KISSsoft Exercises
Bolt calculation 01

Flange Coupling

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Contents

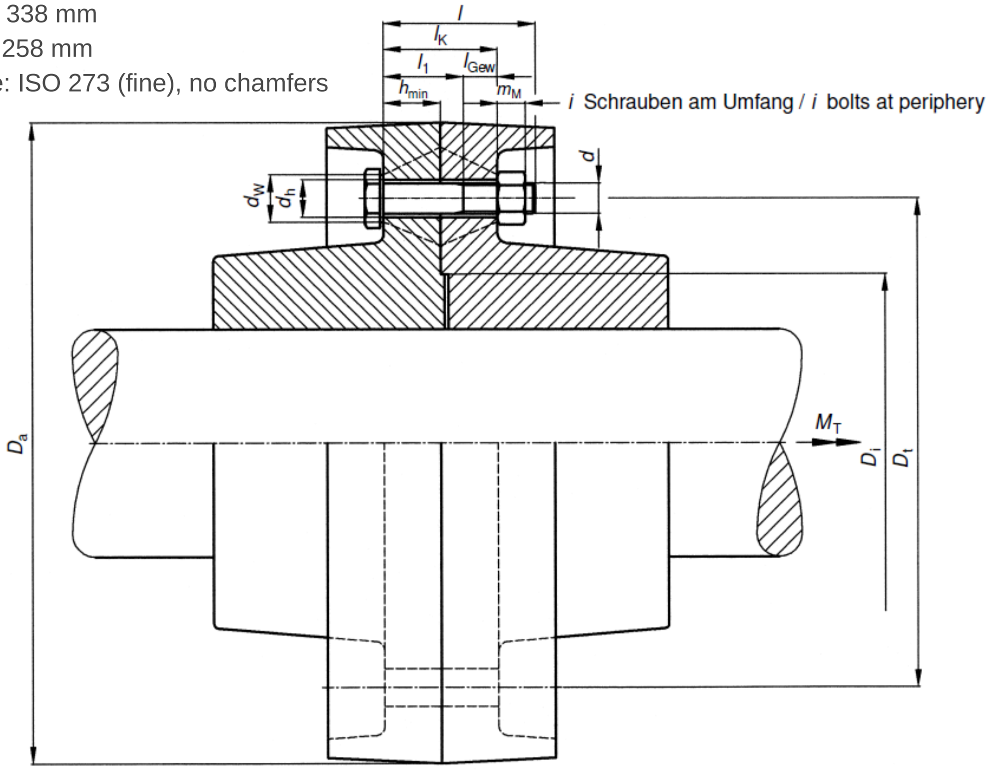
1 Task

Torque: .... 13000 Nm
Material of the coupling parts .... EN-GJL-250, Young's modulus = 1.1×10^5 N/mm^2
Tightening method .... Torque wrench (estimating coefficient of friction), mean value
Coeff. of friction between the parts .... $\mu_{Tmin} = 0.15$
Number of bolts: 12
Load introduction factor: .... n = 1
Coefficients of friction μ_G, μ_K, μ_M: .... 0.12/0.12 (min/max) → class B for the tightening factor
Surface roughness .... Rz = 8μm (head support, nut, clamped parts)
Utilization of yield point: 90%

Nuts EN 24032 for M16, strength class matching the bolt
Hexagonal bolt with shank (A B) EN ISO 4014 - M16 x 80 – 10.9

Flange geometries:

- h_{min} = 30 mm
- l_k = 60 mm
- D_i = 178 mm
- D_a = 338 mm
- D_t = 258 mm
- Bore: ISO 273 (fine), no chamfers



a) Calculate the safeties for pressure, yield point, slipping and shearing.

b) Add washers under the bolt head and nut (without changing any preset washer specifications).

Which two safety factors change in the process and why?

c) Determine whether the bolts are oversized. Can smaller diameters or lower strength grades be used?

2 Solution

2.1 Part a)

Select "Flange connection with torque and forces (multiple bolts)" in the Rating tab:

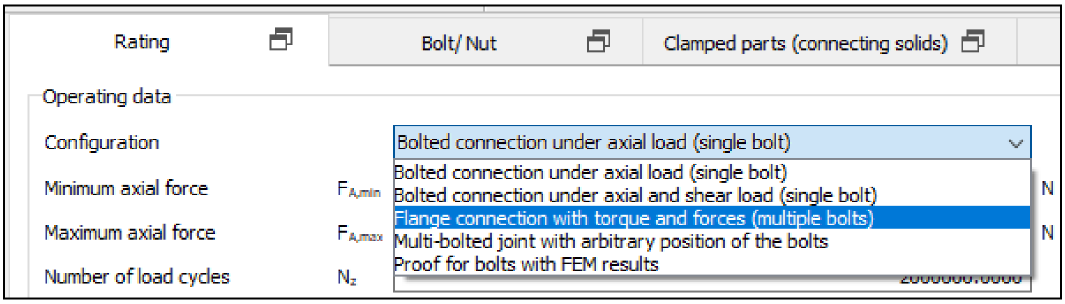


Figure 1. Selecting the configuration.

Now, input the torque and the load application factor:

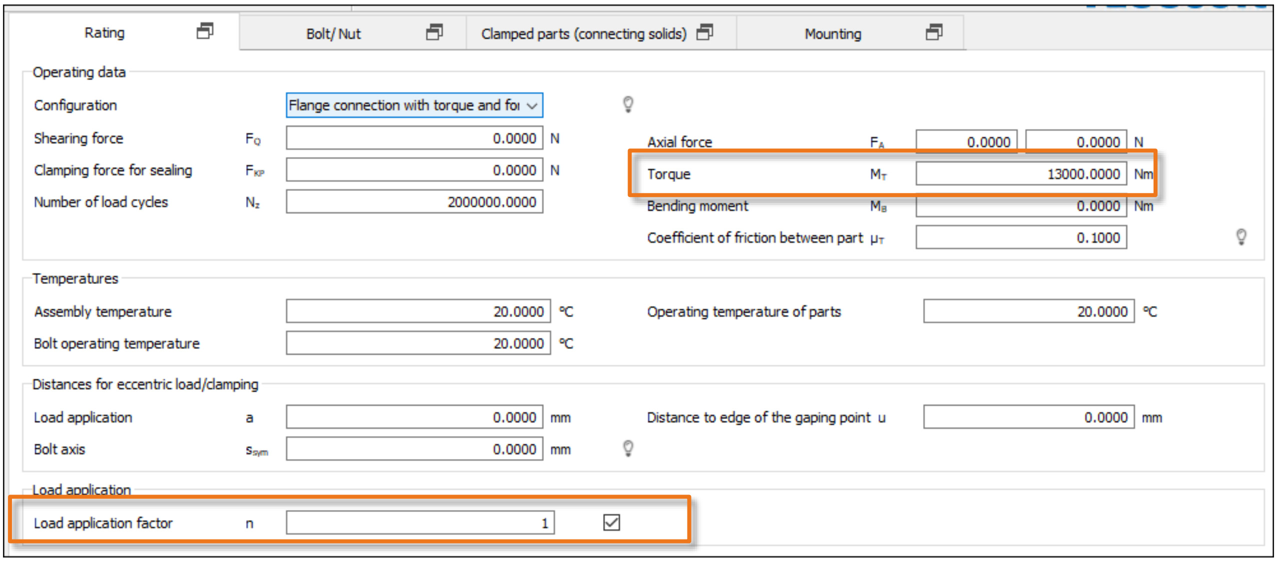


Figure 2. Rating inputs

In this example, the load factor value is set to 1. We are assuming that the load application point is located directly under the head/nut bearing area. This is valid here because besides the clamping forces from the bolt no additional axial forces are applied to the connection

Then, in the "Bolt/Nut" tab enter the number of bolts, type and dimensions of bolts, strength class of bolts and nuts and the standard of the nuts:

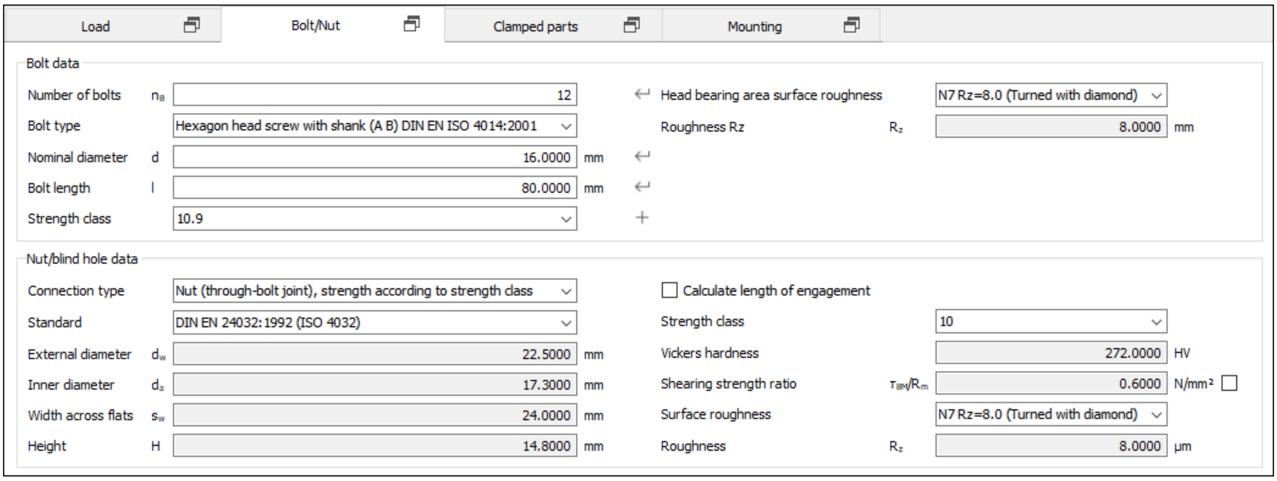


Figure 3. Bolt- and Nut data

The bolt is set with type, nominal diameter, length, and strength class. In addition, the surface roughness must not be overlooked.

To be able to enter the nut, "Through-bolt joint, strength according to strength class" must first be selected. Then the strength class can be selected, and the roughness can be set according to the specifications.

The coupling parts are defined in the "Clamped parts" tab. A message is then displayed to inform you that "Segment of annulus" is the recommended geometry for flange connections.

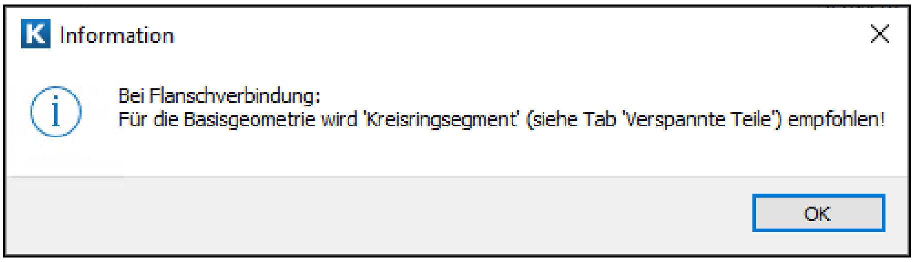


Figure 4. Information window

Select Segment of annulus in the following drop-down menu:

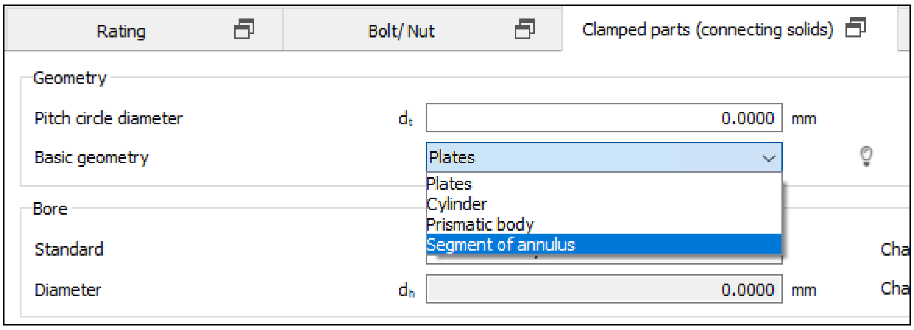
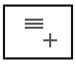


Figure 5. Selecting the basic geometry

Click on the  button to add a second layer in the "Part definition" table and enter the thickness/depth of each layer (30 mm each).

Once you have selected the material (EN-GJL-250) and the depth of layer, we notice that the Young's modulus of the EN-GJL-250 from the database does not match the required Young's from the specifications (Figure 6.).

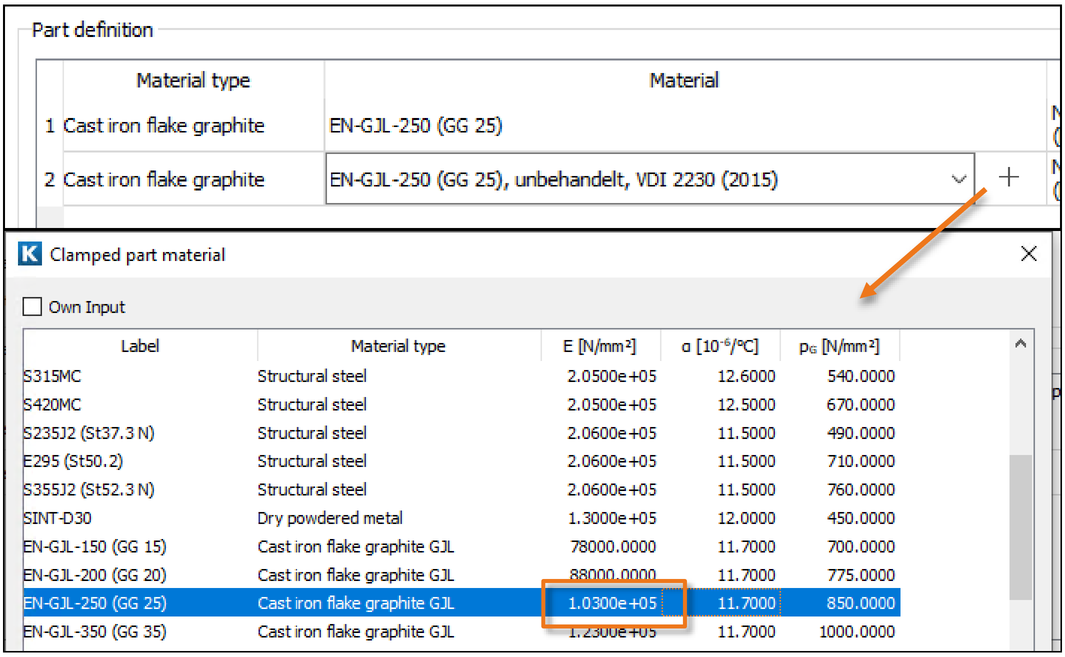


Figure 6. Details of the selected Material

To adjust this, change the material to "Own Input" and adjust the Young's modulus value to match the given value of 110'000 N/mm^2. The remaining inputs remain set to the values of the previously selected material. Finally, set a value of Rz=8 for the surface roughness of both layers.

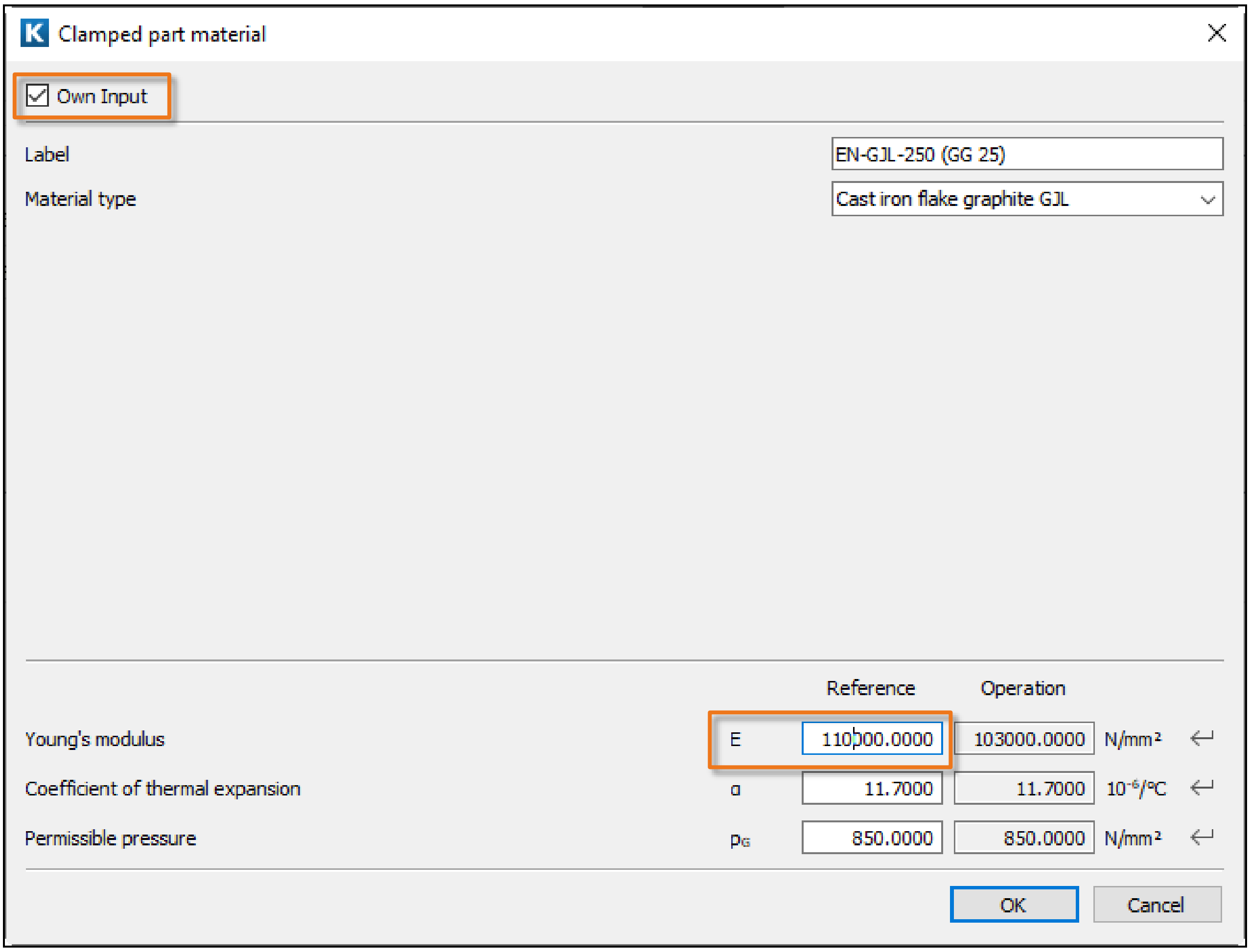


Figure 7. Adjustment of the material properties

In the "Geometry" section, you can then enter the pitch circle diameter in which the bolts are arranged, as well as the outer and inner diameters of the flange and the coefficient of friction between the flange parts.

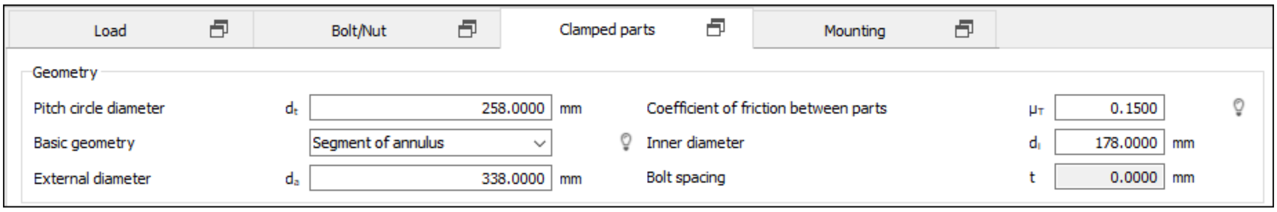


Figure 8. Defining the flange geometry

The bore can be adjusted in the "Bore" section below, in this case we can see that the required standard is already set. Since no chamfers are required, we can leave all the default settings in this section.

Further inputs regarding the assembly conditions are set in the tab "mounting". The minimum utilization of yield strength is already pre-set to 90%.

For the tightening method, "Torque wrench (with estimation of friction coefficient, class B) is selected. In addition to this selection, Class A or the obsolete table from VDI2230:1988 are also available.

You also specify the friction factors in the thread, bearing surface and nut support in this tab.

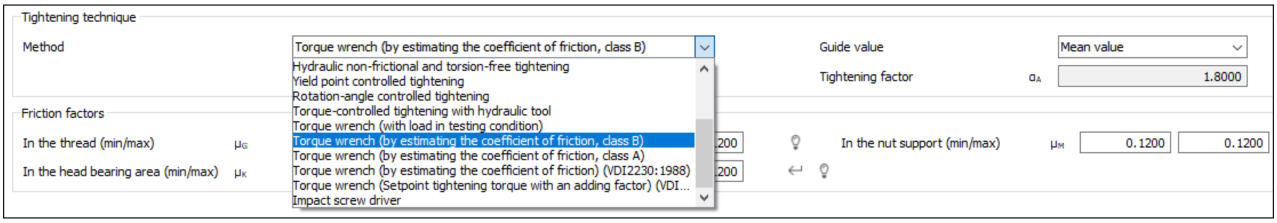
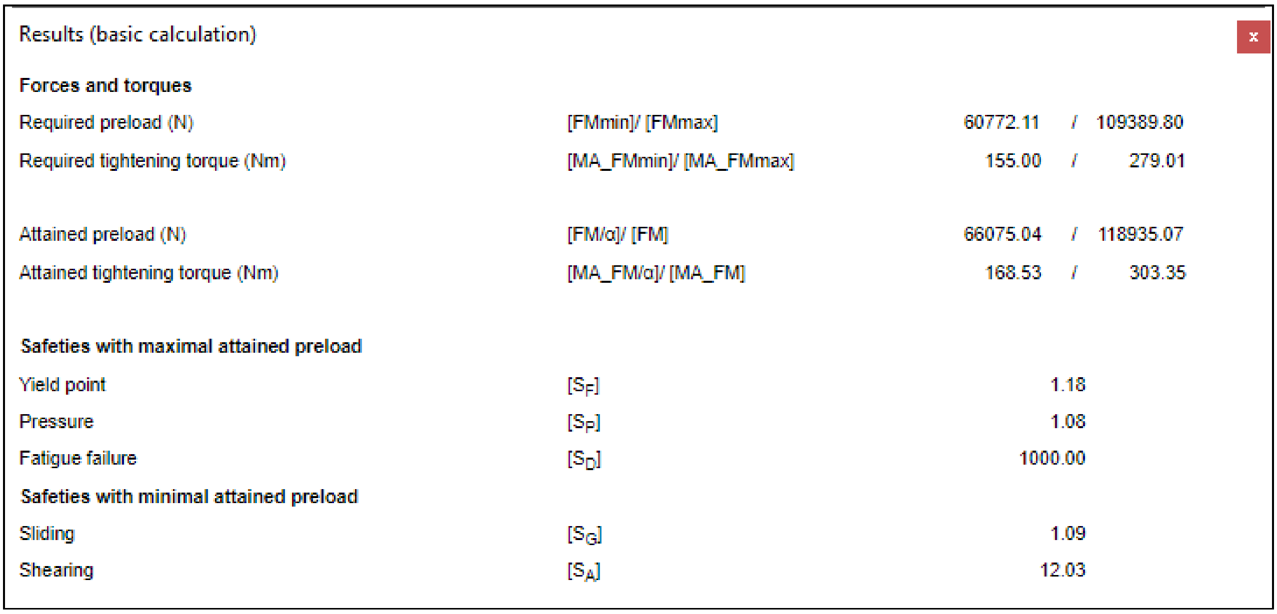


Figure 9. Input of tightening method and friction factors

The calculation results in the following pretension forces/torques and safeties:



Results (basic calculation)

Forces and torques				
Required preload (N)	[FMmin]/ [FMmax]	60772.11	/	109389.80
Required tightening torque (Nm)	[MA_FMmin]/ [MA_FMmax]	155.00	/	279.01
Attained preload (N)	[FM/α]/ [FM]	66075.04	/	118935.07
Attained tightening torque (Nm)	[MA_FM/α]/ [MA_FM]	168.53	/	303.35
Safeties with maximal attained preload				
Yield point	[S_F]	1.18		
Pressure	[S_P]	1.08		
Fatigue failure	[S_D]	1000.00		
Safeties with minimal attained preload				
Sliding	[S_G]	1.09		
Shearing	[S_A]	12.03		

Figure 10. Results

2.2 Part b)

As expected, the addition of washers improves the pressure safety. At the same time, a small decrease in sliding safety can be observed.

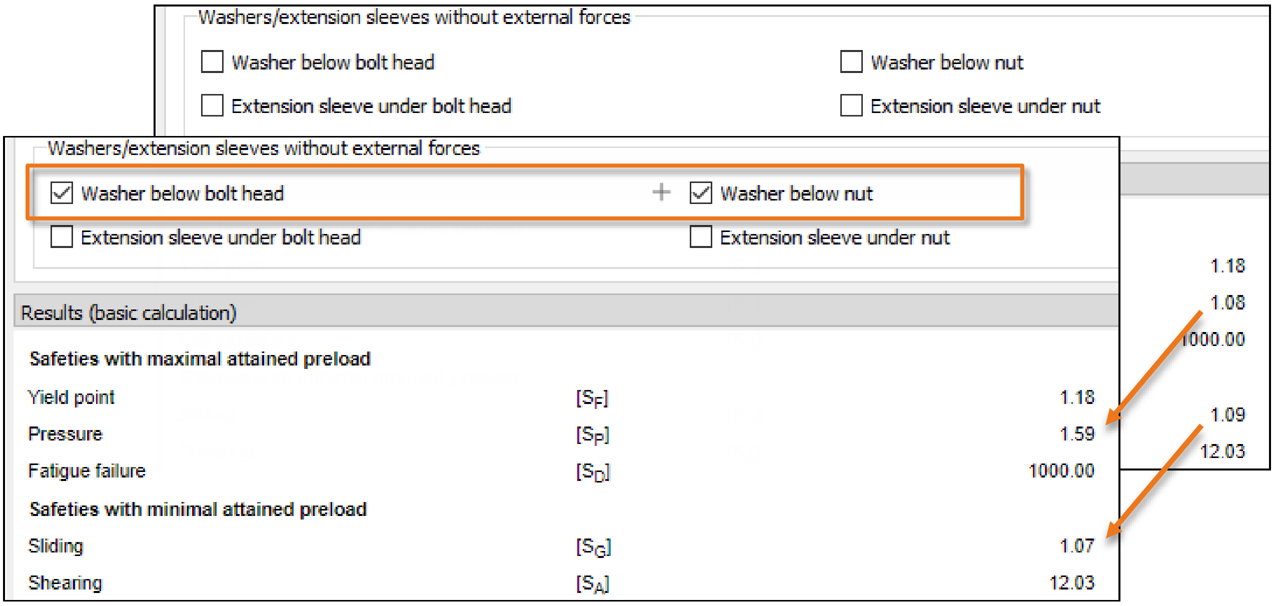


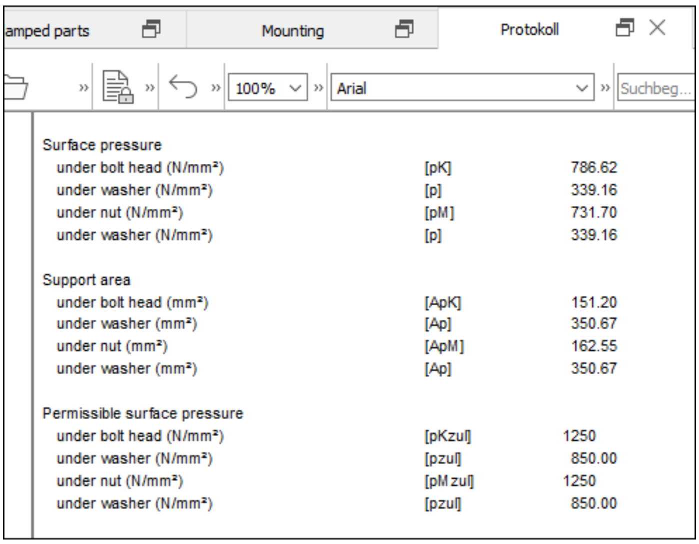
Figure 11. Safety factors with/without washers

The safety against sliding decreases slightly, because with each washer there is an additional contact area in which a certain loss of preload due to embedding will occur.

The safety against pressure is evaluated at each contact surface by comparing the permissible pressure with the actual pressure (force/support surface).

The pressure safety on the clamped part improves because the washer introduces the load on the clamped part over a larger contact area. Although the contact area between the bolt head and the washer is the same as the contact area without the washer, the permissible pressure of the washer is greater than that of the clamped part.

All contact surfaces and pressures are documented in the report in the section "Calculation with maximum attained preload force".



amped parts | Mounting | Protokoll

100% | Arial | Suchbeg...

Surface pressure		
under bolt head (N/mm²)	[pK]	786.62
under washer (N/mm²)	[p]	339.16
under nut (N/mm²)	[pM]	731.70
under washer (N/mm²)	[p]	339.16
Support area		
under bolt head (mm²)	[ApK]	151.20
under washer (mm²)	[Ap]	350.67
under nut (mm²)	[ApM]	162.55
under washer (mm²)	[Ap]	350.67
Permissible surface pressure		
under bolt head (N/mm²)	[pKzul]	1250
under washer (N/mm²)	[pzul]	850.00
under nut (N/mm²)	[pM zul]	1250
under washer (N/mm²)	[pzul]	850.00

Figure 12. Surface pressure in the report

2.3 Part c)

If the strength class or the reference diameter is reduced, such an error message is displayed:

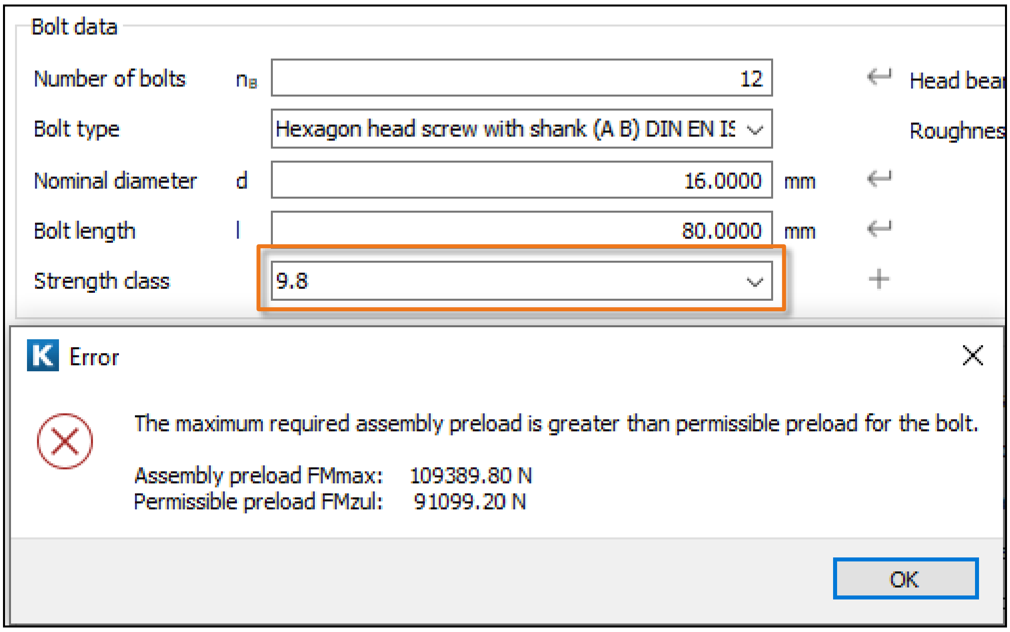


Figure 13. Error message

In other words, the message tells us that the required preload (FMmax) which the connection needs is larger than the permissible preload (FMzul, which is used as the upper FM) which this new bolt can be tightenend to.

This is because FMzul has now become lower due to the smaller bolt / lower strength class. Therefore, the previous size or strength class was just sufficient, but not oversized for this connection.