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Tutorial Series

Shaft Systems – Starter
2-Stage Gearbox

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1. Foreword

1.1 Aim of the tutorial

This starter tutorial for the Shaft Calculation extension MESYS Shaft Systems aims to familiarize users with the functionalities and provide an initial impression of its computational capabilities in analysing aspects related to the use of parallel shafts.
As a limitation, only topics and settings are mentioned or dealt with here, that are appropriate for an assumed familiarity with the product and the exercise content. Please do not hesitate to contact MESYS if you have any questions when using the software.

1.2 Software Version

This tutorial was created with MESYS Shaft Calculation version 12-2024 from 11.02.2025.

1.3 Notes

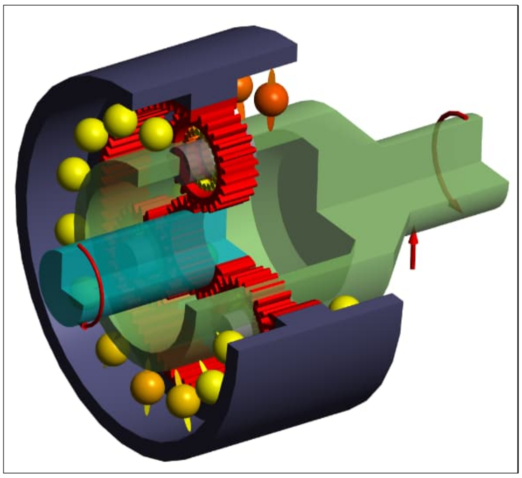
A blue arrow indicates a request to the reader.
A green arrow indicates a conclusion or effect.

2. MESYS Shaft Systems

2.1 General

To get an idea of the possibilities of MESYS shaft systems, we invite you to visit the MESYS website at the specific address for Shaft Systems.

Figure 1



Please consult the corresponding articles on shafts or gears under Home/Downloads/Categories, as illustrated in Figure 2:

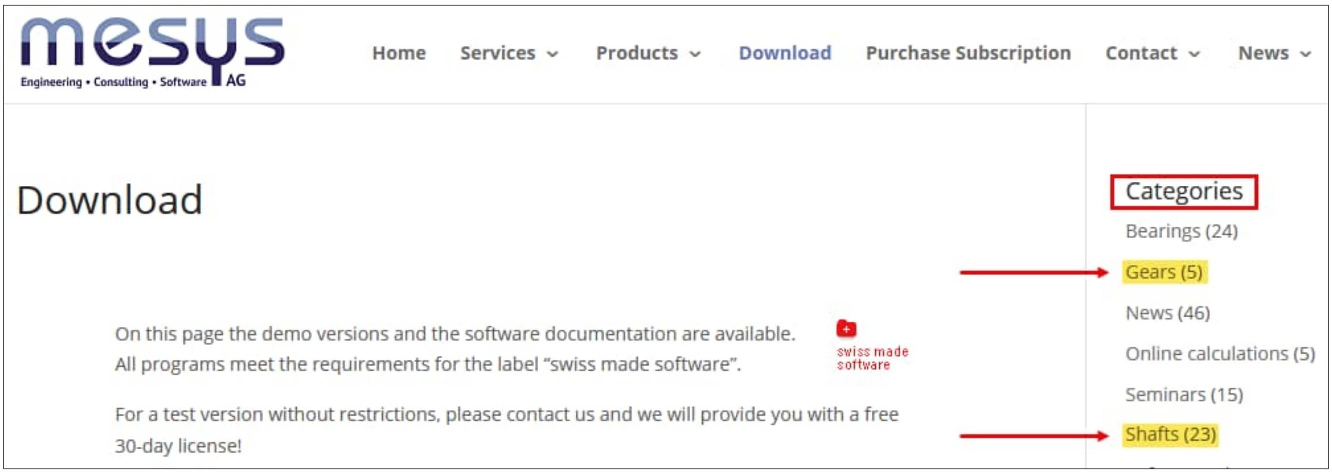


Figure 2

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2.2 Description

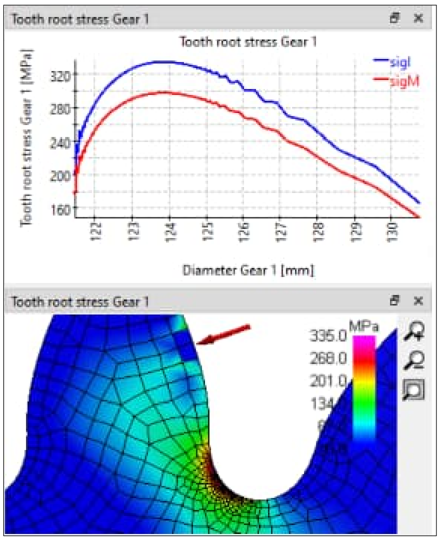


Figure 3

[MESYS Shaft Systems](#) is a software extension to [MESYS Shaft Calculation](#). This makes it possible to display parallel and coaxial shafts in groups and to assign further relationships, connections, conditions or loads to them. This makes it possible to analyse the general dynamic and static states of a gear system or specific resulting bearing states.

With an additional license, gear calculations ([Cylindrical gear pairs](#)) based on corresponding standards (ISO 21771-1 / ISO 6336) can be carried out.

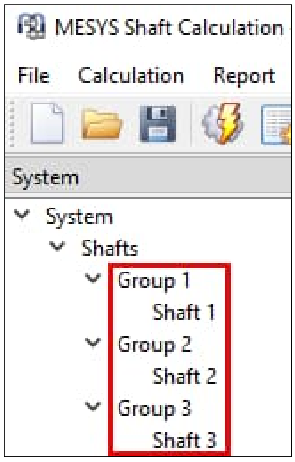


Figure 4

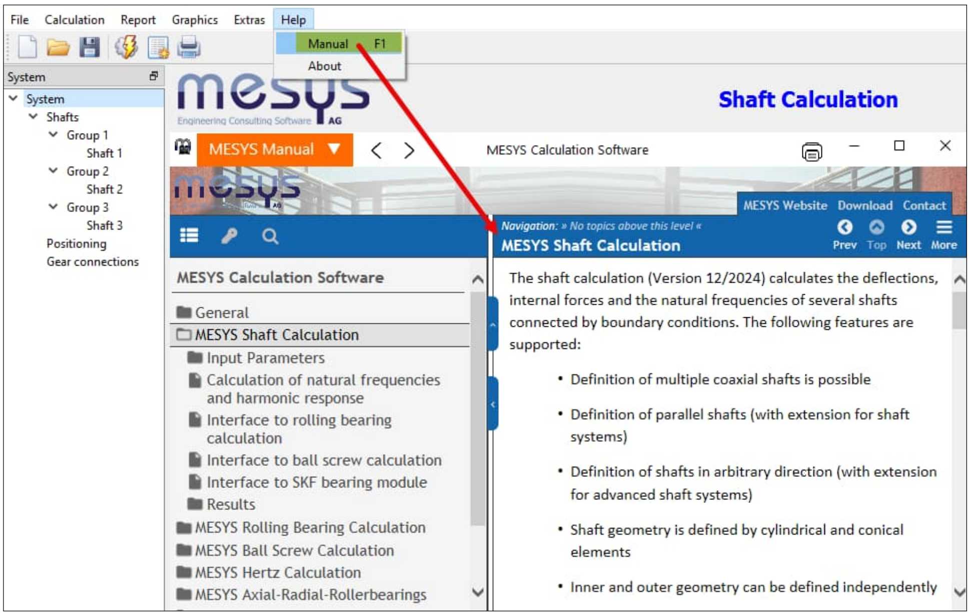
3. Software Manual

3.1 Online-Manual

The software online-manual can be accessed via the user interface by selecting the "Help" menu under "Manual F1" (Fig. 5).

You can open the online manual locally at any time with position-specific content directly via your F1 keyboard or find it via the [website](#).

Figure 5



3.2 Manual as PDF

The software manual can also be found as a PDF file in the main languages within the MESYS installation directory (Figure 6).

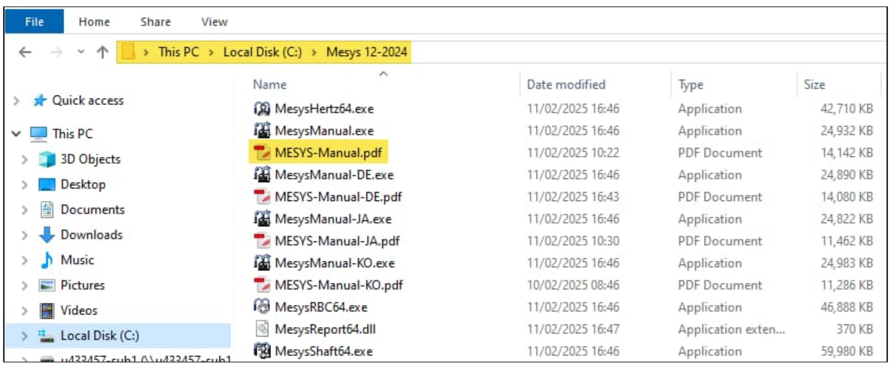


Figure 6

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4. Project of a Shaft System

4.1 Content of the tutorial

An existing 2-stage reduction gearbox is to be used in a new application and its suitability is therefore to be tested. For this common task, MESYS shaft systems are to be used to investigate its suitability and to find the potential for spatial optimization.

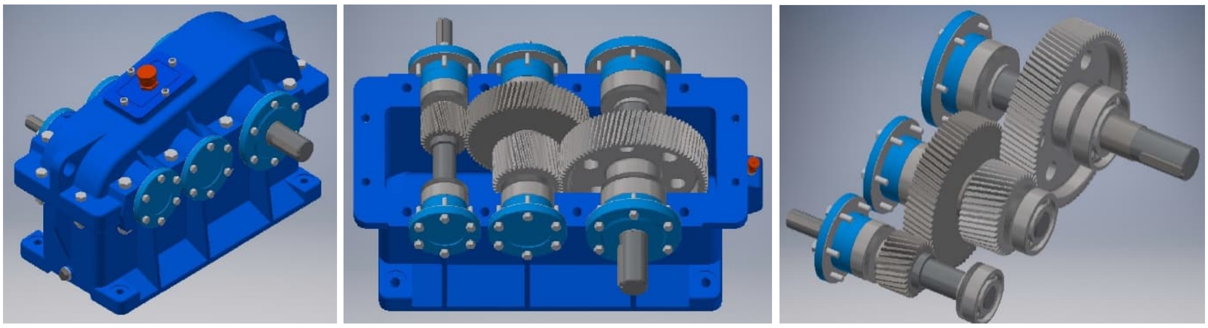
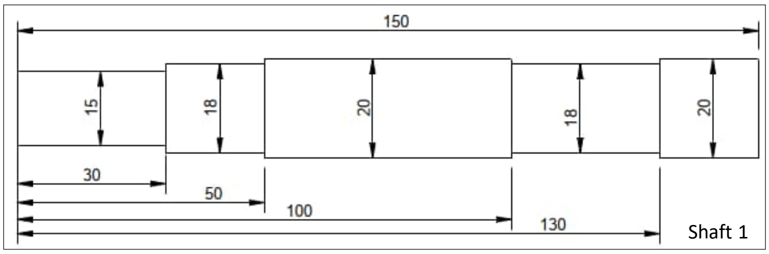
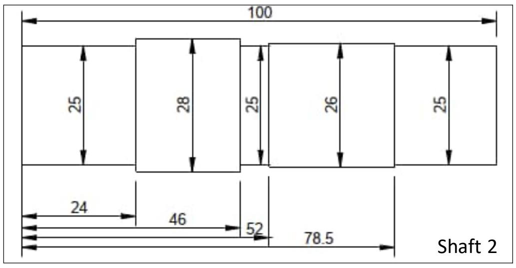


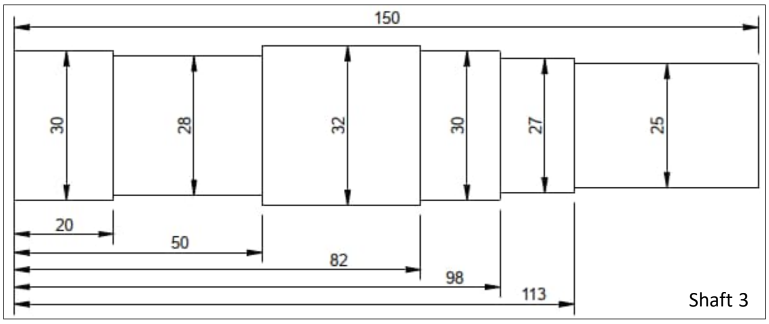
Figure 7

4.2 Initial situation

The current 2-stage gearbox, consisting of 3 shafts, is allegedly defined as follow:







Simplified representation of the shafts.

Table 1

Shaft	Element	Name	Position X	Parameter
Shaft 1	Coupling	Input	10	Mx = 20Nm
	Gear	V1	85	mn=1, α=20, b=20, z=25
	Rolling bearing	B1	60	Deep groove ball bearing 6204
	Rolling bearing	B2	140	Deep groove ball bearing 6204
Shaft 2	Gear	V2	35	mn=1, α=20, b=20, z=60
	Gear	V3	65	mn=1.5, α=20, b=25, z=20
	Rolling bearing	B3	10	Deep groove ball bearing 6205
	Rolling bearing	B4	90	Deep groove ball bearing 6205
Shaft 3	Gear	V4	65	mn=1.5, α=20, b=25, z=50
	Rolling bearing	B5	10	Deep groove ball bearing 6206
	Rolling bearing	B6	90	Deep groove ball bearing 6206
	Reaction coupling	Output	140	

4.3 Modelling

4.3.1 Creating the File

The first step is to analyse the existing gearbox in the current configuration and with the current loads.

Start the MESYS shaft calculation or open a new file via the "New" icon or the File menu item and select 'New' (Figure 8)

The project for the shaft calculation can be given a name and a description under 'System' (Figure 9).

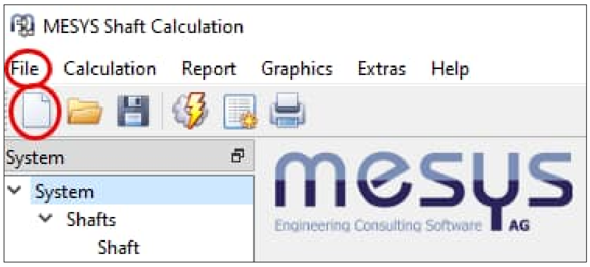


Figure 8

Give the project an example name and save the file.

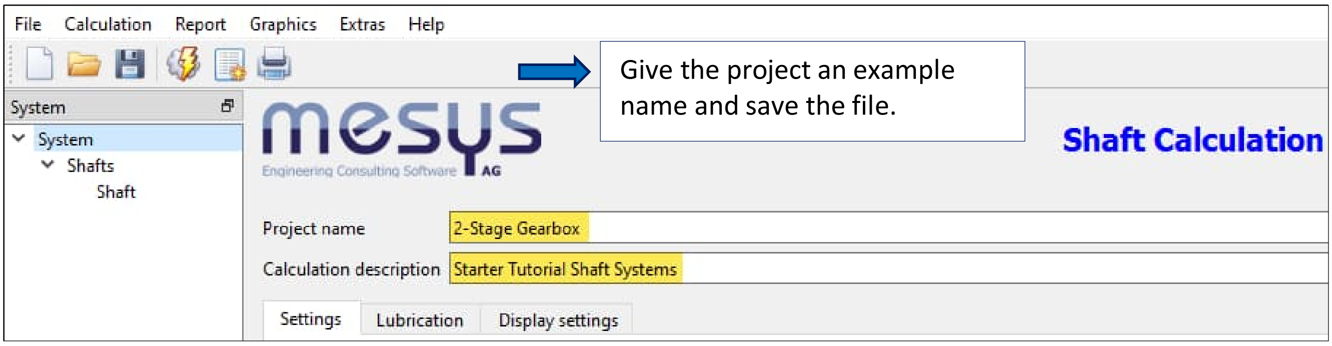


Figure 9

4.3.2 Group

Separate groups are required to calculate parallel shafts.

Please assign 3 groups via the context menu.

Please assign one shaft each and assign the corresponding names (Figure 12).

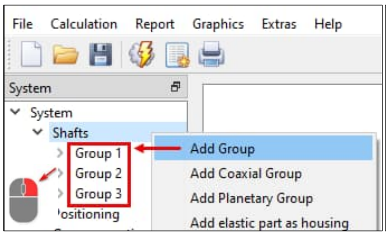


Figure 10

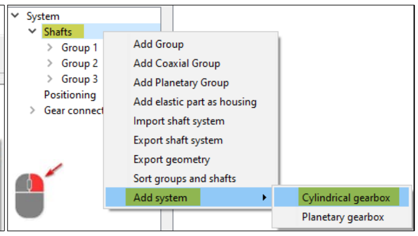


Figure 11

Please note that you can alternatively assign a ready to use 'Cylindrical gearbox' system via the context menu on 'Shafts' (Figure 11).

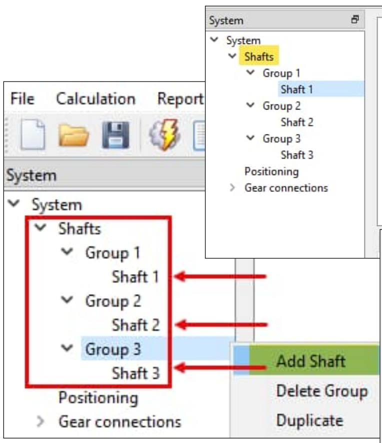
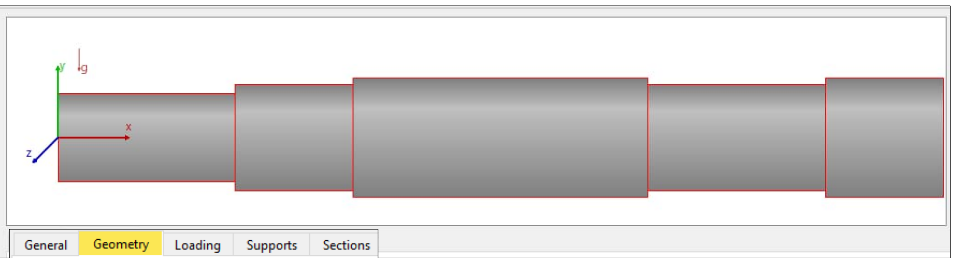
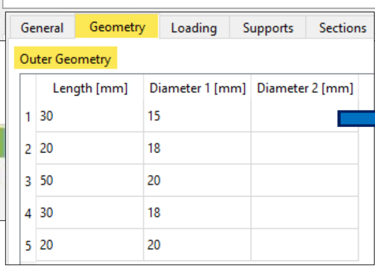


Figure 12





	Length [mm]	Diameter 1 [mm]	Diameter 2 [mm]
1	30	15	
2	20	18	
3	50	20	
4	30	18	
5	20	20	

Please reproduce the geometry of the shafts according to Table 1.

Alternatively, the shaft geometries can be created via import in step format. We are happy to refer you to further tutorials.

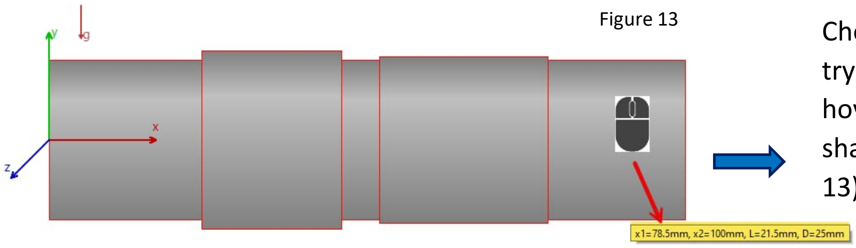


Figure 13

Check and compare your shaft geometry with section [4.3 Initial Situation](#) by hovering the mouse over the interested shaft segment for a moment (Figure 13).

4.3.3 Rolling Bearing

4.3.3.1 Selection

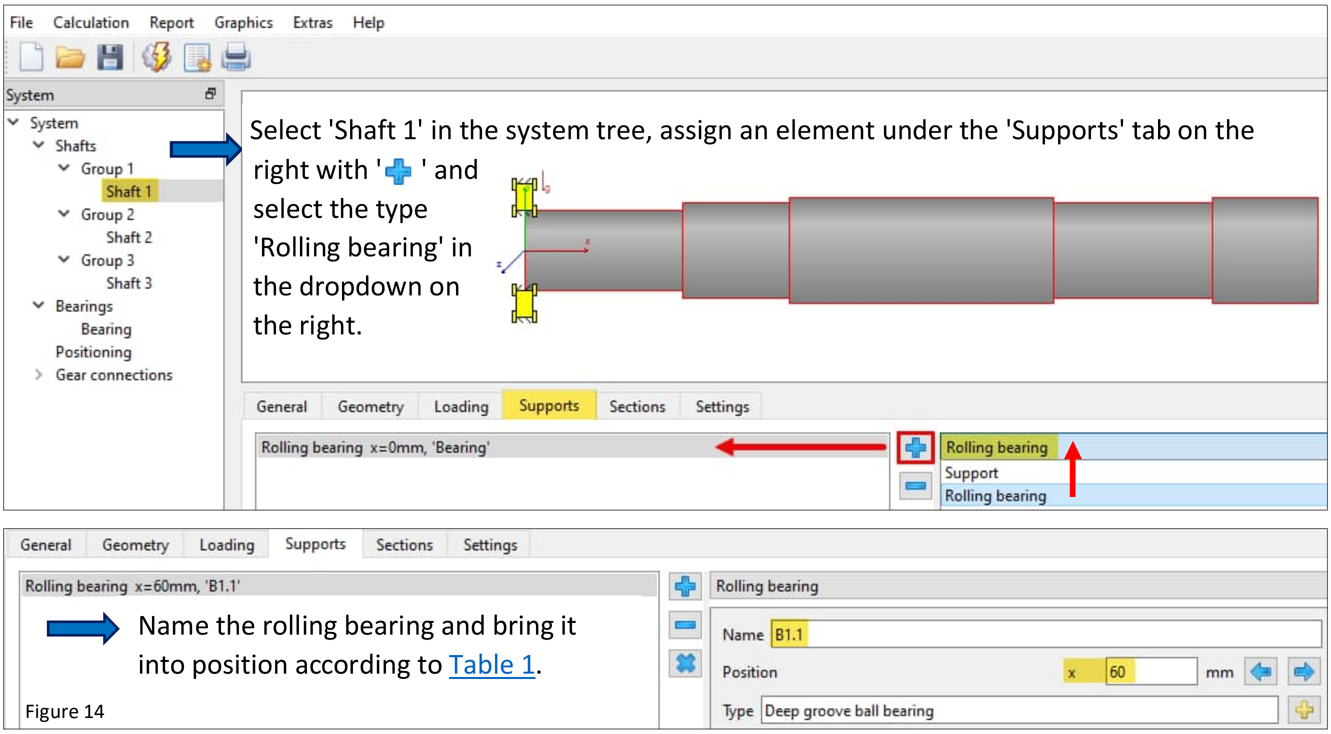


Figure 14

From here, the rolling bearing module for a specific bearing selection can be accessed via the ' ' button at the bottom right, via a window, or in the system tree directly via the representative designation 'B1.1' now shown here (Figure 15).

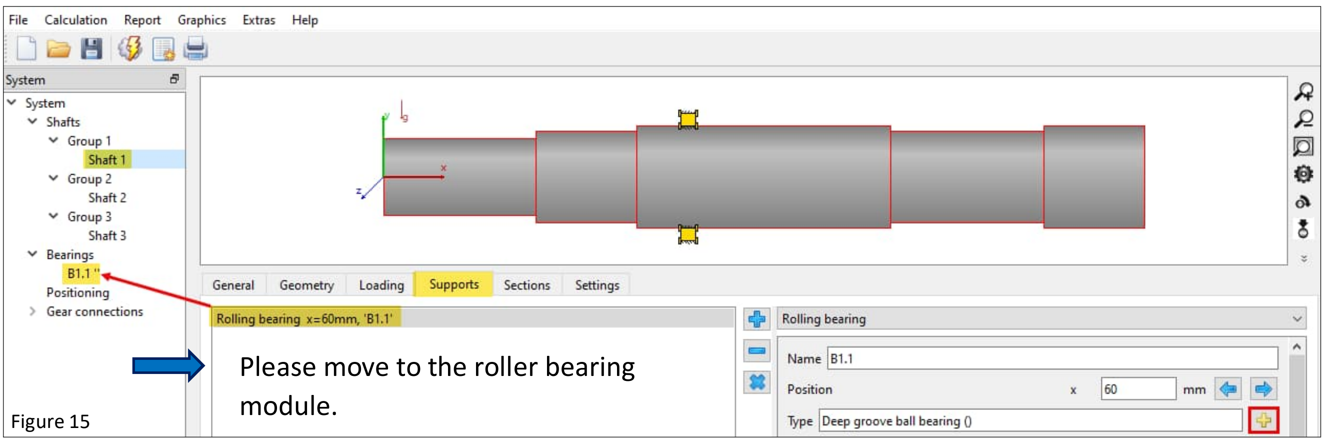
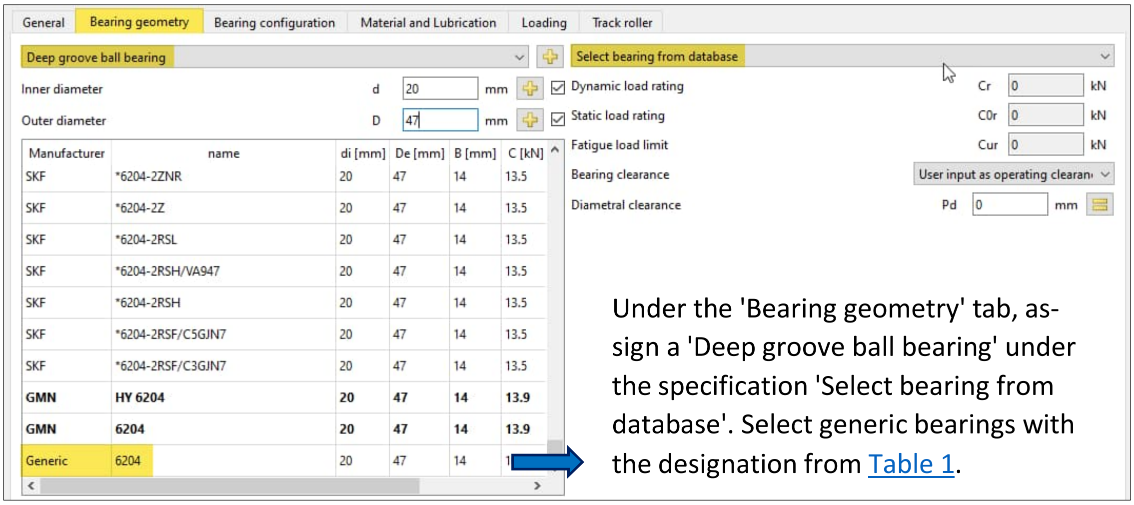
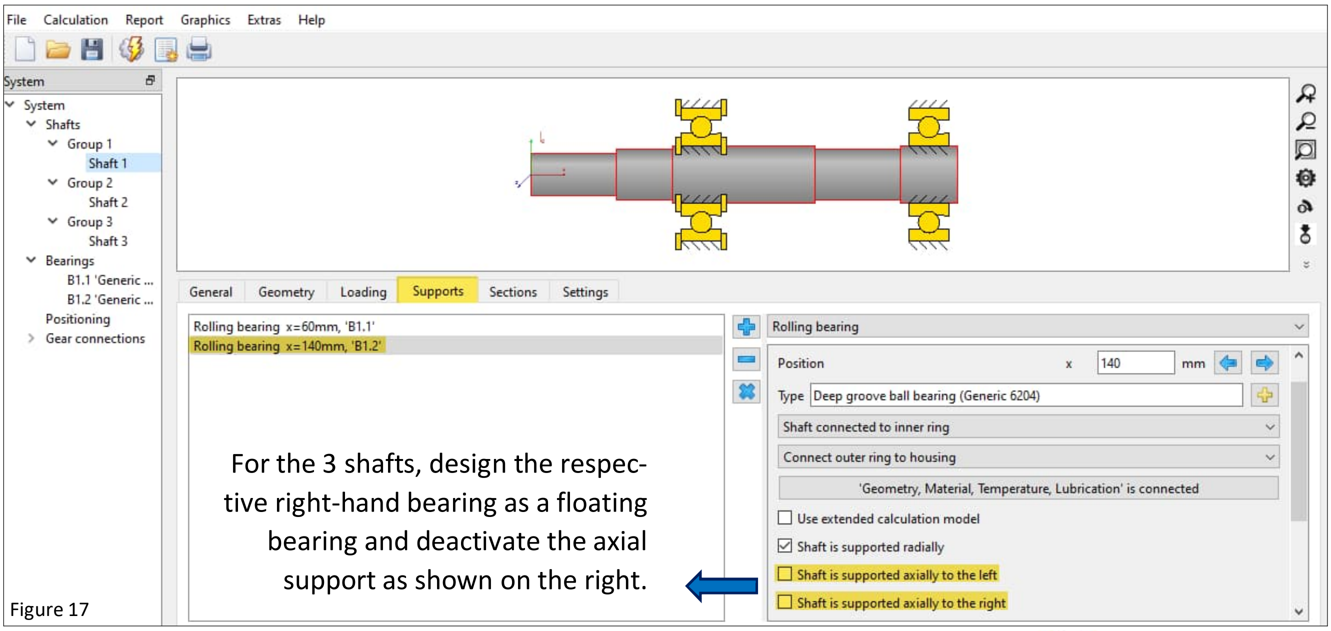


Figure 15



Under the 'Bearing geometry' tab, assign a 'Deep groove ball bearing' under the specification 'Select bearing from database'. Select generic bearings with the designation from Table 1.

Figure 16



For the 3 shafts, design the respective right-hand bearing as a floating bearing and deactivate the axial support as shown on the right.

Figure 17

For the purposes of this tutorial, please leave bearing settings such as 'bearing clearance' or related fits untouched. We would like to refer you to the Starter Tutorial Basics for rolling bearing calculation.

Assign the remaining rolling bearings for all shafts (Figure 18) and assign the corresponding names.

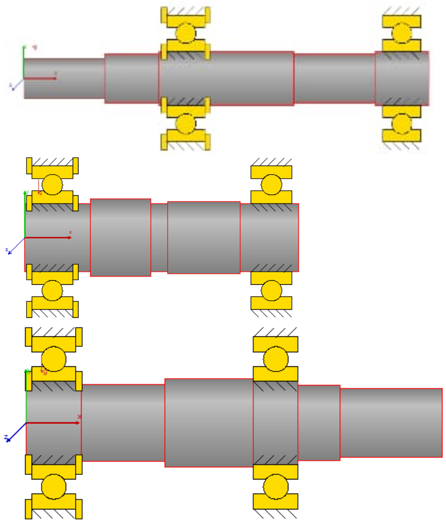


Figure 18

4.3.3.2 Lubricant

Please assign the lubricant (Figure 19):

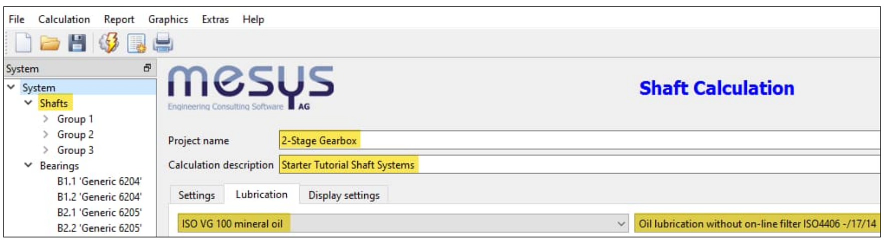


Figure 19

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4.3.4 Gearings

4.3.4.1 Cylindrical gears

Select Shaft 1 in the System tree, assign an element under the 'Load' tab with ' ' and select the 'Spur gear' type in the dropdown on the right (Figure 20).

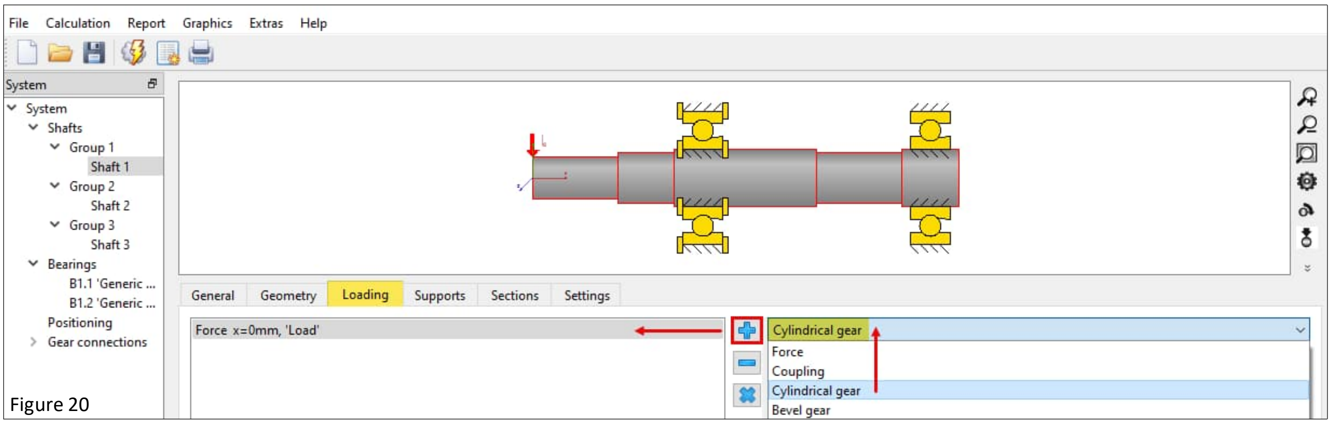

Figure 20

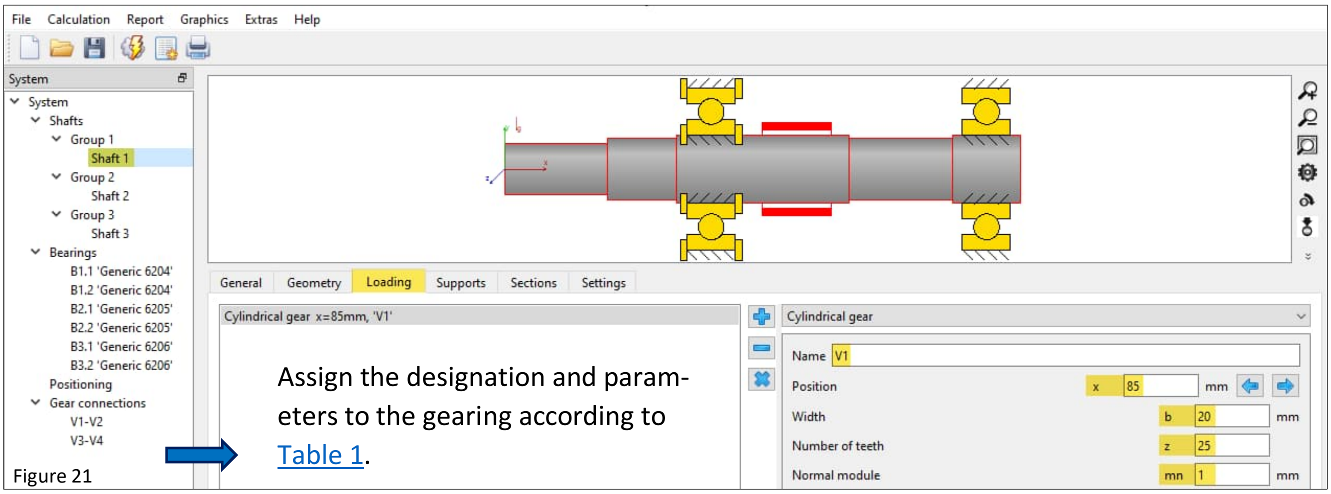

Figure 21

Complete all gearing parameters for the remaining shafts (Fig. 21).

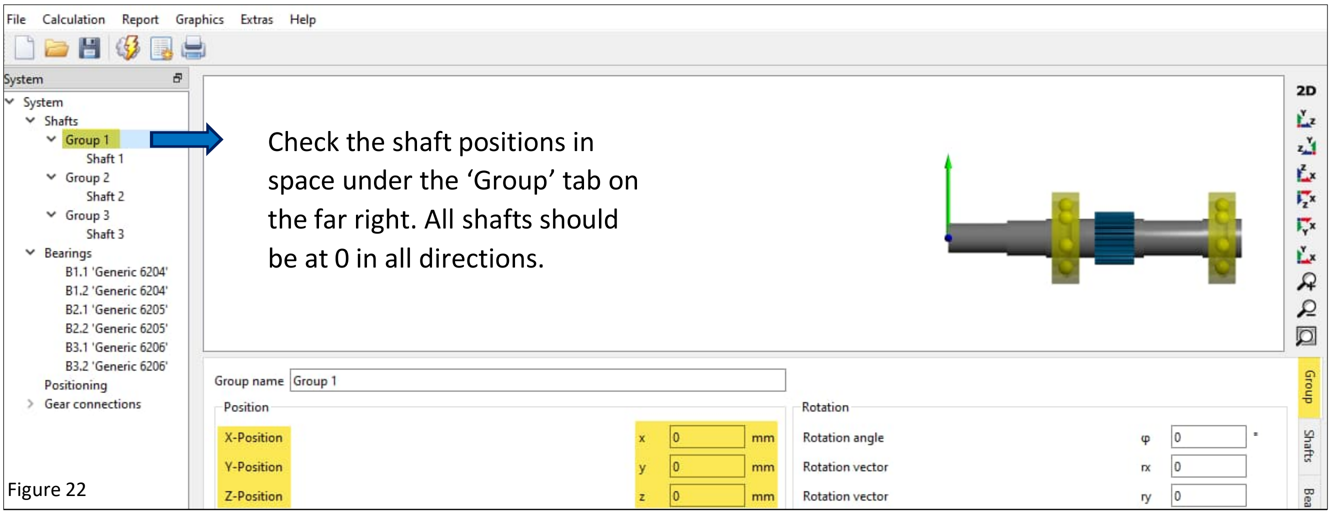

Figure 22

The gears are not aligned with each other (Figure 23).

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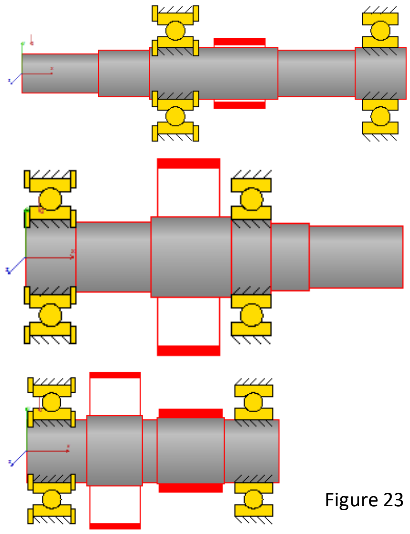


Figure 23

Move to 'Gear connections' via the system tree on the left (Figure 24).

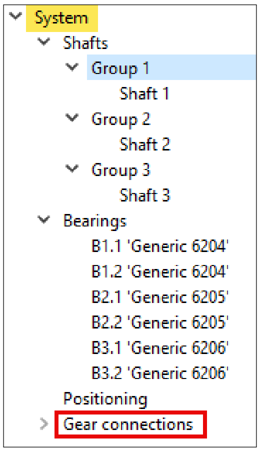


Figure 24

4.3.4.2 Gear connections

In the next step, the gearings must be assigned and brought into engagement. The 'Gear connections' window can be accessed under the system tree (Figure 25).

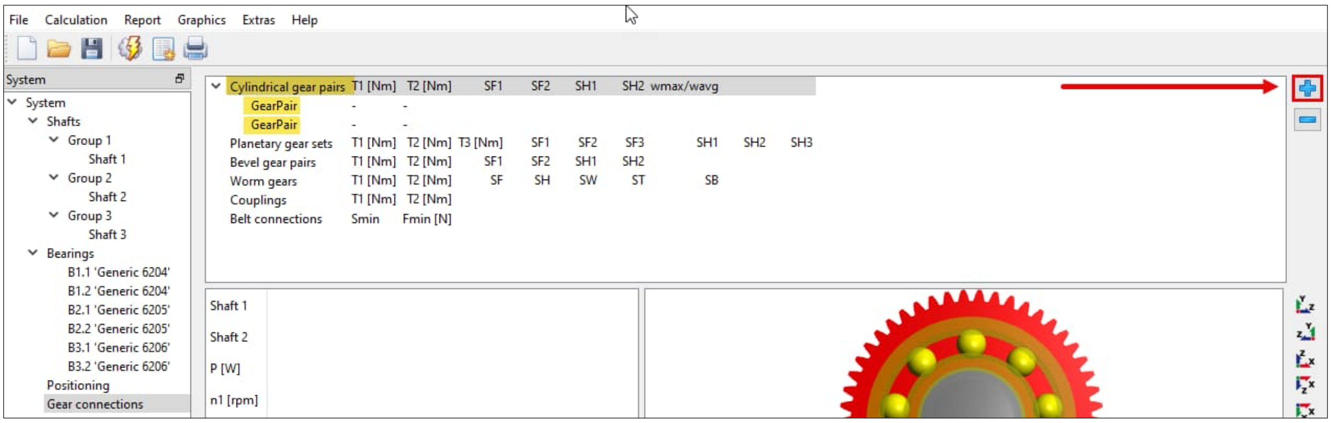


Figure 25

Activate 2 gear pairs ('GearPair') using the ' ' button, as shown in Figure 23.

The shafts and gears in contact can be defined here, and the basic data for the gear pair is displayed. In addition to the individual shaft inputs, the gear data can also be modified in this window. However, through this connection, the data for both gears can be adjusted simultaneously (Fig. 26).

Connect the two gear pairs as shown in Figure 26 and select appropriate colours for them.

GearPair 1 GearPair 2

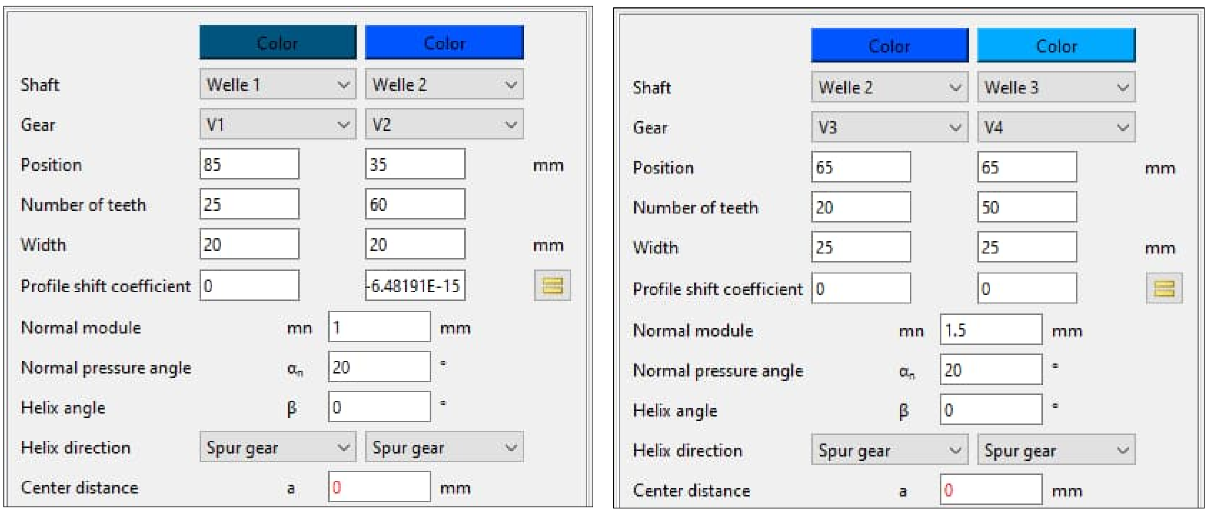


Figure 26

Leave the remaining gear-specific parameters and calculation modes unchanged for the scope of this tutorial.

A series of input and output fields refer to parameters for the design of gearing. For general gear calculations, we are happy to refer to specific training materials.

At this point, the coordinates of all groups are still set to zero. In the right-hand window of the gear connection dialog, all groups are therefore displayed at the coordinate origin (Figure 27).

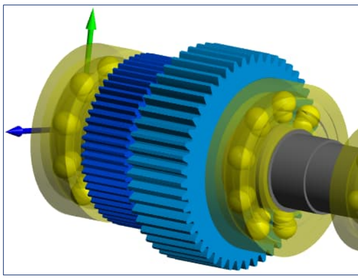
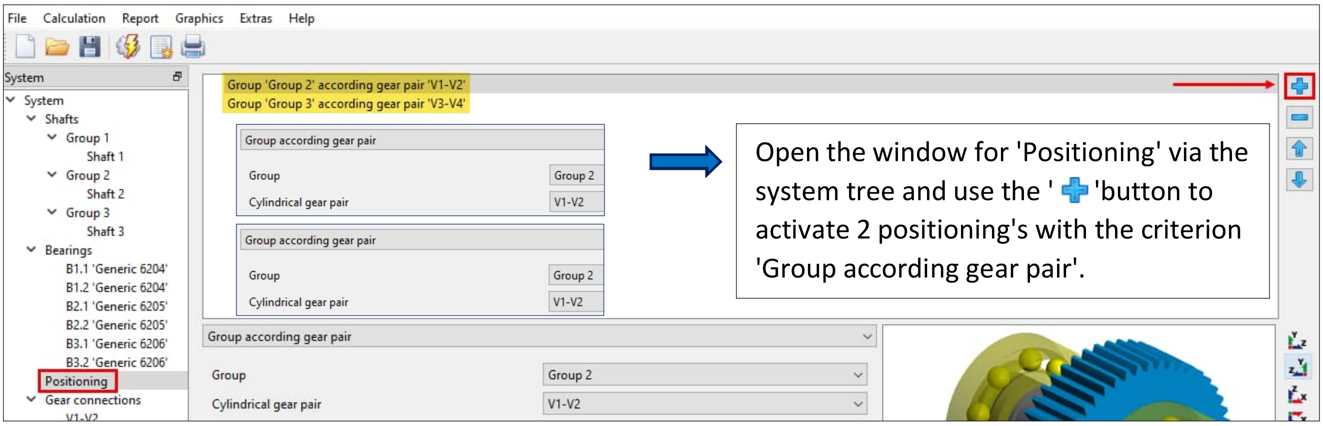


Figure 27

4.3.4.3 Positioning of the Gearings

The groups should now be aligned relative to Group 1 according to the gear connections. The 'Positioning' window can be activated under the system tree (Figure 28). Positioning can be carried out based on various criteria, such as the relationship between gears or groups.

Figure 28



As a result, the groups have now been aligned, which can also be called up in the right-hand window of the 'Gear connections', 'Positioning' and also in the window for 'Shafts' via the System tree (Figure 29).

The coordinates of the groups or shafts can also be viewed numerically via the Group 1-3 system tree and then by selecting the 'Group' tab on the far right.

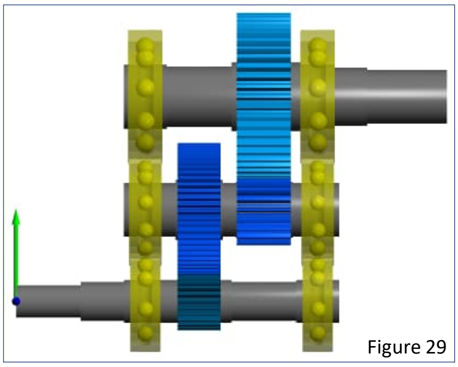


Figure 29

4.3.5 Correction

Figure 29 also shows that the shafts are positioned too close to each other and the roller bearings collide. For the purposes of the tutorial, let's assume that the documentation of the gearing of the analysed gearbox was incorrect. We therefore correct the module in the two gearings in a suitable manner (Figure 30).

Correct the module for V1 & V2 to 1.25 and for V3 & V4 to 1.75.

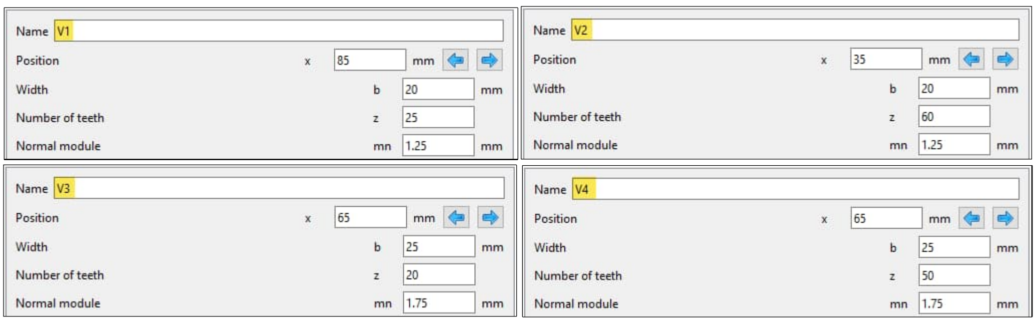


Figure 30

The correction for the gearing and subsequent positioning was successfully carried out (Figure 31).

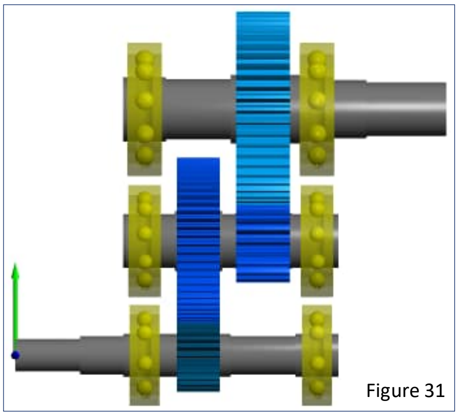


Figure 31

4.3.6 Load

4.3.5.1 Torque

The designed input torque for the current gearbox according to Table 1 is 20 Nm.

Select 'Shaft 1' in the system tree, assign an element under the 'Loading' tab with ' ' and select the type ”Clutch’ from the dropdown on the right (Figure 32). Assign the corresponding name.

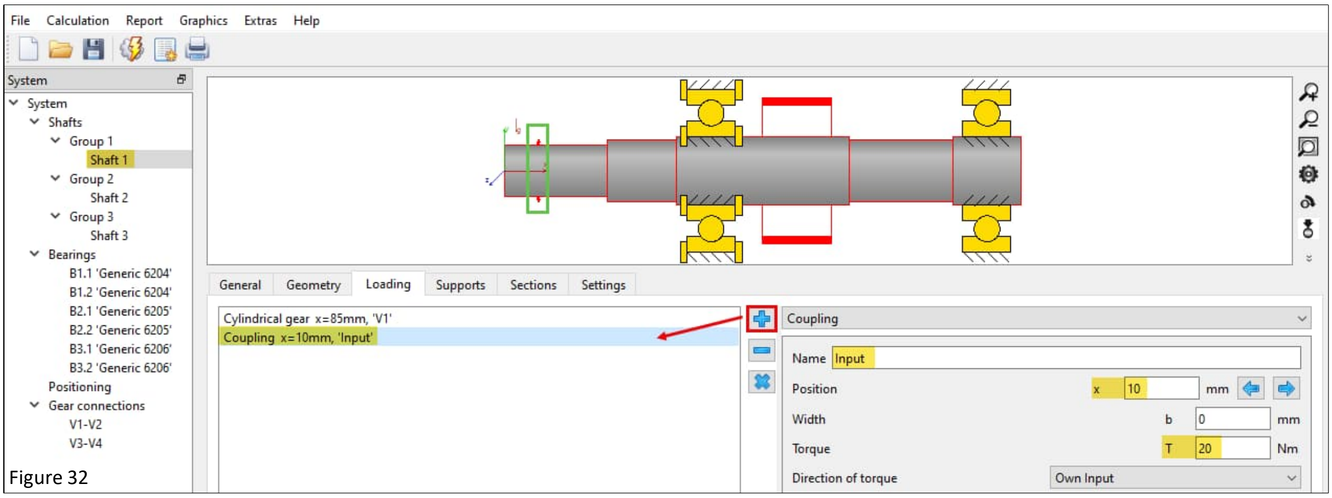
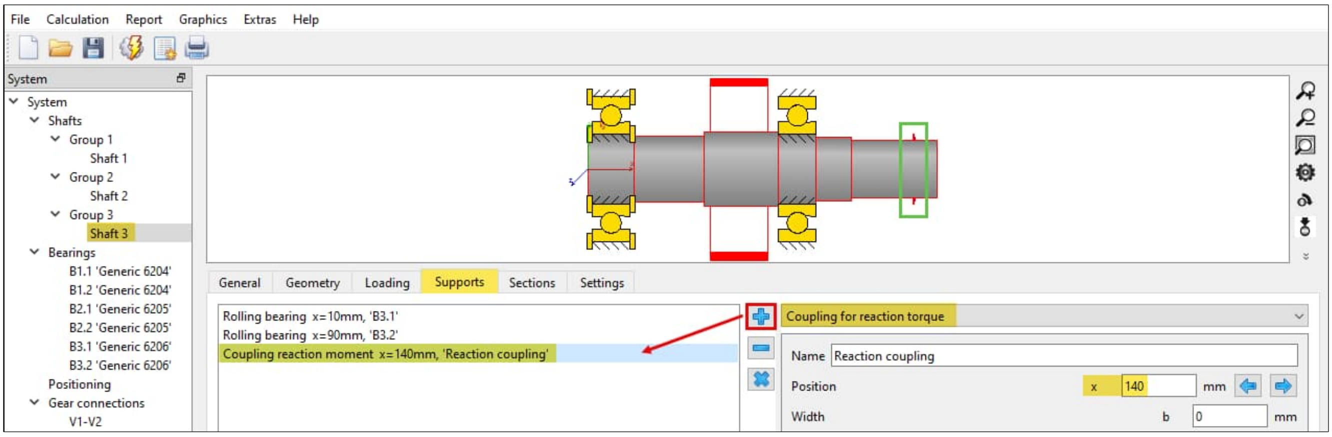


Figure 32

The direction of torque can be defined either by its sign or by selecting 'Shaft is driven' / 'Shaft is driving'. Leave this at 'Own input'.

Select 'Shaft 3' in the system tree, assign an element under the 'Supports' tab with ' ' and select the type 'Coupling for reaction torque' from the dropdown on the right (Figure 33). Assign the corresponding name.

Figure 33



Please note that the display width of a coupling, as well as its activation in modal analysis for the 'Coupling for reaction torque', has no relevance for this calculation.

4.3.6.2 Rotational speed

Before the calculation can be activated, the gearbox should be assigned the usual input speed.

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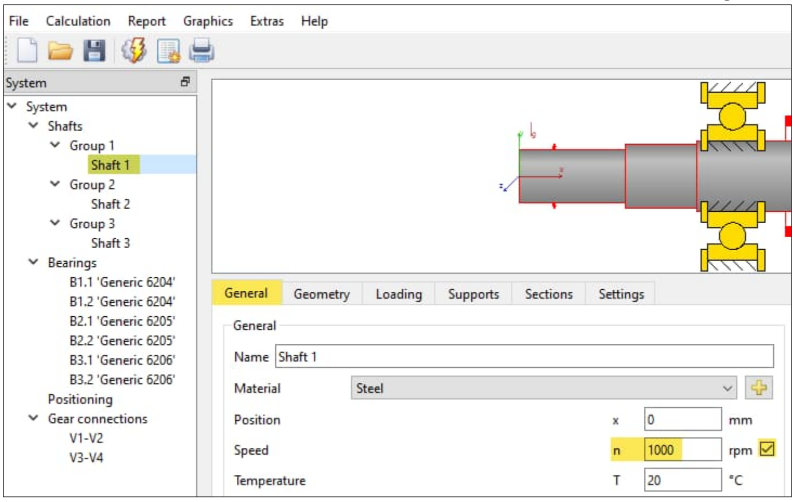
Select 'Shaft 1' in the system tree and assign a speed of 1000 rpm under the 'General' tab (Figure 34).

Figure 34



This concludes the input of the parameters for the mathematical representation of this gearbox.

4.3.7 Optimisation

It is assumed that, within the scope of the preceding task, the total height of the gearbox needs to be limited due to spatial constraints in the application. One possible approach could be relocating Group 2 and Group 3.

Current situation:

	Group 1	Group 2	Group 3
x	0 mm	50 mm	50 mm
y	0 mm	53.125 mm	114.375 mm
z	0 mm	0 mm	0 mm

Viewing direction X

Figure 35

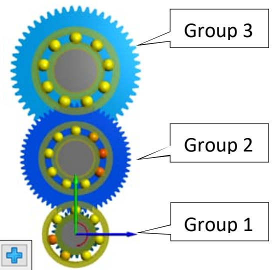
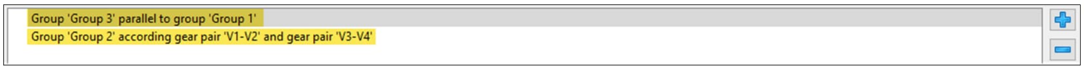


Figure 36

Edit the 2 current positioning rules (Figures 39 / 40).



Generate a third, additional positioning rule (Figure 41).

Shaft 'Shaft 3' according gear pair 'V3-V4'

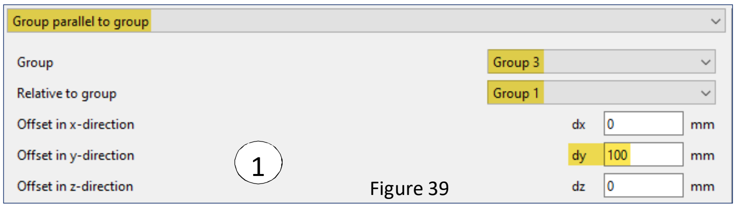


Figure 39

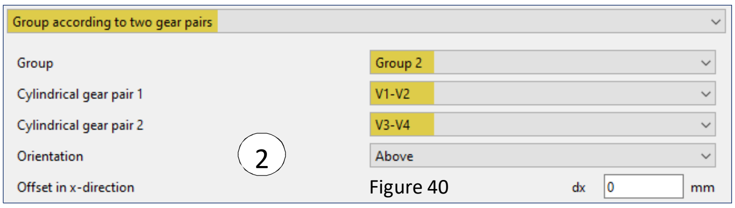


Figure 40

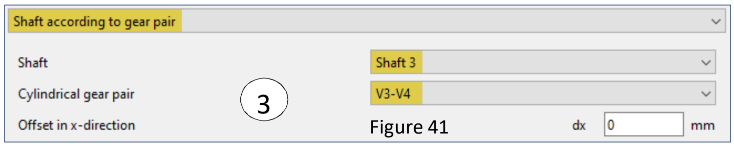
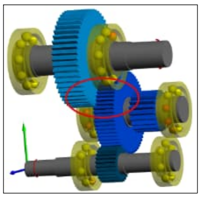


Figure 41

Shaft 3 still requires axial alignment in addition to the 2nd rule.

Figure 37



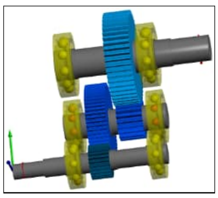


Figure 38

The shafts and gears are now correctly aligned with each other.

New situation:

	Group 1	Group 2	Group 3
x	0 mm	50 mm	0 mm
y	0 mm	45.3535 mm	100 mm
z	0 mm	-27.6645 mm	0 mm

Viewing direction X

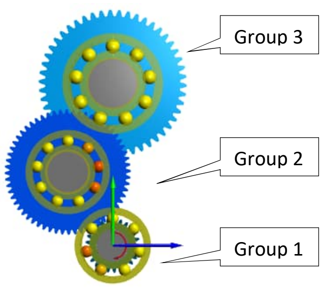


Figure 42

The optimisation to save vertical space was successful (Figure 42).

5. Calculation

5.1 Settings

For gear calculations, the "required service life H" should be defined in the 'Settings' window of the system tree/system if possible (Figure 43). This value is considered not only in the evaluation of the gearing but also in the calculation of shaft strength according to DIN 743. For further information, please refer to the manual under Required Life and Strength Calculation.

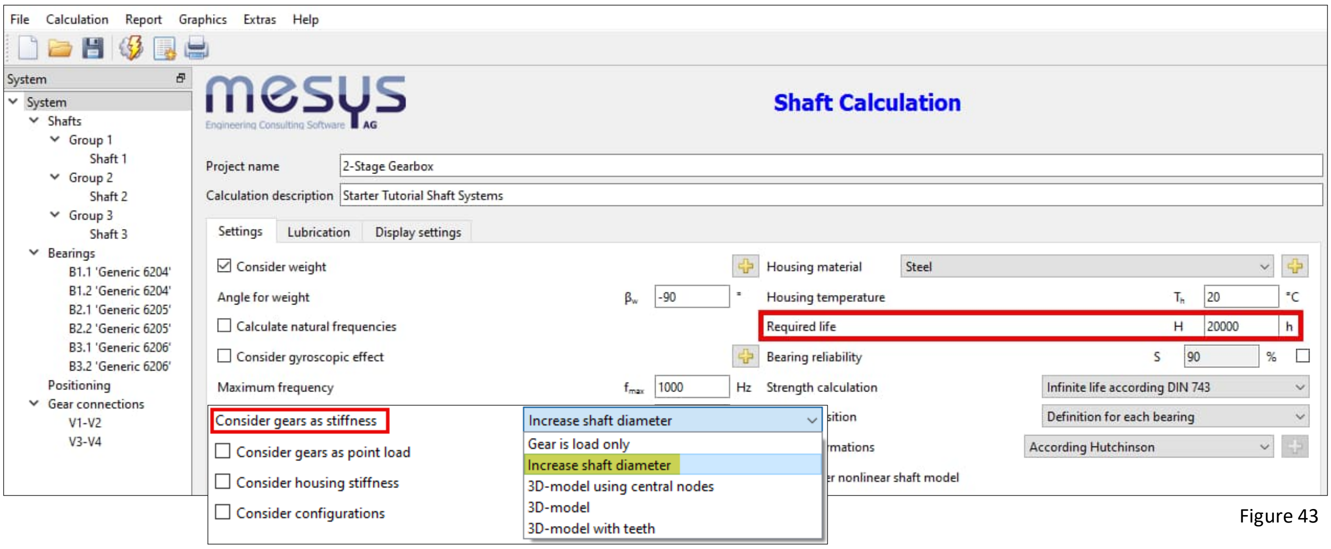


Figure 43

Additionally, a selection should be made for the possible settings under "Consider gears as stiffness" (Figure 43). For example, when selecting 'Increase shaft diameter', the shaft diameter is automatically increased to the root circle diameter plus 0.4 * module. For the root diameter a dedendum of the reference profile of 1.25 is assumed. Please refer to the manual under Consider gears as stiffness for further details on the corresponding settings..

5.2 Calculation step

The calculation step can be carried out via the menu item 'Calculation'/Calculate', directly via the icon under the ribbon or simply by pressing F5.

- Please start the calculation.
- Pay attention to the green tick at the bottom right, which confirms the consistency of the calculation step.

6 Results

6.1 Overview

The 'Result overview' at the bottom of the window shows the most important results (Figure 44). Its contents can be configured as required via the menu Extras / Result overview.

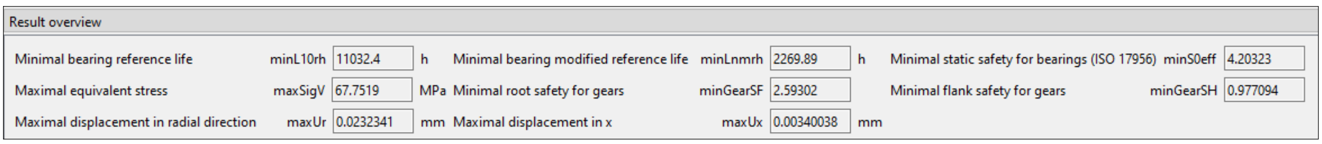


Figure 44

- It becomes evident that by selecting a higher synthetic viscosity and cleanliness class for the lubricant, the modified reference service life (Figure 45) could be significantly increased to the value H.

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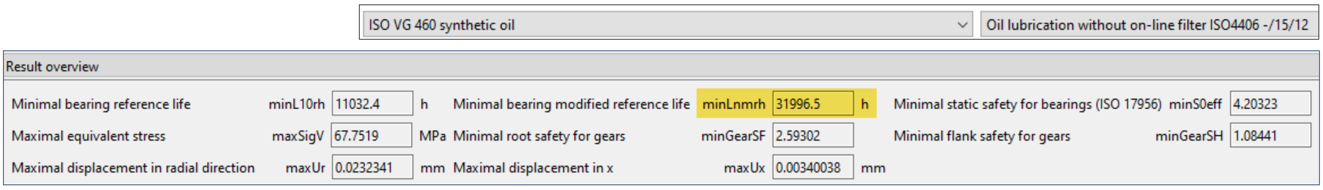
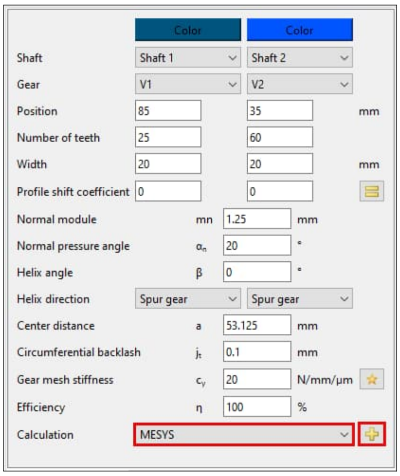


Figure 45

The results overview also displays results depending on the activated license. In the present example calculation, the gear calculation was activated, even though the corresponding inputs were not edited.

Figure 46



If the need arises to use the license for spur gear calculation, the gear calculation can be activated as shown in Figure 46 and evaluated based on the relevant input and output data. We would like to refer to additional literature or the manual under Gear connections for further details.

6.2 Overview of Gear Connections

6.2.1 Gear calculation

The gear calculation can be opened by selecting the gear pair in the system tree under Gear connections (Figure 47). The gear parameters can be edited here, and upon closing the gear calculation, the inputs will be read back into the system.

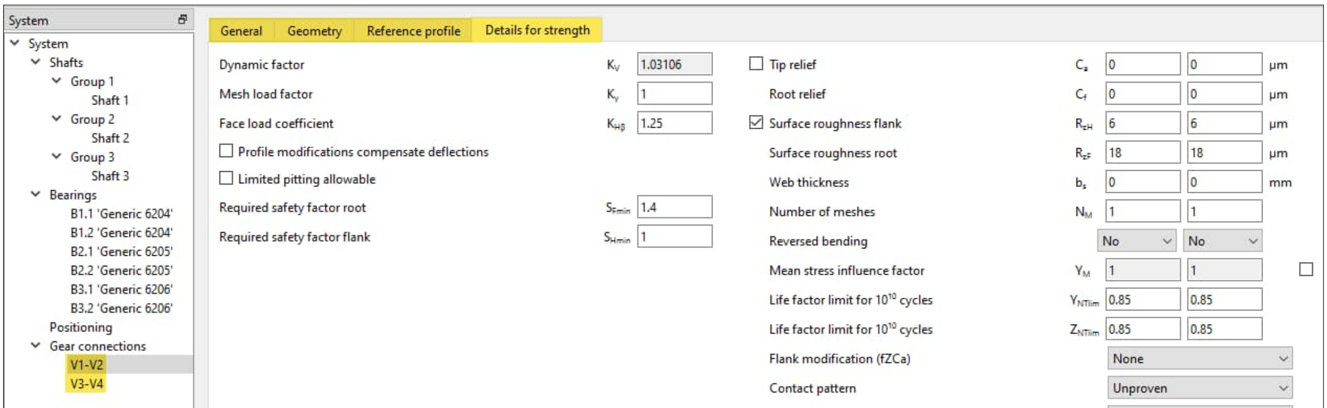


Figure 47

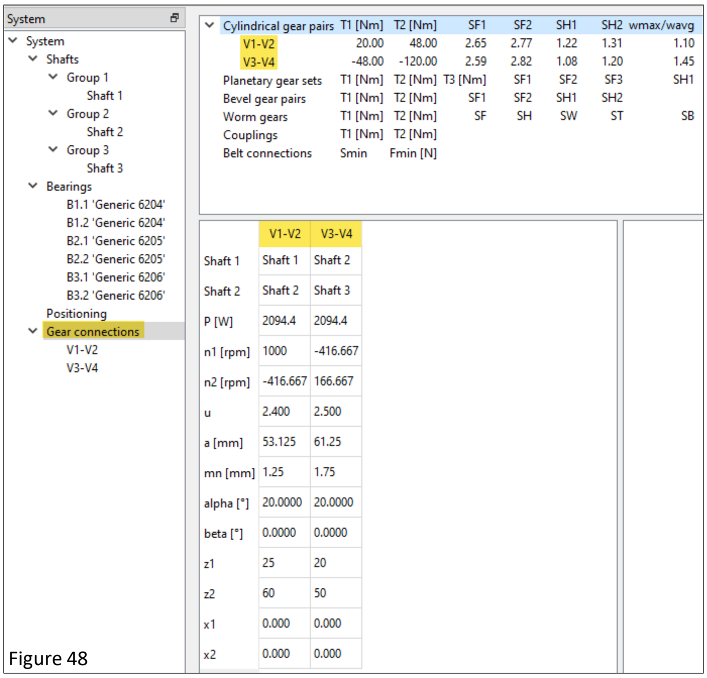


Figure 48

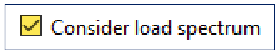
6.2.2 Results of gear calculation

In the 'Gear connections' window (Figure 48), the torques, safety factors for bending strength and pitting resistance (SF / SH), as well as the maximum and average load distribution across the face width (wmax / wavg) according to ISO 6336 are displayed for each gearing.

In the lower window, performance data, geometric data, and profile shift factors (x1 / x2) are displayed.

6.3 Load spectrum

A load spectrum can be entered via the system window under the Settings tab. This allows access to the corresponding input window through the system tree. For more details, please refer to our Shaft Starter Tutorial or the manual under Calculation with load spectrum.



6.4 Graphical Representation of Results

6.4.1 Specific

In addition to numerous other graphics available under the Graphics menu for evaluating the gearing, the line load and gap width over position for the current calculation are shown below (Figure 49).

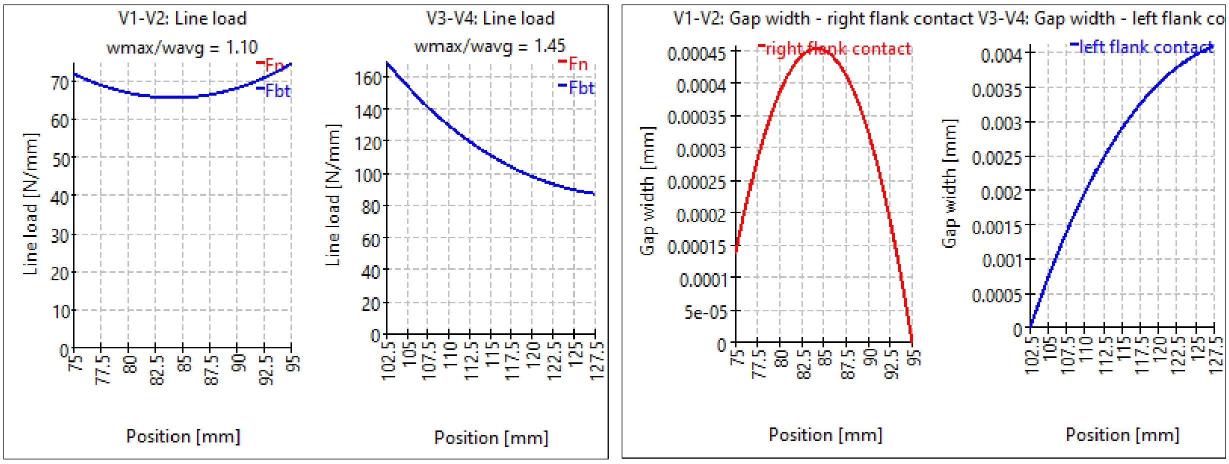


Figure 49

Fn: Normal force
Fbt: Force in the transverse plane (here Fbt = Fn)

➡ The gap width indicates the distance between the flanks if the load transfer were to occur at a single point. In the present case, a flank line correction based on a maximum gap width of 0.45 µm would not be economically justifiable.

➡ The diagrams (Figure 49) were generated using the Increase shaft diameter setting. Tooth engagement stiffness, shaft stiffness, and bearing stiffness influence these diagrams. Additionally, manufacturing errors and housing stiffness also affect the real gearbox.

6.4.2 Graphics Menu

A large selection of graphical result visualisations is available via the 'Graphics' menu (Figure 50).

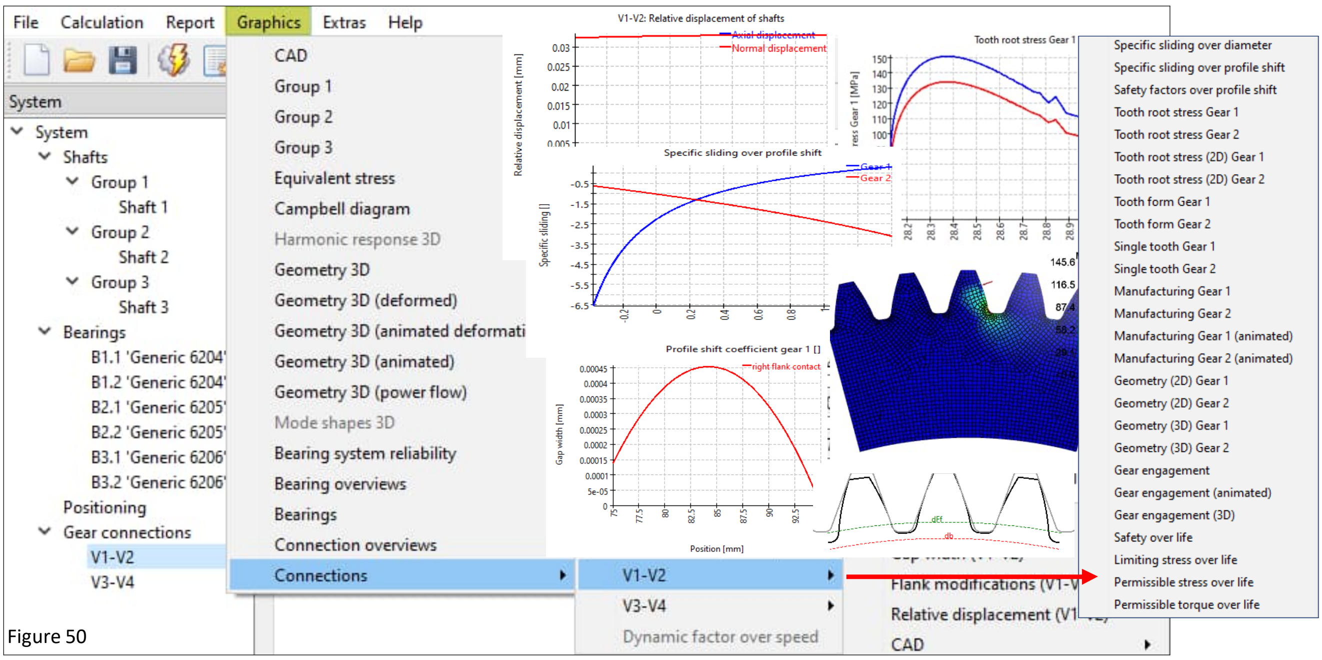


Figure 50

The graphics can be docked to the main programme interface with the current outputs and are automatically updated after each calculation (Fig. 51). Drag the graphics into the results overview or under the menu bar.

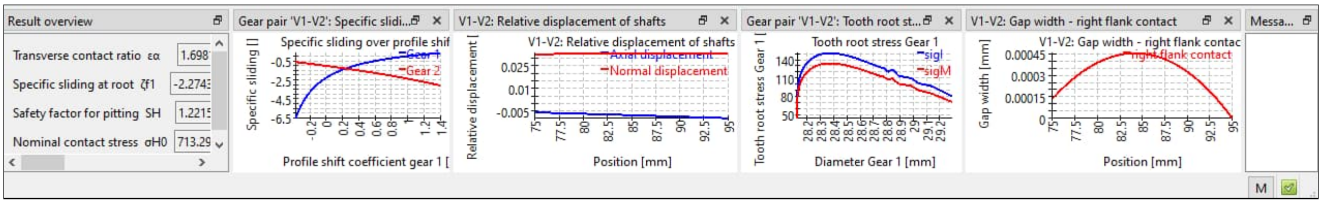


Figure 51

6.4.3 Export

Through the context menu and by selecting the 3D Geometry option, the shaft system or its components can be exported as an STL or STEP file for further use:

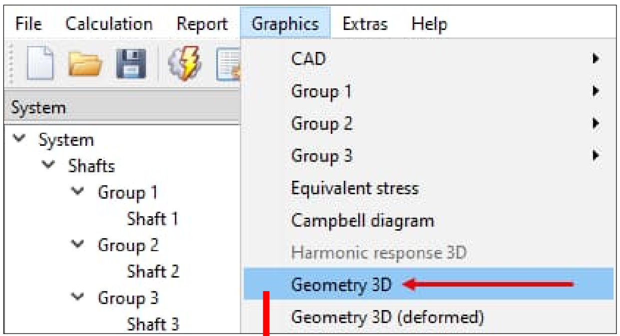
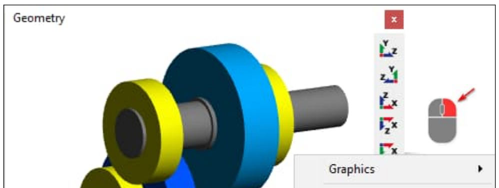
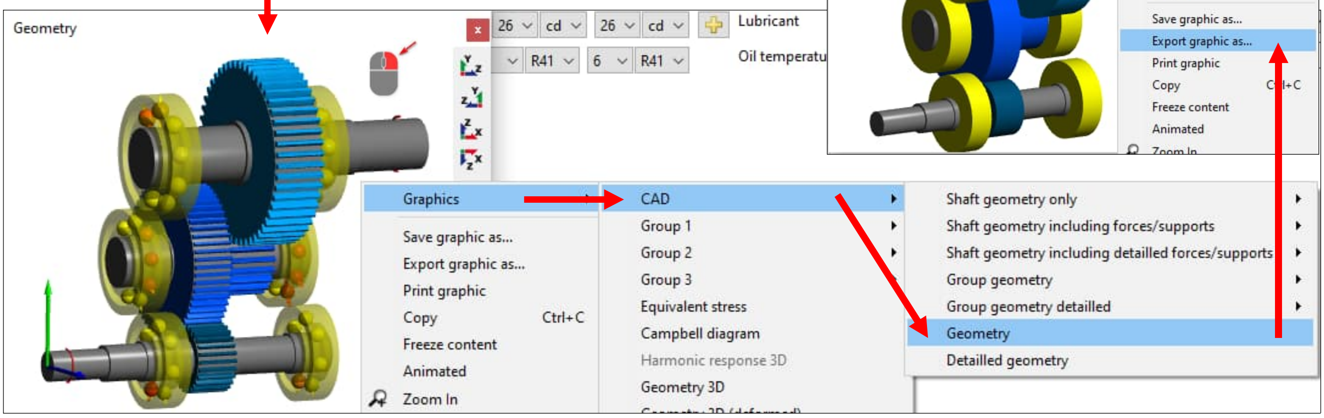


Figure 52





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