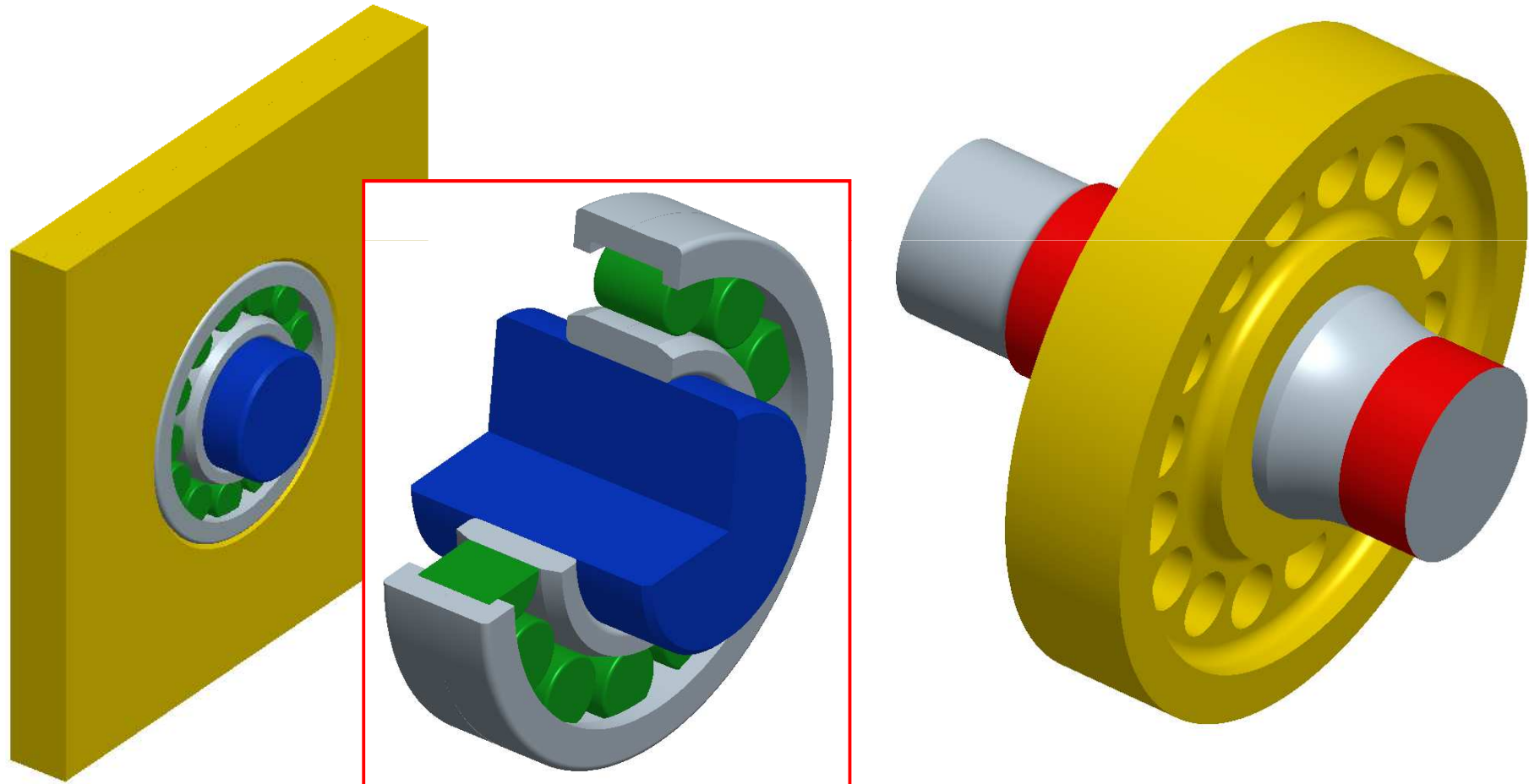


Application Examples of Typical Industrial Components

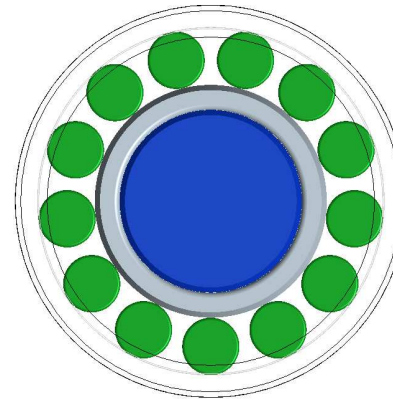
- Rolling load in a cylindrical roller bearing (friction free Hertzian contact)
- Torque transmission in a shaft-hub connection with shrink fit



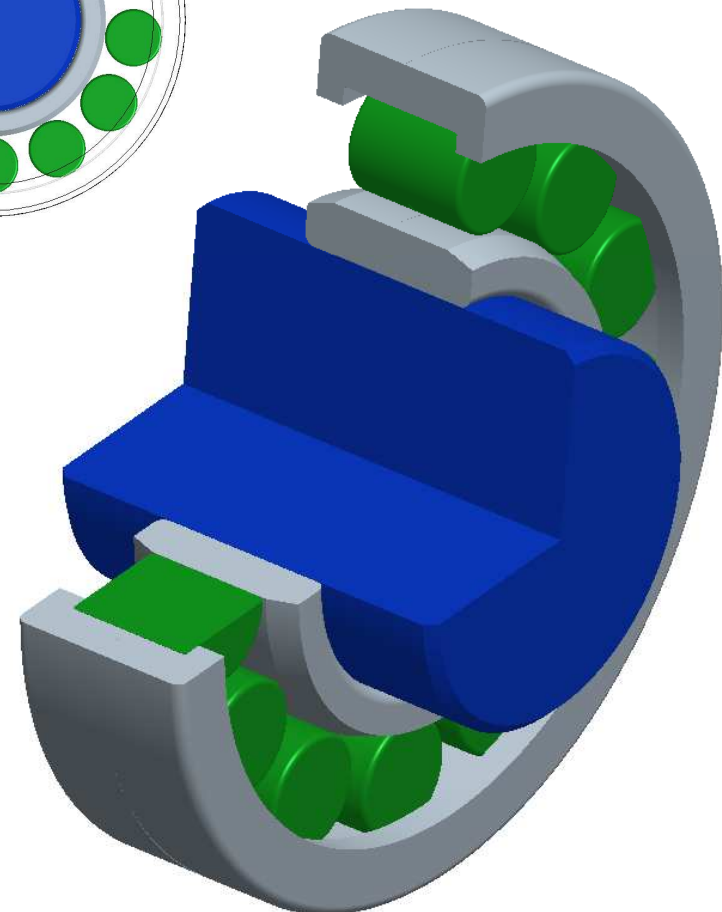
Rolling Load in a Cylindrical Roller Bearing (1)

Details of the Models

- FAG-Cylindrical Roller Bearing NU314E, Load Rating $C_0=220$ kN
- Shaft diameter 70 mm
Housing diameter 150 mm
Bearing width 35 mm
Bearing inner ring outside diameter 89 mm
Bearing outer ring inside diameter 133 mm
Roller length 24 mm, load carrying 22 mm
Roller diameter: 22 mm
(13 rollers)
- Bearing and shaft material: Steel
 $E=210000$ MPa; $\nu=0,3$
- Housing material: Alu
 $E=70000$ MPa; $\nu=0,3$
(alternatively also in Steel)
- Contact without friction



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very much for the information and
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Rolling Load in a Cylindrical Roller Bearing (2)

Background information

- The FAG roller bearing catalogue states that the contact pressure at the maximum stress position between rolling elements and race reaches 4000 MPa on reaching the static load rating C_0 (for this bearing 220000 N). This is a notional value, calculated through the application of Hertzian contact theory assuming linear-elastic material.
- In reality when the bearing is subject to a load C_0 a permanent plastic deformation would occur in the middle of the contact surfaces of the highest loaded roller and race of approximately 1/10000 the roller diameter. Due to high demands for positional accuracy required of the bearing, it should not be loaded as high as C_0 , for dynamic loading the bearing load must be much lower.
- There is no catalogue information advising what material the housing and shaft should be or what fit and bearing play were used as a basis for the 4000 MPa value. For the following studies, these values only serve as guidance to what stresses are to be expected in the rolling elements and the bearing races at various adopted extreme tolerances.

Rolling Load in a Cylindrical Roller Bearing (3)

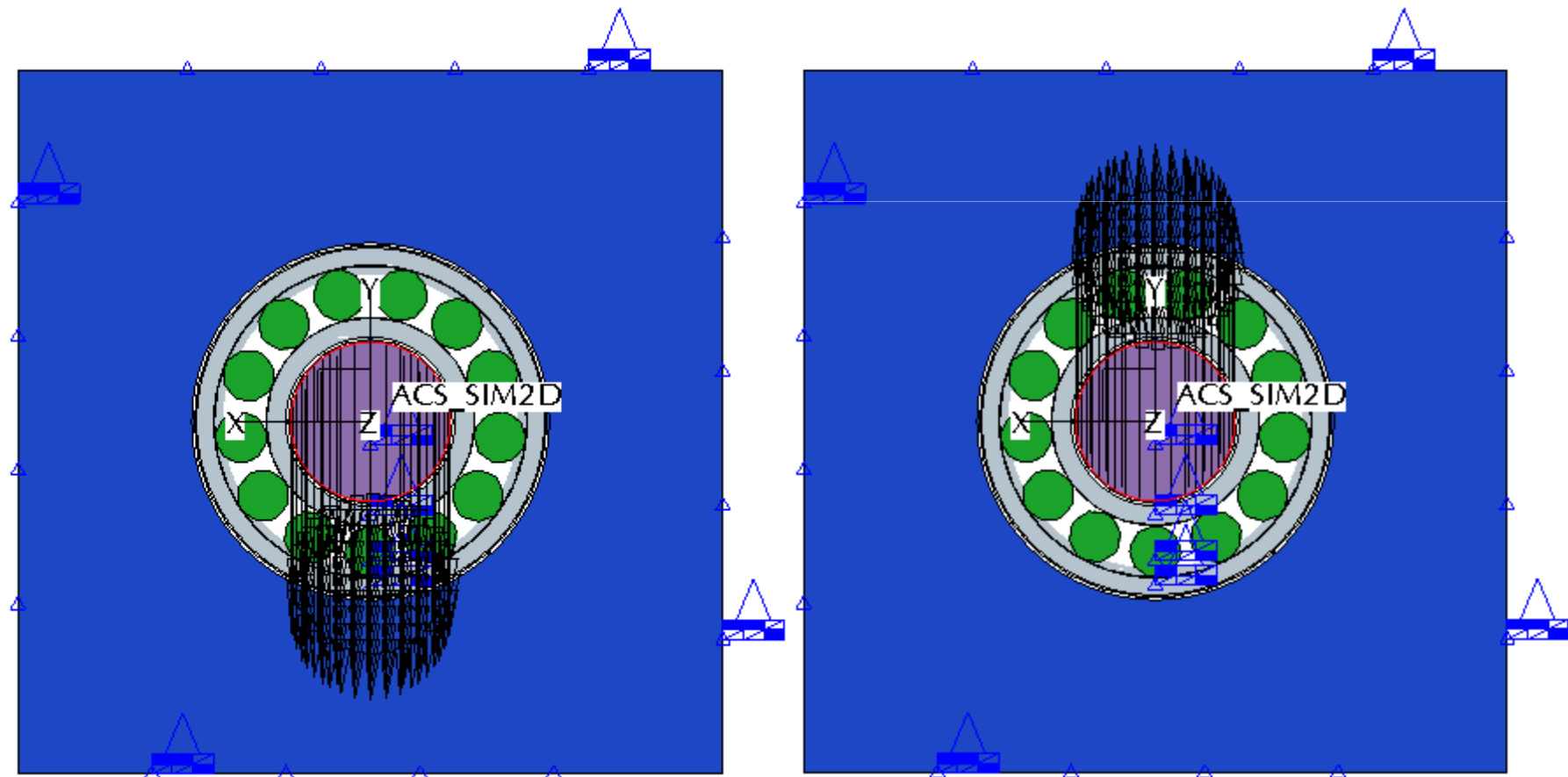
Choice of limits and fit in the model

- To calculate the influence from fitting tolerances to the bearing loading, the model will be analyzed with different extreme clearances:
 - A variant with minimum clearance:
 - Clearance to housing and shaft: 10 μm
 - Bearing clearance also 10 μm ; this means, each rolling element is 5 μm smaller than the half diameter difference between inner- and outer race ring of 22 mm (for this bearing size, this is equivalent to the minimum clearance of a high precise C1NA- clearance group bearing)
 - A variant with maximum clearance:
 - Clearance to housing and shaft : 100 μm
 - Bearing clearance 160 μm , this means, each rolling element is 80 μm smaller than the half diameter difference between inner- and outer race ring of 22 mm (for this bearing size, this is equivalent to the maximum clearance of a C5-clearance group bearing with increased play)
Hint: „Normal“ group C0-bearings of this size have 40-75 μm clearance
 - In addition, for the latter variant the soft Aluminum housing will be replaced by a stiffer steel housing, which should lead to higher contact pressures because of a more worse osculation

Rolling Load in a Cylindrical Roller Bearing (4)

Choice of the external load direction

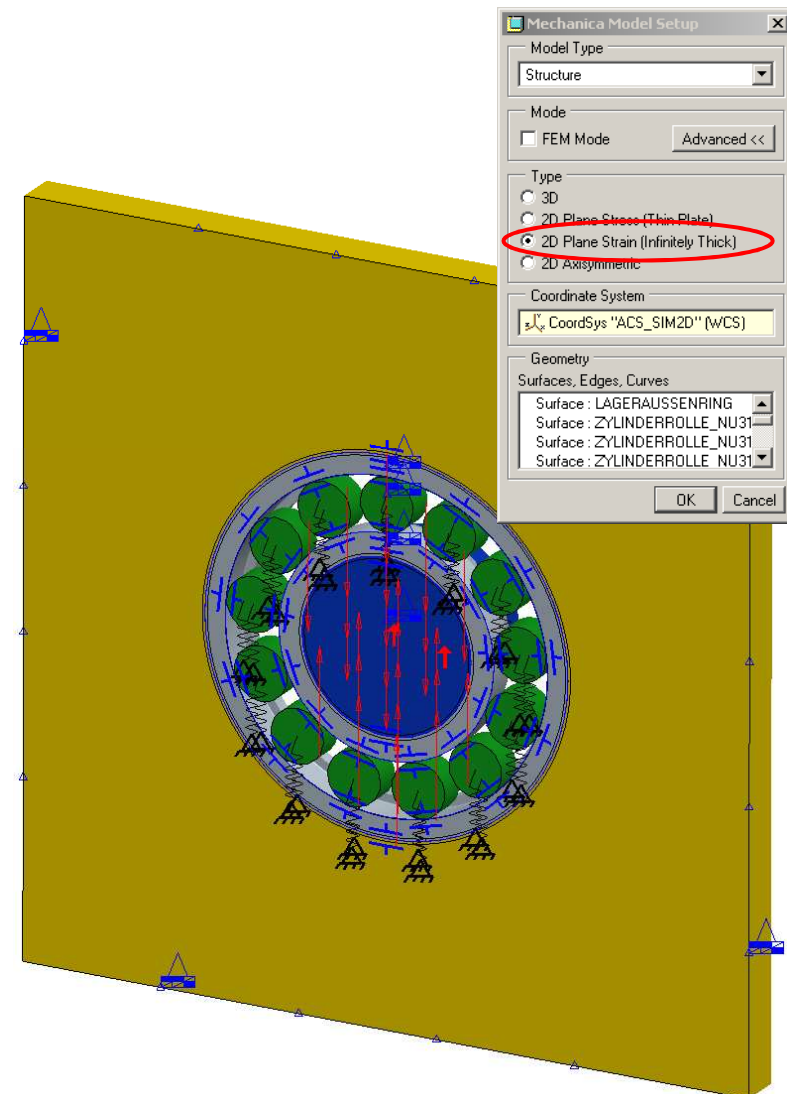
- For all variants the load vector is applied in a way, that six or seven rolling elements are within the loaded half of the bearing



Rolling Load in a Cylindrical Roller Bearing (5)

Idealization

- The idealization of the bearing assembly is difficult, since the Hertzian stress state within a rolling body – having the maximum comparative (shear) stress below the contact surface – is created by preventing of the axial transverse strain. Therefore, here the plane stress state cannot be used.
- In opposite, the „housing plate“ – outside the bearing load introduction – is just loaded in its plane, so here the plane stress condition would be fine for idealization
- Since here just the bearing loads are of interest, the plane strain condition will be selected



Rolling Load in a Cylindrical Roller Bearing (6)

- Ensuring the result quality through improved (refined) meshing and creation of contact specific measures

