Design of gearbox bearing arrangements using BEARINX®
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With this program, it is possible to model complete gearboxes quickly and without errors, taking account of important influencing factors such as elasticities and deformations. This gives significant reductions in development time and cost. Calculation and simulation lead to better systems understanding, which means that critical points can be identified and eliminated at an early stage. Furthermore, the validated models and methods increase the reliability of achieving precise design of the gearbox. BEARINX® is software developed by the Schaeffler Group and has been undergoing continuous development and verification over many years. It can be easily used on a Windows 3D interface and is available in multiple languages, allowing application worldwide within the Schaeffler Group.

The calculation program

BEARINX® models the entire power flow in a gearbox and takes account of all loads, speeds and duty cycles applied as well as all the tooth types used. It also includes the gearbox shafts that may undergo elastic deformation under the stated loads and in accordance with the characteristics of the material used. With BEARINX®, the user can analyse the comparative stress occurring as well as the influence of tolerances.

As a further elastic element, the bearings are assessed by calculating the internal load distribution according to various life theories.

Detailed analysis –
from the gearbox to the rolling contact

1. Gearbox:
   Speeds and load data for all gearbox elements
An important role is played here by lubrication and contamination as well as displacement, tilting and operating clearance. A further criterion for assessing the bearings is the Hertzian pressure taking account of the precise contact profile.

Particular attention must be paid to any localised stress peaks and the hardness curve of the raceways. Due to the modular structure of BEARINX®, it is possible to investigate all these influences, starting from the complete gearbox model. A further useful function in BEARINX® is parametric analysis, through which it is possible to identify the influences and interrelationships (for example, how the rating life depends on the operating clearance). Semi-automatic optimisation of various criteria is also possible.

Further analysis

In addition to these influences which are taken into account as standard, it may be necessary to carry out further analysis. For example, the elastic deformation of the gearbox housing can have a significant influence on the bearing life. By means of coupling the BEARINX® calculation and FEM calculation of the housing, the rigidity of the housing is included in the analysis. In addition to static assessment of the gearbox the Schaeffler Group performs computer modelling of dynamic effects within the bearing and the shafts. The results of such investigations include, for example, frictional torques, time-dependent loads on the cages and critical speeds for the shafts.

The Schaeffler Group also carries out complete FEM calculations that allow comprehensive consideration of all boundary conditions. The underlying knowledge of relationships and influences in the rolling contact is the basis for almost all the analytical methods presented.

Customer versions of BEARINX®

The targeted provision of calculation software allows our customers to benefit from the know-how of the Schaeffler Group.

Figure 2: BEARINX® customer version for the design of gearbox bearing arrangements

2. Shaft system:
   Shaft deformations, cross-sectional values and comparative stresses

3. Bearing:
   Internal load distribution, static safety factor and rating life
In addition to the technically qualified advisory service provided by our External Sales Engineers and Application Engineers, all customers have free access to our electronic catalogue medias® on the Internet.

Furthermore, selected customers and long-standing development partners receive a special customer version of BEARINX®.

With BEARINX®-VIP, the customer can carry out preliminary design himself on all bearing arrangements in a complete gearbox. This has the effect of significantly speeding up the final processing by the Engineering Service of the Schaeffler Group. The introduction of BEARINX®-VIP is implemented within the framework of a seminar lasting a number of days. The conditions of use are regulated by a contractual agreement.

**Examples**

Figure 1 shows the BEARINX® calculation model for the planetary gear sets in a modern automatic gearbox with seven speed stages plus a reverse gear. Figure 3 shows the gearbox model for a travel drive used in various applications.

It has two speed stages generated by the planetary wheel set. The power flow and the directions of rotation are shown as animations. With the aid of BEARINX®, the arrangement of the shafts was optimised and the bearing rating life was increased for all applications.

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4. **Rolling contact:**

Hertzian pressure of a rolling element

4. **Rolling contact:**

Requisite hardness curve in the material
Figure 4 shows the calculation of a wind turbine power train with the housing and adjacent construction in BEARINX®.

Figure 5 shows a mechanical/hydraulic tractor gearbox in which variable portions of the total power are transmitted by mechanical and hydraulic means.

For modelling, it is particularly important to include the loads generated by the hydraulic units in the complete model. This requires intensive co-operation with the customer.

**Schaeffler Group, your expert partner in development**

The Schaeffler Group has more than 70,000 employees at more than 180 locations worldwide and is one of the leading rolling bearing manufacturers and automotive suppliers. Schaeffler AG develops and manufactures precision products for everything that moves.

The Industrial Division supplies rolling bearing and plain bearing solutions and linear and direct drive technology under the INA and FAG brands for around 60 different industrial sectors via its worldwide organization with market proximity and application support service.
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