Run Times
LAWRENCE PUMPS INC.
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The ability to handle both radial loads and bi-directional thrust make angular contact bearings a popular choice in the design of medium to large industrial centrifugal pumps. Our service group frequently assists our customers with problems resulting from the improper installation of paired angular contact bearings. In this month's issue we present a procedure for the proper installation of angular contact bearings, and an inspection method for verifying correct installation.

Dale B. Andrews

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The five critical elements to a successful installation of angular contact bearings: shaft condition, cleanliness, proper heating, bearing orientation and proper tightening.

Shaft Condition

Check shaft total indicated run-out (TIR), dimension of the bearing fit and the condition of the bearing mounting surface and shaft shoulder. The TIR should be less than 0.001" [0.025mm] at the journals with the shaft running in its shaft centers or on roller steady rests in a lathe.

The shaft journal diameter is critical as it determines the internal clearances of the bearing. There is an interference fit between the shaft journal and bearing inner race that will cause the inner race to expand when it is installed on the shaft. Bearing design takes this into consideration. It is important to have shaft journals that are within the tolerances specified by the bearing manufacturer to insure proper internal bearing clearances. Obviously, our recommendation would be the use of an OEM shaft. If you choose not to, we would strongly suggest a very careful dimensional check. A fit that is too loose or too tight will make a big difference in bearing life.

Bearing mounting surfaces should have a 32 RMS finish without nicks, raised indentations or gouges.

Cleanliness

Any foreign material that gets into the bearing will result in damage to the rolling elements and races and a shortened bearing life. Bearings should never be removed from their original packaging until ready for use. They should be handled as little as possible, and should be kept away from dirty areas. Inspect the bearings being used for correct bearing number, damage, rust stains, or metal debris prior to installation. Bearings straight out of the box are not always fit for use.

Proper Heating

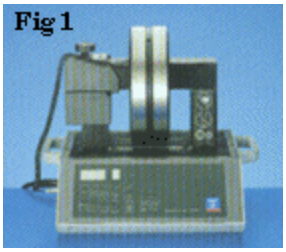
Fig 1

Most bearing manufacturers say that bearings up to a 70 mm (2.75") bore may be press fit. Frankly, that's a pretty large bore for a press fit. A 50 mm (2 in) bore is probably a more realistic press fit limit. That having been said, heating is by far the best method for proper installation. Heating must be done evenly, using an induction heater (Fig 1), oven, or some other approved device for heating the bearing evenly without damage. Flame heating should never be done because it generates localized temperatures that permanently affect the metallurgical properties of the bearing. For many years it was common practice to heat bearings in an oil bath, but in recent years this practice is being used less due to the obvious safety concerns, as well as having to deal with the environmental issue of the waste oil.

The proper temperature for heating a bearing is between 65^{o}C – 120^{o}C (150^{o}F – 250^{o}F). Under no circumstances should the high temperature limit be exceeded. At Lawrence Pumps we typically use 104^{o}C (220^{o}F) as our target temperature. Measure the temperature on the inner race using a calibrated temperature stick, or thermocouple.

Bearing Orientation

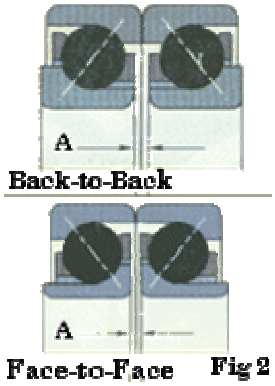

Fig 2

Angular contact thrust bearings typically have a contact angle of between 25 and 40 degrees. They can be paired together in three arrangements, namely tandem, face-to-face or back-to-back. The tandem arrangement increases the thrust capacity in one direction but has no provision for thrust in the opposite direction. However, back-to-back or face-to face pairing of two angular contact bearings provides bi-directional thrust capability. The back-to-back arrangement is the most common configuration (Fig 2). Refer to the manufacturer's drawings for the proper bearing orientation prior to installation.

Note: Prior to bearing installation onto the shaft, be sure to install any components, such as bearing housings, which should be installed onto the shaft prior to the bearings.

If possible, install the bearings together, sliding them onto the shaft until they seat against the shaft shoulder. If properly heated, the bearings will slide easily. If the bearings are to large to safely handle as a pair, install them one at a time, seating the first bearing against the shaft shoulder, and the second bearing against the first bearing. This operation should be executed crisply. The inner race temperature lowers very quickly once it contacts the shaft. Once the bearings are on the shaft, push them, at the inner race, towards the shaft shoulder for about 30 seconds or until the inner races are shrunk onto the shaft. (This prevents them from moving away from the shaft shoulder while they are still hot.)

Proper Tightening

Prior to tightening, gap (A) (Fig 2) exists between the paired inner races. Proper tightening closes this gap and establishes the contact angles for proper installation. If gap (A) is not closed, the internal clearances in the bearing will be too high and the balls will not be properly seated in the races.

Tighten the locknut, without the lack-washer hand tight. Wait about a minute for the shaft to pick up heat from the bearing; then, using a spanner wrench and a hammer, or a piece of clean steel key stock with a good edge, drive on the locknut tight. "Tight" is defined as a distinct feel that the

inner races of the bearing are seated together and the locknut will start to distort if driven tighter. Wait about 10 minutes and re-tighten a second time. Do not use brass or other soft materials to tighten the lock-nut, as soft metals will flake off with impact and contaminate the bearings. While the bearings are cooling, use clean lint-free rags, or oil paper, to cover and protect the bearings from foreign matter contamination.

To check installation, after bearings and shaft are cooled, remove the locknut. Spin the outer races of the bearing. Try to rotate one outer race CW while trying to rotate other outer race CCW. This should be difficult with a normal clearance "CB" designation (third and fourth letter in the bearing code) and not possible with a preloaded bearing such as a "GA", GB" or GC" bearing code designation. Depending on the preload, the bearings should now turn, in the same direction, freely, or with slight resistance. The resistance to turning the bearing should be consistent through 360^{o} degrees of rotation. Inconsistent resistance to rotation is an indication of an incorrectly mounted bearing, or a sign of foreign material in the bearing. If you can not get the bearings to spin with consistent resistance, remove the bearings to investigate. **Do not proceed!**

If everything seems fine, install a new locknut and lock-washer and tighten. It is difficult to over tighten a locknut, but an indication of over tightening is that when rechecking the bearing after final installation of the locknut, the bearing turns through 360^{o} of rotation with inconsistent resistance, whereas prior to installing the locknut everything was fine. The locknut may be on too tight and the inner races are distorted. Try backing off the nut to the next loosest engagement of the lock-washer and rechecking.

Caution: Do not try to remove the locknut with the shaft still hot. This may raise a burr in some shafts. It is best to allow the shaft to cool to ambient and then remove the locknut. Remove the locknut, install the lock-washer, and reinstall the locknut. Then tighten the locknut and set the tabs.

If a bearing must be removed from the shaft, it is generally best to replace it. Whenever a bearing is removed from a shaft there is a risk of damage to the rolling elements and races. The cost of a new bearing is a fraction of the cost of a pump that goes out of service prematurely.

If all is fine, with cleanliness in mind, hand pack the bearing with appropriate grease, if it is grease lubricated. Oil the bearing down with the correct clean oil, if it is oil lubricated. Install housings, covers, seals and slingers to complete rotating element assembly and protect the bearing.

30% of all pre-mature bearing failures are related to improper installation or contamination issues. We've rarely encountered a "bad bearing", but we have seen many poor bearing mounting practices. Good bearing life starts with storage and installation. Following these procedures is a good start towards maximizing the thrust bearing life in your centrifugal pumps.