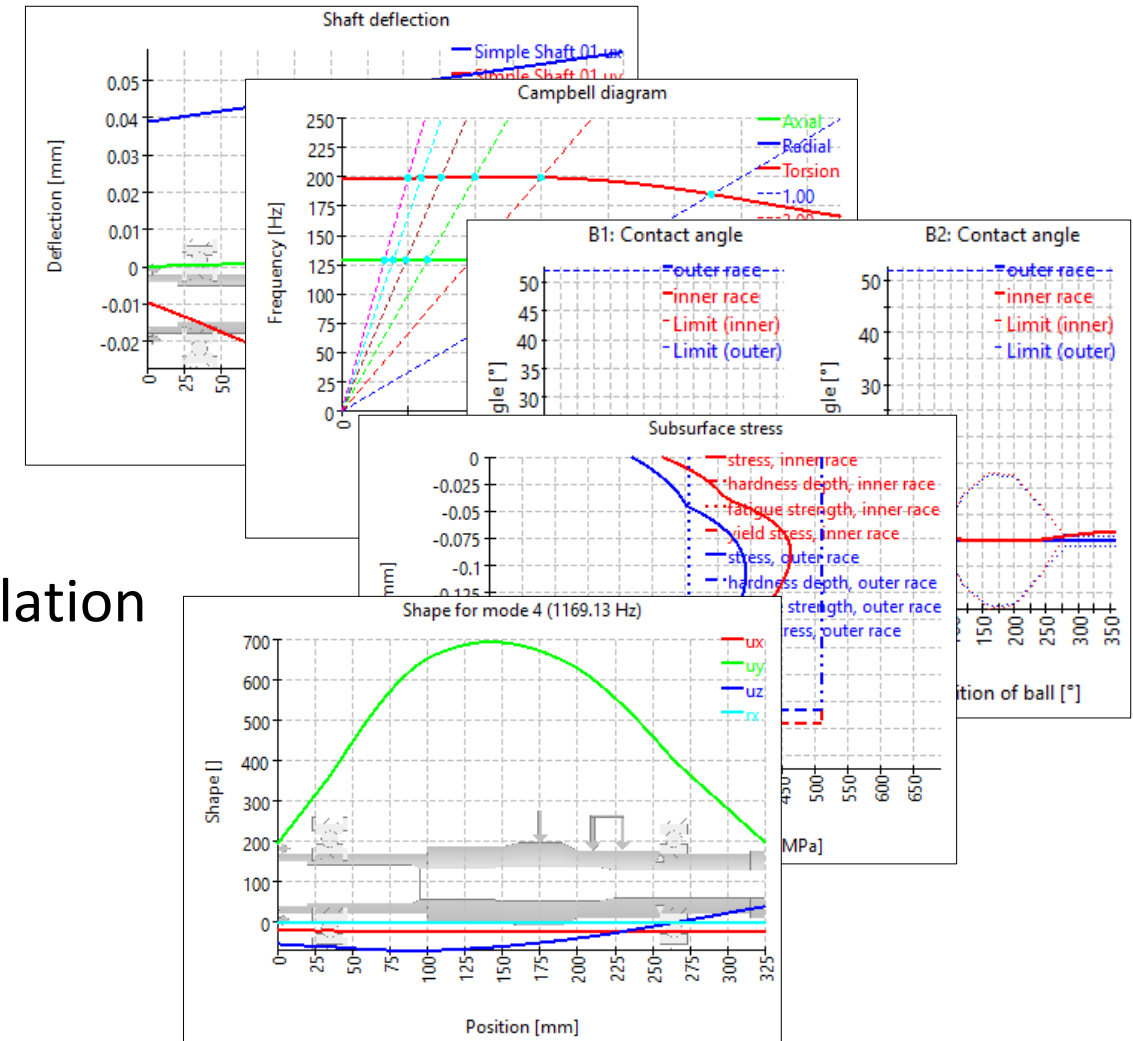
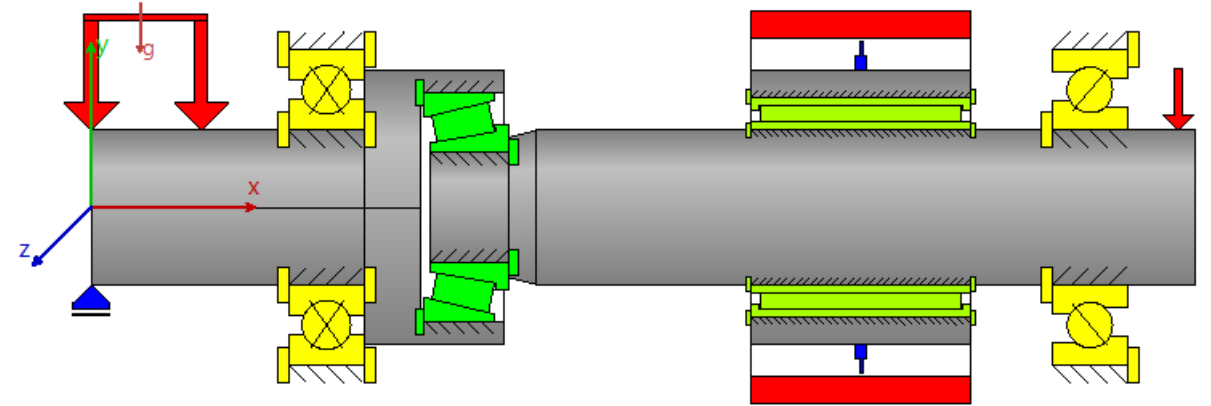


- Integration of MESYS Rolling Bearing Calculation
- Strength calculations according to DIN 743
- Calculation of natural frequencies
- Coaxial, parallel or general shaft position
- Extensions for gear calculations



- The shaft calculation allows the calculation of bearing forces and tilting angles for a system of coaxial shafts.
- Bearings can be connected with a housing or with a second shaft.
- All inputs of the rolling bearing calculation are available in the shaft calculation.
- The calculation of natural frequencies is possible considering nonlinear bearing stiffness.
- The calculation can be run using load spectra.



- The shaft deflection is calculated using finite element beam elements (optionally geometrically nonlinear, considering shear deformations).
- Rolling bearings are coupled to single nodes at inner and outer race.
- Thermal elongations and axial shaft deformation are considered.
- In the calculation of natural frequencies, the inertia of the shaft is considered and optionally the gyroscopic effect.

Shaft calculation System inputs

The screenshot shows the 'mesys Shaft Calculation' software interface. The title bar includes the mesys logo and 'Engineering Consulting Software AG'. The main window has a header with the mesys logo and 'Shaft Calculation'. Below the header, there are input fields for 'Project name' and 'Calculation description'. The 'Settings' tab is active, showing various input fields and checkboxes. Callouts point to specific fields: 'Default values for lubrication' points to the 'Lubrication' tab; 'Weight is considered optionally' points to the 'Consider weight' checkbox; 'Material and temperature for housing' points to the 'Housing material' dropdown (set to 'Steel') and 'Housing temperature' input (set to '20 °C'); 'Options for FEA' points to the 'Strength calculation' dropdown (set to 'Infinite life according DIN 743') and 'Bearing position' dropdown (set to 'Definition for each bearing'); 'Calculate of natural frequencies' points to the 'Calculate natural frequencies' checkbox; 'Activate load spectra' points to the 'Consider load spectrum' checkbox; and 'Calculation of natural frequencies' points to the 'Maximum frequency' and 'Number of frequencies' inputs.

mesys
Engineering Consulting Software AG

Shaft Calculation

Project name:

Calculation description:

Settings | Lubrication | Display settings

☒ Consider weight

Angle for weight: β_w °

☐ Calculate natural frequencies

☐ Consider gyroscopic effect

Maximum frequency: f_{max} Hz

Number of frequencies: N_{freq}

☐ Consider gears as stiffness

☐ Consider gears as point load

☐ Consider housing stiffness

☒ Housing material:

Housing temperature: T_h °C

Required life: H h

☒ Bearing reliability: S % ☐

Strength calculation:

Bearing position:

Shear deformations:

☐ Consider nonlinear shaft model

☐ Consider load spectrum

☒ Calculate modified bearing life

Shaft calculation user interface

System

- System
 - Load spectrum
 - Shafts
 - Shaft 1
 - Shaft 2
 - Shaft 3
 - Bearings
 - B1 - 4-point 'FAG QJ207-XL-MPA-T42A'
 - B2 - TRB 'JTEKT 32205JR'
 - B3 - ACBB 'JTEKT 7207B'
 - B4 - Needle

Selection of view

Inputs for geometry, loading and boundary conditions

Bearing selection from database

Geometry definition in table

General Geometry Loading Supports Sections Settings

Support x=0mm, 'Support'
Rolling bearing x=53.5mm, 'B1 - 4-point'

Rolling bearing

Shaft connected to inner ring
Connect outer ring to housing
'Geometry, Material, Temperature, Lubrication' is connected

☐ Use extended calculation model
☒ Shaft is supported radially
☒ Shaft is supported axially to the left
☒ Shaft is supported axially to the right

Bearing offset δ_x 0 mm
Bearing offset δ_y 0 mm
Bearing offset δ_z 0 mm

Bearing offset from misalignment

Outer Geometry L=94mm Inner Geometry

	Length [mm]	Diameter 1 [mm]	Diameter 2 [mm]
1	62	35	
2	32	62	

	Length [mm]	Diameter 1 [mm]	Diameter 2 [mm]
1	75	0	
2	19	52	

Shaft calculation Rolling bearings

Integration of bearing calculation

Bearing selection

Optional transfer of diameters, material, lubrication data

Rolling bearing

Name: B1 - 4-point

Position: x 53.5 mm

Type: Four point ball bearing (radial) (FAG QJ207-XL-MPA-T42A)

Shaft connected to inner ring

Connect outer ring to housing

'Geometry, Material, Temperature, Lubrication' is connected

☐ Use extended calculation model

☒ Shaft is supported radially

☒ Shaft is supported axially to the left

☒ Shaft is supported axially to the right

Bearing offset δ_x 0 mm

Bearing offset δ_y 0 mm

Bearing offset δ_z 0 mm

Manufacturer	name	di [mm]	De [mm]	B [mm]	alpha
FAG	QJ207-XL-MPA-T42A	35	72	17	35
FAG	QJ207-XL-MPA-S1-T42A	35	72	17	35
FAG	QJ207-XL-MPA-C3-M32G	35	72	17	35
FAG	QJ207-XL-MPA-C3	35	72	17	35
FAG	QJ207-XL-MPA-C2	35	72	17	35
FAG	QJ207-XL-MPA	35	72	17	35
FAG	QJ206-XL-N2-MPA-T42B	30	62	16	35
FAG	QJ206-XL-N2-MPA-T42A	30	62	16	35
FAG	QJ206-XL-N2-MPA-P6-T42B	30	62	16	35
FAG	QJ206-XL-MPA-T42A	30	62	16	35

If the bearing calculation is activated, then File>Load or File>Save are only referencing the bearing calculation data. In this way existing bearing calculation files can be imported.

Using Ctrl-F5 runs the whole system calculation.

Shaft calculation Load elements

Cylindrical gear

Name

Position x 20 mm

Width b 40 mm

Torque T 2000 Nm

Direction of torque Own Input

Angle to contact ζ 0 °

Number of teeth z 22

Normal module mn 3 mm

Normal pressure angle α_n 20 °

Helix angle β_n 0 °

Helix direction Spur gear

Number of teeth of mating gear z2 0

Center distance a 0 mm

Direction of torque with sign, driving or driven

Position gear contact.
0° - on y-axis
90° - on z-axis

Optional data for mating gear. If available the operating pitch diameter is used for calculation of forces

Cylindrical gear

Force

Coupling

Cylindrical gear

Excentric force

Mass

Available load elements

Mass

Name

Position x 30 mm

Width b 20 mm

Mass m 5 kg

Mass moment of inertia Jxx 0 kg m²

Mass moment of inertia Jyy 0 kg m²

Mass moment of inertia Jzz 0 kg m²

In case of a width > 0, the mass is distributed on a line

Mass moment of inertia are optional

A line mass already creates a moment of inertia. This is considered in the software. The total moment of inertia has to be used as input.

Shaft calculation Load spectra

System

- System
 - Load spectrum
 - Shafts
 - Shaft 1
 - Shaft 2
 - Shaft 3
 - Bearings
 - B1 - 4-point 'FAG QJ207-XL-MPA-T42A'
 - B2 - TRB 'JTEKT 32205JR'
 - B3 - ACBB 'JTEKT 7207B'
 - B4 - Needle

Definition load spectrum

Shaft	Comment	Frequency	TOil [°C]	THousing [°C]	T [°C]	n [rpm]	T [°C]	T [°C]
Element								
1	low	0.333333	20	20	20	500	20	20
2	medium	0.333333	25	25	25	1000	25	25
3	high	0.333333	30	30	30	1500	30	30

The sum of frequencies has to be 1

Selection of elements in load spectrum

- General
 - Comment
 - Frequency
 - TOil
 - THousing
 - βw
 - ax
 - ay
 - az
- Shaft 1
- Shaft 2
- Shaft 3
- Show All
- Hide All

General load spectrum for the system with selected parameters

Bearing loads and life for each load spectrum element

Name	L10h [h]	Lnmrh [h]	pmax [MPa]
Shaft 1			
Support			
B1 - 4-point 'FAG QJ207-XL-MPA-T42A'	116509	5825471	1729.40
1:low	233093	11654668	1729.31
2:medium	116526	5826294	1729.34
3:high	77657	3882867	1729.40

Option: Run calculation only for single element of load spectrum

Line of deflection and other graphics are shown for this element

Add, delete or import data

☐ Run calculation for result element only
 Result element: 3
 User input

Shaft calculation Natural frequencies

Calculation with or without gyroscopic effect

Settings

☒ Consider weight

Angle for weight β_w -90 °

☒ Calculate natural frequencies

☐ Consider gyroscopic effect

Number of frequencies N_{freq} 10

Activate calculation of natural frequencies under System

Choose number of frequencies

Mode shapes

Number	f [Hz]	f [1/min]	D [-]	Type
1	335.297	20117.8	0.439809	Axial 'using axial stiffness'
2	363.94	21836.4	0.437909	Axial 'fixed Force'
3	427.851	25671.1	412.383	Axial 'using HousingStiffness'
4	529.502	31770.1	417.875	Axial 'using HousingStiffness'
5	564.71	33882.6	47.8128	Axial 'outerRing'
6	790.88	47452.8	0.760443	Axial 'outerRing', Clockwise (+0.68)
7	956.886	57413.2	72.231	Axial 'using axial stiffness'
8	1035.37	62122.1	0.197338	Radial 'fixed Force'
9	1093.44	65606.2	0.146795	Radial 'fixed Force', Forward whirl (+0.20)
10	1155.81	69348.4	20.5067	Radial 'fixed Force'

Results for natural frequencies

The calculation of natural frequencies is done at equilibrium under defined load conditions, the bearing stiffness in this working point is used.

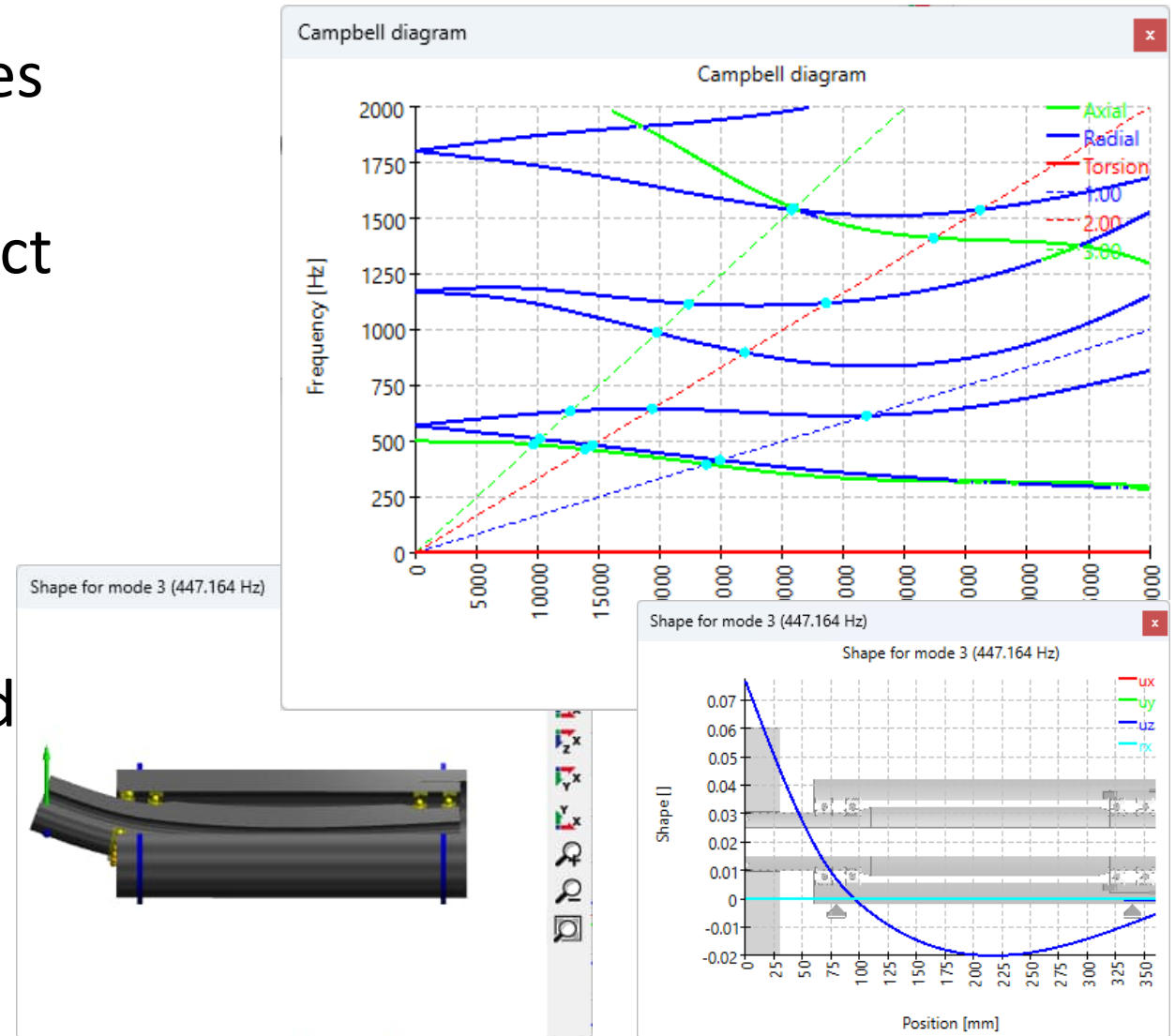
23.04.2025

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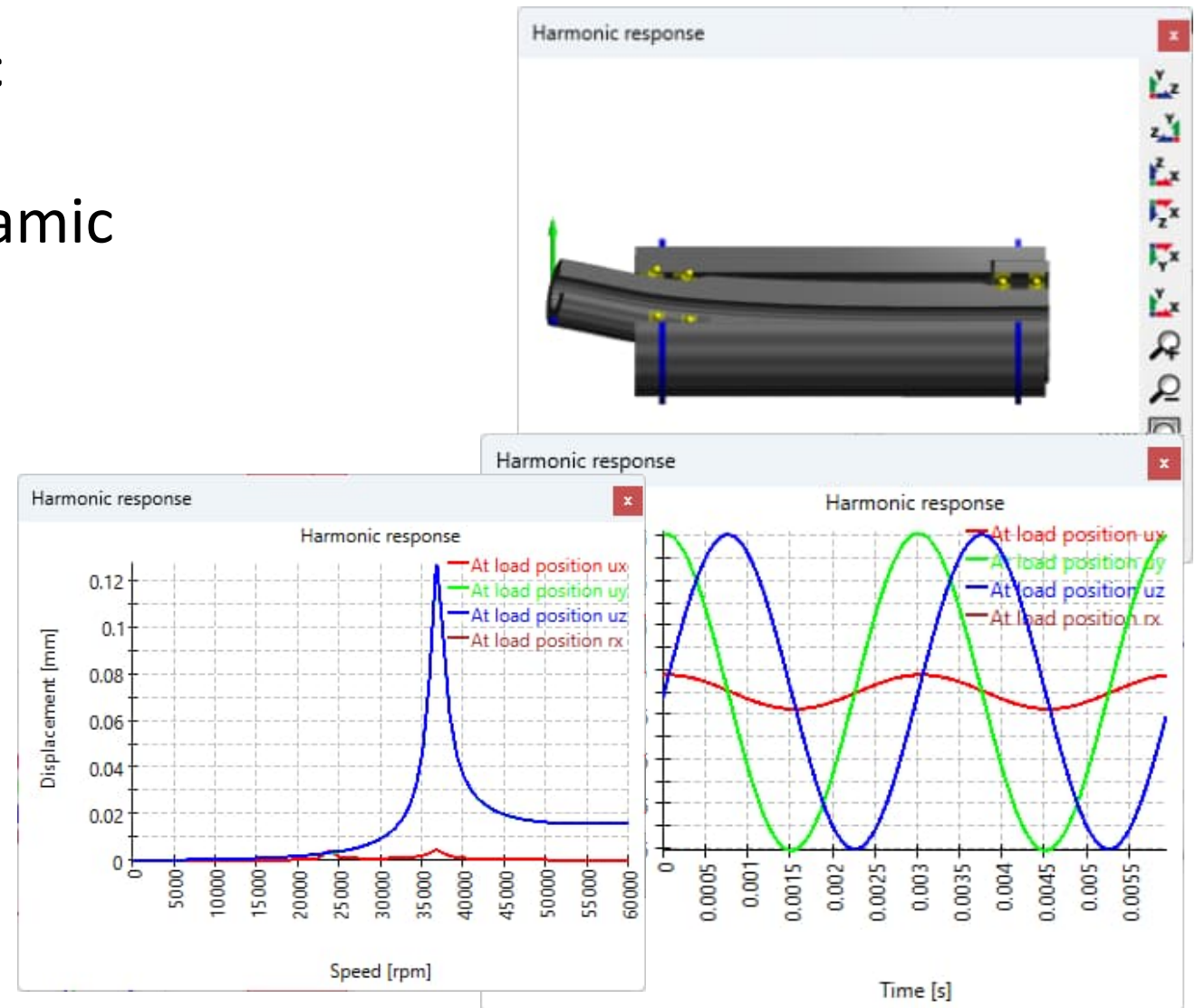
Shaft calculation Natural frequencies

- Calculation of natural frequencies for given speeds
- Consideration of gyroscopic effect and speed dependent bearing stiffness
- Campbell diagram
- Critical speeds
- Mode shapes as 2D-diagram and 3D-Animation



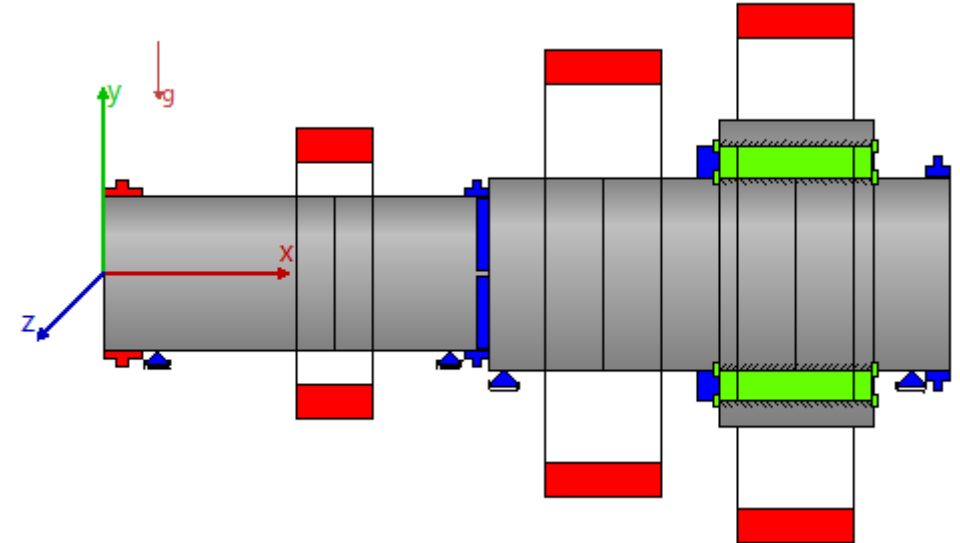
Shaft calculation Harmonic response

- Harmonic response to dynamic forces
- Excitation as imbalance or dynamic force
- Base excitations for supports
- Gear mesh excitations
- Results as amplitudes, velocities and forces
- Diagrams over rotations speed or over time
- 3D-Animation



- For each shaft, it is possible to define either a unique temperature, or a temperature gradient by adding a temperature difference ' ΔT ' (\pm) for those elements created at the outer geometry. The temperature of the housing can be defined as well.
- From the thermal expansions arise axial displacements of the shafts and also, depending on the bearing, axial forces.
- The temperatures are also transferred to the bearing calculation thus having influence on the bearing clearance.

- Idler-wheels in shift gearboxes can be set either as spur gear on the shaft or as idle wheel shaft with a bearing and a general constrain.
- Through configurations, it is possible to deactivate single components for certain gear connections.
- Important: For the created couplings, the rotational degree of freedom must be fixed. Then, at configurations this constraint can be voided.

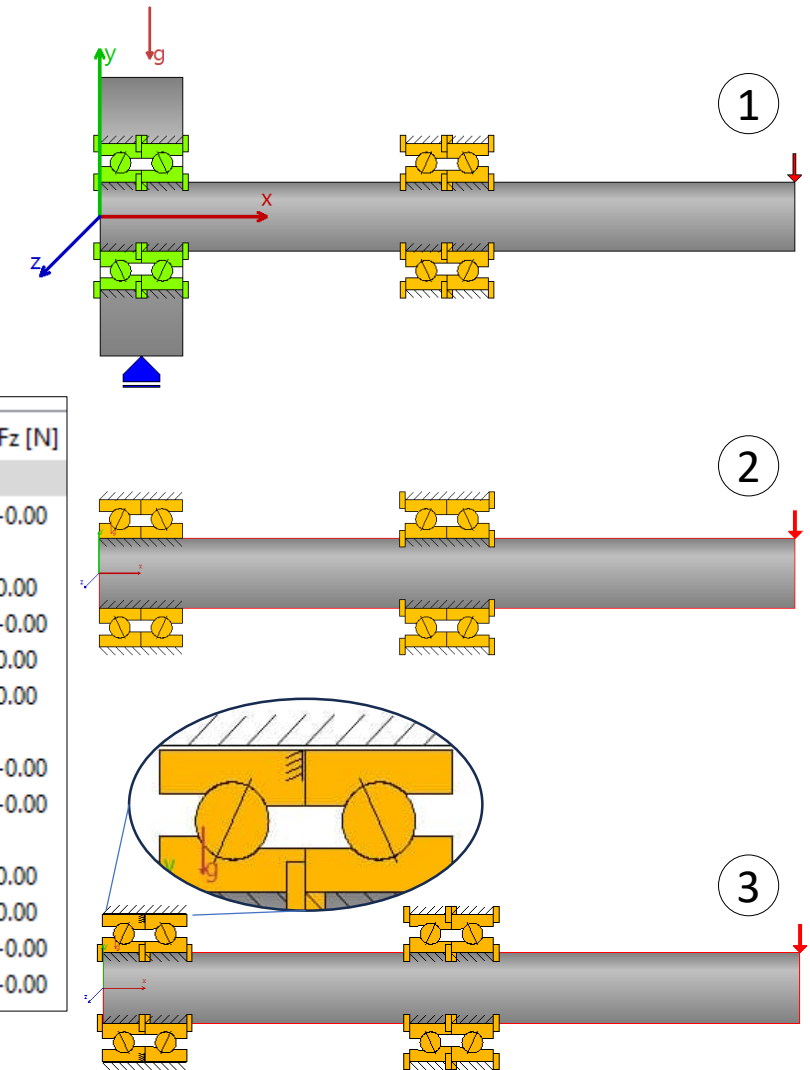


	Name	Direktgang	Syncroning	G1a-G1b
1	G1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2	G2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	G3	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Spindle bearings Sets of bearings

- Variant 1: Define all the bearings on the shaft, use a hollow shaft to perform the role of non-locating bearing.
- Variant 2: Place two bearings on the shaft and use bearing configurations in the bearing calculation. Shorter lives are to be expected here, since it is calculated as double-row bearing.
- Variant 3: The 'extended calculation' model is used. A hollow shaft is not required in this case, as the positional relationships of both rings to all adjacent components can be defined.

Name	L10rh [h]	Lnmrh [h]	pmax [MPa]	S0eff	Fx [N]	Fy [N]	Fz [N]
▼ OuterRing							
Support					0.00	708.81	-0.00
▼ Shaft 1							
B1.1 'Generic 7004D'	280623	5430452	1454.80	24.06	212.58	302.04	0.00
B1.2 'Generic 7004D'	93423	827954	1721.09	14.57	-212.58	413.50	-0.00
B1.3 'Generic 7004D'	13246	40616	1976.06	9.41	908.02	527.99	0.00
B1.4 'Generic 7004D'	579	567	3020.28	2.69	-1208.02	-2248.37	0.00
▼ Shaft 2							
B2.1 'Generic 7004D'	83741	949646	1685.90	15.49	-0.00	700.80	-0.00
B2.2 'Generic 7004D'	550	545	3027.38	2.67	-300.00	-1705.64	-0.00
▼ Shaft 3							
B3.1 'Generic 7004D'	280391	5422427	1455.19	24.04	212.28	302.28	0.00
B3.2 'Generic 7004D'	93662	831430	1720.66	14.58	-212.28	413.13	0.00
B3.3 'Generic 7004D'	13243	40603	1976.13	9.41	908.04	528.12	-0.00
B3.4 'Generic 7004D'	579	567	3020.28	2.69	-1208.04	-2248.38	-0.00

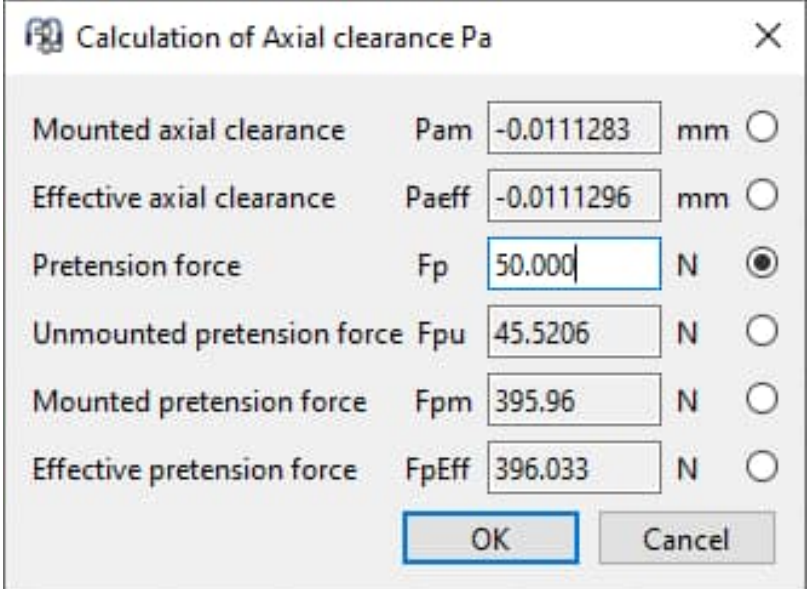


Bearing preload

- A pretension can be entered by using a negative value for the axial clearance P_a , which is shown for angular contact bearings, tapered roller bearings, four-point bearings, cylindrical roller bearings and all axial bearings.
- If with angular contact bearings or tapered roller bearings 'User input' is chosen for 'Bearing clearance', the axial clearance can also be calculated for a given pretension force.

Dependent on the bearing type, several options for the pretension force are available:

- The calculation with " F_p " is using nominal dimensions for the bearings.
- The calculation using " F_{pu} " is using nominal dimensions together with a radial elastic expansion without limit.
- The mounted pretension force " F_{pm} " is calculated using the dimensions after fitting but no temperature or speed.
- The effective pretension force " F_{pEff} " is calculated using the dimensions after fitting and considering temperature and speed.



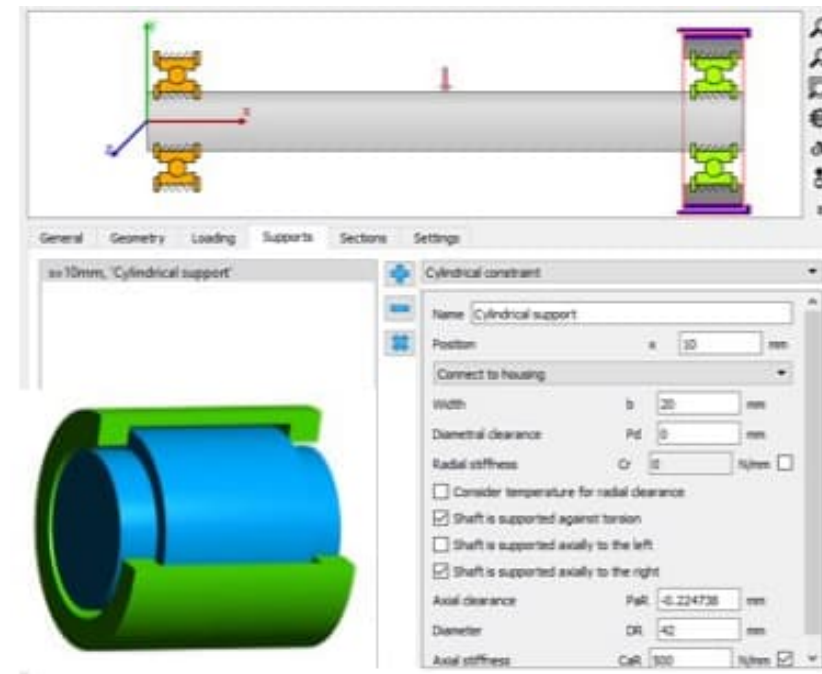
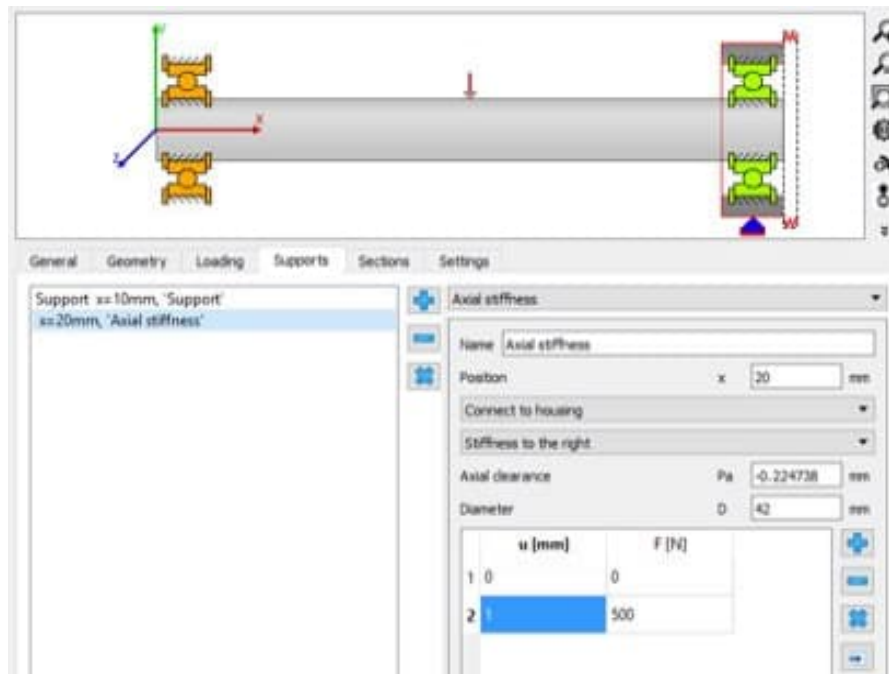
Parameter	Symbol	Value	Unit	Selection
Mounted axial clearance	P_{am}	-0.0111283	mm	<input type="radio"/>
Effective axial clearance	P_{aeff}	-0.0111296	mm	<input type="radio"/>
Pretension force	F_p	50.000	N	<input checked="" type="radio"/>
Unmounted pretension force	F_{pu}	45.5206	N	<input type="radio"/>
Mounted pretension force	F_{pm}	395.96	N	<input type="radio"/>
Effective pretension force	F_{pEff}	396.033	N	<input type="radio"/>

OK Cancel

Bearing preload

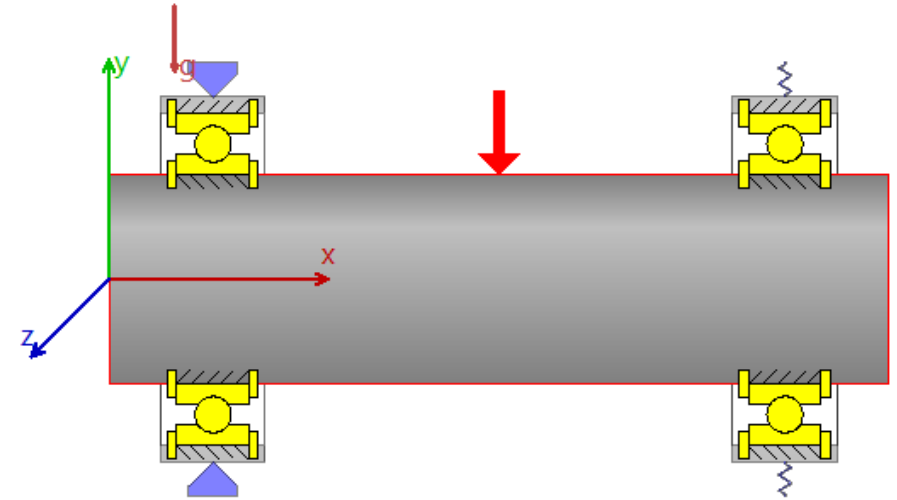
A new axial stiffness allows the input of a nonlinear stiffness. The axial stiffness is distributed over a diameter, therefore a moment load can be taken in case of axial load.

A cylindrical constraint allows to define a radial clearance of a shaft in a tube. Additionally an axial contact can be defined distributed over a diameter.

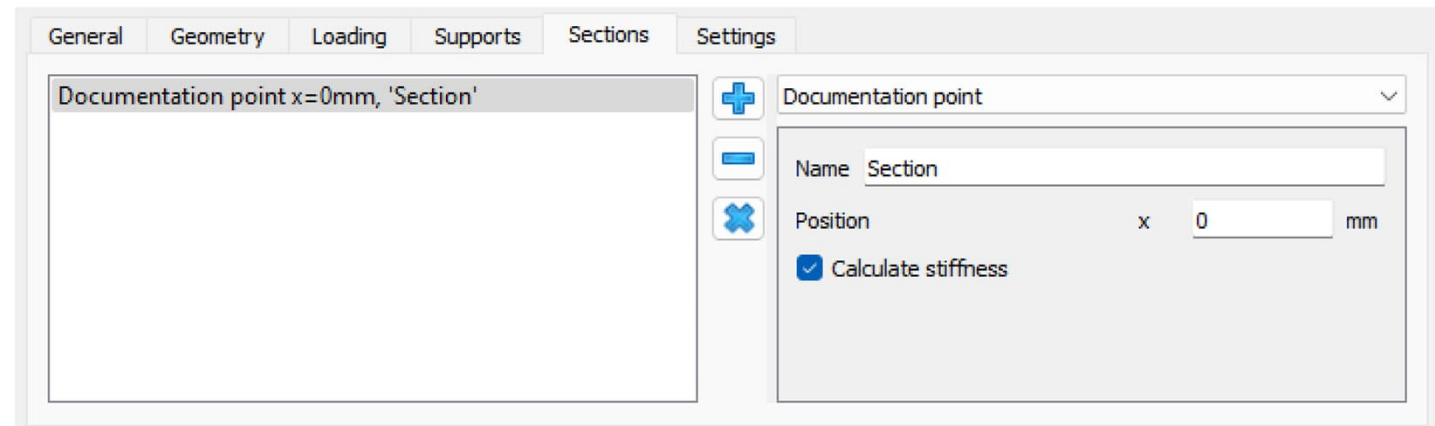


Housing stiffness

- In the past, in order to take into account the housing stiffness in addition to the bearing stiffness, an "Outer-ring shaft" had to be added. Then, this shaft was connected to the rigid environment by means of a general constraint or a stiffness matrix.
- Additionally, it is possible to define directly a housing stiffness matrix. Both for global and local coordinate system, multiple symmetric stiffness matrices can be defined between the supports (only those which are connected to the housing) and the housing, thus acting as boundary condition at its connecting point. This enables the user to simulate different ways of stiffness interaction, also between the bearings or supports by means of the housing. Furthermore, is possible to apply a predefined force, moment, displacement or rotation for the connecting points in any of the three directions, as well as to consider rotation stiffness.
- A housing stiffness can be defined using an imported 3D-STEP housing or a Nastran-mesh.



- For documentation points on shafts a stiffness can be calculated.
- The resulting stiffness values c_{xx} , c_{yy} , c_{zz} , c_{rx} , c_{ry} , c_{rz} are the reciprocals of the main diagonals of the compliance matrix of the selected point.
- This corresponds to the determination of a stiffness by using a testing force and a displacement in the direction of the test force: $C_{yy} = \Delta F_y / \Delta u_y$



Shaft strength according DIN 743 (2012)

- For strength calculation according DIN 743 the material and a few other parameters have to be selected.
- Cross sections can be defined on page «Sections».
- The number of load cycles is calculation from rotation speed and required life as default.

The screenshot displays the 'Sections' tab in the MESYS software, which is divided into two sub-tabs: 'General' and 'Strength'.

General Sub-tab:

- Name: Shaft
- Material: Steel (selected from a dropdown menu)
- Position: x 0 mm
- Speed: n 0 rpm
- Temperature: T 20 °C

Strength Sub-tab:

- Load factor (static): KA_s 1
- Load factor (fatigue): KA_f 1
- Overload case: Constant stress ratio (selected from a dropdown menu)
- Diameter at heat treatment: d_{HT} 0 mm
- Number of load cycles: N 1 10⁶
- Factor for surface work-hardening: KV 1
- Stress ratio, tension: Pulsating (selected from a dropdown menu) 0
- Stress ratio, bending: Alternating (selected from a dropdown menu) -1
- Stress ratio, torsion: Pulsating (selected from a dropdown menu) 0

Influence factors for strength according to DIN 743

- Technological size factor K_1 for reduction of material strength
- Geometrical size influence for stress gradient in bending and torsion
- Notch factor
- Surface roughness and surface hardening
- Influence of mean stress
- Tension, bending and torsion are taken into account
- Calculation for load spectra or limited life

Shaft strength according DIN 743 (2012)

- Two options for calculation of permissible amplitude are available
- The option «constant stress ratio» is on the safe side
- As the equivalent mean stress is used, torsion will influence permissible bending stress

