Turning to Rolling Bearings for Industrial Gearboxes

By Rachel Braddick

Understanding the pros and cons of bearing types for industrial gearboxes and monitoring bearings once in service can help contribute to successful application outcomes.

Rolling bearings play vital roles in supporting the shafts and gear wheels of industrial gearboxes and, often, several different bearing types will function in one gearbox. Even when these precision components are properly designed, manufactured, and specified, however, effectiveness and service life can be threatened at every turn.

Over time, the performance of a bearing in a gearbox system can become compromised due to improper loading, installation, sealing issues, misalignment, poor maintenance practices, extreme operating conditions, and/or other causes. Choosing bearing arrangements with the characteristics and properties most suited for an application will certainly help contribute to operational and longevity expectations.

But a watchful eye on bearings in service is always a practical rule of thumb. Early detection of telltale warning signs of trouble can make a timely difference in keeping gearboxes in play as intended.

Universe of Choices

Almost all rolling bearing types and sizes, including variants from standard, can find appropriate homes in industrial gearboxes — and for good reasons.

In general, rolling bearings enable optimum meshing due to good location with minimum radial and axial play, offer high specific load-carrying capacity with low friction, exhibit less sensitivity to misalignment than plain bearings, will not be influenced by direction of load or rotation, require minimal (if any) design work for the user, and are relatively easy to lubricate.

Within the universe of rolling bearings, specific types can be singled out as especially appropriate candidates for gearbox applications. All have benefited from improvements and enhancements over the years, and particular application requirements and demands will help guide the selection process.

Deep groove ball bearings can suit gearbox applications where shafts have to be located axially and loads are relatively light. They carry radial loads as well as axial loads acting in both directions, perform at very high speeds due to low friction, run quietly, and require little maintenance. Application examples include spur gear units (drive shaft and hollow takeoff shaft), multi-ratio gear units (switching spur gear wheels), geared motors, worm gear units (worm wheels), planetary gears (drive shaft, planetary carrier), and coupling shafts.

Where their raceway geometry has been optimized, these bearing types can become much less sensitive to misalignment, which can help extend bearing life. Enhanced surface finishes have been formulated to help reduce friction and running temperatures, which can improve lubrication conditions for the bearings.

Angular contact ball bearings feature raceways arranged at an angle to the bearing axis (contact angle) enabling them to carry heavier axial loads than deep groove ball bearings. Designs include single row versions (which can be paired), double row arrangements, and four-point contact ball bearings. Depending on the bearing’s configuration, suitable gearbox applications include worm shafts and high-speed spur gear units.

Tapered roller bearings integrate tapered raceways to handle combined radial and axial loads and can be specified with contact angles to accommodate specific load combinations. Since these bearings can support very heavy loads, they will usually be the picks when the load-carrying capacity of alternative deep groove or angular contact
bearings is inadequate for combined load conditions. In addition, the cross-sectional footprint for a tapered roller bearing is relatively small, which contributes to efficacy in applications with combined load. Dominant gearbox applications for these arrangements include spur and helical gear units, bevel and bevel/spur units, and worm gear units.

The latest generations feature an optimum form and finish of the roller end/guide flange contact, which promotes hydrodynamic lubrication; logarithmic raceways to prevent edge stresses; and improved surface topography of raceways for enhanced lubricant film formation and reduced bearing noise.

Spherical roller bearings offer a self-aligning capability to compensate for shaft bending or where there may be errors in alignment between shaft and housing. As a result, they can replace rigid bearings whose misaligned bearing rings would otherwise produce edge stresses. Gearbox applications include many types of gear forms and arrangements.

Notable features and advantages include long symmetrical rollers imparting high load-carrying capacity, “floating” guide ring between the rows of rollers, optimum surface finish to enable high speed operation, and robust metallic cages designed to perform well even under arduous conditions.

Thrust versions of spherical roller bearings deliver the same self-aligning capability. They can be considered for gearboxes where axial forces are produced by the driven machine (such as in extruder gearing and water-turbine gearboxes) and as thrust bearings for pinion and worm shafts of large and heavily loaded bevel and worm gear units.

Compact aligning roller bearings are single row bearings specified as non-locating bearings in industrial gearboxes. They benefit from a compact design with low cross-section and a high radial load-carrying capacity, even when misaligned, and can serve as solutions for heavily loaded shafts in spur gearboxes, pinion shafts in bevel gearboxes, and planetary gears.

Among other advantages, these bearings can achieve up to 30 percent higher load-carrying capacity, compensate for errors of position, and allow for both bearing rings to be mounted with an interference fit to eliminate the potential for wear in the bore.

Cylindrical roller bearings in a variety of designs and configurations exhibit high radial load-carrying capacity, the lowest friction of any roller bearing under purely radial load, and the capability to run at high speeds. These and other characteristics make them ideal as non-locating bearings for all high-performance gearbox units and for positions on intermediate shafts of spur gear units.

Enhancements have encompassed reinforced roller complements and “opened” flanges for increased radial load-carrying capacity, logarithmic roller profiles for optimum stress distribution over the entire roller length, refined raceway microgeometry for reduced friction and consistent lubricant film formation, and a variety of cages (polyamide, steel window-type, and machined brass) promoting proper bearing function.

---

**No Money for Capital Equipment Purchases? NO PROBLEM!**
**Let Pentagear REPOWER your Gear Inspection Machines Today!**

![Image of a brain and gears]

**Same Basic Body...**

**New Smarter Brain!**

**We Put The Smart Stuff Inside!**

**REPOWERED BY Pentagear**

- Analytical Inspection Machine
- Roll Testers
- Single Flank
- DOB Inspection Gauges
- Deburrs Machines

![A gear and a computer]

**NOW WE CAN REPOWER YOUR M&M 3025!**

**Penta Gear Metrology**

6161 Webster St. Dayton, OH
Tel: 937-660-8182 Sales@Pentagear.com
Fax: 937-660-4521 www.gearinspection.com
**DAMAGE MODES**

Selecting the proper bearing arrangement for a gearbox application is the first critical step toward successful performance, but the demands on bearings in service potentially can lead to damage linked most often to fatigue, wear, and fractures.

Fatigue defines a change in the bearing’s material structure caused by repeated stresses in the contacts between rolling elements and raceways. Subsurface fatigue shows as micro-cracks at a certain depth under the surface, and surface-initiated fatigue is flaking that originates at the rolling surfaces.

Wear is the progressive removal of material from the bearing’s sliding or rolling contact surfaces during service. Abrasive wear usually can be linked to inadequate lubrication or ingress of contaminants, and adhesive wear (or smearing) follows transfer of material from one surface to another.

The first visible indication of abrasive wear is usually a fine roughening or waviness of the bearing’s surface. Fine cracks can then develop, and spalling (or surface-initiated fatigue) will occur. If there is insufficient heat removal, the temperature may rise high enough to cause discoloration and softening of the hardened bearing steel.

From adhesive wear, a bearing’s surface assumes a “frosty” appearance and will feel smooth in one direction but distinctly rough in the other. Or, smearing damage may be apparent. One type of smearing develops between sliding surfaces whereby minute pieces of one surface tear away and re-weld to either surface. (Areas subject to sliding friction, such as locating flanges and the ends of rollers in a roller bearing, are usually the first parts to be affected.) Another type of smearing is called “skid-smearing,” which can be detected as patches. This condition can result when rolling elements slide as they pass from the unloaded to the loaded zone, and there is insufficient lubrication in the load zone.

Fractures occur when the ultimate tensile strength of bearing material is exceeded, causing a complete separation of a part of the bearing. Forced fractures result from a stress concentration in excess of the bearing material’s tensile strength; fatigue fractures occur when the fatigue strength limit of the material is frequently exceeded, and thermal cracking (or heat cracking) will form cracks due to high frictional heating.

Regardless of the particular damage mode — whether fatigue, wear, or fractures — root causes will be at the heart of the problem. Two usual suspects are ineffective lubrication and ineffective sealing. Here’s what to look for when attempting to determine whether one of these root causes of damage is culpable:

Lubricant for a rolling bearing separates the rolling elements, cage, and raceways in both the rolling and sliding regions of contact, and rolling bearings will only perform reliably when they are adequately lubricated. Without effective lubrication, metal-to-metal contact occurs between the rolling elements and the raceways, causing wear of the internal rolling surfaces. Most cases of “lubrication failure” will result either from insufficient or excessive lubricant viscosity, over-lubrication, contamination of the lubricant, or inadequate quantity of lubricant.

Without effective sealing, the impact of contaminants on bearings in gearboxes can also be devastating, even affecting lubricant performance. When debris is trapped between a bearing’s raceway and rollers, plastic deformation depressions, or particle denting, can develop. In addition to abrasive matter, non-particle corrosive agents can invade. Water, acid, and many cleaning agents deteriorate lubricants and lead to corrosion. Proper sealing is the key to help keep contaminants out and protect the lubricant in the process.

**MONITORING CHECKLIST**

Monitoring critical parameters can spot early signs of trouble before it’s too late. Here’s a general checklist of parameters to evaluate and/or trend:

**Lubrication:** Lubricant supply in oil bath systems can be checked using simple technology, such as a dipstick. For circulating oil lubrication, however, complex systems will be required to check oil pressure, flow rate, and temperature at each lubrication point. Often, an alarm system will be integrated. Oil samples can be taken and analyzed for contamination levels and oil deterioration.

**Temperature:** Measuring bearing temperature usually will be an avenue for bearings operating at high speeds — and then only as an indication of trends — with temperature preferably measured directly on the bearing rings. In addition, temperature measurements of bearings, gearbox, and oil will help determine the operating viscosity of the oil, which then can open a window into the status of operating conditions.

**Wear:** A clear indication that particles of bearing steel are among perceived wear particles will suggest a bearing has already become damaged. Visual inspection is one way to make the determination; another approach is to position a magnet at the bottom of the bearing box to collect any metallic particles. The particles can then be analyzed to determine whether they are gear-tooth material, bearing material, or from another source, such as contaminants. Ultimately, the gearbox should be inspected to determine the source of any wear, and remedial action should be implemented to prevent further damage.

**Vibration:** Depending on the extent, the presence of vibration, especially when excessive, can be cause for concern. Best practice procedures to monitor vibration include measuring bearing and gear mesh frequencies and then trend these frequencies over time to detect developing problems.

Of course, every application will present unique challenges, but understanding the pros and cons of bearing types for industrial gearboxes — and monitoring bearings once in service — can help contribute to successful application outcomes.