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KISSsoft Tutorial:

Bolt selection and rating according to VDI guideline 2230

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 kisssoft-tut-004-E-bolts.doc
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1 Starting KISSsoft

1.1 Starting the software

Start KISSsoft using „Start/Program Files/KISSsoft 10-2008/KISSsoft“. The following window will appear:

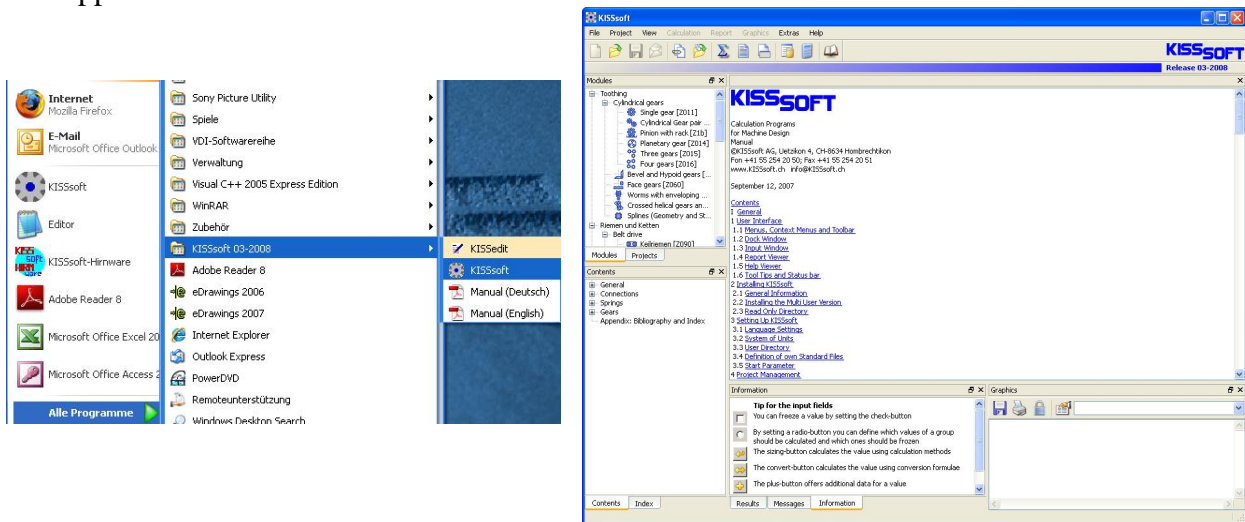


Figure 1.1-1: Start KISSsoft, KISSsoft main window.

1.2 Select Calculation

Using the Module tree window Tab “Modules”, select the bolt analysis:

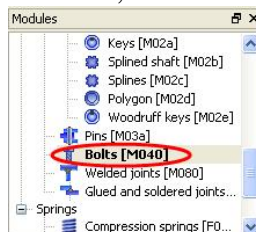


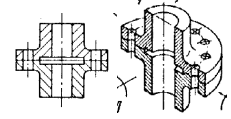
Figure 1.2-1: Selecting Calculation Module “Bolts”.

2 Calculation of a flanged connection

2.1 Task description

Sizing and rating of the bolting for a flanged coupling with data as shown:

Torque to be transmitted	13kNm	Coefficient of friction	0.15
Pitch diameter	258mm	Minimal axial force	0kN
Number of bolts on pitch circle	12	Maximum axial force	10kN
Material flange (left/right)	GG25/34CrNiMo6	Strength class of bolt	10.9
Thickness flange(left/right)	22mm/18mm	Hexagon head screw with shank (AB)	
Surface flange (left/right)	N7/N8	ISO4014	
		Tightening: with dynamometric key	



The connection realised with through bolts (notation according VDI 2230:2003 bolted joint) with nuts and washer under nuts and under bolt head.

This basic data is entered as follows:

Figure 2.1-1: Input of known data, selection of calculation method.

2.2 Proposal for a sensible bolt diameter

After having defined the loads acting and the type/strength of the bolt, the sizing button can be used in order to have the software proposing a suitable bolt diameter. This proposal is based on a simplified method as described in VDI guideline 2230, table 7. This methods tends to result in over-dimensioned bolts, experience shows that the minimal permissible bolt diameter is one to two sizes lower. Note the message issued once the sizing button is pressed.

Figure 2.2-1: Using the sizing button will result in a proposal for the bolt diameter (based on VDI2230), here, M18.

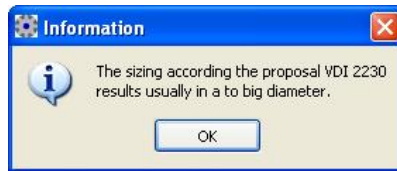


Figure 2.2-2: Message indicating that the resulting bolt diameter may be to large.

The nominal bolt diameter can be changed manually, here to 16mm.

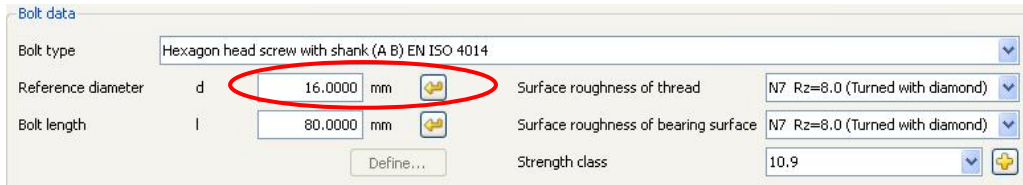


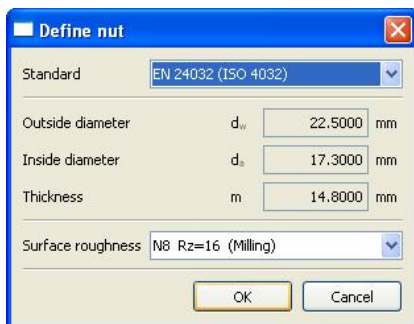
Figure 2.2-3: Nominal bolt diameter set to 16mm.

2.3 Definition of washer and nut

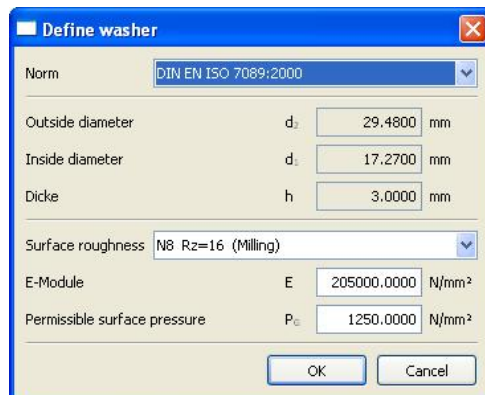
Under the tab ‘Basic data’ the settings for the washer and the nut can be set as follows:



Figure 2.3-1: Call of program module definition.



Choose nut from standard or define own geometry



Defining the washer (once for the washer underneath the nut, once for underneath the bolt head). Choose from standard or define own geometry.

Figure 2.3-2: Detailed input on nut, washer and flange geometry.

2.4 Definition of clamped parts

In the tab „Clamped parts“ is pressed to get a window where all clamped parts (all parts of the connection except for the bolt itself) can be defined. Since a circular flange is calculated, the software recommends – by issuing a respective message – to define the clamped parts as segments of a ring.

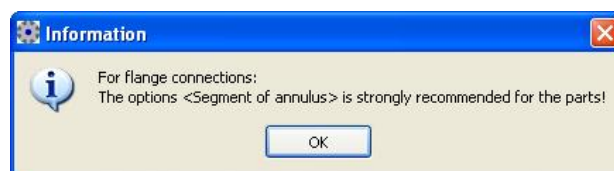


Figure 2.4-1: advice: by calculation of flange connection define of “segments of annulus”

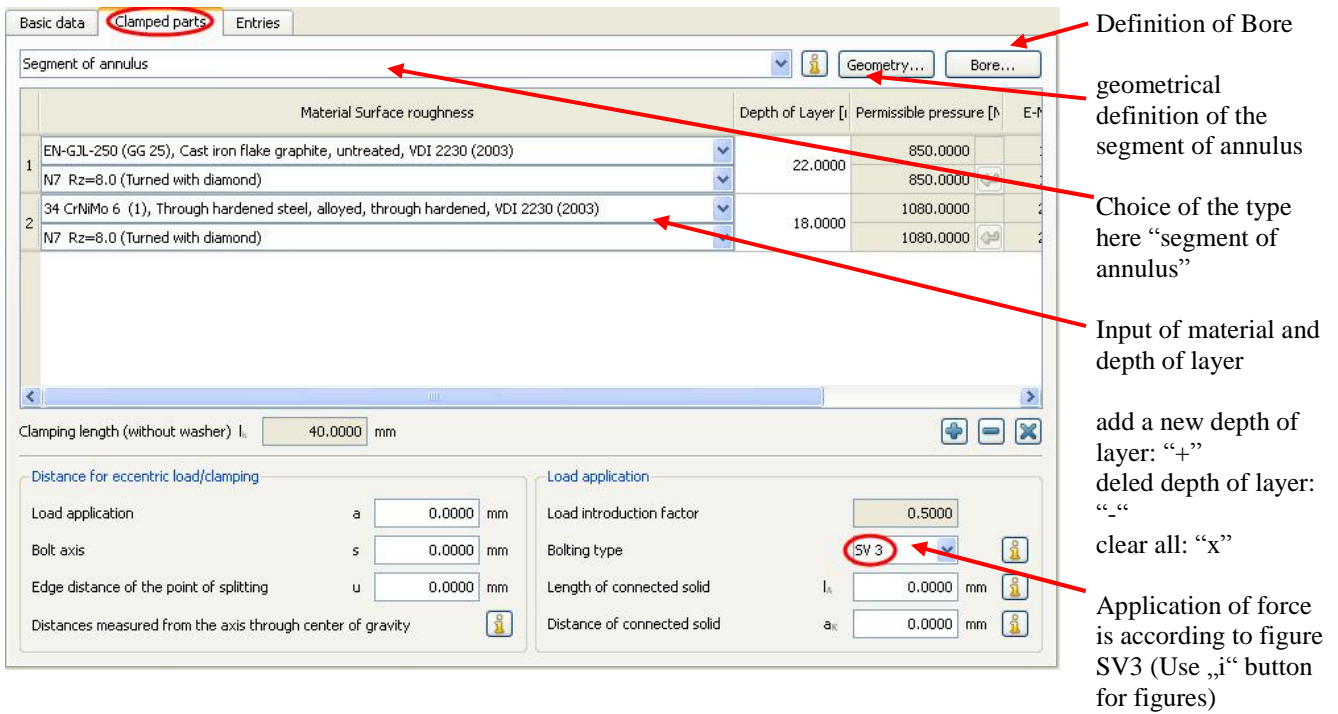
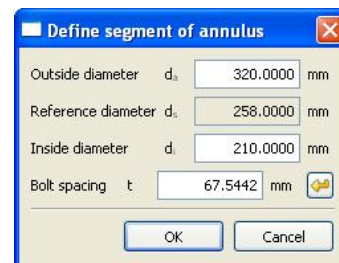


Figure 2.4-2: Definition of the clamped parts



Detailing the through hole. A hole diameter may be defined using "Own definition" in "Standard". Input diameter in field "Diameter"



Information on outer and inner diameter of flange, pitch diameter and bolt pitch (calculate using sizing button)

Figure 2.4-3: Detailed input.

2.5 Definition of the bolt

The specifications for the bolt could be defined in the tab "basic data". The length can be calculated using the sizing button (then, the smallest possible length is calculated, using nominal bolt lengths) or can be defined manually. The definition of the connection is now completed and may be viewed in the graphic below:

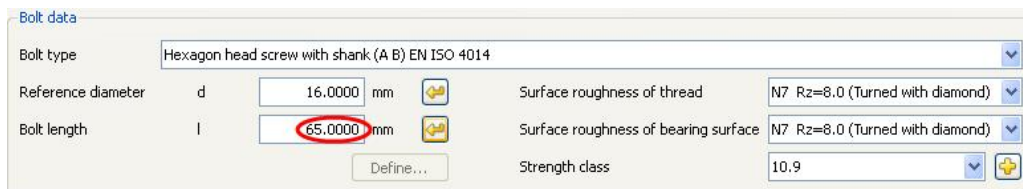


Figure 2.5-1: Calculation or definition of bolt length.

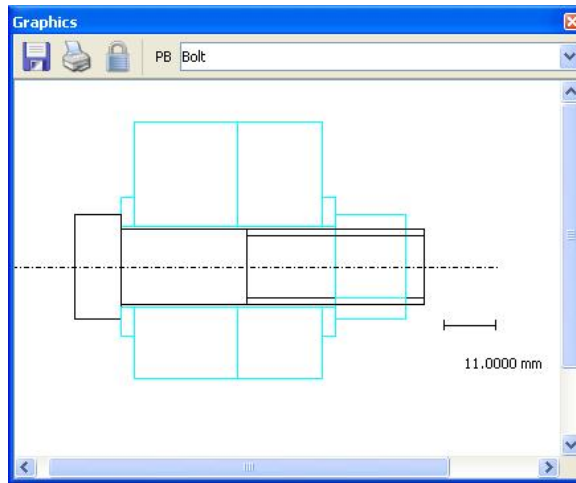




Figure 2.5-2: Connection with flange, bolt, washers and nut.

3 Calculation and results

3.1 Execution of analysis, reports

The analysis is executed using “Σ” (or F5). The most important results are shown in the lower portion of the main window. Using the icon  to the right of “Σ” (or F6) a report containing all input data, analysis parameters, and results is written. From the report back to the calculation goes with icon  in the tool bar. The force-deformation diagram can be viewed using the button “Force-Deformation Diagram“:

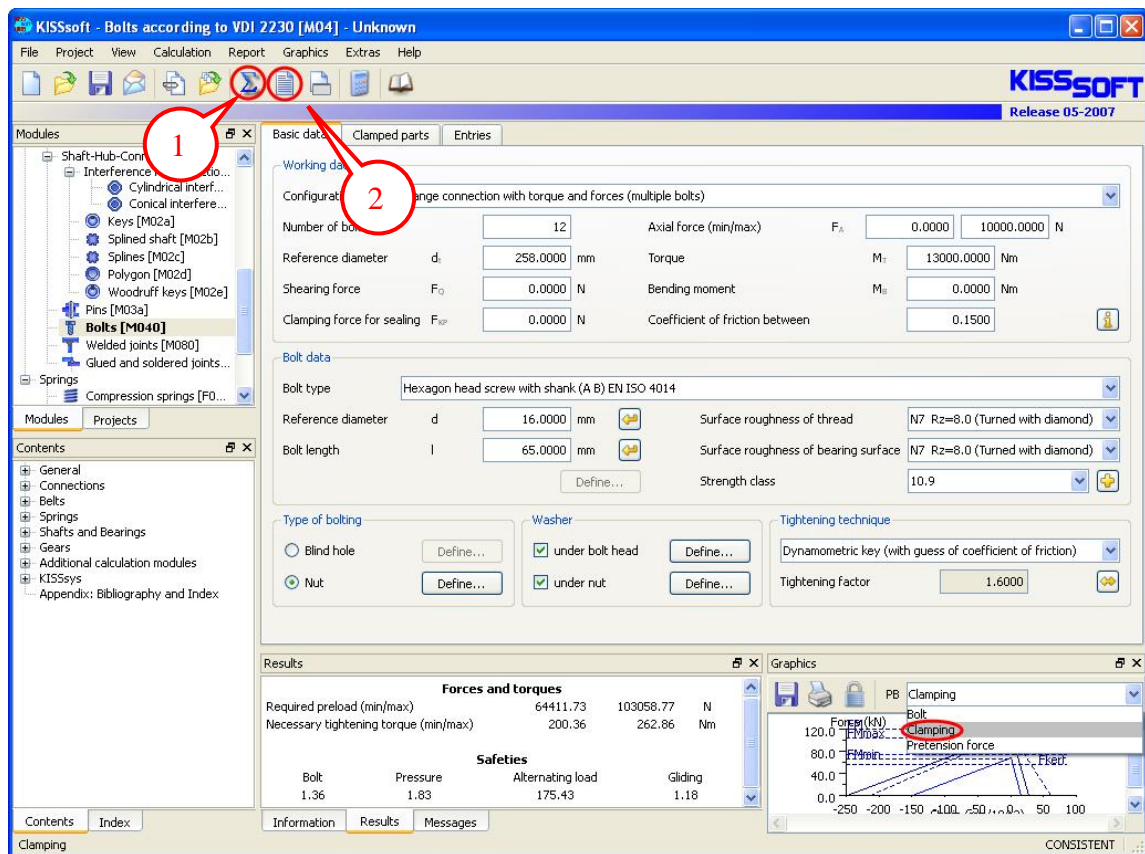


Figure 3.1-1: Execution of analysis, generate report, main results and force-deformation diagram.

Further graphic can be advertising with menu “Graphics”.

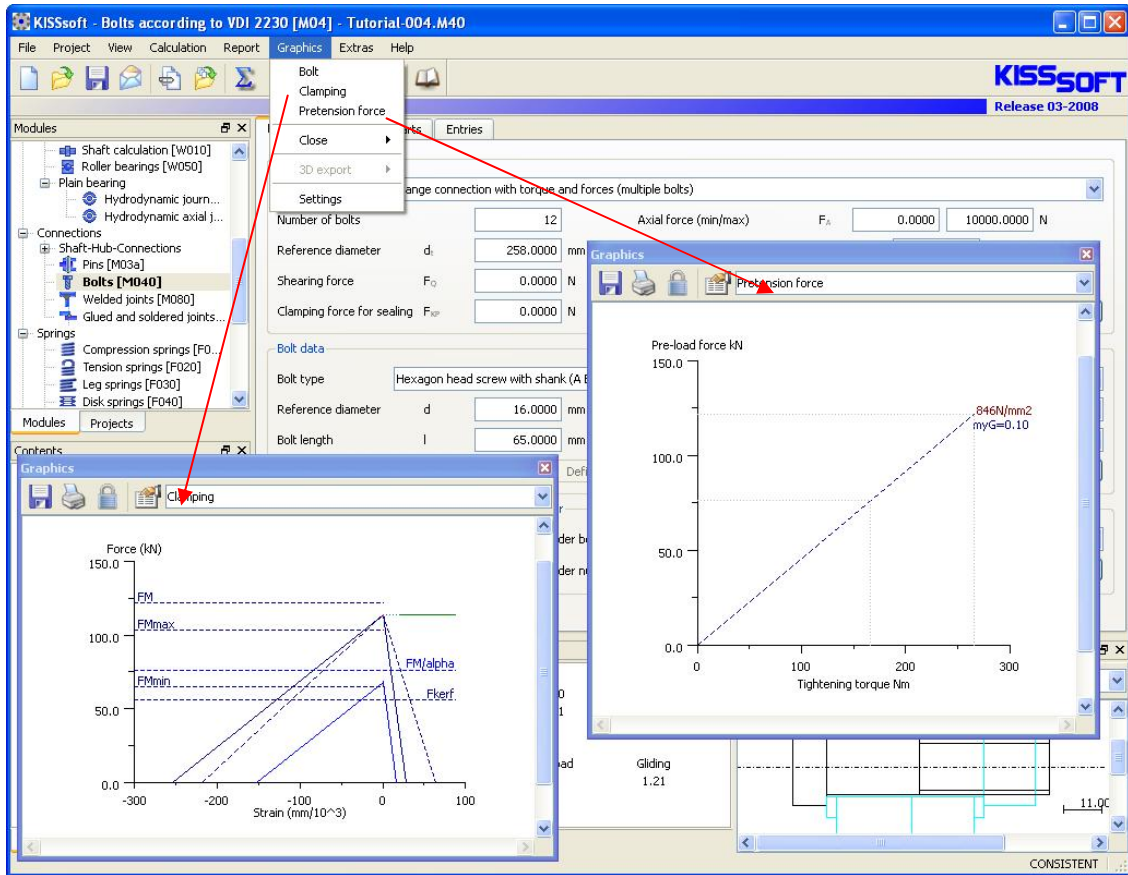


Figure 3.1-2: display further graphic

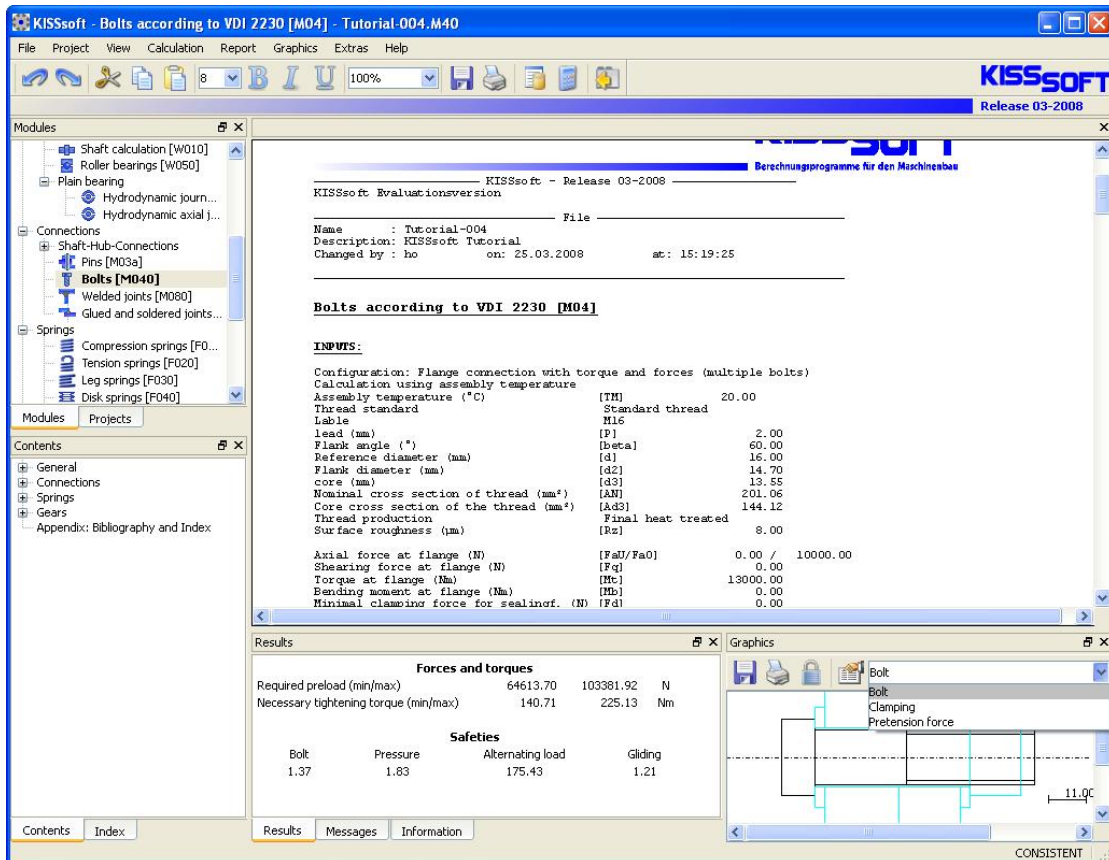


Figure 3.1-3: show the report display and selection other graphics

3.2 Comments on the results generated

Results shown in the main window:

Preload force (N), alphaA=1, alphaA eff	The required mounting pre-tension such that the connection will withstand the loads. A minimal value (tightening factor=1) and a maximum value (tightening factor=1.6 in this example) are shown.
tightening torque (Nm), alphaA=1, alphaA eff	Information on the achieved tightening torque. A minimal value (tightening factor=1) and a maximum value (tightening factor=1.6 in this example) are shown.
Safeties bolt	Safety factor against yield point
Safeties pressure	minimal Safety of surface pressure
Safeties Alternating load	Safety factor against fatigue of screw

Results shown in the report, “Calculating safeties with the maximal required mounting pretension force:

Mounting-Pretensionforce (N) [FM]	Besides the required pre-tension (see table above), in the report, the nominal pre-tension according to VDI2230 is shown. This value is higher than the maximum value of the required mounting pre-tension.
Tightening torque (Nm) [MA]	In the report, the nominal pre-tension according to VDI2230 is shown.

4 Further calculations

4.1 Analysis with a smaller bolt

To complete the example, a test is run to check whether M16 is the smallest possible bolt diameter. For this, the bolt diameter is reduced to M14 and the analysis is executed again. The error message indicates that the connection can not be used with an M14 bolt.

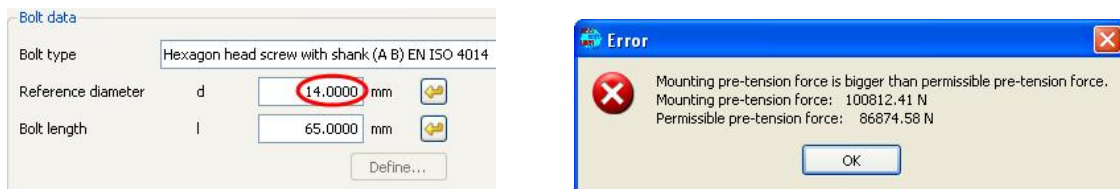


Figure 4.1-1: New bolt diameter M14, execution of analysis, error message indicating that permissible pre-tension force is exceeded

4.2 Constraints, settings

Under the Tab “Entries” “Calculation/Settings” it is possible to do presets for the calculation. These required detailed knowledge of the VDI guideline 2230:2003.

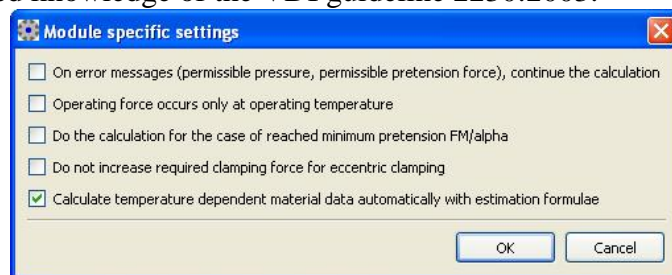


Figure 4.2-1: Module specific settings.

The assumed coefficients of friction between thread and thread hole and between the head of the bolt and the clamped part or washer have a great effect on the analysis. These values have to be

defined in the tab “Entries“. The VDI guideline 2230 recommends values to be used depending on the lubrication applied. These recommendations may be viewed using the “Info buttons”.

The screenshot shows the 'Entries' tab with the following sections:

- Working data:** Configuration (Utilization of yield strength), Number of load cycles ($N_D = 2000000$), Maximum tightening torque ($M_{A,max} = 0.0000$ Nm), Minimum tightening torque ($M_{A,min} = 0.0000$ Nm), Permissible assembly preload ($F_{M,zul} = 0.0000$ N), Minimum utilization of yield strength ($v = 90.0000$ %), Embedding value ($f_z = 0.0000$ mm), Additional embedding value ($f'_z = 0.0000$ mm), Preload loss ($F_z = 0.0000$ N), Maximum utilization of yield strength ($v_{max} = 90.0000$ %).
- Angle of rotation controlled tightening:** Number of steps (1), Pretension (10.0000 %), Plastic deformation (0.0000 %), Maximum yield point (100.0000 %).
- Temperatures:** Assembly temperature ($T_M = 20.0000$ °C), Working temperature, bolt ($T_S = 20.0000$ °C), Operating temperature of parts ($T_P = 20.0000$ °C).
- Coefficient of friction:** In the thread (min/max) (0.1200 / 0.1500), In the bearing surface (min/max) (0.1200 / 0.1500), In the nut support (min/max) (0.1200 / 0.1500). This section is circled in red.

Figure 4.2-2: Coefficients of friction, review recommended values using “Info buttons”

Furthermore, the tightening method is to be chosen. The tightening factor is then calculated accordingly:

The screenshot shows the 'Entries' tab with the following sections:

- Working data:** Configuration (Flange connection with torque and forces (multiple bolts)), Number of bolts (12), Reference diameter ($d_r = 258.0000$ mm), Shearing force ($F_Q = 0.0000$ N), Clamping force for sealing ($F_{Kp} = 0.0000$ 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), Coefficient of friction between parts (0.1500).
- Bolt data:** Bolt type (Hexagon head screw with shank (A B) EN ISO 4014), Reference diameter ($d = 16.0000$ mm), Bolt length ($l = 65.0000$ mm), Surface roughness of thread (N7 Rz=8.0 (Turned with diamond)), Surface roughness of bearing surface (N7 Rz=8.0 (Turned with diamond)), Strength class (10.9).
- Type of bolting:** Blind hole, Nut.
- Washer:** under bolt head, under nut.
- Tightening technique:** Dynamometric key (with guess of coefficient of friction), Tightening factor (1.6000). This section is circled in red.

Figure 4.2-3: Selection of tightening method, resulting tightening factor