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Harshwardhan Gupta's Design Tips–5

Rolling Bearings

A rolling bearing is not just a roller bearing. Let's first define a rolling bearing: A bearing that has rolling elements like balls, parallel rollers, tapered rollers, spherical rollers, needles, etc. is a rolling bearing. In the Twentieth Century, rolling bearings have become extremely common in every corner of World. And they are getting cheaper every day.

What types?

Rolling bearings come in an enormous variety. First, there are the standard types covered by the DIN numbering system common across all manufacturers: This covers standard ball bearings, self-aligning ball bearings, angular contact ball bearings, thrust ball bearings, four-point bearings, plain roller bearings, tapered roller bearings, spherical roller bearings, thrust roller bearings, spherical roller thrust bearings, needle roller bearings, etc. Besides these, there are standard bearing units with seals and housings, popularly but mistakenly called Plummer blocks. Then there are thousands of types of specialized bearings, and a whole branded array of linear rolling bearings, some ordinary – with a limited linear travel, other recirculating, with unlimited travel. So study and research well before deciding.

Advantages:

1. Easy availability, easy replacement, low cost.
2. Very low friction even under heavy loads, so savings on energy and wear.
3. High rigidity under varying loads.
4. No continuous need of lubrication (see below).
5. No wear on the shaft as there is an inner race in most cases.

Limitations:

1. Prone to corrosion if not sealed properly. (Even those made from stainless steel are prone to corrosion if chloride ions are present.)
2. Do not absorb vibrations and do not tolerate contamination.

Design Do's and Don'ts:

1. Choose the bearing properly. Most often, the bearing is already oversized from load and life considerations. For example, a 100Kg load at 1400 rpm may only need a 17mm bore 6203 bearing, but your shaft is, say, 35mm, so the bearing has to be oversized. This is okay. However you can save money by specifying a lighter bearing – say 6007 in place of a 6207 for that 35mm shaft. The bearing is already oversized, don't oversize it further.
2. Choose a sealed bearing - a 6007-2RS in place of a plain 6007. A shielded bearing like 6007-2Z is okay for clean indoor environments, not for dirty and outdoor use.
3. Bearing seals will not seal-in or seal-out even a small amount of pressure. Nor will oil seals! So positively prevent water or other stuff from seep into bearings under even a slight pressure.
4. Repeat after me: Each shaft needs TWO bearings, not one, and not three, and certainly not one rolling and one sliding bearing. Doing so is sure to invite disaster. If the shaft has an eccentric, and that eccentric also has bearings on it, then the shaft is the primary element, definitely needing two bearings, and the eccentric is the secondary element, needing either one or two bearings, depending on the detailed design. Sometimes, for a short axle, one double-row ball bearing, or one double-row angular contact bearing can be used as a virtual bearing pair, but one self-aligning ball bearing (which does have 2 rows of balls) or one single-row ball bearing simply cannot be used by itself.
5. All axial-loading bearings, like tapered roller bearings, ball/roller thrust bearings or single-row angular contact bearings must be used in pairs and at least lightly loaded against each other. They may be of different sizes. With some experience and expert advise, you can

mix two kinds of axial-loading bearings on the same shaft. Putting a ball bearing and a tapered roller bearing is inviting destruction.

6. Wherever possible (usually everywhere) use a sealed rolling bearing and avoid open sliding bearings. Nowadays, except in mass-produces consumer white-goods, rolling bearings are actually cheaper than bronze bearings.
7. Keep the two bearings on a shaft well aligned. If this is not possible, say, in a fabricated assembly, then use self-aligning bearings on both ends.
8. Never ever "match" a bearing to the shaft or to the housing. Look up the bearing catalogue, specify recommended tolerances and fits, and make the parts as per the tolerances without giving the bearing in the hands of the turner. This habit too is a pathetic hangover from the 18th Century!
9. Do not constrain the bearing pair completely. Look up any good manufacturers catalogue and properly understand what is meant by locating-floating arrangement, and apply it. This is a very common cause of bearing failure.
10. If you are pre-loading the bearing intentionally, work out where and how the reaction forces will "flow". Else you will align everything perfectly, then distort the mounting arrangement by preloading, and end up ruining the bearings by inadvertent misalignment.
11. Never run bearing elements on hard-chrome plated surfaces, though ground hard-chromed surface looks perfect for running a needle bearing or a recirculating linear bearing on. It will flake off and ruin everything in a short time.

Duplicate! Duplicate!

Two kinds of "duplicates" are prevalent in the rolling bearing industry: the first spurious type is a new bearing with a counterfeit OEM marking; The second type is a genuine but used bearing, re-conditioned to look like new. You will be surprised to know the extent of this racket. And in many cases, if you call in experts from the original bearing manufacturers, you will find that your "regular" supplier has been taking you for a ride for years, especially if you are in the habit of bargaining excessively.

The first kind is usually (but NOT always) recognizable by poor quality markings, poor quality packs, smudgy packing dates, etc. As they say, counterfeiters are always a step ahead of the genuine guys. The only redeeming fact here is that only the popular (automobile use, agricultural pump use, etc.) bearing sizes are duplicated. Nobody will duplicate an unusual bearing that sells just a few units a year in the whole country.

The second type is easier to recognize: axial scratches in the inner race, buffed-to-mirror-finish outer races, foul-smelling oil, slightly blackened rolling surfaces, etc.

Another class is the "genuine" but cheap stuff from all sorts of mediocre manufacturers. If you use these, you get what you pay for, then pay for what you have got.

Lubrication:

Contrary to popular belief and common sense, rolling bearings require only a very thin oil film for their basic rolling function. Some lubricant in a SEALED housing is required so that the oily-greasy surfaces do not come in direct contact of moist air and other contaminants, and a tiny amount of lubrication is necessary for the cage (or retainer) lightly sliding on the rolling elements or the races. So a little bit of good quality oil or grease in a well-sealed bearing can and does last for the bearing's lifetime. Sealed and lubricated-for-life bearings are really so. The habit of putting oil and grease in every moving joint regularly is a hangover from the 18th Century days of the open bronze bushes oozing black filth.

New (unsealed type) bearings DO NOT come coated with lubricants. What looks like a lubricant is rust-preventive oil, which has no lubricating properties! Wipe it off and lubricate the bearing, then mount it and seal it.

Many machine tool spindle bearings run in continuous oil supply. These bearings are usually heavily pre-loaded for exceptional rigidity, and therefore heat up quite a bit when running. This is normal. Here the continuous oil flow is mainly to cool the bearing, not to lubricate it, really.

Mounting and dismounting:

Never use a hammer directly on a bearing. Use a mallet (popularly called nylon hammer). Do not use aluminium bars to transmit the hammer blow indirectly. The smallest of aluminium particles in the bearings will ruin it sooner than you believe possible – typical case of a tiny ant bringing down an elephant. If possible, press the bearing in place. If hammering is unavoidable, then tap the inner race to fit the inner race, and tap the outer race to fit the outer race, never vice versa – that transmits shocks through the rolling elements and damages the bearings. To take bearings out, use good tools. Most "commercial" bearing pullers are pathetic, difficult to use and often damage the bearings. Take care dirt and chips don't go inside the bearings. DO NOT use kerosene, petrol or diesel to wash the bearings. Use mineral turpentine, and immediately saturate the bearing with its designated lubricant after a wash. Needless to say, keep everything really, really clean.

How to know if a rolling bearing has failed:

Meri Aawaaz Suno!! Listen to the bearing! The best way to listen to a bearing is to use an about 10mm diameter rod, half a metre long. Hold the rod in your hand in such a way that one end of the rod touches the middle segment of your index finger. Then put the tip of that index finger in your ear, then touch the other end of the rod to the bearing housing, or to a stationary place near the bearing. Obviously, do NOT touch the rod to running parts. This is an engineer's stethoscope. You will now hear the bearing running. If the bearing is in good condition, the noise will be a smooth hissing sound. If the bearing is mounted too loose, you will hear a loud rattling sound. If the bearing is "gone", you will hear all sorts of unpleasant noises, much like a road-roller going over loose stones. If it is screeching, rumbling, squeaking, growling, then it's time to change it. If a *brand-new* bearing is also sounding unpleasant, as if it has got small stones inside it, then the bearing is too tight on the shaft or in the housing, or excessively pre-loaded, or over-constrained, and will fail very quickly.

Rolling bearings fail prematurely due to many reasons, and we will cover that next month.

So, seal them well! Make sure the rolling elements never see the light of the day when they are running! Keep the bearings rolling, so you don't slide into a recession!

Next Month: Bearing Failure

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