

KISSsoft Exercises Bolt Calculation 03

Large Gear with Circular Bolt Arrangement

18.05.2022, rel.22b-117, MK

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Sharing Knowledge

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1 Task

115 kNm	
11 kN	
-66 kN	
-65 kN /	95 kN
69 kNm /	-153 kNm
-56 kNm /	56 kNm
	115 kNm 11 kN -66 kN -65 kN / 69 kNm / -56 kNm /



Material:	16 MnCr 5 (plate and through-bolt material)
Tightening factor α _A :	1.0
Coefficient of static friction μ_{Tmin} :	0.1
Number of bolts:	24
Load application factor:	SV2
Coefficients of friction μg, μκ, μm:	0.1
Rz head support:	8 μm
Rz clamped part, through-bolt material:	8 μm

Hexagon headed screw with shank (A B) EN ISO 4014 - M16 x 60 - 12.9 Through-bolting

Gear rim geometry (segment o	f annulus):
Inner diameter:	1000 mm
External diameter:	1200 mm
Depth of layer:	42 mm



Enter the given data and calculate all safety factors.

In this calculation, bear in mind that the torque and shearing forces can accumulate to a larger shear force. What result would this affect? How can this be considered in the calculation?

Tip: Use "Multi-bolted joint with arbitrary position of the screw"

2 Solution

2.1 Basic data

In the Basic data tab, select "Multi-bolted joint with arbitrary position of the bolts" and input the specified data. Right click on the unit to quickly change it to a more suitable unit.

Load	ð		Bolt/Nut	5	Clamped parts	ð	
Operating data							
Configuration			Multi-bolted joint	with arbitra	ry position of the bolts $ \smallsetminus $		
Torque		Мт			0.0000	Nm	
Shearing force x		Fox			2 0.0000	N	kNm
Shearing force y		Foy			0.0000	N	Nm
Clamping force for seali	ng	F _{KP}			0.0000	N	Nµm
Number of load cycles		Nz			2000000.0000		ft•lbf
							in•lbf

Figure 1. Adjusting the units

Make sure you enter the largest forces in terms of magnitude in the right column and the smallest forces (regardless of sign) in the left column to best describe an upper and lower loading situation.

Load 🗗		Bolt/Nut	Ð	Clamped parts	5		Position of bolt 🛛 🗗	Mounting		8			
Operating data													
Configuration		Multi-bolted joint	with arbitrar	y position of the bolts $$		Õ							
Torque	Мт	115.0000			kNm		Axial force		FA		-65.0000 95.0000	kN	
Shearing force x	Fox			11.0000	kN		Bending moment x		M _{Bx}		69.0000 -153.0000	kNm	
Shearing force y	For			-66.0000	kN		Bending moment y		MBy		-56.0000 56.0000	kNm	
Clamping force for sealing	Fise			0.0000	N								
Number of load cycles	Nz			200000.0000									
Temperatures													
Assembly temperature				20.0000	°C		Operating temperature of parts				20.0000 %	:	
Bolt operating temperature				20.0000	°C								
Distances for eccentric load/clar	mpina												
Load application	a			0.0000	mm		Distance to edge of the gaping point		u l		0.0000 m	n	
Bolt axis	Sam			0.0000	mm	Õ	5 51 51						
Land and tasks													
Load application				0.5000		1	to a state of a second second second				0.0000		0
Load application factor	n			0.5000			Length of connected solid		<u>ا</u> ۸۱		0.0000 m	n	¥
Bolting type		SV 2		~		Ŷ	Distance of connected solid		ak		0.0000 m	n	
				Fig	ure 2.		Load inputs						

After entering all the forces, torque, and moments you can select the load introduction factor type SV2 and leave the remaining inputs on their default value.

Bolt, blind hole 2.2

Then, we switch to the next tab "Bolt/Nut" and enter the type of the bolt, the size, strength and the roughness of the head bearing surface.

Load		8	Bolt/Nut	5	Clamped parts		5	Position of bolt	5	Mounting	5	
Bolt data												
Bolt type		Hexago	n head screw with shank (/	A B) DIN EN	ISO 4014:2 \vee		Head	bearing area surface rough	ness	N7 Rz=8.0 (Turned wit	h diamond)	/
Nominal diameter	d				16.0000 mm	\leftarrow	Roug	nness Rz	Rz		8.000) mm
Bolt length	Т				60.0000 mm	\leftarrow						
Strength class		12.9			\sim	+						



Then we define the material and roughness of the blind hole material. Beware that the blind hole material is never entered as one of the clamped parts.

Nut/blind hole data			
Connection type	Blind hole (tapped thread joint) $\qquad \lor$		
Counter bore depth t_{s}	0.0000	mm	ô
Material type	Case hardening steel \sim		
Material	16 MnCr 5 (1), case-hardened, VDI 2230 (2015) $\qquad \lor$		+
Surface roughness	N7 Rz=8.0 (Turned with diamond) $\qquad \lor$		
Roughness R _z	8.0000	μm	

Figure 4. Defining the blind holes.

Clamped parts 2.3

For the clamped parts, select 'Segment of annulus' as the basic geometry. The depth of layer, i.e. the thickness of the gear that is to be clamped, is 42 mm. The gear is the only clamped body. Then input the material, the surface roughness (Rz = 8) and the friction between the parts.

Load 🗗	Bolt/N	Nut 🗗	Clamped parts	5		Position of bolt	5	Мо	unting	8		
Geometry												
Pitch circle diameter	dt	1100.0000 m				Coefficient of friction be	tween par	ts	μτ	0.1000		Q
Basic geometry		Segment of annulu	is v		Ô	Inner diameter			d,	1000.0000	mm	
External diameter	da		1200.0000	mm		Bolt spacing			t	0.0000	mm	
Bore												
Standard		ISO 273: 1979/DIN	EN 20273: 1992 fine 🗸 🗸		Chamfer at head					с _к 0.0000 mm		
Diameter	dh		0.0000	mm		Chamfer at nut			См	0.0000	mm	
Part definition												
Material type		Material				Roughness		Rz [µm]	Depth of lay	ver [mm]		
1 Case hardening steel	16 MnCr 5 (1), eins	satzgehärtet, VDI 2	230 (2015)	N7	Rz=	8.0 (Turned with diamond	d)	8.0000	4	2.0000		

Figure 5. Clamped parts

Since the position of the bolts may be arbitrary for the chosen configuration, the bolt spacing will not be automatically derived in this case. To input the bolt spacing we can use the formula input feature to directly calculate the spacing. Right click on the input field and then calculate the spacing based on the pitch circle diameter and the number of bolts:

	Clamped parts	ð		Position of bolt	5		Mounting	5		
us	1100.0000 ~ 1200.0000] mm]] mm	Ô	Coefficient of friction Inner diameter Bolt spacing	on betwee	en parts	Ø	μτ di t	0.1000 1000.0000 mm 0.0000 mm Formula input: 1100*PI/24	Ç

Figure 6. Formula input for bolt spacing

2.4 Position of bolts

Click on the sizing button to position all the bolts simultaneously. Define the circle by entering the radius and number of bolts.

	Load	5	Bolt/N	lut 🗗		Clamped pa	arts	Ð	Pos	sition of bo	lt	8
Cor	nditions									Preview		
Fac Ver	ctor for thrust bolt ification for bolt n Use maximum rec	o.	1 ad	0000 0 🔽 K Size position	s of bol	ts				×		
Pos	Take into accoun	t signs of shea	ring force	Arrangement Cir Center point Radius	de x _m /y _m	0. r	.0000	0.000	∨ 00 mm	Õ		
	x-coordinate	y-coordinate	Factor	Number of bolts		n		24			x	
1	0.000	0.00	0 1.00									
2	0.000	0.00	0 1.00		_					_		
3	0.000	0.00	0 1.00			Accept	Cal	culate	Cance	1		
							← [[=_====================================		<		

Figure 7. Sizing button for the bolt positions

Click on "Calculate" and "Accept" to transfer the bolt positions to the "Position of bolt" tab.



Figure 8. Preview of the bolt positions

Uncheck "Use maximum required clamping force" if it is active so that each bolt is calculated with its local required clamping force instead of the maximum required clamping force occurring in the connection. To correctly sum up the force vectors of shearing force and forces caused by the torque, activate the "consider signs of shearing force" flag. Activating this flag is more accurate but less conservative.

Conditions		
Factor for thrust bolt Verification for bolt no.	1.0000 1 amp load f shearing force	

Figure 9. Conditions for the loads in the configuration

For the mounting, most inputs are left on their default settings (tightening to 90% of yield strength).

The given friction values also already correspond to the default values.

For the input of the tightening factor we select "Own input" as tightening method and enter the factor 1. We thus assume that we can set the tightening torque practically without any scatter.

Tightening technique						
Method	Own Input	\sim	Tightening factor	ØA	1.0000	\leftrightarrow

Figure 10. Input of tightening factor

2.5 Calculation

When performing the calculation, we get the following warning message because the bolt length does not exist in the selected standard. We can either accept the new bolt length or select "Own input" as the bolt type in the Bolt/Nut tab.

K War	K Warning ×					
Â	Schraube 24: The length of the bolt has been changed according to the standard. New bolt length: 65.0000 mm Remark: For inputs which do not correspond to the standard, you have to use the option 'Own input'!					
	OK					

Figure 11. Warning message regarding the bolt length

We accept this change for the moment, and we will clarify later if maybe there is something wrong with the length in our specifications.

2.6 Results

Results (basic calculation) x											
No.	SF	SFTemp	SD	SDTemp	SP	SPTemp	SG	SGTemp			
1	1.159	1.159	15.205	15.205	1.374	1.374	2.210	2.210			
2	1.157	1.157	8.500	8.500	1.372	1.372	2.186	2.186			
3	1.156	1.156	6.305	6.305	1.370	1.370	2.078	2.078			
4	1.155	1.155	5.380	5.380	1.370	1.370	1.922	1.922			
5	1.155	1.155	5.062	5.062	1.370	1.370	1.758	1.758			
6	1.156	1.156	5.185	5.185	1.371	1.371	1.614	1.614			
7	1.157	1.157	5.809	5.809	1.372	1.372	1.498	1.498			
8	1.159	1.159	7.310	7.310	1.375	1.375	1.411	1.411			
9	1.161	1.161	11.207	11.207	1.377	1.377	1.350	1.350			
10	1.163	1.163	30.607	30.607	1.380	1.380	1.310	1.310			
11	1.163	1.163	34.471	34.471	1.379	1.379	1.250	1.250			
12	1.158	1.158	10.915	10.915	1.374	1.374	1.165	1.165			
13	1.154	1.154	6.628	6.628	1.368	1.368	1.099	1.099			
14	1.150	1.150	4.932	4.932	1.363	1.363	1.052	1.052			
15	1.147	1.147	4.103	4.103	1.359	1.359	1.026	1.026			
16	1.144	1.144	3.690	3.690	1.356	1.356	1.022	1.022			
17	1.143	1.143	3.538	3.538	1.354	1.354	1.044	1.044			
18	1.143	1.143	3.597	3.597	1.354	1.354	1.094	1.094			
19	1.144	1.144	3.887	3.887	1.355	1.355	1.178	1.178			
20	1.146	1.146	4.506	4.506	1.358	1.358	1.299	1.299			
21	1.149	1.149	5.736	5.736	1.362	1.362	1.463	1.463			
22	1.153	1.153	8.490	8.490	1.366	1.366	1.670	1.670			
23	1.157	1.157	17.825	17.825	1.372	1.372	1.912	1.912			
24	1.161	1.161	153.727	153.727	1.377	1.377	2.147	2.147			

Figure 12. Results