

KISSsoft Exercises Bolt calculation 01

Flange Coupling

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Sharing Knowledge

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Task 1

Material of the coupling parts EN-GJL-250, Young's modulus = 1.1 x 10⁵ N/mm² Coeff. of friction between the parts $\dots \mu_{Tmin} = 0.15$ Load introduction factor:n = 1 Surface roughness $Rz = 8\mu m$ (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:

- $h_{min} = 30 \text{ mm}$ •
- $I_{k} = 60 \text{ mm}$
- $D_i = 178 \text{ mm}$
- $D_a = 338 \text{ mm}$



- 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:

Rating	8		Bolt/ Nut	ð	Clamped parts (connecting so	olids) 🗗	
Operating data							_
Configuration			Bolted connection	n under axia	l load (single bolt)	~	
Minimum axial force		F _{Amin}	Bolted connection Bolted connection	under axial under axial	load (single bolt) and shear load (single bolt)	N	1
Maximum axial force		F _{A,max}	Flange connection Multi-bolted joint	n with torque with arbitrar	e and forces (multiple bolts) y position of the bolts	N	1
Number of load cycles		Nz	Proof for bolts wit	th FEM resul	ts 2	00000.0000	

Figure 1. Selecting the configuration.

Now, input the torque and the load application factor:

	Rating	5		Bolt/ Nut	ð	Clamped p	arts (co	nnectin	g solids) 🗗		Mounting	ð				
	Operating data															
	Configuration			Flange connection	n with torque a	and for \sim		Õ								
	Shearing force		Fq			0.0000	N		Axial force		FA		0.0000	0.0000	N	
	Clamping force for sealing	g	F _{KP}			0.0000	N		Torque		MT			13000.0000	Nm	
	Number of load cycles		Nz		2000	000.000			Bending mom	ent	MB			0.0000	Nm	
									Coefficient of	friction bet	ween part µ⊤			0.1000]	Ç
	Temperatures															
	Assembly temperature					20.0000	° C		Operating ter	nperature of	fparts			20.000) ℃	
	Bolt operating temperatu	ire				20.0000	° C									
	Distances for eccentric lo	ad/clamp	ing													
	Load application		а			0.0000	mm		Distance to e	dge of the g	aping point u			0.000) mm	
	Bolt axis		Ssym			0.0000	mm	Q							_	
	Load application															
ĺ	Load application factor		n			1]									

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:

Load		Ð	Bolt/Nut	٦	Clamped part	s	6	Mounting	Ð				
Bolt data													
Number of bolts	n _B				12		\leftarrow	Head bearing area surface	roughness		N7 Rz=8.0 (Turned with diamo	nd) 🗸	
Bolt type		Hexago	n head screw with shank (A	B) DIN EN	ISO 4014:2001 V			Roughness Rz		Rz		8.0000	mm
Nominal diameter	d				16.0000	mm	\leftarrow						
Bolt length	I.				80.0000	mm	\leftarrow						
Strength class		10.9			~		$^+$						
Nut/blind hole data													
Constant in the second													
Connection type		Nut (thr	rough-bolt joint), strength a	ccording t	o strength class \sim			Calculate length of enga	agement				
Standard		Nut (thr DIN EN	rough-bolt joint), strength a 24032: 1992 (ISO 4032)	ccording to	o strength class v			Calculate length of enga Strength class	agement		10	~	
Standard External diameter	dw	Nut (thr	rough-bolt joint), strength ac 24032: 1992 (ISO 4032)	ccording to	o strength class v v 22.5000]]] mm		Calculate length of enga Strength class Vickers hardness	agement		10 27	~ 72.0000	HV
Standard External diameter Inner diameter	d _w da	Nut (thr	rough-bolt joint), strength ar 24032: 1992 (ISO 4032)	ccording t	o strength class ~ 22.5000 17.3000]] mm] mm		Calculate length of engr Strength class Vickers hardness Shearing strength ratio	agement	τ _{8М} /R _m	10	× 72.0000 0.6000	HV N/mm²
Standard External diameter Inner diameter Width across flats	d _w d _a s _w	Nut (thr	rough-bolt joint), strength ac 24032: 1992 (ISO 4032)	ccording to	o strength class 22.5000 17.3000 24.0000]] mm] mm] mm		Calculate length of engr Strength class Vickers hardness Shearing strength ratio Surface roughness	agement	τ _{вМ} /R _m	10 27 N7 Rz=8.0 (Turned with diamo	<pre></pre>	HV N/mm²

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:

Rating	8	Bolt/ Nu	ıt	ð	Clamped parts (connecting	solids)	8
Geometry							
Pitch circle diameter		dt			0.0000	mm	
Basic geometry			Plates		~		Q
Bore			Plates Cylinder Prismatic	body			
Standard			Segment	of annul	us		Cha
Diameter		dh			0.0000	mm	Cha

Figure 5. Selecting the basic geometry

Click on the \square 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.).

Material	type	Ma	aterial		
1 Cast iron flake gr	raphite EN-GJL-250 (GG 25	5)			
2 Cast iron flake gr	aphite EN-GJL-250 (GG 25	ö), unbehandelt, VDI	2230 (2015)		~ +
Clamped part mater	ial				
] Own Input					
Label	Material type	E [N/mm ²]	a [10 ⁻⁶ /°C]	p _G [N/mm²]	,
315MC	Structural steel	2.0500e+05	12.6000	540.0000	
120MC	Structural steel	2.0500e+05	12.5000	670.0000	
120MC 135J2 (St37.3N)	Structural steel Structural steel	2.0500e+05 2.0600e+05	12.5000 11.5000	670.0000 490.0000	
420MC 235J2 (St37.3 N) 195 (St50.2)	Structural steel Structural steel Structural steel	2.0500e+05 2.0600e+05 2.0600e+05	12.5000 11.5000 11.5000	670.0000 490.0000 710.0000	
420MC 235J2 (St37.3 N) 195 (St50.2) 155J2 (St52.3 N)	Structural steel Structural steel Structural steel Structural steel	2.0500e+05 2.0600e+05 2.0600e+05 2.0600e+05	12.5000 11.5000 11.5000 11.5000	670.0000 490.0000 710.0000 760.0000	
420MC 135J2 (St37.3 N) 195 (St50.2) 155J2 (St52.3 N) NT-D30	Structural steel Structural steel Structural steel Structural steel Dry powdered metal	2.0500e+05 2.0600e+05 2.0600e+05 2.0600e+05 1.3000e+05	12.5000 11.5000 11.5000 11.5000 12.0000	670.0000 490.0000 710.0000 760.0000 450.0000	
420MC 235J2 (St37.3 N) 295 (St50.2) 555J2 (St52.3 N) NT-D30 I-GJL-150 (GG 15)	Structural steel Structural steel Structural steel Structural steel Dry powdered metal Cast iron flake graphite GJL	2.0500e+05 2.0600e+05 2.0600e+05 2.0600e+05 1.3000e+05 78000.0000	12.5000 11.5000 11.5000 11.5000 12.0000 11.7000	670.0000 490.0000 710.0000 760.0000 450.0000 700.0000	
420MC 235J2 (St37.3 N) 295 (St50.2) 355J2 (St52.3 N) NT-D30 I-GJL-150 (GG 15) I-GJL-200 (GG 20)	Structural steel Structural steel Structural steel Structural steel Dry powdered metal Cast iron flake graphite GJL Cast iron flake graphite GJL	2.0500e+05 2.0600e+05 2.0600e+05 2.0600e+05 1.3000e+05 78000.0000 88000.0000	12.5000 11.5000 11.5000 11.5000 12.0000 11.7000 11.7000	670.0000 490.0000 710.0000 760.0000 450.0000 700.0000 775.0000	
420MC 235J2 (St37.3 N) 195 (St50.2) 355J2 (St52.3 N) NT-D30 4-GJL-150 (GG 15) 4-GJL-200 (GG 20) 4-GJL-250 (GG 25)	Structural steel Structural steel Structural steel Structural steel Dry powdered metal Cast iron flake graphite GJL Cast iron flake graphite GJL Cast iron flake graphite GJL	2.0500e+05 2.0600e+05 2.0600e+05 2.0600e+05 1.3000e+05 78000.0000 88000.0000 1.0300e+05	12.5000 11.5000 11.5000 11.5000 12.0000 11.7000 11.7000 11.7000	670.0000 490.0000 710.0000 760.0000 450.0000 700.0000 775.0000 850.0000	

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/mm². 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.

K Clamped part material				×
Own Input				
Label		EN-GJL-250 (0	GG 25)	
Material type		Cast iron flake	e graphite GJL	\sim
		Reference	Operation	
Young's modulus	E	110000.0000	103000.0000 N/mm ²	\leftarrow
Coefficient of thermal expansion	٥	11.7000	11.7000 10 ⁻⁶ /°C	\leftarrow
Permissible pressure	PG	850.0000	850.0000 N/mm ²	\leftarrow
			OK Cano	el

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.

Load	5	Bolt/Nut	5	Clampe	ed parts	ð	Mounting	5			
Geometry											
Pitch circle diameter		dt	258.	0000 mm	Coe	efficient of fr	iction between parts		μт	0.1500	ç
Basic geometry		Segment of annulu	s	\sim	🖞 Inn	er diameter			di	178.0000 mm	n
External diameter		da	338.	0000 mm	Bol	t spacing			t	0.0000 mn	ı

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.

Tightening technique			
Method	Torque wrench (by estimating the coefficient of friction, class B)	Guide value	Mean value 🗸
	Hydraulic non-frictional and torsion-free tightening Yield point controlled tightening Potation-andie controlled tightening	Tightening factor	G _A 1.8000
Friction factors	Torque-controlled tightening with hydraulic tool Torque wrench (with load in testing condition)	_	
In the thread (min/max) μ_G	Torque wrench (by estimating the coefficient of friction, class B) 200 Torque wrench (by estimating the coefficient of friction, class A)	In the nut support (min/max)	μ _M 0.1200 0.1200
In the head bearing area (min/max) $\ \mu_{\kappa}$	Torque wrench (by estimating the coefficient of friction) (VDI2230:1988) Torque wrench (Setpoint tightening torque with an adding factor) (VDI	¢ ♀	
	Impact screw driver		

Figure 9. Input of tightening method and friction factors

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

Results (basic calculation)				x
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	1	
Pressure	[S _P]	1.08	1	
Fatigue failure	[S _D]	1000.00		
Safeties with minimal attained preload				
Sliding	[S _G]	1.09)	
Shearing	[S _A]	12.03	4	

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.

Washers/extension sleeves without ext	ernal forces	Uwasher below nut	t
Washer below bolt head	+ 🗹 Wash	er below nut	
Extension sleeve under bolt head	Exten	sion sleeve under nut	
			1.18
Results (basic calculation)			1.00
Safeties with maximal attained preload			1000.00
Yield point	[S _F]	1.18	1.00
Pressure	[S _P]	1.59	12.03
Fatigue failure	[S _D]	1000.00	12.03
Safeties with minimal attained preload			
Sliding	[S _G]	1.07	-
Shearing	[S _A]	12.03	

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	ð	Mounting	ð	Protokoli 🗗 🔀
) }	À » ↔	» 100% v » Arial		✓ » Suchbeg
Surface pr	ressure			
under bo	olt head (N/m	m²)	[pK]	786.62
under w	asher (N/mm	2)	[p]	339.16
under nu	ut (N/mm²)		[pM]	731.70
under w	asher (N/mm	2)	[p]	339.16
Support ar	rea			
under bo	olt head (mm²)	[ApK	() 151.20
under w	asher (mm²)		[Ap]	350.67
under nu	ut (mm²)		[ApM	/I] 162.55
under w	asher (mm²)		[Ap]	350.67
Permissibl	le surface pre	ssure		
under bo	olt head (N/m	m²)	[pKz	zul] 1250
under w	asher (N/mm	2)	[pzu	I] 850.00
under nu	ut (N/mm²)		[pM z	zul] 1250
under w	asher (N/mm	²)	[pzul	il] 850.00

Figure	12.	Surface	pressure	in	the	report
riguic	12.	ounacc	pressure		uic	repon

2.3 Part c)

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

Bolt data														
Number o	of bolts	n _B								1	2		\leftarrow	Head bear
Bolt type	•		Hexag	jon hea	ad so	rew wi	ith sha	nk (A	B) DIN	NEN IS	~			Roughnes
Nominal	diameter	d								16.000	0	mm	\leftarrow	
Bolt leng	th	1								80.000	0	mm	\leftarrow	
Strength	class		9.8								~		$^+$	
			-											
K Error	г													×
Error	The max Assembly Permissit	imum y prel ple pro	i require load FM eload F	:d asse max: Mzul:	embly 109 91	/ preloa 9389.8 099.20	ad is g 0 N) N	reate	r than	permiss	ble	preload	l for	× the bolt.

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.