KISSsoft Exercises
Bolt Calculation 03

Large Gear with Circular Bolt Arrangement

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Sharing Knowledge

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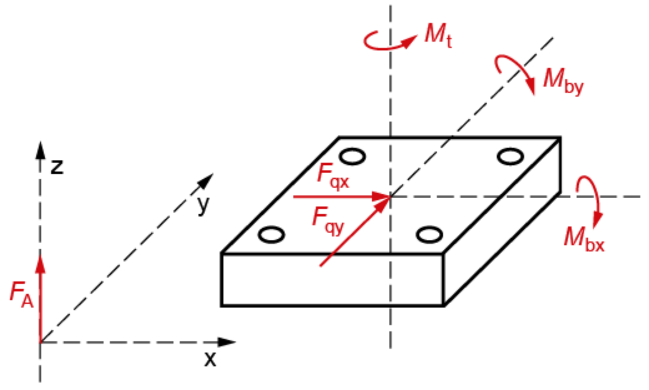
1 Task



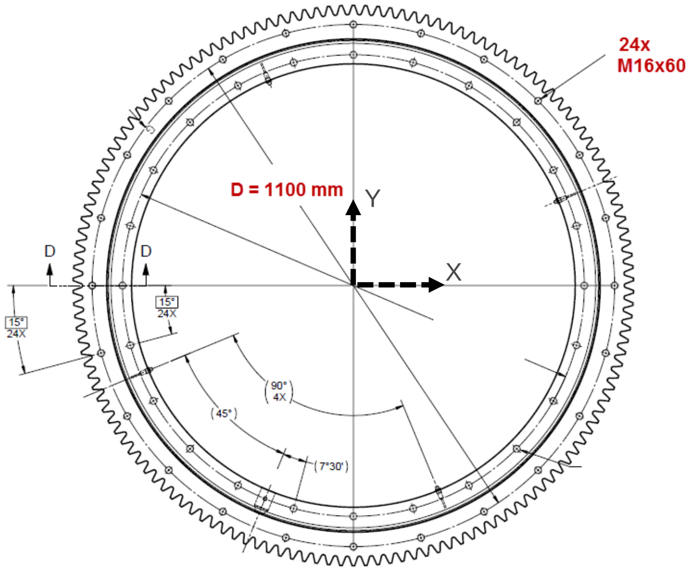
Torque:	115 kNm		
Shearing force FQx:	11 kN		
Shearing force FQy:	-66 kN		
Axial force FA:	-65 kN	/	95 kN
Bending moment x:	69 kNm	/	-153 kNm
Bending moment y:	-56 kNm	/	56 kNm

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 μ_G, μ_K, μ_M:	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 of 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.

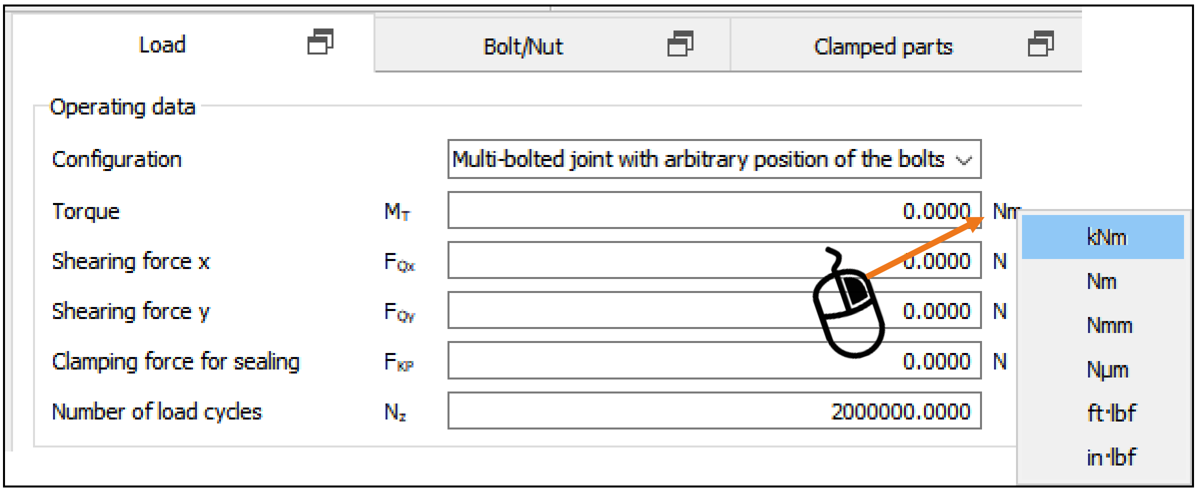


Figure 1. Adjusting the units

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.

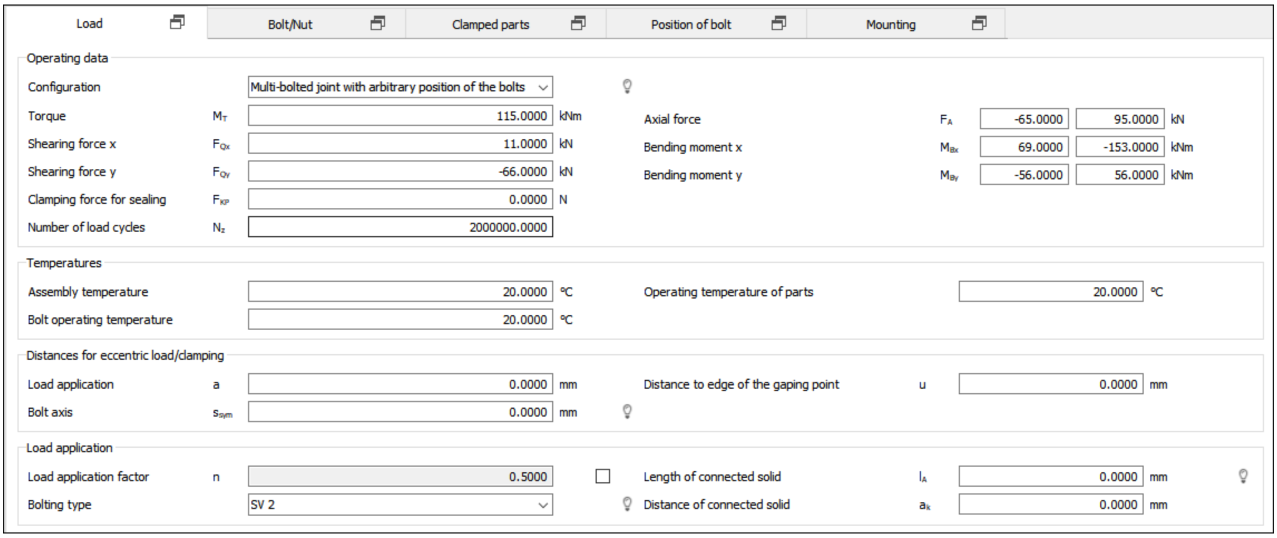


Figure 2. Load inputs

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.

2.2 Bolt, blind hole

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.

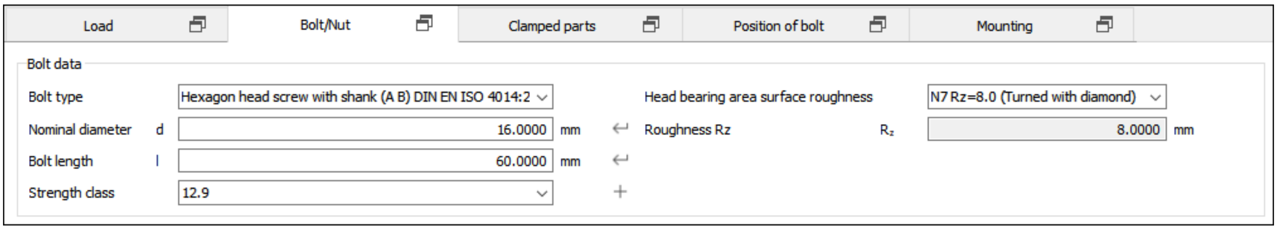


Figure 3. Bolt data

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.

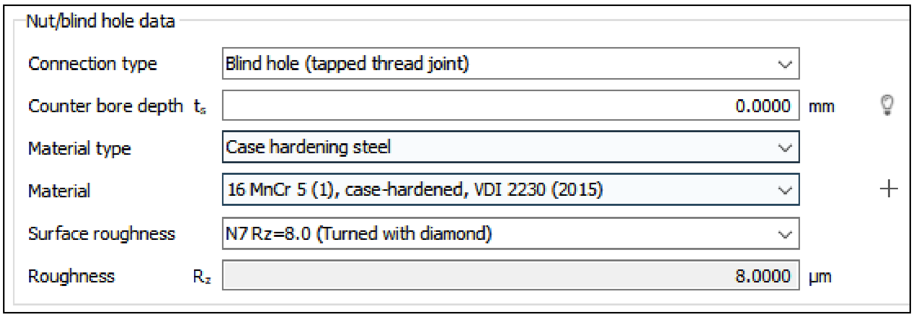


Figure 4. Defining the blind holes.

2.3 Clamped parts

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.

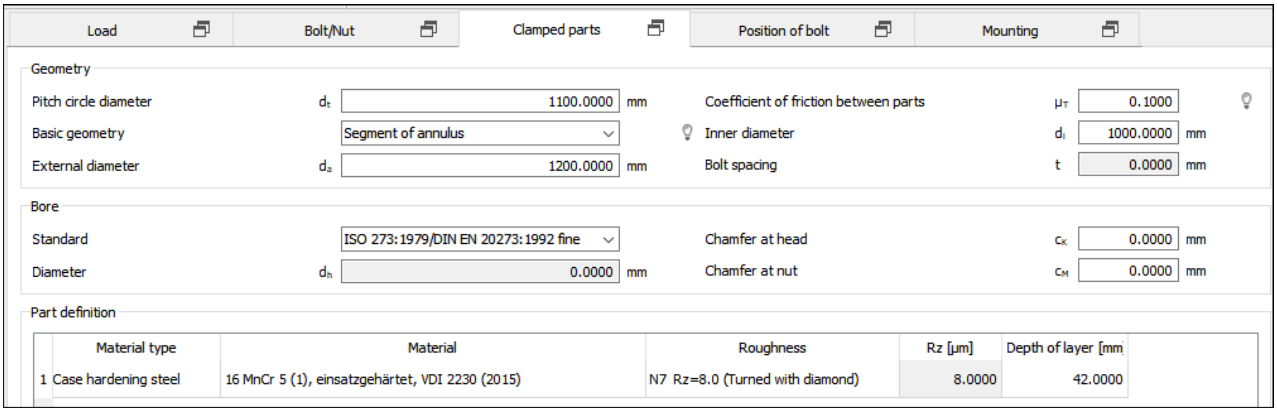


Figure 5. Clamped parts

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:

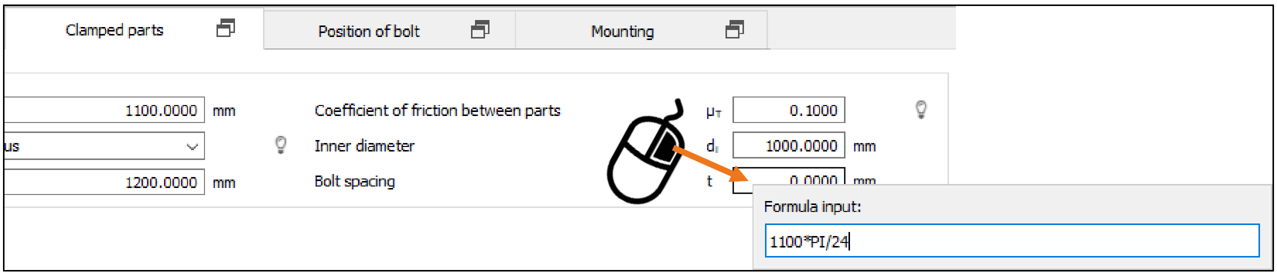


Figure 6. Formula input for bolt spacing

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.

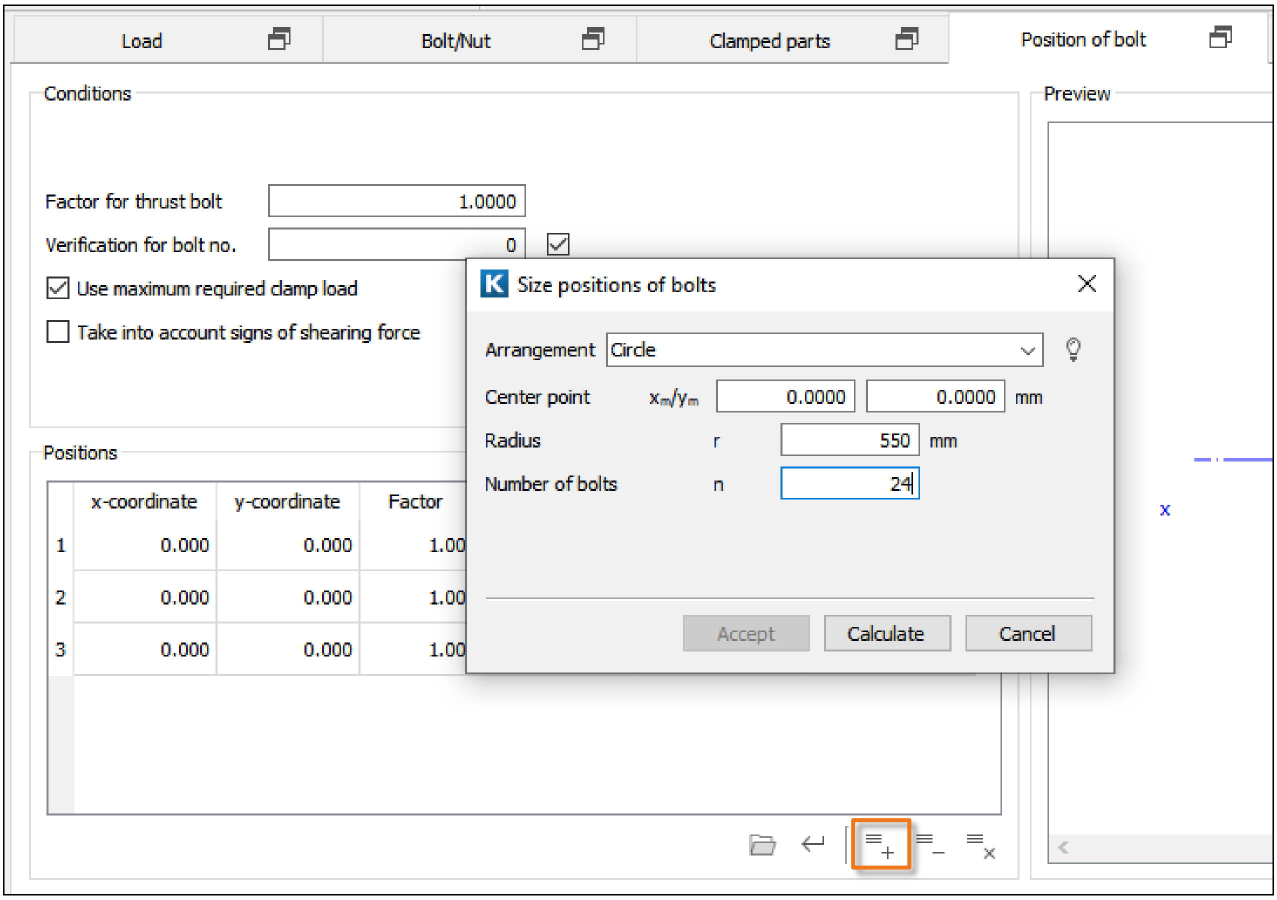


Figure 7. Sizing button for the bolt positions

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

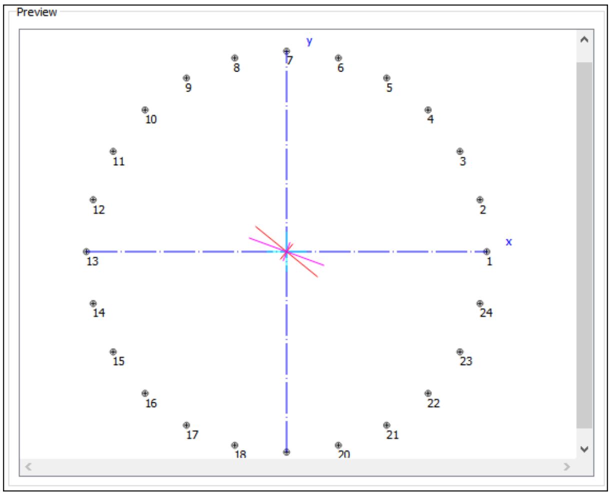


Figure 8. Preview of the bolt positions

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.

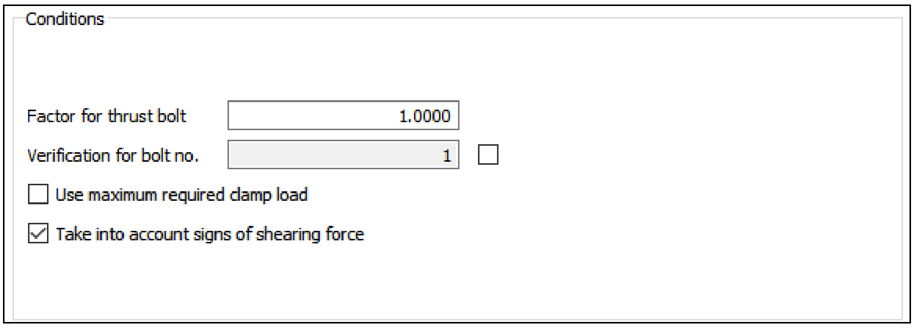


Figure 9. Conditions for the loads in the configuration

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.

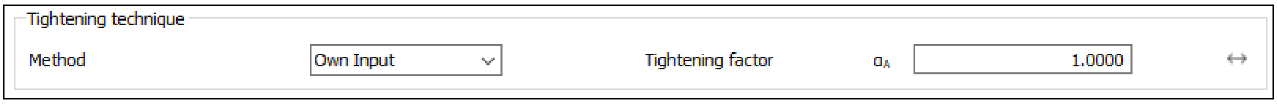


Figure 10. Input of tightening factor

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.

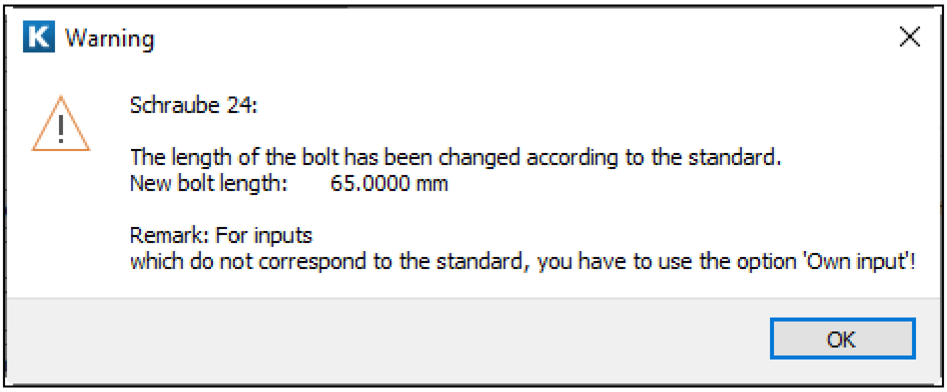


Figure 11. Warning message regarding the bolt length

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)

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