KISSsoft
Drivetrain Design Solutions

KISSsoft 2019 – Tutorial 4

Bolt calculation according to VDI 2230

KISSsoft AG
A Gleason Company
Rosengartenstr. 4, 8608 Bubikon
Switzerland

T. +41 55 254 20 50
F. +41 55 254 20 51
info@KISSsoft.AG
www.KISSsoft.AG

Sharing Knowledge

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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 03-2019→KISSsoft 03-2019. This opens the following KISSsoft user interface:

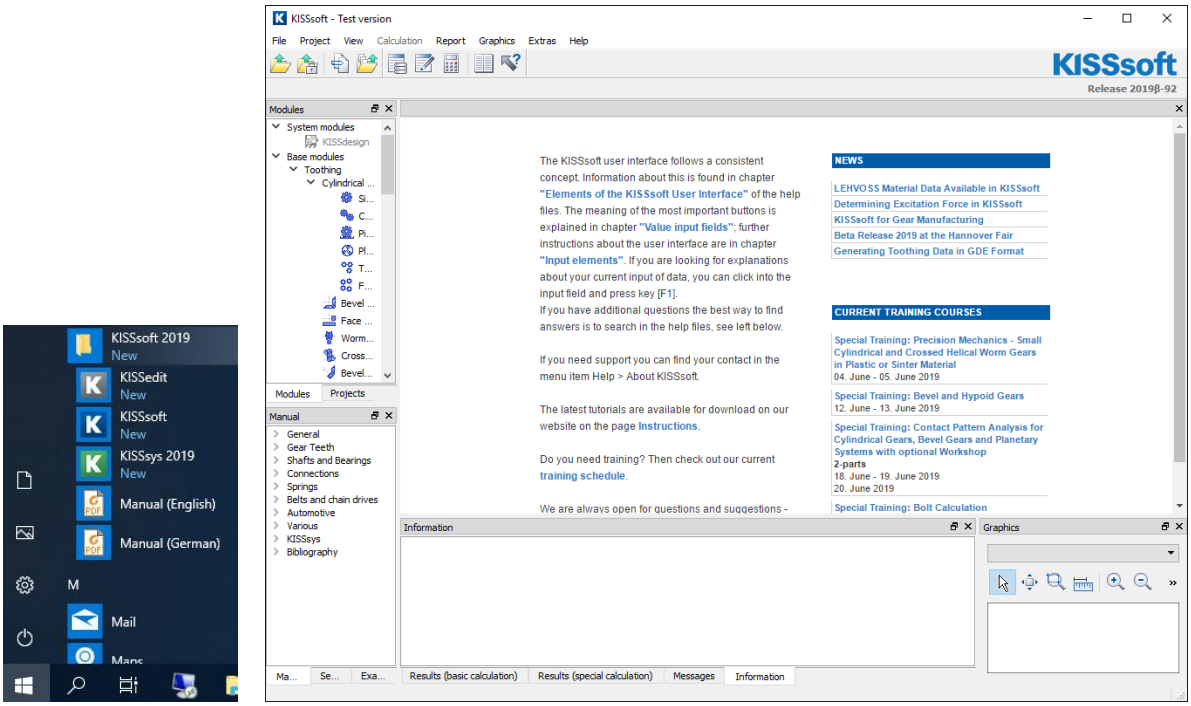


Figure 1. Starting KISSsoft, initial window

1.2 Selecting a calculation

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

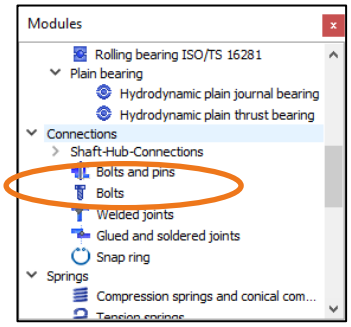
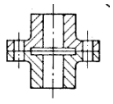
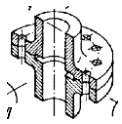


Figure 2. Selecting the «Bolts» calculation module

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	
		Axial force upper value	10 kN	
Material flange (left/right)		Bolt strength class	10.9	
EN-GJL-250 (GG25)/34CrNiMo6				
		Type: hexagon headed bolt with shank (AB)		
Thickness flange (left/right)	22 mm/18 mm	EN ISO 4014,		
Flange surface (left/right)	N7/N8	Tightening: with torque wrench		
Flange outer diameter	320 mm			

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:

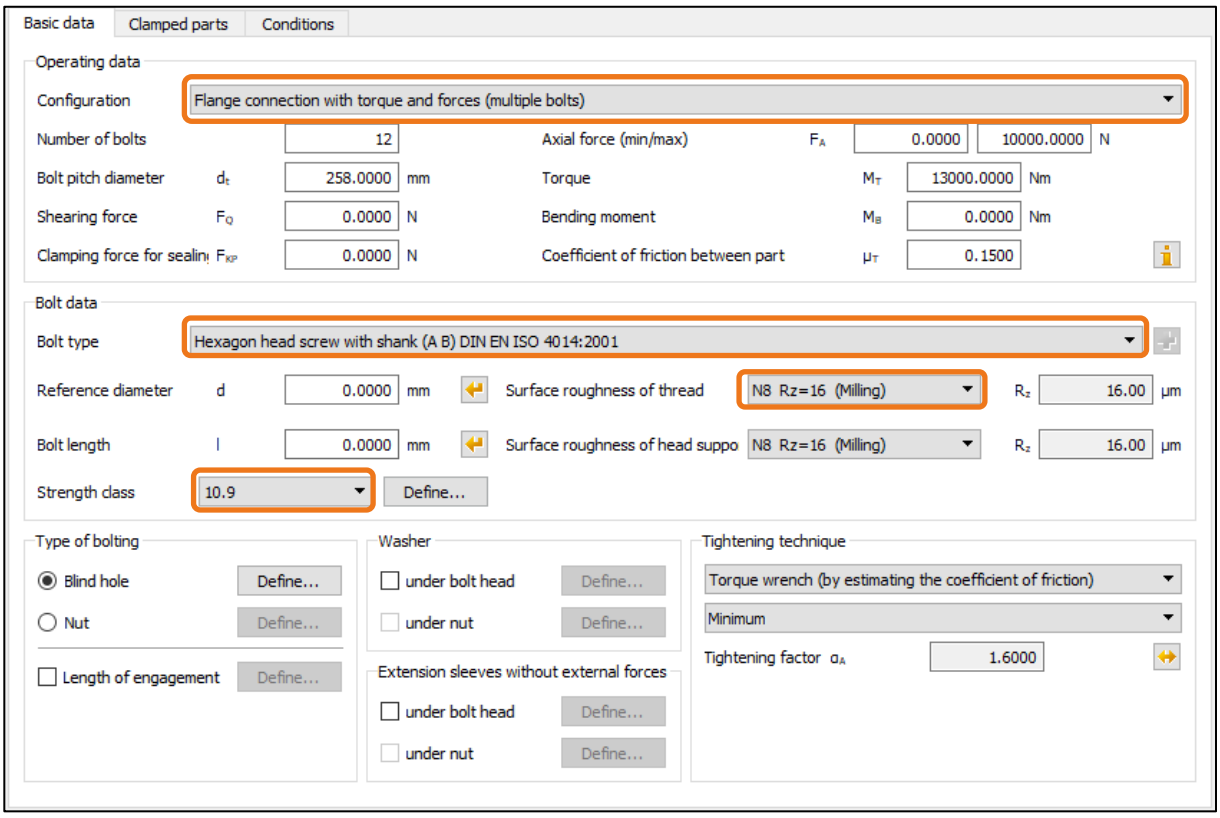


Figure 3. Inputting known data, selecting the calculation method

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.

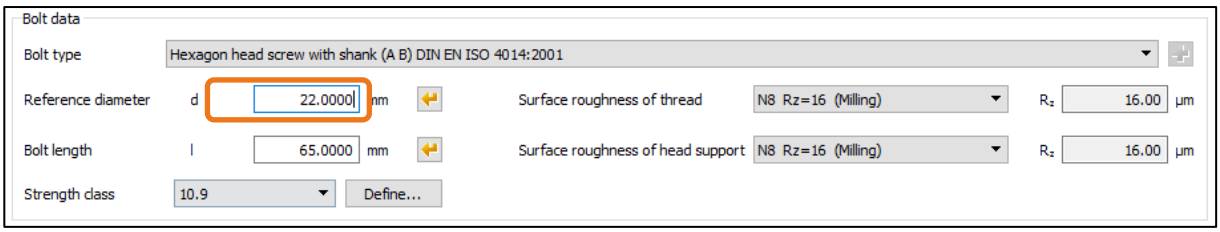


Figure 4. Sizing the bolt diameter

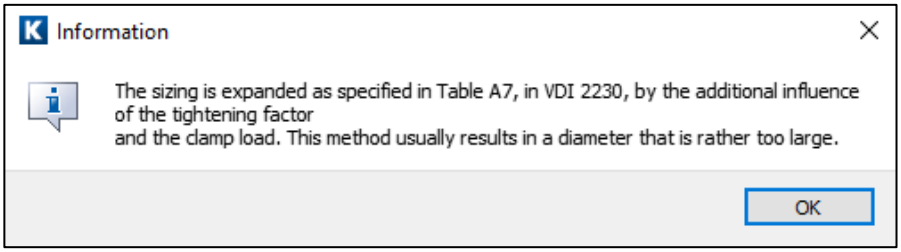


Figure 5. Message indicating that the proposed bolt diameter may be too large

You can reduce the reference diameter to 16mm manually:

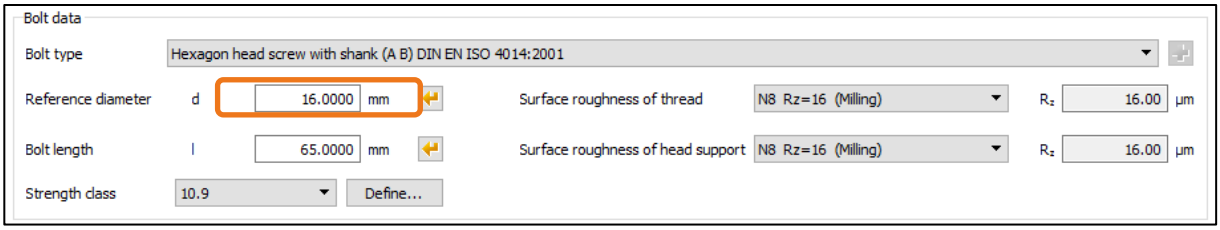


Figure 6. Reference bolt diameter set manually to 16mm

2.3 Definition of nuts and washers

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

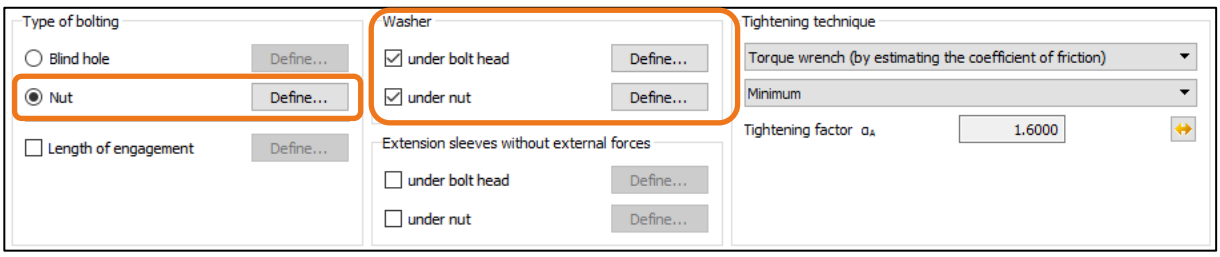
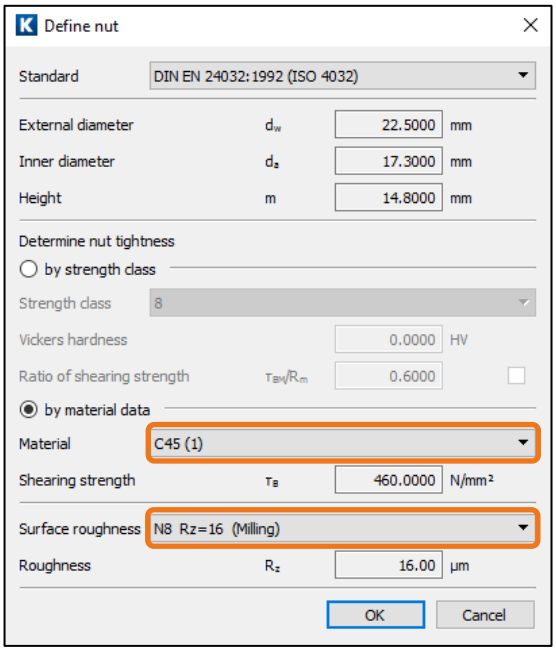
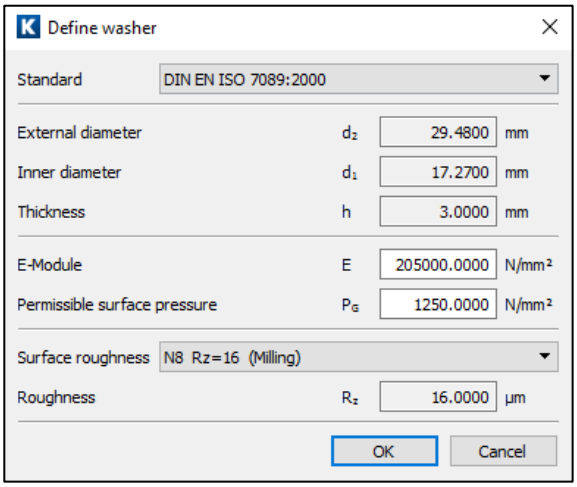


Figure 7. Input for washers and nuts



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:

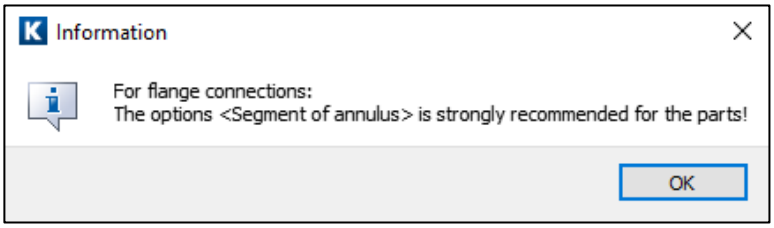


Figure 9. Note when you define a «Segment of annulus» when calculating flanged connections

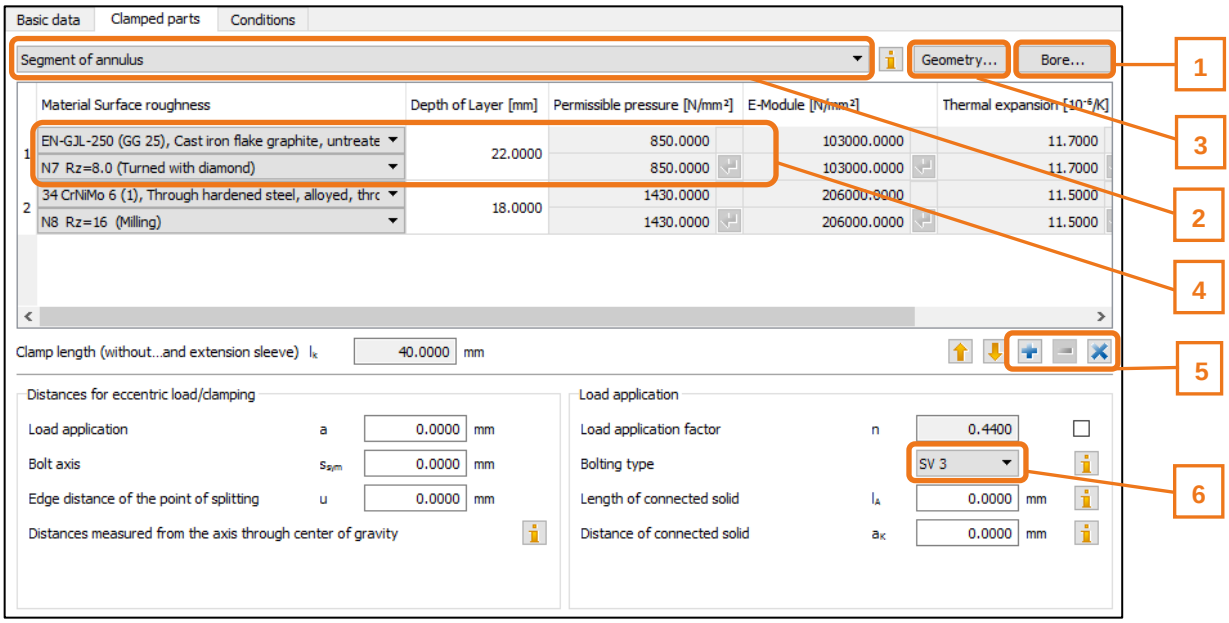
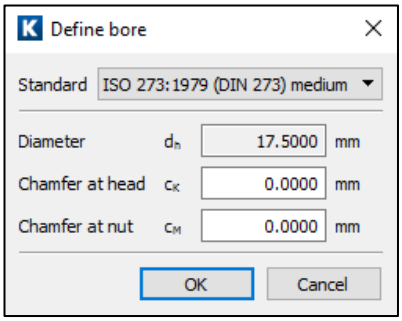


Figure 10. Definitions of screw-connected parts, calls to the relevant subscreens

(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:

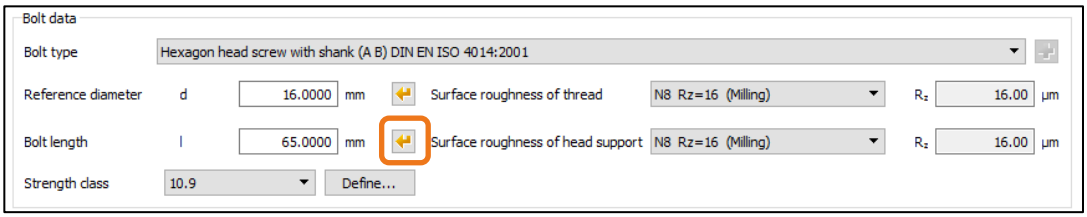


Figure 12. Final definition of the bolt

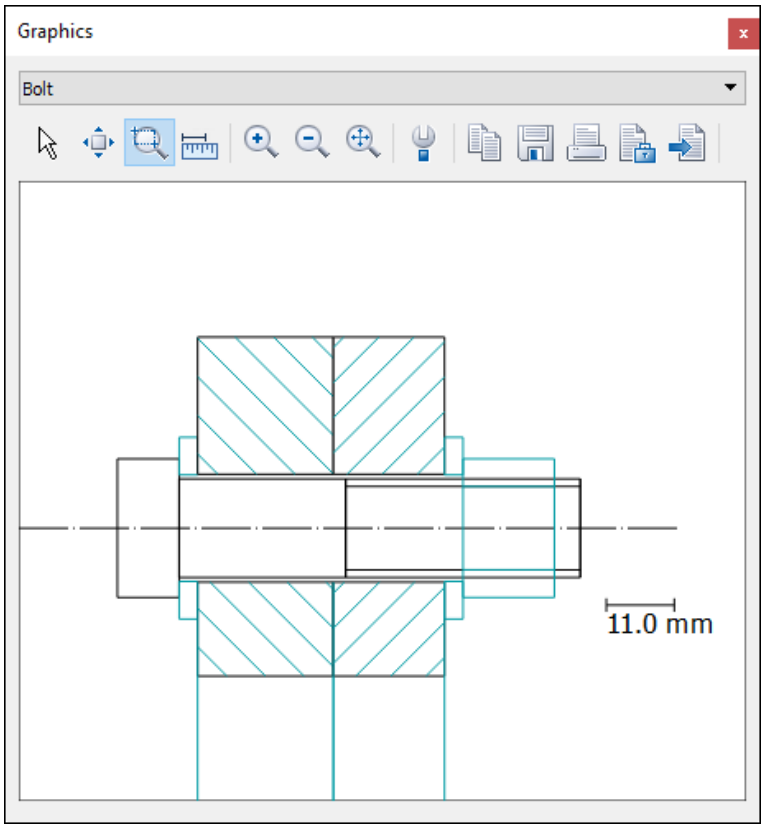


Figure 13. Display showing bolt with flange, washers and nut

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).

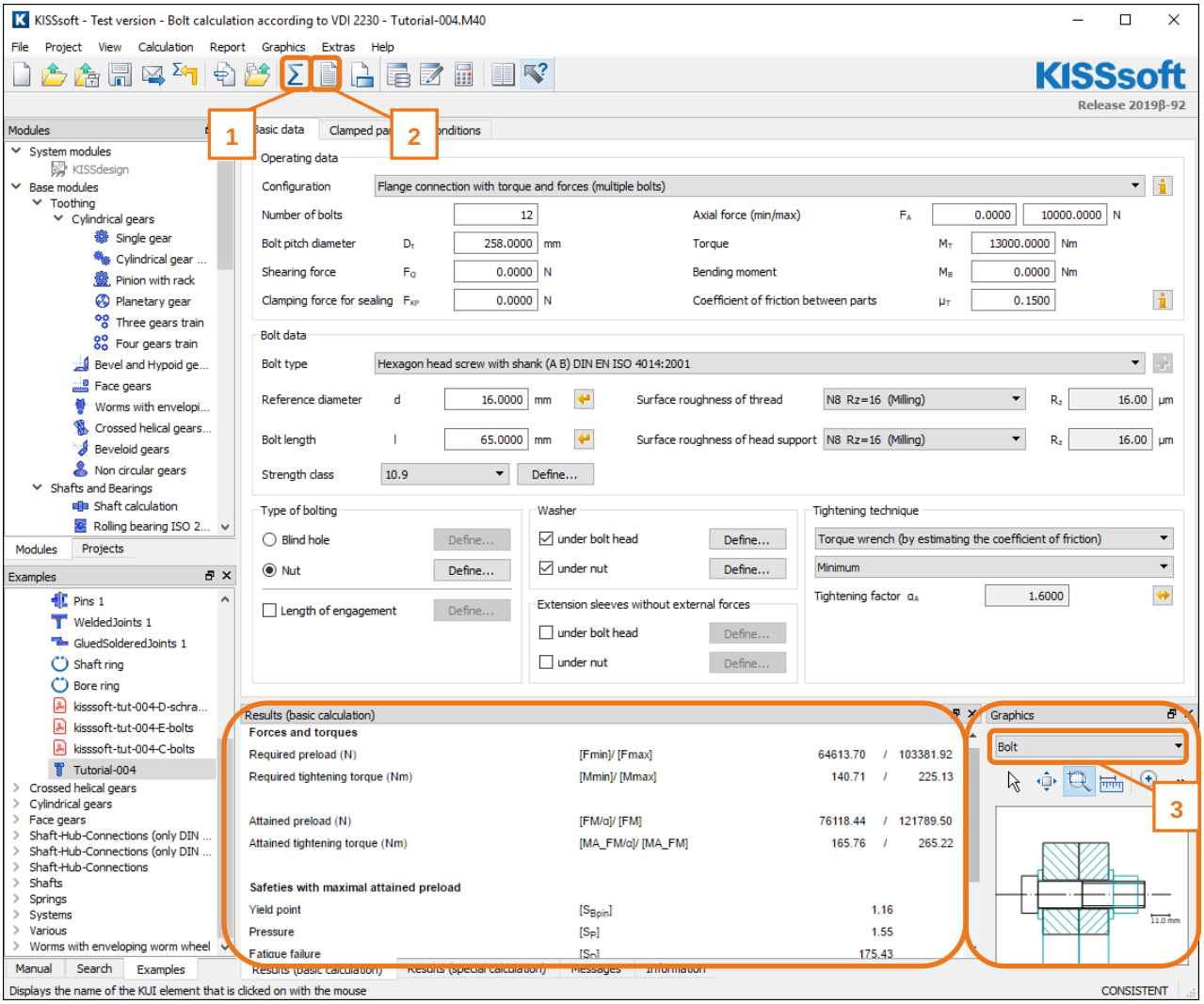


Figure 14. Running the calculation, resulting bolt geometry, results overview

You can also display more graphics by clicking the **«Graphics»** menu option:

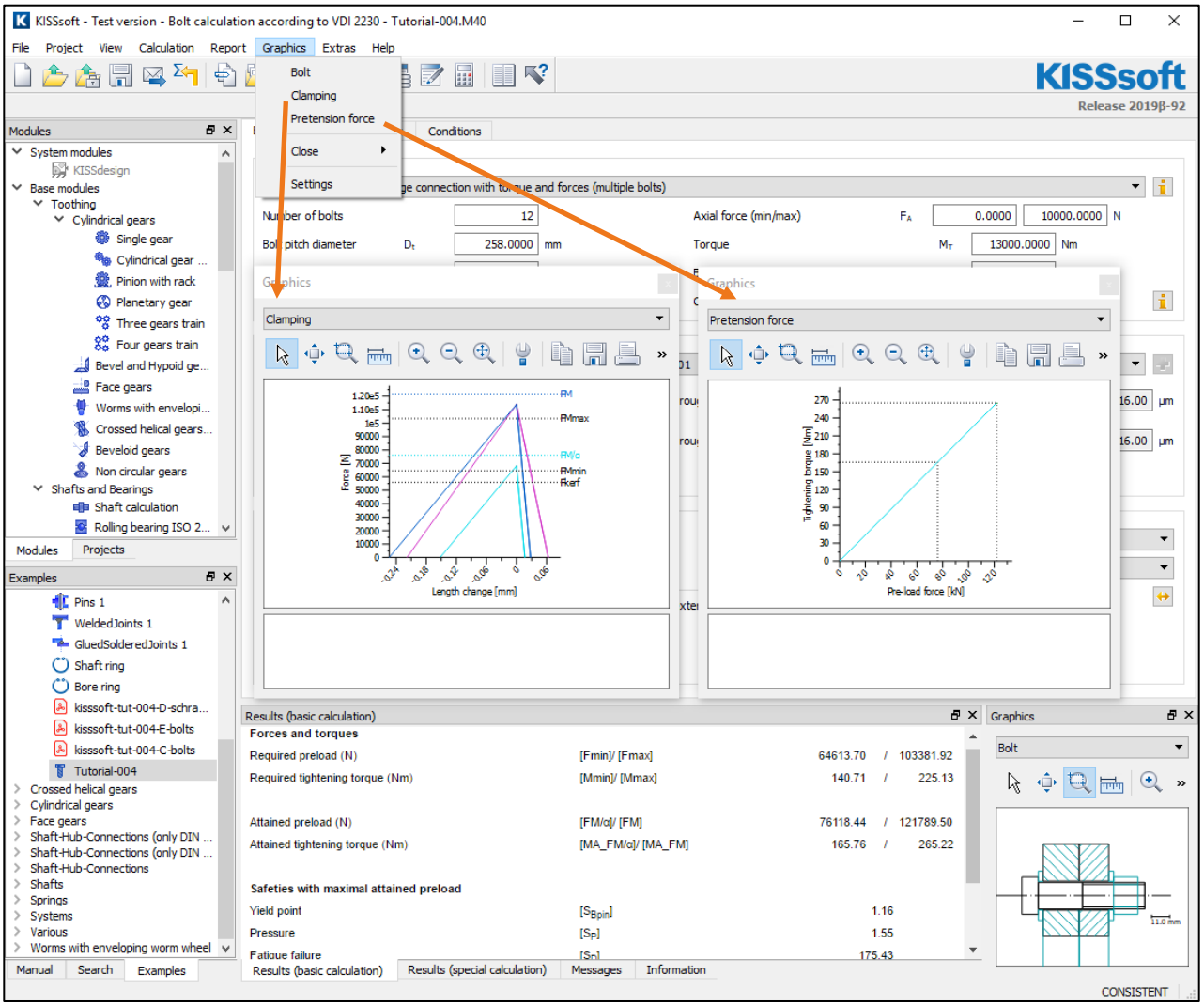


Figure 15. Display containing other graphics

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

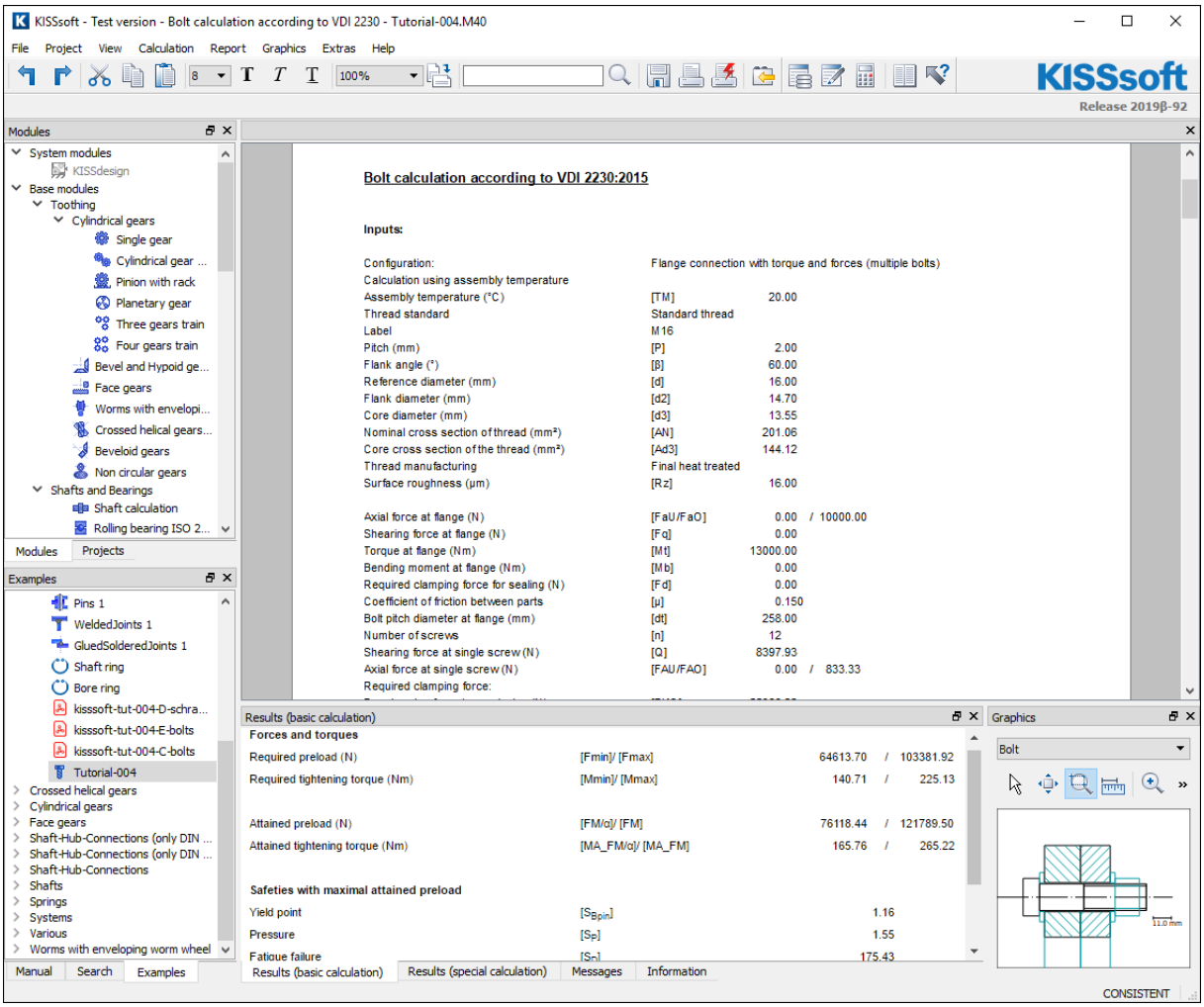


Figure 16. Displaying the report and changes to the displayed graphic

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) [FMtab]	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.

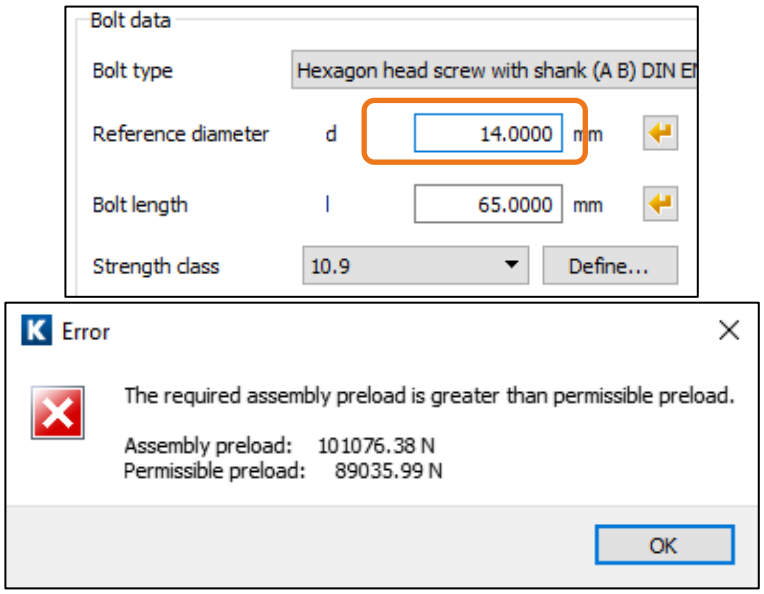


Figure 17. Input new bolt diameter, -> run calculation, -> error message

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 2230:2015.

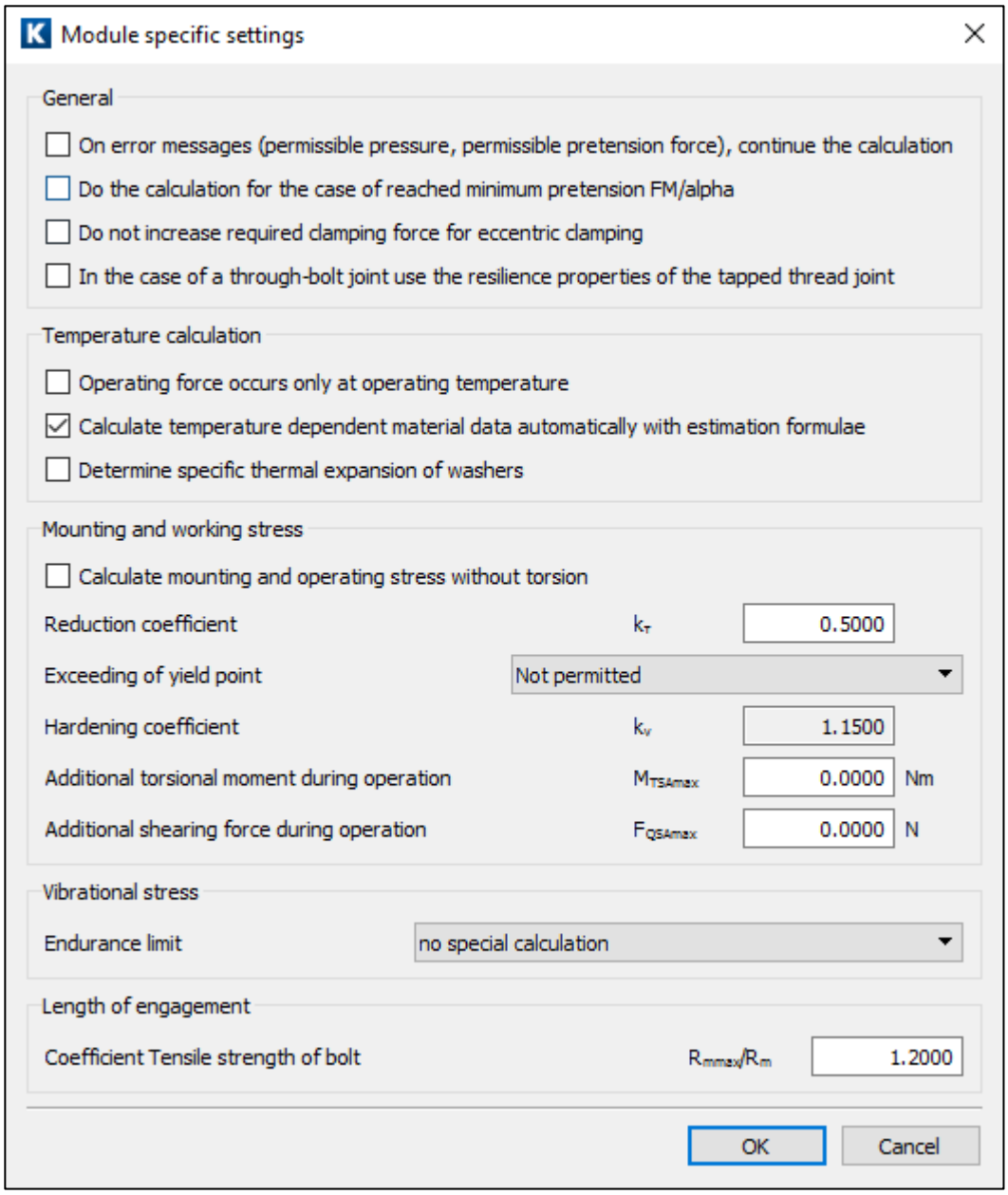


Figure 18. Module-specific settings

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 **«Conditions»** tab. The VDI guideline proposes a number of different friction coefficients. Click the «Info buttons» to display these in the information window.

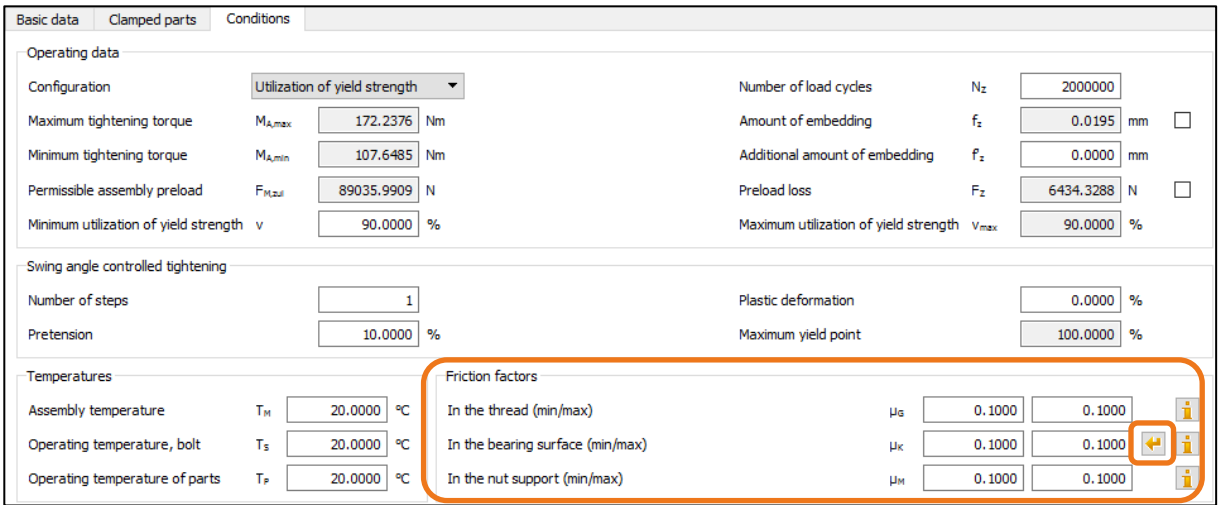


Figure 19. Settings used to perform a calculation according to VDI 2230 in the «Conditions» tab

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

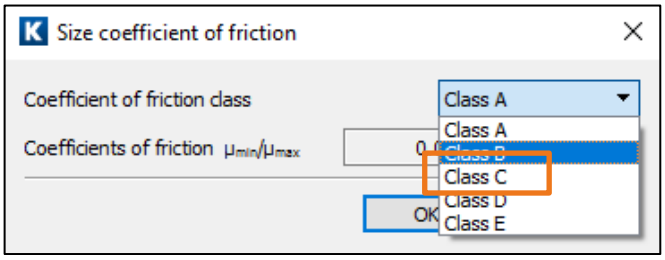


Figure 20. Selection of the friction coefficient classes according to table A5 in VDI 2230

You can also specify the tightening factor in the **«Basic data»** tab.

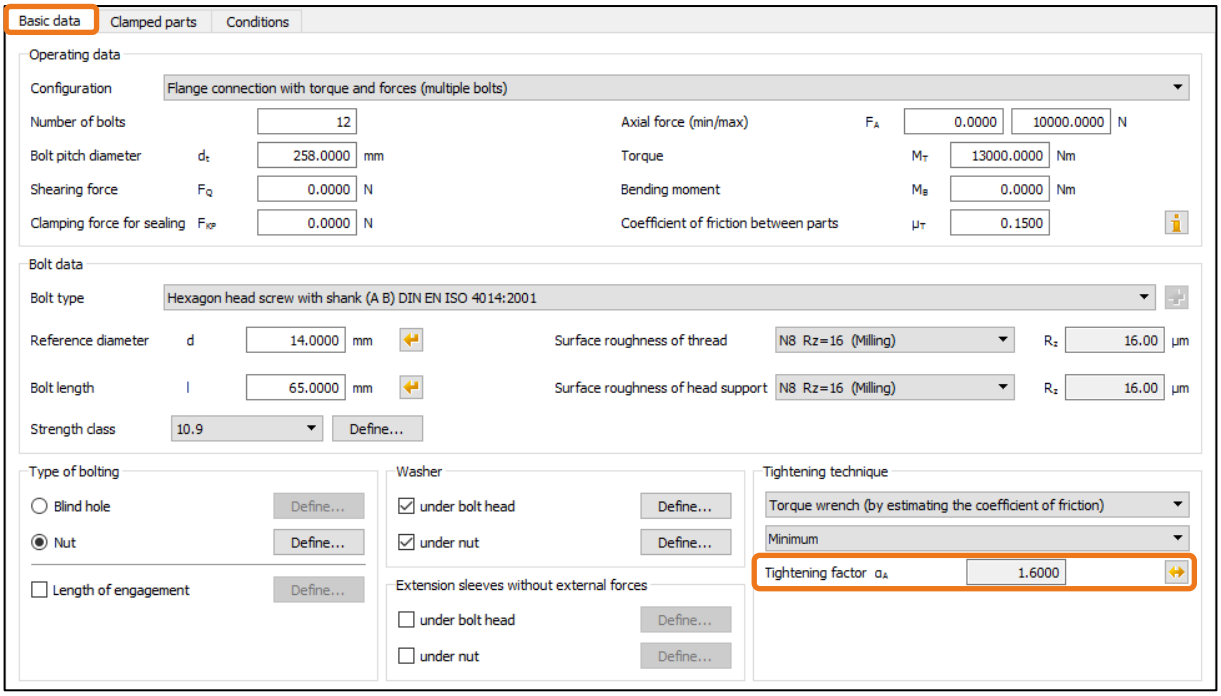


Figure 21. Tightening factor in Basic data

4.3 FEM calculation comparison Model class III

To begin, open the calculation example in accordance to the standard Bolts (VDI 2230, Example 1). Then execute the calculation without clamping force.

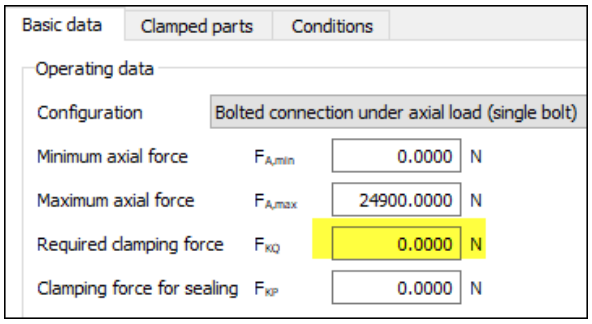


Figure 22. Setting without clamping force

The following results are determined.

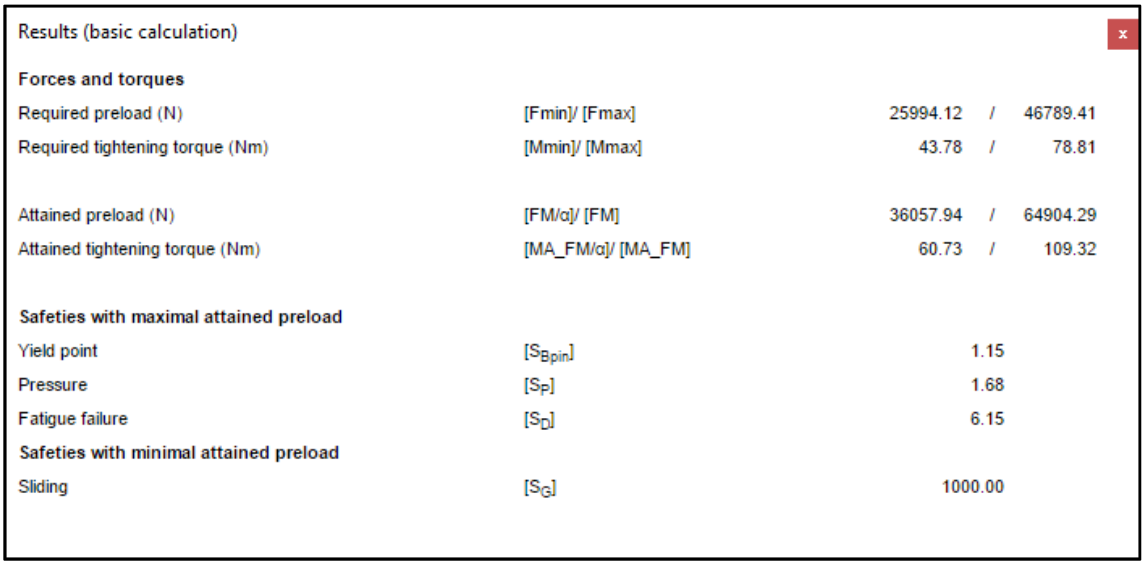
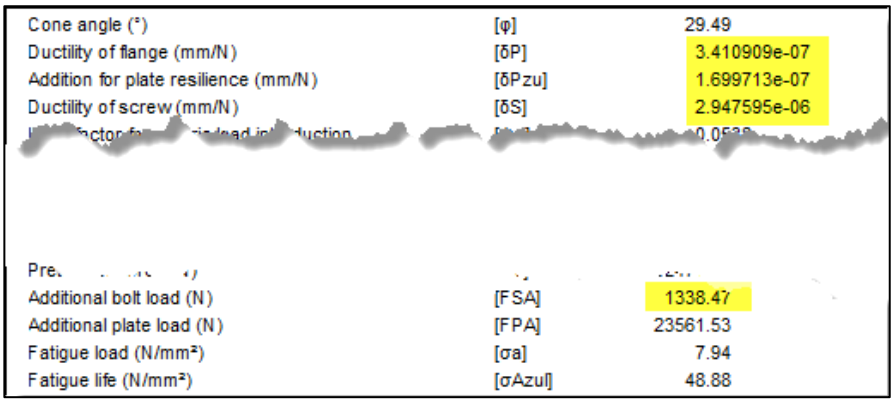


Figure 23. Results of the modified calculation

A report is generated. The marked values from the calculation report are relevant.



If similar values for F_{SA}, δ_S and δ_P, are determined with the help of a FEM calculation according to model class III, this leads to the entries made in the tab "Results from FEM calculation".

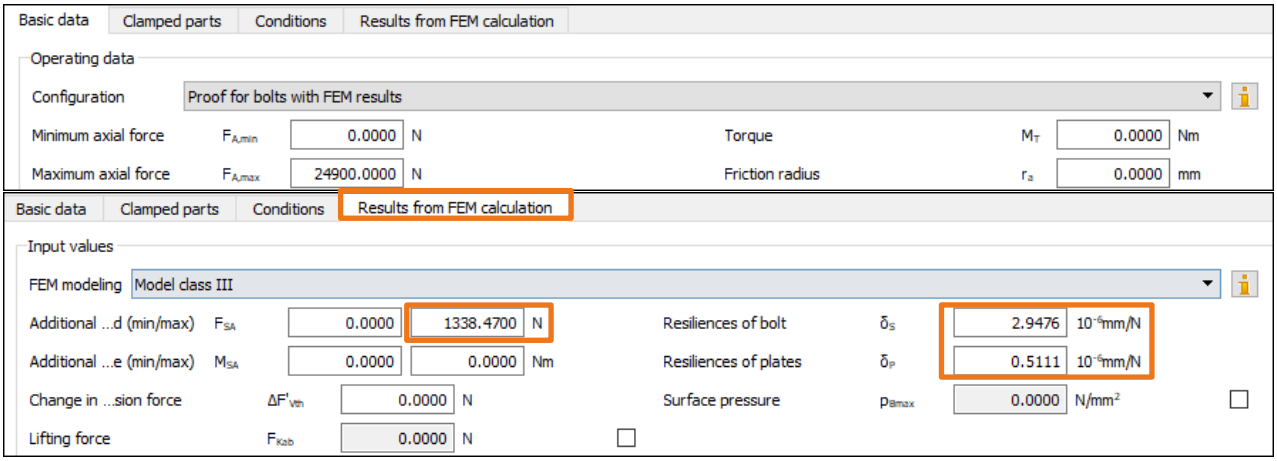


Figure 24. Comparable input values for inputs from modeling with FEM

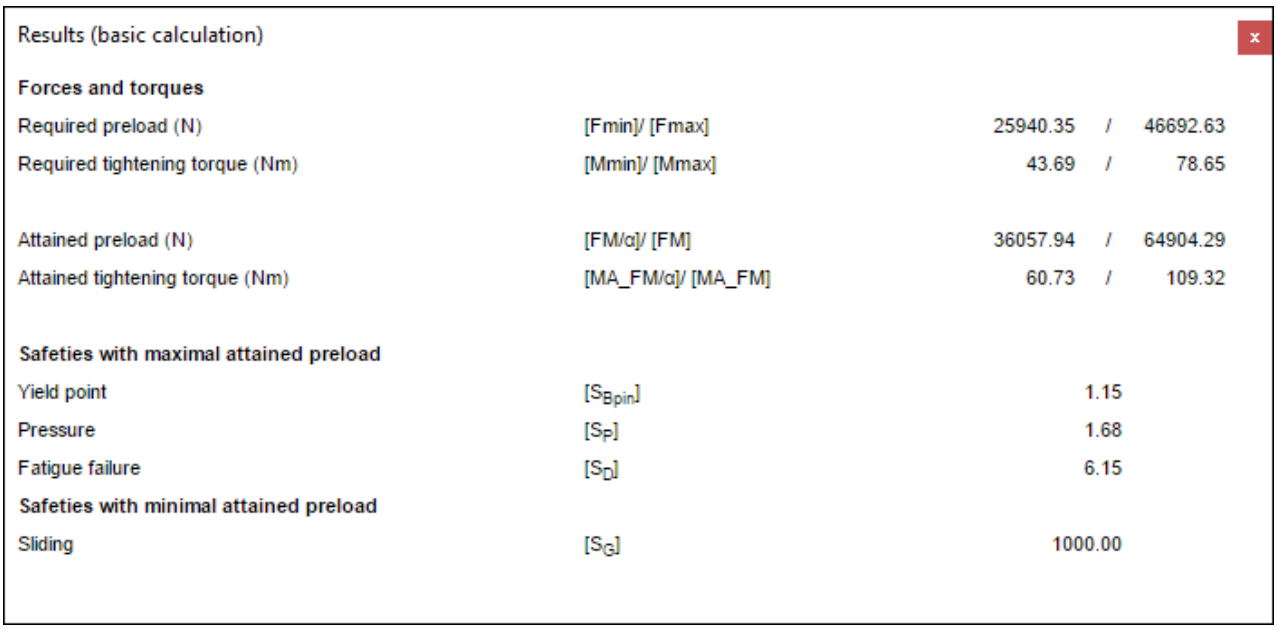


Figure 25. Calculation results with FEM

The comparison of the two results (see results in Figure 23 and Figure 25) shows only minor differences.