Lez.: - Rolling Contact Bearing

Bearings are elements that allow relative motion between components, it also helps realise constraints.

Usually the rolling friction coefficient is lower than the sliding friction coefficient, so they are more common.

pg. 2

The roller bearing is the simplest type of bearing.

The balls roll between rings, they usually have cages and seals as well.

pg. 2 left more detailed.

There are many different types of rolling contact bearings but as many others customs can be ordered.

There are 3 main bearing manufacturers:

- SKF
- Shabler
- one other (didn't hear)

The catalogues for bearings are books which explain theory and how to use different equations, and other practical information.

Classifications:

Shape of rolling element

There are bearings based on spheres or roller bearings.
Usually roller bearings are able to sustain higher stresses since the roller bearings distribute pressures over a greater area, reducing pitting.

Another classification can be made based on the direction of sustainable loads:

- ↳ Radial → just radial loads
- ↳ Thrust → Just axial
- ↳ Angular → Mixed but just from one direction.

Another classification is the ability to accomodate misallignment.

- ↳ They can allow even degrees of misallignment
- ↳ For the rotation check we have to check there permissible rotation angles.

Bearings allow to idealize constraints.

- ↳ To idealize the contraints we don't have specific bearings, rather the constraints are idealized by what is around the bearings and what we allow to move in our assembly.

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The difference between the slider and roller is if we have a locating bearing or non-locating bearing.

A locating bearing allows movements (other than rotation) usually a translation, these are rollers.

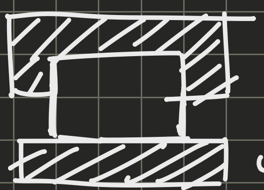
Roller vs. Hinge

↳ We check if the outer ring can move, if the inner ring can move or if the rolling element allows relative motion between rings.

↳ Spheres don't allow relative motion, but they still allow rotations.

The difference between a hinge and total fix is if it blocks rotations.

Even small rotations are rotations so they are hinges.



} still a roller since the roller can slide allowing relative motion, accomodating axial displacement.

If it is a hinge or roller is based on how we constrain the bearing.

pg. 7 → clear image difference between pin/hinge and roller.

Constraining bearings

↳ Seeger rings, circlips, snaprings.

↳ Spacers and shims. → allow us to recover tollerances.

↳ Lock nut

↳ Shoulders (in the shaft)

↳ There are infinite possibilities.

In order to use bearings as constraints, means that
way
we have to introduce notches, and means that they can
have an effect on the static and fatigue checks.
→ like if we use elastic rings.

If they are in some wrong places we may have to
consider both sides with appropriate calculations.
We may also introduce some other things to
reduce the notch effect. We have to use our wits to
minimize the number of issues.

We can also use big spacers to do the same job
we wanted to do the job where we would have used
notches.

fig. 10 Peterson diagram for seats of elastic rings.

To accomodate the housing we must pay attention
to the fillet radii and shoulder height.

↳ We generally want to use as large a radii as possible but in many cases to accommodate the bearings we will usually have to reduce it.

↳ A way to not reduce it, if we cannot, is to either use relief grooves or use spacers, to allow larger radii.

All bearings have a maximum radius they can interact with, so we have to check this and apply it if we can, this will have an effect on our checks, which is something we can't do much about

The height of the shoulder is also critical, the catalogues include the most appropriate maximum and minimum values for both shafts.

Failure of rolling contact Bearings.

↳ Basically how to select a bearing, we are cherry-picking the best bearing of the available ones.

The problem for bearings is pitting, so once again the issue is contact fatigue. This means that they generally break over time.

In most cases the failures are due to issue related to the lubrication.

Rolling bearings are subject to static, fatigue, or mixed loads.

Static cases include stationary or slightly oscillating bearing, or rare impacts or other cases.

Static strength is limited by the permissibile plastic strain.

A plastic strain equal to .05% of the diameter of the rolling element.

This permissible plastic strain corresponds to a possible Hertz pressure $p_{H,amm}$ of the order of 4000 MPa.
This is high considering the $\sigma_m$ of steels, and is possible because we are accepting plasticity, and since it's in such a small area which is surrounded by elasticity meaning that it won't fracture. It does fracture but in the form of pitting.
This is why we limit based on the accumulated plastic deformation.

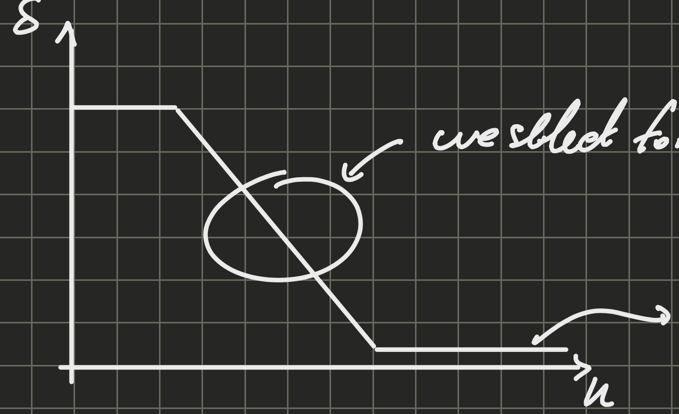
In the catalogue we are given limit loads in [kN] which corresponds to the plastic deformation from the Hertz pressure.
This means that for us we no longer have to use the contact theory to size our bearings.
We know what is happening but we don't need to do contact problems.

For just radial loads: $P_0 = F_r$
↳ static load.
If we have a mix, the catalogue gives us an idea on how to calculate the directional forces to compare to $C_0$.

Dynamic Strength

↳ The idea is the same, we are give C as the maximum dynamic load to which to compare.

We need to remember that bearings don't have infinite life and therefore they need to be replaced, they will always sooner or later fail.




Since we are constantly in a cyclic plastic field, sooner or later the fracture will begin.

Basic dynamic load rating : C → load for which 90% of bearings will work for at least $10^6$ cycles, before failure.

$$L_{nm} = a_1 \cdot a_2 \cdot a_3 \cdot L_{10}$$

$$L_{10} = \left(\frac{C}{P}\right)^p \quad p = 3 \quad p = \frac{10}{3}$$

$a_1$ = reliability

$a_2 = \ldots$

$a_3 = \ldots$

There are tables that help to determine $a_1, a_2, a_3$

Viscosity ratio: $K = \frac{\nu}{\nu_1}$

$\underbrace{\phantom{\nu_1}}_{\text{from 2 diagram}}$

Lubricant Nomenclature → ISO (number)

↓

viscosity at 40°C

Mixed strength

↳ We have both static and dynamic loads.

$$F_m = f_m \cdot (F_1 + F_2)$$

$$P = F_m$$

$$P = X \cdot F_m + Y \cdot F_a$$

This requires a whole rewrite of the last part, since he went very fast.