

Optimizing a cylindrical bearing as used in a planetary gearbox

Bearing designer, KISSsoft release 03-2017

EES KISSsoft GmbH

Hauptstrasse 7 6313 Menzingen Switzerland

Tel: +41 41 755 33 20 h.dinner@EES-KISSsoft.ch www.EES-KISSsoft.ch

SHARING KNOWLEDGE

1 Document information

1.1 Document change record

Revision Date Author Com		Author	Comments
0	15.5.15	HD	Original document

1.2 Table of content

1 Docu	ment information	. 2
1.1	Document change record	
1.2	Table of content	
1.3	References	. 2
2 Exam	nple application	. 3
	Gearbox model	
2.2	Import of the bearing data	. 4
2.3	Calculation with given bearing data	. 5
2.4	Bearing fine sizing	

1.3 References

[1] KISSsoft 03-2017A

2 Example application

2.1 Gearbox model

A bevel helical planetary gearbox with input speed of 1700RpM, input torque of 3000Nm and 534kW power is analyzed. The first stage is a spiral bevel gear. The second stage is a spur gear (cylindrical) and the output stage is a planetary stage with four planets. Each planet has four planet bearings. The system is shown below.

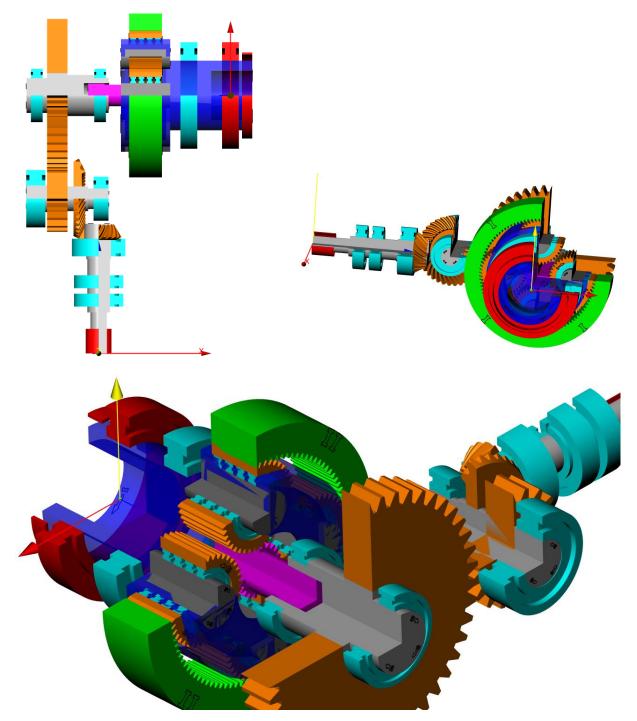
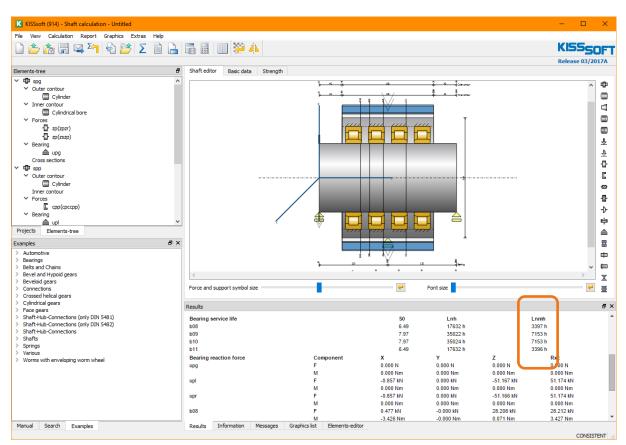


Figure 2.1-1 Gearbox model.

See file "THE-KSO-AS-1753-00-EES-Bearing-Designer.ks".



In this example, we find that the two outermost bearings have a low lifetime at 3396 hours only:

Figure 2.1-2 Resulting bearing life in the planet.

Using "File/Save as", we can export the shaft model and save it:

К	KISSsoft ((914) - Shaft	calculati	on - THE-K	SO-AS-1	753-00-	EES-Bearing-	Desig
File	View	Calculation	Report	Graphics	Extras	Help		_
	New						Ctrl+N	
۵	Open						Ctrl+O	Ē
2	Open ex	dusively						edito
R	Save						Ctrl+S	Ŀ-
	Save as.							
	Save as	template						

Figure 2.1-3 Export of the shaft model from KISSsys into a separate KISSsoft file.

2.2 Import of the bearing data

Start the bearing design tool by opening the module "Rolling bearing ISO/TS 16281":

KISSsoft (914) - Rolling bearing ISO/TS 16281 - Untitled			– 🗆 🗙
File Project View Calculation Report Graphics Extras He	lp		
🗋 📤 🔓 🖼 🍇 🎦 🖨 🔚	i i i i i i i i i i i i i i i i i i i		KISS _{SOFT}
			Release 03/2017A
Modules 🗗 🗙	Bearing data Rating Inner ring	Outer ring	
Cylindrical gear pair	File interface		
Pinion with rack Network Planetary gear	File name		Element type Rolling bearing

6 Four gears train	Data exchange Own Input	•	Shaft no. 1 🖨 Bearing no. 1 🖨
Bevel and Hypoid gears	Bearing data		
Eace gears	-	11 · / · · · ·	Diametral dearance Pa 0.0000 mm
Worms with enveloping worm wheels	Type Deep groove b	ball bearing (single row)	Diametral dearance P _d 0.0000 mm
Crossed helical gears and Precision mechanics worms	Number of balls/rollers	Z 0	Basic dynamic load rating Cr 0.0000 N
Beveloid gears	Ball / roller diameter	D _w 0.0000 mm	Vickers hardness HV 660
 Non circular gears Shafts and Bearings 			
Sharts and bearings In Shaft calculation	Reference diameter	D _{pw} 0.0000 mm	
Rolling bearing ISO 281, ISO 76	Radius of curvature, inner ring	rı 0.0000 mm 🖓	
Rolling bearing ISO/TS 16281	Radius of curvature, outer ring	r. 0.0000 mm	
 Plain bearing 	reades or carvatale, outer mig	10 010000 IIIII (2	

Figure 2.2-1 Module for single bearing calculation with inner geometry.

Now, import the previously save shaft file. Select that the bearing load is imported and select that the first connecting roller bearing is imported (the one on the left side, with the lowest life):

Bearing data	Rating Inner ring Oute	er ring
🛛 🗹 File interfa	ace	
File name ing	g-Designer-Planet-Shaft.W10	Element type Connecting rolling bearing 🔻
Data exchang	ge Bearing load 🔻	Bearing no. 1 🖨

Figure 2.2-2 Import of the shaft file previously exported from KISSsys.

Run the calculation / import by pressing "F5". The bearing inner geometry is then estimated as shown below:

Γ	Bearing data									
	Туре	Cylindrical roller bearing (sin	gle row)	•	Axial clearance	Pa	5.6000	mm		
	Number of balls/rollers	Z	17		Diametral clearance	P₫	0.0000	mm		
	Ball / roller diameter	Dw	14.4953 mm		Basic dynamic load rating	Cr	134000.0000	N		
	Reference diameter	D _{pw}	144.9900 mm		Fatigue load limit	Cu	20800.0000	N		
					Effective roller length	Lwe	18.7517	mm	+	i
					Vickers hardness	HV	660			

Figure 2.2-3 Bearing data, original design.

See file "THE-KSO-AS-1753-00-EES-Bearing-Designer-Left-Side-Bearing-Step-1.W51"

2.3 Calculation with given bearing data

We can now remove the link to the external shaft file:

Bearing data	Rating	Inner ring	Outer ring									
File interface												
File name ing	File name ing-Designer-Planet-Shaft.W10											
Data exchang	e Bearing	load	~									

Figure 2.3-1 Remove the link to the external shaft file.

And we adjust the (estimated) bearing data to rounded values:

Bearing data						
Туре	Cylindrical roller bearing (single row)	Axial clearance	Pa	0.0000 m	m	
Number of balls/rollers	Z 17	Diametral clearance	Pd	0.0000 m	m	
Ball / roller diameter	D _w 14.5000 mm	Basic dynamic load rating	Cr	134000.0000 N		ן
Reference diameter	D _{pw} 145.0000 mm	Effective roller length	Lwe	18.8000 m	m	+ i
		Vickers hardness	HV	660		

Figure 2.3-2 Rounded values for bearing data.

When running the calculation, we find the load capacity of Cr=134 kN.

Results				×
Cr	134.261 kN L10r	552.49		
Reference rating service life	Lnrh	54083.493 h		
pmax_i	1653.889 N/mm ²	inside		
pmax_o	1495.999 N/mm ²	outside		
ux	-0.597 µm	Fx	-0.000 kN	
uy	-27.970 µm	Fy	28.205 kN	
uz	-0.424 µm	Fz	0.477 kN	
гу	-0.000 mrad	My	0.071 Nm	
ſZ	0.012 mrad	Mz	-3.426 Nm	

Figure 2.3-3 Resulting capacity for original bearing design.

The stress distribution in the bearing is as shown below:

Graphics					×
Load distribution 3D			•		4
Hertzia	n pressure [N/	/mm2]			٦
0.000	413.472	826.945	1240.417	1653.889	
					J
			4		
		l -	Y		
			, 🕤		
			×		

Figure 2.3-4 Stress level of about 1650MPa in the bearing.

See file "THE-KSO-AS-1753-00-EES-Bearing-Designer-Left-Side-Bearing-Step-2.W51"

2.4 Bearing fine sizing

Use the bearing fine sizing function and set it up as shown below:

Fine sizing							
Bearing inputs	Results	Graphic					
Fixed, predefine	ed bearing d	ata					
Inner diameter			d [120.0000	mm
External diamet	er		D [180.0000	mm
Width			в [28.0000	mm
Variable bearing	data						
				Minimum	Maximum	Step	
Number of rollin	g elements		z [16	18	1	
Diameter of rolli	ng element		D _w	13.0000	16.0000	0.2500	mm
Reference diam	eter		D _{pw}	140.0000	150.0000	1.0000	mm
Radial clearance	e		p ₀ [0.0000	0.0000	0.0000	mm
Effective length	ofroller		L _{we}	18.8000	18.8000	0.0000	mm
Constraints that	t must be fu	Ifilled					
Density of rollin	g bodies (mi	n/max)	v	60	0.0000	95.0000	%
Minimum outer r	ing thicknes	s	ta [3.5000	mm
Minimum inner ri	ing thicknes	s	tı [3.5000	mm
Ratio of roller le	ength to bea	ring width (min/i	max) L _{we} /b	10	0.0000	99.0000	%

Figure 2.4-1 Bearing fine sizing, setup

Run the calculation and find several possible bearing designs with different roller diameter, pitch diameter and so on:

Fine sizi	ng						
Bearing in	puts Results	Graphic					
Nr.	d [mm]	D [mm]	B [mm]	Z	D _w [mm]	D _{pw} [mm]	p₀ (µm)
0	120.0000	180.0000	28.0000	17	16.0000	143.0000	0.0000
1	120.0000	180.0000	28.0000	17	16.0000	144.0000	0.0000
2	120.0000	180.0000	28.0000	18	15.0000	142.0000	0.0000
3	120.0000	180.0000	28.0000	18	15.0000	143.0000	0.0000
4	120.0000	180.0000	28.0000	18	15.2500	143.0000	0.0000
5	120.0000	180.0000	28.0000	18	15.2500	144.0000	0.0000
6	120.0000	180.0000	28.0000	18	15.2500	145.0000	0.0000
7	120.0000	180.0000	28.0000	18	15,5000	143.0000	0.0000

Figure 2.4-2 Resulting bearing proposals.

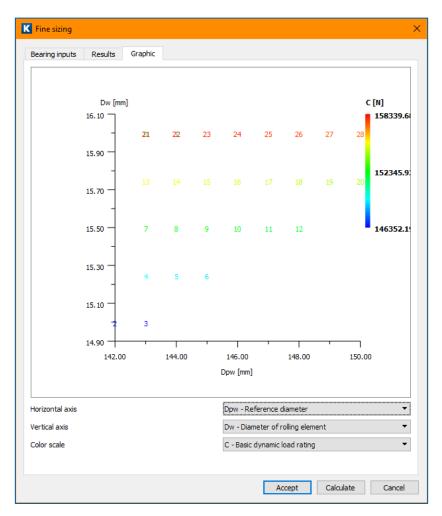


Figure 2.4-3 Graphical display of capacity vs. roller diameter and bearing pitch diameter.

Select the bearing design with the highest capacity as result and press "Accept". The bearing data is transferred and the calculation is executed.

	Bearing data Rating Inner ring Outer ring											~
	Data exchange Bearing load					Bearing no. 1 🗘						
	Bearing data											
	Туре	Cylindrical roller bearing (single row)				Axial clearance	Pa	0.0000	mm			
	Number of balls/rollers	Z	17			Diametral clearance	Pd	0.0000	mm			
	Ball / roller diameter	Dw	16.0000	mm		Basic dynamic load rating	Cr	151695.2864	Ν			
	Reference diameter	D _{pw}	143.0000	mm		Effective roller length	Lwe	18.8000	mm		+	1
						Vickers hardness	HV	660				_
6	Kesults											×
L	Cr Deference rating equica life pmax_i pmax_o ux uy uy uz ry rz			151.695 kN L10r Lock 1601.527 N/mm ² 1431.323 N/mm ² -0.771 µm -28.502 µm -0.434 µm -0.000 mrad 0.016 mrad	J	852.29 83430.564 h inside outside Fx Fy Fz My Mz		28.2 0.47 0.07	0 kN 205 kN 7 kN 11 Nm 26 Nm			

Figure 2.4-4 Resulting bearing design and resulting capacity.

With the modified bearing design, the contact pressure has now dropped to about 1600MPa. Accordingly, the capacity has increased from 134.0 kN to 151.7 kN.

Graphics				x
oad distributio	n 3D			⊾ ₽
Hertzian	n pressure (N/m	m2]		
. 000	400.382	800.764	1201.146	1601.527
		·		
		1		
		×	r en	
-	1		-	
	- p			

Figure 2.4-5 Improved bearing design with lower contact stress.

See file "THE-KSO-AS-1753-00-EES-Bearing-Designer-Left-Side-Bearing-Step-3.W51"