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Tutorial

Shaft systems - Starter
3-speed manual gearbox

Table of contents

1. Foreword 2
1.1 Aim of the tutorial 2
1.2 Prerequisite 2
1.3 Software version 2
1.4 Notes 2
2 MESYS Shaft Systems 2
3. Shaft System Project 2
3.1 Content of the tutorial 2
3.2 Initial situation 2
3.2.1 Requirements 2
3.2.2 Definition of main components 3
4. Model 3
4.1 Concept 3
4.2 Computational representation 3
4.2.1 Geometries 3
4.2.2 Overview of parameters 3
4.2.3 Boundary conditions & loads 4
4.2.4 Gear connections 5
4.2.5 Positioning 5
4.3 Configuration 6
4.3.1 General 6
4.3.2 Operating States 6
4.3.3 Load spectrum 7
5. Results 8

1. Foreword

1.1 Aim of the tutorial

This starter tutorial for MESYS Shaft Systems presents the software's functionalities and provides an overview of the computational analysis of parallel shaft systems. It covers only those topics and settings that are based on a fundamental familiarity with the product and are aligned with the exercise content.

1.2 Prerequisite

MESYS Shaft Systems is an extension of MESYS Shaft Calculation. Successful completion of this tutorial requires that the tutorials Starter Basics for MESYS Rolling Bearing Calculation and Starter Basics for MESYS Shaft Calculation have been successfully completed. Please do not hesitate to contact MESYS if you have any questions regarding the use of the software.

1.3 Software version

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

1.4 Notes

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

2 MESYS Shaft Systems

To get a complementary picture of the possibilities of MESYS Shaft Systems, we cordially invite you to visit the MESYS website at the specific address for Shaft Systems.

3. Shaft System Project

3.1 Content of the tutorial

This content is intended to provide the user with some guidelines for modelling gear changes in parallel shaft transmissions.
As part of the design of a stationary milling system for agricultural applications, a three-stage gearbox driven by a 12 kW diesel engine is to be implemented. The mechanical suitability of the proposed configuration will be evaluated using the MESYS Shaft Calculation software. In addition, operation in each gear is to be evaluated in terms of load and service life using a load spectrum.

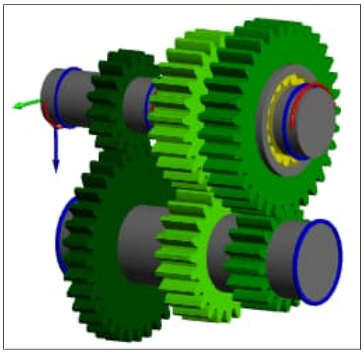

Figure 1

3.2 Initial situation

3.2.1 Requirements

The following requirements must be taken into account due to the interfaces to system components:

Input speed:	2000 rpm
Engine torque:	approx. 50 Nm
Output speeds:	530 / 870 / 2000 rpm
Torque output:	approx. 190 / 115 / 50 Nm

3.2.2 Definition of main components

Since this is a focused examination of gear-shifting behaviour modelling within the MESYS Shaft Systems module, supporting elements such as required rolling bearings are abstracted and represented generically as 'Support'. In the following content, neither a housing nor the detailed mechanics of the synchronizer hub or sleeve will be modelled, nor will condition-dependent influences such as temperature or material properties be taken into account.

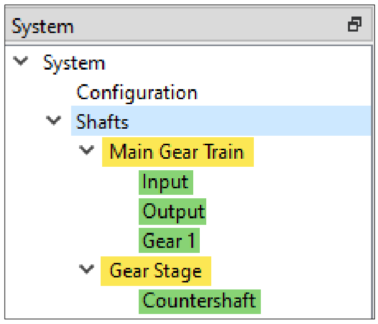

Figure 2

The gearbox should consist of two 'groups', which in turn each contain the necessary shafts. Due to the numerous elements in the model to be created, practical designations and abbreviations are to be defined for the sake of clarity (Table 2).

Designation		Outer geometry [mm]		Internal geometry [mm]		Position in X [mm]	Speed [rpm]
Group	Shaft	Length	Diameter	Length	Diameter		
Main Gear Train	Input	50	20	-	-	0	2000
	Output	60	25	-	-	50	-
	Gear 1	20	40	20	33	80	-
Gear Stage	Countershaft	100	28	-	-	0	-

Table 1

Main Gear Train: Gear Stage: Countershaft

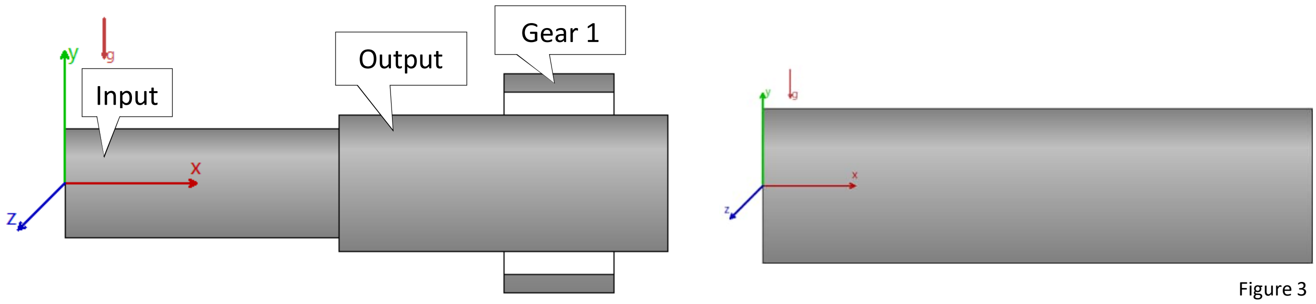

Figure 3

4. Model

4.1 Concept

Figure 3 suggests that the idealized model is intended to illustrate two possible approaches for representing a gear-shifting process. One approach, applied to 1st gear, involves a more realistic representation using a synchronizer hub; the other, applied to 2nd gear, uses a further simplified method by activating or deactivating a gear connection. Before diving into the details, let us set up the model with the geometries, loads, and boundary conditions as described in the following sections.

4.2 Computational representation

4.2.1 Geometries

➡ Please create a file, assign a project name and create the intended groups and their shaft geometries using Table 1.

4.2.2 Overview of parameters

The necessary settings for 'Supports' and 'Loading' of the model for both groups are summarized in the tables below.

Main Gear Train	Type	Element	Name	Position in X [mm]	Parameters (deviation from standard values)
Input	Supports	Support	INS1	7	-
		Support	INS2	45	-
		Coupling for reaction torque	INRT	48.5	b=3mm

		General constraint	SS3	50	Connect with 'output': Displacement & rotation in x is 'fixed'
	Loading	Coupling	Input	2.5	b=5 mm,T=50 Nm
		Cylindrical gear	INGW0	30	b=10 mm, z=17, mn=2, α=20°
Output drive	Supports	Support	OTS1	2	-
		Support	OTS2	55	-
		Rolling bearings	OTRB	40	Generic needle roller bearing K 25x33x20; outer ring (OR) is connected to '1st gear'
		Coupling for reaction torque	Output	58.5	b=3 mm
	Loading	Cylindrical gear	OTGW2	15	b=15 mm, z=27, mn=2, α=20°
1st gear	Supports	General constraint	SS1	0	Connect with 'output': Displacement & rotation in x is 'fixed'
	Loading	Cylindrical gear	G1GW1	10	b=15 mm, z=33, mn=2, α=20°
Group Translation	**Type**	**Element**	**Name**	**Position in X [mm]**	**Parameters (deviation from standard values)**
Countershaft	Supports	Support	CSS1	0	-
		Support	CSS2	100	-
	Loading	Cylindrical gear	CSGW0	20	b=10 mm, z=33, mn=2, α=20°
		Cylindrical gear	CSGW2	55	b=15 mm, z=23, mn=2, α=20°
		Cylindrical gear	CSGW1	80	b=15 mm, z=17, mn=2, α=20°

Table 2

Legend:

INS1 /2	Shaft support:	Input shaft, support, numbering
INRT	Coupling for reaction torque:	Input shaft, reaction torque
SS3	Connection of transmission:	Synchroniser sleeve 3rd gear
INGW0	Cylindrical gear:	Input shaft, gear wheel, from torque source
OTS1 /2	Shaft support:	Output shaft, support, numbering
OTRB	Rolling bearing:	Output shaft, rolling bearing
OTGW2	Cylindrical gear:	Output shaft, gear wheel, 2nd gear
SS1	Connection of the transmission:	Synchronizer sleeve 1st gear
G1GW1	Cylindrical gear:	1st gear. Gear wheel on synchroniser sleeve gear 1
CSS1 /2	Shaft support:	Countershaft, support, numbering
CSGW0 /1 /2	Cylindrical gear:	Countershaft, gear wheel, numbering

➡ Please assign the Supports and Loads listed in Table 2 to the corresponding components.

➡ At an input speed of 2000 rpm, the use of the components listed in Section 4.2.2 results in output speeds of 530.73 / 877.67 / 2000 rpm. This fulfils the requirement specified in Section 3.2.1.

4.2.3 Supports & loads

After implementing the Supports and Loads, the shafts should be as follows:

Main gear Train: Gear Stage:

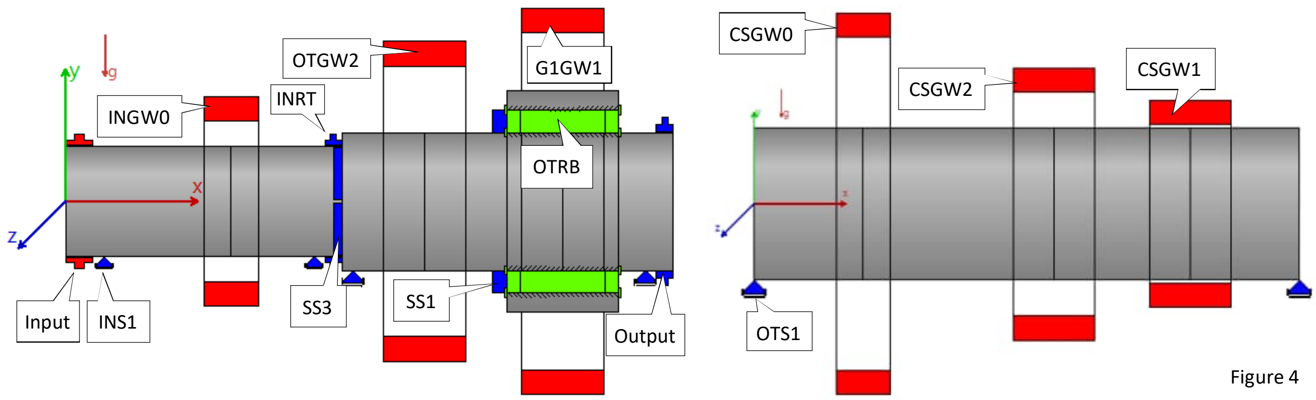

Figure 4

4.2.4 Gear connections

In the next step, the model requires the definition of gear pairs. This dialog can be accessed via the system tree under 'Gear Connections', where the corresponding pairings must be configured.

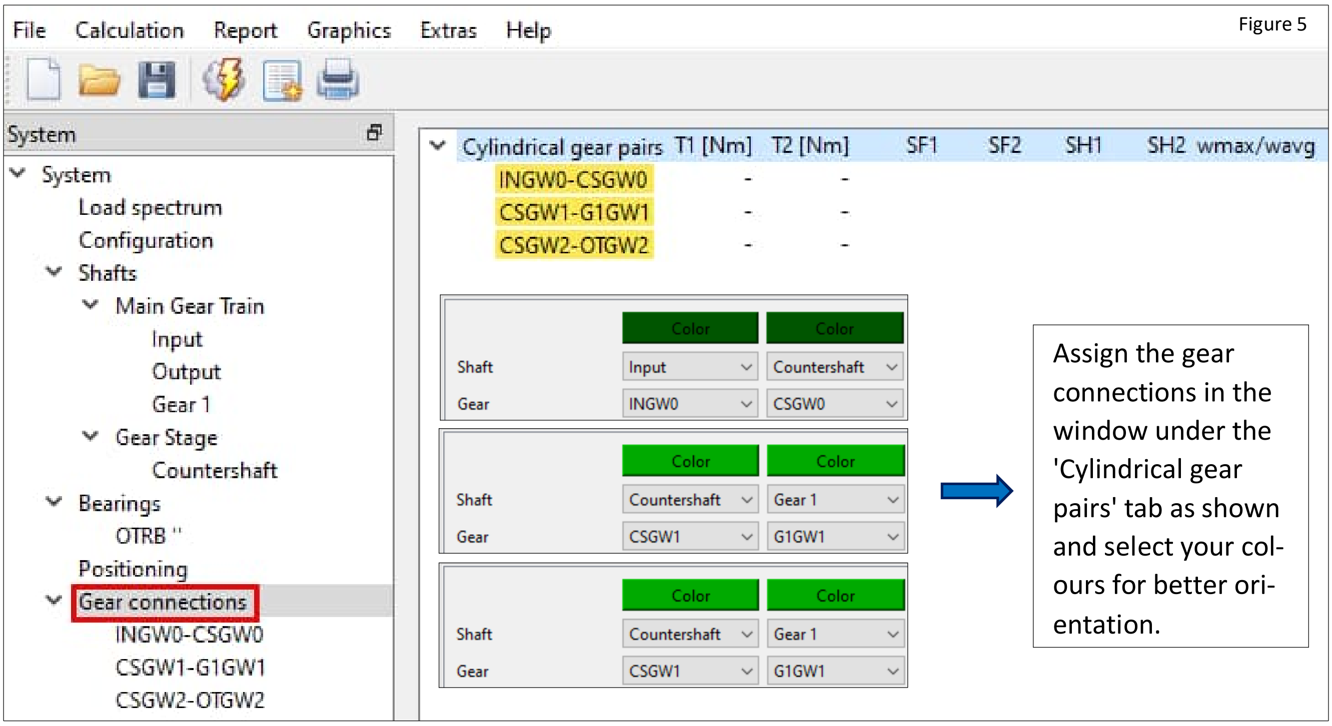

Figure 5

4.2.5 Positioning

The groups or shafts must now be aligned relative to each other based on the defined gear connections. In the following process, all gear meshes will be mathematically related to one another. The 'Positioning' window can be accessed via the System tree (see Figure 6). Positioning can be carried out using various criteria, such as the relation between gears or between groups.

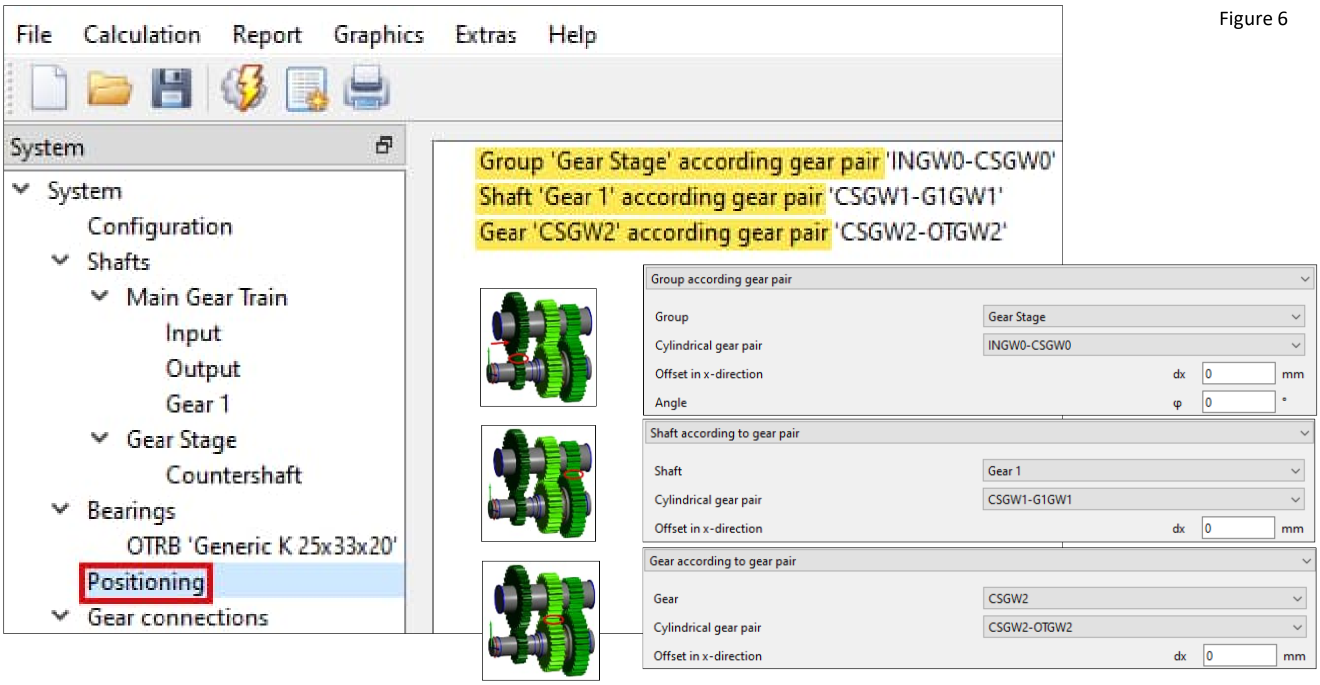

Figure 6

Assign the positioning as shown in Figure 6.

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At this point, the basic configuration of the model is complete.

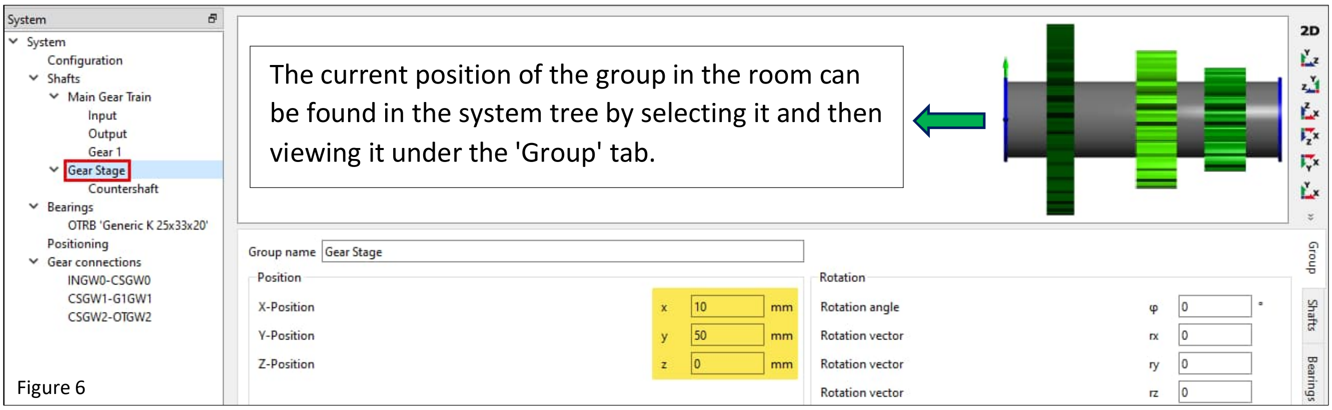
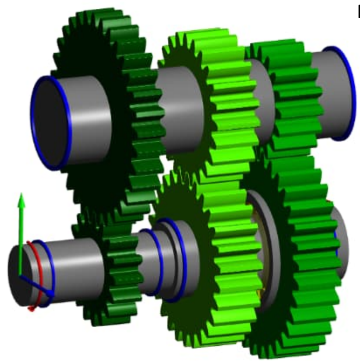


Figure 6

The gearbox system should now appear in the inclined ZX plane as shown in Fig. 7.


Picture 7

4.3 Configuration

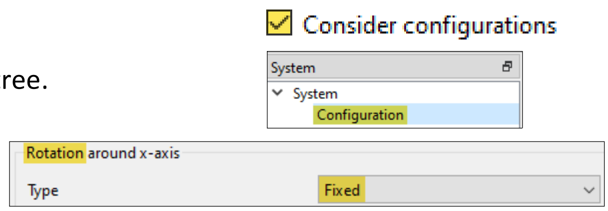
4.3.1 General

The following section uses the option of analysing the gearbox separately in its various operating states. This function is available in MESYS Shaft Systems via the "Consider Configurations" option and is immediately available when working with groups.

Activate this function under System/Settings.

This sets up the 'Configuration' entry in the system tree.

Please note that the conditions in 'Configuration' are only available if the torsion (rotation) is set in the relative 'General constraint' (Supports).

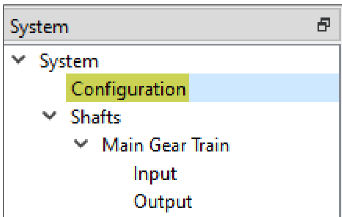


Picture 8

4.3.2 Operating States

By enabling or disabling specific elements, we aim to represent conditions that should either be considered or ignored within the simulation. This approach makes it possible to analyse the gearbox in its various engaged gear states.

Select the 'Configuration' entry in the system tree and assign the following lines with the corresponding name using '✚':



	Name	INRT	SS3	SS1	CSGW2-OTGW2	Output
1	1. Gang	☐	☐	☑	☐	☑
2	2. Gang	☐	☐	☐	☑	☑
3	3. Gang	☐	☑	☐	☐	☑
4	Neutral	☑	☐	☐	☐	☐

Picture 9

Use the dropdown menu at the bottom of the 'Configuration' window to select the desired state via 'Active Element' for detailed analysis.

Active element

As mentioned in chapter 4.1, the 2 switching principles can be recognized from this.

1st gear The principle of gear shifting is the activation of the SS1 shift sleeve.
2nd gear The principle of gear shifting is the activation of the gear pair CSGW2-OTGW2.

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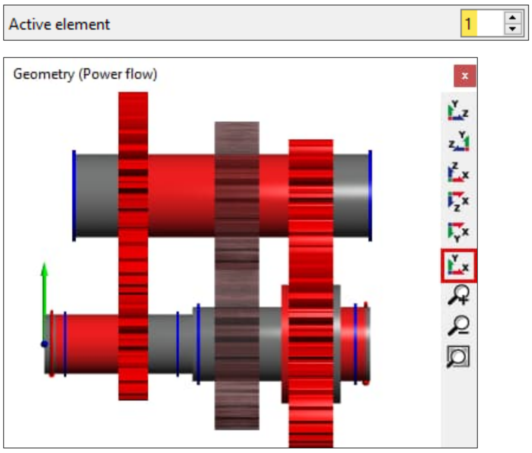
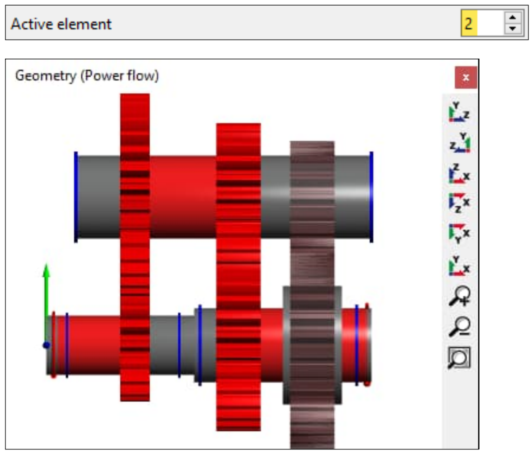
Use the Graphics menu to view the specific 3D geometries for power flows in the XY plane.

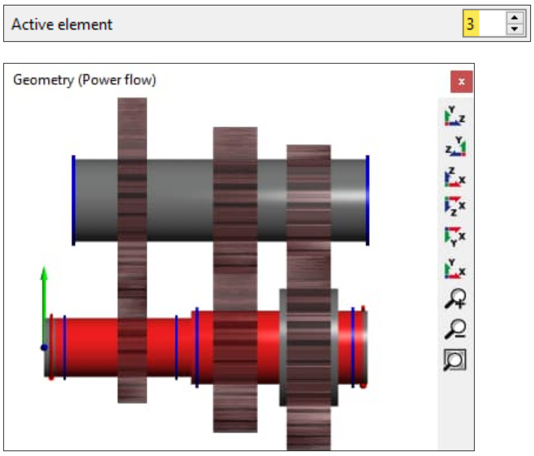
1st gear



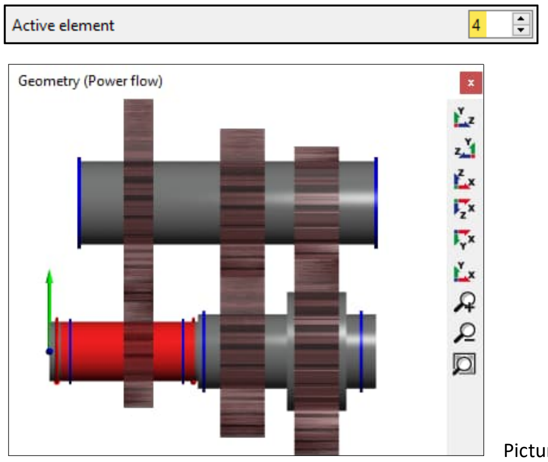
2nd gear



3rd gear (direct)

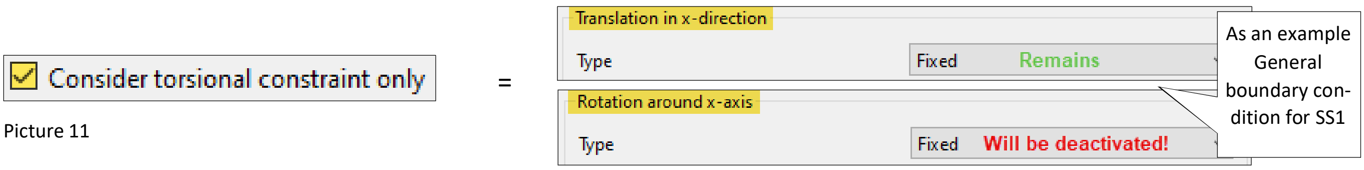


Neutral



Picture 10

If the option "Consider torsional constraint only" is active, clearing the flags for the constraints only disables the torsional constraint of specific 'General constraint'; constraints in all other directions are not affected.

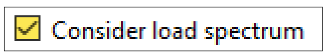


Picture 11

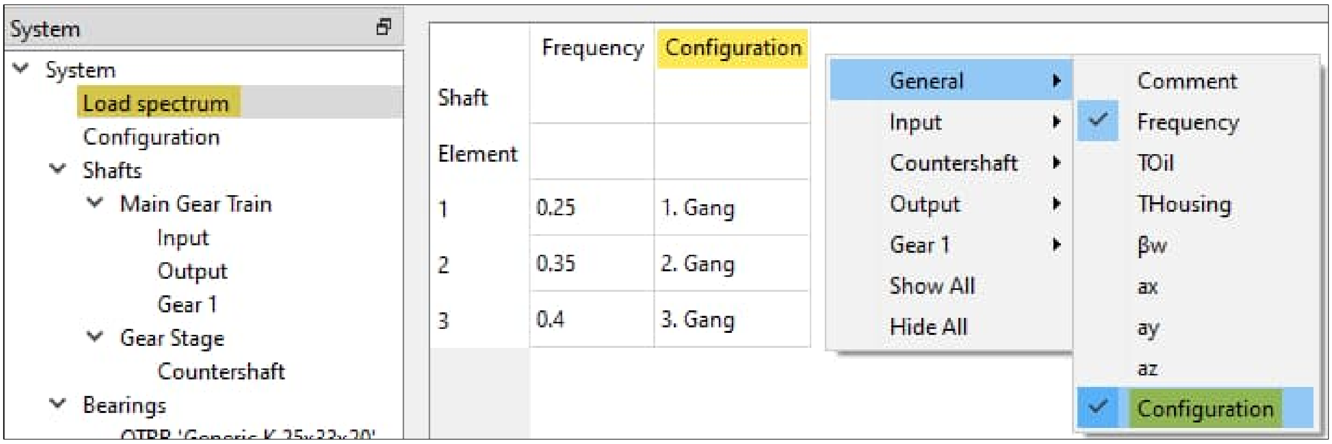
4.3.3 Load spectrum

If there is now a need to include the time components for the various dwell times in the gears (referred to here as states) and use them to perform service life analyses, this can be set up as usual after the corresponding activation under System/Settings. The configuration now appears via the context menu (Fig. 12) and can be selected accordingly.

Activate the load spectrum and enter the elements as shown in Fig. 12.



Picture 12



5. Results

Of course, you have access to the usual result views provided by the MESYS Shaft Calculation and MESYS Cylindrical Gear Pairs modules — including the general results overview, gear connection results, bearing results such as operating conditions and lifetime, as well as all available reports.

MESYS wishes you an instructive and profitable experience with our tutorials. If you have any queries, suggestions or questions, please do not hesitate to contact info@mesys.ch .