

Optimizing a cylindrical bearing as used in a planetary gearbox

Bearing designer, KISSsoft release 03-2017

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1 Document information

1.1 Document change record

Revision	Date	Author	Comments
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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.

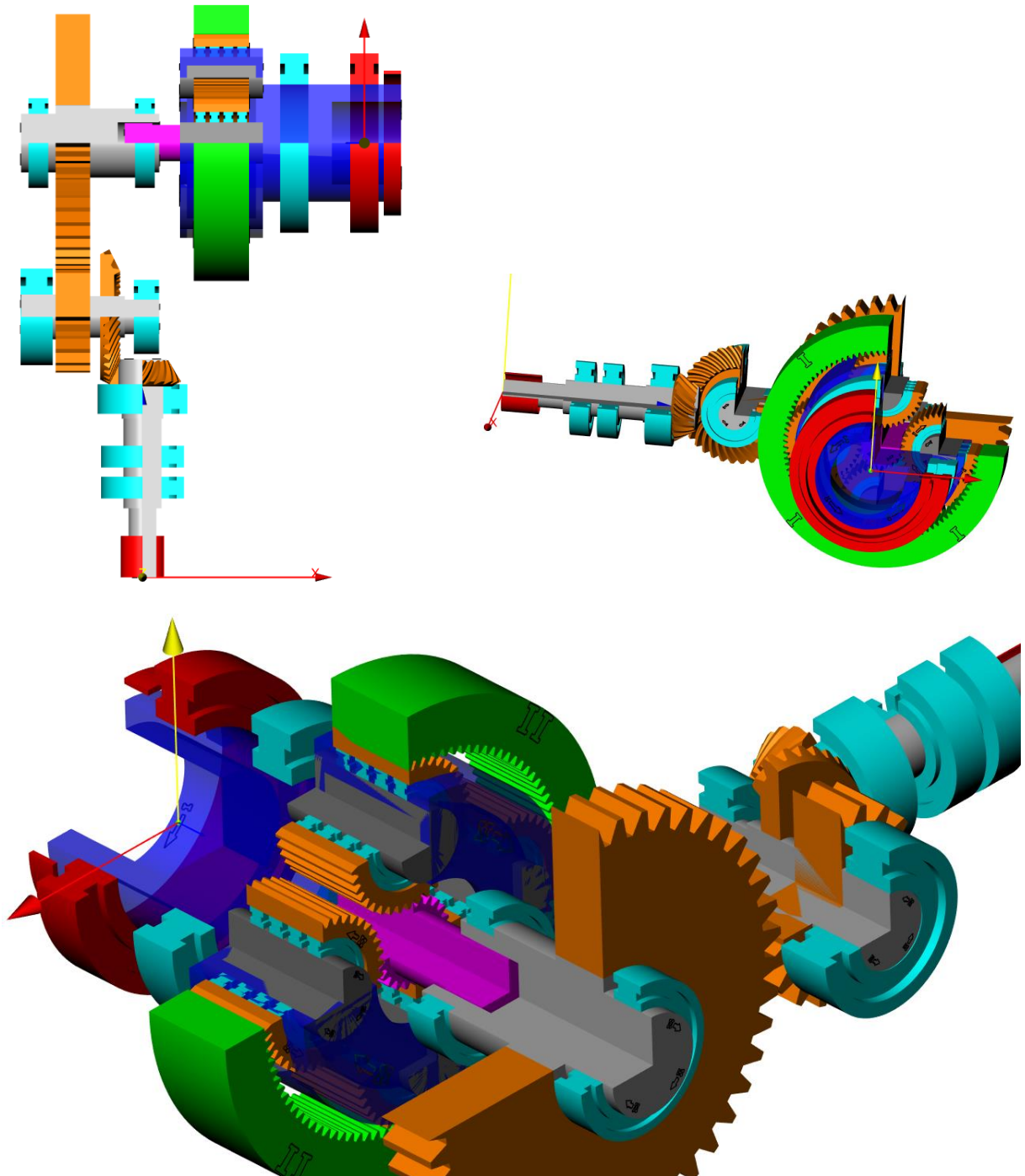


Figure 2.1-1 Gearbox model.

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:

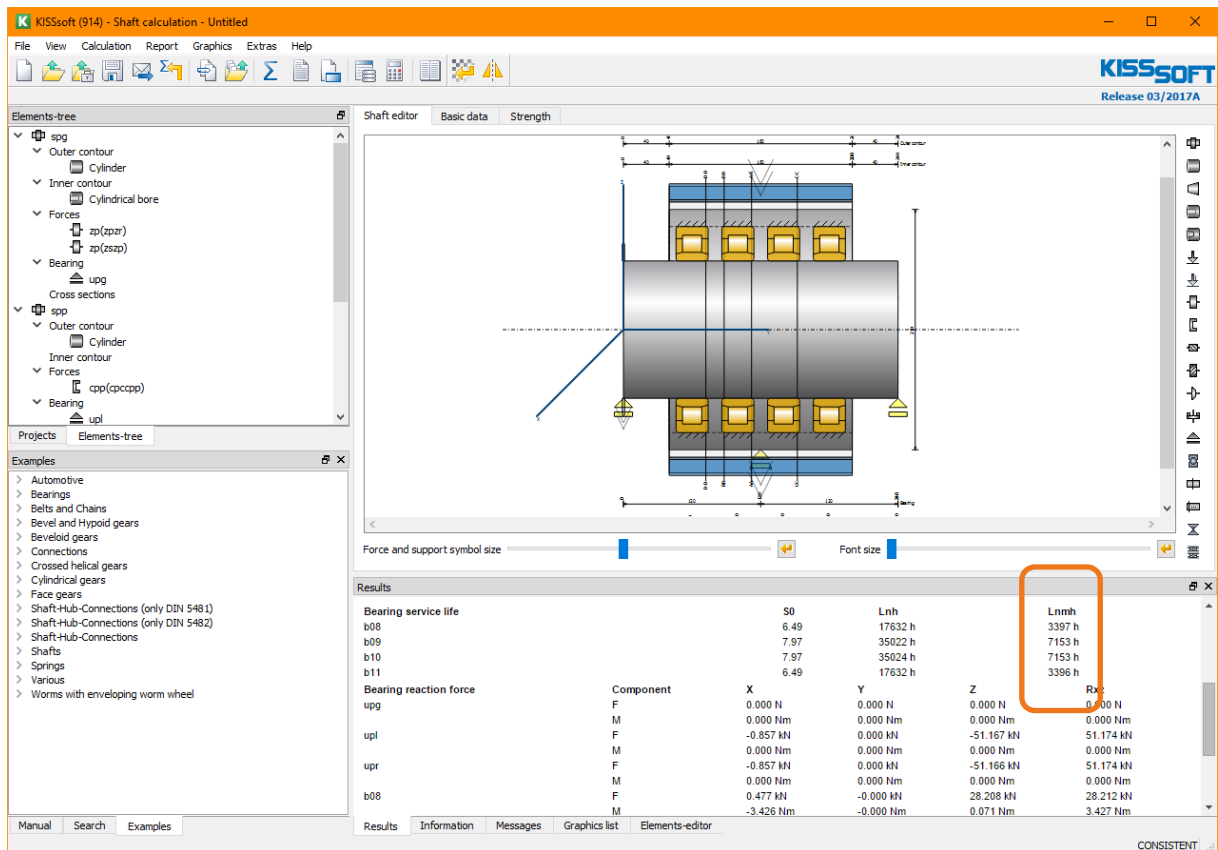


Figure 2.1-2 Resulting bearing life in the planet.

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

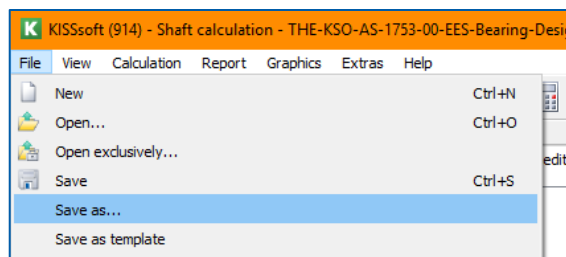


Figure 2.1-3 Export of the shaft model from KISSsys into a separate KISSsoft file.

2.2 Import of the bearing data

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

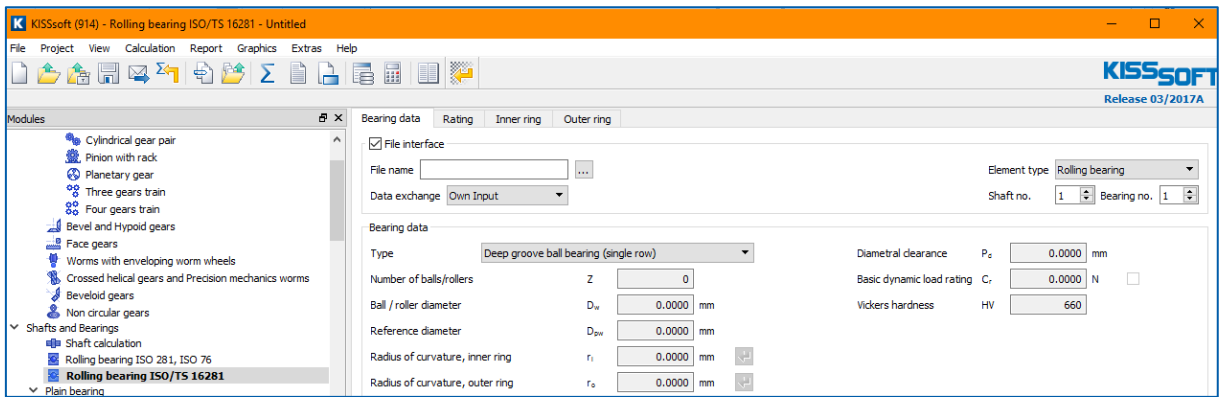


Figure 2.2-1 Module for single bearing calculation with inner geometry.

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):

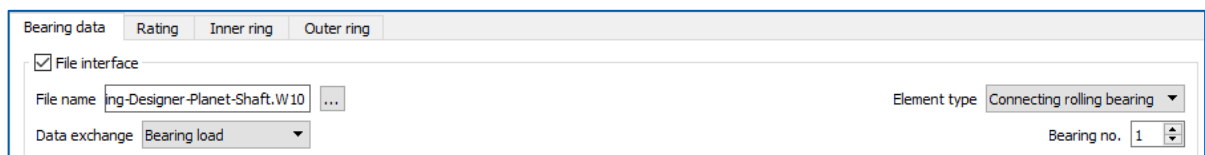


Figure 2.2-2 Import of the shaft file previously exported from KISSsys.

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

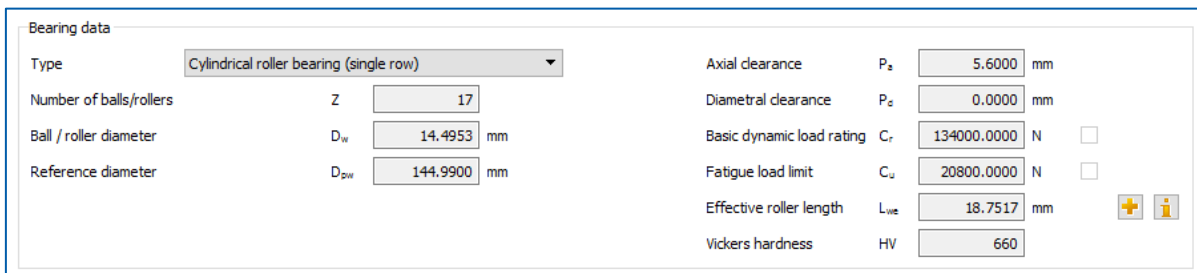


Figure 2.2-3 Bearing data, original design.

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:

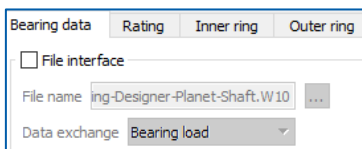


Figure 2.3-1 Remove the link to the external shaft file.

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

Bearing data			
Type	Cylindrical roller bearing (single row)	Axial clearance	P_a 0.0000 mm
Number of balls/rollers	Z 17	Diametral clearance	P_e 0.0000 mm
Ball / roller diameter	D_w 14.5000 mm	Basic dynamic load rating	C_r 134000.0000 N <input type="checkbox"/>
Reference diameter	D_{pw} 145.0000 mm	Effective roller length	L_{ve} 18.8000 mm <input type="checkbox"/>
		Vickers hardness	HV 660

Figure 2.3-2 Rounded values for bearing data.

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

Results			
C_r	134.261 kN		
	L_{10r}	552.49	
Reference rating service life	L_{nrh}	54083.493 h	
p_{max_i}	1653.889 N/mm ²	inside	
p_{max_o}	1495.999 N/mm ²	outside	
u_x	-0.597 μ m	F_x	-0.000 kN
u_y	-27.970 μ m	F_y	28.205 kN
u_z	-0.424 μ m	F_z	0.477 kN
r_y	-0.000 mrad	M_y	0.071 Nm
r_z	0.012 mrad	M_z	-3.426 Nm

Figure 2.3-3 Resulting capacity for original bearing design.

The stress distribution in the bearing is as shown below:

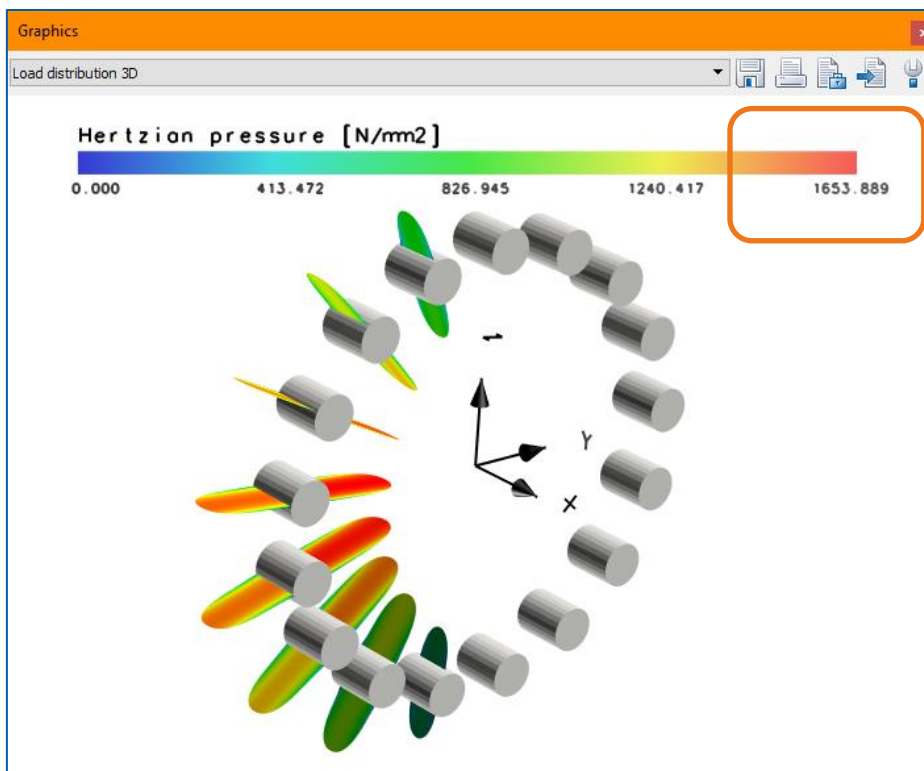


Figure 2.3-4 Stress level of about 1650MPa in the bearing.

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:

Fixed, predefined bearing data

Inner diameter	d	120.0000	mm
External diameter	D	180.0000	mm
Width	B	28.0000	mm

Variable bearing data

		Minimum	Maximum	Step	
Number of rolling elements	Z	16	18	1	
Diameter of rolling element	D_w	13.0000	16.0000	0.2500	mm
Reference diameter	D_{pw}	140.0000	150.0000	1.0000	mm
Radial clearance	p_c	0.0000	0.0000	0.0000	mm
Effective length of roller	L_{we}	18.8000	18.8000	0.0000	mm

Constraints that must be fulfilled

Density of rolling bodies (min/max)	v	60.0000	95.0000	%
Minimum outer ring thickness	t_s		3.5000	mm
Minimum inner ring thickness	t_i		3.5000	mm
Ratio of roller length to bearing width (min/max)	L_{we}/b	10.0000	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:

Nr.	d [mm]	D [mm]	B [mm]	Z	D_w [mm]	D_{pw} [mm]	p_c [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.

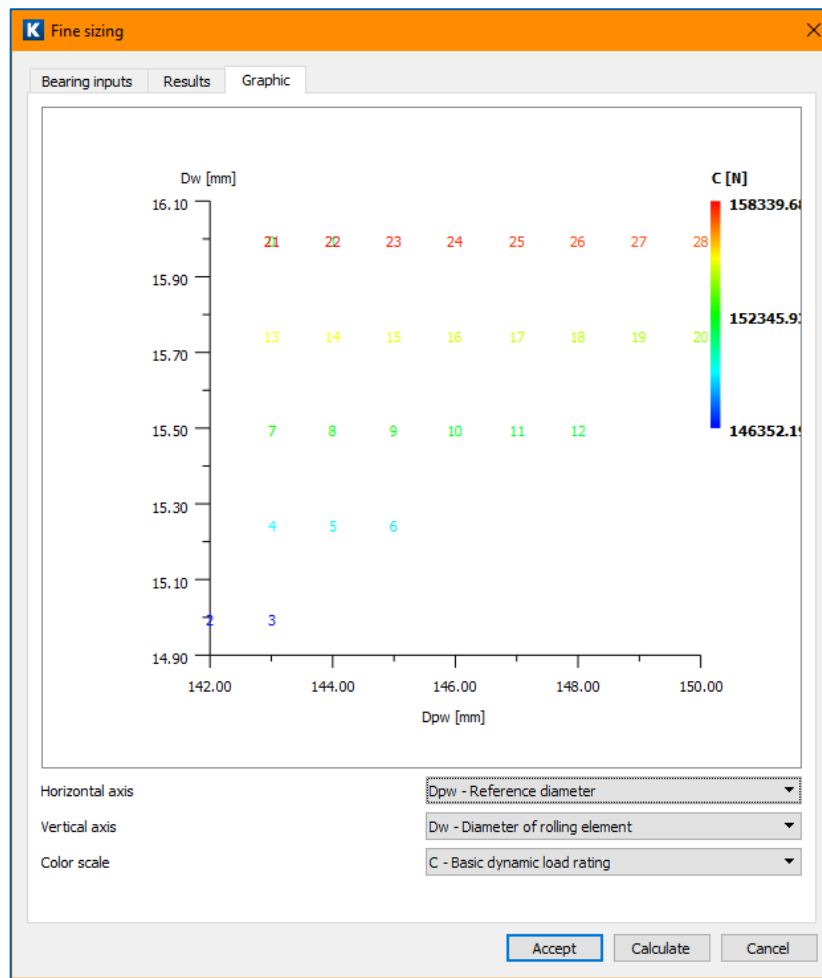


Figure 2.4-3 Graphical display of capacity vs. roller diameter and bearing pitch diameter.

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

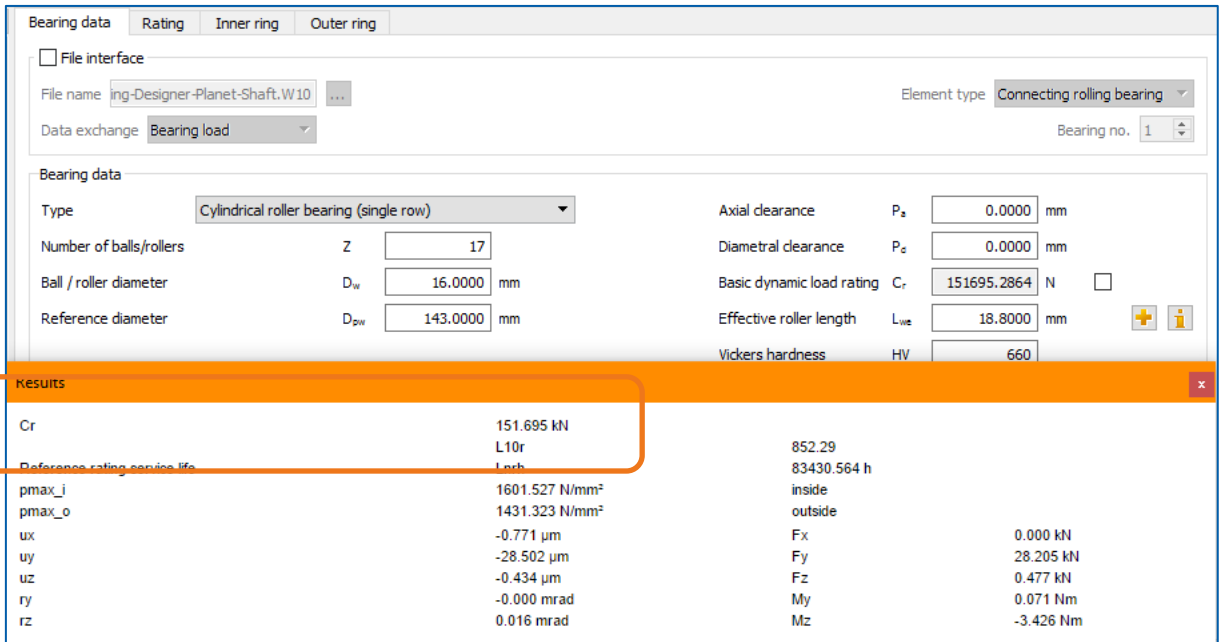


Figure 2.4-4 Resulting bearing design and resulting capacity.

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.

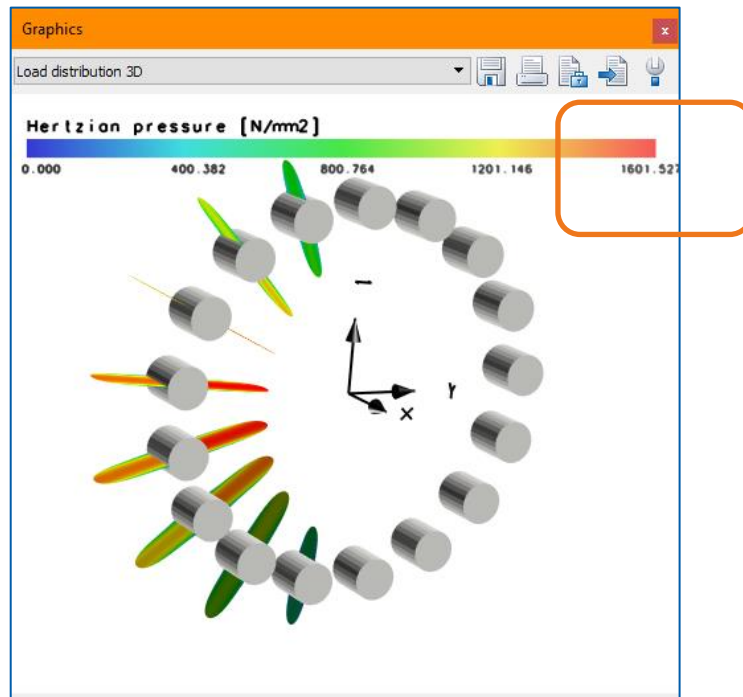


Figure 2.4-5 Improved bearing design with lower contact stress.

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