KISSsoft Exercises
Bolt calculation 02

Connecting Rod Bearing Bolts

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1 Task

Enter the following bolt connection in KISSsoft and calculate the safety factors. Eccentric clamping and load as shown in the sketch

Loads

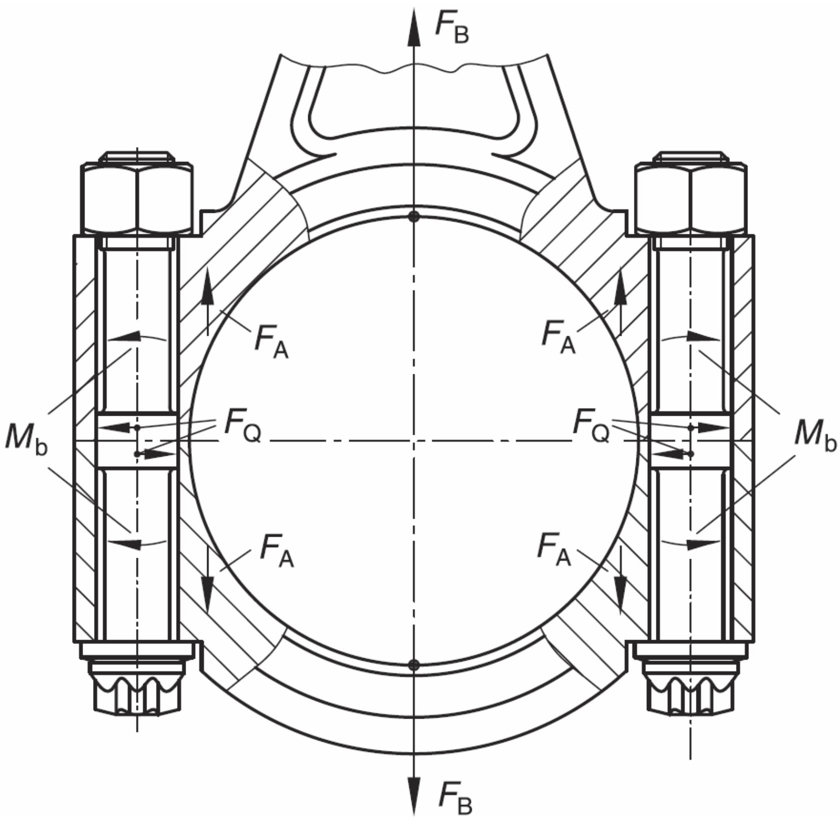
Axial operating force in the interface:	F_{Amax} = 5000 N (=F_B/2)
	F_{Amin} = 0 N
Shearing force in the interface:	F_{Qmax} = 2440 N
Bending moment in the interface:	M_b = 48 Nm
Torque in the interface:	M_T = 0 Nm
Number of load cycles:	2'000'000

Note about bending moment: The bending moment is transferred into an axial force with distance. The distance can then be determined from the bending moment and the axial force:

Load application: $a = M_B / F_A$= 48 Nm / 5000 N = 0.0096 m

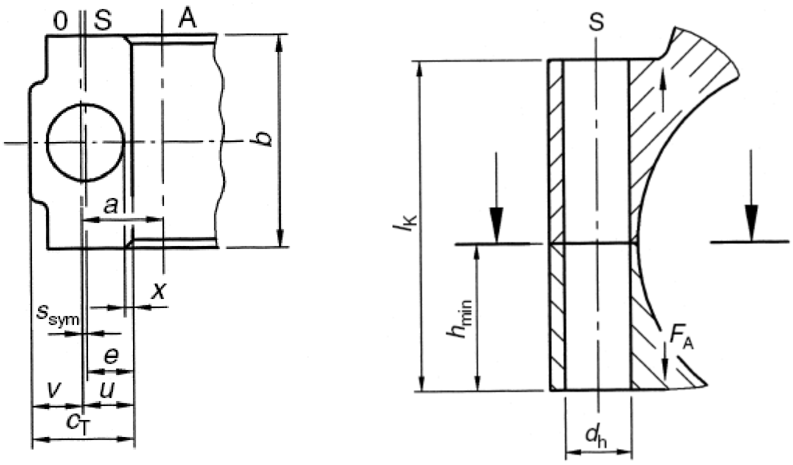
Other details:

Rotation-angle-controlled tightening	(100% utilization of yield point)
Friction factor between parts:	μ_{Tmin} = 0.15
Surface roughness of the parts:	R_z=16µm
Coefficient of friction head, nut:	μ_K, μ_M: 0.12
Coefficient of friction for the thread:	according to friction class B, μ_G = 0.08 … 0.14
Material:	C45 with Young's modulus = 205000 N/mm^2, through hardened from R_m = 700 N/mm^2 to R_m = 900 N/mm^2. As a result, the permissible pressure rises from 770 to 990 N/mm^2 (linear extrapolation)
Bolting type:	SV 1
Length of connection piece:	2.95 mm

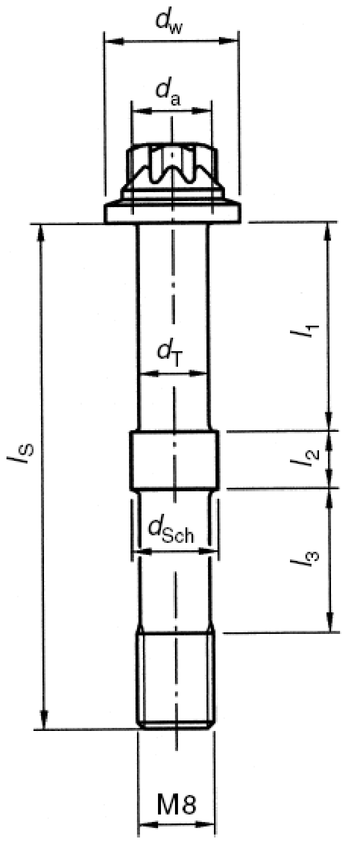


Part dimensions:

b (width of prismatic body)	25 mm
c_T, c_B (perpendicular to width)	12 mm
u	6 mm
h_{min}	20 mm
l_K	45 mm
x – Restwandstärke / residual wall thickness	1 mm
d_h	9 mm



Bolt sizes:



Anti-fatigue bolt (necked-down cross section dt=0.9*d3)
Strength class 12.9 (RM/RP0.2 = 1220/1100 N/mm^2)
Young's modulus = 210000 N/mm^2
Nuts EN 24032 for M8, strength class matching the bolt

l_S	=	53	mm	$d_{a,max}$	=	9	mm
l_1	=	22	mm	d_h	=	9	mm
l_2	=	6	mm	d_T	=	5,82	mm
l_3	=	15	mm	d_W	=	12,3	mm
P	=	1,25	mm	d_{Sch}	=	9	mm
A_T	=	26,6	mm^2	d_2	=	7,188	mm
A_{d_3}	=	32,84	mm^2	d_3	=	6,466	mm
A_S	=	36,6	mm^2	d_S	=	6,827	mm

Width across flats s = 9 mm
Height of bolt head k = 8 mm

2 Solution

2.1 Operating data

Before you can input the shearing force, you must first change the configuration to "Bolted connection under axial load and shearing force (single bolt)". Then input the forces, number of load cycles and the torque (not the bending moment).

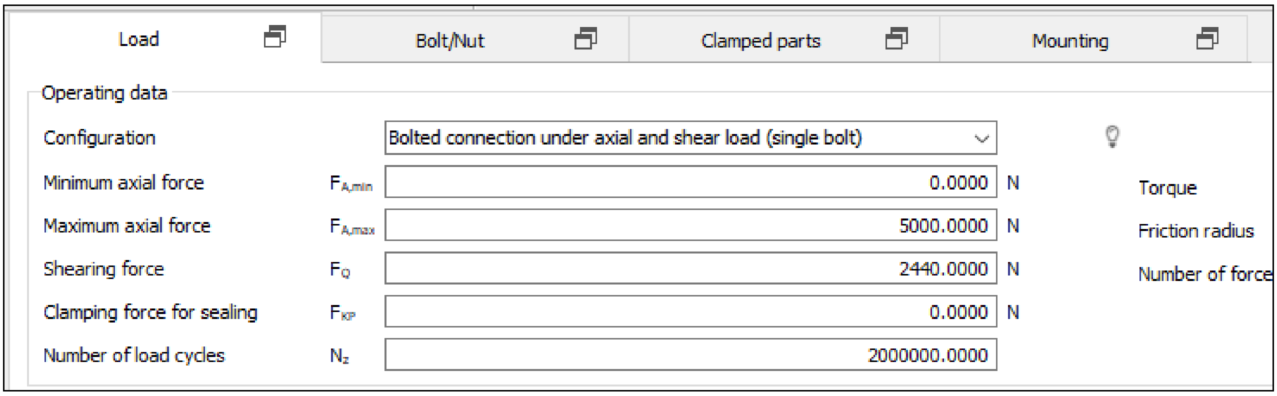


Figure 1. Input of the forces

The bending moment is not input directly because it is not an independent (free) moment but directly caused by the already entered axial force. So instead of entering the moment, the value for the load application distance "a" is entered in the "Clamped parts" tab.

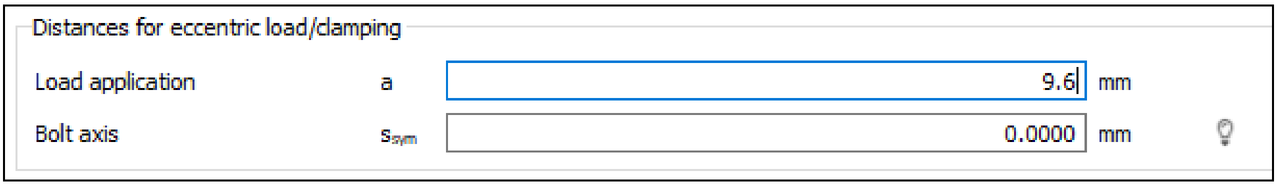


Figure 2. Input of the load application factor "a".

2.2 Determination of s_{sym} and u:

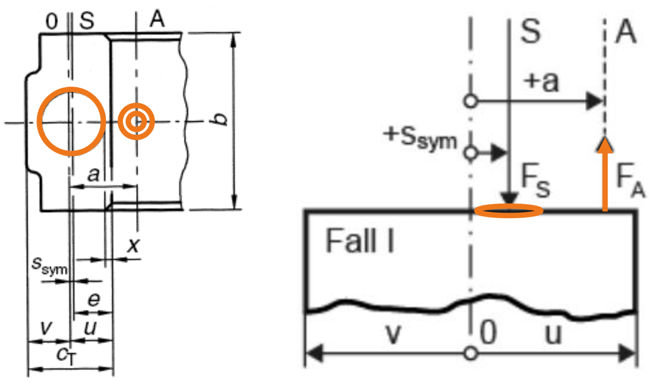


Figure 3. Compare the current case with the figure in the diagram (Case 1) from the VDI standard.

The clamping/loading case corresponds to "Case 1" in the figures shown in the VDI standard. The force from the bolt axis and the axial force both apply from the same side of the line of symmetry. The bolt axis lies between the line of symmetry and the force contact point.

The eccentricity of the bore, or the distance of the bolt axis from the line of symmetry s_{SYM} is calculated from $\mathbf{c_T}$, the bore diameter **dH** and the residual wall thickness **x**. In this case, this distance is 0.5 mm.

The distance of the gaping point from the line of symmetry "u" is simply half the part thickness, i.e. 6 mm.

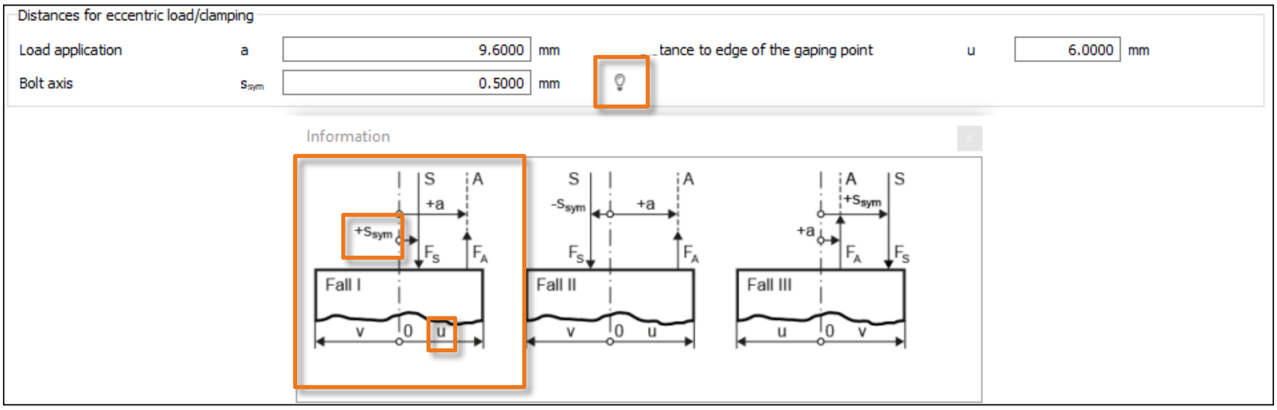


Figure 4. Input of s_{sym} and u, Information window showing the three possible cases

2.3 Load introduction factor:

Select "SV 1" as the bolting type. The length of the connection piece is also defined, according to the conditions, as 2.95 mm. You will find the derivation of this value in the VDI standard, in example 4, calculation step 3. The distance of the connected solid is set to 0 mm.

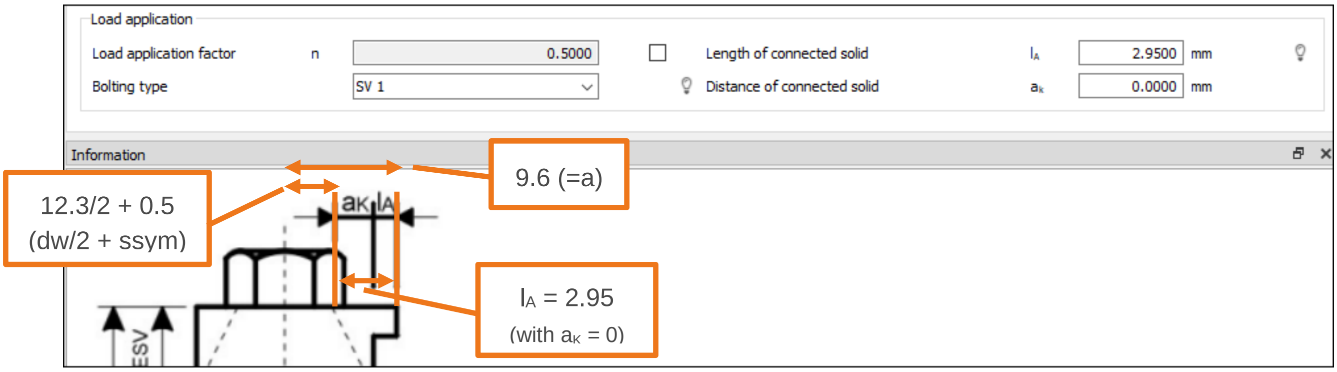


Figure 5. Deriving the length of the connected solid

Based on these entries the load application factor "n" will then be automatically determined during the calculation.

2.4 Clamped parts:

Next, the clamped parts can be entered. As the clamped parts are rectangular and relatively narrow, meaning that the clamping deformation cone cannot expand unhindered, we select "Prismatic body" as the basic geometry. The friction coefficient in the contact surface can be entered next to it.

The width "b" of the body is the dimension perpendicular to the direction from where the force is introduced. The length along that force direction is entered as "cB". And since in this case the contact area is not significantly narrower than what we assume to be the basic solid we enter the same amount for "cT".

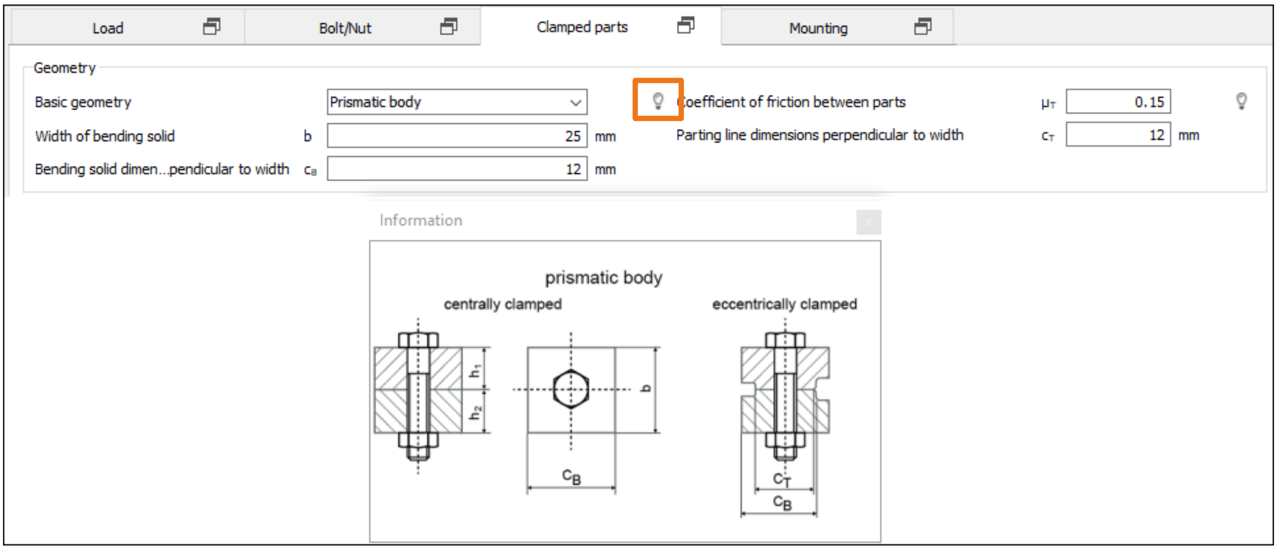


Figure 6. Geometry of the clamped parts

To achieve the correct bore diameter "dh", click on the "Bore" button and change the standard from "fine" to medium". As the resulting diameter is not displayed until after the calculation has been performed, you can also click on "Own Input" and enter a value manually.

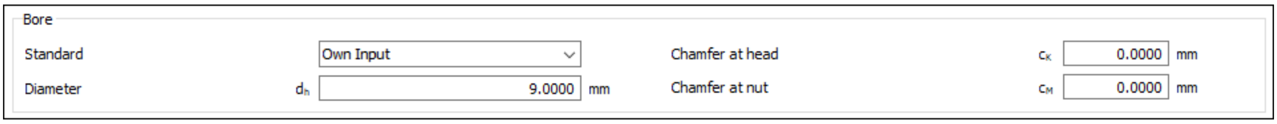


Figure 7. Input of bore diameter

Afterwards the depth of the layers and the material data can be entered. The thickness of the layers can be derived from the total clamping length and h_{min}. Also check to make sure each layer has the correct roughness.

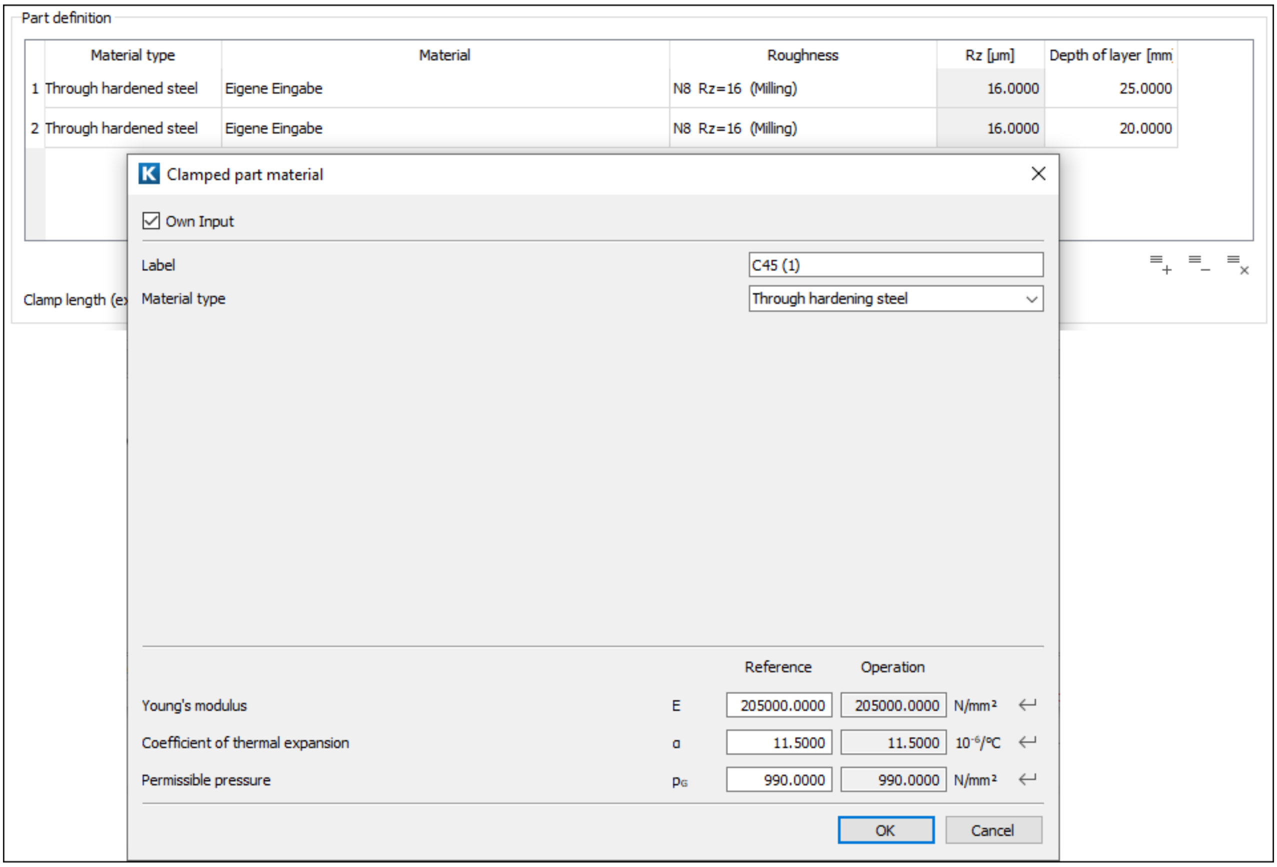


Figure 8. Layer thickness, roughness and material

2.5 Bolt, Nut:

Set the bolt type for the bolt to "Own Input" so that you can input the bolts exact dimensions at a later stage in the calculation.

Then enter the length and nominal diameter.

You can select strength class 12.9 directly. However, you should then reset it to "Own Input" again so that you can adjust the Young's modulus.

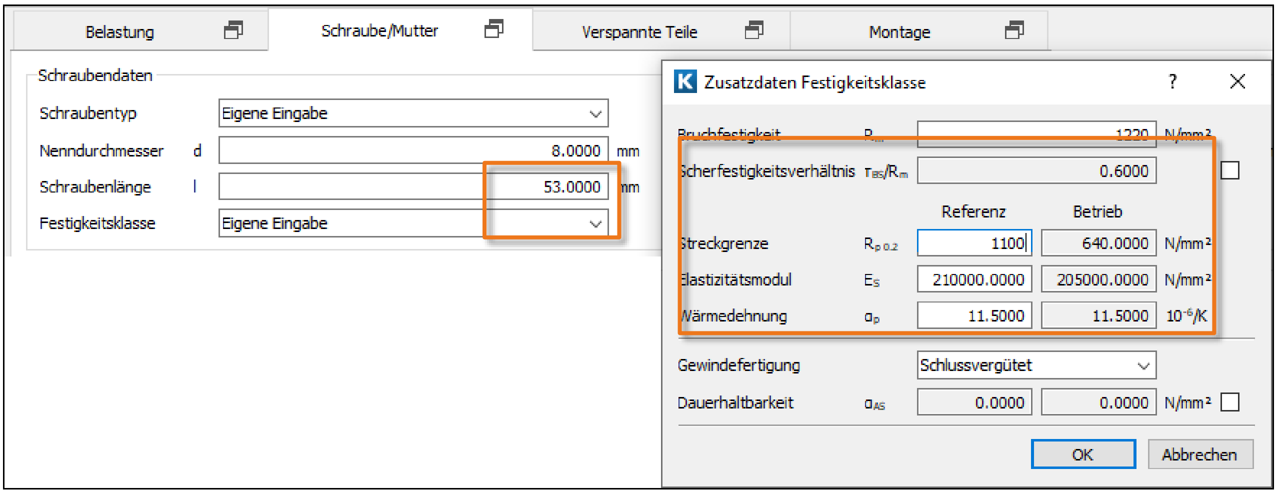


Figure 9. Settings for the bolt type and strength

Click on the (+) button next to "Bolt type" to input the detailed bolt dimensions and the shank segments in the table at the bottom.

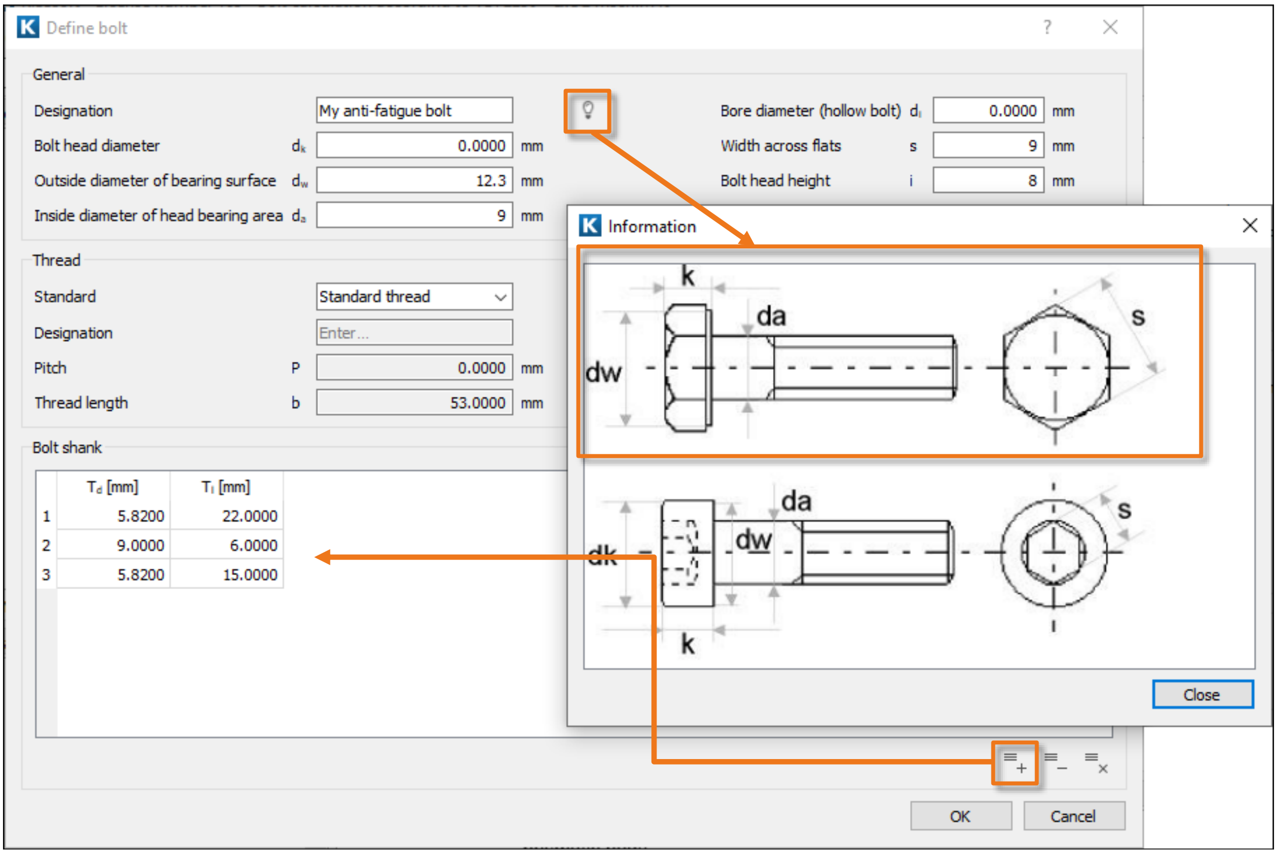


Figure 10. Define bolt.

To define the nut, first select the connection type and choose "strength according to strength class". Then make sure that the correct standard is selected and enter the strength class to match the bolt (12) as well as the roughness.

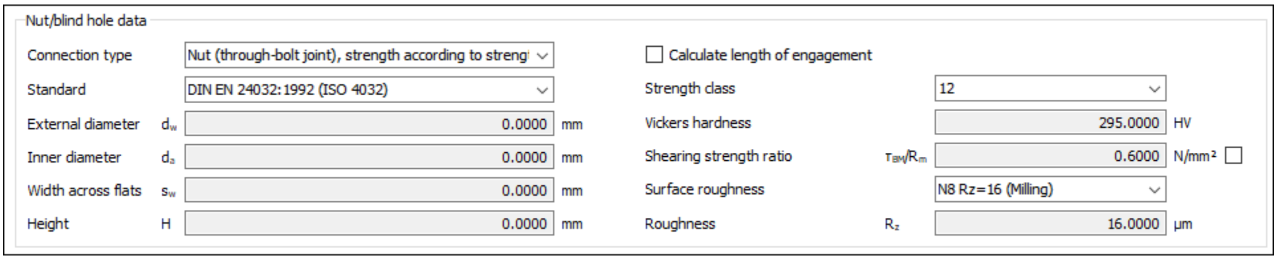


Figure 11. Defining the nut

2.6 Mounting

Select "Rotation-angle controlled tightening", as the tightening technique. The tightening factor, or the variation of pretension force, is then derived from the variation in the coefficient of friction and the yield strength.

Figure 12. Tightening technique.

100% utilization of the yield point is requested. You input this in the "Conditions" tab:

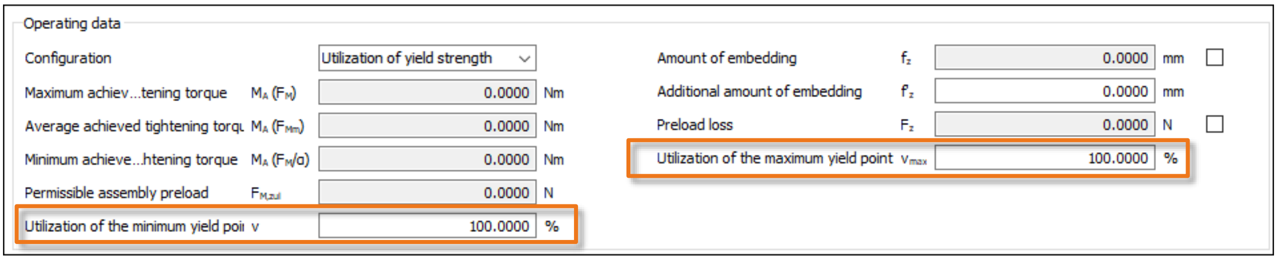


Figure 13. Yield point utilization during assembly.

Finally, enter the friction coefficients according to the specifications:

Figure 14. Friction factors

2.7 Results

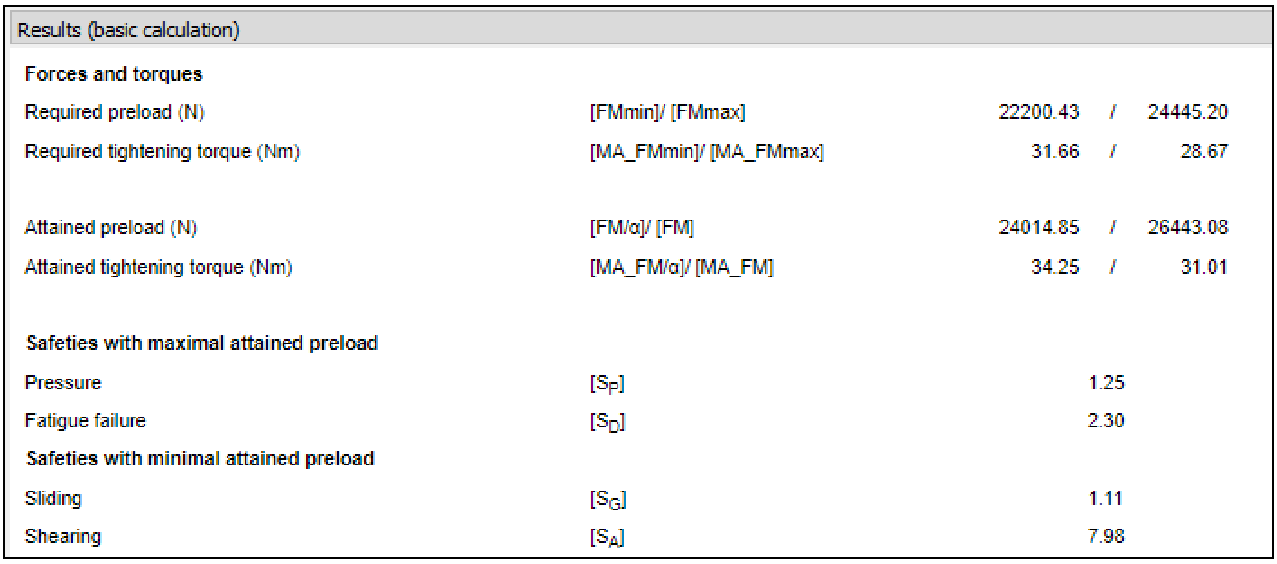


Figure 15. Results window