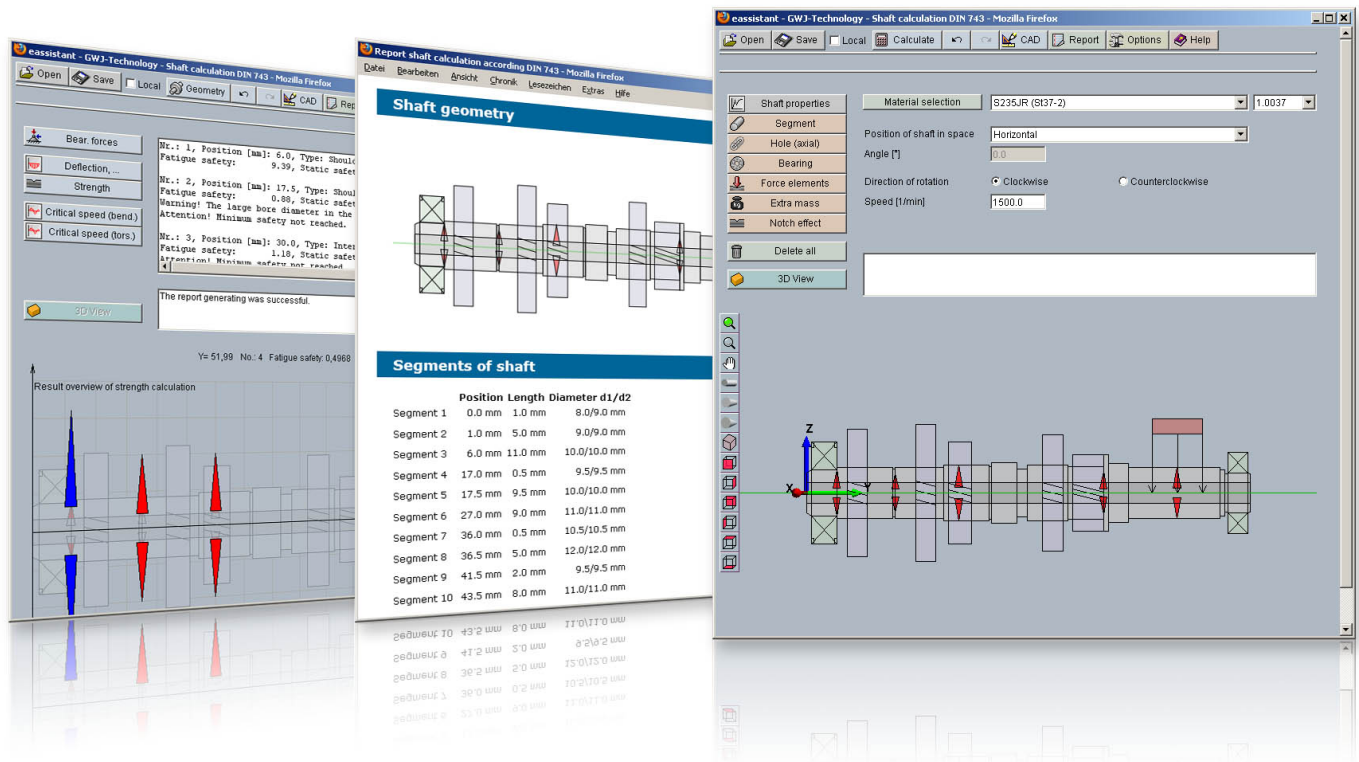


Calculation Example

Shaft with Strength According to DIN 743



Release July 2013

Contents

0.1	Calculation Examples: Shaft According to DIN 743	3
0.1.1	Start the Calculation Module	3
0.1.2	First Calculation Example	3
0.1.3	Start Calculation	12
0.1.4	Documentation: Calculation Report	15
0.1.5	Save Calculation	17
0.1.6	Second Calculation Example	18
0.1.7	Start Calculation	22
0.1.8	Documentation: Calculation Report	23
0.1.9	Save Calculation	24

0.1 Calculation Examples: Shaft According to DIN 743

0.1.1 Start the Calculation Module

Please login with your username and your password. Select the module 'Shaft calculation' through the tree structure of the project manager by double-clicking on the module or clicking on the button 'New calculation'.

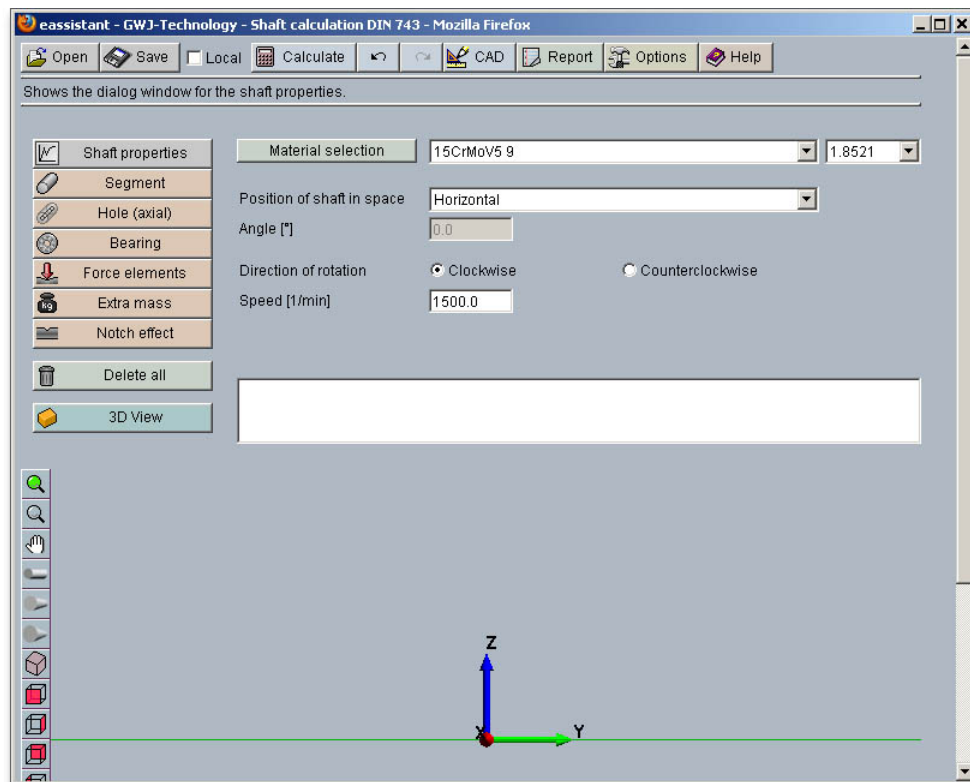


Figure 1: Start the calculation module

0.1.2 First Calculation Example

This calculation example shows a winding shaft with a fixed and movable bearing and an extra mass.

Create Shaft Segments

Click the button 'Segment' in order to create the first shaft segment. Enter a length of 50 mm and a diameter of 20 mm into the input fields.

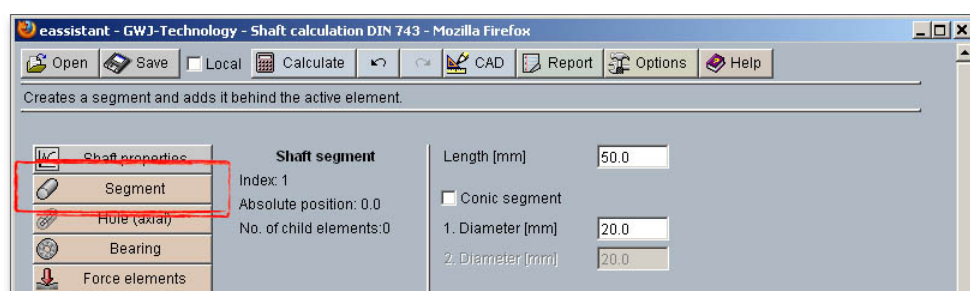


Figure 2: Create the first segment

The first segment is represented.

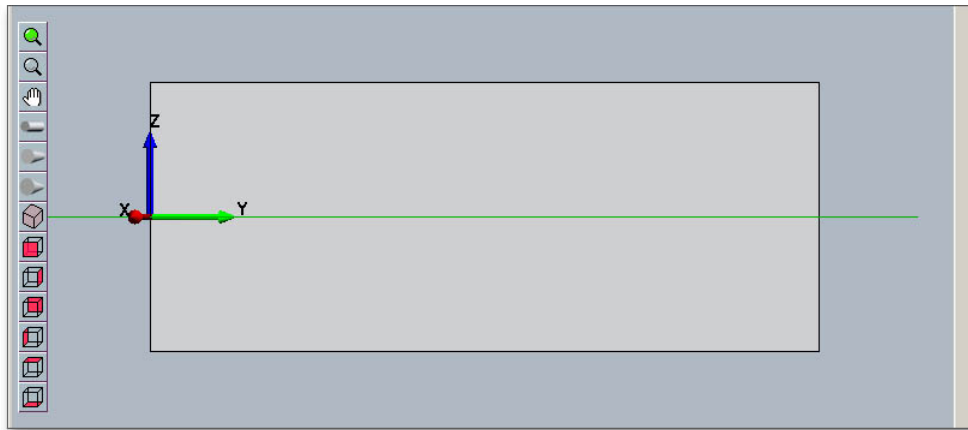


Figure 3: Representation of the created and defined shaft segment

To create the second shaft segment, click the button 'Segment' again. The second segment has a length of 400 mm and a diameter of 50 mm.

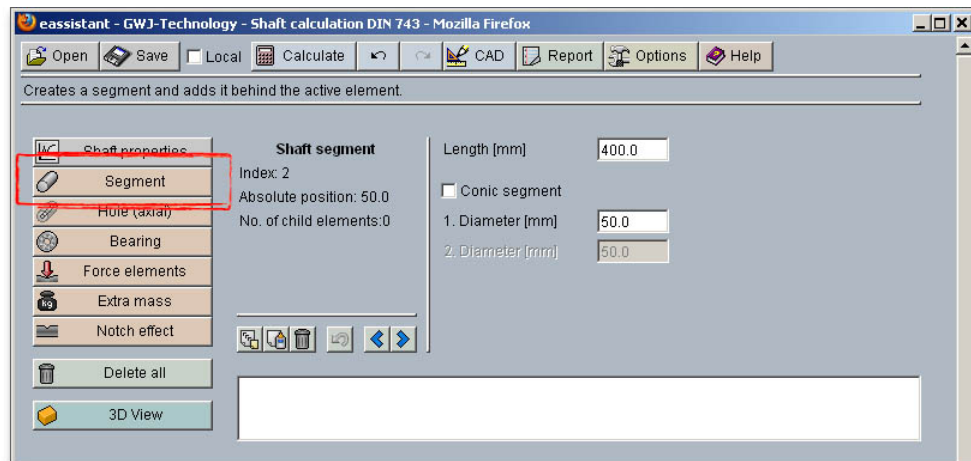


Figure 4: Create the second segment

This second segment is represented.

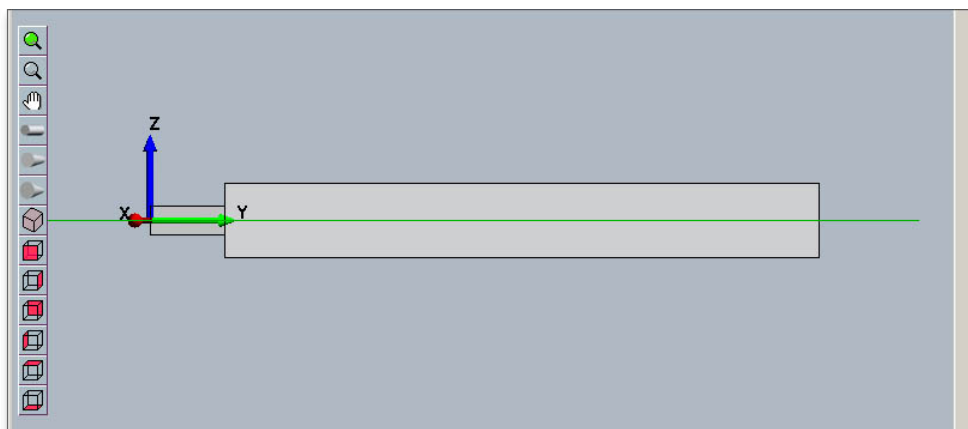


Figure 5: Representation of the second segment

The third shaft segment gets the same dimensions as the first shaft segment. That is why we can use the 'Copy' and 'Add' function to create the third segment. Click on the first segment.

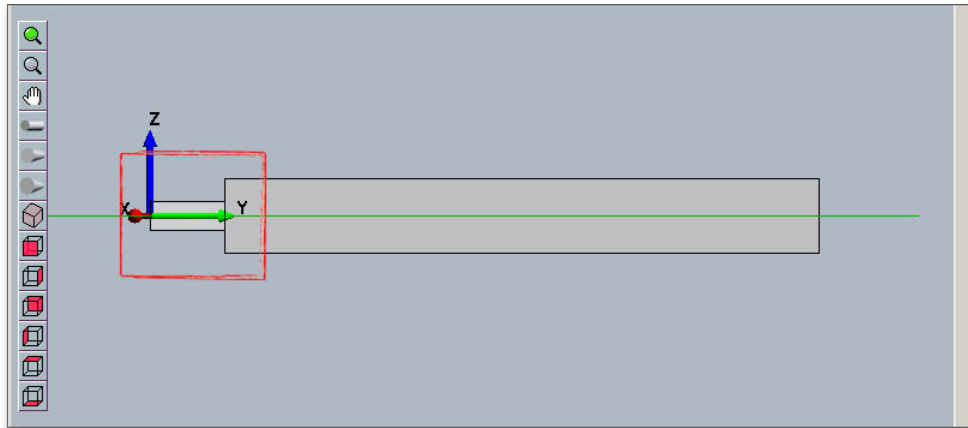


Figure 6: Select the first segment

Click on the button 'Copy'.

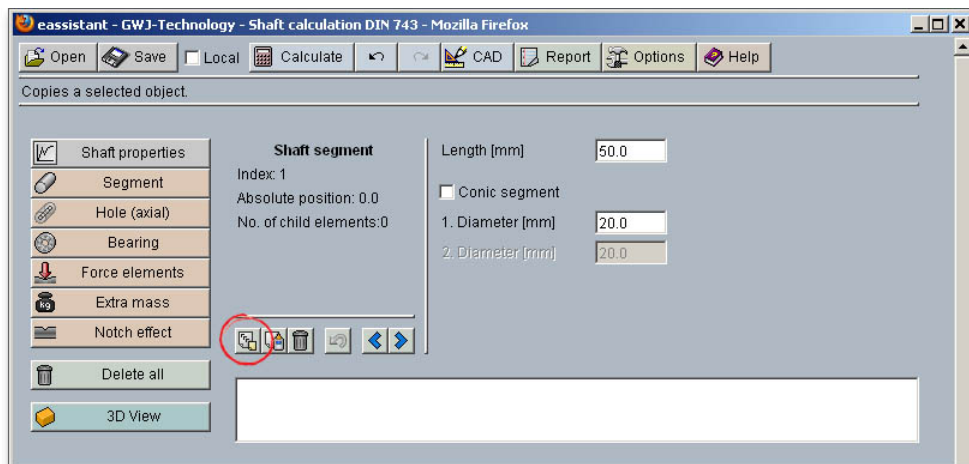


Figure 7: Copy the first segment

Select the second segment and place the third segment next to it.

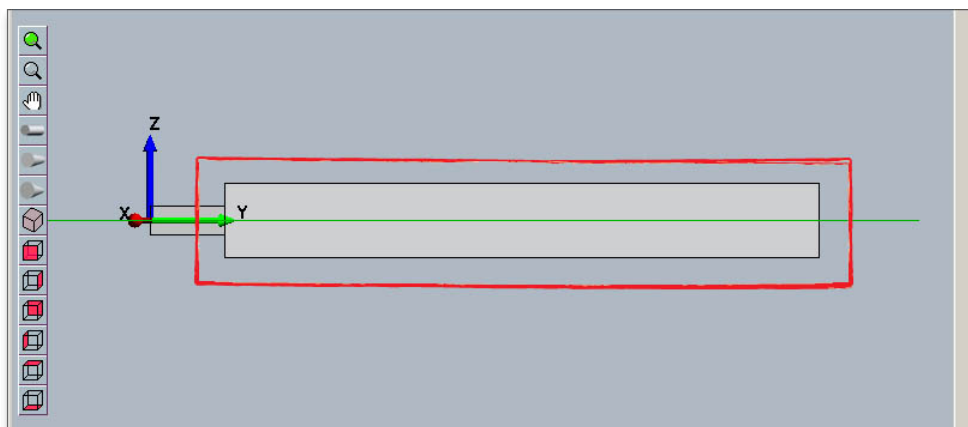


Figure 8: Select the second segment

Click on the button 'Add'.

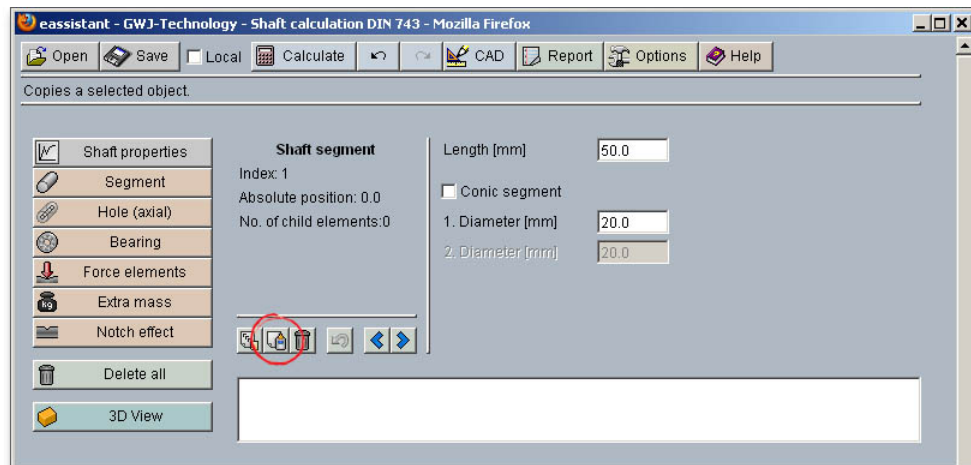


Figure 9: Add the segment

The copied segment is added as a third shaft segment.

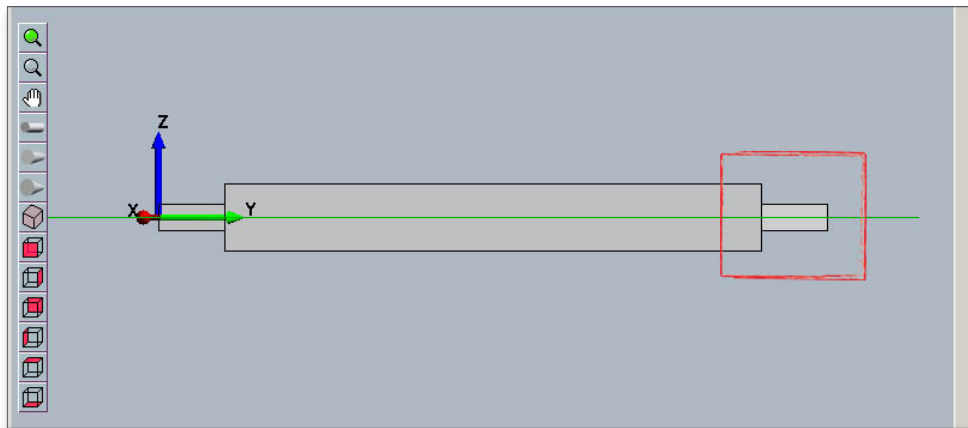


Figure 10: Add the third shaft segment

Note: If you select a segment and you click the right mouse button, a new context menu will open. Choose the menu items 'Copy' and 'Add'.

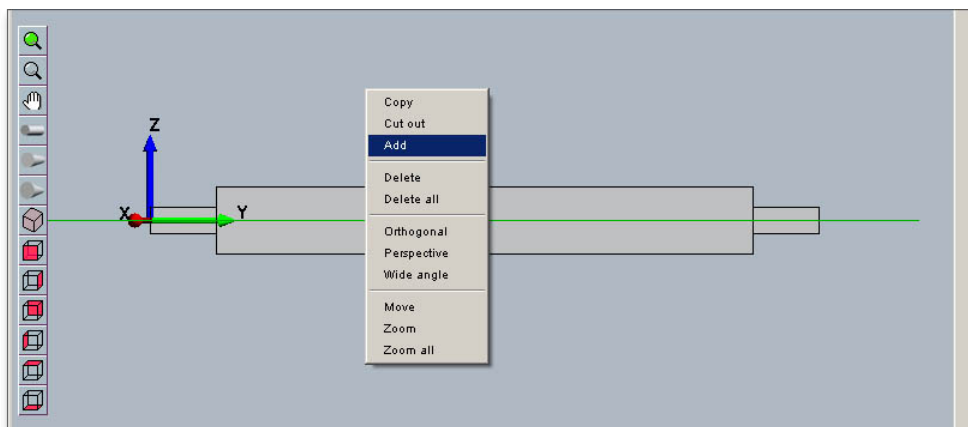


Figure 11: Right-click to open context menu

Create Axial Hole

Click the button 'Hole (axial)' in order to create the first hole. Enter a length of 70 mm and a diameter of 0 mm into the input fields.

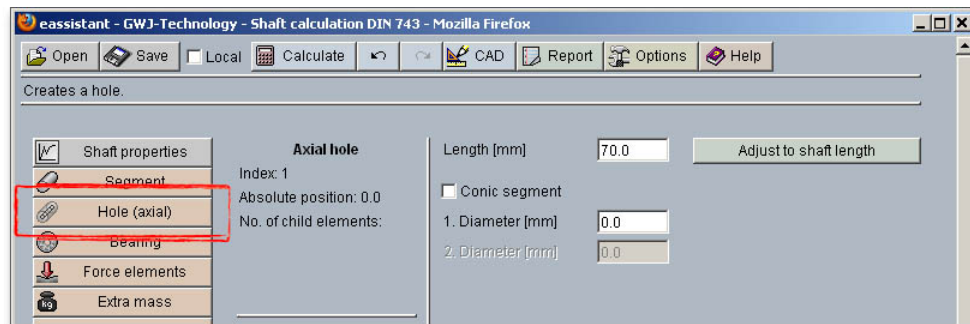


Figure 12: Create the first axial hole

Click the button 'Hole (axial)' again in order to create a second hole. Enter a length of 360 mm and a diameter of 40 mm into the input fields.

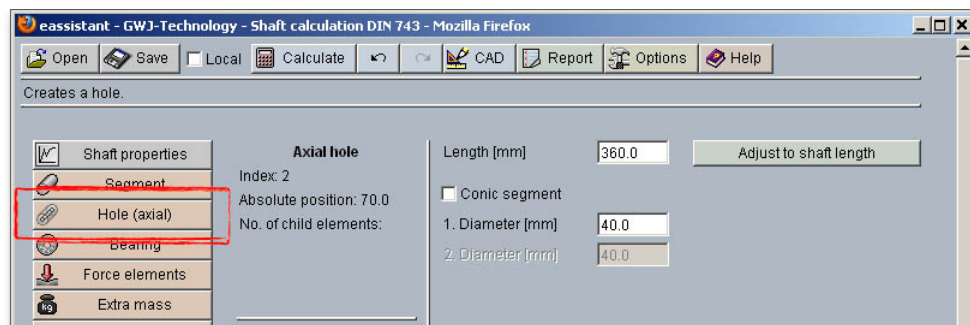


Figure 13: Define the second axial hole

The hollow shaft is represented.

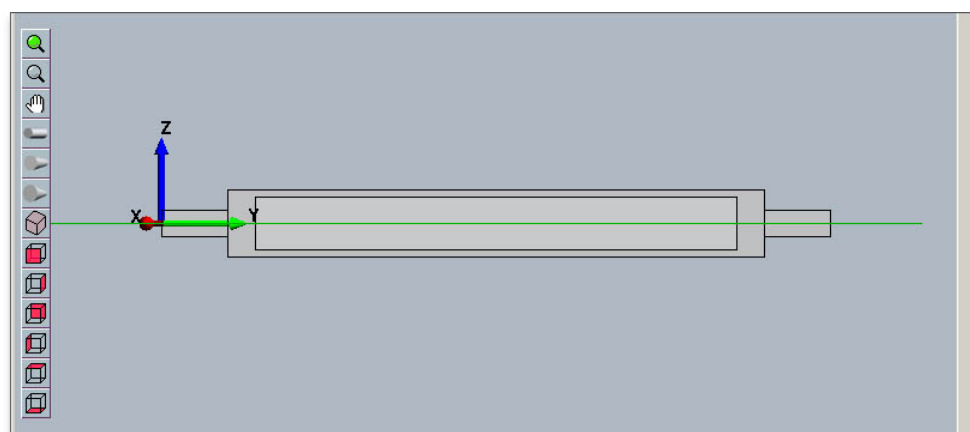


Figure 14: Representation of the axial hole

Note: Use your keyboard to select the individual elements. For example, if you want to change from the value input of a shaft segment to the selection mode, then press the 'Page down' key. Then use the two arrow keys to select the elements. Use the cursor keys 'Up' and 'Down' to move from the shaft segments to the axial holes. In order to change the input values of an element, press 'Page up'.

Add Bearing

Select the first shaft segment to add the bearing to the shaft.

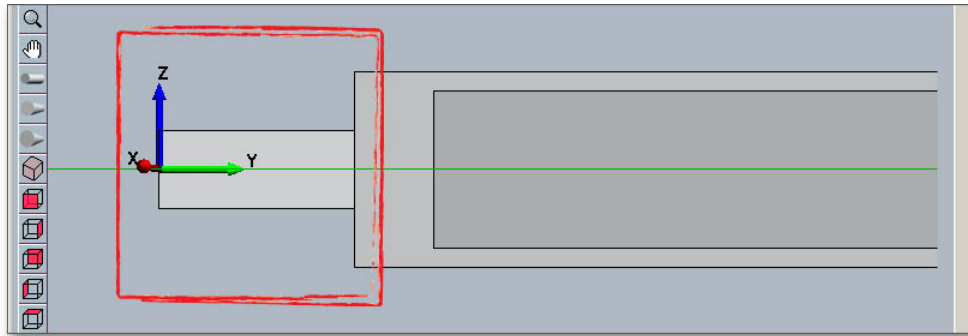


Figure 15: Select a segment

Click on the button 'Bearing'.

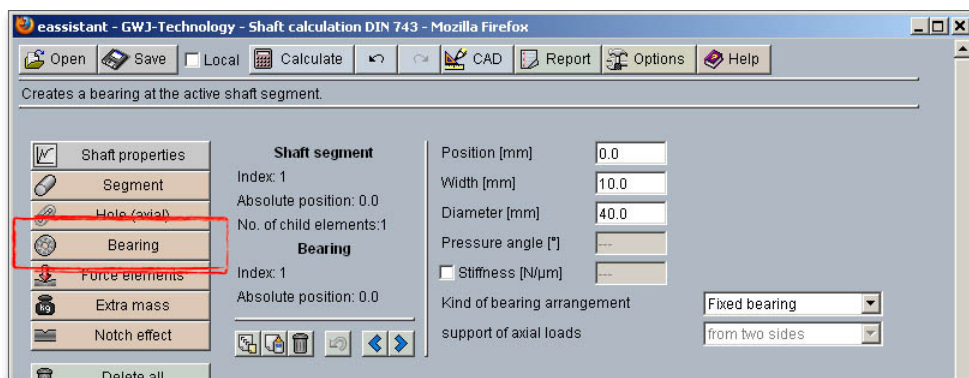


Figure 16: Button 'Bearing'

A bearing is added. Enter 20 mm for the bearing position, 10 mm for the bearing width and 40 mm for the bearing diameter. As bearing arrangement, select 'Fixed bearing' from the listbox.

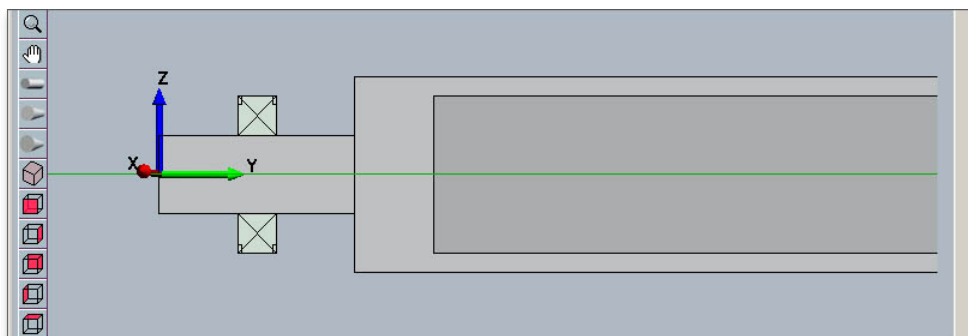


Figure 17: Add the first bearing

In order to add the second bearing, select the first bearing and click the button 'Copy'.

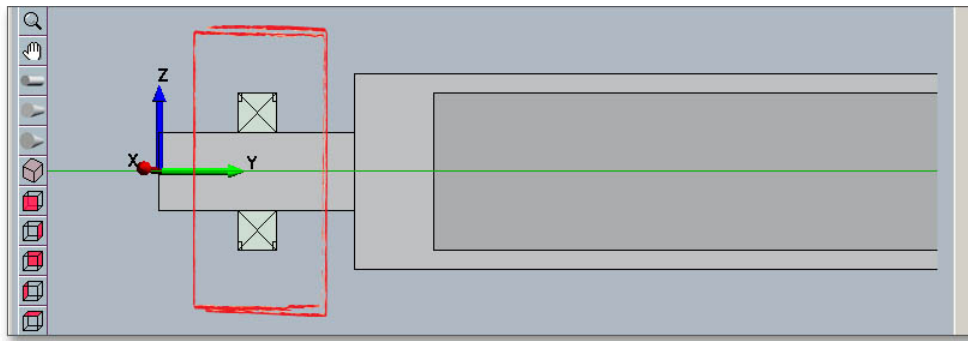


Figure 18: Select the first bearing

Select the third shaft segment and click the 'Add' button. Because the bearing is copied, it is not necessary to define the position, width and diameter of the bearing, you just need to define the bearing arrangement. Select 'Movable bearing' from the listbox.

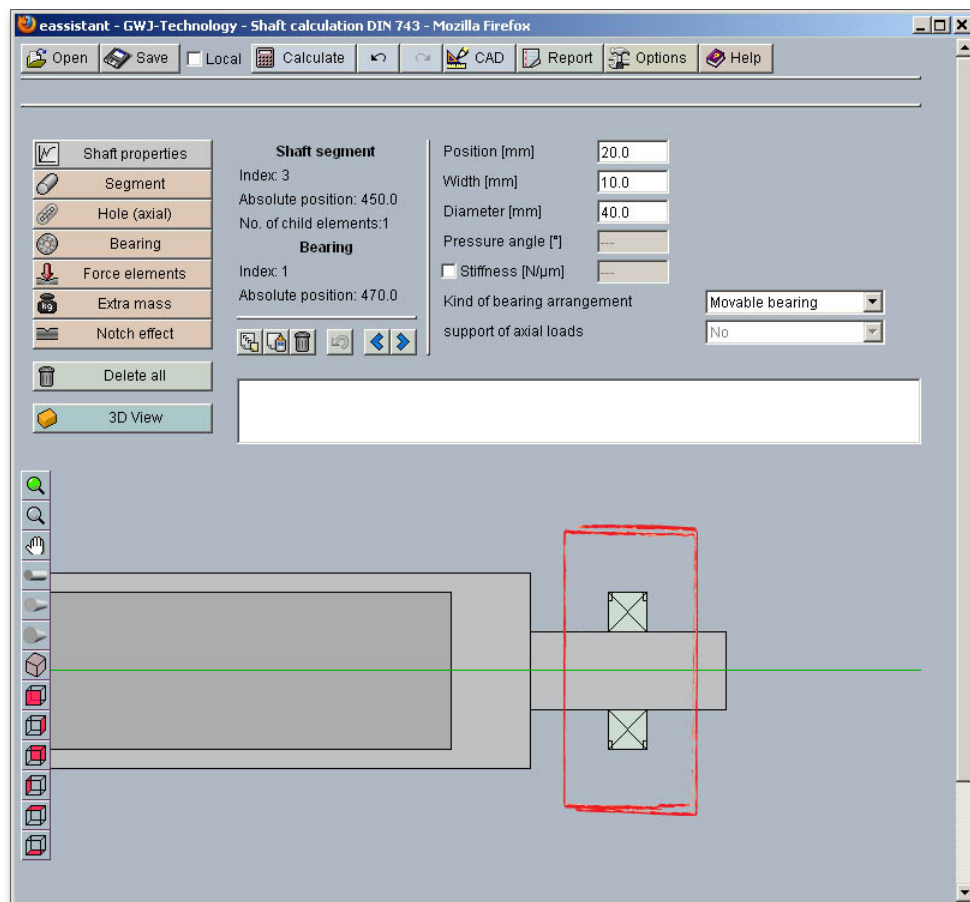


Figure 19: Define the second bearing

Define Load as Extra Mass

To position the load, select the second shaft segment.

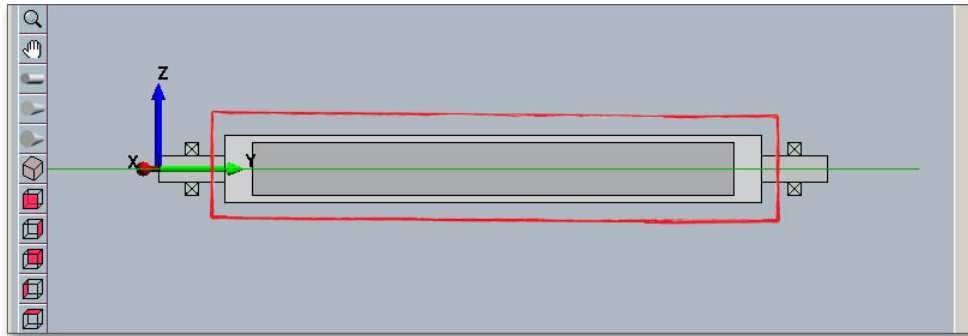


Figure 20: Select a shaft segment

Click on the button 'Extra mass'.

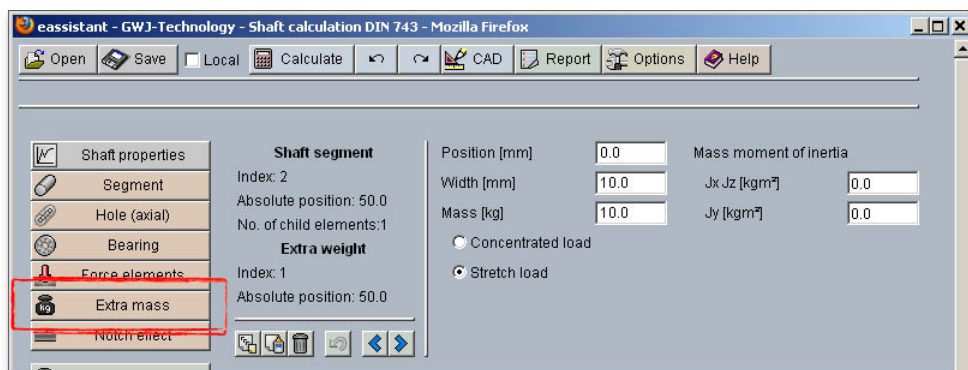


Figure 21: Button 'Extra mass'

The extra mass will be positioned on the shaft segment. Please define the extra mass with 50 mm for position, 300 mm for width and 950 kg for mass.

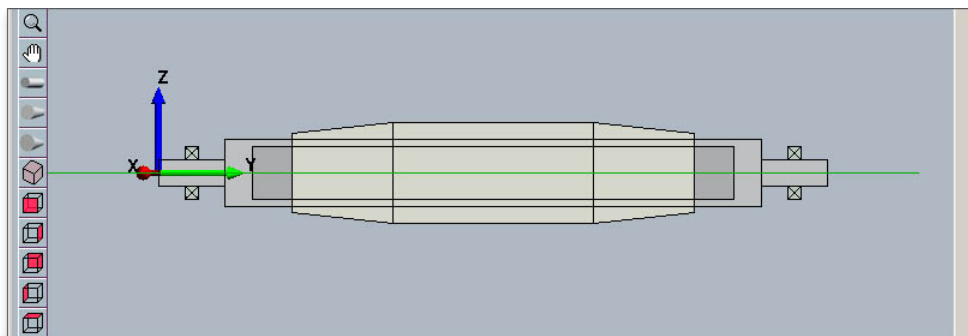


Figure 22: Extra mass is added

Define Notch Effect

Click on the button 'Notch effect' in order to add the notch effects.

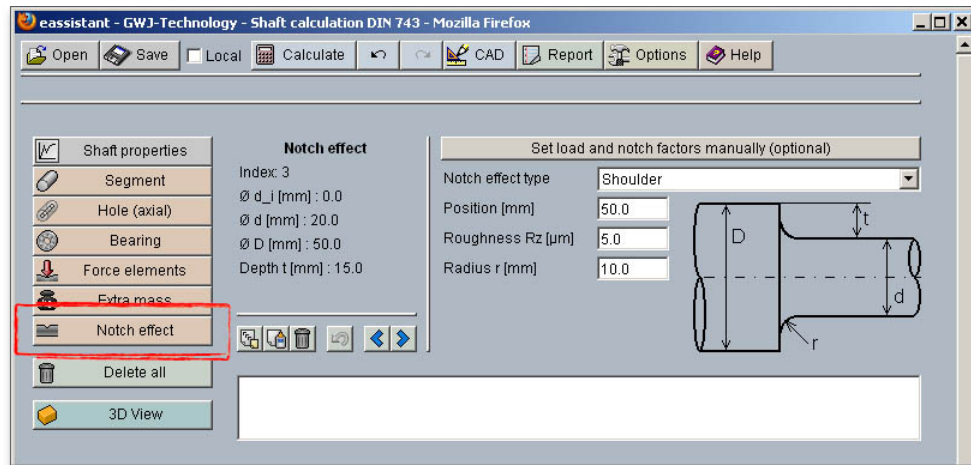


Figure 23: Button 'Notch effect'

A notch effect is added and can be placed on the shaft. Enter the position of the notch effect or change the position with the two arrow keys. Select the notch effect from the listbox.

Define the following notch effects:

- First notch effect: On left shaft section - notch effect type 'Shoulder' with roughness $R_z = 5$ mm and radius $r = 10$ mm
- Second notch effect: On right shaft section - enter the same values as for the notch effect on the left shaft section
- Third notch effect: On shaft center: select the notch effect type 'Interference fit'

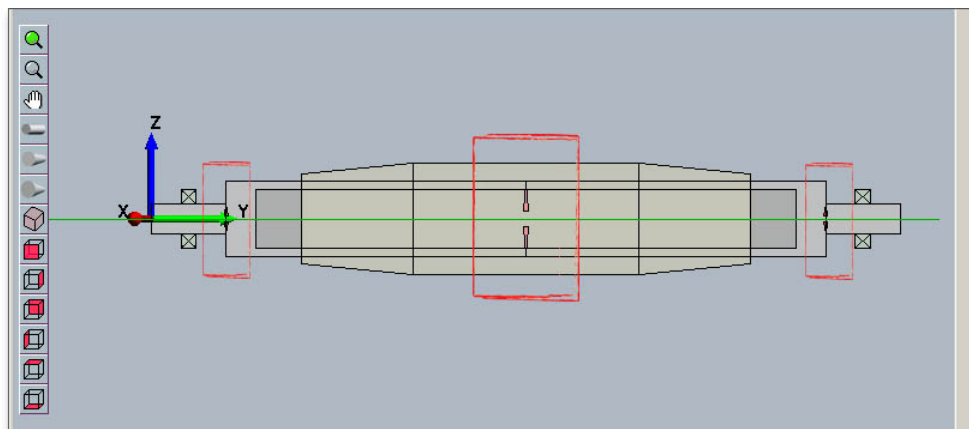


Figure 24: Notch effects

0.1.3 Start Calculation

After defining the entire shaft geometry with bearings, loads and notch effects, you can start your calculation. To start the calculation, click the button 'Calculate'. The button changes then its description into 'Geometry' and you get into the calculation part. The calculation part enables you to carry out the calculation. If you want to modify the geometry of the shaft, you have to go back to the geometry part. To do so, please click the button 'Geometry'.

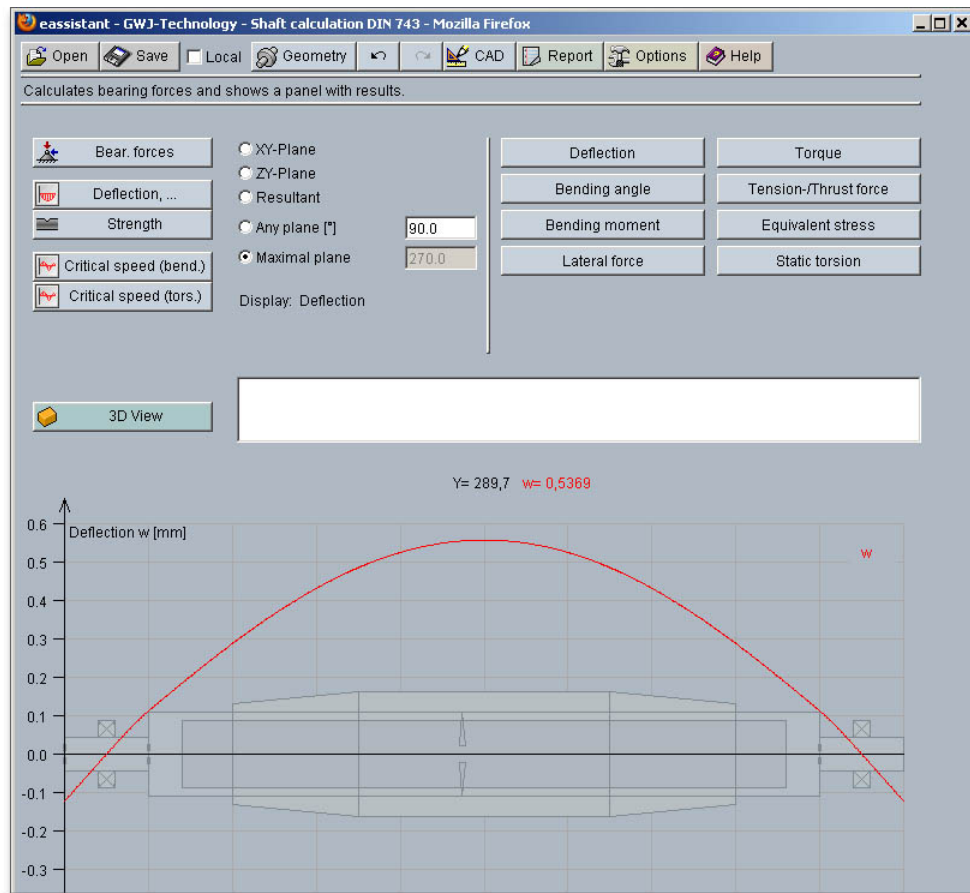


Figure 25: Calculation part

When you are in the calculation part of the module, it is not possible to change the geometry. In order to change the geometry, please go back to the geometry part by clicking the 'Geometry' button.

Here, you can carry out the different calculations, e.g., the strength calculation according to DIN 743.

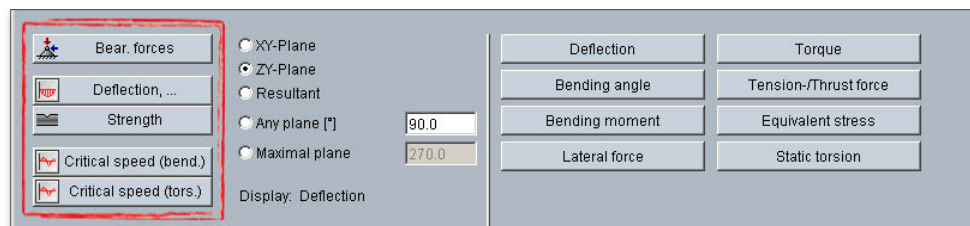


Figure 26: Different calculations

Calculation of Bearing Forces

In order to start the calculation of bearing forces, click the button 'Bearing forces'.

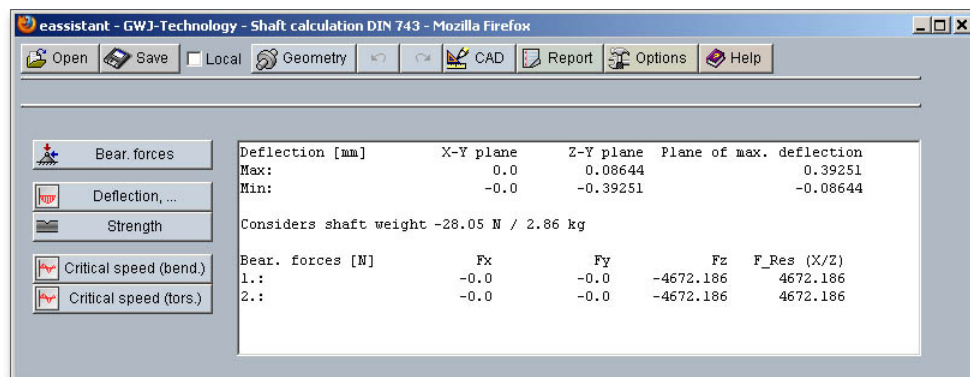


Figure 27: Calculation of bearing forces

Calculation of Deflection

Click the button 'Deflection' to start the calculation of the deflection, bending angle and bending moment. Open the different diagrams for forces and moments.

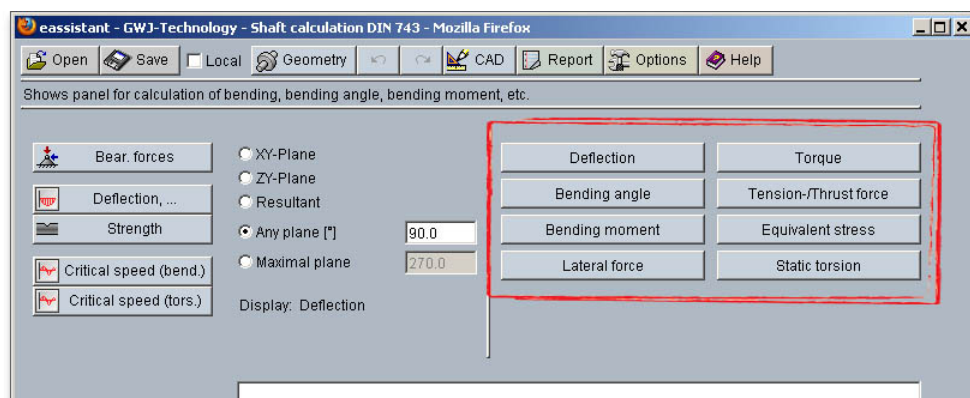


Figure 28: Interactive diagrams of forces and moments

You can select all values for deflection directly from the representation with just a mouse click. The values appear in the text field.

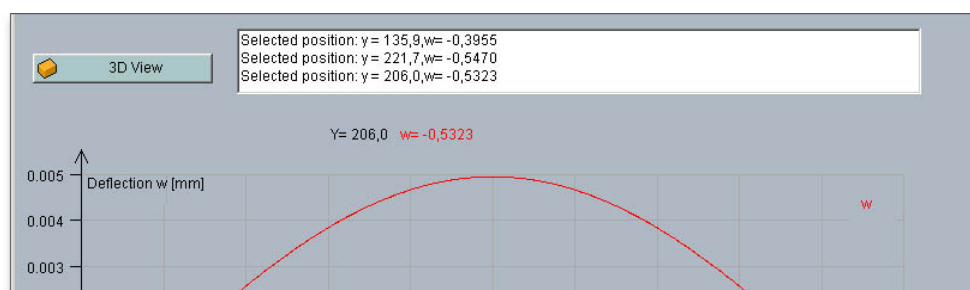


Figure 29: Select values by mouse-click

Calculation of Strength According to DIN 743

Start the strength calculation by clicking the button 'Strength'. The strength calculation provides a complete static and fatigue proof of strength according to DIN 743. The exact values appear in the text field and can be selected with a mouse click from the graphical representation.

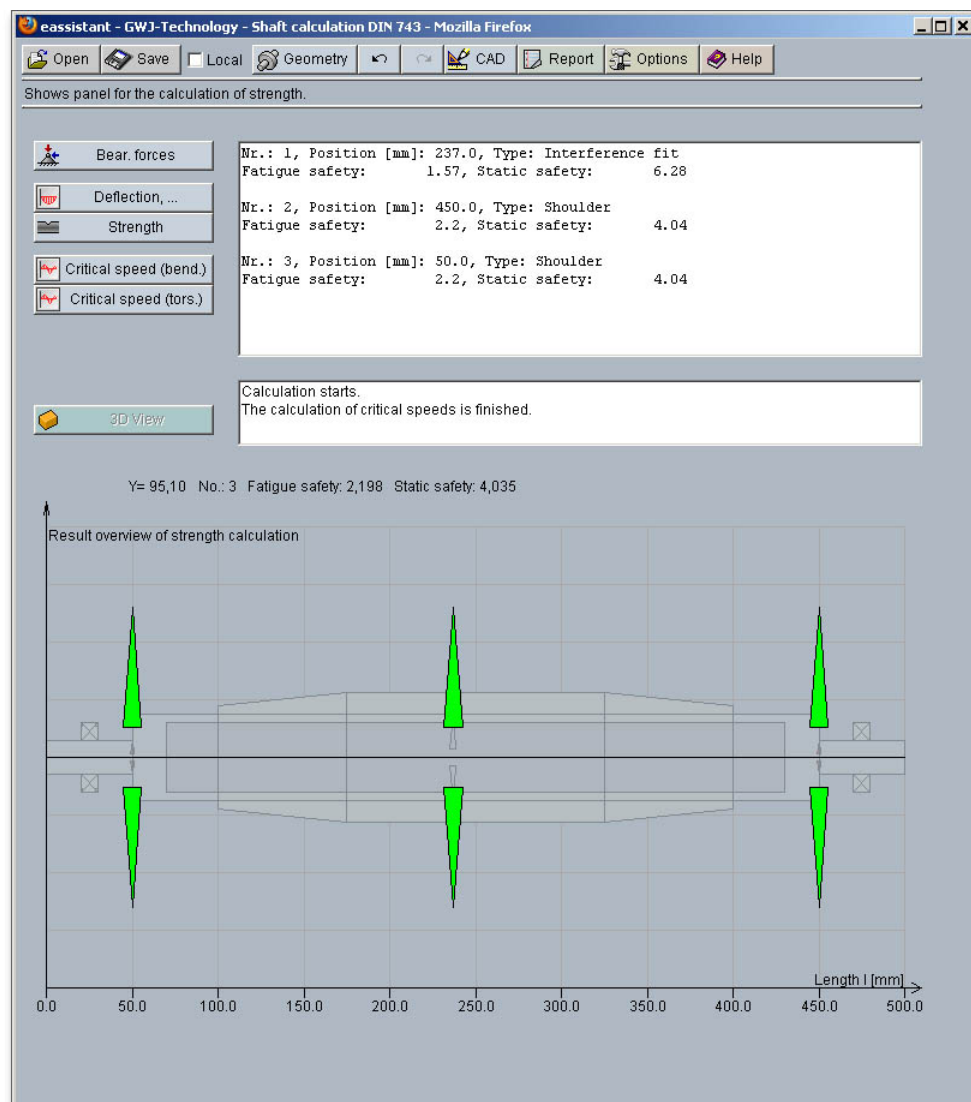


Figure 30: Strength calculation with a representation of the cross sections

The text field shows the most important calculation results. The calculation report provides all detailed calculation results. In addition, the results for the cross sections are represented in three different colors:

- Red marked cross section: The minimum safety is not achieved.
- Green marked cross section: The safety is fulfilled (up to three times higher than the defined minimum safety).
- Blue cross section: The safety is more than three times higher than the minimum safety.

Calculation of Critical Speed (Bending)

Start the calculation of the critical speeds by clicking the button 'Critical speed (bending)'. Gyroscopic effects, moments of inertia, deflection due to shear can be taken into consideration.

To do so, please activate the appropriate check box.

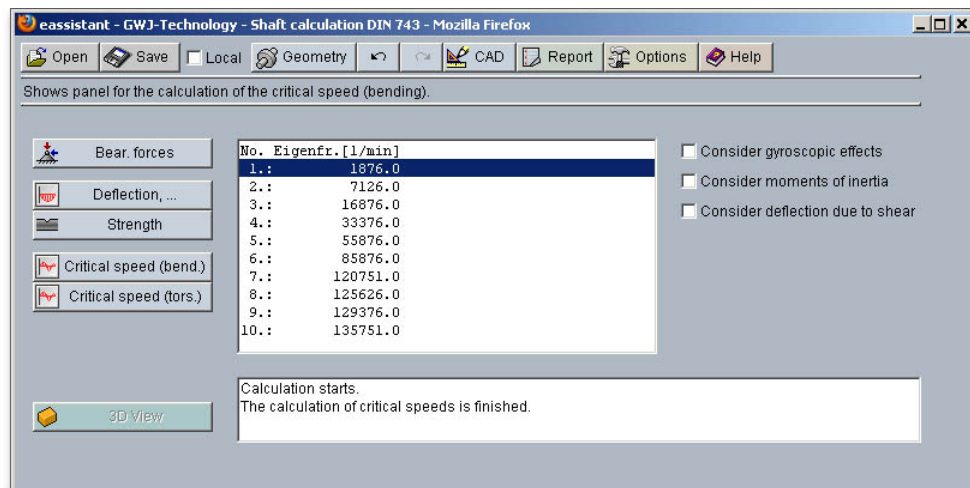


Figure 31: Critical speed (bending)

Calculation of Critical Speed (Torsion)

Click the button 'Critical speed (torsion)' in order to start the calculation of the critical speed.

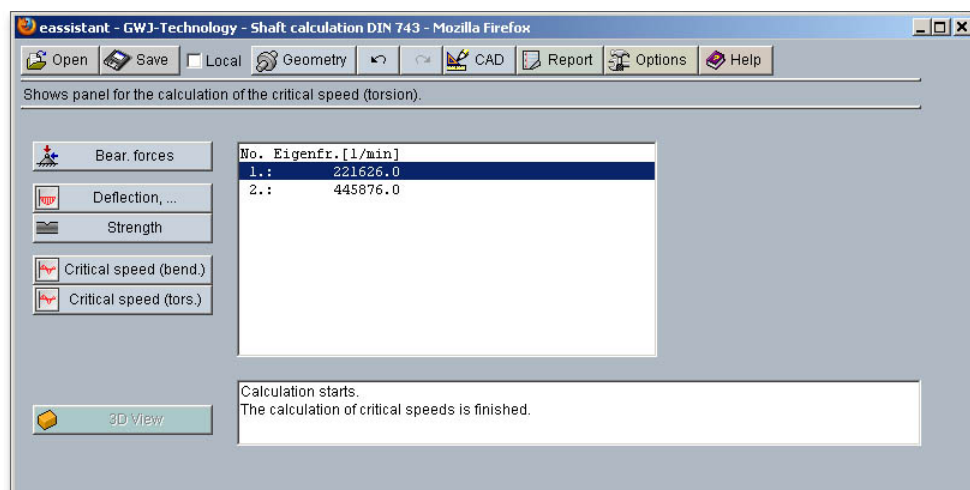


Figure 32: Critical speed (torsion)

0.1.4 Documentation: Calculation Report

Now you can create the calculation report. Click on the button 'Report'.

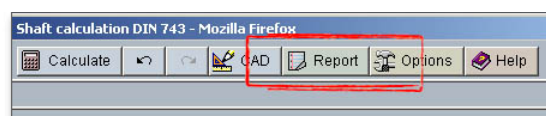


Figure 33: Button 'Report'

First the report configurator appears. The report configurator allows you to select which diagrams should appear in the calculation report and if the results of the strength calculation should be in the report, too.

Options for the report

Selection of diagrams for the report

	XY	YZ	Resultant	Any	Max	
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> All
Deflection	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bending angle	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bending moment	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lateral force	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Torque			<input type="checkbox"/>			<input type="checkbox"/>
Tension-/Thrust force			<input type="checkbox"/>			<input type="checkbox"/>
Equivalent stress			<input type="checkbox"/>			<input type="checkbox"/>
Static torsion			<input type="checkbox"/>			<input type="checkbox"/>
Results of the calculation of the critical speeds (bending)					<input type="checkbox"/>	
Diagrams for modes of vibration of critical speeds (bending)					<input type="checkbox"/>	1-3
Results of the calculation of the critical speeds (torsion)					<input type="checkbox"/>	
Diagrams for modes of vibration of critical speeds (torsion)					<input type="checkbox"/>	1-3
Results of strength calculation					<input type="checkbox"/>	

Ok Cancel

Figure 34: Report configuration

During the generation of the report, a waiting screen appears. During the generation of the report, a waiting screen appears. But you can continue to work with the calculation module. The length of time for the generation of the report depends on the number of diagrams which have to be generated.

You can navigate through the report via the table of contents that provides links to the input values, results and figures. This calculation report contains all input data, the calculation method as well as all detailed results. The report is available in HTML and PDF format. The calculation report saved in HTML format, can be opened in a web browser or in Word for Windows. In HTML format, the figures are displayed in 'gif' format. In case a SVG viewer is available, you can display all graphics in SVG format. Right-clicking on the picture allows to zoom in and zoom out.

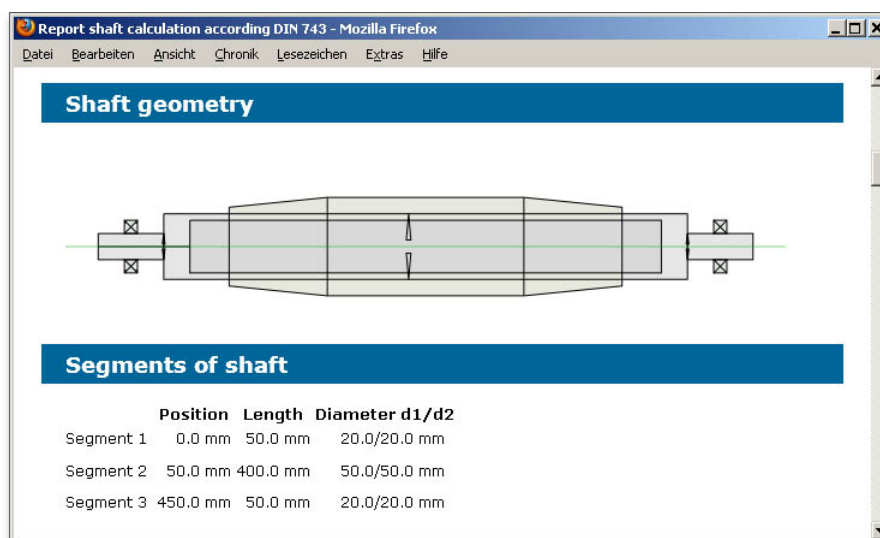


Figure 35: Calculation report

You may also print or save the calculation report:

- To save the report in the HTML format, please select 'File' → 'Save as' from your browser menu bar. Select the file type 'Webpage complete', then just click on the button 'Save'.
- If you click on the symbol 'Print', then you can print the report very easily.
- When you click on the symbol 'PDF', then the report appears in the PDF format. If you right-click on the PDF symbol, you should see the 'Save Target As' option. Click on that option and you will see the dialog box for saving the report.

0.1.5 Save Calculation

When the calculation is finished, you can save it to your computer or to the eAssistant server. Click on the button 'Save'.

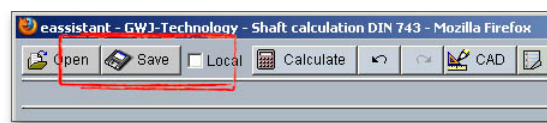


Figure 36: The button 'Save'

Before you can save the calculation to your computer, you need to activate the checkbox 'Enable save data local' in the project manager and the option 'Local' in the calculation module. A standard Windows dialog for saving files will appear. Now you will be able to save the calculation to your computer.

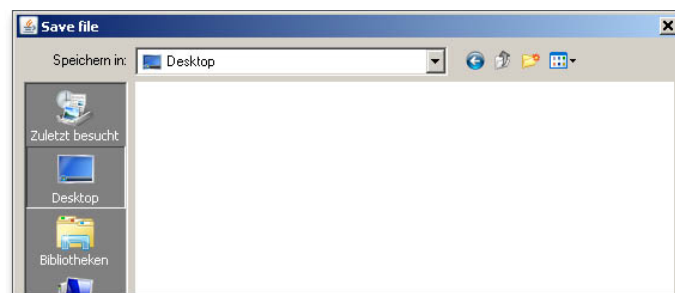


Figure 37: Standard Windows dialog for saving the file

In case you do not activate the option in order to save your files locally, then a new window is opened and you can save the calculation to the eAssistant server. Please enter a name into the input field 'Filename' and click on the button 'Save'. Then click on the button 'Refresh' in the project manager. Your saved calculation file is displayed in the window 'Files'.

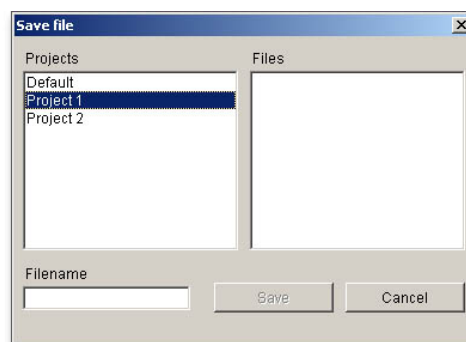


Figure 38: Save the calculation

0.1.6 Second Calculation Example

Here you find another example that shows how easy it is to create a shaft.

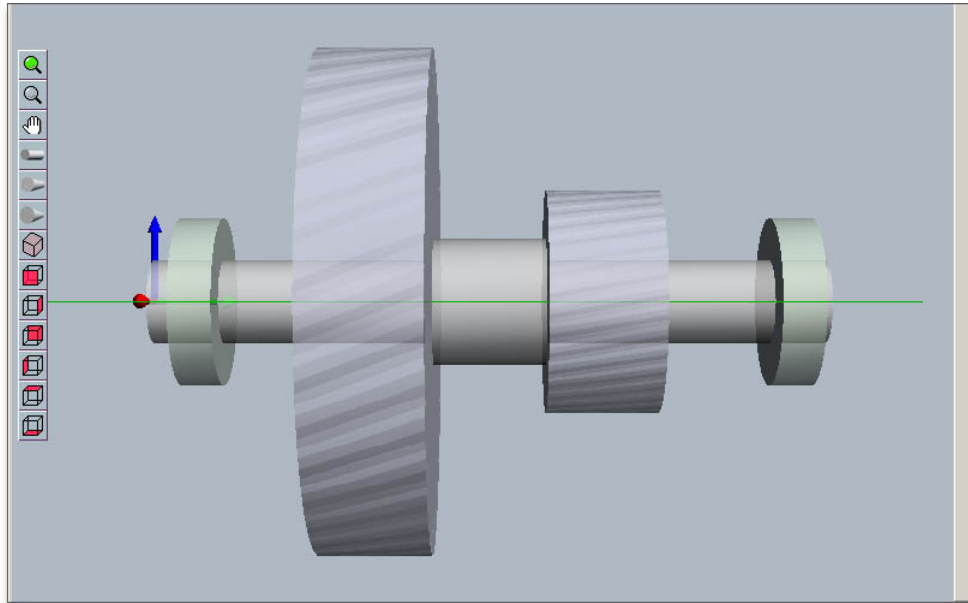


Figure 39: Shaft

Create Shaft Segments

Create three shaft segments. Please enter the following input values:

1. Shaft segment: Length $l_1 = 100$ mm Diameter $d_1 = 30$ mm
2. Shaft segment: Length $l_2 = 40$ mm Diameter $d_2 = 45$ mm
3. Shaft segment: Length $l_3 = 100$ mm Diameter $d_3 = 30$ mm

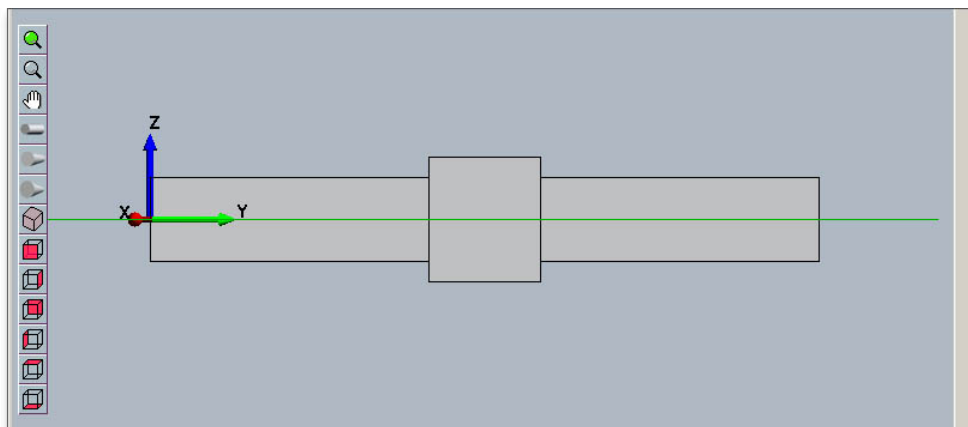


Figure 40: Shaft segments

Add Bearings

Then add the two bearings. Please enter the following input values:

1. Bearing: Position = 10 mm Width $b_1 = 15$ mm Diameter $d_1 = 60$ mm Fixed bearing
2. bearing: Position = 80 mm Width $b_2 = 15$ mm Diameter $d_2 = 60$ mm Movable bearing

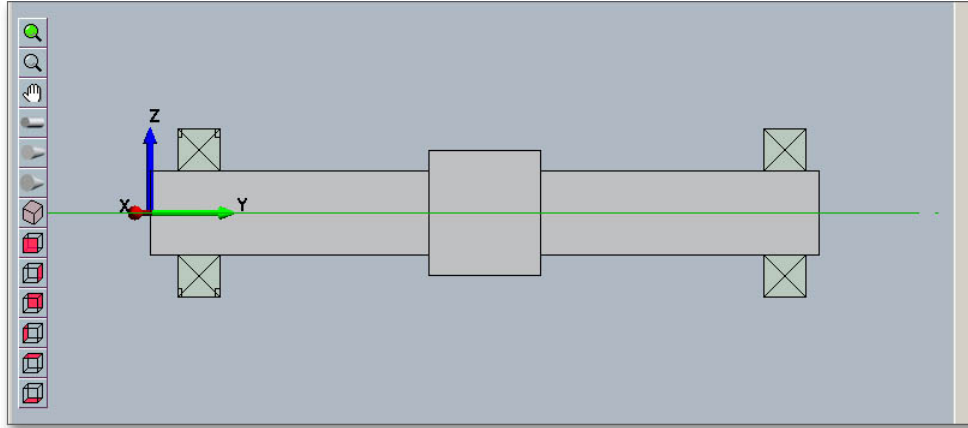


Figure 41: Bearing

Create First Cylindrical Gear

In order to create the cylindrical gear, select the first shaft segment. Click on the button 'Force elements' and select the menu item 'Cylindrical gear' from the submenu. Use the input mask to define the cylindrical gear. Enter the following input values:

- Position = 60 mm
 Width $b_1 = 40$ mm
 Reference circle $d_{T1} = 180$ mm
 Helix angle $\beta_1 = 25^\circ$
 Pressure angle $\alpha_1 = 20^\circ$
 Position of action = 90°
 Torque $T_1 = 320$ Nm
 Mass $m_1 = 0.0$ kg

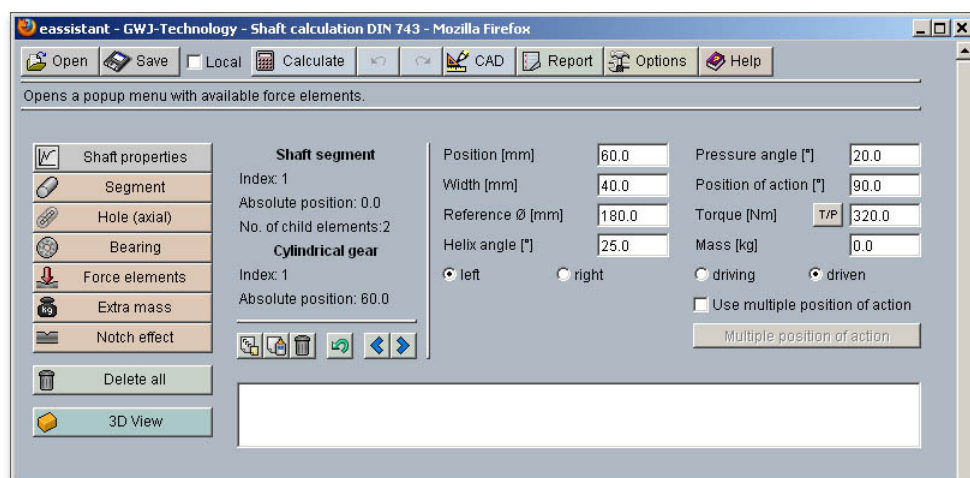


Figure 42: Define the first cylindrical gear

The first cylindrical gear is represented.

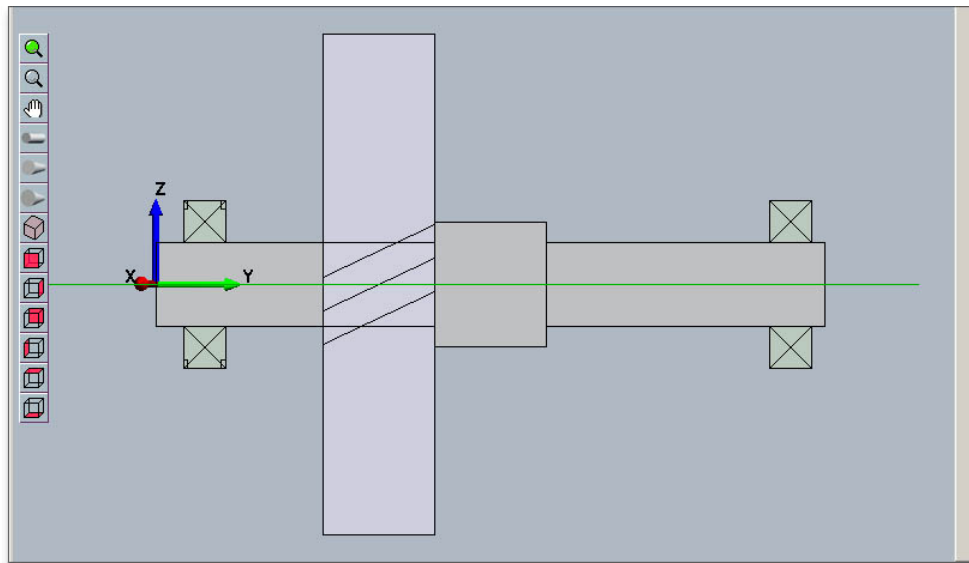


Figure 43: First cylindrical gear

Create Second Cylindrical Gear

To create the second cylindrical gear, select the third shaft segment. Click on the button 'Force elements' and select the menu item 'Cylindrical gear' from the submenu. Please enter the following values into the input mask:

Position = 0 mm
 Width $b_2 = 40$ mm
 Reference circle $d_{T2} = 80$ mm
 Helix angle $\beta_2 = 25^\circ$
 Pressure angle $\alpha_2 = 20^\circ$
 Power of action = 270°
 Torque $T_2 = 320$ Nm
 Mass $m_2 = 0.0$ kg

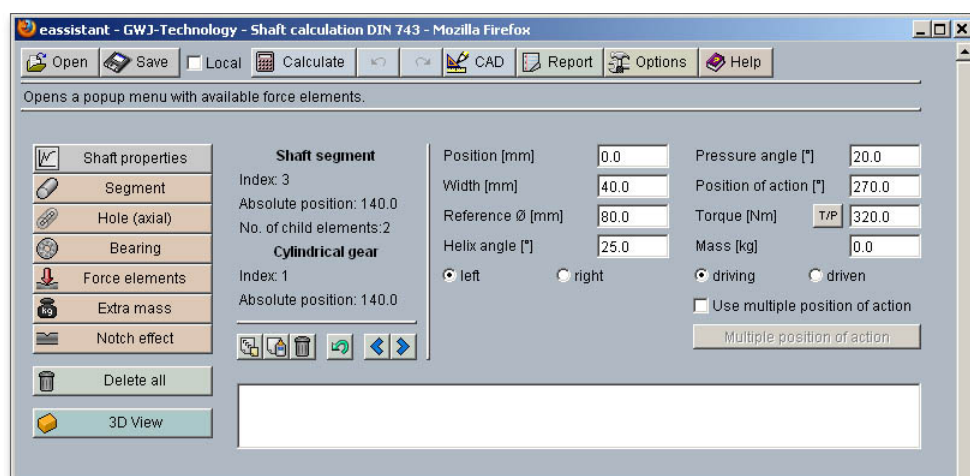


Figure 44: Define the second cylindrical gear

Both cylindrical gears will be represented.

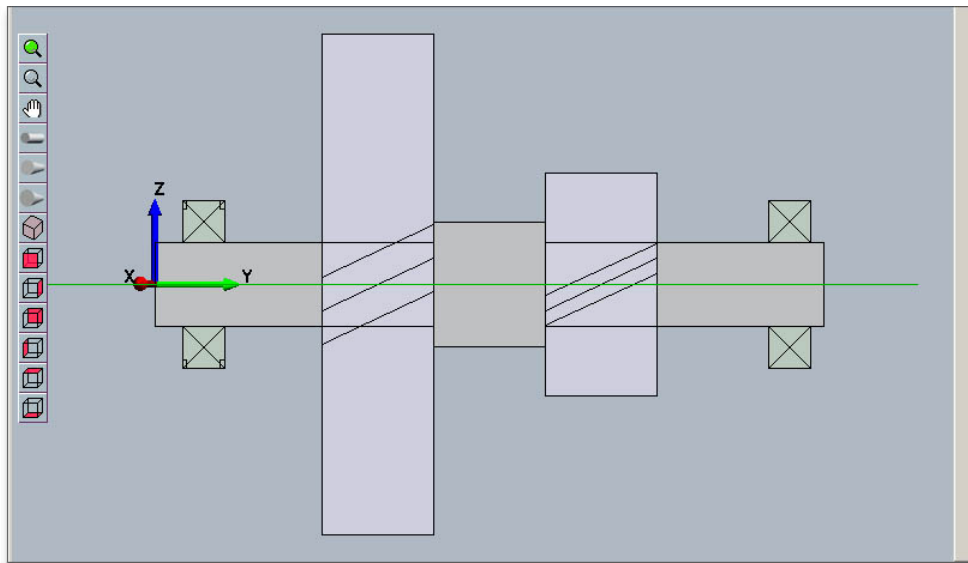


Figure 45: Two spur gears created

Then you can display the shaft in different views. Click the button '3D view' and select the different views from the toolbar and zoom into the graphic. Click on the button 'Calculate' and switch from the geometry part into the calculation part. There you can run the calculations (find detail information in the section 'How to start the calculation'). The button 'Report' allows you to generate a report.

Result

Clicking the '3D view' button displays the three-dimensional presentation. The three-dimensional view allows to modify the elements. Select the element and change, for example, the position, length or diameter. To do so, please use the appropriate input fields. Click on the '2D / 3D view' button again to switch back to the two-dimensional representation.

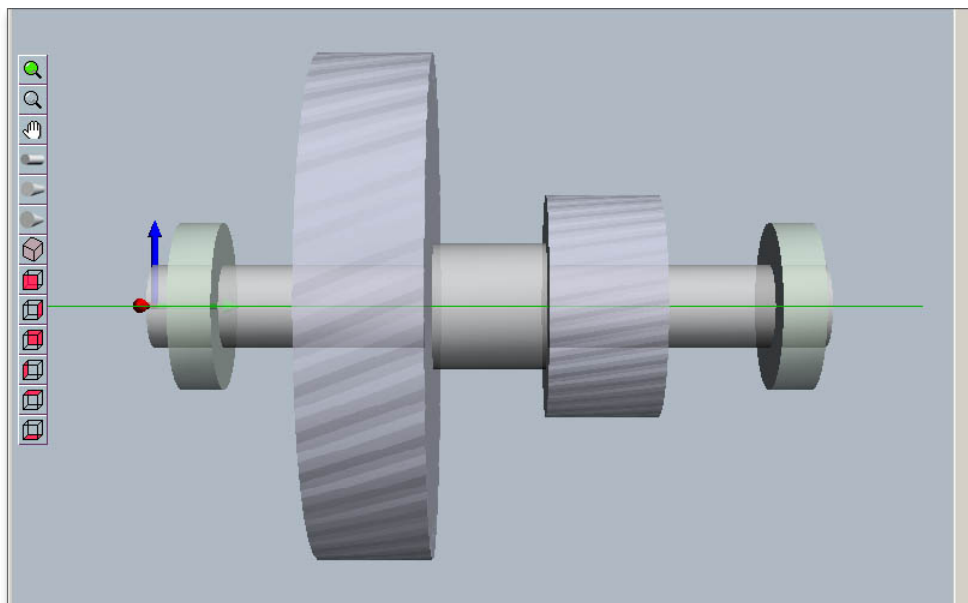


Figure 46: 3D view of the shaft

0.1.7 Start Calculation

After defining the entire shaft geometry with the cylindrical gears and the bearings, you can start your calculation. To start the calculation, click the button 'Calculate'. The button changes then its description into 'Geometry' and you get into the calculation part. The calculation part enables you to carry out the calculation. If you want to modify the geometry of the shaft, you have to go back to the geometry part. To do so, please click the button 'Geometry'. With just one click, the following calculations can be carried out:

- Bearing forces
- Deflection, bending angle, bending moment,...
- Strength
- Critical speed (bending)
- Critical speed (torsion)

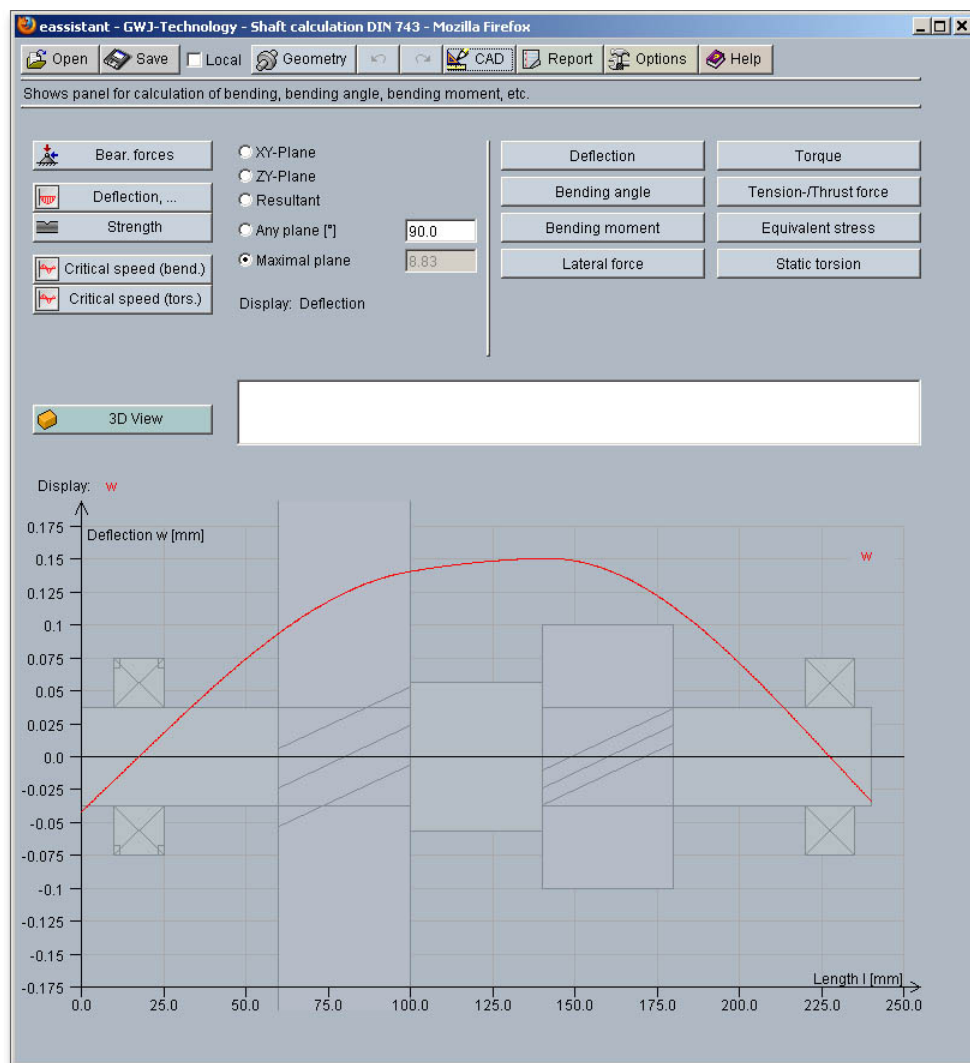


Figure 47: Start of calculation

When you are in the calculation part of the module, it is not possible to change the geometry. In order to change the geometry, please go back to the geometry part by clicking the 'Geometry' button.

0.1.8 Documentation: Calculation Report

Now you can create the calculation report. Click on the button 'Report'.



Figure 48: Button 'Report'

First the report configurator appears. The report configurator allows you to select which diagrams should appear in the calculation report and if the results of the strength calculation should be in the report, too. You can navigate through the report via the table of contents that provides links to the input values, results and figures. This calculation report contains all input data, the calculation method as well as all detailed results. The report is available in HTML and PDF format. The calculation report saved in HTML format, can be opened in a web browser or in Word for Windows. In HTML format, the figures are displayed in 'gif' format. In case a SVG viewer is available, you can display all graphics in SVG format. Right-clicking on the picture allows to zoom in and zoom out.

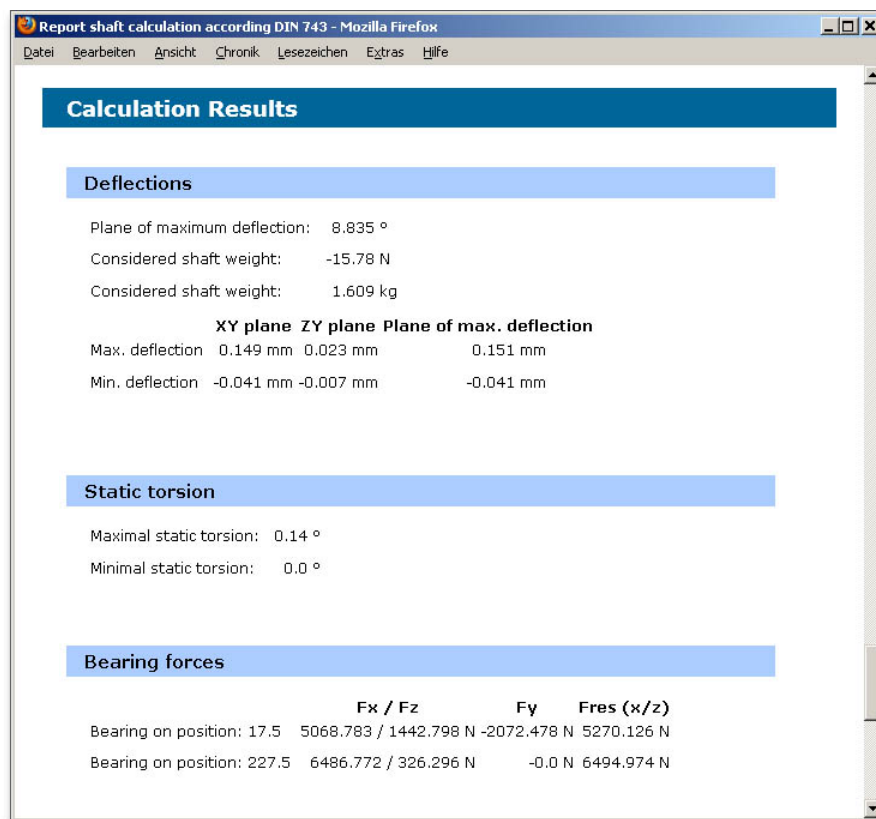


Figure 49: Calculation report

You may also print or save the calculation report:

- To save the report in the HTML format, please select 'File' → 'Save as' from your browser menu bar. Select the file type 'Webpage complete', then just click on the button 'Save'.
- If you click on the symbol 'Print', then you can print the report very easily.
- When you click on the symbol 'PDF', then the report appears in the PDF format. If you right-click on the PDF symbol, you should see the 'Save Target As' option. Click on that option and you will see the dialog box for saving the report.

0.1.9 Save Calculation

When the calculation is finished, you can save it to your computer or to the eAssistant server. Click on the button 'Save'.

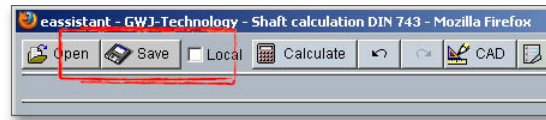


Figure 50: Button 'Save'

Before you can save the calculation to your computer, you need to activate the checkbox 'Enable save data local' in the project manager and the option 'Local' in the calculation module. A standard Windows dialog for saving files will appear. Now you will be able to save the calculation to your computer.

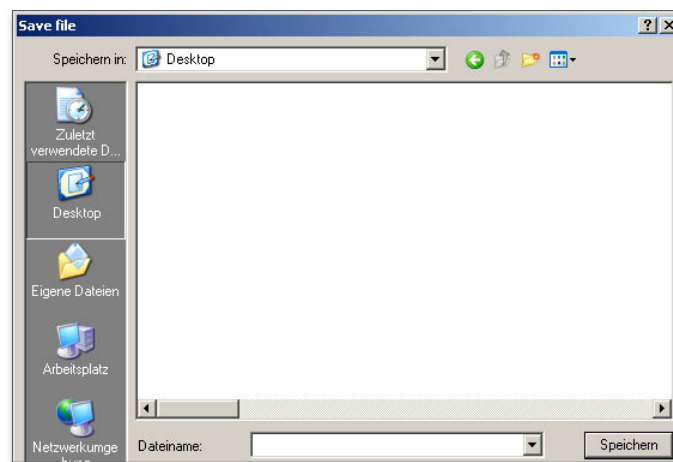


Figure 51: Standard Windows dialog for saving the file

In case you do not activate the option in order to save your files locally, then a new window is opened and you can save the calculation to the eAssistant server. Please enter a name into the input field 'Filename' and click on the button 'Save'. Then click on the button 'Refresh' in the project manager. Your saved calculation file is displayed in the window 'Files'.

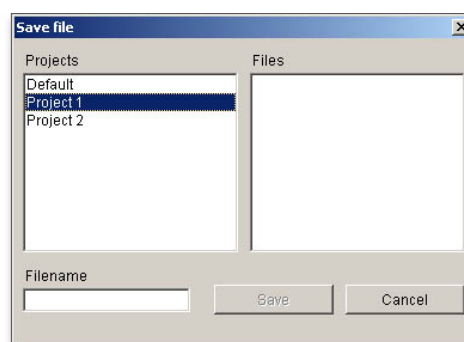


Figure 52: Save the calculation

Our manual is improved continually. Of course we are always interested in your opinion, so we would like to know what you think. We appreciate your feedback and we are looking for ideas, suggestions or criticism. If you have anything to say or if you have any questions, please let us know by phone +49 (0) 531 129 399-0 or email eAssistant@gwj.de.