

Tutorial Series

Rolling Bearing Analysis - Starter Basics First Results

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1. Foreword 1.1 Aim of the tutorial

This starter tutorial for <u>MESYS Rolling Bearing Calculation</u> 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 12-2024.

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 <u>Rolling Bearing Analysis</u>.

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





3. Software Manual

3.1 Manual online



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.

ile Home Sha	re View				
→ · ↑ 🚺 > 1	This PC 🔸 Lo	ocal Disk (C:) > MESYS 12-2024			
	^	Name	Date modified	Туре	Size
📌 Quick access		MesysHertz64.exe	02/12/2024 11:43	Application	41,71
Cesktop	1	MesysInterface3D64.dll	26/11/2024 14:12	Application exten	35
Downloads	1	MesysManual.exe	14/07/2024 17:52	Application	23,58
Documents	*	MESYS-Manual.pdf	11/07/2024 09:00	PDF Document	12,35
Pictures	*	🚰 MesysManual-DE.exe	14/07/2024 17:52	Application	23,66
	ai i	MESYS-Manual-DE.pdf	13/07/2024 12:13	PDF Document	12,36
- Active Disterious		AmesysManual-JA, exe	14/07/2024 17:52	Application	23,86
Beginner		MESYS-Manual-JA.pdf	13/07/2024 10:09	PDF Document	9,95
Drafts		🚰 MesysManual-KO.exe	14/07/2024 17:52	Application	23,84
Import Geometry		MESYS-Manual-KO.pdf	13/07/2024 10:22	PDF Document	9,70
This DC		A MesysRBC64.exe	02/12/2024 11:41	Application	45,95

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.

File	Calculation	Report	Graphics	Extras	Help
	2	\$			



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

						Figu
le Calculation Rep	ort Graphics Extras Help					
🗋 🚞 💾 🍕						
General Bearing ge	ometry Bearing configuration	Material and Lub	rication Lo	ading	Track roller	
	US are		F	Rolli	ng Bearing Calculation	
Project name	Starter Tutorial					
Calculation description	First Results					
Settings						
Reliability		S	90	%	Calculation for medium clearance	~
Limit for alSO		alSOMax	50		Rolling element has maximum temperature	
Friction coefficient		μ	0.1		First rolling element on y-axis	~
Calculate lubricar	nt film thickness				Gyroscopic moment is not considered	
Consider centrifu	gal force				Rolling element set life is not calculated	
Consider tempera	ature gradient in fits				Elastic ring expansion is not considered	~

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 '<u>Input Parameters</u>' 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 alSO

The <u>factor aISO</u> 'modifies' the rating and reference life in

Limit for alSO alSOMax 50

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:

$$a_{\rm ISO} = f\left(\frac{e_{\rm C} C_{\rm U}}{P}, \kappa\right)$$

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 alSO \leq 50.



4.3.3 Centrifugal force

Taking <u>centrifugal force</u> 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

Consider temperature gradient in fits

If the '<u>Consider temperature gradient in fits</u>' 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 <u>5.2.6</u>.

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

Rolling element has maximum temperature

The rolling element temperature influences the resulting operating clearance. This can be set to ring temperature, averaged ring tem-

perature 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 <u>5.2.5</u>.

Further information on elastic expansion can be found in the Manual.

4.3.8 Load spectrum

Use load spectrum

Another method of analysing the application behaviour is to consider different conditions or load states. If the checkbox for '<u>Use load spectrum</u>' 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.

Calculate modified life

MESYS AG



Elastic ring expansion is not considered

Consider centrifugal force



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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.



General	Bearing geometry	Bearing config	juration	Material and Lubrication	Loading					
Deep gro	oove ball bearing				~ +					
Deep gro	ove ball bearing									
Deep gro	ove ball bearing (doub	le row)			4					
Axial dee	p groove ball bearing				25					
Angular	contact ball bearing						Fig	gure 5		
Angular	contact ball bearing (do	ouble row)	ons for selected bearing type				Х			
Axial ang	jular contact ball bearin	1g	-0			-		10		
Axial ang	jular contact ball bearing	ig (double row)	Bear	ing has filling slot						
Four poir	nt ball bearing (radial)									
Four poir	nt ball bearing (axial)		Bear	ing inner ring is shaft						
Three poi	int ball bearing (split in	ner ring)	🗌 Bear	ing outer ring is housing						
Three poi	int ball bearing (split ou	iter ring)		·		e a salari	1	100		
Self align	ing ball bearing (single	row)	User	Use ring diameter for equivalent cross section for calculation of fits						
Self align	ing ball bearing (doubl	e row)	Calc	ulate load capacity for hybrid	bearings au	tomatica	lly			
Duplex b	earings			1.4. Jacob and an angle of the basheded						
Cylindric	al roller bearing			ulate load capacity for hybrid	bearings					
Cylindric	al roller bearing (double	e row)	Calc	ulate X/Y-factors based on fre	e contact ar	ngle				
Needle b	earing		Dermire	ible ellipse length entio			100			
Axial cyli	ndrical roller bearing		Permissi	ible ellipse length ratio			100	70		
Axial cyli	ndrical roller bearing (d	louble row)	Lower st	tress limit for truncation	pn	nin(eLR)	1	MPa		
Tapered r	oller bearing			contraction in accordance				1		
Tapered r	oller bearing (double re	(wa	User	SO conformity in case of sma	Il conformit	У				
Axial tap	ered roller bearing		Limit fo	r conformity for dynamic load	d rating	f_limCr	0.515			
Barrel rol	ler bearing		12424			E Emercon	0.515	1		
Toroidal r	roller bearing		Limit to	r conformity for static load rat	ting 1	_limcor	0.515			
Spherical	roller bearing		Tolerand	ce for conformity inner race		∆fi	0			
Half radia	al spherical roller bearin	ig					-	1		
Axial sph	erical roller bearing		lolerand	e for conformity outer race		Δte	0			
Cross roll	ler bearing (radial)		Friction	coefficient for fitting		ufit	0.1]		
Cross roll	ler bearing (axial)		1222					_		
Angular r	roller bearing (radial)		Reduct	ion of load rating because of l	hardness ac	cording t	o Harris	~		
Angular r	roller bearing (axial)				Г	OK	Can	cel		
					L	UN		LCI		

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):

General Bearing geometry	Bearing configuration	Material ar	nd Lubrication	Loading	Track roller	
Deep groove ball bearing				~ 🕂	Enter outside geometry only	
Inner diameter		d	0	mm 🕂	Enter outside geometry only Enter outside geometry and load capacity	
Outer diameter		D	0	mm 🕂	Enter inner geometry Enter inner geometry and load capacity	
Width		В	0	mm	Select bearing from database	
Number of rolling elements		Z	0		Bearing clearance	User input as operating clearance
Diameter of rolling elements		Dw	0	mm	Diametral clearance	Pd 0 mm
Pitch diameter		Dpw	0	mm		
Conformity inner ring		fi	0.52			
Conformity outer ring		fe	0.52			
Shoulder diameter inner ring		dSi	0	mm 🕂		
Shoulder diameter outer ring		dSe	0	mm 🔶		

4.4.2 Enter outside geometry only

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

General Bearing geometry E	earing configuration Material	al and Lubrication Loading	Track roller			
Deep groove ball bearing		× 🗘	Enter outside geometry only			~
Inner diameter	d	0 mm 🔂	Dynamic load rating	El	3	Cr 0 kN
Outer diameter	D	0 mm 🔂	Static load rating	5	Ø	C0r 0 kN
Width	в	0 mm	Fatigue load limit			Cur 0 kN
This can be the choice	if the internal geo	ometry and load	ratings are not known.	Cr 35.888	kN	Figure 7
The software calculate	es these after the f	first <u>calculation</u>	command on the basis	C0r 21.3049	kN	
of generic internal geo	metry and in acco	rdance with ISO 2	281 and ISO 76 (Fig. 7).	Cur 1.11028	kN	



nner diameter	d	0	mm
Duter diameter	D	0	mm
🔞 Define deformations of inner ring			3
Deformation of raceway	○ Gap width betwe	en ring an	d shaft
Type of input	Point data		v
ψ[°] u_r [mm] u_x [mm] n [mrad]			4

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 <u>calculation command</u> on the basis of generic internal geometry and in accordance with ISO 281 or ISO 76.

General	Bearing geometry	Bearing configuration	Material	and Lubrication	Loading	Track roller				
Deep groo	ove ball bearing				~ 4	Enter outside geometry and load capacity				~
Inner diam	eter		d	40	mm 🕂	Dynamic load rating		Cr	25.735	kN
Outer diam	neter		D	80	mm 🛟	Static load rating	653	C0r	15.9028	kN
Width			в	23	mm	Fatigue load limit	-	Cur	0.828755	kN
									Fi	gure 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.

General Bearing geometry Bearing configuration	Material an	d Lubrication	Lo	ading	g Track roller	
Deep groove ball bearing			~	÷	Enter inner geometry	~
Inner diameter	d	40	mm	÷	Dynamic load rating	Cr 25.735 kN
Outer diameter	D	80	mm	4	Static load rating	C0r 15.9028 kN
Width	в	23	mm		Fatigue load limit	Cur 0.828755 kN
Number of rolling elements	z	9		÷	Bearing clearance	User input as operating clearance \vee
Diameter of rolling elements	Dw	11.1125	mm		Diametral clearance	Pd 0 mm 🗮
Pitch diameter	Dpw	60	mm	*		
Conformity inner ring	fi	0.52				
Conformity outer ring	fe	0.52				

4.4.4.2 Number of rolling elements

Number of rolling el	ements	Z	9			÷
Diameter of rolling	🚷 Enter parameters					×
Pitch diameter	Enter number of rolling elements					
Conformity inner rir	Maximum fill angle	ψREi	max	300	•	
Conformity outer rid	Minimum distance between rolling elements	δRE	min	1	mr	m
Shoulder diameter i			ОК		Cancel	

The <u>number of rolling elements</u> 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.



Diameter of rolling eler	nents	Dw 0		mm 😑	The ' 📇 ' - button opens the dialogue to
Pitch diameter		Dpw 0		mm 😭	calculate the number of rolling ele
Contact angle		α 0		•	the contact angle from the specified
Conformity inner ring	🔞 Calculate Z, Dw from frequencies			×	damage frequencies. This can be used i
Conformity outer ring	Speed of inner ring	ni	60	rpm	damage frequencies are specified for a bearing but geometry data is missing
Shoulder diameter inn	Speed of outer ring	ne	0	rpm	(Fig. 12).
Shoulder diameter out	Pitch diameter	Dpw	60	mm	
	Damage frequency for inner race	fip	8.0641	1/s	
	Damage frequency for outer race	fep	5.9359	1/s	
	Damage frequency for rolling element	frp	4.9230	1/s	
isult overview	Number of rolling elements	z	0		
	Roller diameter	Dw	0	mm	Z <u>14</u>
	Nominal contact angle	α	0	•	Dw 11.9061 mm
	ОК	Calcula	ite Ci	ancel	α <u>39.9978</u>

Please go to a manufacturer's product page and load the product data from Fig. 13.

→ Search for the basic frequencies here. Designation 7208-B-XL-TVP ▲ Basic frequency factors related to 1/s Overrolling frequency factor on outer ring BPFF0 5,9359 ● Basic frequencies (PDF) Overrolling frequency factor on outer ring BPFF1 8,0641 Overrolling frequency factor on rolling element BSFF 2,4615 Ring pass frequency factor on rolling element RPFFB 4,9230	uct page and load the product data for an angular contact ball bearing 7208 with suffix 'B' Alternatively, use the data from Fig. 13.		Main Dim d D B C _r C _{or} C _{or} C _{or} r c _{ur}	ensions & Performance I 40 mm 80 mm 18 mm 36.000 N 23.500 N 1.630 N 11.900 1/min 8.600 1/min 0,367 kg	Data Bore diameter Outside diameter With Basic dynamic load rating, radia Basic static load rating, radia Fatigue load limit, radial Limiting speed Reference speed Weight
	 Search for the basic frequencies here. Basic frequencies (PDF) 	Designation Basic frequency factors related to 1/s Overrolling frequency factor on outer rin Overrolling frequency factor on inner rin Overrolling frequency factor on rolling el Ring pass frequency factor on rolling ele	g g ement ement	208-B-XL-TVP BPFF0 BPFF1 BSFF RPFFB	5,9359 8,0641 2,4615 4,9230

Figure 14 (Source: Schaeffler Medias) Speed factor of rolling element set for rotating outer ring FTFF_o

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.

0,5760



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 ' $\frac{1}{2}$ ' - button.

Conformity inner ring Conformity outer ring Shoulder diameter inner ring of the force. selected using Contact angle left Contact angle left

0

α

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

Contact angle

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 <u>corresponding chapter</u> of the Manual.



Figure 16

Figure 15

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 <u>results overview</u> 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%.

Shoulder diameter inner ring	dSi 0		mm	÷
Shoulder diameter outer ring	dSe 0		mm	÷
	B Enter Factor for shoulder diameter			×
	Enter Factor for shoulder diameter			
	Factor shoulder diameter inner ring fSi	30	9	6
esult overview	Factor shoulder diameter outer ring fSe	30	9	6
	ОК		Cancel	

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 be-

Figure 18

tween 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 <u>Manual</u> 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.

Enter inner geometry and load capacity						
Dynamic load rating	Cr	36	kN			
Static load rating	C0r	23.5	kN			
Fatigue load limit	Cur	1.63	kN			
		Figu	ire 19			

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

Observe the changes in the <u>Result overview</u> at the bottom of the user interface.

Result overview		5
Maximal pressure	(0.00103878 MPa Static safety factor SF 9999 Static safety factor (ISO 17956) S0eff 99.99	
Reference load	f 0 N Viscosity ratio κ 0 Free contact angle $\alpha 0$ 40	۰
Effective diametral clearance	f 0.22284 mm Effective axial clearance Paef 0 mm Maximum spin to roll ratio maxSpinToRol 0	
Maximum contact angle differer	χ 0 °	

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

Figure 20

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.

Angular conta	ct ball bearing					~	÷	Select bearing from database
Inner diameter			d	40	r	nm 🕂		Dynamic load rating
Outer diameter			D	80	r	nm 🕂		Static load rating
Manufacturer	name	di [mm]	De [mm]	B [mm]	alpha [°]	C [kN]	1^	Fatigue load limit
FAG	7208-B-XL-2RS-TVP-L038	40	80	18	40	36	i	Bearing clearance
FAG	7208-B-XL-2RS-TVP	40	80	18	40	36	í	Axial clearance
NSK	7208C	40	80	18	15	36. <mark>5</mark>	2	
NSK	7208BEAT85	40	80	18	40	38 <mark>.</mark> 5	i	
NSK	7208BW	40	80	18	40	32	:	Figure 21

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

Angular contac	t ball bearing					\sim	÷	Select bearing from database			`
nner diameter Outer diameter			d D	40 80	r	nm 🔶	P) Dynamic load rating Static load rating	c	r 36 Or 23.5	kN kN
Manufacturer	name	di [mm]	De [mm]	B [mm]	alpha [°]	C [kN]	10	Fatigue load limit	C	ur 1.63	kN
SKF	*7208 BEGAP	40	80	18	40	36.5	2	Bearing clearance	User input as	operating clear	ance \
SKF	*7208 BECBY	40	80	18	40	36.5	í	Axial clearance	Pa 0	μη	m
SKF	*7208 BECBP	40	80	18	40	36.5	ć				
SKF	*7208 BECBM	40	80	18	40	36.5	:	Filter a generic angula	r contact	ball bea	aring
SKF	*7208 BECBJ	40	80	18	40	36.5	i	with $d = 70 \text{ mm}$, $D = 80$) mm, B =	18 mm,	anc
SKF	7208 BE-2RZP	40	80	18	40	34.5	:	$\alpha = 40^\circ$, then double-c	lick on it.	Unce the	e se
SKF	*7208 ACCBM	40	80	18	25	41.5	:	lection has been made	e, the unc	lerlying	con
Generic	7208B	40	80	18	40	28.1556	1	tact angle can be view	ed by swit	tching to	o In
							×	 put of external geome 	try , for in	istance.	



4.4.7 Bearing clearance

4.4.7.1. General

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.

		Figure 23
Bearing clearance		User input as operating clearance $$
Axial clearance	Bearing with contact angle	From database User input as operating clearance User input
		User input as range

There are also the settings 'From database', 'User input as operating clearance' and 'User input' / as range.

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.

Bearing clearance	User input as range	~ 🛟
Diametral clearance Radial bearing	Pd 0.22284	mm
Bearing tolerance	ISO 492 - PO	~

Figure 24

Figure 25

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 <u>Software Manual</u>.

4.4.7.2 User input

This setting allows the bearing clearance to be entered before installation (Fig. 25). The effects of temperature or interference in

)	Bearing clearance	User input	~		
2	Axial clearance	Pa	0	μm	

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

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.

				Figu	re 26
Bearing clearance	Useri	nput			~
Axial clearance		Pa	0	μm	
Bearing tolerance	🔞 Calculation of Axial cleara	nce P	a		×
Fit to shaft	Mounted axial clearance	Pam	-0.00717004	mm	0
Surface roughness shaft	Effective axial clearance	Paeff	-0.00717004	mm	0
Shaft inner diameter	Pretension force	Fp	0	N	۲
Fit to housing	Unmounted pretension force	Fpu	0	N	0
Surface roughness housing	Mounted pretension force	Fpm	941.533	N	0
Housing outer diameter	Effective pretension force	FpEff	941.533	N	0
		(ОК	Cancel	

- 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

For radial angular contact ball bearings, a preload class can be defined from the bearing database, provided that this information has been trans-

Bearing clearance	User input 💦
Axial clearance	Light preload Medium preload
Bearing tolerance	Heavy preload

Figure 27

ferred (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'.

	I	Bearing clearance	User input	~	
--	---	-------------------	------------	---	--

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.

17000	Axial internal clearance, preload and preload force of bearing sets with universal bearings in 0 or X arrangement	Bore code	Bore code of bearing pair Nominal dimension							Preload force F _{V max} N			
28 (Source: SKF	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		UA	UB	UO	UL				UL			
			Bearing series										
			70В, 72В, 70В 72В 73В 74В			74B	70B	72B	73B	74B			
		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	-
Assign the 72	08B a preload according	04	28	16	0	-4	-5	-6	-8	103	103	146	258
to the UL clas	ss given by an imaginary	05	34	19	0	-4	-4	-6	-8	115	112	200	300
manufacturer.		06	34	19	0	-5	-5	-7	-8	141	157	250	365
		07	40	22	0	-5	-6	-7	-9	172	208	300	462
Figure 29	(Source Schaeffler, HR1)	08	40	22	0	-5	-6	-8	-10	200	246	385	535

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 μ m.

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 μ m) / 2 = -3 μ m (Fig. 30).

Bearing clearance	User input 🗸 🗸
Axial clearance	Pa -3.03731 µm 🚍
Bearing tolerance	🔞 Calculation of Axial clearance Pa 🛛 🗙
	Mounted axial clearance Pam -0.00303731 mm O Effective axial clearance Paeff -0.00303731 mm O
	Unmounted pretension force Enu 246
	Mounted pretension force Fpm 272.233 N O Effective pretension force FpEff 272.233 N O OK Cancel

4.4.8 Bearing tolerance

4.4.8.1 General

Bearing tolerance	ISO 492 - P0	\sim	ISO 492 - PO		~
Eithe shaft	Not considered	^	1.6		
Fit to shart	Nominal dimensions		ко		<u>т</u>
Surface roughness shaft	Define interference		Rz	4	μm
	Define multi-layer interference			-	-
Shaft inner diameter	User input		dsi	0	mm
Fit to housing	ISO 492 - P0		H7		4
······	ISO 492 - P6				
Surface roughness housing	ISO 492 - P5		Rz	4	μm
Housing outer diameter	ISO 492 - P4		dha	0	- 1
Thousing outer diameter	ISO 492 - P2	\sim	une	U]

Figure 31

taken into account in accordance with <u>ISO 492</u> (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 di-

The bearing tolerance can be

ameter) 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.

Bearing tolerance		Define inte	erference		~
Interference shaft inner rir	g	lwi	5.5028	μm	
Shaft inner diameter		dsi	10	mm	
Interference housing oute	r ring	lwe	-3	μm	
Housing outer diameter		dhe	100	mm	
	Calculate interference				×
	Speed of inner ring		ni 8000		rpm
	Effective interference sha	ft - inner ring lw	viOp 5		μm
Figure 32			ОК	Cance	el

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 μ m inside and -3 μ m outside! A speed effect can be read from this.

In <u>Chapter 5</u> '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.

General	Bearing geometry	Bearing configuration	Material and Lubrication	Loading	Track roller	
Axial loa	d		Fx 991.504	N O	Displacement	<mark>υχ 0</mark> μm 🍥
Speed in	iner ring		ni 8000	rpm [Inner ring rotates to load	
						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

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.



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.

File Calculation Report Graphics Extras He 3 Calculate F5 Thermal permissible speed Ge Grease operating life Wheel bearing L Load rating diagram Import load distribution F Parameter variation Parameter variation (statistical) Parameter variation (optimization) Grease operating life × Calculate grease operating life kf 1.6 Factor for bearing type Factor for environment KU 1 Grease temperature limit Tlimit 70 °C *

OK

Cancel

Figure 35

Figure 34

compared with each other.

in



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.

General	Bearing geometry	Bearing configuration	Material and Lubrication	Loading Track roller	
Axial load	d		Fx 991.504	N O Displacement	<u>ux</u> 0 μm 🥥
Radial loa	ad		Fy 0	N	uy 0 mm O
Radial loa	ad		Fz 0	N	uz 0 mm O
Moment			My 0	Nm O Rotation angle	ry 0 mrad 🖲
Moment			Mz 0	Nm O Rotation angle	rz 0 mrad 🖲
Speed in	ner ring		ni 8000	rpm 🛛 Inner ring rotates to load	
Speed ou	iter ring		ne 0	rpm 🔲 Outer ring rotates to load	
Temperat	ture inner ring		Ti 20	°C Temperature outer ring	Te 20 °C



4.4.8.5 Menu 'Extras'

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 online¹.

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:

Result overview									8
Modified reference rating life In	ımrh 2.439e+07 h	Maximal pressure	pmax	923.627	MPa	Static safety factor	SF	94.0283	
Static safety factor (ISO 17956) S	0eff 79.4024	Reference load	Pref	456.785	N	Viscosity ratio	к	7.97427	
Free contact angle	α0 40 °	Effective diametral clearance	Pdeff	0.203418	mm	Effective axial clearance	Paeff	-0.00578171	mm
Maximum spin to roll ratio maxSp	oinToR(0.291228	Maximum contact angle diff	erence Z	Δα 7.49616	•	Basic reference rating life	L10r	234185	
Ellipse length ratio inner race e	eLR_i 208.571 %	Ellipse length ratio outer race	e eLR_e	256.701	%	Extension contact ellipse inner r	ing dC	im 53.0167	mm
Extension contact ellipse outer ring	g dCen 68.0584 mr	n							

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.

diameter and speed in the report preamble for correctness.



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	lw_i	5.50	5.50	5.50	μm
Effective interference inner ring	lw_iop	5.00	5.00	5.00	μm
Interference outer ring	lw_e	-3.00	-3.00	-3.00	μm
Effective interference outer ring	lw_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) μ m is reduced to 5 μ m by the speed effect.



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 <u>Manual</u>.

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).

											-
ieneral	Bearing geometry	Bearing configuration	Material	and Lubricatio	on	Loadin	g Track roller				
Material											
Surface I	hardness inner race			58	HRC		Surface Hardness outer race		58	HRC	
Core stre	ength inner race		Rm	1200	MPa		Core strength outer race	Rm	1200	MPa	
Hardnes	s depth inner race		hdi	0	mm		Hardness depth outer race	hde	0	mm	
Surface	roughness inner race		Rq	0.114068	μm	*	Surface roughness outer race	Rq	0.114068	μm	*
Surface	roughness roller		Rq	0.114068	μm	*	Material rolling element Steel			\sim	-
Material	inner race Steel					÷	Material outer race Steel			~ ~	-
Material	shaft Steel				~	•	Material housing Steel			~	4

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 <u>Manual</u>.

ile Calculation Report Graphics	Extr	as Help		
🗋 늘 💾 🧳 🌉 🖶	۲	Language Unit system	:]	
General Bearing geometry Bea		Database		Material
Material Surface hardness inner race Core strength inner race	() ()	Result overview Settings License Tools		Material Bearings Material DIN743 Material (orthotropic) Material ISO 6336

Figure 43

Figure 42

	Figure 44
ISO VG 220 mineral oil	~
Own Input	1
ISO VG 46 mineral oil	
ISO VG 68 mineral oil	
ISO VG 100 mineral oil	
ISO VG 150 mineral oil	
ISO VG 220 mineral oil	
ISO VG 320 mineral oil	
ISO VG 460 mineral oil	
ISO VG 680 mineral oil	
ISO VG 46 mineral oil (EP additives)	×
Oil lubrication with on-line filter ISO4406 -/17/14	~
Oil lubrication without on-line filter ISO4406 -/13/10	^
Oil lubrication without on-line filter ISO4406 -/15/12	
Oil lubrication without on-line filter ISO4406 -/17/14	
Oil lubrication without on-line filter ISO4406 -/19/16	
Oil lubrication without on-line filter ISO4406 -/21/18	
Grease lubrication, High cleanliness	
Grease lubrication, High cleanliness Grease lubrication, Normal cleanliness	
Grease lubrication, High cleanliness Grease lubrication, Normal cleanliness Grease lubrication, Slight to typical contamination	
Grease lubrication, High cleanliness Grease lubrication, Normal cleanliness Grease lubrication, Slight to typical contamination Grease lubrication, Severe contamination	

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).

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 fa	The contamination factor eC is used to calculate the factor alSO							
the modified service l	ife (Figure 46).		Contamination factor ed	C 0				
Lubrication								
ISO VG 46 mineral oil	~	Oil lubrication without on-line filter	SO4406 -/17/14	~ 4				
Viscosity at 40°C	nu40 46 mm²/	's Temperature	TOil	70 °C 🔽				
Viscosity at 100°C	nu100 7 mm²/	's Oil density	ρ	870 kg/m ³				
contains effective EP additives		Pressure viscosity coefficient	α	0 1/MPa				
According to ISO 291 the pr	acance of ED ad							

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.



4.7.2 Input spaces

Axial load	Fx	991.504 N	O Displacement	ux	0	μm	0
Radial load	Fy	0 N	Oisplacement	uy	0	mm	0
Radial load	Fz	0 N	Oisplacement	uz	0	mm	0
Moment	Му	0 Nm	○ Rotation angle	ry	0	mrad	۲
Moment	Mz	0 Nm	○ Rotation angle	rz	0	mrad	۲

A <u>force or displacement</u> (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 <u>contact us</u>. Detailed information on this can be found in the <u>Manual</u>. 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 <u>Tolerance report</u> 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 $\cancel{0}$ +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. Bearing tolerance ISO 492 - P5

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

Please round the current cold <u>nominal interference</u> and assign an ISO class IT6 (16 μ m) diameter tolerance to the shaft and a IT7 (35 μ m) to the housing.

L			
	Surface roughnes	is housing Rz <mark>6</mark>	μm
🚯 Tolerances for shaft	×	🚳 Tolerances for Housing	×
Own input for shaft tolerances Upper allowance for shaft tolShaft_e Lower allowance for shaft tolShaft_i OK	mm mm Cancel	Own input for housing tolerances Upper allowance for housing tolHousing_e 0.01 Lower allowance for housing tolHousing_i -0.025 OK Ca	mm mm

Figure 50

 \sim

um

Rz 6

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	∆ds	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	lw_i	24.60	21.54	12.60	3.66	0.60	μm
Effective interference inner ring	lw_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	lw_e	22.60	18.67	0.60	-17.47	-21.40	μm
Effective interference outer ring	lw_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 μ m.

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
Fit to shaft	k6	Fit to housing	К7	4 -
Surface roughness shaft	Tolerances for shaft	Surface roughness housing	🔞 Tolerances for Housing	×
Shaft inner diameter Fit to housing	Own input for shaft tolerances	Housing outer diameter	Own input for housing tolerances Upper allowance for housing tolHousing_e 0.01	mm
Surface roughness housing Housing outer diameter	Lower allowance for shaft tolShaft_i 0.003 mm OK Cancel		Lower allowance for housing tolHousing i -0.02	5 mm Cancel

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

Axial load	Fx	1448.64 N O Displacement	ux	0	μm	۲
					-	

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 calcu-

°C

Temperature inner ring Ti 40

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.

Temperature outer ring

5.2.5 Elastic ring expansion

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

Elastic ring expansion based on medium radial force
Elastic ring expansion is not considered
Elastic ring expansion based on minimal radial force
Elastic ring expansion based on medium radial force
Figure 52
Axial load Fx 2098.57 N

Te 32

°C



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	∆ds	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	lw_i	23.60	20.54	11.60	2.66	-0.40	μm
Effective interference inner ring	lw_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	lw_e	18.60	14.76	-0.90	-16.56	-20.40	μm
Effective interference outer ring	lw_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 <u>Effective interference outer ring</u> (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.



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	0



The <u>Effective axial clearance</u> (Paeff) in the 'mean value' has decreased substantially compared to the initial unmounted Pa of $-3.03731 \,\mu$ m 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 <u>effective free contact</u> <u>angle</u> (α Oeff) and the <u>Effective diametral clearance</u> (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 μ m, 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:



Consider temperature gradient in fits

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

Table /

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 <u>load spectrum</u>.

5.4.2 Load rating

To <u>determine the bearing sizes according to the rating life</u> or <u>load capacity</u>, 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.

Radial load

2000 N

Fy



Result overview							
Modified reference rating life	Lnmrh 13294.7 h	Maximal pressure	pmax	1817.45	MPa Static safety factor	SF	12.3413
Station and a transformer (ISO 17056)	CO-66 12 10 42	Deferre en la est	Dest	2005 4	N. Managita anti-		2 22065
Static safety factor (ISO 17950)	SUET 12.1043	Reference load	Pret	2085.4	IN VISCOSITY ratio	к	2.33900
Effective diametral clearance	Pdeff 0.193858 mm	Effective axial clearance	Paeff	-0.0116741	mm Maximum spin to roll ratio maxSpin	ToRoll	0.472401

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.											✓ Use load spectrum			
The input fields under the 'Loading' tab now ap-	Ge	ner	ral Bearin	ng geome	try I	Bearing	configurati	on Mat	erial and L	ubrication	Load	<mark>ling</mark> T	rack roller	
pear as an input table.			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	
Figure 55	1	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 ' $rac{1}{2}$ ' - button at the bottom right.

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

									Figu	ire 56
Result overview										8
Ellipse length ratio inner race	eLR_i	157.929	%	Maximum contact angle difference	Δα	7.26839	° Maximal pressure	LS_pmax	1682.23	MPa
Maximum spin to roll ratio	LS_maxSpinToRoll	0.360434]	Minimal pressure	LS_pmin	545.57	MPa Modified reference rating life	LS_Lnmrh	43838.2	h
Static safety factor (ISO 76)	LS_S0	13.5625]	Static safety factor	LS_SF	15.563	Viscosity ratio	к	2.2859	

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

\Rightarrow	☑ inner Ring rotates to load	Outer ring rotates to load	Results for No 1

5.4.4 Parameter variation

A dialogue for parameter variations is displayed via the menu item 'Calculation'/'Parameter variation' (<u>4.4.8.4</u>) (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 <u>Software Manual</u>.



Figure 57







6. Results 6.1 Reports

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 <u>4.4.8.6</u>.

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'.

			liguic 02				
Result overview			8				
Basic reference rating life	LS_L10rh 12860.2	h Modified reference rating life	LS_Lnmrh 43838.2 h				
Maximal pressure	LS_pmax 1682.23	MPa Static safety factor	LS_SF 15.563				
Static safety factor (ISO 17956)	LS_S0eff 15.1606	Viscosity ratio	к 2.2859				
MOCUL	MESYS Rolling Bearing Calculation 12-2024						
	File name:						
Engineering Consulting Software		Tutorials/2024/Starter/Basics/RBC/ENG/Mesys Files/					
			m				
	Project name:	Starter Tutorial					
🛞 Report options							
Please select the contents for the report							
Compliant and distribution		Combined and distribut	ing 2D				
Graphic: Load distribution		Graphic: Load distribut	ion 20				
Graphic: Contact stress		🗹 Graphic: Contact angle	1				
🗹 Graphic: Spin to roll ratio		Graphic: Ball advance					
Graphic: Ball orbit speed		Graphic: Maximum bal	l gap between races				
Graphic: Wear Parameter PVmax		Graphic: Wear Paramet	er OV				

					_						
igure 63					А	В	С	D	E	F	
igure 65				1	Load case	1					
Rep	ort	Graphics	Extras	Help	2		ux [µm]	uy [µm]	uz [µm]	ry [mrad]	rz [mrad]
1	Show	report		F6	3	Fx [N]	212.9289	66.52366	-1.8E-07	-2E-06	-1721.27
	Show report	4	4	Fy [N]	66.4652	163.428	-1.6E-07	-1.5E-06	-3929.03		
Prir	Print	report			5	Fz [N]	-2.1E-07	1.55E-08	184.1099	4475.018	3.53E-06
	Save	report as			6	My [Nm]	-5.1E-09	3.5E-10	4.473138	114.6083	8.76E-08
3	Repo	rt options			7	Mz [Nm]	-1.72216	-3.92524	3.79E-09	3.6E-08	100.9723
	Present to see 1		8	Load case	2						
	керо	n tempiate	>		9		ux [µm]	uy [µm]	uz [µm]	ry [mrad]	rz [mrad]
	Save report in language		*	10	Fx [N]	217.7691	61.28462	-5.5E-09	2.42E-07	-1551.14	
	Save special report as		11	Fy [N]	61.02589	158.7982	1.75E-07	-3.1E-06	-3846.97		
			12	Fz [N]	1.86E-07	-1.2E-07	170.2751	4152.423	3.61E-07		
	lolera	ance report		-	13	My [Nm]	4.68E-09	-2.9E-09	4.145374	106.8561	1.32E-08
	Resul	t tables		_	4	Mz [Nm]	-1.55158	-3.83722	-4.5E-09	8.02E-08	99.20982

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

Radial expansion of races



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).

Result overview 🗗	Orthogonal shear stress over depth 🗗 🗶	Radial expansion of races 🗗 🗙	Contact stress 🗗 🗙	Wear Parameter PVmax S
Basic reference rating life LS_L10rh 12860.2 h Modified ref Maximal pressure LS_pmax 1682.23 MPa Static safety Static safety factor (ISO 17956) LS_S0e 15.1606 Viscosity ratii Free contact angle a0 40 * Effective diar Effective axial clearance Paeff -0.0127609 mm Maximum co Ellipse length ratio inner race e.R.i 153.872 % Ellipse length Extension contact ellipse inner ring dCir 53.2247 mm Extension contact	Orthogonal shear stress over depth Postion(minor axis): x = 0.1203mm, yz = 0.1416fn 10 (pmax: 1425MPa) 10 (pmax: 1425MPa)	Radial expansion of races 0.022	Contact these Contact these Co	Wear Parameter PVmax P
< >	Depth [mm]	Position [mm]	Position of ball [*]	Position of ball [°]

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 <u>Manual</u> only.

Tutorials/2024/Starter/Basics/RBC/ENG/Mesys Files/

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 forget-ting the <u>Tolerance report</u> already used in this context.

MESYS Rolling Bearing Calculation 12-2024

Project name:

Description

Date:

C:/Users/

Starter Tutorial First Results

Tuesday, 28, January 2025



Please print out the standard Report.

Rolling Bearing Calculation

Figure 67

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 <u>info@mesys.ch</u>.