Calculation Service for Rolling Bearings

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Rolling bearings are sophisticated, precise machine parts that provide exceptional load bearing capacity (Figure 1). Their proper use requires a precise analysis of the load distribution within the entire elastic system. Manufacturers of rolling bearings have developed programs for this purpose, and these are used to help customers during the design process.

1 Rolling bearings have requirements

The best rolling bearings function smoothly in the best machine only if the two are adapted to each other properly. How can this be done?

Rolling bearing manufacturers can provide the answer to this question: They supply more than just a product. They also advise design engineers on the right choice and the proper assembly. To introduce the full range of rolling bearing products, manufacturers provide their expertise on CD-ROM or on the Internet [1, 2]. Additionally, the rolling bearing manufacturer’s consulting engineer works closely with the design engineer, making use of advanced calculation systems that run on fast computers. The demands placed on services are high. The primary target areas include:

- modeling of the elastic shaft/bearing housing structure
- determining load distribution in the non-linear system
- converting load-bearing performance to a rating life prediction
- taking all operating conditions and the loading conditions into account
- quickly identifying and implementing optimization measures
- providing professional evaluation, and documenting the proposed solution

These are the basic technical requirements. This calculation service must also be properly integrated into the design process. Steps designed to decrease design time are essential for gaining a competitive edge in terms of quality and a timely market presence.

Is the calculation service up to this challenge? A real-life example will provide an answer to this question below.
2 The manufacturer has the right tool

When a customer of the rolling bearing manufacturer INA Wälzlager Schaeffler oHG needs advice on a new bearing design, he/she contacts the local INA engineering service and discusses the design with an experienced consulting engineer. General problems, technical data and the boundary conditions required for the rolling bearing analysis are discussed. The design is then simulated on the computer, and calculations are performed. The INA consulting engineer is well equipped for this task. He/she uses the BEARINX® program - a new development from the experts at INA. The program combines many years of experience with the latest programming techniques. Once the program has been started, a look at the screen will convince the user that this program is highly specialized for rolling bearing analysis. It allows complete designs to be calculated for arrangements calling for both rolling bearings and linear guidance systems. A clearly structured Windows interface provides a user friendly work environment.

3 The model appears on screen

Calculation starts with modeling. The consulting engineer uses the information provided by the customer and describes the geometry and operating data for the design. Taking gears as an example, the following steps are performed (Figs. 2 and 3):
- description of the power flow
- definition of gear elements
- assignment of operating data
- determination of shaft geometry
- positioning of bearings

After the data has been entered, data for bearing geometry are read from a database, and standardized options for mounting and the choice of material and lubricant are proposed. The program’s most helpful asset though is that it displays almost immediately all geometric information on the screen in the form of a virtual 3-D model of the gear including the bearing supports (Fig. 4). The consulting engineer can recognize right away whether the shaft is properly aligned and the bearing correctly positioned. By simply turning, moving, activating or deactivating the image, even extremely complex gear designs involving nested planetary gears can be depicted clearly and in great detail. Applications involving linear motion can also be dealt with using the software. One example that can be mentioned here is the linear guidance system in a machine tool (Fig. 5). This calculation model greatly facilitates communication between the consulting engineer and the customer. It ensures that both parties refer to the same model, one that is based on the same assumptions and preconditions. This saves a great deal of time with follow up calls between the parties.
4 Calculation details
After the model has been completely described, the consulting engineer can perform calculations. Now the full capabilities of BEARINX® can really be put to the test. The model displayed on the screen is accompanied by a detailed system of equations for performing calculations. The rolling bearings are incorporated into the overall structure as intensely statically indeterminate non-linear subsystems. Other quantities that must be taken into consideration during the calculation include:
- operating clearance or preload
- load-dependent pressure angle displacements for ball bearings
- the profiles of rollers and roller races for cylindrical and needle roller bearings
- the effect of undercutting in contact mating
- tilting and edge stresses
- mounting conditions and production tolerances for bearing seats and mounting defects
- lubrication conditions and contamination
- elasticity values for shafts and tables
- housing and ambient elasticity values (machine bed)

These calculations are performed by powerful computers available at all calculation support stations in the INA engineering service. Access to a central network is not required. This independence makes the calculation service fast and flexible. Calculations take only a few minutes, even for complex models.

The consulting engineer reviews the results of the calculation which appears on the screen. Many options are available. Tables and graphics can be displayed for the following topics:

Gears:
- load parameters for all types of operations
- the tooth, belt, and chain forces of the gear steps
- centrifugal force through planetary wheels

Shafts:
- deformation and sectional dimensions
- axial, bending, and torsional stresses as well as equivalent stress
- stress increases due to notches
- critical speeds for spindles having rolling bearing supports

Bearings:
- internal load distribution
- rating life according to standardized procedures and latest rating life theory

Contact mating:
- contact pressure, stresses, and actual and required hardness curves
- pressure ellipses and their examination (taking rib geometries into account)

The consulting engineer starts with the total service life of the rolling bearing. The computed prediction is then compared with customer requirements. If the discrepancies are unacceptable, he/she takes a look at the details by following up on the power flow from the gear teeth through the shaft. The load distribution for all rolling elements of the bearing support, right down to the individual contacts (Fig. 6) can then be analyzed. One or more critical bearings positions are quickly identified. He/she then turns to an extraordinary BEARINX® feature: parametric analysis. This analysis makes it possible to change key influencing variables automatically, such as bearing clearance and the position of the load application in a specified value range. The results help the consulting engineer understand how all of these parameters interact. Recommendations for optimizing the design can then be made. This is the last step in the calculation process. The engineer summarizes all the results (Fig. 7) and meets with the customer.
5  Creativity based on experience

At a joint meeting, the development team presents what it has learned from the rolling bearing analysis (Fig. 8). Real technology comes to life from the results of these theoretical calculations. The INA consulting service has made a contribution that is competent, in the right place at the right time, and the results can be duplicated for safety concerns.

6  Future Prospects

New programs such as BEARINX® can provide effective support for rolling bearing design during machine construction. Yet this development goes even beyond that. Models are being refined, and the design phase and consultation with the customer are becoming increasingly intertwined in the overall process. Future methods employed by the rolling bearing manufacturer in this regard must remain the subject of a future article.

Bibliography:


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