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Tutorial Series

Rolling Bearing Analysis - Starter Basics First Results

Table of Contents

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1. Foreword

1.1 Aim of the tutorial

This starter tutorial for MESYS Rolling Bearing Calculation introduces the basic functions of the software and provides an initial impression of the capabilities of computational bearing analysis. It deliberately covers only those topics and settings that are necessary for getting started with the product and the associated exercises.

Please do not hesitate to contact MESYS if you have any questions when using the software.

1.2 Software Version

This tutorial was created with MESYS Rolling Bearing Analysis Version 12-2025.

1.3. Notes

- A blue arrow indicates a request to the reader.
- A green arrow indicates a conclusion or effect.

2. MESYS Rolling Bearing Analysis - strengths and possibilities

To get an idea of the possibilities of MESYS Rolling Bearing Analysis, we cordially invite you to visit the MESYS website at the specific address for Rolling Bearing Analysis.

Please also consult the corresponding articles for Rolling Bearing Analysis under Home/Products/Categories/Rolling Bearings as shown in Fig. 1:

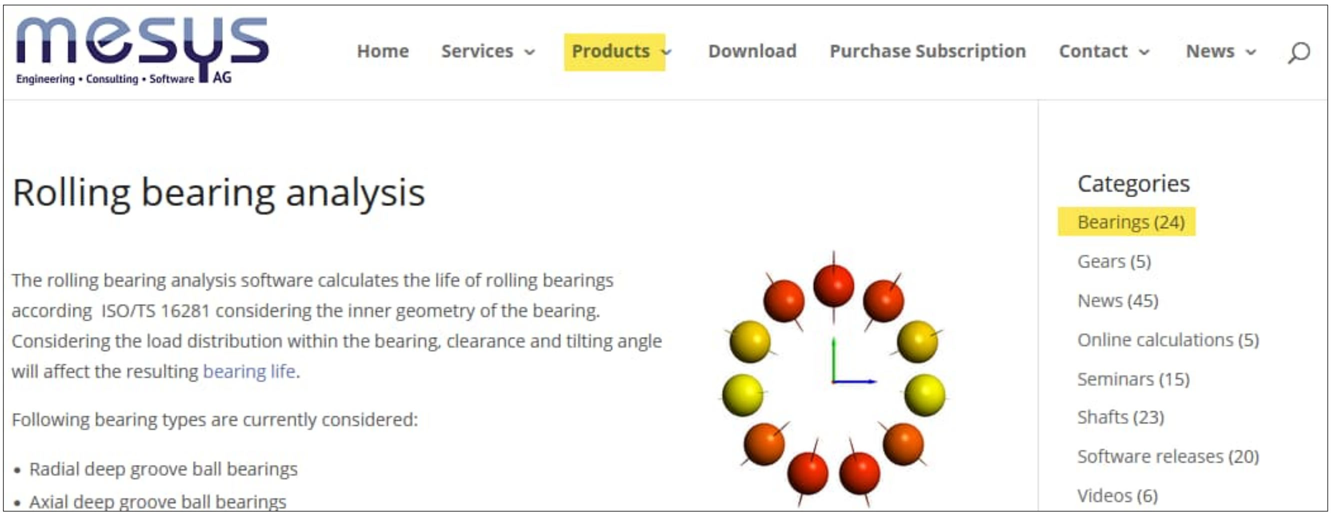
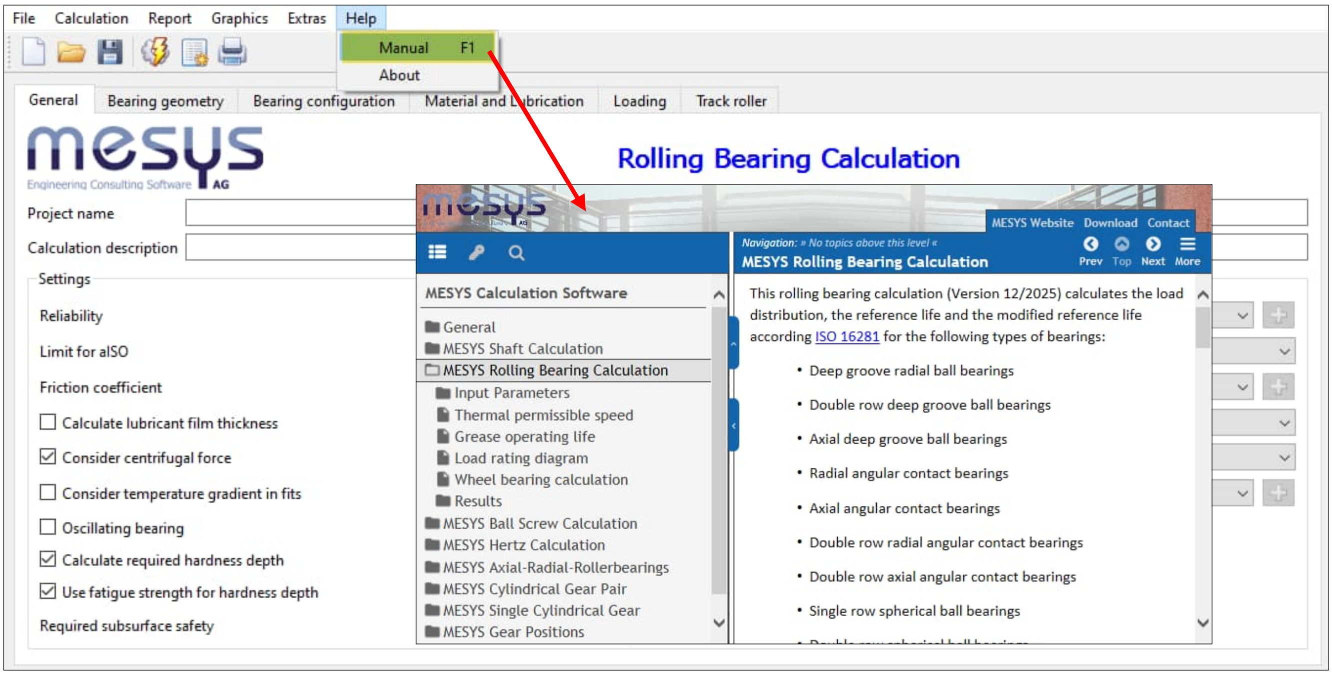


Figure 1

3. Software Manual

3.1 Manual online

Figure 2

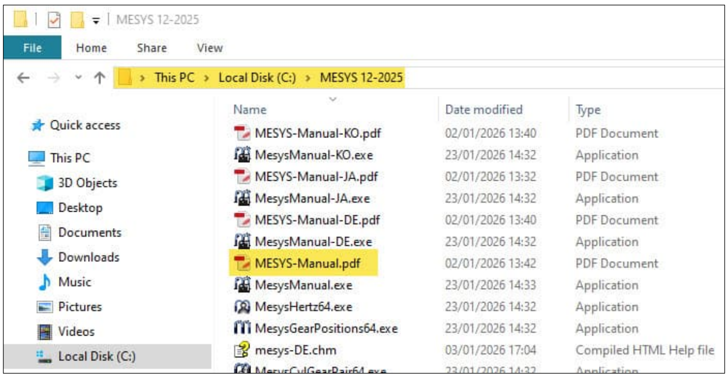


The Software Manual can be called up via the user interface by selecting the 'Help' menu under 'Manual F1':

You can also open the Software Manual locally at any time with position-specific content directly via your F1 keyboard.

3.2 Manual as PDF

You can also find the Software Manual in PDF format in the main languages in the MESYS installation directory (Fig. 3) or directly on the MESYS website under 'Downloads/General downloads'.



4. Calculation of rolling bearings

4.1 General

The MESYS Rolling Bearing Analysis software calculates the basic reference rating life and the modified reference rating life according to ISO 16281, considering the load distribution, as well as the basic rating life and modified rating life according to ISO 281 for currently 31 rolling bearing designs.

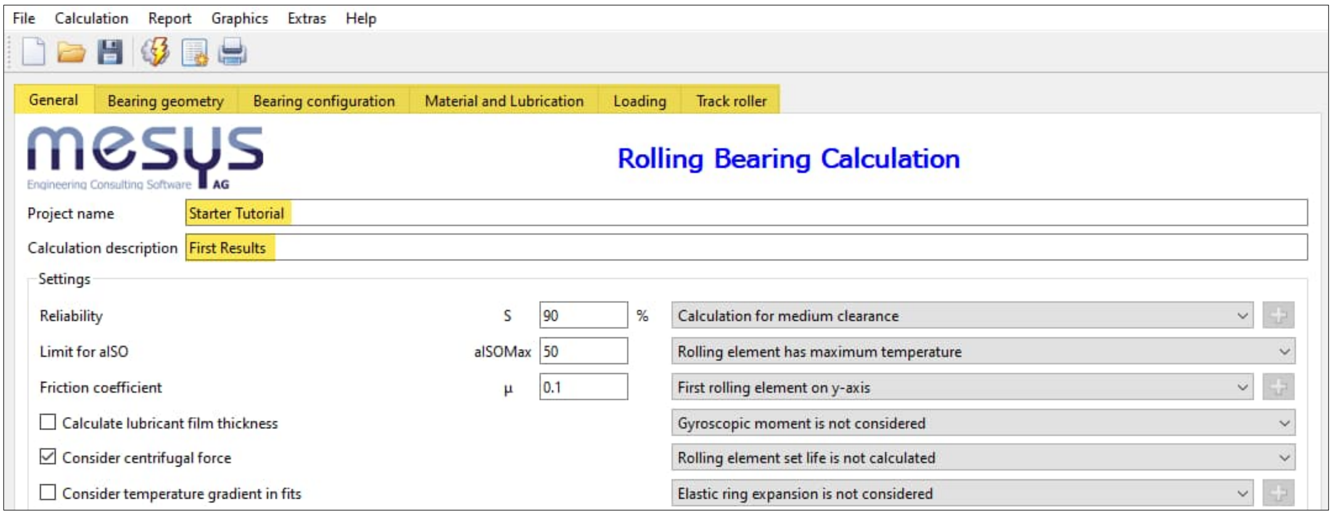
➡ Please start the MESYS Rolling Bearing Analysis software.

4.2 Menu functions

Not all menus consist of self-explanatory content. This tutorial will guide you through the relevant content and explanations as part of the tasks set and the input process.

After starting the software, the user interface is presented in 6 tabs: 'General', 'Bearing geometry', 'Bearing configuration', 'Material and lubrication', 'Loading' and 'Track roller'.

Figure 4



The 'General' tab offers you a wide range of possible settings. Due to the potential scope of this 'Starter Tutorial', it is not possible to go into all the functions of the software in detail. Please refer to the online Manual under 'Input Parameters' and the corresponding subchapters for further details.

We would like to transfer some calculation tasks to the software as part of an imaginary tutorial project.

➡ Choose a suitable name and description for the imaginary project as shown in Fig. 4.

Let's take a closer look at settings that are often used in practice using a common bearing type. Assume that the standard default settings at the start of the programme are a good starting point for the step-by-step approach to a standard rolling bearing calculation due to their widespread use.

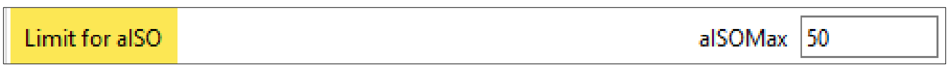
4.3 Settings under 'General'

4.3.1 Overview

This tutorial provides a simplified overview of the settings listed under 'General', which are either used here or important for comprehension. We will focus on the essential points and appreciate your understanding if we only touch on some functions briefly and have to omit others.

➡ For the time being, leave all settings as they are by default when you start the programme.

4.3.2 Factor aISO



The factor aISO 'modifies' the rating and reference life in such a way that a more realistic forecast for the actual service life of the rolling bearing is provided. A value of 1 corresponds to normal conditions, while values above 1 define favourable conditions. Formula 26 from ISO 281 defines the derivation of the bearing factor (f), fatigue limit load (Cu) and equivalent load (P) as follows:

$$a_{ISO} = f\left(\frac{e_C\, C_u}{P}, \kappa\right)$$

The factors eC (contamination) und κ (viscosity ratio) take into account the contamination and the condition of the lubrication.

ISO 281 limits this factor to aISO ≤ 50.

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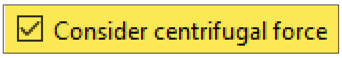
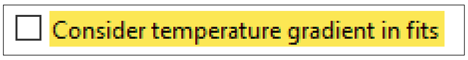
4.3.3 Centrifugal force



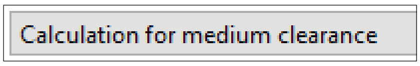
Taking centrifugal force into account increases the load on the outer ring and reduces the load on the inner ring. This leads to different pressure angles on the inner and outer ring and therefore to an increased bore to roll ratio.

4.3.4 Temperature gradient in fits



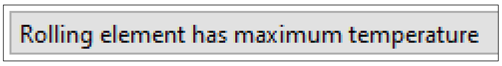
If the 'Consider temperature gradient in fits' option is activated, shaft and housing temperatures can be entered in addition to inner and outer ring temperatures. This is necessary if temperature gradients are to be taken into account. See also chapter 5.2.6.

4.3.5 Selection for clearance



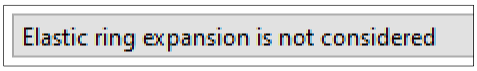
Either the minimum, minimum probable, medium, maximum probable, maximum or user-defined value from the underlying fit and nominal clearance tolerance spectrum can be used for the calculation.

4.3.6 Rolling element temperature



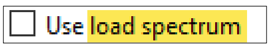
The rolling element temperature influences the resulting operating clearance. This can be set to ring temperature, averaged ring temperature or a temperature assigned by your own input.

4.3.7 Elastic ring expansion



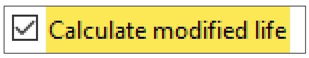
The expansion or shrinkage of bearing rings that occurs under realistic consideration, such as from axial preload, influences the resulting preload or the interference in fits. These important influences can be numerically approximated by activating 'Elastic expansion of the rings' in the calculation. See also chapter 5.2.5.
Further information on elastic expansion can be found in the Manual.

4.3.8 Load spectrum



Another method of analysing the application behaviour is to consider different conditions or load states. If the checkbox for 'Use load spectrum' is activated, the input screen under the 'Load' tab is displayed as an input table. See also chapter 5.4.3.

4.3.9 Modified life



If this flag is set, the modified life is calculated for ISO 281 and ISO 16281. This requires information about the lubrication concept and potential contamination.

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4.4 Bearing geometry

4.4.1 Overveiw

The current version of the MESYS Rolling Bearing Analysis provides 31 rolling bearing designs for calculation, including subtypes. Under the 'Bearing geometry' tab (Fig. 5), the required bearing type can be preselected using the drop-down menu.

Numerous other settings can be made using the ' ' - button (Fig. 5). However, we would like to explain these in more detail in further documents.

Please leave the default settings as they are.

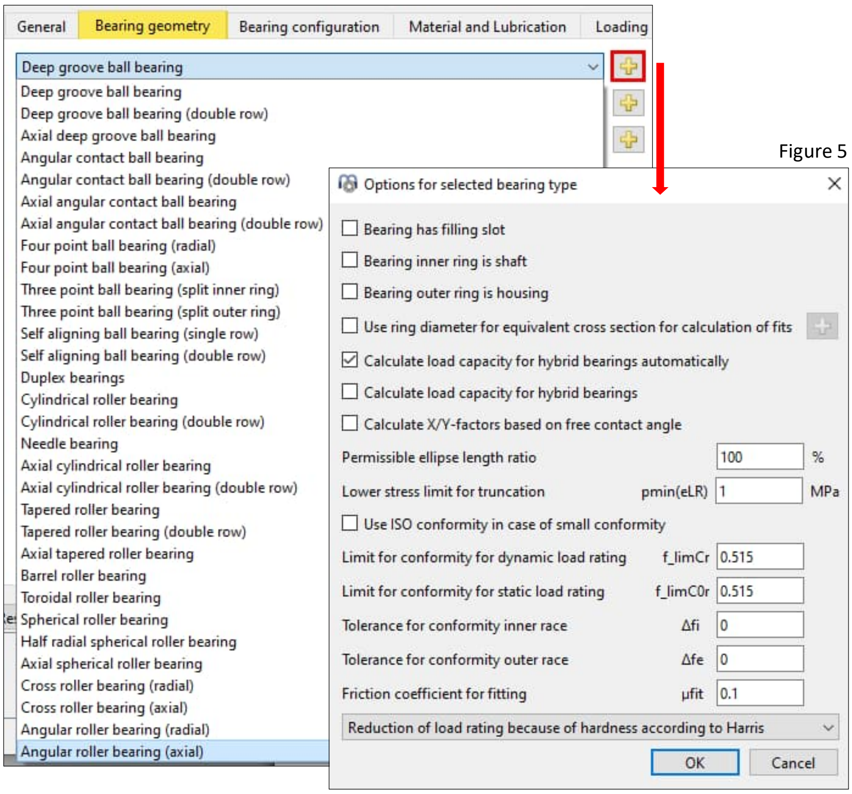


Figure 5

On the right-hand side, we can select the input mode for the type of rolling bearing via dropdown. There are 5 available here (Figure 6):

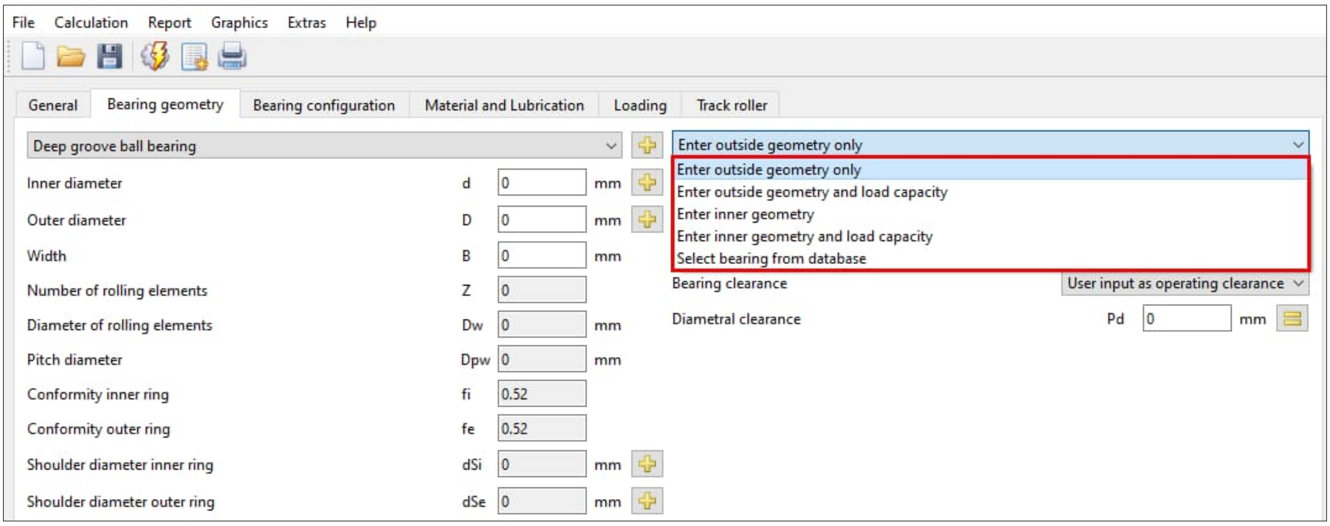
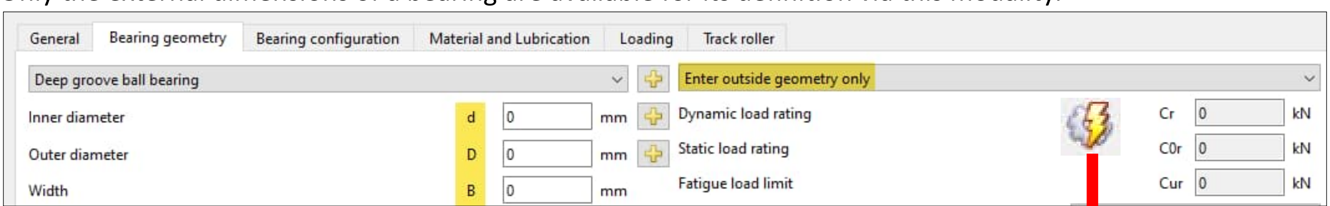


Figure 6

4.4.2 Enter outside geometry only

Only the external dimensions of a bearing are available for its definition via this modality.



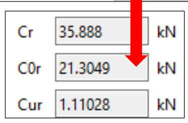
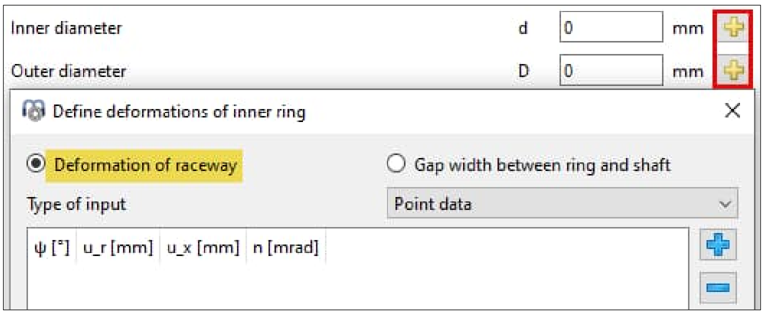


Figure 7

This can be the choice if the internal geometry and load ratings are not known. The software calculates these after the first calculation command on the basis of generic internal geometry and in accordance with ISO 281 and ISO 76 (Fig. 7).



Localised deformations can be assigned to the tracks using the ' ✚ ' - button (Fig. 8). However, we would like to explain this specific option in more detail in further documents.

Figure 8

4.4.3 Enter outside geometry and load capacity

In addition, the fields for dynamic load rating, static load rating and fatigue limit load can also be labelled with this modality (Fig. 9).

If the load ratings are not known, the fields can also be left blank. The software calculates these according to the calculation command on the basis of generic internal geometry and in accordance with ISO 281 or ISO 76.

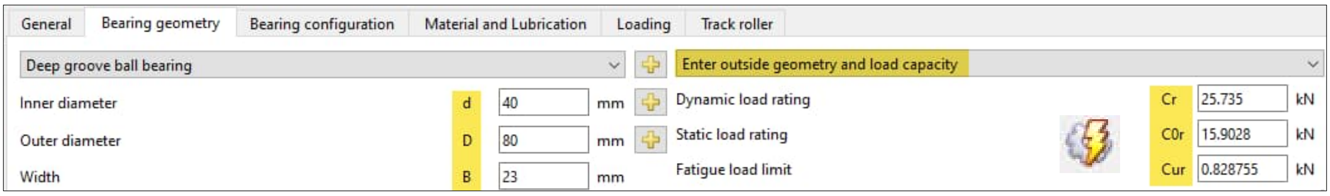


Figure 9

4.4.4 Enter inner geometry

4.4.4.1 General

The substantial values that define the internal geometry can be entered in the corresponding fields using this mode (Fig. 10).

The load ratings are calculated and entered after the first calculation command on the basis of the values entered for the internal geometry and in accordance with ISO 281 and ISO 76.

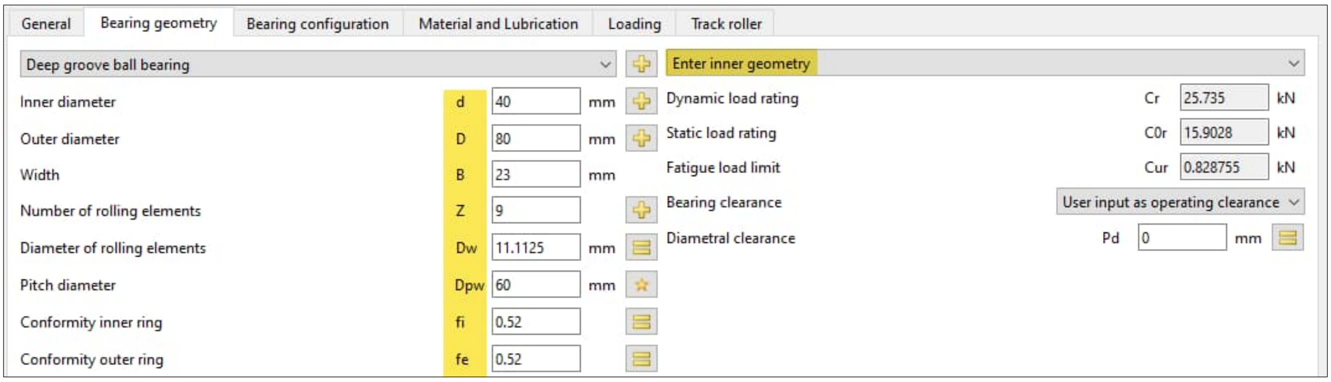
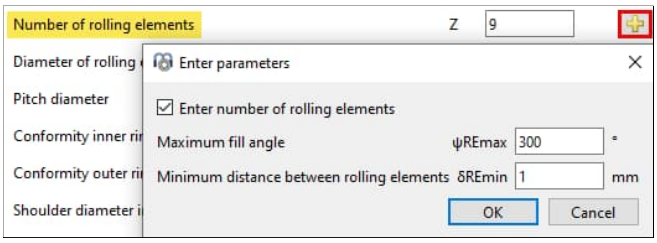


Figure 10

4.4.4.2 Number of rolling elements

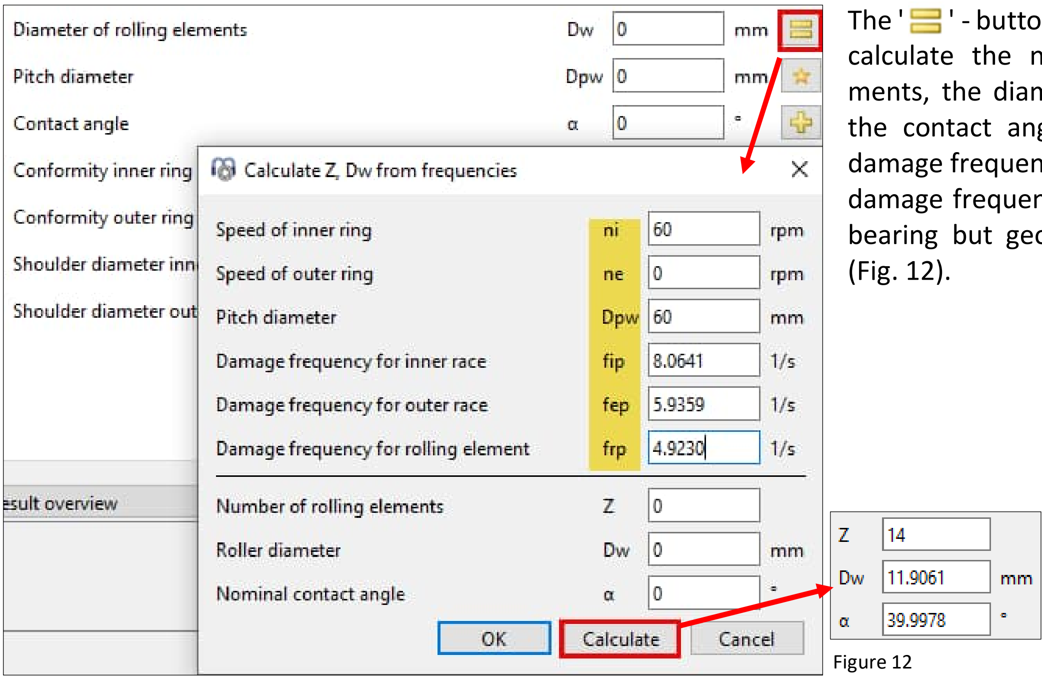


The number of rolling elements Z can be calculated automatically via the ' ✚ ' - button on the right based on a maximum filling angle and a minimum distance between the rolling elements. We would like to deal with this specific option (Fig. 11) in further documents.

Figure 11

4.4.4.3 Diameter of rolling elements

For tapered roller bearings, the diameter of the roller centre is used as input if this is known.



The ' ' - button opens the dialogue to calculate the number of rolling elements, the diameter of the roller and the contact angle from the specified damage frequencies. This can be used if damage frequencies are specified for a bearing but geometry data is missing (Fig. 12).

Figure 12

- Please go to a manufacturer's product page and load the product data for an angular contact ball bearing 7208 with suffix 'B' Alternatively, use the data from Fig. 13.

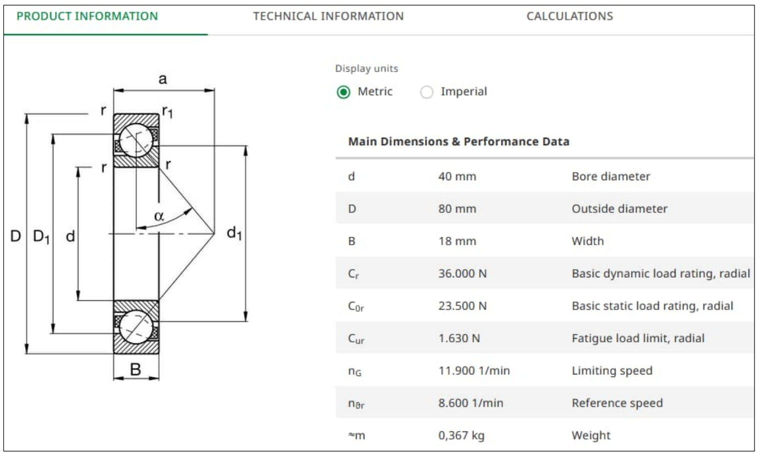


Figure 13 (Source: Schaeffler Medias)

- Search for the basic frequencies here.

Basic frequencies (PDF)

Designation	7208-B-XL-TVP	
Basic frequency factors related to 1/s		
Overrolling frequency factor on outer ring	BPFFO	5,9359
Overrolling frequency factor on inner ring	BPFFI	8,0641
Overrolling frequency factor on rolling element	BSFF	2,4615
Ring pass frequency factor on rolling element	RPFFB	4,9230
Speed factor of rolling element set for rotating inner ring	FTFF_i	0,4240
Speed factor of rolling element set for rotating outer ring	FTFF_o	0,5760

Figure 14 (Source: Schaeffler Medias)

- Go to the Bearing geometry tab and transfer the data under 'Enter inner geometry'. Open the dialogue for 'Diameter of rolling elements' using the ' ' - button (Fig. 12).
- Enter the basic frequencies as shown in Fig. 14 and start the calculation via the open dialogue for entering the damage frequencies.
- Please check the results Z / Dw / α via Comparison using Fig. 12 .

4.4.4.4 Pitch diameter

The pitch circle diameter is the diameter between the centres of the rolling elements. If this value is not known, the mean diameter of the inner and outer bearing diameter can also be used as an approximation.

4.4.4.5 Contact angle

The contact angle must be specified for angular contact ball bearings, four point contact ball bearings, self-aligning ball bearings, tapered roller bearings and spherical roller bearings.
For tapered roller bearings, the angle on the outer ring is used as this is the direction of the force.

The direction of the contact angle can be selected using the ' ' - button.

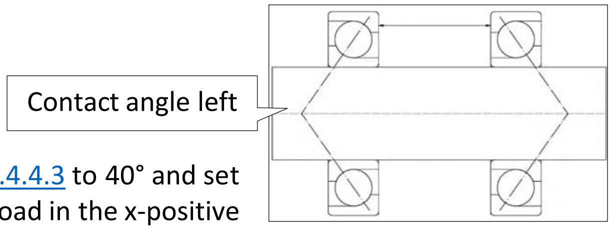


Figure 15

➡ Please round the pressure angle calculated under 4.4.4.3 to 40° and set it to one position to the left for a subsequent axial load in the x-positive direction.

4.4.4.6 Conformity

The conformity is the ratio between the radius of curvature of a bearing ring and the ball diameter. For geometrical reasons, the value must be greater than 0.5. For further information related to relevant standards, please refer to the corresponding chapter of the Manual.

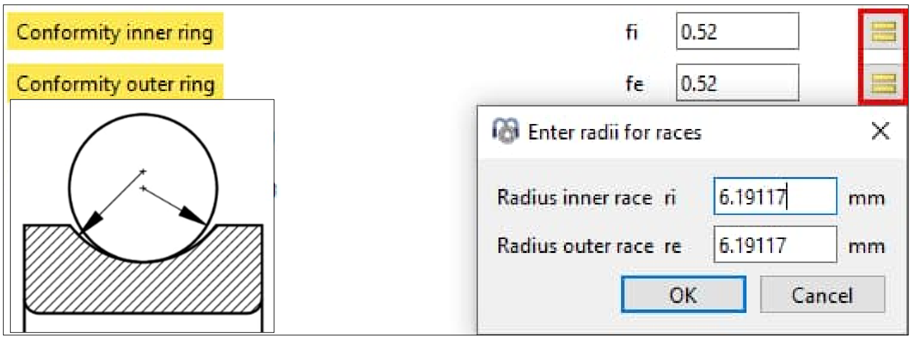


Figure 16

The conformity can be entered directly (Fig. 16) or alternatively via the relevant radii by opening the corresponding dialogue using the ' ' - button.

➡ Please enter fi / fe = 0.52 for the conformity.

4.4.4.7 Shoulder diameter inner & outer ring

To monitor the current state of the contact ellipse and any expansion beyond the shoulder, it is continuously evaluated. The required shoulder diameter can be displayed in the results overview and in the main protocol together with an length ratio eLR_i, eLR_e, which represents a certainty regarding the minimum shoulder length. The length ratio is defined as the length from the lower end of the contact ellipse to the shoulder (the green line in the diagram) divided by the length of the contact ellipse (red line in the diagram in Fig. 17). The value should therefore be greater than 1 or 100%.

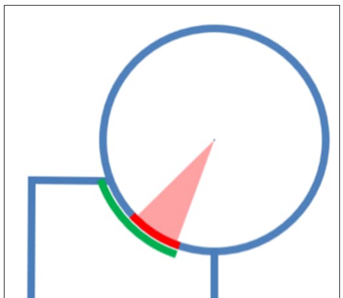


Figure 17

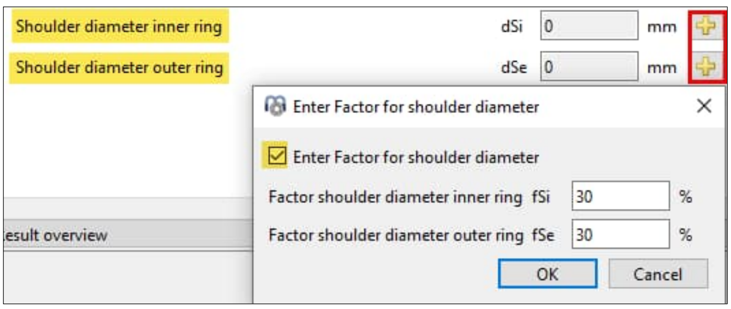


Figure 18

Instead of using an absolute value dSi / dSe, the shoulder height can also be defined as a percentage of the ball diameter (Figure 18). A factor of 50% would mean a shoulder up to the pitch circle diameter, so that the factor should be between 10% and 40% for most bearing types. The use of this factor allows a standard geometry when changing the ball diameter or pitch. Please refer to the Manual for more detailed information.

4.4.5 Enter inner geometry and load capacity

Since bearing manufacturers often use higher load ratings than those calculated according to the standards, it is possible to enter the load ratings in addition to the internal geometry. The load ratings are then used to calculate the rating life.

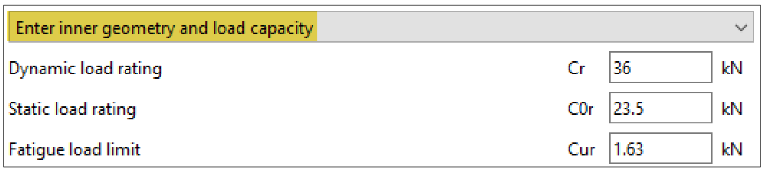


Figure 19

Please transfer the load ratings of the imaginary manufacturer and start the calculation.

Observe the changes in the Result overview at the bottom of the user interface.

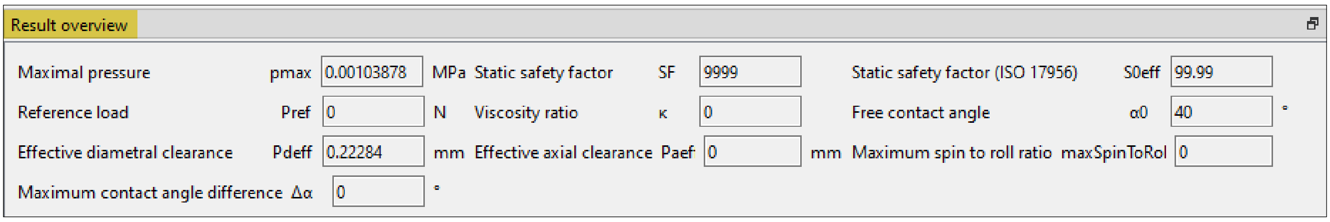


Figure 20

A service life is only issued here once a speed has been assigned.

4.4.6 Select bearing from database

Instead of the rolling bearing geometry being entered by the user, it can be selected from a database (Fig. 21). Inside and outside diameters can be optionally defined. This limits the number of bearings displayed in the list.

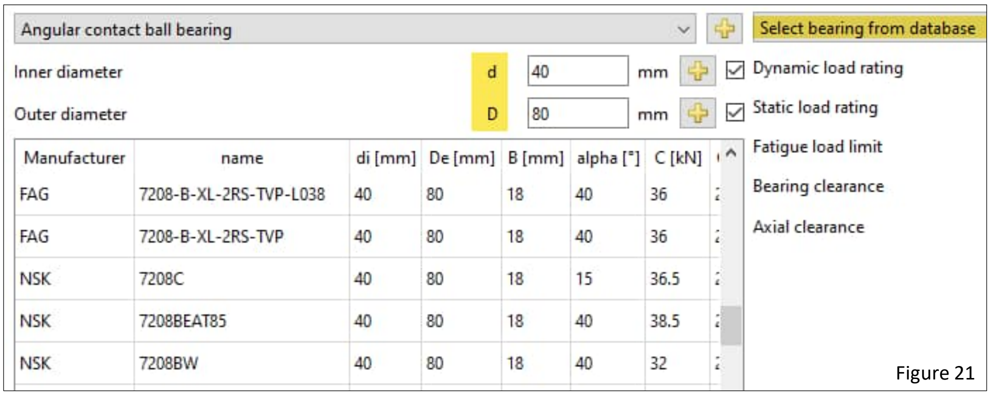
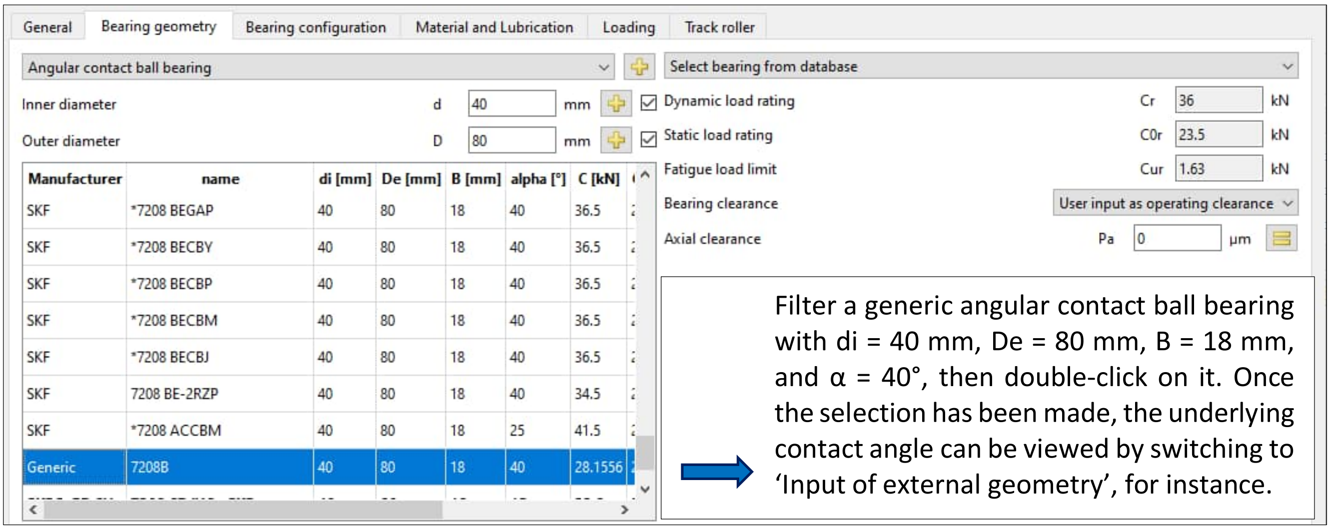


Figure 21

By clicking on the column designation, the data can be displayed in ascending or descending order according to this column.



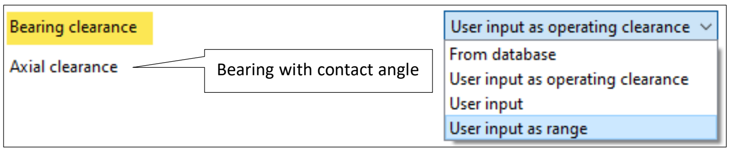
Filter a generic angular contact ball bearing with di = 40 mm, De = 80 mm, B = 18 mm, and α = 40°, then double-click on it. Once the selection has been made, the underlying contact angle can be viewed by switching to 'Input of external geometry', for instance.

Figure 22

4.4.7 Bearing clearance

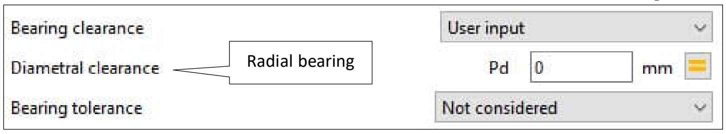
4.4.7.1. General

Figure 23



The bearing clearance can be set automatically in accordance with (ISO 5753, 2009) (C2...C5) for deep groove ball bearings, four point contact bearings, self-aligning ball bearings, spherical roller bearings and cylindrical roller bearings. There are also the settings 'From database', 'User input as operating clearance' and 'User input' / as range.

Figure 24



Depending on the bearing design, i.e. whether it is a pure radial bearing, bearing with contact angle or pure thrust bearing, the software lists the corresponding input fields.
Due to the potential scope of this starter tutorial, it is not feasible to cover all types and their corresponding input fields in detail. For further details, please refer to the relevant chapter in the Software Manual.

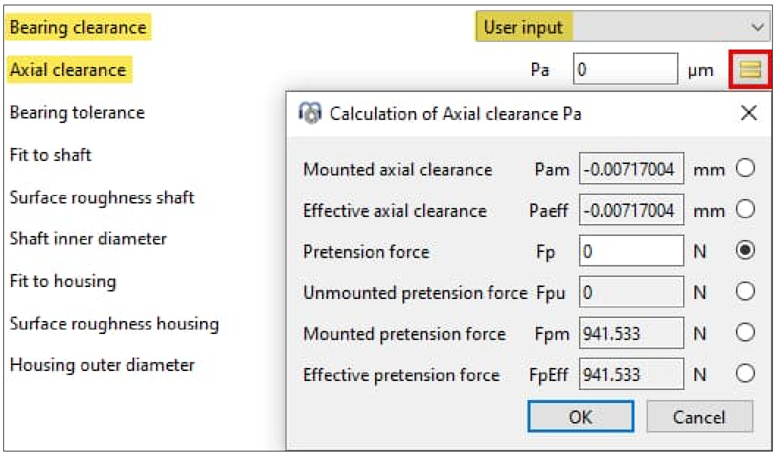
4.4.7.2 User input

Figure 25

This setting allows the bearing clearance to be entered before installation (Fig. 25). The effects of temperature or interference in fits are also taken into account. This is the recommended setting if, for example, you want to analyse the change in clearance in the application condition under consideration.

4.4.7.3 Calculation of axial clearance

Figure 26



In the case of an axial clearance setting, such as for radial rolling bearings with a contact angle (Figure 26), an effective bearing clearance can be calculated, entering a nominal, unmounted, mounted or effective preload force, which can be assigned via the ' ' - button in the dialogue.

There are several options for entering the preload force:

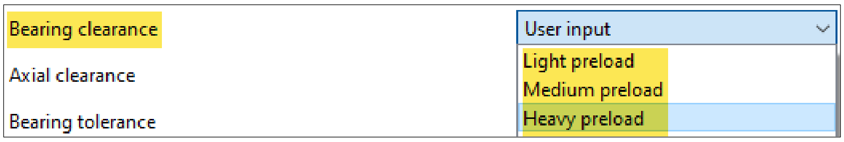
- The calculation with 'Fp' uses the preload value of the bearings declared by the manufacturer.
- The calculation with 'Fpu' uses the preload value of the bearings declared by the manufacturer together with an unlimited radial elastic expansion. This option can be used if the manufacturer determines the preload axial displacement, using the preload value corresponding to the measured loads.
- The assembled preload force 'Fpm' is calculated with preload values after assembly, but without temperature and speed effects.
- The effective preload force 'FpEff' is calculated using the preload values after assembly and taking temperature and speed into account.

> Please note:
>
> It may be necessary to clarify with the manufacturer how the preload axial displacement (axial play, Pa) is determined for the declared preload force. This allows the correct type of axial clearance calculation to be selected.

When defining bearing clearance for pure radial bearings, a dialogue with the input fields corresponding to the bearing type is opened at this point.

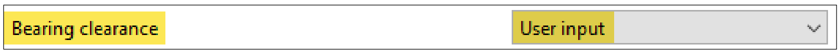
4.4.7.4 Preload classes for radial angular contact ball bearings

Figure 27



For radial angular contact ball bearings, a preload class can be defined from the bearing database, provided that this information has been transferred (Fig. 27). For GMN products, for instance, additional selections are available, such as 'Light preload force', 'Medium preload force' and 'Heavy preload force'.

Please select ' User input' for 'Bearing clearance'.



In the context of our example, we would like to assume, that the resulting preload-displacements (Pa) of the imaginary manufacturer, originate from declared preload-corresponding measuring loads.

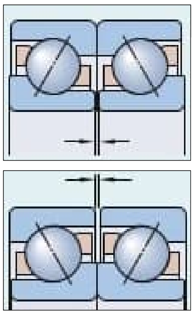


Figure 28 (Source: SKF 17000)

Axial internal clearance, preload and preload force of bearing sets with universal bearings in O or X arrangement for tolerance classes Normal, 6, 5

UA = bearing with small axial internal clearance
UB = bearing with smaller axial internal clearance than UA
UO = bearing clearance-free in O or X arrangement
UL = bearing with light preload

Bore code	Axial internal clearance or preload of bearing pair, Nominal dimension (µm) UA	UB	UO	UL				Preload force $F_{V\,max}$ (N) UL			
Bearing series	70..-B, 72..-B, 73..-B, 74..-B			70..-B	72..-B	73..-B	74..-B	70..-B	72..-B	73..-B	74..-B
00	22	14	0	–	−3	–	–	–	38	–	–
01	24	15	0	–	−4	−5	–	–	53	82	–
02	24	15	0	–	−4	−5	–	–	62	99	–
03	24	15	0	–	−4	−6	–	–	77	123	–
04	28	16	0	−4	−5	−6	−8	103	103	146	258
05	34	19	0	−4	−4	−6	−8	115	112	200	300
06	34	19	0	−5	−5	−7	−8	141	157	250	365
07	40	22	0	−5	−6	−7	−9	172	208	300	462
08	40	22	0	−5	−6	−8	−10	200	246	385	535

Assign the 7208B a preload according to the UL class given by an imaginary manufacturer.

Figure 29 (Source Schaeffler, HR1)

It can be seen from the catalogue data (Fig. 29) that such an unmounted preload in a duplex set in the O or X position of aforementioned dimension and contact angle, corresponds to a preload displacement (Pa) of 6 µm.

The software gives a displacement Pa for 246 N preload unmounted, corresponding to the effect on the individual bearing, in the magnitude of (preload displacement duplex = -6 µm) / 2 = -3 µm (Fig. 30).

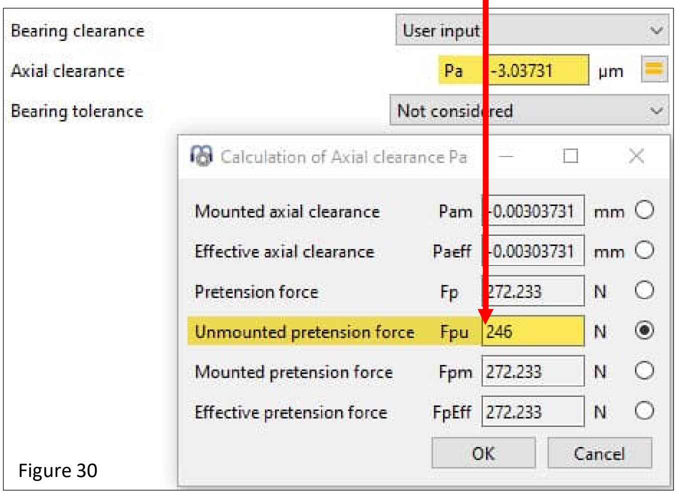


Figure 30

4.4.8 Bearing tolerance

4.4.8.1 General

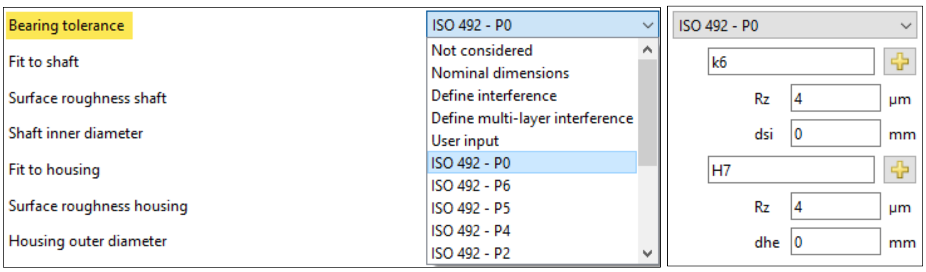


Figure 31

The bearing tolerance can be taken into account in accordance with ISO 492 (P0...P2). The other input fields in this area make it possible to describe the interfaces to the rolling bearing, such as fit, roughness and condition of the shaft (inside diameter) and housing (outside diameter) (Fig. 31).

In addition to the possible settings via tolerance classes from ISO 492, 'Not considered' can be selected, whereby the bearing is only exposed to the temperatures for the calculation. With 'Nominal dimension', it is assumed that there is no tolerance range.
Additional information on bearing tolerances can be found in the Software Manual.

In addition to the bearing tolerance, the definition of the bearing clearance / preload (4.4.7) described in the previous chapter, the effect of the speed and temperatures to be entered subsequently and any expansion of the rings due to stress (5.2.4) are also important input variables for evaluating the reaction of a rolling bearing. The sum of the effects flows into the calculation of the actual interferences on the bearing rings and thus into the 'Tolerances protocol'. More on this in chapter 4.4.8.7.

4.4.8.2 Define interference

If it is not clear which fit should be selected due to application conditions, the 'Define interference' setting can be extremely helpful. This allows you to define a cold interference for a target interference in an operating state.

Please assign a hollow shaft (dsi) of 10 mm, an outer diameter for the housing (dhe) of 100 mm and a clearance on the housing outer ring of 3 µm as shown in the picture on the right.

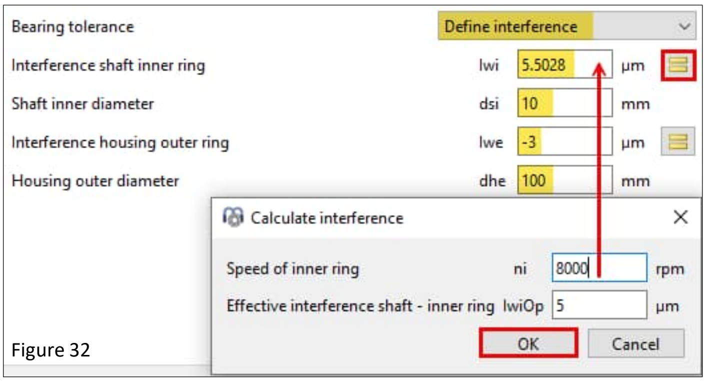


Figure 32

The dialogues open via the '' - button. Please enter a speed of 8000 rpm and a target interference of 5 µm inside (Fig. 32).

A dynamic interference of 5.5028 µm is calculated for our current state under an unmounted preload of 246 N, at a speed of 8000 rpm and actual static interference of 5 µm inside and -3 µm outside! A speed effect can be read from this.

In Chapter 5 'Application design', we then want to check whether the specified interference have been calculated correctly under the specified conditions. So before we switch to a standard ISO fit, assign a roughness and assume temperatures, we should not bring all influencing inputs into play for the time being.

4.4.8.3 Calculation step under speed

Let us now describe the input fields in the 'Loading' tab in advance according to our example.

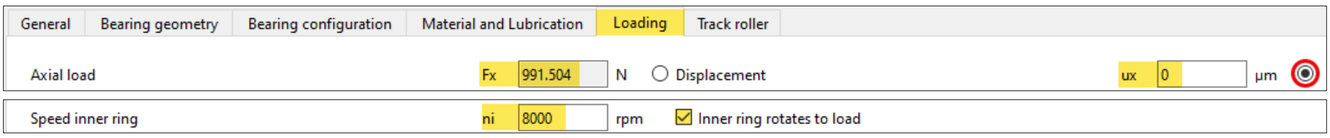


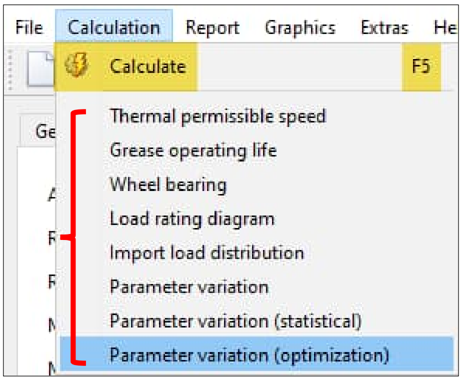
Figure 33

Please set the axial bearing displacement ux to 0 (Fig. 33). Please take note of the specific content of the 'Loading' tab in chapter 4.7.2 for a corresponding understanding.

Please assign the bearing a speed of 8000 rpm and specify 'Inner ring rotates to load'. The software then assumes a stationary load on a rotating inner ring (Fig. 33).

4.4.8.4 Ongoing results

Figure 34



The calculation step is started via the 'Calculate' item (Fig. 34), via F5 or then via the corresponding icon under the menu ribbon.

The Thermal reference speed in accordance with (ISO 15312, 2018) and the Thermal permissible speed in accordance with (DIN 732, 2010) can be calculated by the software. We would like to explain these topics more closely in subsequent publications.

The Grease operating life (Fig. 35) can be determined using the FAG calculation method and output via the report.

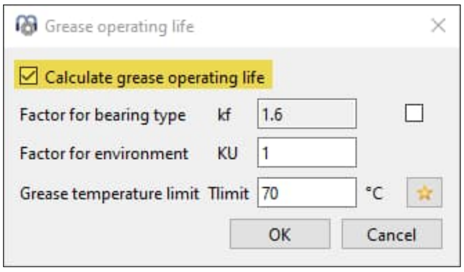


Figure 35

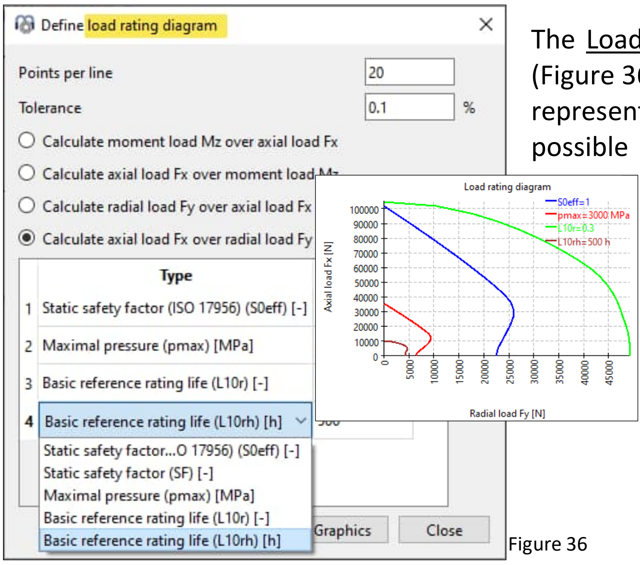


Figure 36

The Load rating diagram (Figure 36) generates the representation of four possible diagrams in which the variables of the XY axes are compared with each other.

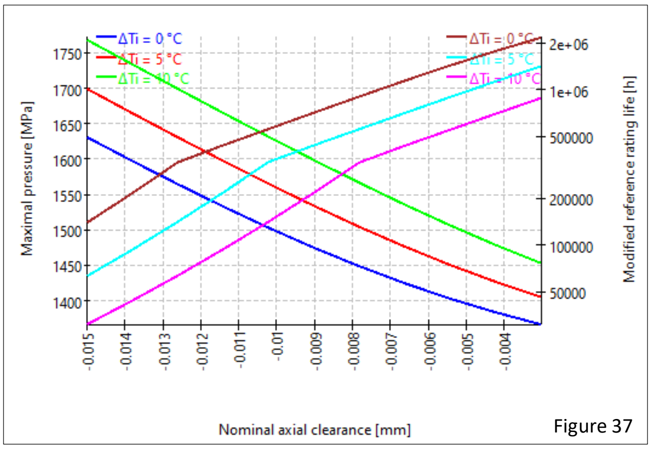


Figure 37

Parameter variation (Fig. 37) allows the user to carry out parameter studies, the results of which are displayed in tables and graphs. Typical applications are, for example, the visualisation of service life over clearance or displacements over load. See chapter 5.4.4.

Parameter variation (statistical) supports the analysis of statistical distributions.

Please activate the calculation process.

This gives us an axial load Fx of 991,504 N (Fig. 38), which results from the unmounted preload of 246 N and the current fit (4.4.8.2).

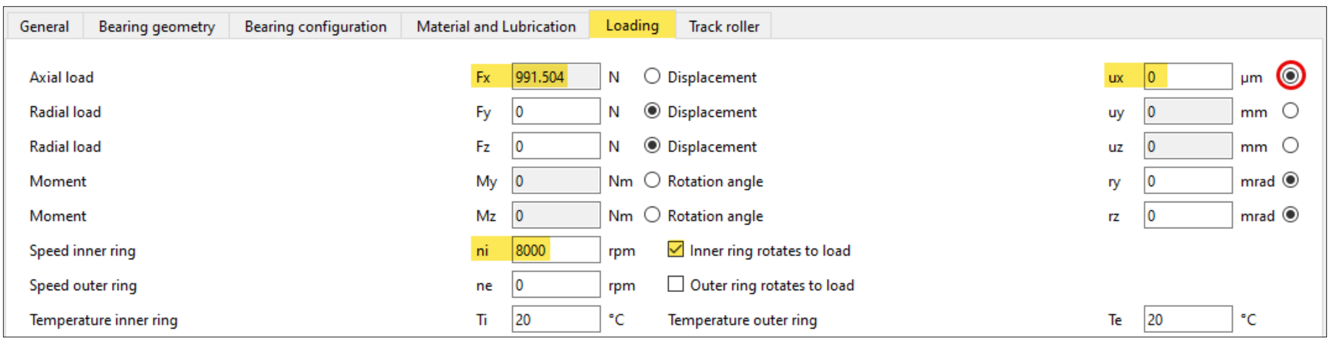
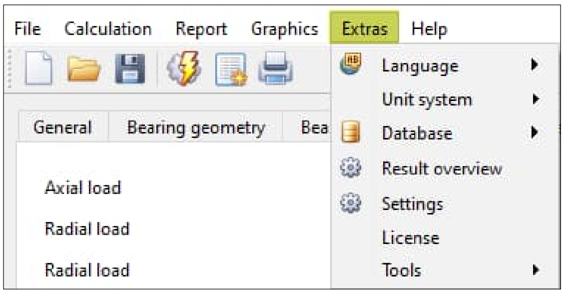


Figure 38

4.4.8.5 Menu 'Extras'

Figure 39



The software can be operated in 9 languages and in both metric and US unit systems.
In addition to the links to material, lubricant, rolling bearing, tolerance, manufacturer and gear tool databases, an import from an existing database or an encrypted export of data can also be initiated here.
The content of the Results overview window at the bottom of the user interface (see 4.4.8.6 below) can be edited via 'Results overview'.
You will also find licence information and additional 'Tools' such as 'Multi-layer interference fit', which is also available online[1].

4.4.8.6 Actual Result overview

The content in the results overview at the bottom of the user interface (Fig. 40), which is not yet relevant for our sample calculation, appears as follows:

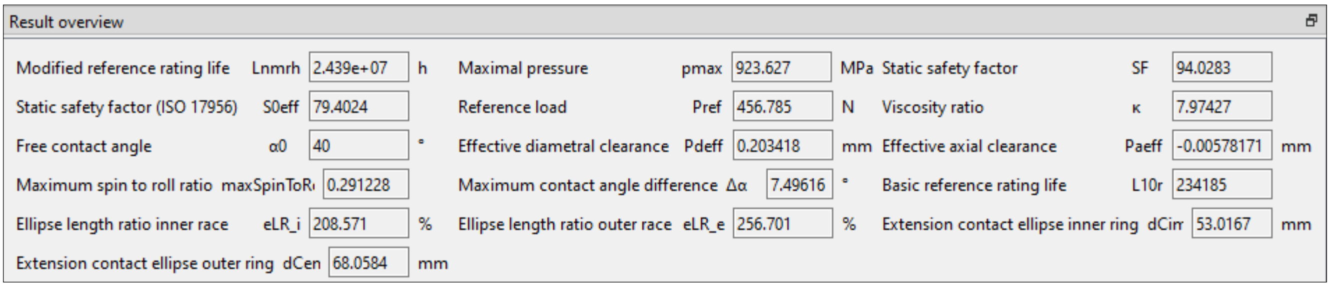


Figure 40

4.4.8.7 Tolerance report

Using the 'Tolerance report' (Fig. 41), we would like to check in the current state of the file whether our target interference from chapter 4.4.8.2 have arrived correctly.

Please print the Tolerances report and check the details such as diameter and speed in the report preamble for correctness.

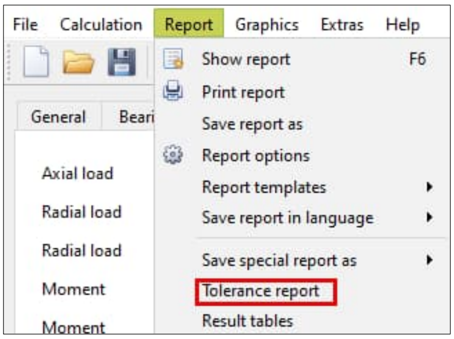


Figure 41

Table 1

Properties for different clearance		Minimum	Mean value	Maximum	Unit
Nominal axial clearance	Pa	-3.04	-3.04	-3.04	µm
Interference inner ring	Iw_i	5.50	5.50	5.50	µm
Effective interference inner ring	Iw_iop	5.00	5.00	5.00	µm
Interference outer ring	Iw_e	-3.00	-3.00	-3.00	µm
Effective interference outer ring	Iw_eop	-3.00	-3.00	-3.00	µm

The target interference (Iw_iop) has arrived exactly (Table 1). The cold interference of 5.5 (5.5028) µm is reduced to 5 µm by the speed effect.

[1] Multi-layer interference fits

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info@mesys.ch
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4.5 Settings under 'Bearing configuration'

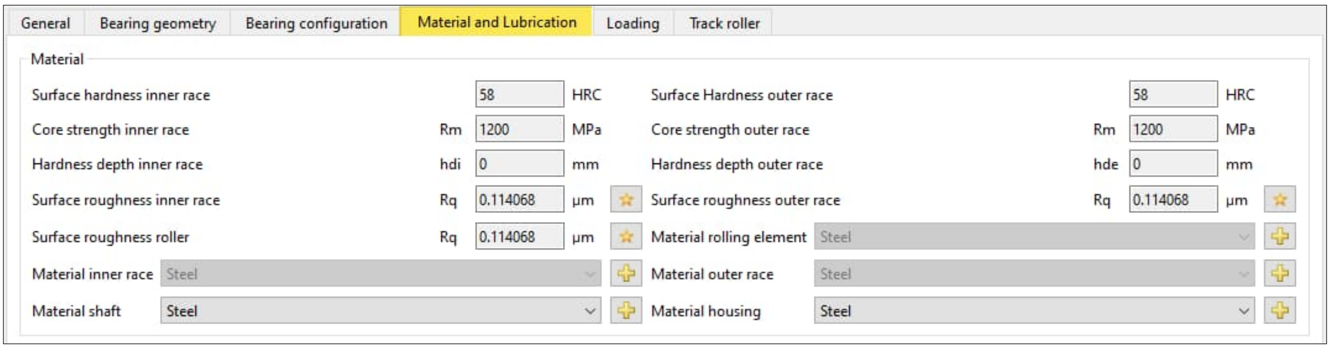
A bearing set can be compiled from a bearing type under this tab. A pairing of a multiple number can thus be displayed and calculated. However, we would like to explain this configuration option in more detail in further documents and would like to skip it in this tutorial. Additional information on bearing configuration can be found in Manual.

4.6 Settings under 'Material and lubrication'

4.6.1 Material

The material properties for the rolling element, inner and outer ring, shaft and housing are used to calculate the load distribution and interference between the bearing and shaft/housing. Hardness, its depth and surface roughness can also be entered (Fig. 42).

Figure 42



These data fields can also be viewed in the material tables (Fig. 43). We would like to skip this input screen and the associated level of detail in this tutorial. Detailed information on material can be found in the Manual.

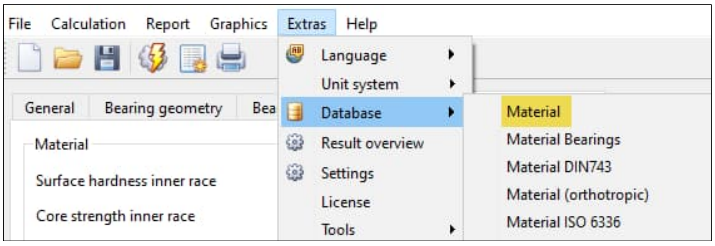
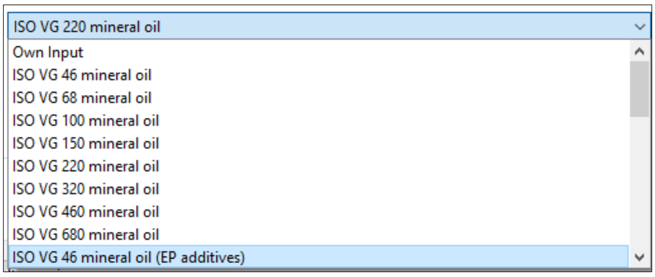


Figure 43

4.6.2 Lubrication

Figure 44



The drop-down menu on the left offers the choice of a predefined quality with mineral or synthetic base oil as well as an own input option for defining the lubricant (Fig. 44).

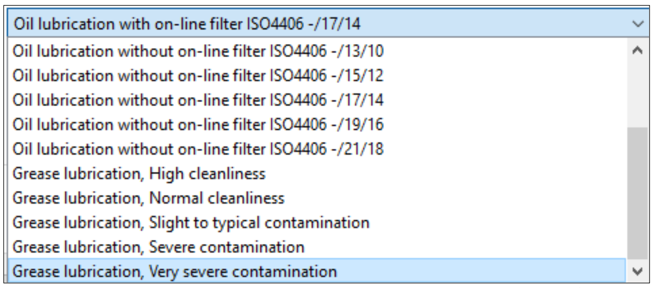
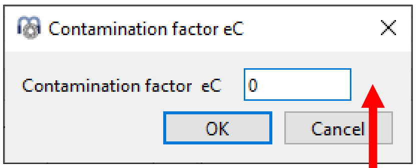


Figure 45

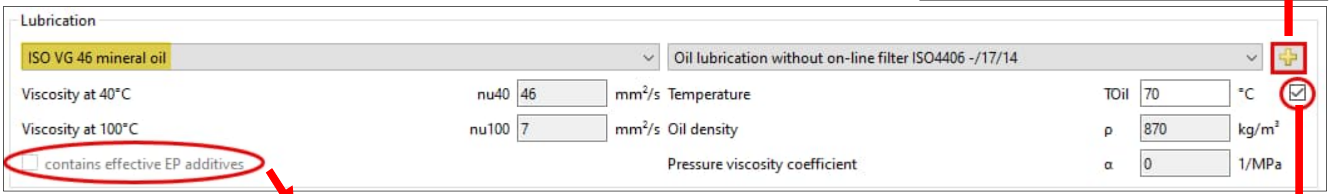
The drop-down menu on the right (Fig. 45) can be used to differentiate between grease or oil lubrication, but also to select the degree of filtration according to ISO 4406 for oil and the degree of contamination according to ISO 281 for grease.

Figure 46



The contamination factor eC is used to calculate the factor aISO of the modified service life (Figure 46).

Figure 47



According to ISO 281, the presence of EP additives has an influence on the calculation of the aISO factor for the modified life.

If the checkbox behind the oil temperature is not activated, the software assumes the set rolling element temperature for its temperature. See 4.3.6.

Please select a viscosity grade ISO VG 46 mineral and an oil lubrication without filtration 17/14, according to Fig. 47.

Leave the eC contamination coefficient unchanged and leave the lubricant temperature at 70°C.

4.7 Settings under 'Loading'

4.7.1 General

The coordinate system in MESYS is defined as follows:

- Direction X is defined as the axis direction.
- The Y-axis points upwards to the first rolling element and the angle is positive around the X-axis or clockwise in the right-hand diagram (viewed in the direction of the X-axis).
- The angle starts with zero at the first rolling element on the Y-axis.
- Torques are positive if they act around the corresponding axis.
- The load acts on the inner ring, so that a positive load in the Y direction leads to a load on the rolling elements on the upper side, as shown in Fig. 48.

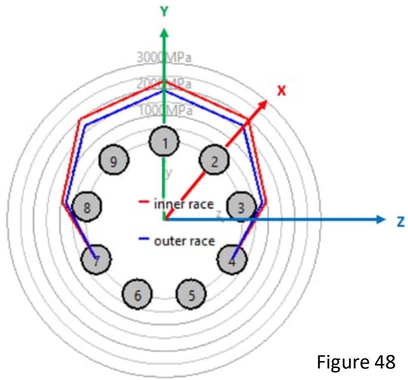
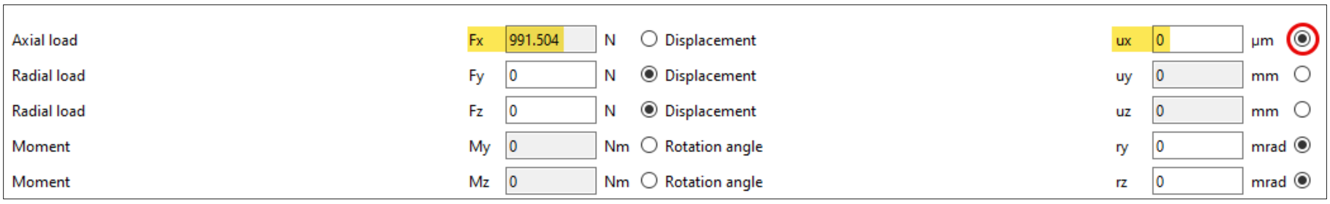


Figure 48

4.7.2 Input spaces

Figure 49



A force or displacement (ux) can be entered for each coordinate direction as required (Fig. 49). If the ring, with which the preload is applied is to be held axially fixed on our angular contact ball bearing as assumed, the displacement in the axial direction (ux) can be set to zero and the reaction force in the axial direction (Fx) is calculated via vector split as a function of the contact angle.

A moment load or tilting can only be entered for two directions, as the rotation around the bearing axis (X) cannot be restricted.

4.8 Calculation of track rollers

If you have purchased a licence for the calculation of 'support rollers' and are interested in training for this extension, we would like to ask you to contact us. Detailed information on this can be found in the Manual. In this respect, we will skip the content under the 'Track roller' tab in this tutorial.

5. Application design

5.1 Methodology

The successful design of a rolling bearing follows a proven methodology. The MESYS rolling bearing calculation provides decisive support and takes over a large part of the necessary tasks. In the following, we would like to go through some of the most important steps together.

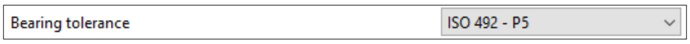
5.2 Interference fits

5.2.1 Tolerance report

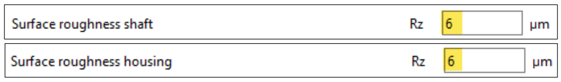
The Tolerance report has shown that fits for target overlaps can be found very quickly with MESYS. Now it is obvious that nobody manufactures a nominal dimension of Ø +5.5028 µm for a shaft according to chapter 4.4.8.2 and that other influencing variables affect the real actual interference. Furthermore, bearing diameters also have defined tolerance zones.

5.2.2 Tolerance & roughness

- Please assign the angular contact ball bearing 7208B a tolerance class P5.



- Please assign a roughness for shaft and bore of Rz = 6.



- Please round the current cold nominal interference and assign an ISO class IT6 (16 µm) diameter tolerance to the shaft and a IT7 (35 µm) to the housing.

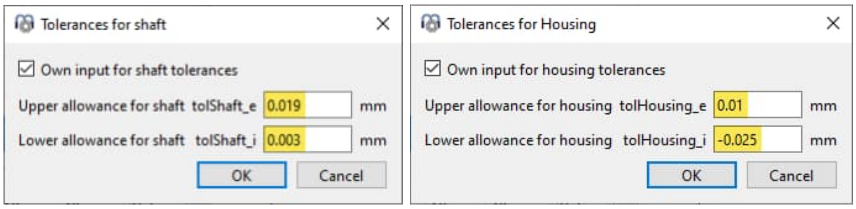


Figure 50

- The Tolerance report of it should look like this:

Table 2

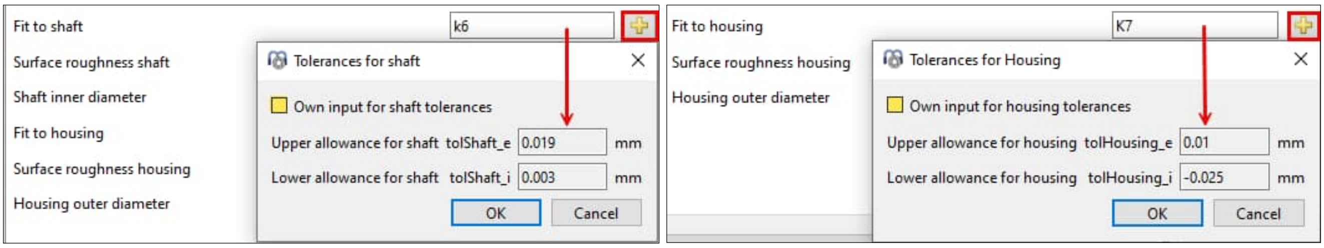
Properties for different clearance		Minimum	Minimum probable	Mean value	Maximum probable	Maximum	Unit
Nominal axial clearance	Pa	-3.04	-3.04	-3.04	-3.04	-3.04	µm
Tolerance shaft	Δds	19.00	16.96	11.00	5.04	3.00	µm
Tolerance bearing inner ring	Δd	-8.00	-6.98	-4.00	-1.02	0.00	µm
Interference inner ring	Iw_i	24.60	21.54	12.60	3.66	0.60	µm
Effective interference inner ring	Iw_iop	24.10	21.04	12.10	3.15	0.10	µm
Tolerance bearing outer ring	ΔD	0.00	-0.80	-4.50	-8.20	-9.00	µm
Tolerance housing	ΔDh	-25.00	-21.87	-7.50	6.87	10.00	µm
Interference outer ring	Iw_e	22.60	18.67	0.60	-17.47	-21.40	µm
Effective interference outer ring	Iw_eop	22.60	18.67	0.60	-17.47	-21.40	µm

- The effective interference inner ring under maximum, just covers the worst case positively with 0.1 µm.
- The effective interference on outer ring is practically compensated with a mean value of 0.6 µm.

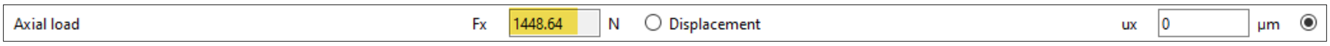
5.2.3 ISO Fit

- For better industrial visualisation, please change the fit to the shaft to k6 and that of the bore to K7 (Fig. 51).

Figure 51



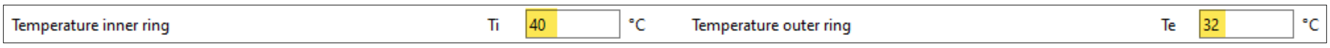
Due to the above adjustments to the application conditions, the axial force has increased from 991.504 N to 1448.64 N:



5.2.4 Temperature difference

In our example, let's assume that the temperatures on the inner and outer ring could be measured or qualitatively estimated:

Please enter a temperature of 40°C for the inner ring and 32°C for the outer ring and start calculation.



The resulting axial force has now increased to 2,321.73N with the temperature gradient shown. This could mean that ring expansion becomes substantially relevant.

5.2.5 Elastic ring expansion

Please assign the elastic ring expansion under medium radial force to the bearing under the 'General' tab (Fig. 52).

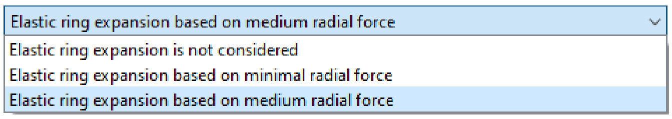
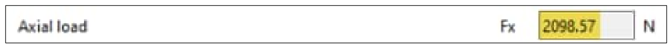


Figure 52

The following calculation step shows that the axial force has thus decreased again in a comprehensible manner.



Please refer to the relevant chapter in the Manual for detailed information on elastic expansion of the rings.

The current protocol tolerances from the settings just made (Table 3):

Table 3

Properties for different clearance		Minimum	Minimum probable	Mean value	Maximum probable	Maximum	Unit
Nominal axial clearance	Pa	-3.04	-3.04	-3.04	-3.04	-3.04	µm
Tolerance shaft	Δds	18.00	15.96	10.00	4.04	2.00	µm
Tolerance bearing inner ring	Δd	-8.00	-6.98	-4.00	-1.02	0.00	µm
Interference inner ring	Iw_i	23.60	20.54	11.60	2.66	-0.40	µm
Effective interference inner ring	Iw_iop	24.11	21.05	12.11	3.16	0.10	µm
Tolerance bearing outer ring	ΔD	0.00	-0.89	-4.50	-8.11	-9.00	µm
Tolerance housing	ΔDh	-21.00	-18.05	-6.00	6.05	9.00	µm
Interference outer ring	Iw_e	18.60	14.76	-0.90	-16.56	-20.40	µm
Effective interference outer ring	Iw_eop	20.55	16.71	1.05	-14.62	-18.46	µm

Residual overlap on shaft (Iw_iop) below 'Maximum' is positive even in the 'worst' tolerance sum.

The Effective interference outer ring (Iw_eop) is practically compensated for in the 'mean value'. This means that there is no displaceability, as required for a floating bearing for instance.

Table 4

Effective diametral clearance	Pdeff	171.27	176.20	193.50	201.34	203.79	µm
Effective axial clearance	Paeff	-26.47	-23.13	-11.90	-7.04	-5.56	µm
Effective free contact angle	α0eff	36.16	36.70	38.53	39.33	39.58	°

The Effective axial clearance (Paeff) in the 'mean value' has decreased substantially compared to the initial unmounted Pa of -3.03731 µm from chapter 4.4.7.4 (Table 4).

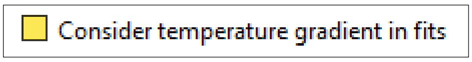
It is also important to mention at this point that there is a direct correlation between the effective free contact angle (α0eff) and the Effective diametral clearance (Pdeff). Small nominal contact angles result in even smaller effective free contact angles after all influences and can lead to compensation of the diametral bearing clearance (apex radial clearance). However, a value of 171.27 µm, as shown here in the worst case (minimum), is in no way a reason for an immediate risk.

5.2.6 Temperature gradient

With reference to chapter 5.2.4, it should be noted that bearing seats are often positioned close to a heat source, such as a rotor. This can cause the shaft temperature to be higher than the actual inner ring temperature, which is also constantly lower by an amount due to oil lubrication.

Housing temperature can also be colder than at the bearing outer ring due to housing cooling.

MESYS offers the option of taking this into account using 'Consider temperature gradient in fits'. See the 'General' tab:



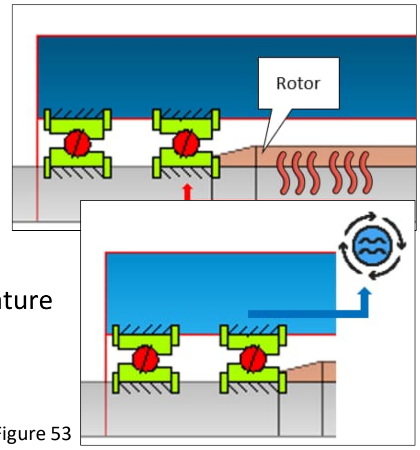


Figure 53

Please refer to the Manual for detailed information on taking temperature gradients into account.

5.3 Assembly / disassembly

The 'Tolerances protocol' provides an insight into the potential need for induction devices for mounting (mounting) the bearings and thus also the expected loads during a hypothetical disassembly (Table 5):

Properties for different clearance		Minimum	Minimum probable	Mean value	Maximum probable	Maximum	Unit
Mounting force inner ring (µfit=0.1)	Ffit_i	4567.5	3988.0	2292.5	598.1	19.5	N
Mounting force outer ring (µfit=0.1)	Ffit_e	1838.7	1494.9	93.5	0.0	0.0	N

Table 5

5.4 Loading

5.4.1 General

The loads resulting from work steps, weight or dynamic effects must be entered. For this purpose, MESYS Rolling Bearing Calculation provides the option of an evaluation under static conditions, as under the 'Load' tab, as well as an analysis under a load spectrum.

5.4.2 Load rating

To determine the bearing sizes according to the rating life or load capacity, the software offers the basic and modified life according to ISO 281 / 16281 and static safety factors according to ISO 76 or ISO 17956. The results overview in the lower part of the screen (Fig. 54) provides an immediate evaluation:

Please enter a radial force in Fy of 2000 N under the 'Load' tab.

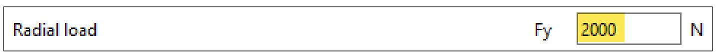
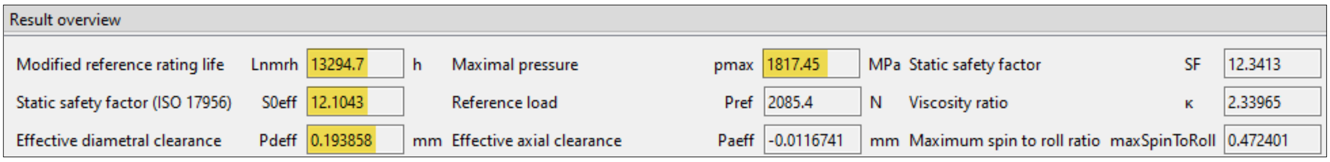


Figure 54

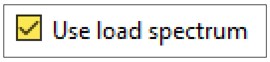


No overload is recognisable via maximum pressure and static safety factor (Fig. 54).

5.4.3 Load spectrum

An investigation of the bearing behaviour using a load spectrum can provide further important findings:

Please tick the 'Use load spectrum' box under the 'General' tab.



The input fields under the 'Loading' tab now appear as an input table.

Figure 55

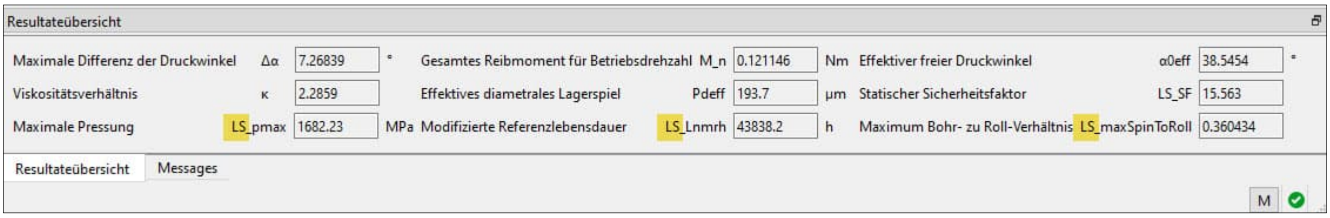
General | Bearing geometry | Bearing configuration | Material and Lubrication | Loading | Track roller

	Frequency	ux [mm]	Fy [N]	Fz [N]	ry [mrad]	rz [mrad]	ni [rpm]	ne [rpm]	T_i [°C]	T_e [°C]	TOil [°C]
1	0.5	0	1500	0	0	0	4000	0	40	32	60
2	0.5	0	1500	0	0	0	8000	0	42	32	70

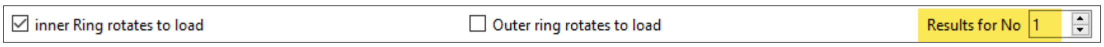
Please enter the values in the running example as shown above (Fig. 55) by activating rows using the ' ' - button at the bottom right.

The common values from the load spectrum now appear in the results overview with the prefix 'LS' (Fig. 56):

Figure 56



The remaining values are there for the load spectrum element preselected in the bottom of the input mask:



5.4.4 Parameter variation

A dialogue for parameter variations is displayed via the menu item 'Calculation'/'Parameter variation' (4.4.8.4) (Fig. 57). It enables the user to carry out parameter studies, the results of which are displayed in tables and graphs. Typical applications are, for example, the visualisation of service life over clearance or displacements over load. Optional optimisation for a parameter is also available. For further information on parameter variation, see the corresponding entries in the Software Manual.

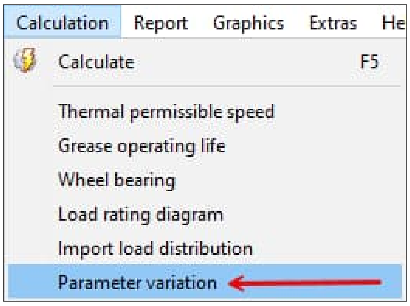


Figure 57

At this point, starting from our Pa = -3.03731 µm from an unmounted preload of 246 N, let's reduce it in 10 steps to -15 µm.

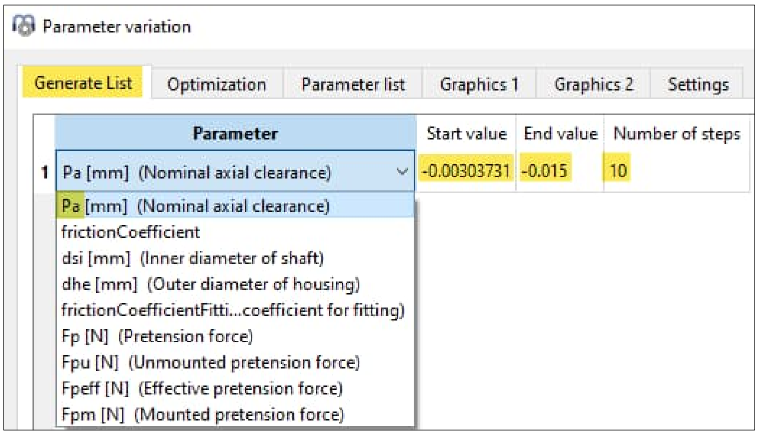


Figure 58

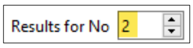
Please select the elements from the parameter list (Fig. 59).

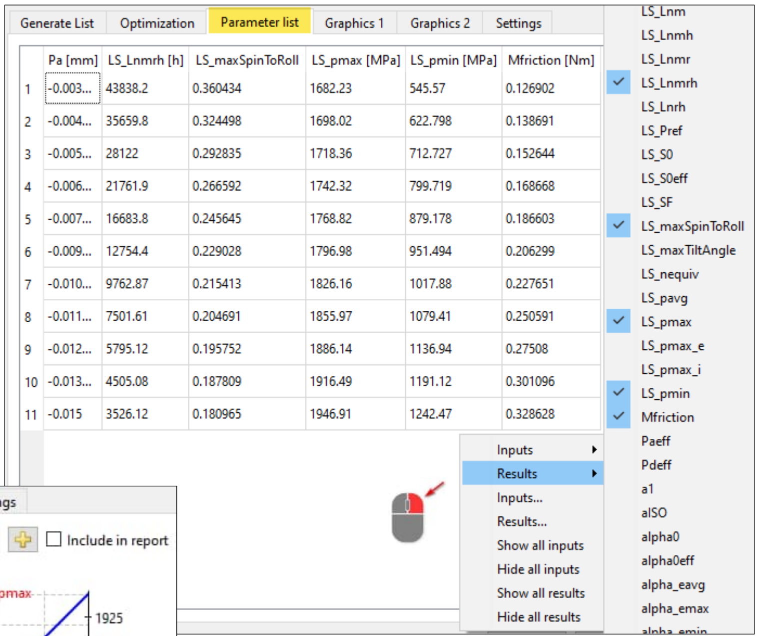
For load spectrum (LS):

- Mod. Reference service life Lnmrh
- SpinToRoll as parameter for kinematics
- Max. Contact tension pmax
- Min. contact tension pmin

For load case 2:

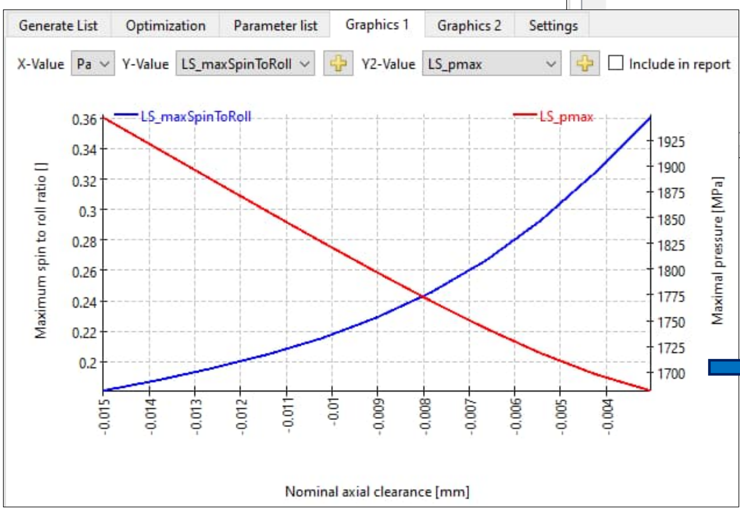
- Load dependent frictional torque Mfriction





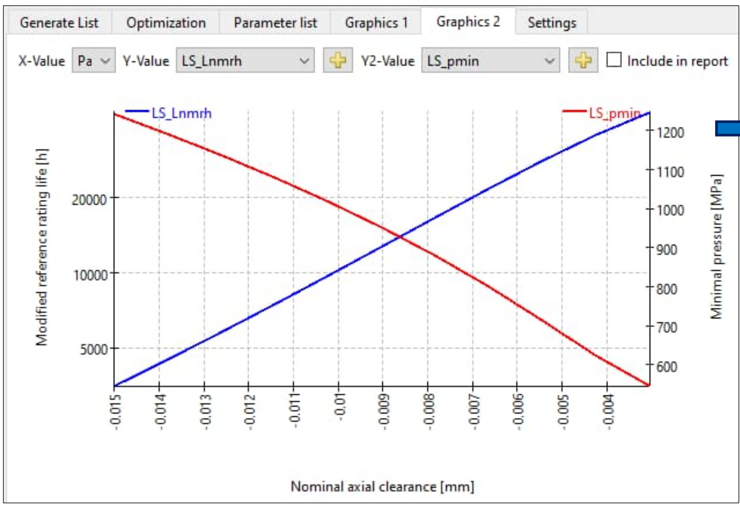
	Pa [mm]	LS_Lnmrh [h]	LS_maxSpinToRoll	LS_pmax [MPa]	LS_pmin [MPa]	Mfriction [Nm]
1	-0.003...	43838.2	0.360434	1682.23	545.57	0.126902
2	-0.004...	35659.8	0.324498	1698.02	622.798	0.138691
3	-0.005...	28122	0.292835	1718.36	712.727	0.152644
4	-0.006...	21761.9	0.266592	1742.32	799.719	0.168668
5	-0.007...	16683.8	0.245645	1768.82	879.178	0.186603
6	-0.009...	12754.4	0.229028	1796.98	951.494	0.206299
7	-0.010...	9762.87	0.215413	1826.16	1017.88	0.227651
8	-0.011...	7501.61	0.204691	1855.97	1079.41	0.250591
9	-0.012...	5795.12	0.195752	1886.14	1136.94	0.27508
10	-0.013...	4505.08	0.187809	1916.49	1191.12	0.301096
11	-0.015	3526.12	0.180965	1946.91	1242.47	0.328628

Figure 59



Please create the diagram SpinToRoll and pmax over axial bearing clearance as an example.

Figure 60



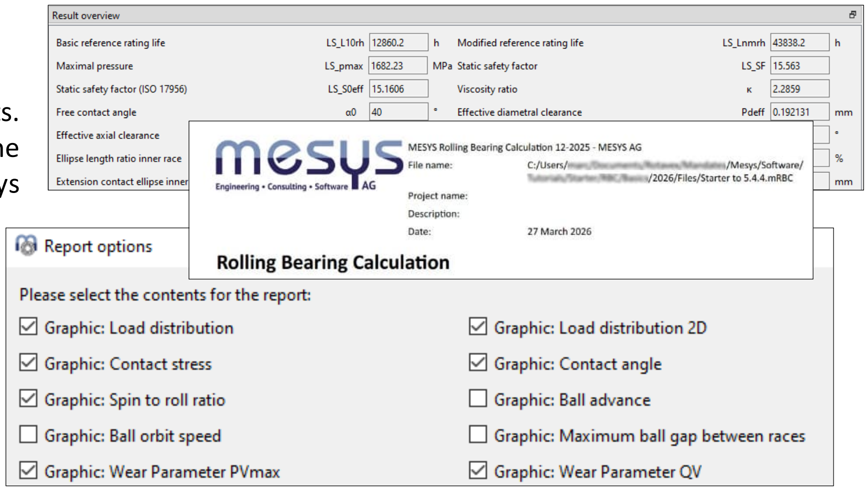
Please create the diagram Lnmrh sevice life and pmin over axial bearing clearance as an example.

Figure 61

6. Results

6.1 Reports

Figure 62

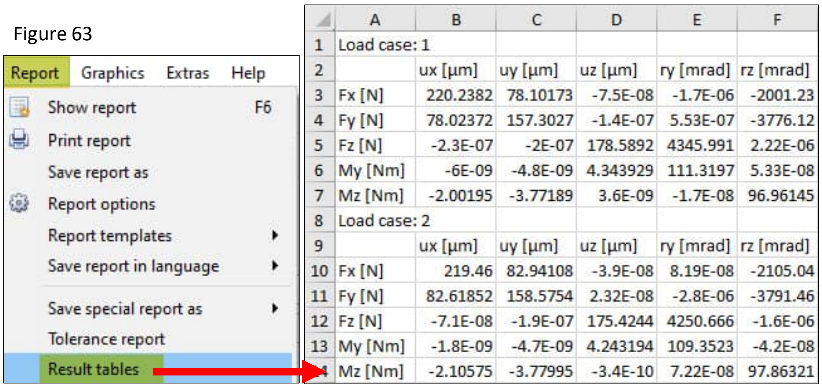


Results are available in various outputs. The standard results overview at the bottom of the user interface is always available and updated, as already mentioned in chapter 4.4.8.6.

A main Report as PDF or DOCX with standard content as well as additional content via 'Report options' can be called up using the 'Report' menu.

A spreadsheet with results for further processing in XLSX format can be opened by default under menu 'Report'/'Result tables'.

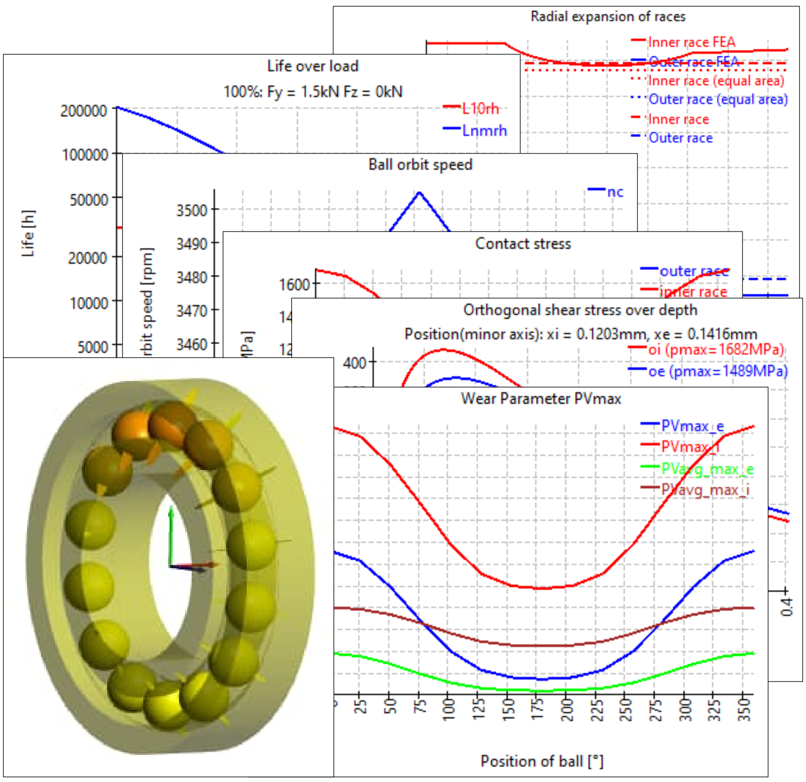
Figure 63



	A	B	C	D	E	F
1	Load case: 1					
2		ux [µm]	uy [µm]	uz [µm]	ry [mrad]	rz [mrad]
3	Fx [N]	220.2382	78.10173	-7.5E-08	-1.7E-06	-2001.23
4	Fy [N]	78.02372	157.3027	-1.4E-07	5.53E-07	-3776.12
5	Fz [N]	-2.3E-07	-2E-07	178.5892	4345.991	2.22E-06
6	My [Nm]	-6E-09	-4.8E-09	4.343929	111.3197	5.33E-08
7	Mz [Nm]	-2.00195	-3.77189	3.6E-09	-1.7E-08	96.96145
8	Load case: 2					
9		ux [µm]	uy [µm]	uz [µm]	ry [mrad]	rz [mrad]
10	Fx [N]	219.46	82.94108	-3.9E-08	8.19E-08	-2105.04
11	Fy [N]	82.61852	158.5754	2.32E-08	-2.8E-06	-3791.46
12	Fz [N]	-7.1E-08	-1.9E-07	175.4244	4250.666	-1.6E-06
13	My [Nm]	-1.8E-09	-4.7E-09	4.243194	109.3523	-4.2E-08
14	Mz [Nm]	-2.10575	-3.77995	-3.4E-10	7.22E-08	97.86321

6.2 Graphics

The 'Graphics' menu provides a wide range of 2D and 3D graphical representations and functions relating to deformation, load distribution, kinematics, wear variables, shear stress or service life.



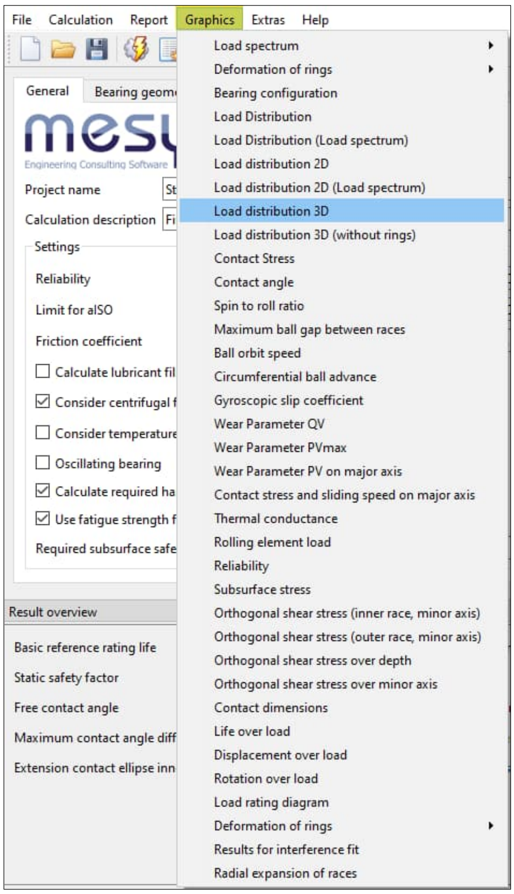


Figure 64

The graphics can be docked to the main programme interface and are automatically updated with each calculation.

The visualisations can be dragged and dropped into the user interface under the menu bar or into the results overview as shown here (Fig. 65).

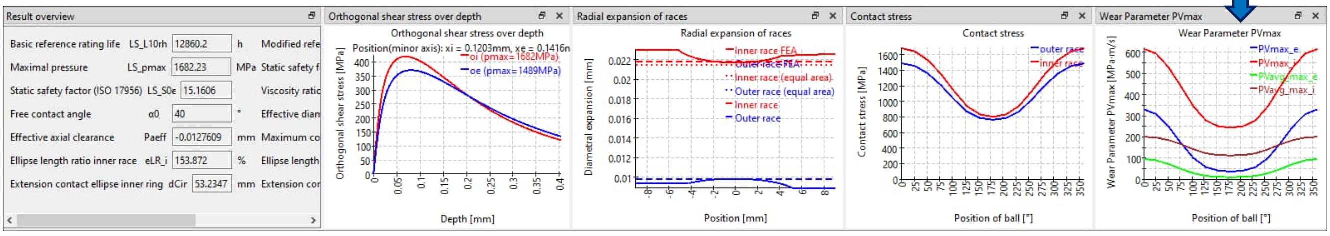


Figure 65

6.3 Further results

Due to the limited scope of this tutorial, we would like to mention the other results, such as grease operating life under menu 'Calculation', materials and their calculation with reference to heat treatment, results relating to lubrication conditions, bearing configurations, oscillating bearings, evaluation of pressure ellipses, consideration under minimum, medium and maximum clearance, effect of gyroscopic torques and much more, with reference to the Manual only.

6.4 Reports

The standard Report can be specifically edited with extensive content via 'Report options'. Furthermore, the protocol can be saved separately in the available languages. It is possible to add report templates and not forgetting the Tolerance report already used in this context.

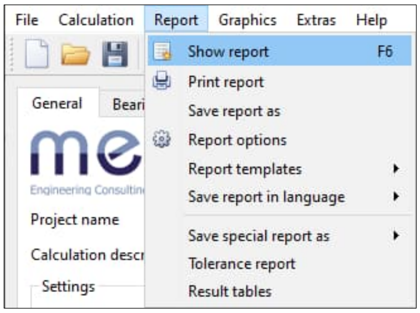


Figure 66

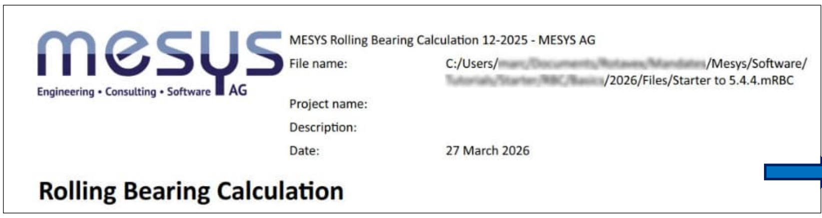


Figure 67

Please print out the standard Report.

MESYS wishes you an instructive and profitable experience with our tutorials. If you have any questions, suggestions or queries, please do not hesitate to contact info@mesys.ch .