bearings. Gear teeth are also analyzed with a high level of detail. Data records and calculation models can be easily exchanged with other programs via different interfaces.

Caba3D

Caba3D – a dynamic view inside the bearing

As part of the Bearinx Simulation Suite, the Caba3D MBS software allows a view inside rolling bearings. It enables a precise analysis of the dynamic processes that take place inside a rolling bearing. This means that the movement patterns of the bearing components, the forces acting between them, and the frictional power that is generated can be determined. These results allow statements to be made regarding the minimum load, the risk of smearing, and surface-induced damage. Stresses and damage can be predicted by analyzing the elasticity of cages.

Telos

Telos – where the focus is on contact

The Telos program is the detailed contact simulation within the Bearinx Simulation Suite. Telos considers the lubrication conditions in individual contacts, for example between the rolling elements and the raceway in detail. The effects of surface damage and coatings can thus be analyzed as well. Furthermore, it is possible to specify different input values with a time curve. The input data from a Bearinx simulation model can also be automatically transferred using a special interface.

Dynamic simulation is an essential component in the development of quiet, low-vibration machinery. With our Simpla program, we provide a suitable tool for dynamic simulation tasks.
Simpla enables the efficient creation of dynamic models, the subsequent performance of simulations, and the comprehensive and simple evaluation of results.

The simulation tasks and models can have any level of complexity ranging from simple rotor systems through to complete wind turbines.
The decisive factors are often the correct modelling of the interactions in vibration systems in the simulation and gaining a better understanding of these with the aid of the simulation. A range of different calculation methods are available for this purpose within Simpla.

Simpla – the simulation platform

The focus of Simpla is on high model quality and an efficient model design. It is used as a pre and post-processer for the dynamic simulation of systems with any level of complexity.

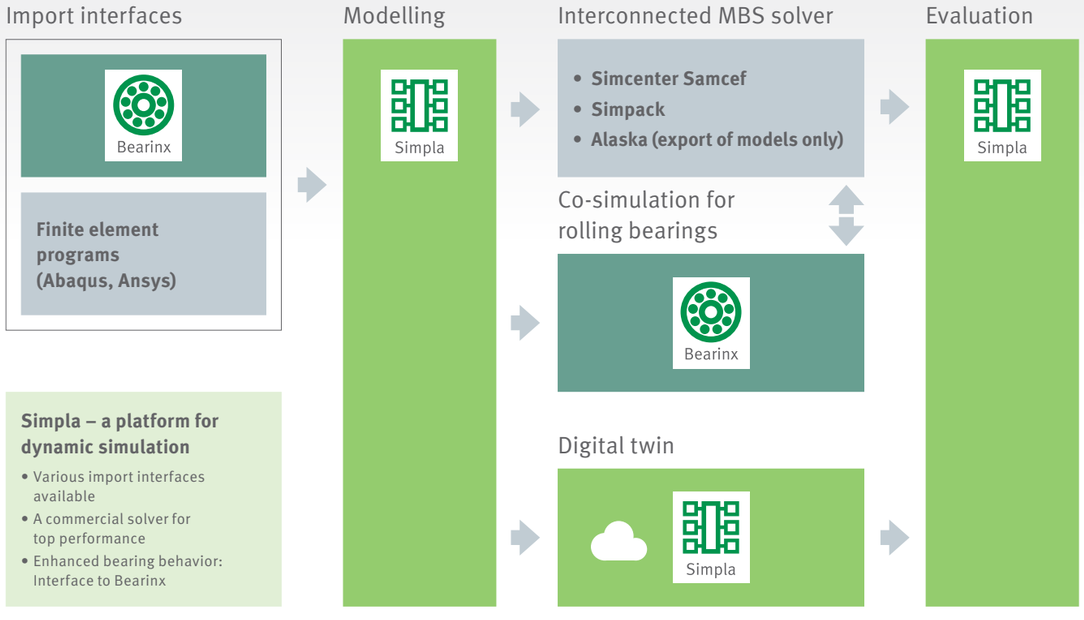
Simpla has a wide range of automated interfaces to CAE tools that are used in the development process, such as Schaeffler's Bearinx program or the Abaqus FEM program and automatically generates simulation models for various solvers for multi-body simulation (MBS), such as Simpack or Simcenter Samcef. The intuitive user interface also allows "non-simulation experts" access to dynamic simulations.

The Simpla post processor provides the option of analyzing simulation results in relation to the time and frequency ranges. The further processing of results is largely automated in order to ensure that the same evaluations and model animations can be generated.

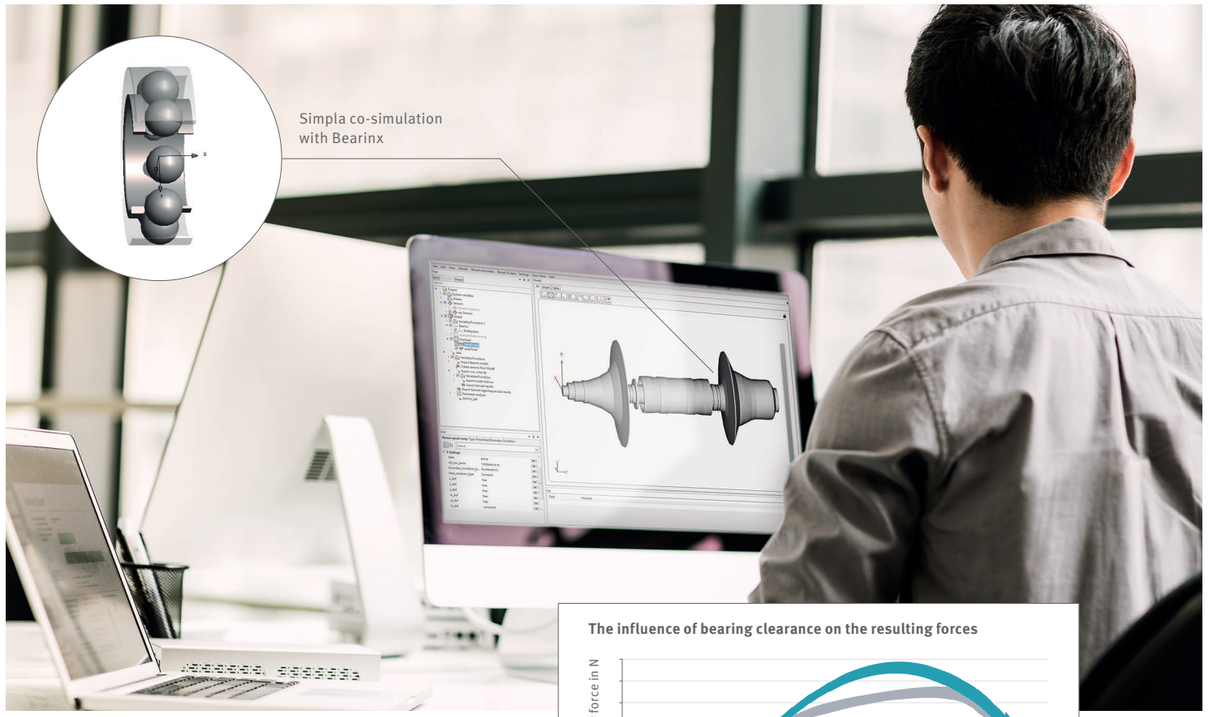
Your entry into the world of machine learning and cloud systems is now fast thanks to Simpla.

Simpla has proved effective as a powerful tool for system simulation in numerous projects, both internally and in collaboration with customers.

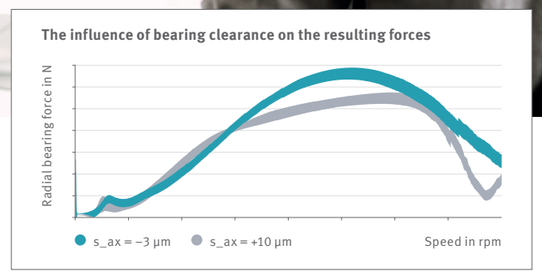
Modelling process and workflows in Simpla



System dynamics with detailed rolling bearing models



Analysis of rotor dynamics in a turbocharger



Rolling bearings in multi-body simulation

Small details can make a big difference in systems based on rolling bearings. The bearing clearance of rotors with rolling bearing supports can have a significant influence on the vibration amplitude level. With Simpla, we provide the option of integrating rolling bearing models with various levels of detail into the multi-body simulation.

We also create access to the well-founded calculation methods in Schaeffler's Bearinx program via interfaces.

One option for modelling rolling bearings is to describe their behavior using a rigidity matrix. It can be calculated through automated linearization of the bearing behavior at the operating point. Coupling effects between the individual degrees of freedom are also modelled. If a radial load is applied to a tapered roller bearing, for example, axial forces also occur due to the coupling. Modelling using a rigidity matrix is a very numerically efficient method.

If the non-linear behavior of the bearing has a significant influence on the system or the bearing loads vary during the simulation, the rolling bearing can be integrated into the dynamic simulation using a Bearinx co-simulation.
The non-linear characteristics of the bearing including the coupling effects of the individual degrees of freedom can also be modelled realistically in every time step.

Bearing acoustics in the system

We prefer our machinery – and especially our rolling bearings – to be as quiet as possible. If, however, raceways or rolling elements have deviations, Simpla can calculate their effects on the acoustic behavior of the system. This is done by specifying raceway deviations in Bearinx and integrating the bearing model into the Simpla simulation.

Rotor dynamics

The following aspects are the main priority in high-speed rotor systems such as turobchargers, spindles, and electrical machines:

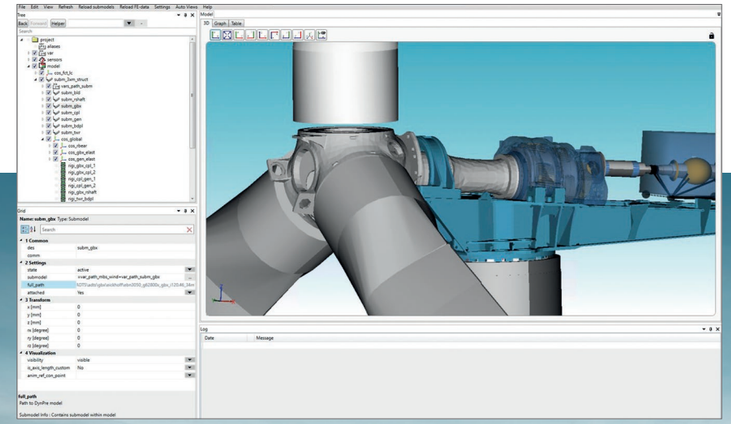
- Do resonances occur in the operating speed range and are these critical?
- Do non-linearities of the rolling bearings, for example, have an effect on deflection amplitudes, bearing forces, and resonances?
- Can the housing be optimized in order to positively influence the dynamic behavior of the rotor system?

All these questions can be analyzed using Simpla. The automated interface ensures a simple transition from the linear rotor dynamics in Bearinx to the non-linear rotor dynamics in Simpla. Natural frequencies and damping values as a function of speed can also be calculated in Simpla. These can be used as a basis for stability analyses.

A complex application with various aspects – simulation of a wind turbine

Simpla can also solve complex simulation tasks. In wind turbines, for example, a challenge is posed by the strong coupling between aerodynamics, mechanical vibration, the electrical system, and not least the control system.
Simpla offers a link for combining the interactions of various components and various manufacturers via its interfaces and the substructuring of models. Models are jointly created in Simpla in cooperation with wind turbine manufacturers, gearbox manufacturers, and Schaeffler as a supplier of bearings. The substructuring of models is of significant benefit in order to carry out the validation of models in a number of steps, for example. This allows the drive train model to be validated against test rig measurements, and the model of the entire system to be validated against field measurements.

Simulation model of a wind turbine



Efficient methods for optimum solutions

Gearbox dynamics – we model every aspect from the tooth contact through to the connection of the gearbox housing

The constant tooth mesh in gearboxes causes vibrations and has a decisive influence on the acoustic behavior. Dynamic simulations carried out using Simpla can help to make gearboxes as quiet and vibration-free as possible.

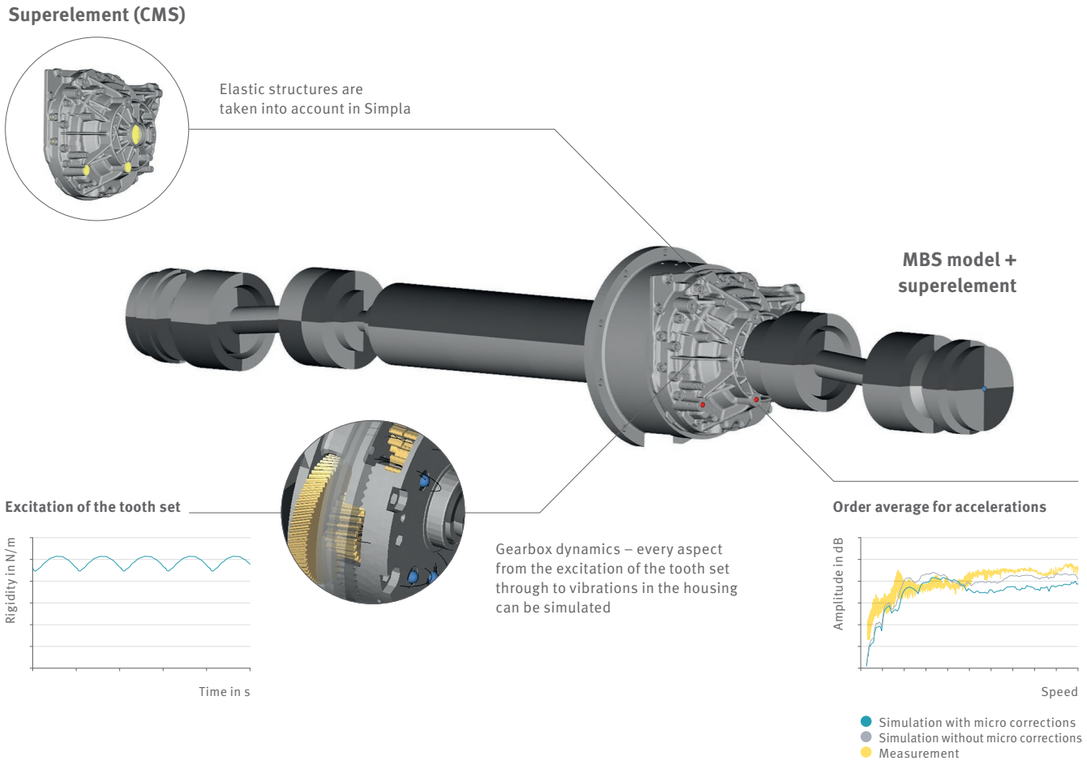
When modelling gearboxes, it is essential that the transmission behavior from the tooth mesh to the housing surface or connection points on the machine carrier or vehicle frame are modeled with sufficient accuracy. It is also essential to describe the tooth contact as accurately as possible.
Both of these requirements can be ensured by using Simpla in combination with the Simcenter Samcef MBS solver.

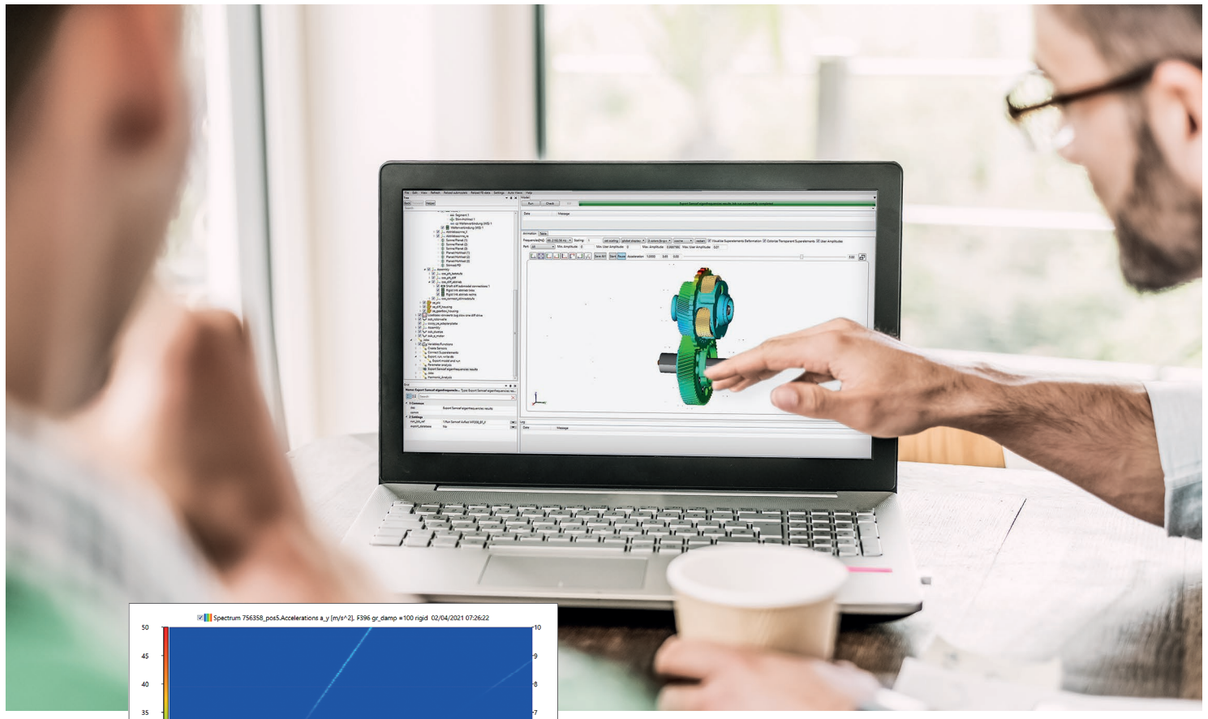
The transmission behavior is also described by means of detailed rolling bearing models and elastic components, such as planet carriers or housings. The latter are integrated into the simulation model as superelements.

The Simcenter Samcef solver provides a range of different tooth set elements. The most accurate tooth set element allows the efficient calculation of the non-linear tooth contact for each time step of the transient simulation. The influence of the system deformation on the tooth mesh is automatically taken into account during this process.
The excitation behavior of the tooth set can be minimized by means of tooth corrections. A detailed analysis of their effects can be carried out using Simpla.

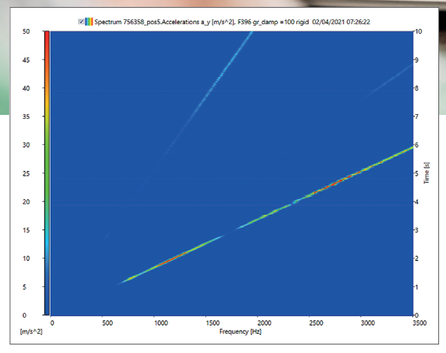
In addition to the transient simulation which can be used to calculate, for example, gearbox runups, further analysis methods are also available. In combination with the harmonic analysis, the modal analysis helps to gain an understanding of what components vibrate during resonance peaks and thus provides an approach for optimization. This also applies to the transfer path analysis, which enables an analysis of what transmission elements, such as bearings, mainly transmit vibrations from the source of excitation to the housing.

The Simpla post-processor is a highly suitable tool for evaluating gearbox simulations. It can be used for creating, for example, waterfall diagrams or order averages. This allows an analysis of the resulting levels at various points on the housing for the individual orders of the tooth set in runup simulations.





Animation of results (modal analysis)



Waterfall diagram of a gearbox runup (transient analysis)

Machine learning and cloud systems

The entire process from the creation of the simulation model through to the training and application of machine learning (ML) models is supported by Simpla. The complex signal analysis that is implemented in Simpla can be used for simulation results and for measurement data, which are available in various formats such as DIAdem, Famos, and csv. To enable further use of the available data, various ML libraries such as XGBoost, ML.Net, and Tensorflow (neural networks) have been integrated. Through the integration of ML.Net, the Simpla user is provided with functionalities, which automatically select the most suitable ML algorithm and suggest suitable parameterization.

Both simulation and measurement data can have a very large volume. For this reason, individual parts or complete processing chains can be transferred to cloud systems via Simpla at the push of a button. This allows the services to be used independently of the location.

Further information

www.schaeffler.de/calculation

Information on other parts of the Bearinx Simulation Suite

Caba3D – An insight into rolling bearing dynamics
www.schaeffler.de/Publication_CABA3D

Information on other parts of the Bearinx Simulation Suite

Bearinx – High-Level Bearing Design
www.schaeffler.de/Publication_BEARINX

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