

KISSsoft 03/2017 – Tutorial 4

Bolt calculation according to VDI 2230

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Contents

1	Starting KISSsoft.....	3
1.1	Starting the software.....	3
1.2	Selecting a calculation.....	3
2	Calculation of a flanged connection	4
2.1	Task.....	4
2.2	Proposal for a reasonable bolt diameter.....	5
2.3	Definition of nuts and washers	5
2.4	Definition of clamped parts	6
2.5	Definition of the bolt.....	7
3	Analysis and results	9
3.1	Performing the analysis, report.....	9
3.2	Comments on the results.....	11
4	Further Calculations.....	12
4.1	Analysis with a smaller bolt	12
4.2	Constraints, settings	12

1 Starting KISSsoft

1.1 Starting the software

You can call KISSsoft as soon as the software has been installed and activated. Usually you start the program by clicking "Start→Program Files→KISSsoft 03-2017→KISSsoft 03-2017". This opens the following KISSsoft user interface:

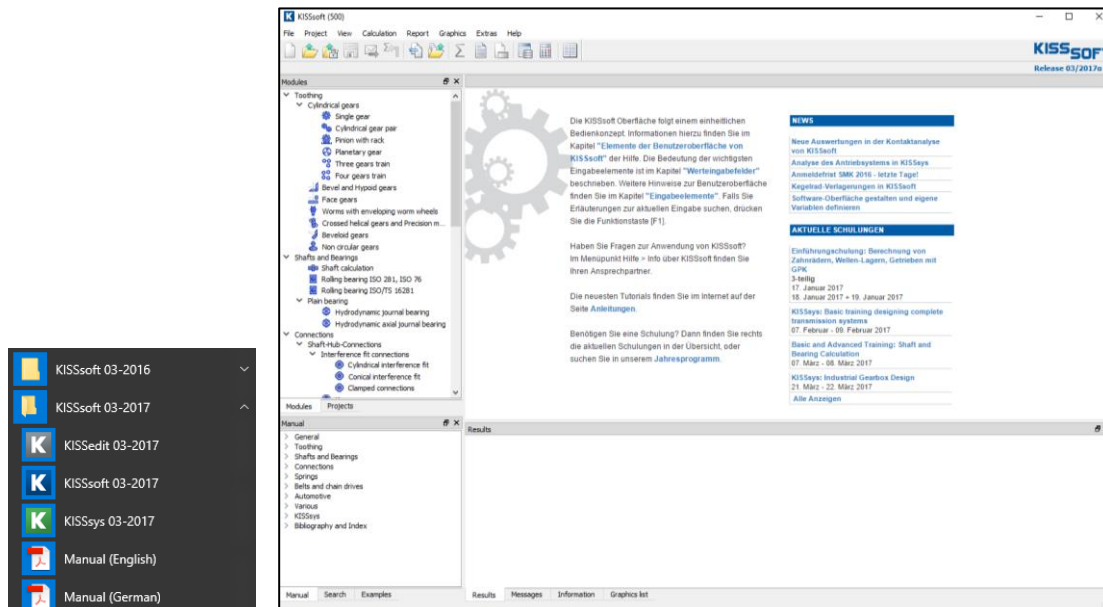


Figure 1. Starting KISSsoft, initial window

1.2 Selecting a calculation

In the Modules tree window, select the "**Modules**" tab to call the bolt calculation module:

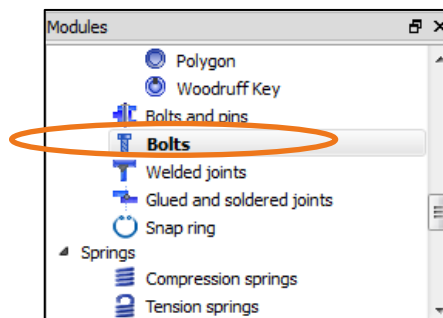
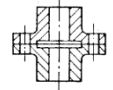
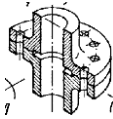


Figure 2. Selecting the "Bolts" calculation module

2 Calculation of a flanged connection

2.1 Task

Size and verify the bolting for a flanged coupling using the following data:

Torque to be transmitted	13 kNm	Flange inner diameter	210 mm	
Pitch diameter	258 mm	Coefficient of friction	0.15	
Number of bolts on pitch circle	12	Axial force lower value	0 kN	
Material flange (left/right)	EN-GJL-250 (GG25)/34CrNiMo6	Axial force upper value	10 kN	
Thickness flange (left/right)	22 mm/18 mm	Bolt strength class	10.9	
Flange surface (left/right)	N7/N8	Type: hexagon headed bolt with shank (AB)		
Flange outer diameter	320 mm	EN ISO 4014,		
		Tightening: with torque wrench		

The connection is made using through bolts (notation as specified in VDI 2230:2014 - bolted joint) with nuts, with washers under the nuts and under the bolt head. If you require a different input unit, click with the right-hand mouse button on the unit you want to change to open the corresponding selection list. You can then simply select the unit you want from this list and change the units used in the calculation. Input this data in the **"Basic data"** tab as follows:

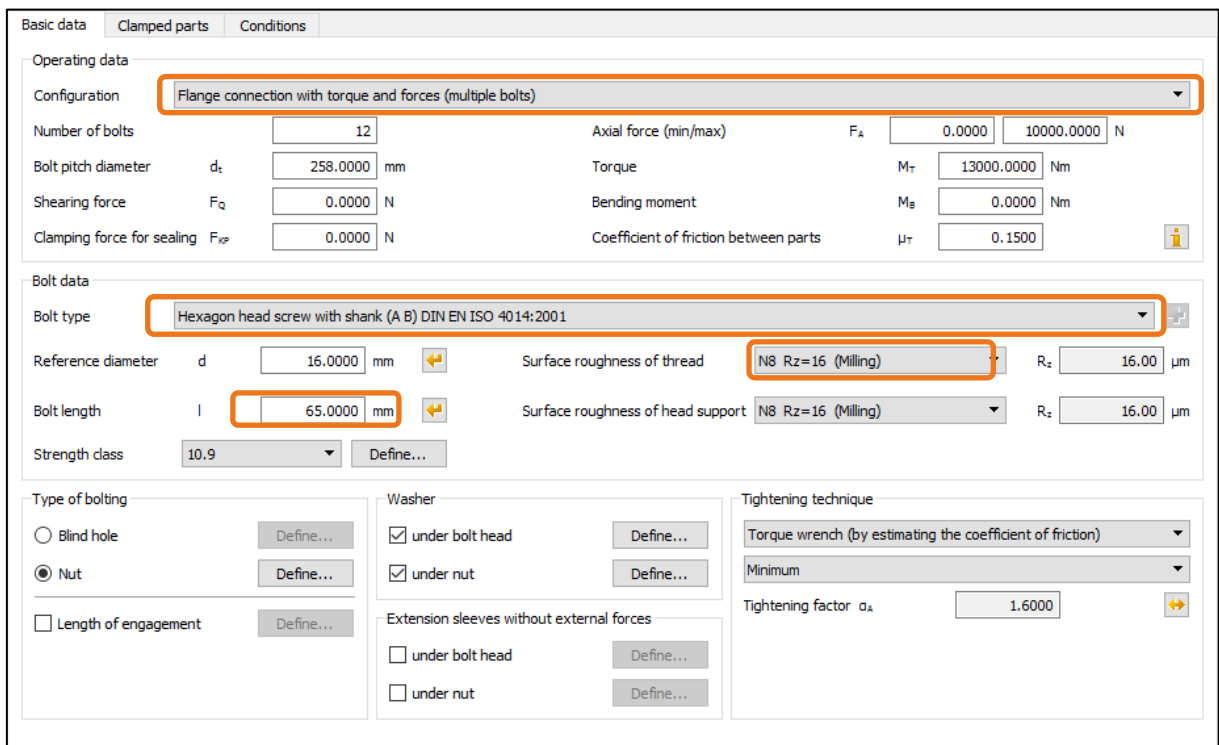
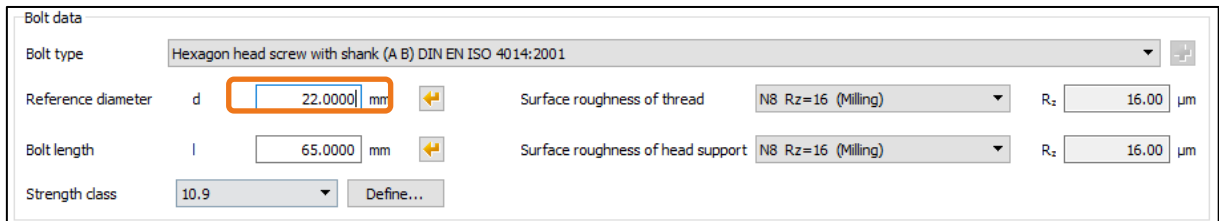


Figure 3. Inputting known data, selecting the calculation method

2.2 Proposal for a reasonable bolt diameter

After you have defined the load and input the basic data for the bolt, click the **"Sizing button"** in the main window. The program proposes values for a suitable bolt diameter. This proposal is based on a simplified bolt layout as specified in VDI 2230:2014. This method usually results in over-dimensioned bolts. Experience shows that the minimum permitted bolt diameter is often one or two sizes lower! Note the message that appears when you click the Sizing button. When you click the Sizing button, the software suggest a reference diameter based on VDI 2230: 2014, in this case, M22.



The screenshot shows the 'Bolt data' dialog box. The 'Bolt type' is 'Hexagon head screw with shank (A B) DIN EN ISO 4014:2001'. The 'Reference diameter' d is set to 22.0000 mm. The 'Bolt length' l is 65.0000 mm. The 'Strength class' is 10.9. Surface roughness settings are N8 Rz=16 (Milling) for both thread and head support, with R_z values of 16.00 μm .

Figure 4. Sizing the bolt diameter

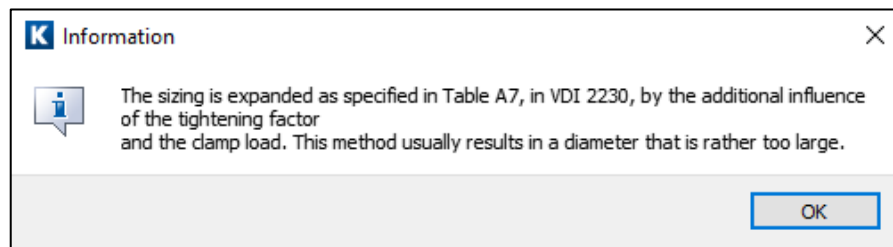
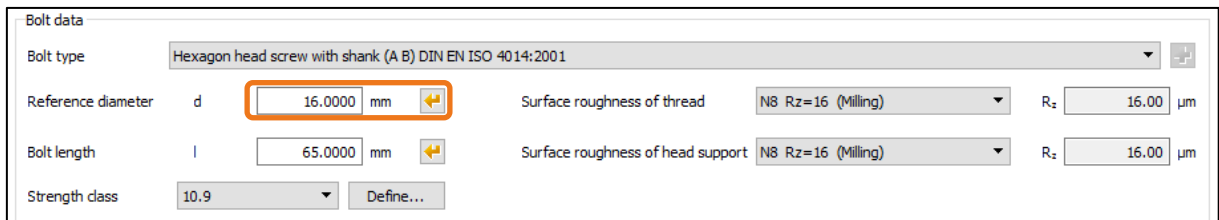


Figure 5. Message indicating that the proposed bolt diameter may be too large

You can reduce the reference diameter to 16 mm manually:

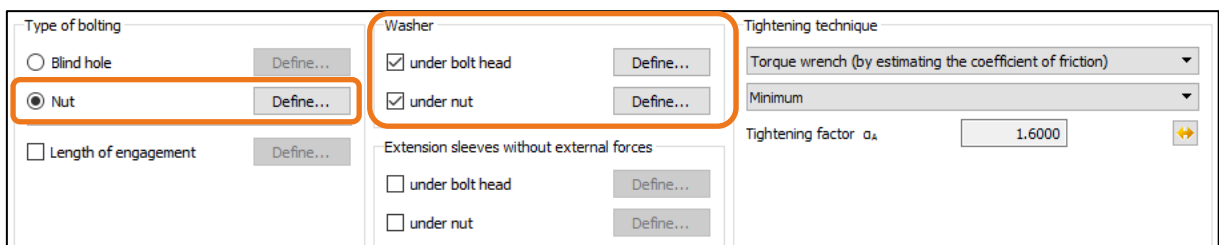


The screenshot shows the 'Bolt data' dialog box with the 'Reference diameter' d manually set to 16.0000 mm. All other parameters remain the same as in Figure 4.

Figure 6. Reference bolt diameter set manually to 16mm

2.3 Definition of nuts and washers

In the **"Basic data"** tab you can now input the data for the nuts and washers:



The screenshot shows the 'Basic data' dialog box. The 'Type of bolting' is set to 'Nut'. Under 'Washer', the options 'under bolt head' and 'under nut' are checked. The 'Tightening technique' is 'Torque wrench (by estimating the coefficient of friction)' and the 'Tightening factor' a_s is 1.6000.

Figure 7. Input for washers and nuts

Either select the nut from the standard or input your own geometry.

Washer details. Either select the washer from the standard or input your own geometry

Figure 8. Defining the nut and washers. (The values for the diameter etc. do not appear until you input the data)

The values for all fields are set automatically after you select from a Standard. In this case, you only need to input the material and surface roughness.

2.4 Definition of clamped parts

The "**Clamped parts**" tab contains all the details about clamped parts. As a flanged connection is being calculated, the software recommends you to define the geometry of the clamped parts (flange) as segments of an annulus:

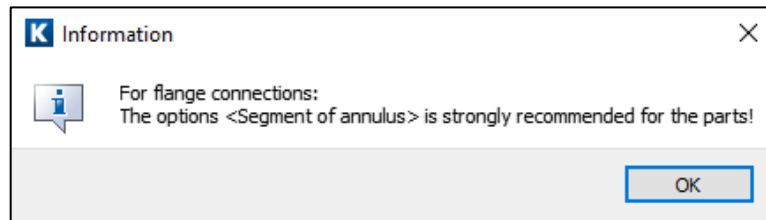


Figure 9. Note when you define a "Segment of annulus" when calculating flanged connections

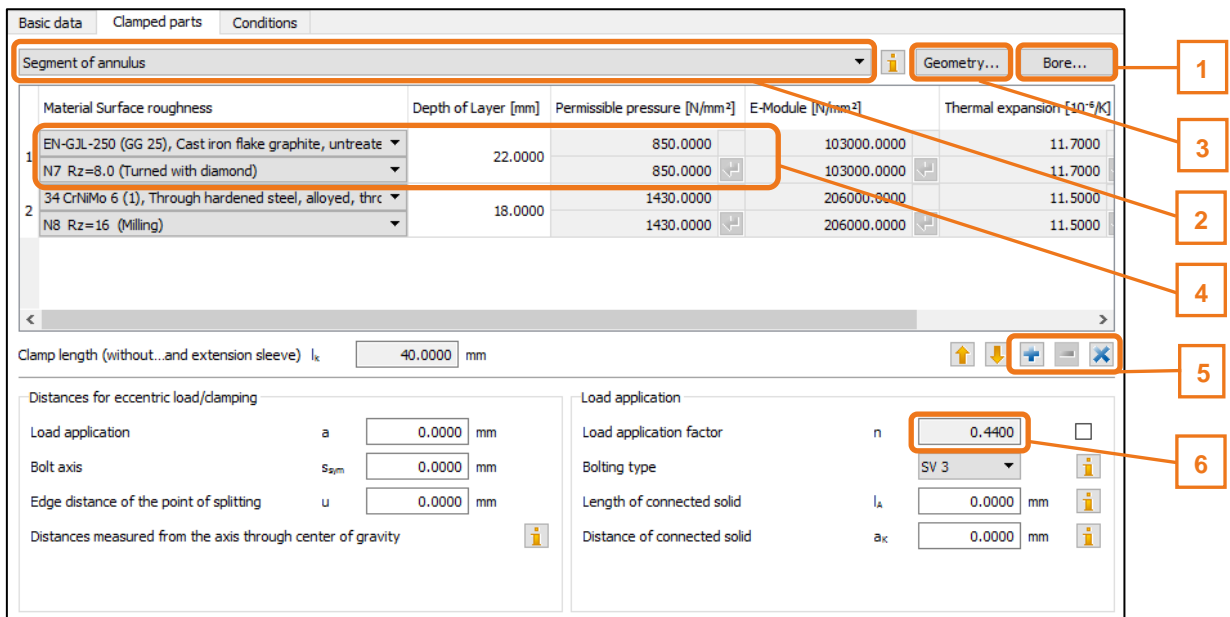



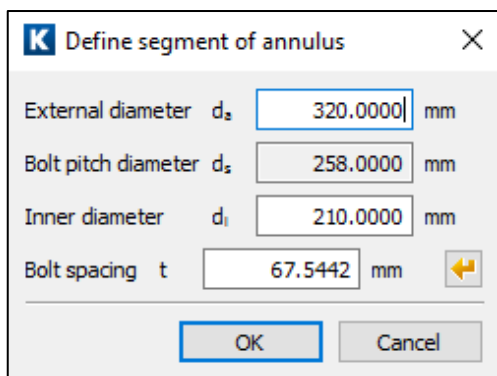
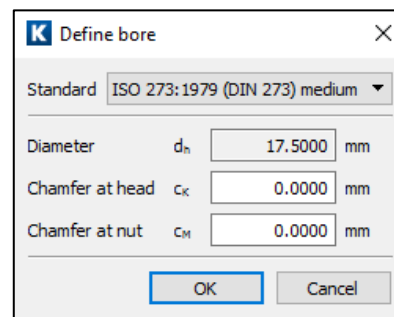


Figure 10. Definitions of screw-connected parts, calls to the relevant subscreens

- (1) Definition of bore
- (2) Select the type of the connected parts, here **"Segment of annulus"**
- (3) Define the geometry of the segments of an annulus
- (4) Input of Depth of Layer, select Material and roughness
- (5) Insert new layer: 
Remove layer: 
Clear all: 
- (6) Type of load application




Details about the outer and inner diameter, pitch diameter and bolt spacing (click the Sizing button to define the bolt spacing value)



Details of the bore: you can define your own bore diameter by selecting **"Own definition"** from the **"Standard"** drop-down list and inputting the diameter in the **"Diameter"** field.

Figure 11. More details about the type of connected parts

2.5 Definition of the bolt

In the **"Basic data"** tab you can now define the bolt length by clicking the "Sizing button"  (smallest standard bolt length) or input a value manually. The calculation is now complete and the connection is displayed in the graphics window:

Bolt data					
Bolt type	Hexagon head screw with shank (A B) DIN EN ISO 4014:2001				
Reference diameter	d	16.0000 mm	Surface roughness of thread	N8 Rz=16 (Milling)	Rz: 16.00 μm
Bolt length	l	65.0000 mm	Surface roughness of head support	N8 Rz=16 (Milling)	Rz: 16.00 μm
Strength class	10.9 Define...				

Figure 12. Final definition of the bolt

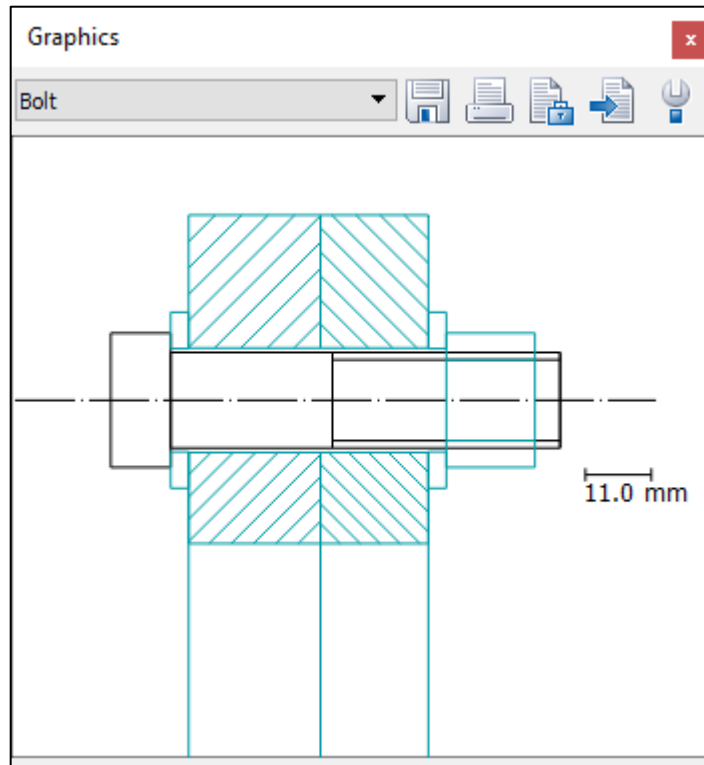





Figure 13. Display showing bolt with flange, washers and nut

3 Analysis and results

3.1 Performing the analysis, report

This predefines all the data so you can verify the connection. To do this, click the  icon (1) in the command bar (or press F5). The most important results are displayed in the "Results" window. To call the detailed report, either press F6 or click the icon  (2). To return from the report to the analysis, click the  icon in the tool bar. Make selections from the selection list to change the graphic (screw) displayed (3).

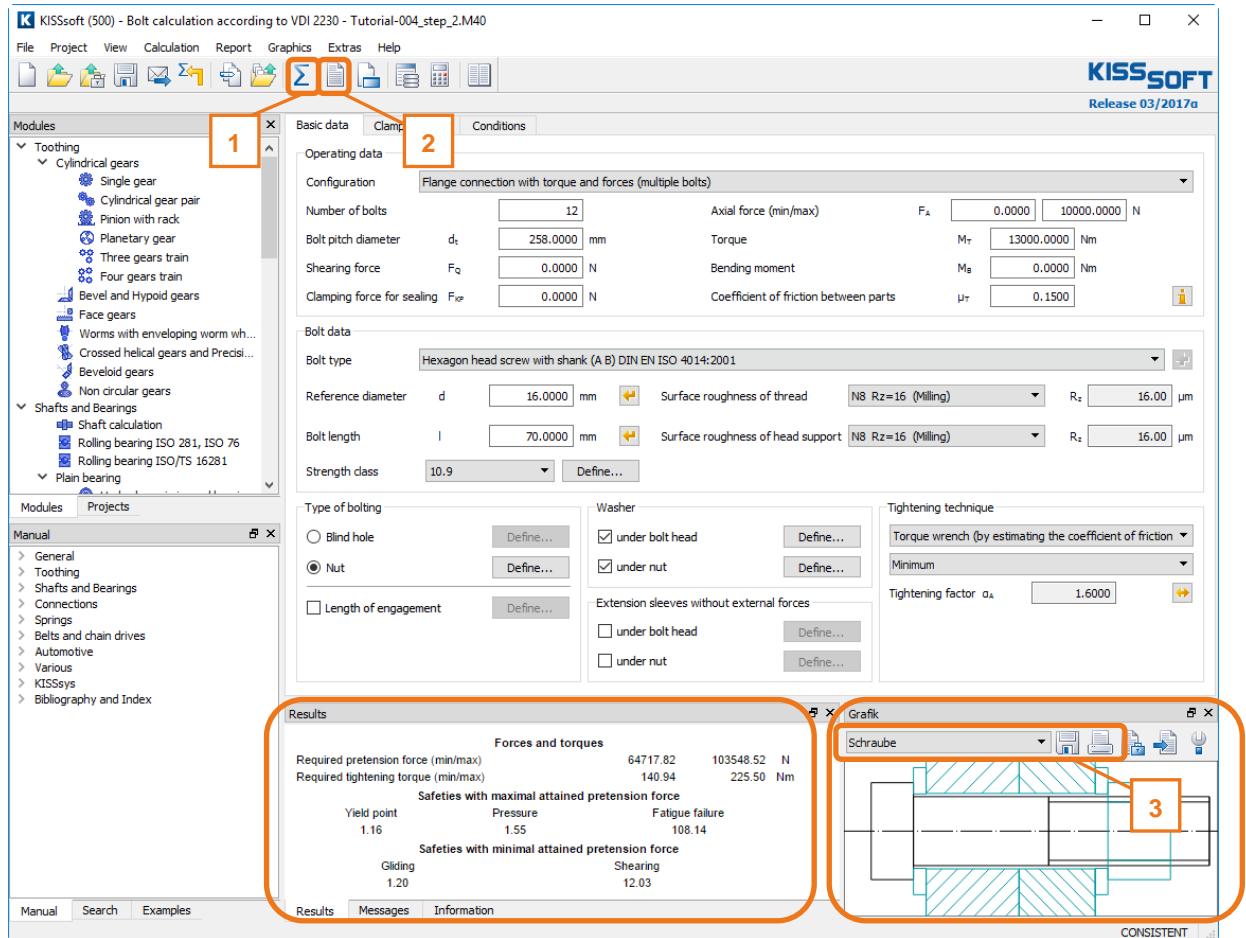


Figure 14. Running the calculation, resulting bolt geometry, results overview

You can also display more graphics by clicking the "Graphics" menu option:

The screenshot displays the KISSsoft software interface for bolt calculation. The 'Graphics' menu is open, showing options for Bolt, Clamping, Pretension force, Close, and Settings. An orange arrow points from the 'Pretension force' option to a graph titled 'Pretension force'. Another orange arrow points from the 'Settings' option to a graph titled 'Clamping'. The main window shows a 'Flange connection with torque and forces (multiple bolts)' configuration with the following parameters:

- Number of bolts: 12
- Bolt pitch diameter d_t : 258.0000 mm
- Clamping force F_c : 0.0000 N
- Axial force (min/max) F_A : 0.0000 / 10000.0000 N
- Torque M_T : 13000.0000 Nm
- Bending moment M_b : 0.0000 Nm

Two graphs are displayed:

- Clamping:** A line graph showing Force [N] on the y-axis (0 to 1.20e5) versus Length change [mm] on the x-axis (-0.18 to 0.06). It features four curves: FM (blue), FMmax (magenta), FM/σ (cyan), and FMmin (green).
- Pretension force:** A line graph showing Pre-load force [kN] on the y-axis (0 to 130) versus Tightening torque [Nm] on the x-axis (0 to 240). The curve shows a linear relationship up to approximately 180 Nm, then levels off.

The 'Results' section displays the following data:

Forces and torques		
Required pretension force (min/max)	64717.82	103548.52 N
Required tightening torque (min/max)	140.94	225.50 Nm
Safeties with maximal attained pretension force		
Yield point	1.16	
Pressure	1.55	
Fatigue failure		108.14
Safeties with minimal attained pretension force		
Gliding	1.20	
Shearing		12.03

The 'Grafik' section shows a 3D model of a bolt and nut assembly labeled 'Schraube'.

Figure 15. Display containing other graphics



To call the detailed report, click the icon or either press F6:

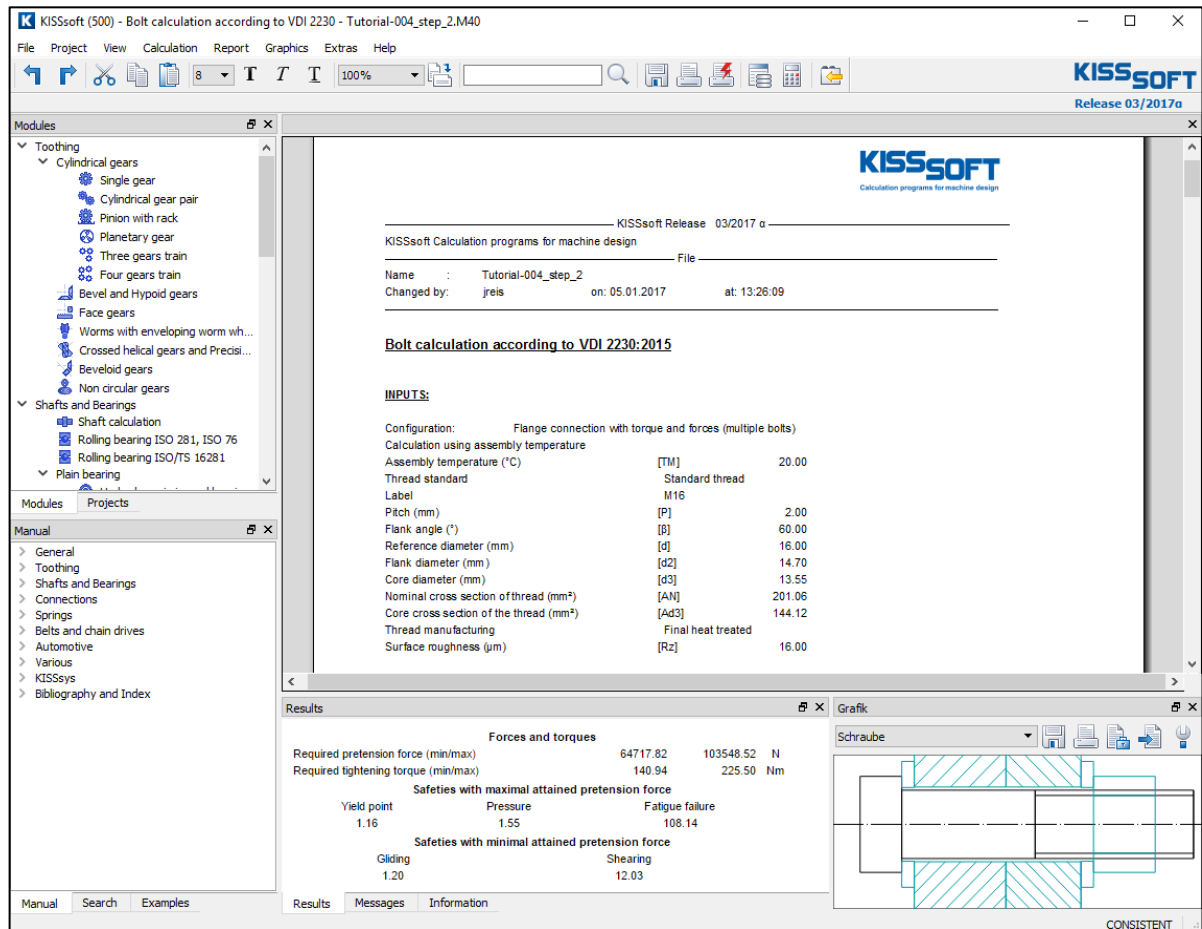


Figure 16. Displaying the report and changes to the displayed graphic

3.2 Comments on the results

Results displayed in the main window:

Pretension force (N), alphaA = 1, alphaA eff	Indicates the pretension force required to ensure the connection will withstand shear forces. Both the minimum value (tightening factor = 1) and the maximum value (tightening factor = 1.6, in this example) are shown.
Starting torque (Nm), alphaA = 1, alphaA eff	Information about the tightening torque achieved, minimum value (tightening factor = 1) and also maximum value (tightening factor = 1.6, in this example).
Bolt safety	Safety factor against yield point
Pressure safety	Minimum safety factor of surface pressure
Alternating load safety	Safety factor against fatigue of bolt

Results shown in the report, "Calculating safeties with the maximum required mounting pretension force" section:

Mounting pretension force (N) [FM]	In addition to the required pretension force (see table above), the report also lists the mounting pretension force. This value corresponds to the values for tightening torque specified in Appendix A of VDI2230
Tightening torque (Nm) [MA]	Value for tightening torque. This value corresponds to the values for tightening torque specified in Appendix A of VDI2230

4 Further Calculations

4.1 Analysis with a smaller bolt

Finally, you should check whether M16 is the smallest possible bolt diameter. To do this, reduce the bolt diameter to M14 and then repeat the calculation. The message tells you that a connection using a M14 bolt is not mathematically possible.

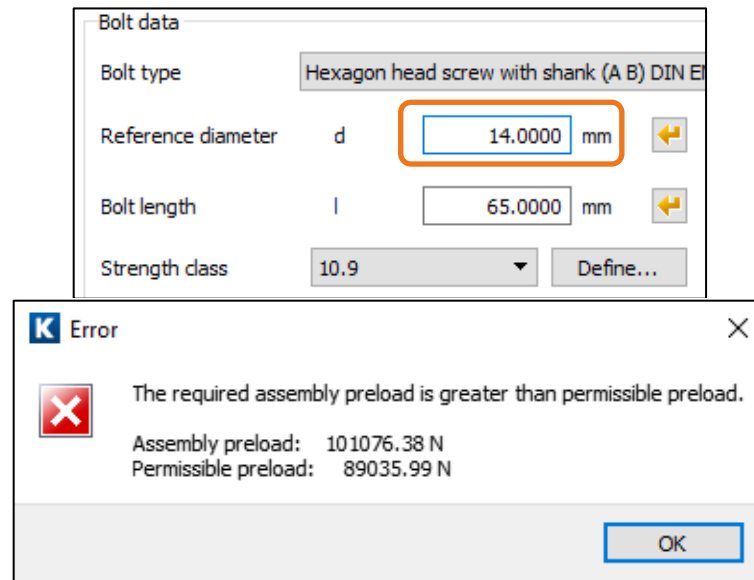


Figure 17. Input new bolt diameter, -> run calculation, -> error message

4.2 Constraints, settings

You can input more values for the calculation in the input window in the "**Entries**" tab, and in the "**Calculations/Settings**" menu option. However, this requires a detailed knowledge of VDI guideline 2230:2014.

K Module specific settings
✕

General

On error messages (permissible pressure, permissible pretension force), continue the calculation

Do the calculation for the case of reached minimum pretension FM/alpha

Do not increase required clamping force for eccentric clamping

In the case of a through-bolt joint use the resilience properties of the tapped thread joint

Temperature calculation

Operating force occurs only at operating temperature

Calculate temperature dependent material data automatically with estimation formulae

Determine specific thermal expansion of washers

Mounting and working stress

Calculate mounting and operating stress without torsion

Reduction coefficient k_r

Exceeding of yield point Not permitted ▼

Hardening coefficient k_v

Additional torsional moment during operation M_{TSmax} Nm

Additional shearing force during operation F_{QSmax} N


Vibrational stress

Endurance limit no special calculation ▼

Length of engagement

Coefficient Tensile strength of bolt R_{mmax}/R_m

Figure 18. Module-specific settings

The critical values in the calculation are the assumed coefficients of friction between the thread and thread hole and between the head/nut and clamped part. You must input these values in the "Entries" tab. The VDI guideline proposes a number of different friction coefficients. Click the "Info buttons"  to display these in the information window.

Basic data		Clamped parts		Conditions	
Operating data					
Configuration	Utilization of yield strength		Number of load cycles	N_z	2000000
Maximum tightening torque	$M_{A,max}$	172.2376 Nm	Amount of embedding	f_z	0.0195 mm <input type="checkbox"/>
Minimum tightening torque	$M_{A,min}$	107.6485 Nm	Additional amount of embedding	f_z	0.0000 mm
Permissible assembly preload	$F_{N,zul}$	89035.9909 N	Preload loss	F_z	6434.3288 N <input type="checkbox"/>
Minimum utilization of yield strength	v	90.0000 %	Maximum utilization of yield strength	v_{max}	90.0000 %
Swing angle controlled tightening					
Number of steps	1		Plastic deformation	0.0000 %	
Pretension	10.0000 %		Maximum yield point	100.0000 %	
Temperatures					
Assembly temperature	T_{H1}	20.0000 °C	Friction factors		
Operating temperature, bolt	T_S	20.0000 °C	In the thread (min/max)	μ_a	0.1000 / 0.1000 <input type="button" value="Sizing"/>
Operating temperature of parts	T_P	20.0000 °C	In the bearing surface (min/max)	μ_k	0.1000 / 0.1000 <input type="button" value="Sizing"/>
			In the nut support (min/max)	μ_n	0.1000 / 0.1000 <input type="button" value="Sizing"/>

Figure 19. Settings used to perform a calculation according to VDI 2230 in the "Conditions" tab

By clicking the "Sizing button" you can select the friction values according to the friction coefficient classes see the table A5 in VDI 2230.

K Size coefficient of friction ✕

Coefficient of friction class Class A ▼

Coefficients of friction μ_{min}/μ_{max} 0.1 / 0.1

Class A
 Class A
 Class B
 Class C
 Class D
 Class E

Figure 20. Selection of the friction coefficient classes according to table A5 in VDI 2230

You can also specify the tightening factor in the "Basic data" tab.

The image shows a software interface for configuring bolted connections, divided into three tabs: "Basic data", "Clamped parts", and "Conditions". The "Basic data" tab is active and contains the following sections:

- Operating data:** Configuration: "Flange connection with torque and forces (multiple bolts)". Parameters include Number of bolts (12), Bolt pitch diameter d_t (258.0000 mm), Shearing force F_Q (0.0000 N), Clamping force for sealing F_{ϕ} (0.0000 N), Axial force (min/max) F_A (0.0000 / 10000.0000 N), Torque M_T (13000.0000 Nm), Bending moment M_B (0.0000 Nm), and Coefficient of friction between parts μ_T (0.1500).
- Bolt data:** Bolt type: "Hexagon head screw with shank (A B) DIN EN ISO 4014:2001". Parameters include Reference diameter d (14.0000 mm), Bolt length l (65.0000 mm), Strength class (10.9), Surface roughness of thread (N8 Rz=16 (Milling) with R_z 16.00 μm), and Surface roughness of head support (N8 Rz=16 (Milling) with R_z 16.00 μm).
- Type of bolting:** Radio buttons for "Blind hole" and "Nut" (selected). A "Length of engagement" checkbox is present.
- Washer:** Checkboxes for "under bolt head" and "under nut" (both checked).
- Extension sleeves without external forces:** Checkboxes for "under bolt head" and "under nut" (both unchecked).
- Tightening technique:** "Torque wrench (by estimating the coefficient of friction)" selected. A "Minimum" dropdown is shown. The "Tightening factor α_s " is set to 1.6000 and is highlighted with an orange box.

Figure 21. Tightening factor in Basic data