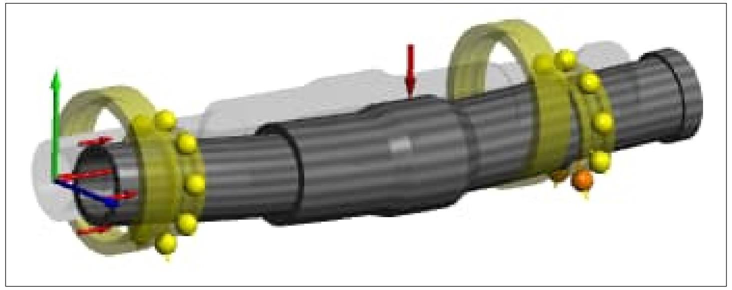
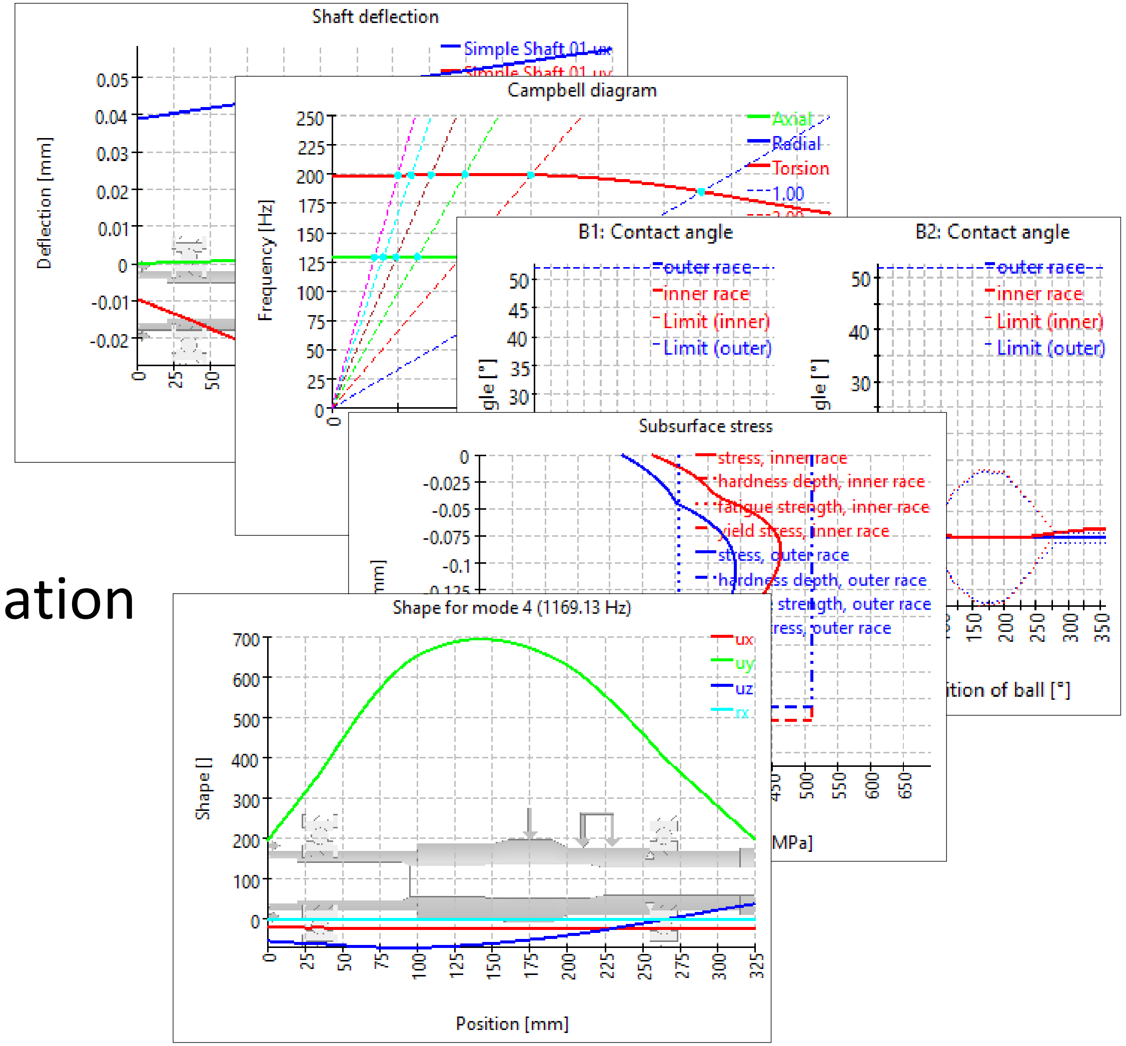
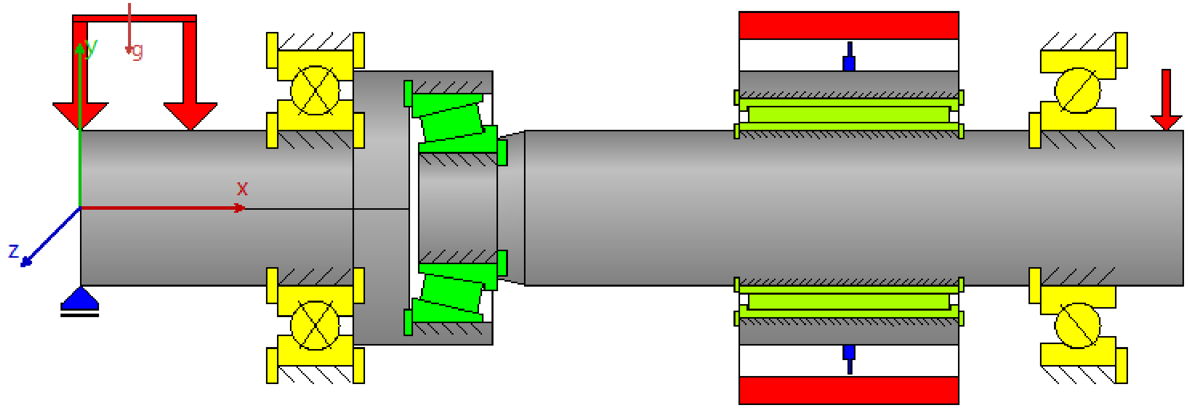
MESYS Shaft Calculation





- 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

Shaft calculation

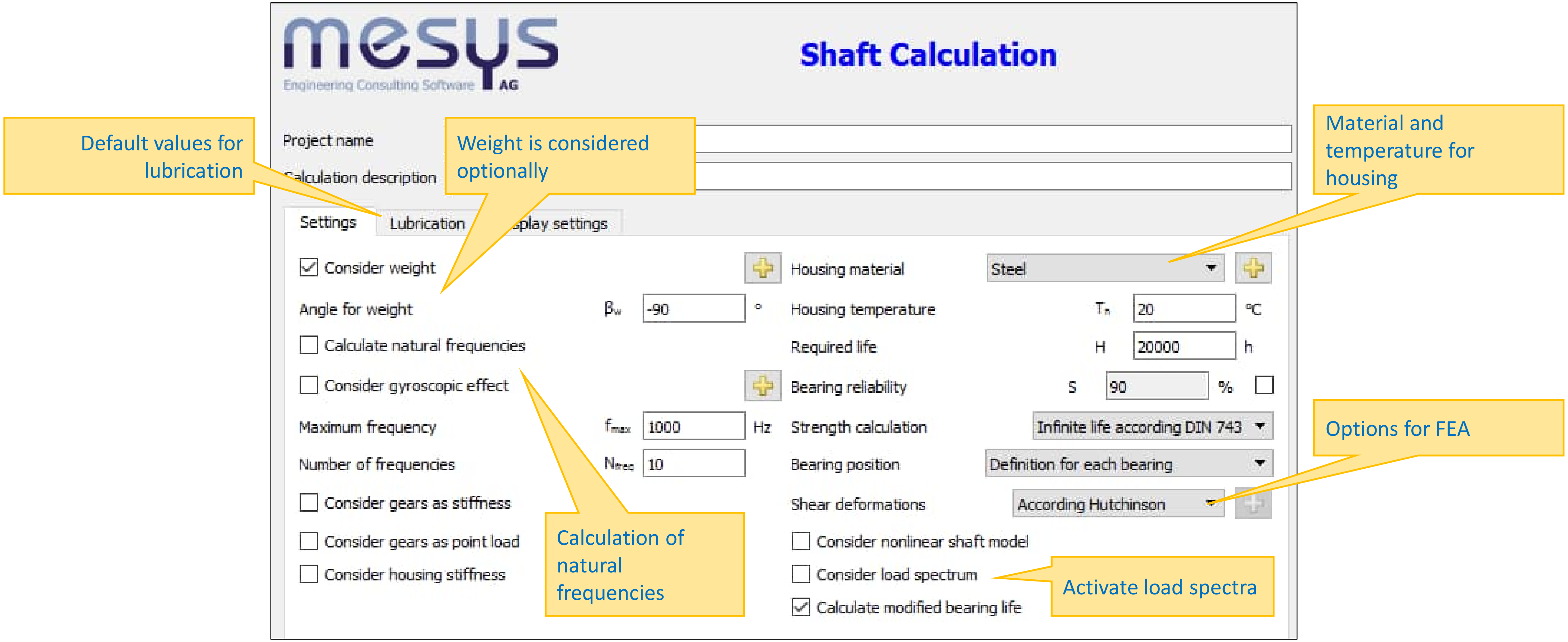


- The shaft calculation allows the calculation of bearing forces and tilting angles for a system of coaxial shafts.
- Bearings can be connected with a housing or with a second shaft.
- All inputs of the rolling bearing calculation are available in the shaft calculation.
- The calculation of natural frequencies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

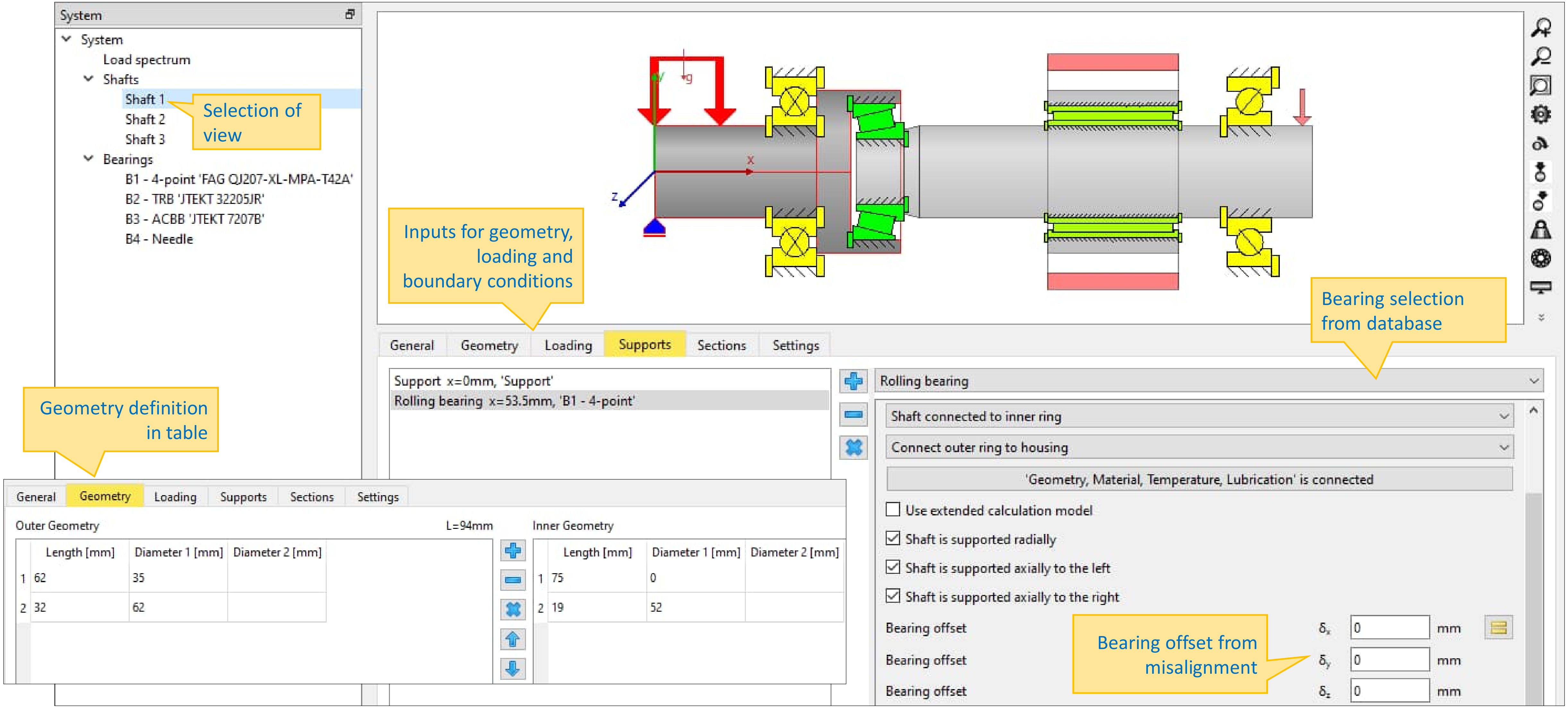
Shaft calculation

- 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.

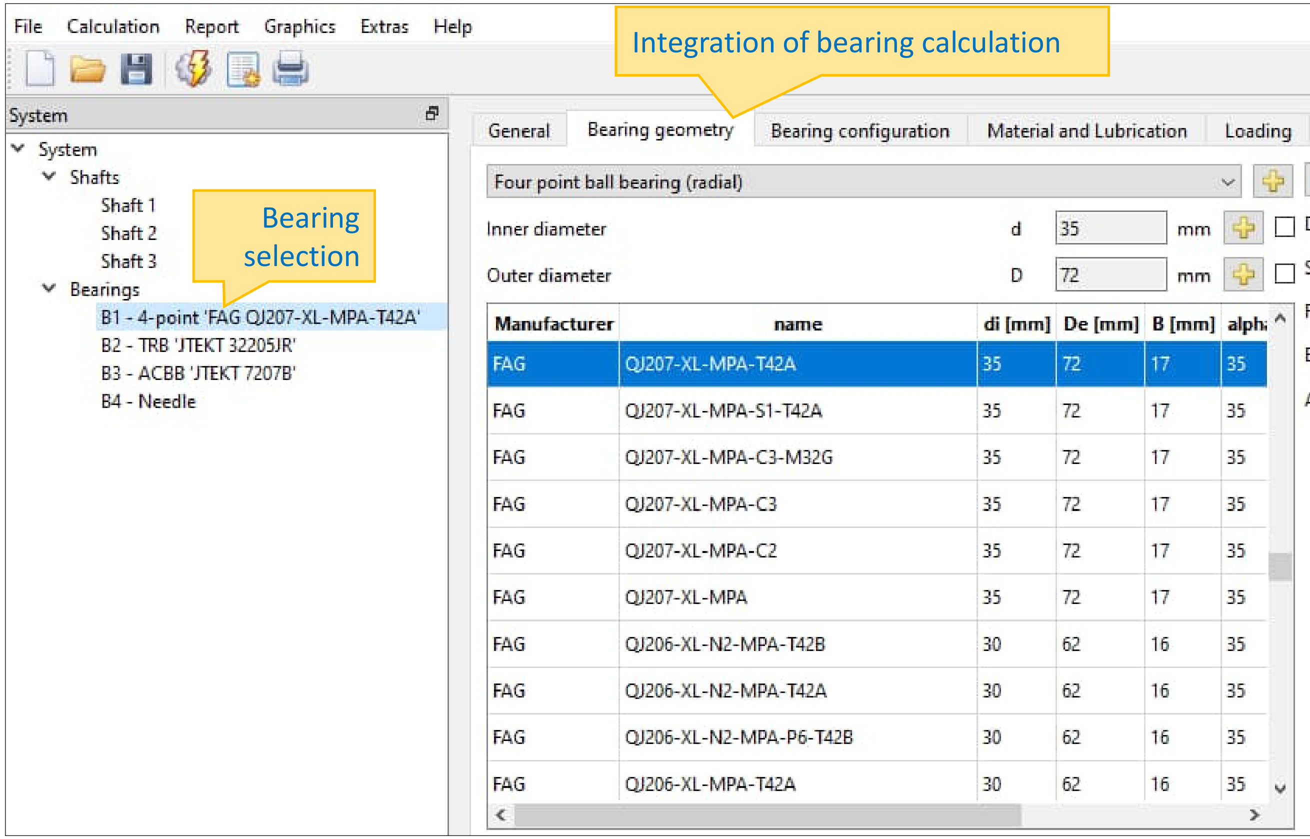
Shaft calculation System inputs

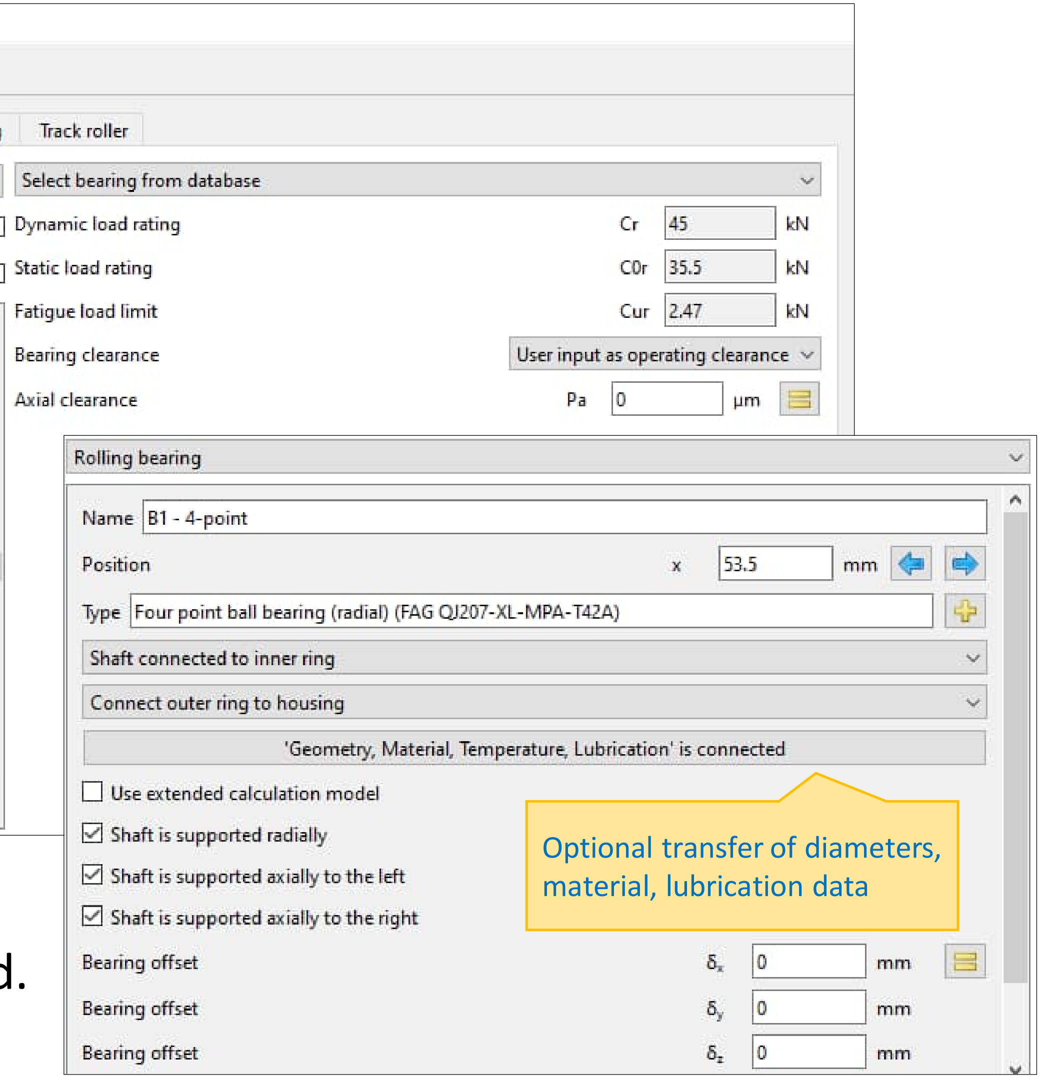


Shaft calculation user interface



Shaft calculation Rolling bearings

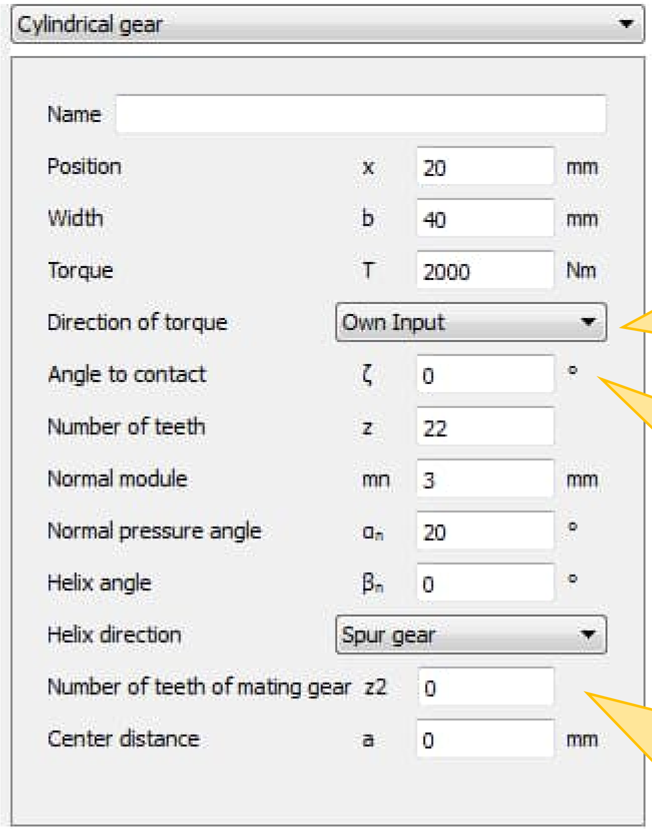




If the bearing calculation is activated, then File>Load or File>Save are only referencing the bearing calculation data. In this way existing bearing calculation files can be imported.

Using Ctrl-F5 runs the whole system calculation.

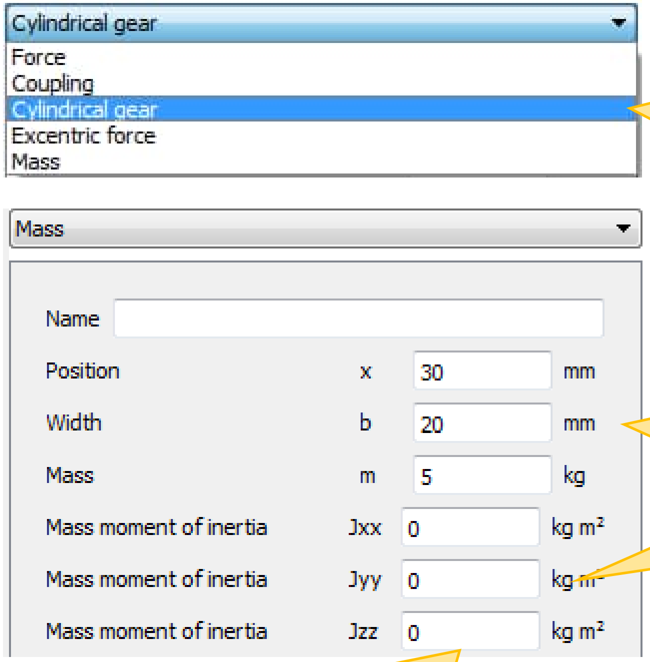
Shaft calculation Load elements



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



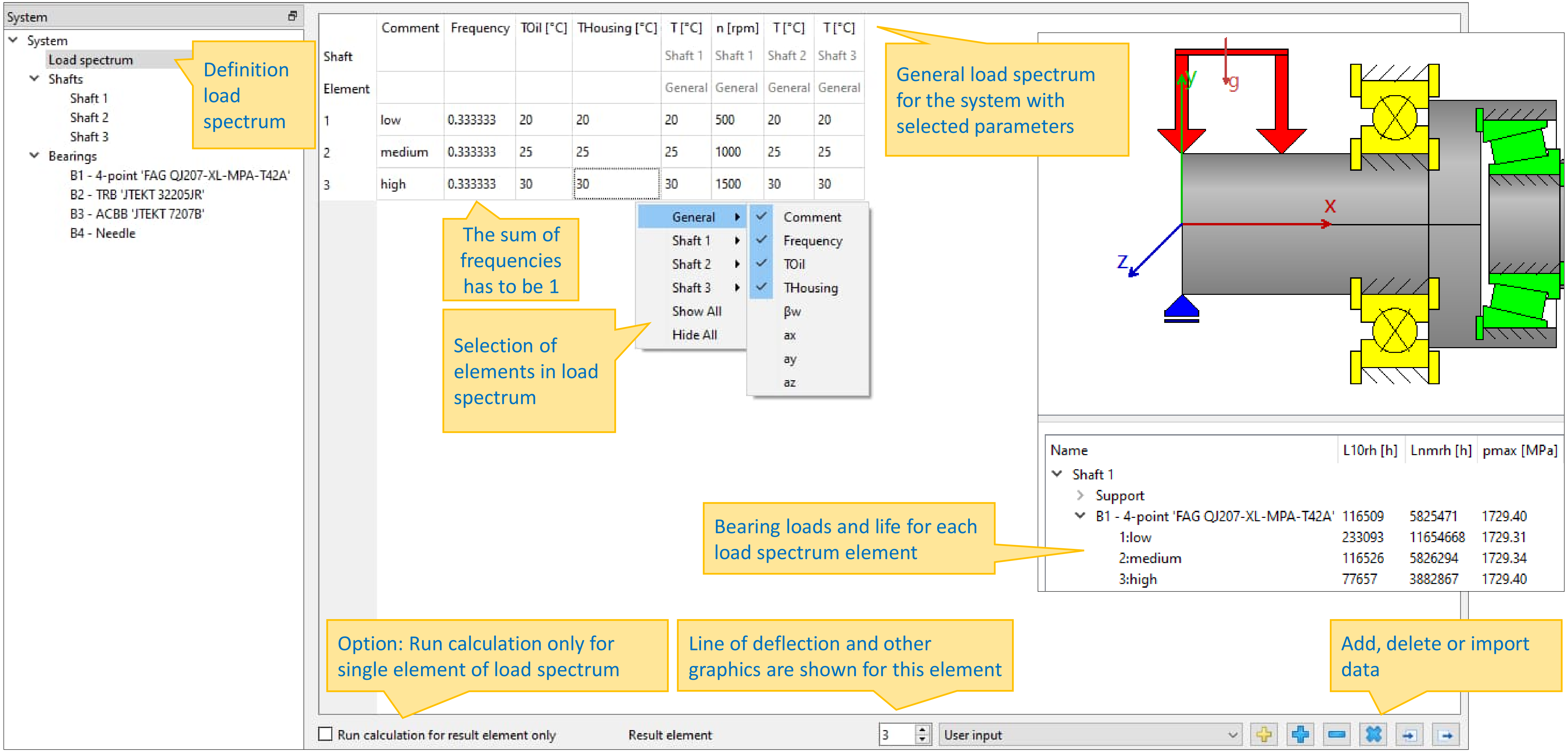
Available load elements

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

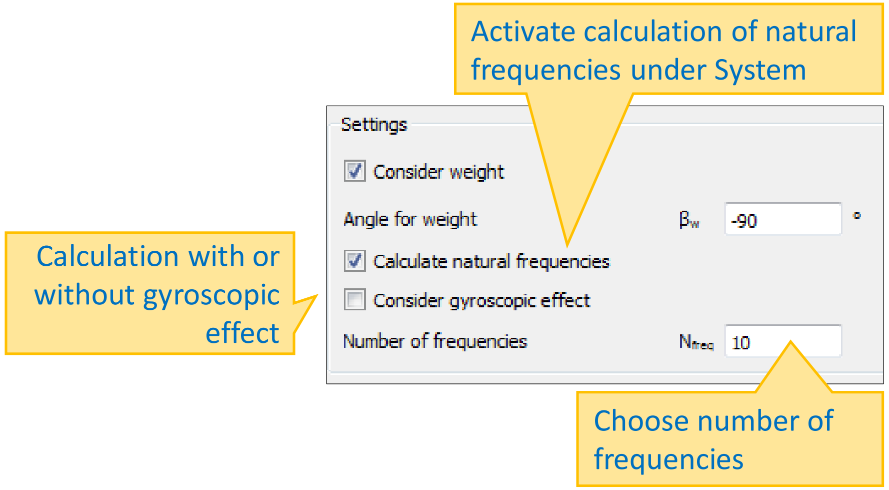
Mass moment of inertia are optional

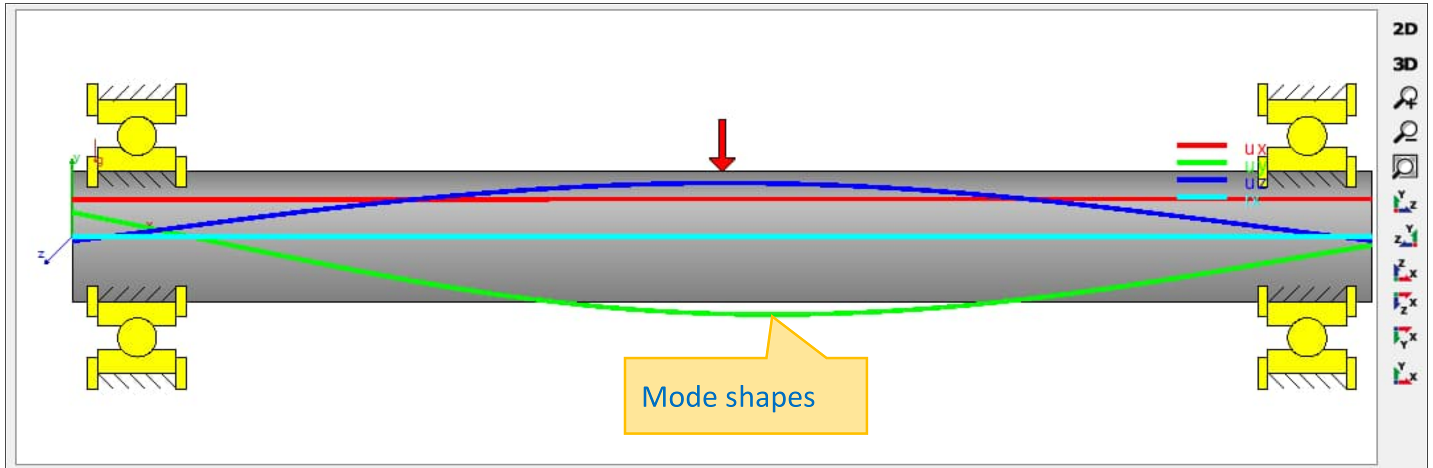
A line mass already creates a moment of inertia. This is considered in the software. The total moment of inertia has to be used as input.

Shaft calculation Load spectra



Shaft calculation Natural frequencies





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'

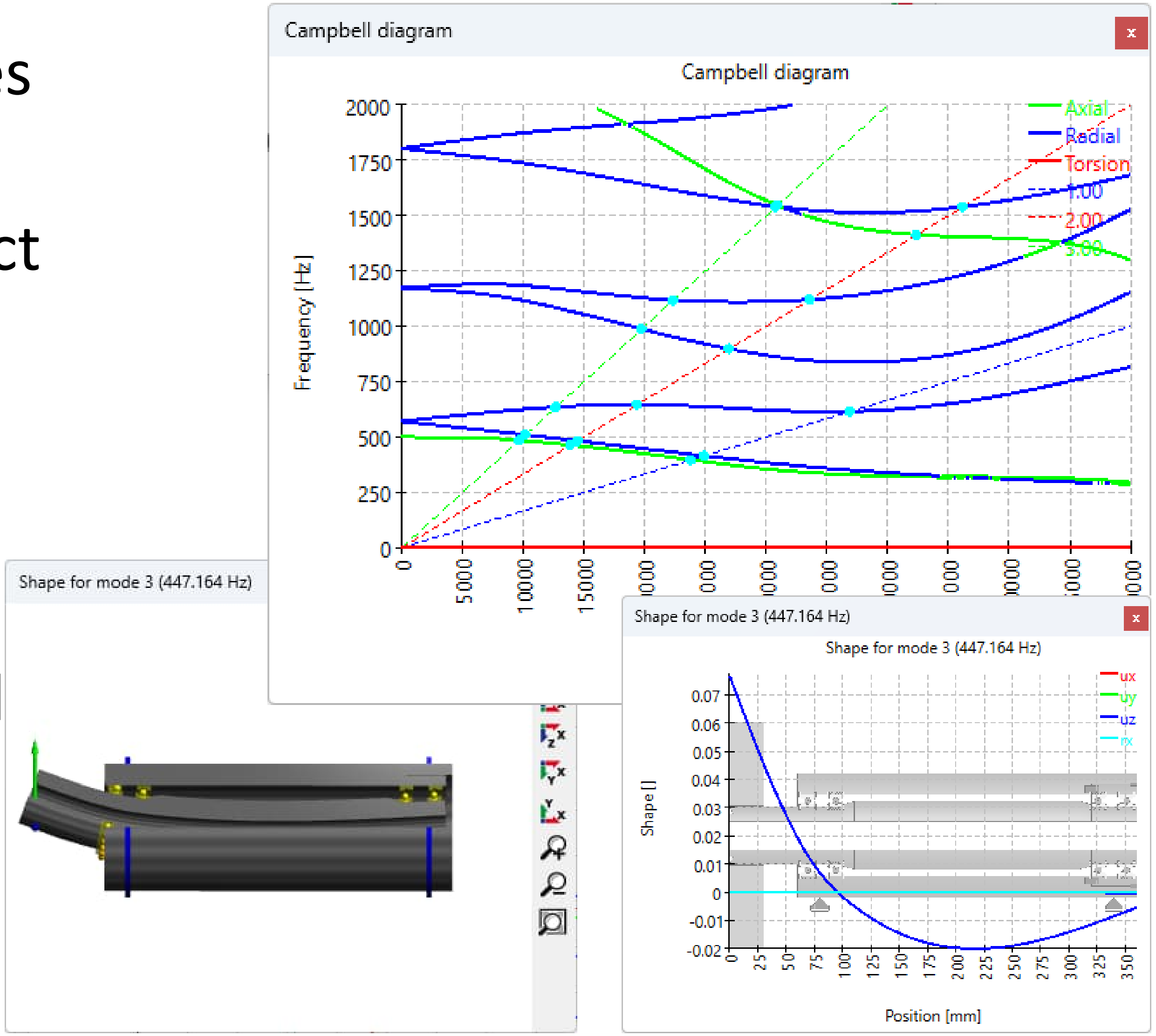
Group | Shafts | Bearings | Frequencies

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.

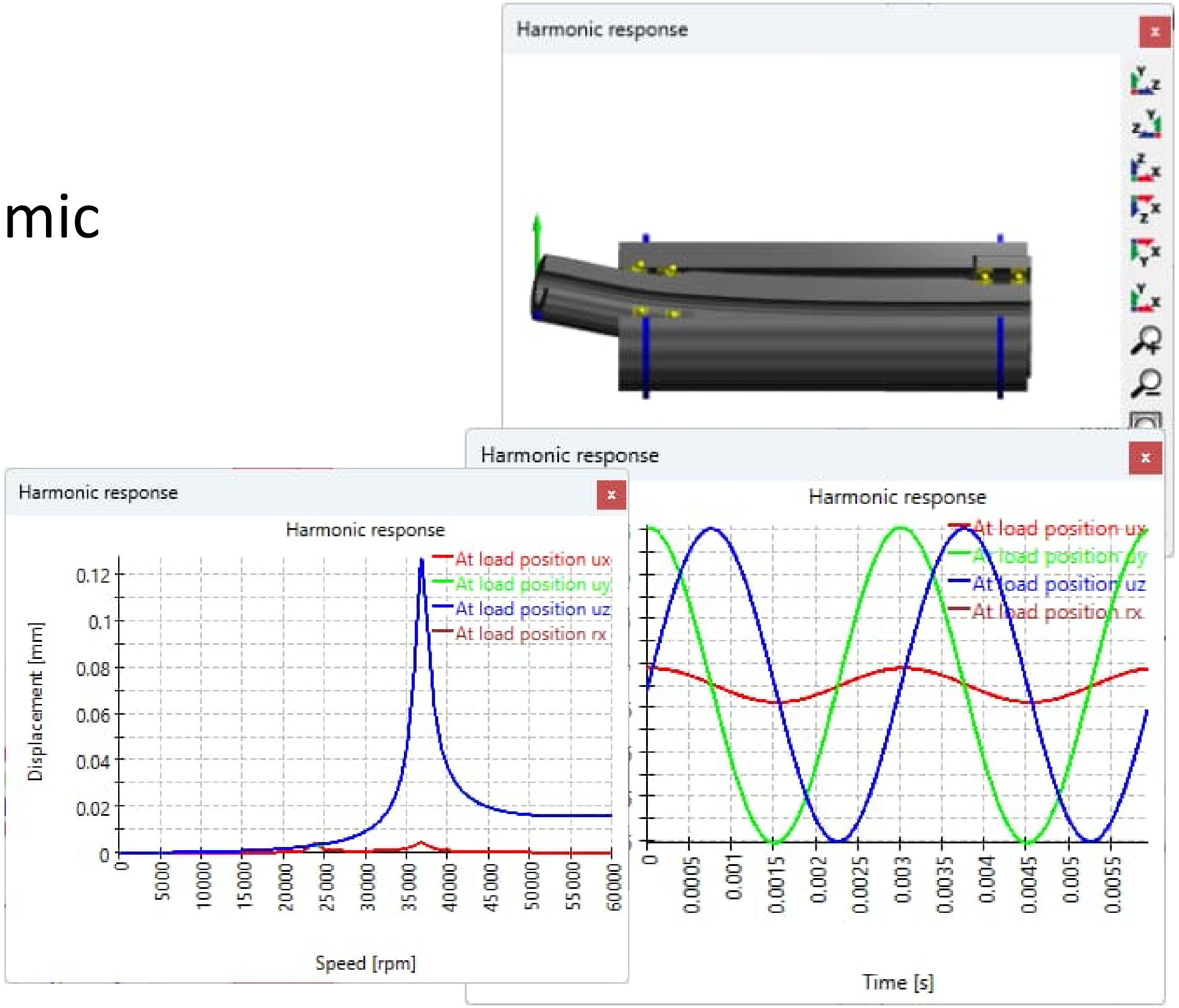
Shaft calculation Natural frequencies

- 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

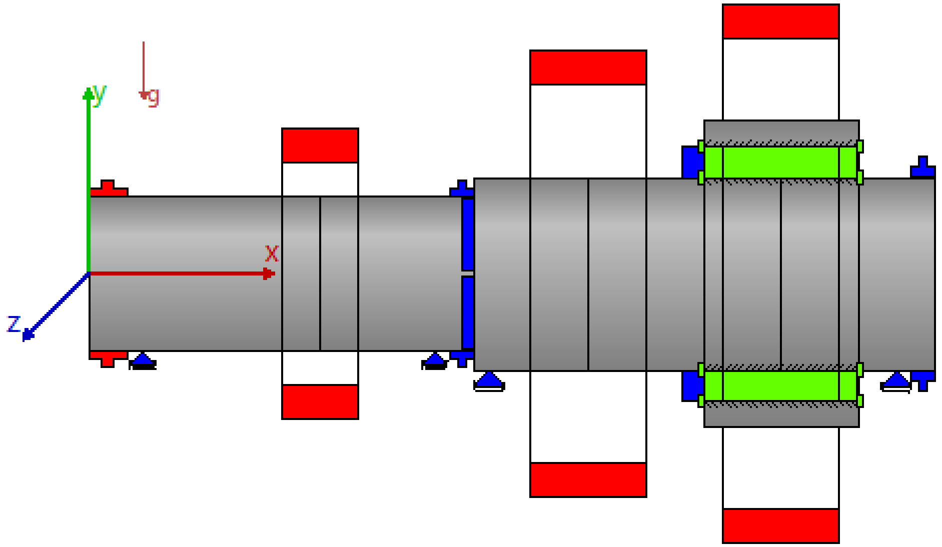


Temperatures

- For each shaft, it is possible to define either a unique temperature, or a temperature gradient by adding a temperature difference ‘ΔT’(±) 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.

Shift gearboxes

- 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.

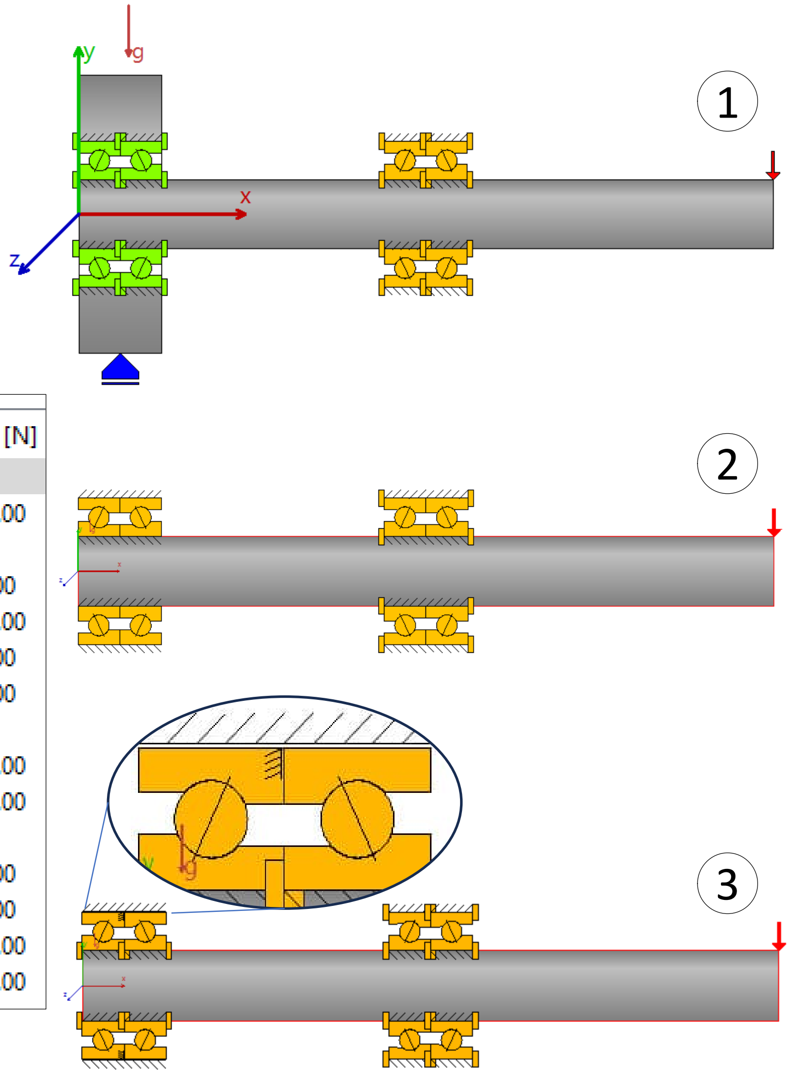


	Name	Direktgang	Syncronring	G1a-G1b
1	G1	☐	☐	☑
2	G2	☐	☑	☐
3	G3	☑	☐	☐

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

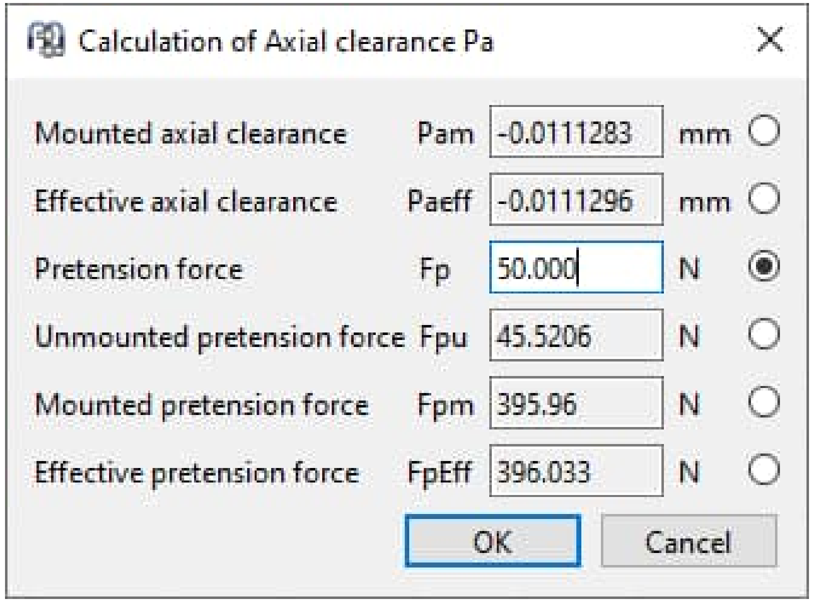


Bearing preload

- A pretension can be entered by using a negative value for the axial clearance Pa, 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:

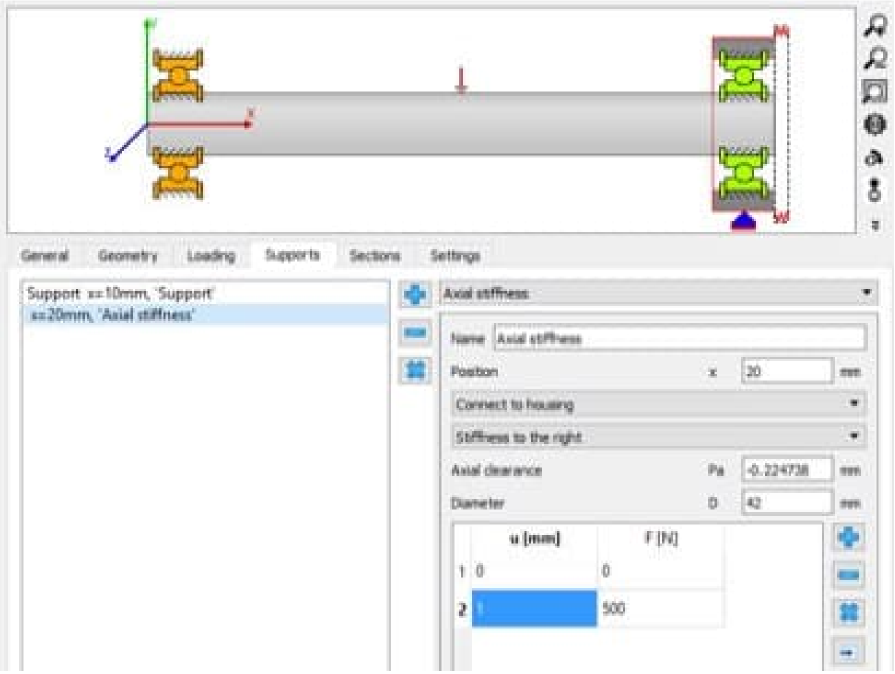
- The calculation with “Fp” is using nominal dimensions for the bearings.
- The calculation using “Fpu” is using nominal dimensions together with a radial elastic expansion without limit.
- The mounted pretension force "Fpm" is calculated using the dimensions after fitting but no temperature or speed.
- The effective pretension force “FpEff” is calculated using the dimensions after fitting and considering temperature and speed.

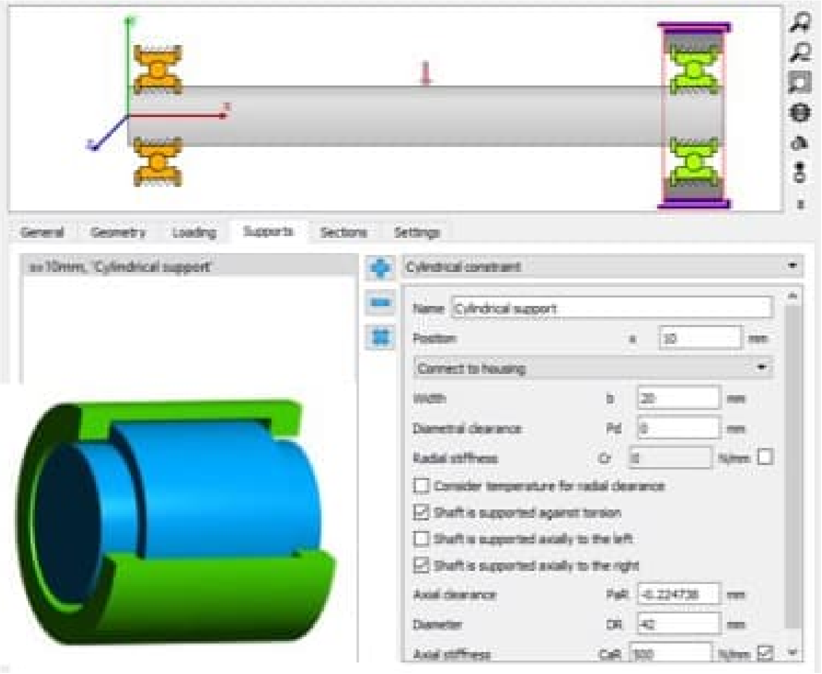


Bearing preload

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.

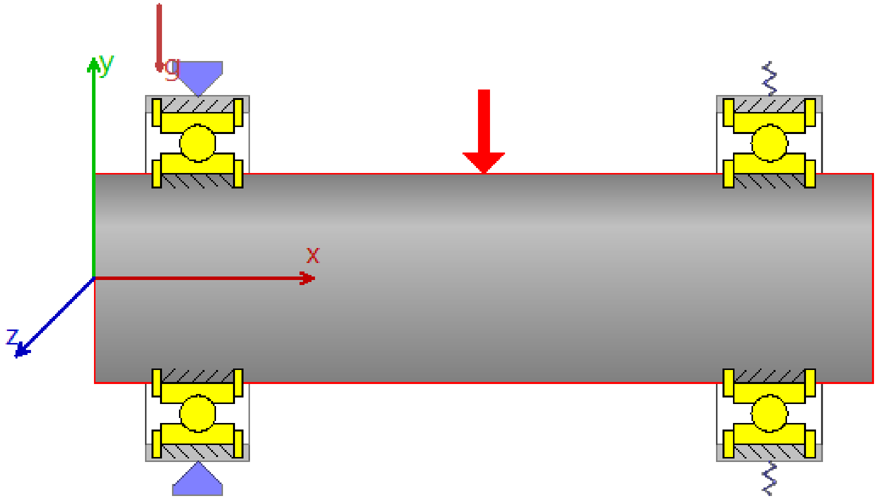
A cylindrical constraint allows to define a radial clearance of a shaft in a tube. Additionally an axial contact can be defined distributed over a diameter.





Housing stiffness

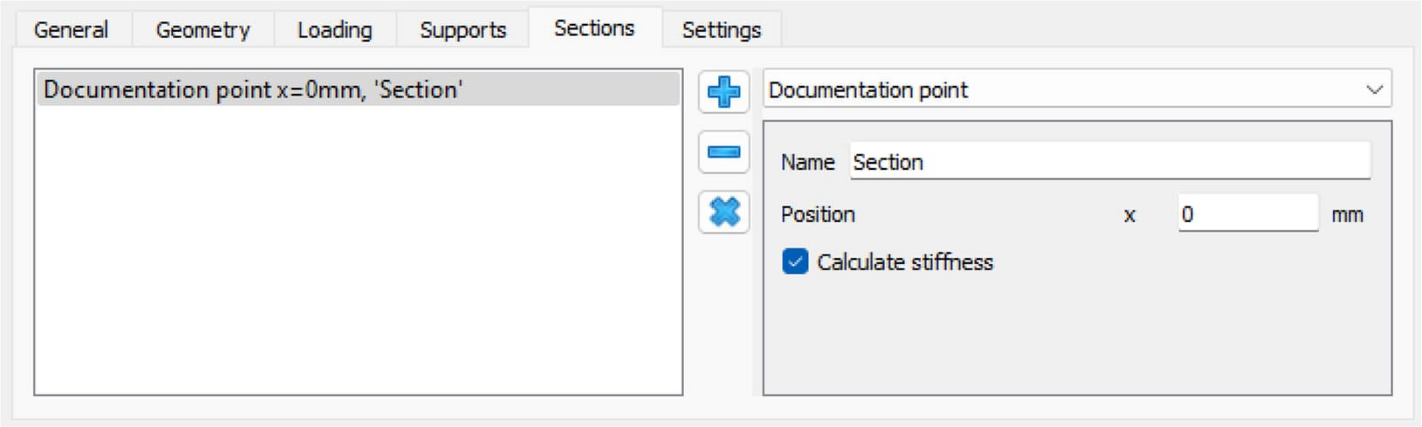
- In the past, in order to take into account the housing stiffness in addition to the bearing stiffness, an "Outer-ring shaft" had to be added. Then, this shaft was connected to the rigid environment by means of a general constraint or a stiffness matrix.



- 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.

Stiffness of shafts

- For documentation points on shafts a stiffness can be calculated.
- The resulting stiffness values cxx, cyy, czz, crx, cry, crz 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: Cyy = ΔFy/Δuy



Shaft strength according DIN 743 (2012)

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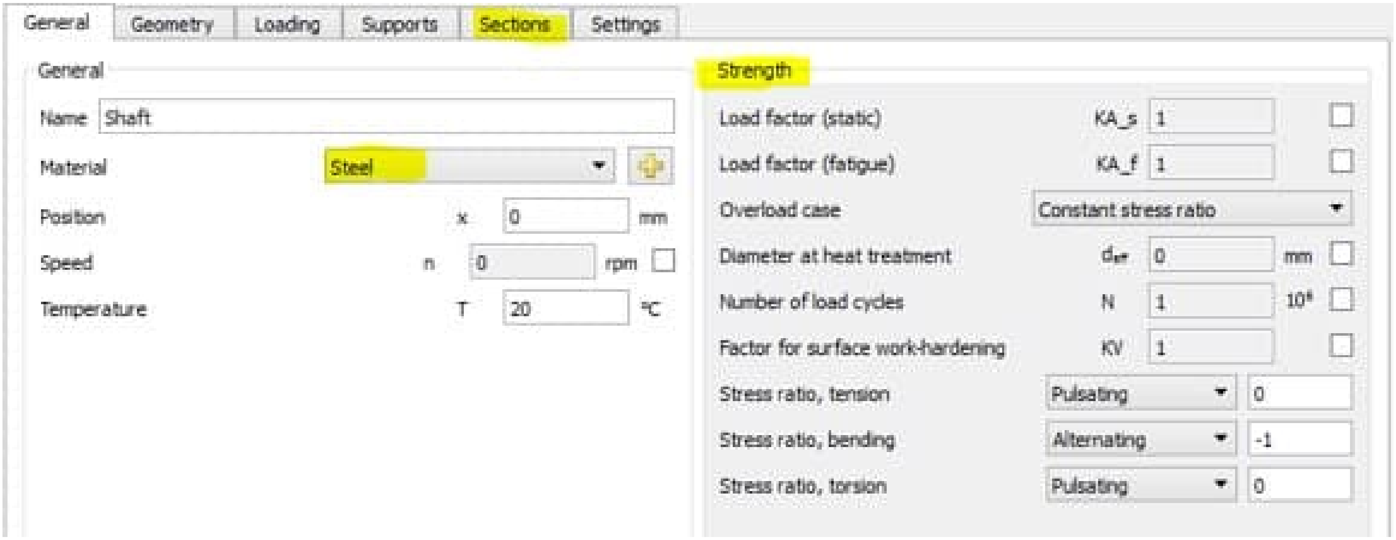
- For strength calculation according DIN 743 the material and a few other parameters have to be selected.
- Cross sections can be defined on page «Sections».
- The number of load cycles is calculation from rotation speed and required life as default.



Influence factors for strength according to DIN 743

- Technological size factor K1 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