KISSsoft 03/2017 – Tutorial 6

Shaft editor

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1 Starting the Shaft Editor

1.1 Starting the Shaft Editor

For more information, refer to KISSsoft Tutorial 005, Shaft Calculation, Section 1.2.

1.2 Call the Shaft Editor, Settings

The main shaft calculation screen (Figure 1) consists of these tabs: "Shaft editor", "Basic data" and "Strength". In the Shaft editor you can model various shafts, taking into account their constraints and loads. These shafts can then be used in other calculations (deformation, strength etc., see Tutorial 005).

You can input fundamental settings (shaft position, speed, sense of rotation) directly in the "Basic data" tab. Click on the "Calculation/Settings" menu item to make further settings (for more information about calculation-specific settings: press "F1" Help/Manual):

![Figure 1. Shaft editor, module-specific settings, input speed, materials etc.](image-url)
2 Modeling a Shaft

2.1 General Remarks

To model a shaft in the KISSsoft system, you must input the main dimensions, notch geometry, external loads and supports/constraints and critical cross sections. You define these values in the "Elements-tree". To do this, select the appropriate element and right-hand mouse click to display a list of elements that can be added to the calculation. You can also create sub-elements for axially symmetrical contours (cylinders and cones).

![Elements-tree and shaft model](image)

**Figure 2.** The five most important elements required to create a shaft

<table>
<thead>
<tr>
<th>Elements</th>
<th>Data about</th>
<th>Necessary data</th>
<th>To define</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer/inner contour</td>
<td>Shaft section</td>
<td>Diameter and length of a shaft section, surface roughness</td>
<td>( A, I_{xx}, I_{zz}, I_p, W_{xx}, W_{zz}, W_p )</td>
<td>Gray</td>
</tr>
<tr>
<td>Cylinder/Cone</td>
<td>Notch</td>
<td>Type of notch, geometry</td>
<td>( \alpha_k )</td>
<td>White</td>
</tr>
<tr>
<td>Forces</td>
<td>Loads</td>
<td>Centric or eccentric force/vectors of moment, machine elements for load introduction</td>
<td>( F_y, Q_x, Q_z, M_{bx}, M_{bz}, T )</td>
<td>Blue</td>
</tr>
<tr>
<td>Bearing</td>
<td>Bearings</td>
<td>Selection of roller bearings, information about bearing stiffness, degrees of freedom</td>
<td>Reaction forces, constraints</td>
<td>Yellow</td>
</tr>
<tr>
<td>Cross sections</td>
<td>Critical cross section</td>
<td>Effect of notch, position, geometry, surface roughness</td>
<td>Notch factors, strains</td>
<td>Black</td>
</tr>
</tbody>
</table>
2.2 Co-ordinates system

Note that the coordinates system is right-handed and Cartesian

Positive x-axis: Out of the screen  
Positive y-axis: Along the length of the shaft, from left to right  
Positive z-axis: From bottom to top  
Position of contact: Positive angle counter clockwise (looking towards the positive direction of the y-axis), with zero position in the x-axis.

You can display or hide the coordinates system by activating/deactivating the "Show coordinate system" checkbox in the "Module specific setting".

![Figure 3. Shaft editor tab in Module specific settings dialog](image)

Alternatively you can, with the right mouse button, click the corresponding sub-menu in the shaft editor selected for the activation (see Figure 4).

2.3 Editing functions, screen view

The following editing functions are available in the graphical Shaft editor:

<table>
<thead>
<tr>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ key, - key, Home key</td>
<td>Zoom in/zoom out/full screen</td>
</tr>
<tr>
<td>Mouse left-click</td>
<td>Select element/move element (when flag is enabled)</td>
</tr>
<tr>
<td>Mouse right-click</td>
<td>Zoom in/zoom out/full screen</td>
</tr>
<tr>
<td>Delete</td>
<td>Delete selected element</td>
</tr>
<tr>
<td><img src="image" alt="Shaft mirror icon" /></td>
<td>Shaft mirror</td>
</tr>
</tbody>
</table>

To move the forces and bearing icons, the corresponding sub-menu can be selected for activation by right mouse click.
On the right-hand side of the Editor you see the following icons that make it easier to input the elements:

- Add shaft
- Add cylinder
- Add conus
- Add bore
- Add conical bore
- Centric force/vector of moment
- Eccentric force/vector of moment
- Add machine element, cylindrical gear, etc. ...
- ...
- ...
- ...
- Add bearing
- Add roller bearing
- Add limited/free cross section
- Add general joint
- Add connecting bearings

### 2.4 Entering main dimensions

To define a shaft section, select the element in the "Elements-tree ➔ Outer contour" or select the element in the shaft editor, or select the element in the shaft editor. (Figure 5).
You then define the diameter, length and surface roughness in the Elements-editor. Every new shaft section you add can be positioned either before (to the left) or after (to the right) of existing sections. To add a shaft section to an existing section, first select the existing section with a left-hand mouse click and then right-hand mouse click and select “paste before” or “paste after” to insert the new shaft section. To modify an existing element in the Elements editor, simply select it with a left-hand mouse click.

If a main element is active in the Elements-tree, e.g. “Outer contour”, the Elements-list is shown (Figure 6). There, it is possible to modify the elements, too.
Bores ("Inner contour → cylindrical bore") are also added to the existing shaft, from left to right. However, if you only want the bore to be present on the right-hand end of the shaft, first define a bore with diameter zero from the left-hand end of the shaft.

### 2.5 Inputting Notch Geometry

Before you can add a notch, you must select a shaft section (left-hand mouse click on the section, to display that section in red) or a suitable element in the "Elements-tree" on which the notch is to be positioned. First right-hand mouse click on shaft section in the Elements-tree and then select the appropriate notch. Here you can select one of the various notch types that are available (for example, circumferential groove). After you select the notch type, you see a dialog in which you can define the geometry and position (reference dimension: the left end of the selected shaft section) of the notch.

The sub-elements "Radius", "Chamfer" and "Relief groove" do not need to be positioned because these are set automatically on the selected end (left/right) of the current shaft section.

To add a general notch effect, select "General notch effect". You input the corresponding notch factors directly in the "Elements-editor".

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Figure 6. Call the Elements-list
2.6 Inputting Loads

2.6.1 General forces

Select "Forces→Centrical load" or "Forces→Eccentric load" in the "Elements-tree" to define a load vector (three forces, three moments), that have either an effect on the mid line of the shaft or an eccentric effect. You can also predefine linear loads. The force vector is shown symbolically in the graphic as a single arrow in the negative z-direction and not as a vector.

2.6.2 Machine elements

In addition to allowing the input of general force vectors, KISSsoft also provides a range of predefined machine elements. Here, the resulting forces on the shaft are determined from the geometry of the machine elements and the predefined power. As you no longer need to convert the helix angle and reference diameter, for example, manually, the load data you input is significantly less prone to errors.

In "Forces", select a machine element. The dialog shown in Figure 8 then appears.
Here you can now define and position the machine element. You can also define the load and its effective direction.

Elements-editor for defining the "Cylindrical gear" element
Direction: (power flow)
Driving: The shaft drives a system. Power is drawn from the machine element.
Driven: the shaft is driven from outside. Power is applied to the machine element.
Position of contact:
From the positive x-axis, counter clockwise (to the positive z-axis.)
Position of the cylindrical gear on the shaft (y-coordinate)

Two machine elements are used in this example: one coupling/motor (Figure 10) and a cylindrical gear (Figure 9).
Here power is applied to the shaft from outside, which is why it is "driven".
You must ensure that the total power applied to and drawn from the system equals zero, otherwise, this warning message appears:

![Warning message](image)

Figure 11. Warning message to tell you that the power balance in the system is not equal

### 2.7 Adding Bearings

In KISSsoft system you can define either general bearings or roller bearings.

#### 2.7.1 General bearings

A bearing is defined in the Elements-tree. In the Elements-tree, click on "Bearings" and then right-hand mouse click on "Support" or "Roller bearing" to add these elements. A simple dialog appears in the Elements-editor. You can then position the bearings (input the bearing's y-coordinate, measured from the left-hand end of the shaft). In the next step, enter the bearing type.
2.7.2 Inputting roller bearings

In the Elements-tree, click on "Bearings" and then right-hand mouse click on "Roller bearing" to add these elements. Alternatively, you can select the bearing in the graphic. To do this, click the "Shaft editor" tab.

You can then define the bearing data:

- Positioning bearings
  - Will the bearing take axial forces?
  - Select bearing construction
  - Select bearing type
  - The bearing diameter is determined automatically on the basis of the bearing position

- Select radial bearing clearance group
- If required, specify bearing offset
- If required, specify bearing stiffness
- If required, input factors for the calculation of the thermally safe operating speed

2.7.3 Special bearings

You can also input stiffness values for bearings. These are then taken into account when calculating load, deformation and also when calculating eigenfrequencies. This allows you to simulate the influence of roller bearing or housing stiffness. However, you must determine this using a different method (for example, in an FEM calculation).

You must use several individual bearings to fully model linear bearings. In this case, you must use bearings that have resilience/stiffness values!
2.8 Sizing for constant equivalent stress

Now optimize the shaft geometry (main dimensions) so that the equivalent stress (nominal stress) is more or less constant along the length of the shaft (lightweight construction). In the module-specific settings, input the data on which this calculation is based (see Figure 15). Here you can input the equivalent stress on which the calculation is based (in this example 100 N/mm²).

In the menu, click "Sizing" -> "for strength" to start the calculation to define the outer contour of the shaft for the specified load so that the predefined equivalent stress is achieved in each cross section.
Figure 16. Call the "Sizing"-> "for strength" menu option by clicking with the right-hand mouse button on the shaft.

The resulting contour appears as a green line. You can now modify the shaft's dimensions – insofar as is practical to suit the design – to match this green line. This enables you to achieve an even load (excluding the notches) along the entire shaft.

Figure 17. Original geometry with proposal for the diameter (green line), right: Modified shaft geometry, with "Sizing" -> "for strength" menu called.

### 2.9 Sizing for maximum bending

In a similar way, you can also optimize shaft geometry to ensure that the permitted bending (deflection) is not exceeded. This permitted deflection is predefined here as shown in Figure 14 (here 0.1 mm). After you click "Sizing"-> "for deflection" to call the calculation, a factor is calculated by which all the shaft diameters are increased/reduced to ensure that the degree of deflection matches the predefined value. The resulting shaft geometry is then displayed as a magenta line. You can now modify the shaft's dimensions – insofar as is practical to suit the design – to match this magenta line.

Figure 18. Original geometry with proposal for the diameter (magenta line), right: Modified shaft geometry, call "Sizing"-> "for deflection"
2.10 Several shafts

You can now use the shaft system's calculation module to input and analyze several coaxial shafts at the same time in the same shaft calculation. This type of modeling is very useful, for example, when analyzing the shaft in a planetary gear.

Figure 19. Example Shafts 6 (wind turbine main shaft)