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KISSsoft Tutorial: Roller Bearings

1 Task

1.1 General

In the KISSsoft system, roller bearings are usually analyzed as part of the shaft analysis process. The calculation of roller bearings that is also available in the KISSsoft software is not discussed here. In this case, roller bearings are not viewed separately from their environment. Instead, they are treated as part of a system that consists of a shaft, external load and bearing. The great advantage of this approach is that the calculation of loads placed on the roller bearing is performed automatically and therefore is less prone to user errors. The same applies to statically over-determined systems. You can also analyze individual bearings that are subject to a known load. For more information about this, see section 2.4.

1.2 Task

The multiple bearings shown in the example in Figure 1.1 are to be analyzed. The system is statically over-determined: The first bearing is positioned within the shaft and the third bearing is an axial bearing supported on its right-hand side. The other bearings are not subject to axial forces.

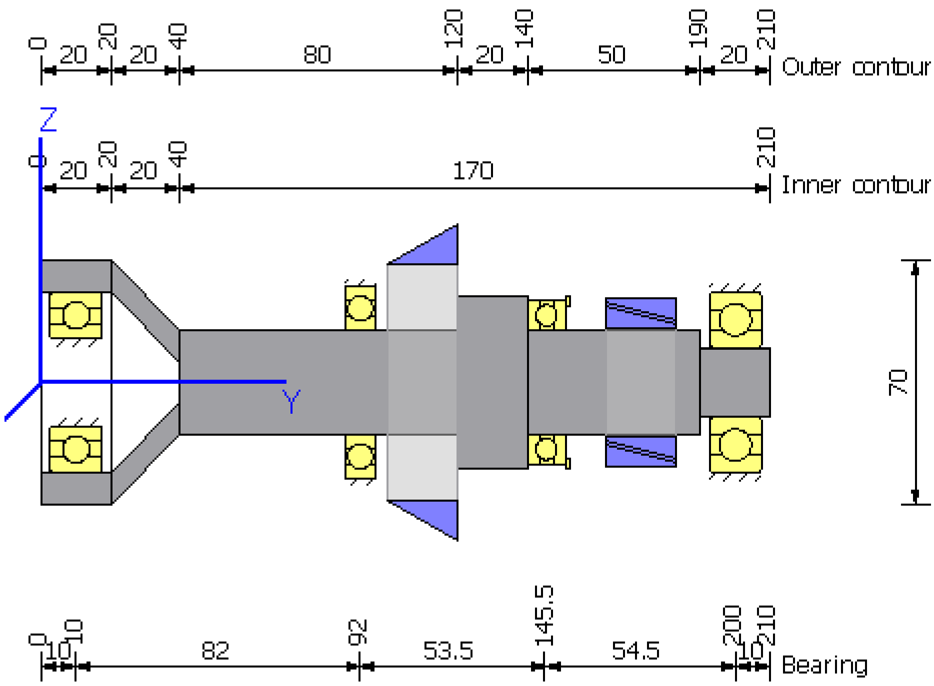


Figure 1.1 Example bearings for this tutorial

Position y [mm]	*Type*	*Type*	*Type of bearing*	*Dimensions*
10	Koyo 6205	Deep groove ball bearing (single row)	Non-locating bearing	d=25 mm D=52 mm
92	Koyo 16006	Deep groove ball bearing (single row)	Non-locating bearing	d=30 mm D=55 mm
145	Koyo 51106	Axial groove ball bearing (single row)	Axial bearing, adjusted on right side →	d=30 mm D=47 mm
200	Koyo 6304	Deep groove ball bearing (single row)	Non-locating bearing	d=20 mm D=52 mm

Table 1.1 Bearing types and positions

1.3 Modeling the system

First of all, model the shaft geometry as shown in Figure 1.1 (see also Tutorial 006: Shaft Editor). In a second step, define the two force elements (bevel gear and cylindrical gear) with the data shown in Table 1.2.

Position [mm]	*Type*	*Angle*		*Pitch diameter [mm]*	*Width [mm]*	*Power [kW]*	*Direction*
		Meshing [°]	*Helix [°]*				
110	Bevel gear	20	0	80	20	30	driven
173	Cylindrical gear	20	15	40	20	30	driving

Table 1.2 Loads

The reference cone angle of the bevel gear is δ=30°.

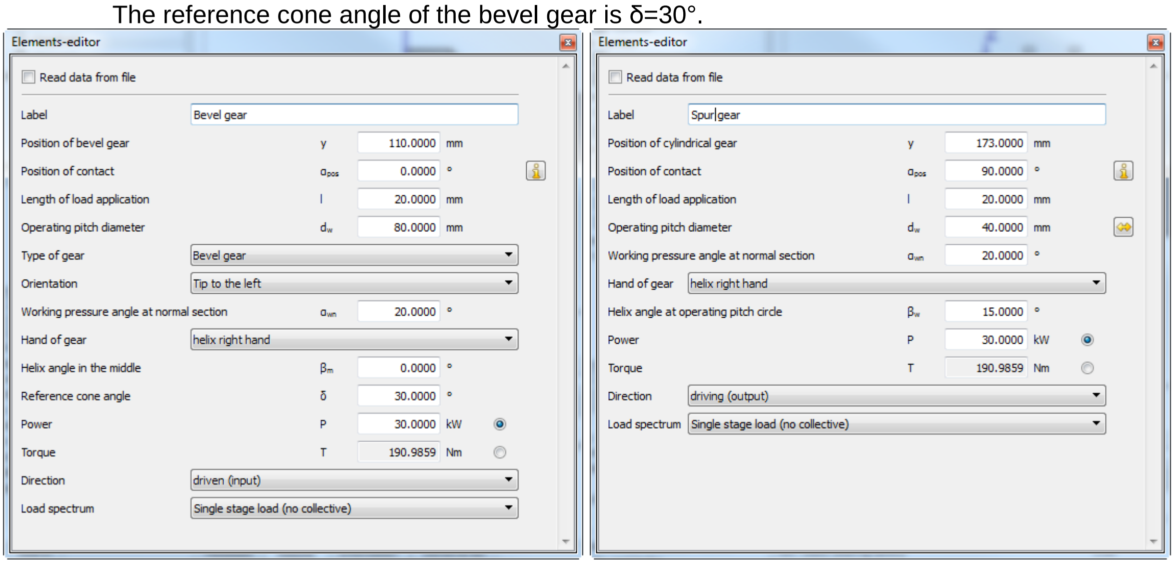


Figure 1.2 Defining the force elements

After this, the following system should be available in the graphical Shaft editor:

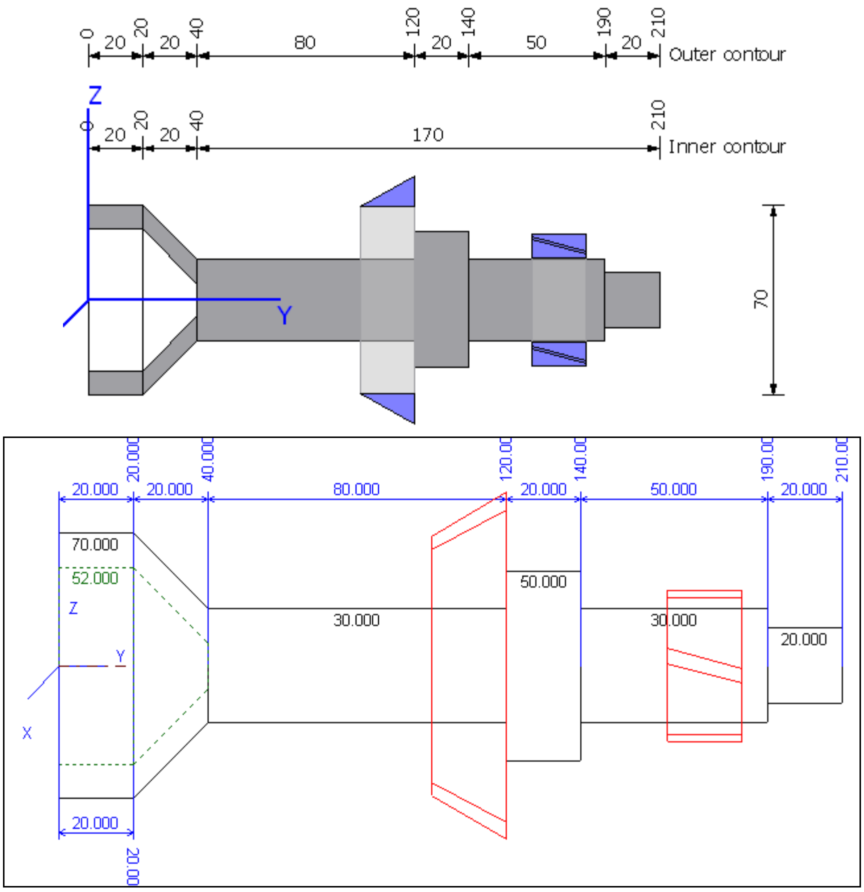


Figure 1.3 Geometry of the shaft and force elements

1.4 Adding bearings

In the **"Elements-tree"**, right-hand mouse click on "Bearing" and then select the **"Roller bearing"** option from the context menu:

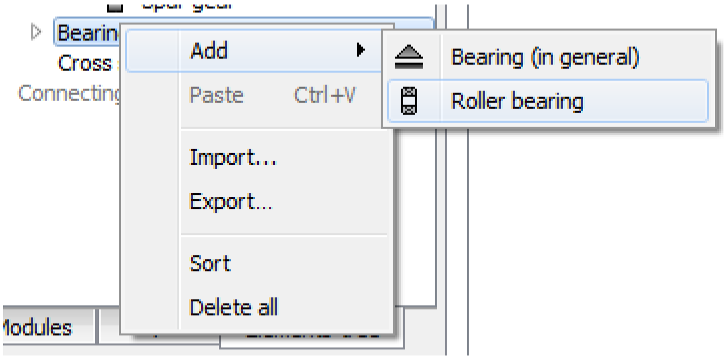


Figure 1.4 "Elements-tree" with the context menu for the "Bearing" group

As shown in Figure 1.4, the **"Elements-editor"** lists the most important bearing parameters. To position the bearing at y=10 mm within the shaft, click the radio button to the right of the **"External diameter"** input field. From the drop-down list with the same name, select the entry 52.00 mm and select **"Type Koyo 6205 (d=25 mm, D=52 mm, B=15 mm)"** from the drop-down list for the label. Then click the Sizing button to the right of the drop-down lists for the Inner diameter or External diameter to modify the relevant diameter to the shaft's geometry at the specified position.

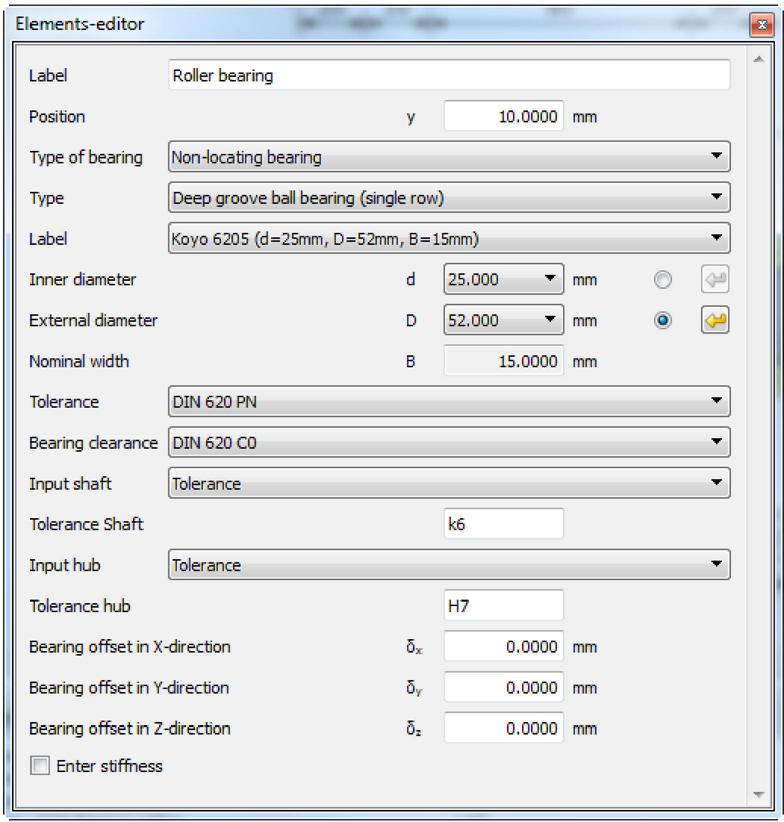
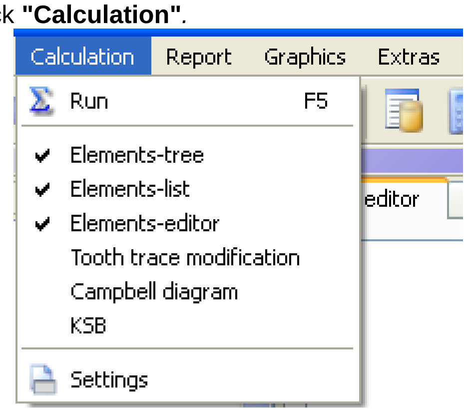


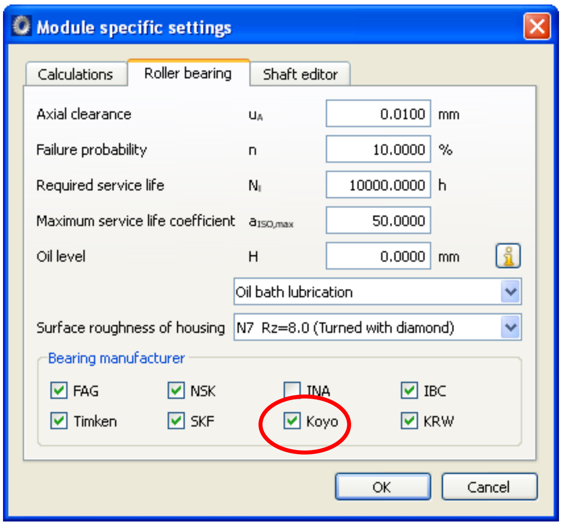
Figure 1.5 "Elements-editor" with roller bearing parameters

If this bearing is not present in the list, check that bearings produced by Koyo have been included in the list of available bearings. To do this:

1. In the menu bar, click **"Calculation"**.



2. There, select **"Settings"**. This opens the **"Module specific settings"** window.
3. In the "Bearing manufacturers" group you can now select the companies you want to include in the list of available bearing manufacturers. If necessary, activate "Koyo" by clicking the checkbox of the same name.



4. Click OK to close the window.

The system comprising shaft, loads and bearings should now look like the one shown in Figure 1.1.

1.5 Roller bearing calculation

Start the shaft calculation by clicking on Σ in the tool bar or else press F5 to run the roller bearing calculation. You can see a quick overview of the results in the **"Results"** window (see Figure 1.6). Please note that you must enter the bearing names manually.

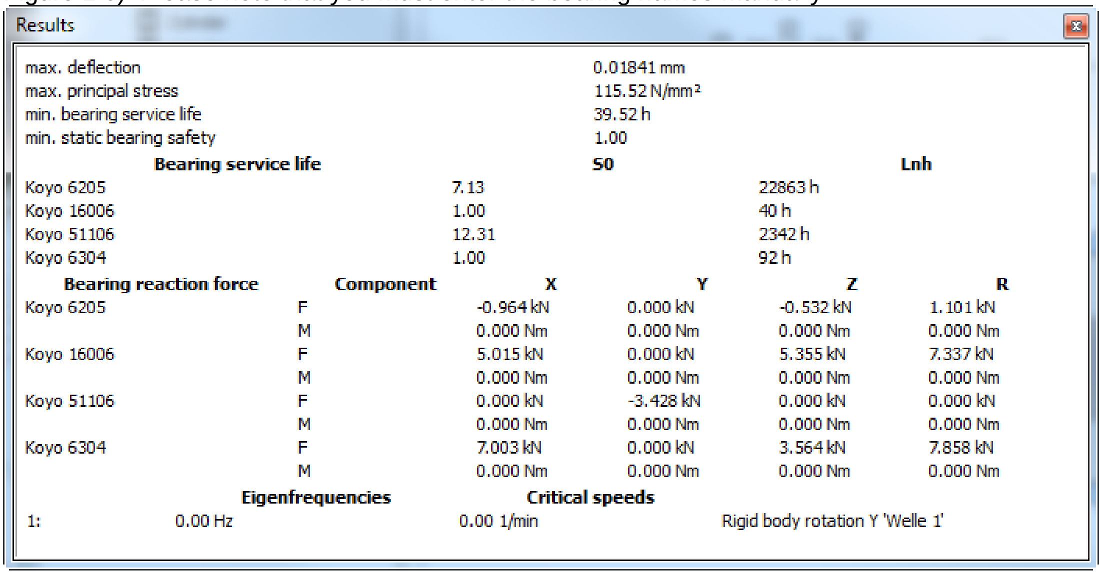


Figure 1.6 "Results" window with a quick overview of the roller bearing analysis

In the "Bearing service life" list you will now see the following values for each bearing:

S0	Static safety/Static load number (C_0) in [h]
Lnh	Nominal service life in [h]
Lnmh	Modified nominal service life in [h][1]
Lnrh	Nominal service life as specified in ISO 281: 2007-02 supplementary sheet 4 in [h][2]
Lnmrh	Modified nominal service life as specified in ISO 281: 2007-02 supplementary sheet 4 in [h]5[5]

1 If you select "*Enhanced bearing service life according to ISO 281*" in *the "Basic data" tab"*

2 If you select "*Roller bearing service life according to ISO/TS 16281*" in the drop-down list for *Roller bearing* in the *"Basic data"* tab.

The Bearing reaction force list shows the reaction forces and moments for each component (see Figure 1.7). Here the F_y component refers to the axial force, and the M_y component refers to the torque.

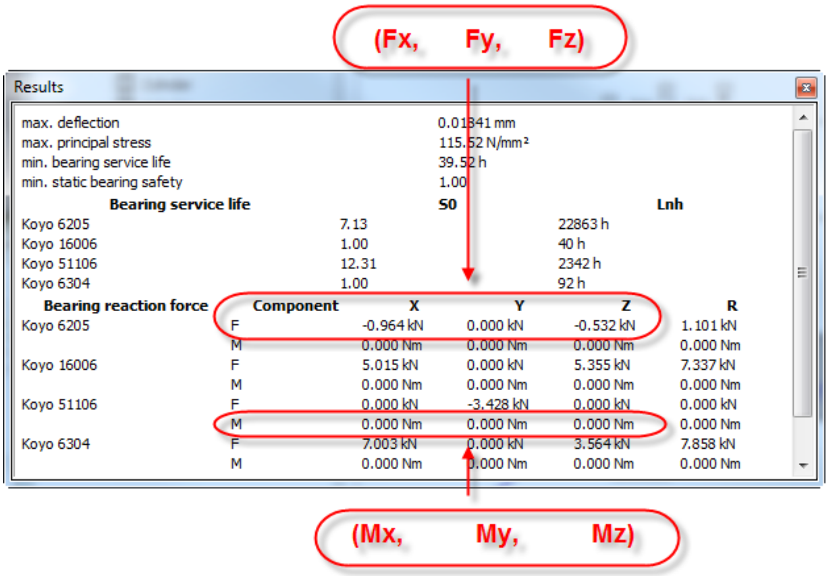


Figure 1.7 Components of bearing reaction forces and moments

1.6 Settings

Some settings have a direct effect on roller bearing analysis. These parameters are listed below.

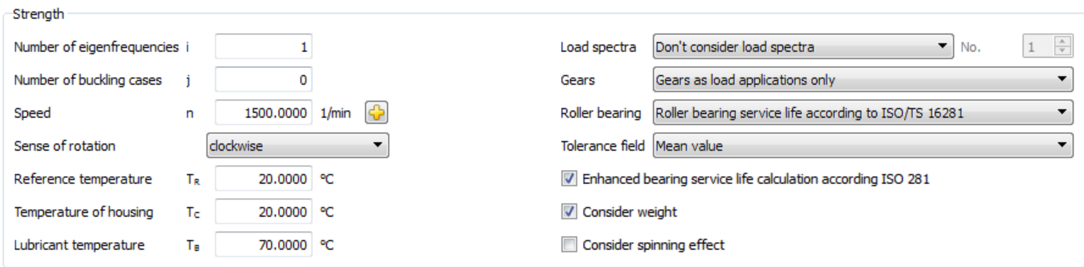


Figure 1.8 "Strength" group in the "Basic data" tab with values that have a direct effect on roller bearing analysis

Speed: the higher the speed, the shorter the service life in [h].

Sense of rotation: possibly changes the sign of axial load. For example, this happens when helical gears are used. This changes the effect of load on the bearing.

Lubricant temperature: a higher lubricant temperature reduces the service life coefficient.

Roller bearing: in the Roller bearing drop-down list, you can select one of the four following options:

"Roller bearings, classical calculation (contact angle not considered)"

Roller bearings primarily place constraints on the degree of freedom of movement found in displacement and/or rotation, which is why they are modeled in this way when you select this option. You can enter any value as the stiffnesses for translation and rotation, no matter what type or size of bearing is involved. Any correlations between axial and radial forces (i.e. as in tapered roller bearings) are ignored.

"Roller bearings, classical calculation (contact angle considered)"

The same applies as described in Point 1, but with the difference that the correlation between axial and radial forces, such as shown by tapered roller bearings, is included in the calculation.

"Roller bearing stiffness calculated from inner geometry"

This takes into account internal roller bearing data, such as roller diameter, and race radius, to determine bearing stiffness. If no detailed data is available, it will be estimated on the basis of the size and type of bearing.

"Roller bearing service life according to ISO/TS 16281 supplementary sheet 4"

Service life calculation taking into account internal bearing geometry. The results are displayed in the **"Results"** window with Lnrh or Lnmrh.

"Enhanced bearing service life calculation according to ISO 281"

If a flag is set in this checkbox, the influence of the lubricant is taken into consideration in the bearing service life calculation. The results are displayed in the **"Results"** window with Lnmh or Lnmrh.

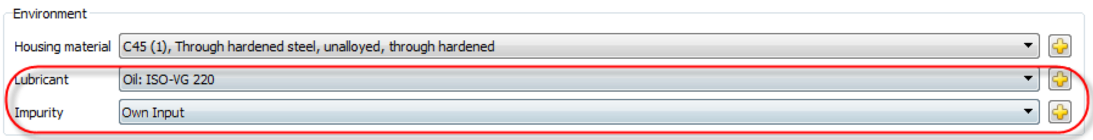


Figure 1.9 The "**Material and lubrication** " group in the "Basic data" tab with lubrication parameters

Lubricant: the choice of the type of lubricant affects the service life coefficient.

Impurity: the impurity coefficient e_C affects the service life coefficient.

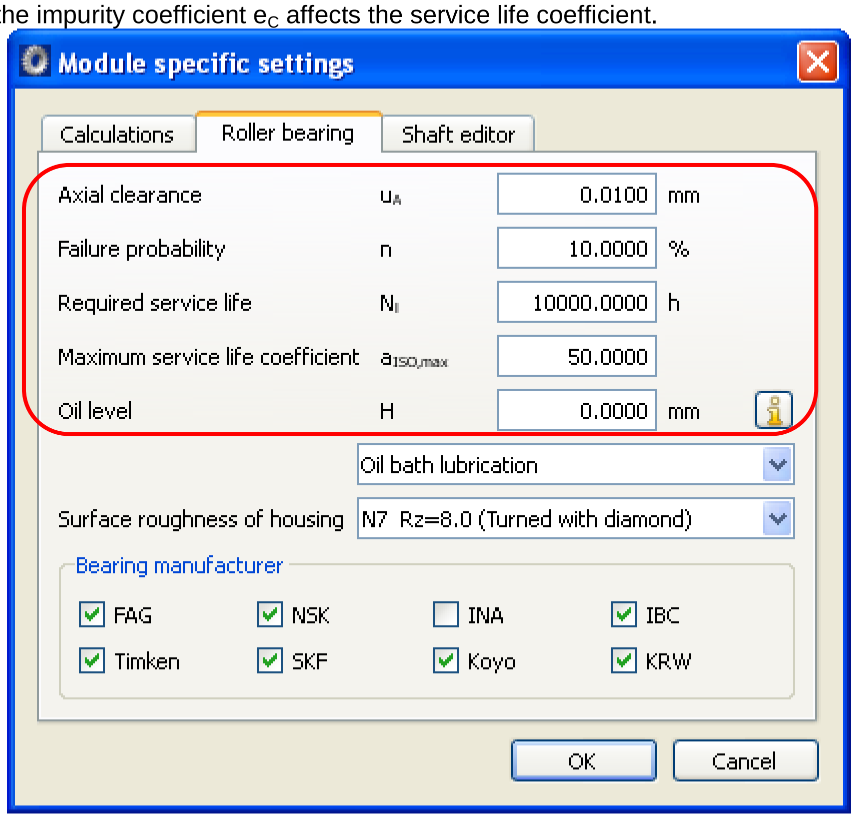


Figure 1.10 The "**Module specific settings**" window, with "Roller bearing" tab and roller bearing parameters

Failure probability: a_1 is used in the roller bearing service life calculation. By default it is set to 10%, but can be altered here.

Required service life: this specifies the required service life in the roller bearing calculation. However, this value does not actually affect the roller bearing calculation. If the calculated service life drops below the required service life, the program issues a warning message.

Maximum service life coefficient: in this input field you define the upper limit for the service life coefficient a_{ISO}.

The default value defined in ISO 281:2007-2 is a_{ISO}=50.

2 Further calculations

2.1 Calculation with Load Spectra

In the **"Basic data"** tab, in the **drop-down list** for load spectra, you can specify whether the load spectra defined when the shaft was modeled (e.g. cylindrical gear) are to be taken into account (see Figure).

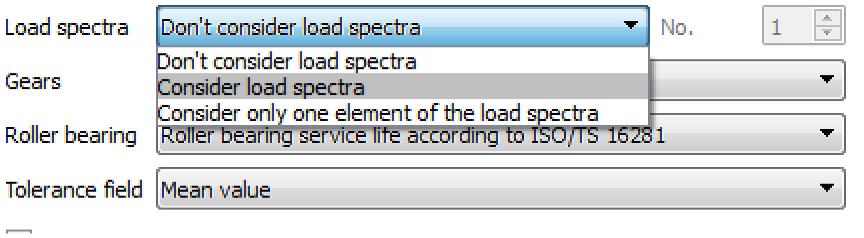


Figure 2.1 Drop-down list for ***load spectra*** in ***"Basic data"***

To do this, select the **"Consider load spectra"** option.

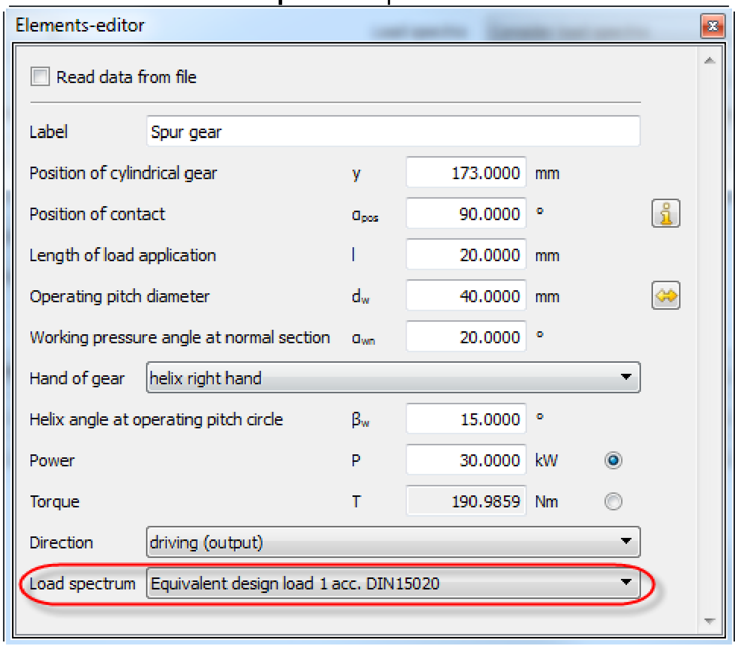


Figure 2.2 Example that takes a load spectrum into consideration for the force element *cylindrical gear*

To add your own load spectrum entry to the database, follow these steps:

1. Open the database tool via **"Extras"→ "Database tool"**.
2. At the prompt (for authorization to write data to the database), click Yes. This opens the database tool window.
3. Here, select the Load spectra table and click Edit. The database tool window now shows a list of the entries in the LASTKOLL table.
4. Here you have two options for how to define your own load spectrum. Either select a data record from the list and change it, or generate an entirely new data record. If you decide to use the first option, select an existing data record from the list and then click the button.
5. If you want to create a completely new entry, click the button without first selecting an existing entry.
6. In both cases, the **"Create a new entry"** dialog window appears. Here you can input any name for your load spectrum in the **"Label"** input field.

7. Here you can either enter the actual load spectrum directly, in the table in the lower part of the window, or input the name of the file to be used for the load spectrum in the **"File name"** input field. The file name must have the **dat** file extension, e.g. **own load spectra.dat** and be saved to the <KISSsoft installation folder>/DAT folder.
8. If a file with the same name is already present, click the **"Edit button"** to start an editor with which you can edit the file contents.

In each case you see the frequency, torque or torque factor and speed factor in a line, separated by tab spaces. In Figure you see the "myLoadSpectrum.dat**"** file as it appears in the Windows Notepad editor.

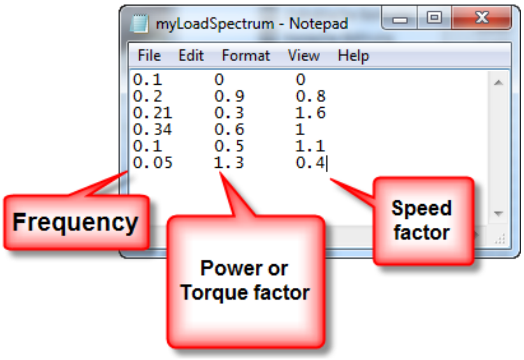


Figure 2.3 Example of a file with your own load spectrum data The values are displayed in a line, each separated by a tab

The values in this file are multipliers of the reference values **"Power"** or **"Torque"** and **"Speed"**.

Example:

Let us suppose that you have entered the following reference values in the Basic data input window or

in the Elements-editor for the cylindrical gear force element:

P = 115kW, n = 1500U/min

In addition, you then decide to input multipliers for power and not for torque (see Figure).

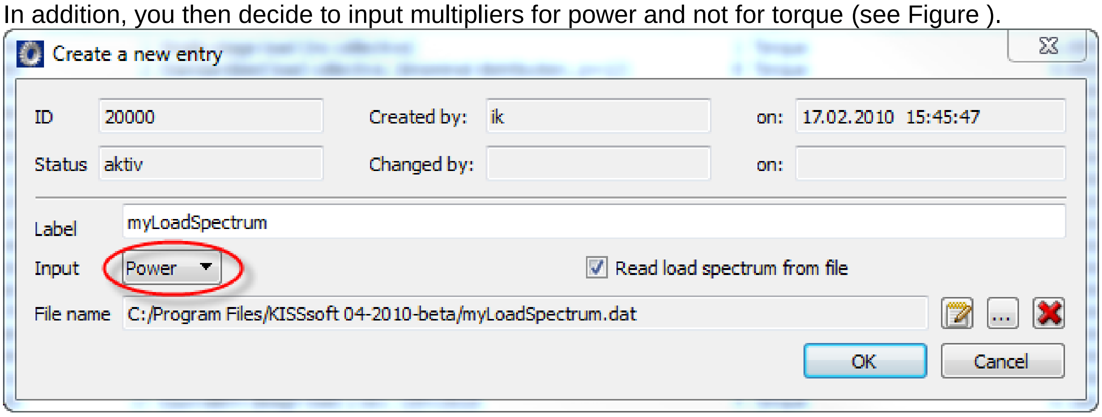


Figure 2.4 "Create a new entry" window with the efficiency factor (power) selected

In the Input drop-down list you can specify whether you want to multiply the power or the torque with the values of the load spectrum. For the load spectrum shown in Figure you then see the absolute values, as displayed in Table 2.1:

Frequency [%]	*Power [kW]*	*Speed [1/min]*
10	0	0
20	103.5	1200
21	34.5	2400
34	69	1500
10	57.5	1650
5	149.5	600

Table 2.1 Example of a load spectrum

2.2 Calculating the thermally admissible operating speed limit

The method used to determine the thermally admissible reference speed is described in DIN 732-2 (draft). This limit can differ greatly from other permitted service speeds because the reference conditions only apply to fully defined cases. In order to define the thermally admissible service speed, you must first define the reference thermal service speed for each case. This is the bearing-specific speed of rotation reached under predefined operating conditions such that the heat development (friction) balances the heat dissipation (through bearing contact and lubrication). Mechanical or kinematic criteria are not taken into account for this speed.

The reference values (temperatures, load, lubricant viscosity, reference face of the bearing etc.) have been fixed so that the reference speeds with either oil or grease lubricated bearings will result in identical values.

To open the "Thermally admissible service speed" window, first switch to the Roller bearings [W050] calculation module. To do this, activate the **"Module tree window"** in the upper right-hand window by clicking on the corresponding **"Modules"** tab (see Figure 2.5).

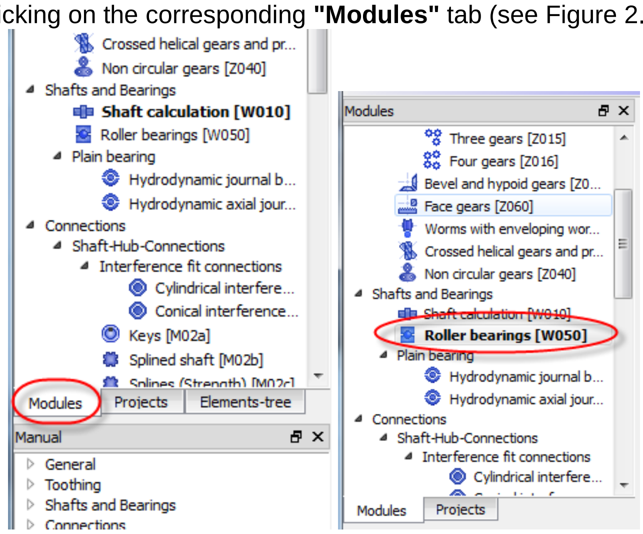


Figure 2.5 Switching to the "Roller bearings [W050]" calculation module

In the "Modules tree window" then double-click on Roller bearings [W050]. You can now input parameters for the calculation in KISSsoft in the Roller bearing calculation module in the Thermally admissible service speed input window. Open the **"Thermally permissible service speed"** input window by clicking the **"Calculation"→"Thermally permissible service speed"** menu (see Figure).

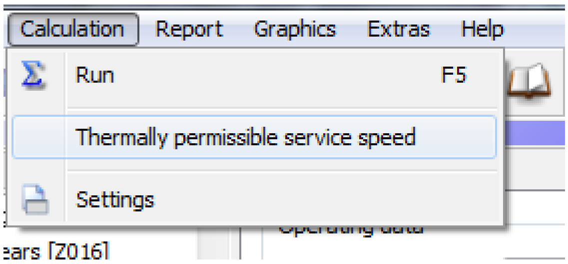


Figure 2.6 Activating the input window "***Thermally permissible service speed***"

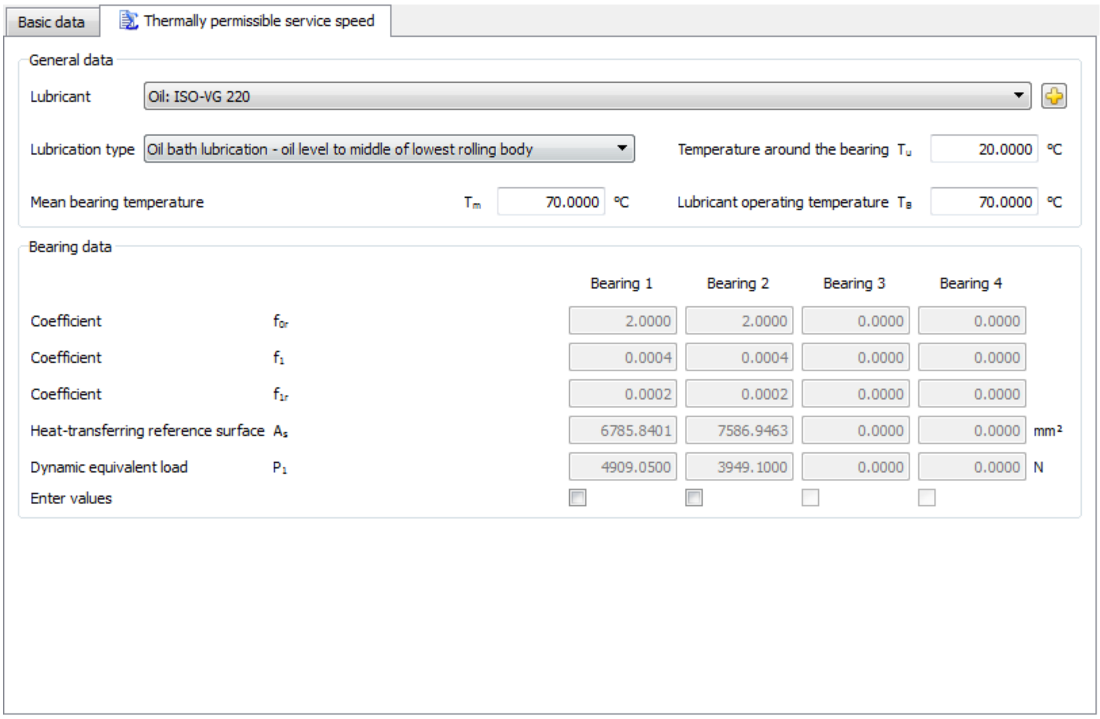


Figure 2.7 Thermally permissible service speed"

2.3 Extending the roller bearings database

Data for several thousand roller bearings (from Koyo, NSK, SKF or Timken) is already stored in the KISSsoft system. You can also add any missing bearing data to this database. To add a new bearing to the database, follow these steps:

1. Open the database tool via **"Extras"→"Database tool"**.
2. At the prompt (for authorization to write data to the database), click Yes. This opens the database tool window.
3. Here, from database W000, select the table of the corresponding roller bearing type, for example, description **"Deep groove ball bearing (single row)"**, table **"W05WNORM10"**. Then click **"Edit**". The database tool window now shows a list of the entries in the **"W05WNORM10"** *table.*
4. You now have two options for defining your own roller bearing. Either select a data record from the list and change it, or generate an entirely new data record. If you decide to use the first option, select an existing data record from the list and then click the button.
5. If you want to create a completely new entry, click the button without first selecting an existing entry.
6. In both cases, the "Create a new entry" dialog window appears. You can now input any name for your roller bearing in the "Bearing label" input field. There are two tabs available here for inputting bearing parameters, these are: **"Basic data"** and **"Inner geometry"**. Although "Basic data" is mandatory, you can input any values for inner geometry. If no inner geometry data is available, it is approximated based on the data entered in "Basic data".
7. Then click OK to confirm your entries. Then click "Save" to save your new entry, in the database tool window. Note that no message appears to tell you that you have saved the

file successfully. The roller bearing you have just added appears at the end of the list and has a sequential number >= 20000.

2.4 Calculating a single bearing with known loads

If you want to analyze a single bearing with a known load, you do not need to model an entire system that includes a shaft, loads and bearings. Instead, simply click on the **"Basic data"** tab to open a window with the same name.

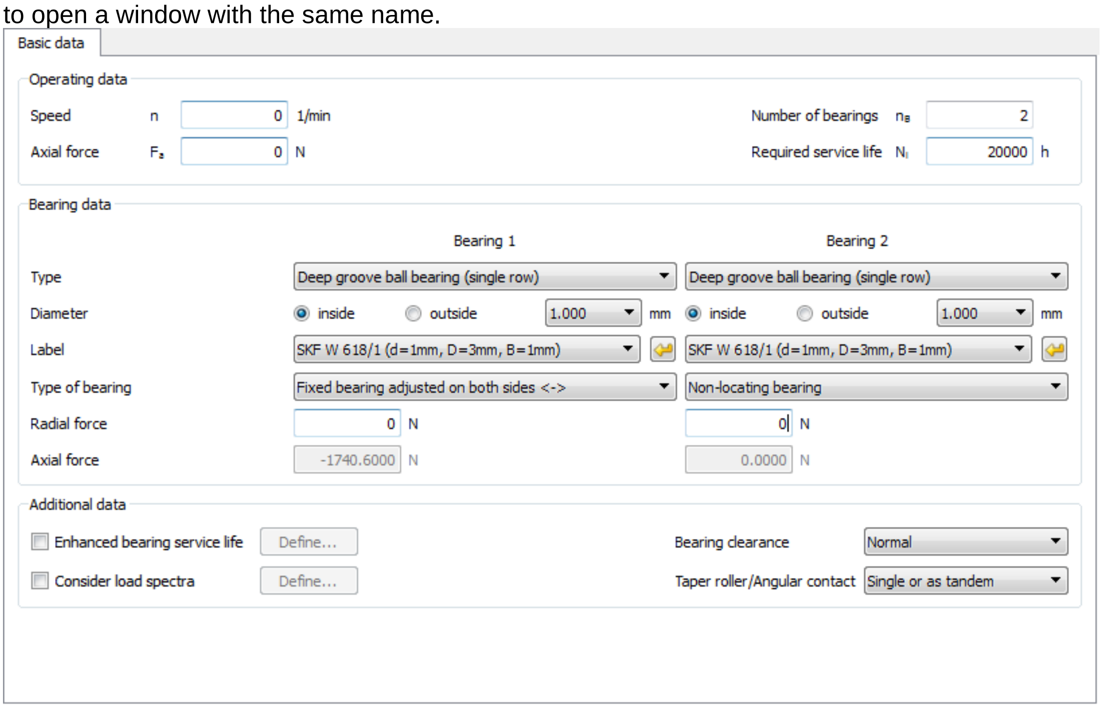


Figure 2.8 Active "Basic data" tab in the Roller bearing calculation module

Radial loads are defined for each bearing in the "Bearing data" group and axial force is predefined globally in the "Operating data" group. The distribution of axial force on the individual roller bearing depends on which type of axial support is selected for each bearing. To perform the calculation then either click Σ or press "F5".