

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:	$F_{Amax} = 5000 \text{ N} (=F_B/2)$
	$F_{Amin} = 0 N$
Shearing force in the interface:	$F_{Qmax} = 2440 \text{ N}$
Bending moment in the interface:	$M_b = 48 \text{ Nm}$
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: $a = M_B / F_{A} = 48 \text{ Nm} / 5000 \text{ N} = 0.0096 \text{ m}$

Other details:

Rotation-angle-controlled tightening	(100% utilization of yield point)
Friction factor between parts:	$\mu_{Tmin} = 0.15$
Surface roughness of the parts:	Rz=16µm
Coefficient of friction head, nut:	μк, μм: 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
Ι _K	45 mm
x – Restwandstärke / residual wall thickness	1 mm
dh	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/mm²) Young's modulus = 210000 N/mm² Nuts EN 24032 for M8, strength class matching the bolt

I _S	=	53	mm	d _{a,max}	=	9	mm
<i>I</i> ₁	=	22	mm	d _h	=	9	mm
<i>I</i> ₂	=	6	mm	d _T	=	5,82	mm
l ₃	=	15	mm	d _w	=	12,3	mm
Р	=	1,2	5 mm	d _{Sch}	=	9	mm
AT	=	26,6	mm ²	d ₂	=	7,188	3 mm
Ada	=	32,8	4 mm ²	d ₃	=	6,466	3 mm

ds

=

6,827 mm

Width across flatss = 9 mmHeight of bolt headk = 8 mm

As

=

36,6 mm²

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).

	Load	ð		Bolt/Nut	ð	Clamped parts	ð		Mounting	ð
1	Operating data									
	Configuration			Bolted connection	under axia	l and shear load (single bolt)		\sim	ç	
	Minimum axial force		F _{A,min}				0.	0000	N	Torque
	Maximum axial force		F _{A,max}				5000.	0000	N	Friction radius
	Shearing force		Fo				2440.	0000	Ν	Number of force
	Clamping force for sealing	g	F _{KP}				0.	0000	Ν	
	Number of load cycles		Nz				2000000.	0000		

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.

Γ	Distances for eccentric load/clamp	ing			
	Load application	а	9.6	mm	
	Bolt axis	Ssym	0.0000	mm	Q

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 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.

Bore						
Standard	Own Input v		Chamfer at head	C _K	0.0000	mm
Diameter d _h	9.0000	mm	Chamfer at nut	См	0.0000	mm



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.

Part definition							
Materi	ial type	Material		Roughness	Rz [µm]	Depth of layer [mm	
1 Through hard	ened steel	Eigene Eingabe	N8 Rz=16	(Milling)	16.0000	25.0000	
2 Through hard	ened steel	Eigene Eingabe	N8 Rz=16	(Milling)	16.0000	20.0000	
	K Clampe	d part material			×	:	
	🗹 Own Inp	ut					
	Label			C45 (1)		=_+	≡_ ≡_×
Clamp length (ex	Material typ	2		Through hardening steel	~		
				Reference Operation			
	Young's mod	ulus	E	205000.0000 205000.0000	N/mm² ←		
	Coefficient of	of thermal expansion	a 🗌	11.5000 11.5000] 10 ⁻⁶ /⁰C ←		
	Permissible p	pressure	PG	990.0000 990.0000	N/mm² ←		
				ОК	Cancel		

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.

Belastung	ð	Schraube/Mutter	8	Vers	pannte	e Teile	ð		Monta	ge 🗗			
Schraubendaten						к	Zusatzdaten	n Festigke	eitsklass	e		?	×
Schraubentyp	Eigene	Eingabe		~		Bruk	chfectigkeit		P		1220	N/mm2	
Nenndurchmesser d				8.0000	mm	Sch	erfestigkeitsv	verhältnis	τ _{es} /R _m		0.6000		
Festigkeitsklasse	Eigene	Eingabe	+	~						Referenz	Betrieb		
		-	-	I		Stre	eckgrenze		R _{p 0.2}	1100	640.0000	N/mm ²	
						Elas	stizitätsmodul		Es	210000.0000	205000.0000	N/mm²	
						När	rmedehnung		ap	11.5000	11.5000	10 ⁻⁶ /K	
						Gew	vindefertigun	g		Schlussvergütet	~]	
						Dau	ierhaltbarkeit		OAS	0.0000	0.0000	N/mm²	
										[OK	Abbred	hen

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.

K Def	fine bolt					? ×
Gene	ral					
Desig	nation			My anti-fatigue bolt		Ø Bore diameter (hollow bolt) di 0.0000 mm
Bolt h	nead diameter		dk	0.0000	mm	Width across flats s 9 mm
Outsi	ide diameter of be	aring surface	d _w	12.3	mm	Bolt head height i 8 mm
Inside	e diameter of hea	d bearing area	da	9	mm	K Information ×
Threa	ad					k
Stand	dard			Standard thread \sim		
Desig	ination			Enter		
Pitch			Ρ	0.0000	mm	dw - [
Threa	ad length		ь	53.0000	mm	
Bolt s	hank					
	T _d [mm]	T _I [mm]				eb eb
1	5.8200	22.0000				s du
2	9.0000	6.0000		•	-	<mark>→ dk → [- ½</mark>] - ^q → [] - → ((+)) →
-	510200	1010000				
						k 1
						Close
						OK Cancel

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.

Nut/blind hole data						
Connection type	Nut (through-bolt joint), strength according to strengi $ \sim $		Calculate length of engagement			
Standard	DIN EN 24032: 1992 (ISO 4032) ~		Strength class		12 ~	
External diameter d _w	0.0000	mm	Vickers hardness		295.0000	HV
Inner diameter d _a	0.0000	mm	Shearing strength ratio	τ _{вм} /R _m	0.6000	N/mm²
Width across flats s _w	0.0000	mm	Surface roughness		N8 Rz=16 (Milling) V	
Height H	0.0000	mm	Roughness	Rz	16.0000	μm

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.

Tightening technique						
Method	Yield point controlled tightenin $ \smallsetminus $	Guide value		Mean value	\sim	
		Tightening factor	ØA		1.0000	\leftrightarrow



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

Operating data						
Configuration	Utilization of yield strength \sim	Amount of embedding	fz	0.0000	mm	
$Maximum \ achievtening \ torque \ M_{A} \ (F_{M})$	0.0000 N	Additional amount of embedd	ding f _z	0.0000	mm	
Average achieved tightening torq. $M_{A}\left(F_{Mm}\right)$	0.0000 N	Vm Preload loss	Fz	0.0000	Ν	
Minimum achievehtening torque M_A (F _M /a)	0.0000 N	Im Utilization of the maximum yie	eld point v _{max}	100.0000	%	
Permissible assembly preload F _{M.zul}	0.0000 N	N			_	
Utilization of the minimum yield poir ν	100.0000 %	%				

Figure 13. Yield point utilization during assembly.

Finally, enter the friction coefficients according to the specifications:

Friction factors									
In the thread (min/max) µ _g	G	0.0800	0.1400	Õ	In the nut support (min/max)	μм	0.1200	0.1200	Õ
In the head bearing area (min/max) $\ \mu_{\kappa}$	к	0.1200	0.1200	← Ç					

Figure 14. Friction factors

2.7 Results

Results (basic calculation)				
Forces and torques				
Required preload (N)	[FMmin]/ [FMmax]	22200.43	1	24445.20
Required tightening torque (Nm)	[MA_FMmin]/ [MA_FMmax]	31.66	1	28.67
Attained preload (N)	[FM/α]/ [FM]	24014.85	1	26443.08
Attained tightening torque (Nm)	[MA_FM/α]/ [MA_FM]	34.25	1	31.01
Safeties with maximal attained preload				
Pressure	[S _P]	1.25		
Fatigue failure	[S _D]	2.30		
Safeties with minimal attained preload				
Sliding	[S _G]	1.11		
Shearing	[S _A]	7.98		

Figure 15. Results window