KISSsoft 2019 – Tutorial 4

Bolt calculation according to VDI 2230
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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:

![Starting KISSsoft, initial window](image1)

1.2 Selecting a calculation

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

![Selecting the «Bolts» calculation module](image2)
2  Calculation of a flanged connection

2.1 Task

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

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

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](image)

![Figure 5. Message indicating that the proposed bolt diameter may be too large](image)

You can reduce the reference diameter to 16mm manually:

![Figure 6. Reference bolt diameter set manually to 16mm](image)

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](image)
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](image1)

To call the detailed report, click the icon ![icon](image2) or either press F6:
3.2 Comments on the results

Results displayed in the main window:

<table>
<thead>
<tr>
<th>Pretension force (N), alphaA = 1, alphaA eff</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting torque (Nm), alphaA = 1, alphaA eff</td>
<td>Information about the tightening torque achieved, minimum value (tightening factor = 1) and also maximum value (tightening factor = 1.6, in this example).</td>
</tr>
<tr>
<td>Bolt safety</td>
<td>Safety factor against yield point</td>
</tr>
<tr>
<td>Pressure safety</td>
<td>Minimum safety factor of surface pressure</td>
</tr>
<tr>
<td>Alternating load safety</td>
<td>Safety factor against fatigue of bolt</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Mounting pretension force (N) [FMtab]</th>
<th>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</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque (Nm) [MA]</td>
<td>Value for tightening torque. This value corresponds to the values for tightening torque specified in Appendix A of VDI2230</td>
</tr>
</tbody>
</table>
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.

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

You can also specify the tightening factor in the «Basic data» tab.
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](image)

The following results are determined.

![Figure 23. Results of the modified calculation](image)

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

![Table](image)

If similar values for $F_{SA}$, $\delta_5$ and $\delta_P$, 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”.

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