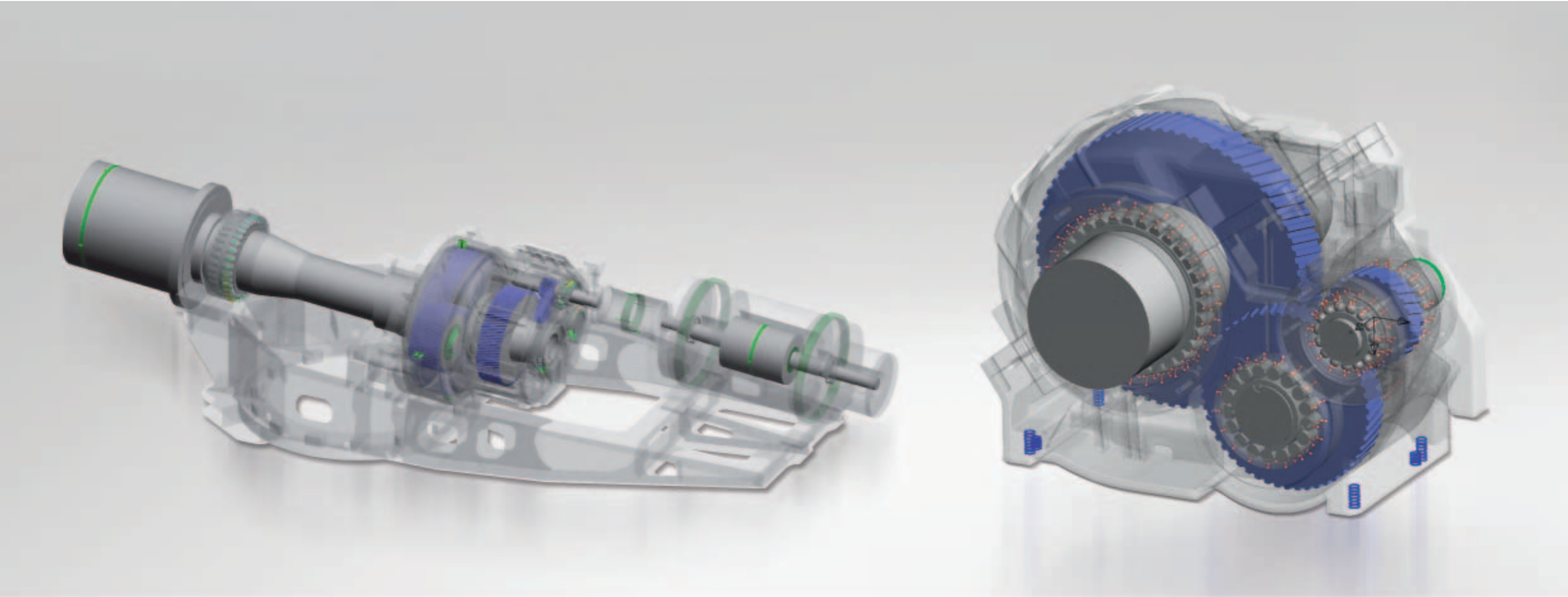
SCHAEFFLER



Design of Transmission Bearing Arrangements using BEARINX-VIP

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Figure 1: Planetary gear sets in an automatic gearbox

BEARINX

BEARINX is the ideal tool for designing and analysing rolling bearing arrangements in complex systems. It has been developed and used successfully at Schaeffler for decades.

Through continuous further development and verification, the program enables exact interpretations and helps to reduce times and costs in product development.

BEARINX maps complete gearbox models and leads to an improved understanding of the system, thus permitting an early response to critical points.
All specified elasticities and deformations are recorded, starting from rolling element and raceway contact in the bearing through to 3D contact at the tooth flank. In this way, the elastic environment and its influence on the resulting load distribution in the bearing can also be recorded and taken into consideration using finite element matrices of influencing factors.

The Windows program is suitable as a daily tool for the application engineer, supporting the generation of models with 3D visualisation and facilitating simple operation. An input wizard for load case-dependent data significantly increases ease of use.

Calculation options

BEARINX essentially offers two modelling variants: Generation of a decoupled transmission with logic structure or the coupled transmission calculation.

The coupled transmission calculation also permits the modelling of the elastic environment and takes account of the ovalisation of the bearings.

The mutual influence of the shaft systems is taken into consideration by means of housing rigidities and tooth contacts in the equilibrium calculation and the load distribution.

The fatigue rating life is calculated in line with the current status of standardisation to DIN 26281 (ISO/TS 16281).
The reference rating life is based on the determination of the Hertzian contact pressure, which is derived from the actual load situation, including the settings for operating clearance, and takes account of the exact profile data of the rolling elements and raceways.

In addition, the influences of lubrication and contamination are also factored into the calculation for the adjusted reference rating life. In order to estimate the strength of the shaft on an approximate basis, the uniaxial comparative stress according to von Mises is determined, taking account of the influence of notch factors.

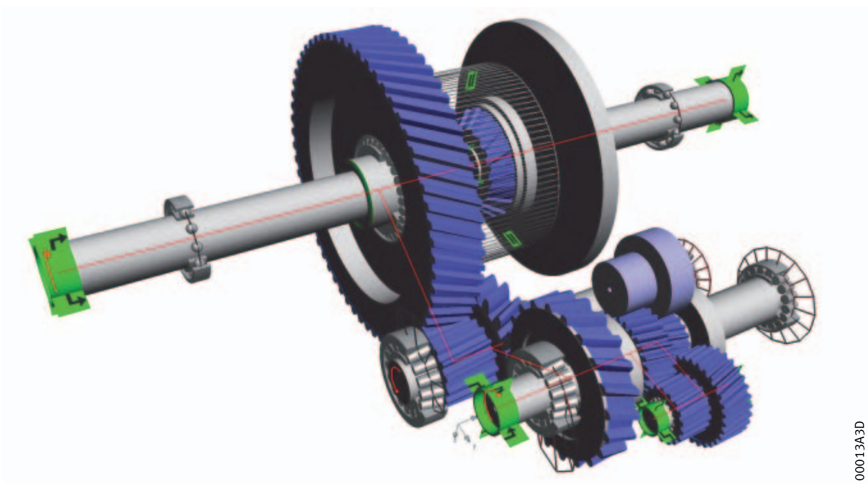

Figure 2: BEARINX gearbox model used for a travel drive

Further analysis

The in-house version of BEARINX offers further analysis options such as:

- Frictional torque calculation with detailed output of results
- Rotor dynamics with the calculation of natural frequencies, natural forms and critical speeds
- Noise calculation including definition of geometrical deviations on the surface of rollers and raceways.

OptiKit provides a powerful tool within the program for optimising individual parameters.

Data exchange (REXS)

Schaeffler is participating in the project run by the Research Association for Power Transmission Engineering (FVA) to create a standardised format for the exchange of gearbox data.

Files in REXS format (**R**eusable **E**ngineering E**X**change **S**tandard) can be imported and exported in the gearbox calculation.

Further information:

- https://www.rexs.info

Customer version BEARINX-VIP

Schaeffler development partners benefit particularly from our calculation options. The locally installed BEARINX-VIP version provides them with access to the full gearbox calculation, with the added option of exchanging data via REXS.

The variant analysis integrated in BEARINX-VIP permits a more detailed analysis of the influence and limits of individual parameters.

Further analysis options offered by the in-house version can also be accessed via the Schaeffler Engineering Service.

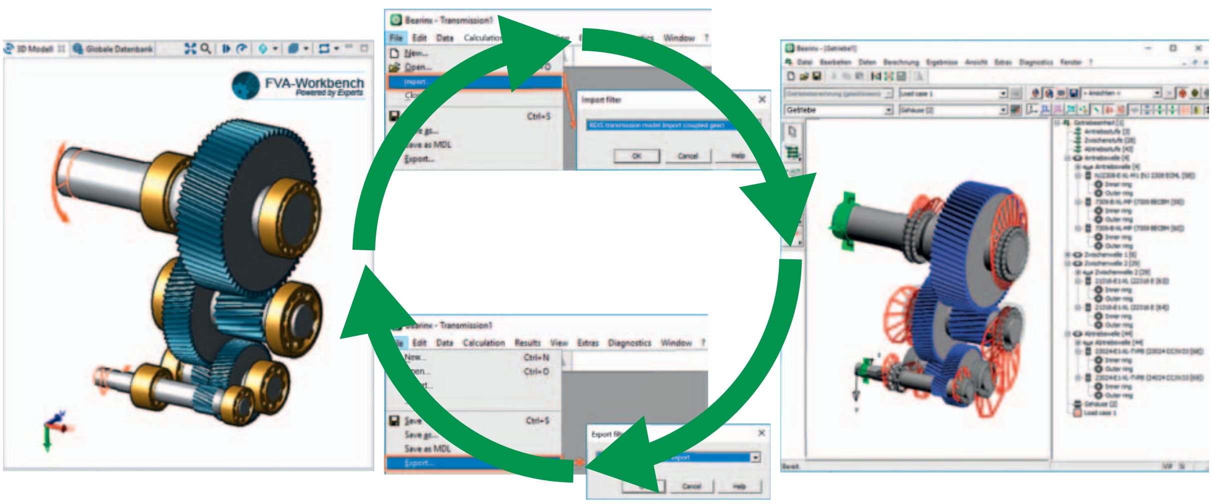

Figure 3: Export and import with the aid of gearbox interfaces standardised in accordance with the FVA

Integration of the elastic environment

In many applications, the elastic adjacent construction has an influence on the distribution of bearing load and thus on the rating life, which cannot be disregarded.

For this reason, BEARINX not only offers the option of taking into consideration the elastic components arising from the shafts and bearings, but also the influence of the adjacent and component elasticity in the bearing design.

The adjacent elasticity can be incorporated in the calculation for components that are fixed to the inertial environment (such as gearbox bearings to the housing).

These are boundary conditions that are explicitly specified in the creation of the reduced stiffness matrix. Elastic components can also be considered which are defined in the calculation model as free bodies or shafts. In this way, it is possible to integrate parts such as planet carriers, free housings and rotationally asymmetrical shafts (such as balancer shafts) as elastic components in the calculation model.

Additional data can be taken into consideration and improve the accuracy of the result:

- Preliminary deformations such as screw or press connections
- Inherent mass of the bearings and shafts
- Centrifugal forces
- Thermal expansion.

Reduced stiffness matrices are included in the program, which originate from a finite element program such as ABAQUS or ANSYS.

Finally, a visualisation of the displacement condition permits an assessment of the results.

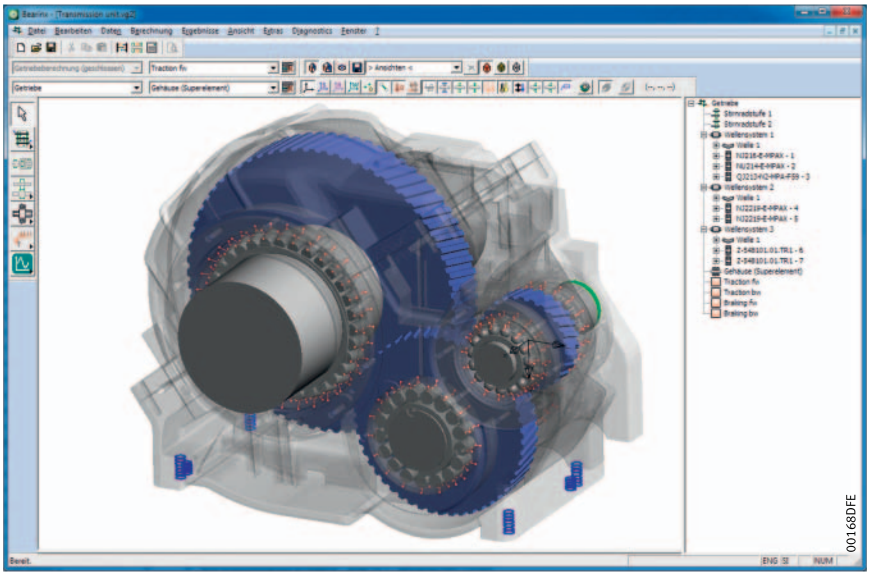

Figure 4: BEARINX gearbox model with elastic environment

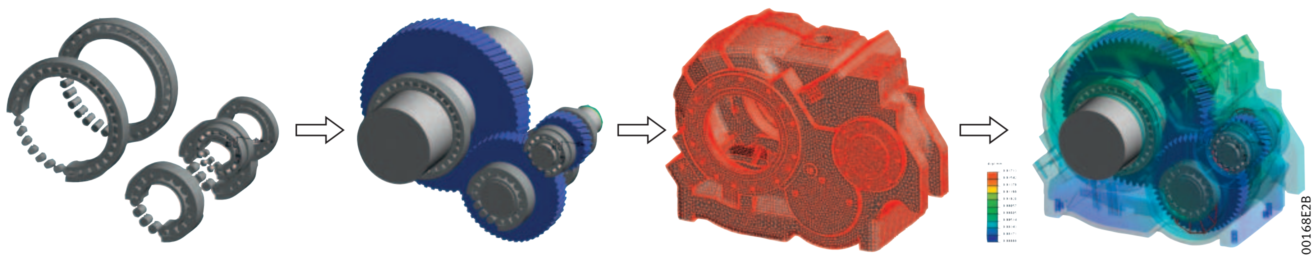

Figure 5: Generation of the calculation model including free bodies and shafts

3D tooth contact

In addition to the simplified modelling options for spur gear sets, the “3D tooth contact” calculation module is also available in the coupled transmission calculation, thus permitting detailed mapping and analysis of the load distribution across the entire tooth width, with the inclusion of through-rolling.

The 3D tooth contact takes account of both the macrogeometry and microgeometry at the tooth flank and extends to the influence of the gear profile, i.e. the clearance between the flanks. Corrections to the microgeometry can be defined for the transverse profile, the flank surfaces, the flank lines and for various profile deviations.

The contact stiffness is determined according to Hertz (non-linear) and the stiffness of the tooth and mesh according to Weber and Banaschek.

The calculation module in the coupled transmission calculation takes account of the complex interaction between bearing load distribution and load distribution at tooth contact. Operating clearance, displacement and tilting of the bearing affect the load distribution at tooth contact. Conversely, the load distribution at tooth contact affects the load distribution of the bearing, whereby deflection of the shaft must be taken into consideration in both directions.

Results for 3D tooth contact

The load carrying capacity of the tooth set, flank pressures, tooth root stresses, transmission deviations and friction losses are, for example, calculated and outputted in the results document.

By way of example, the resulting pressures at the tooth flanks are visualised in an easily understood 3D representation.

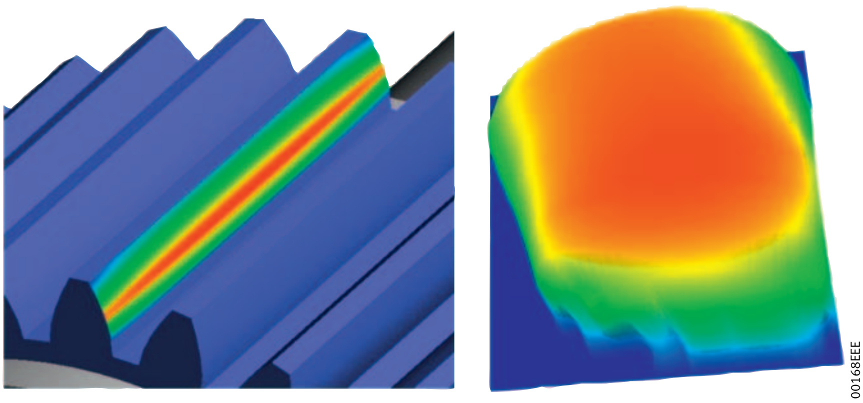

Figure 6: Spur gear set with 3D tooth contact

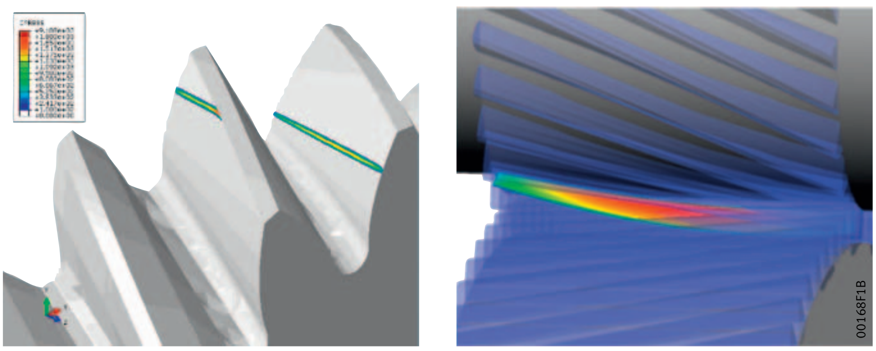

Figure 7: 3D tooth contact with engagement

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