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Bearing life testing for incoming inspection

Abstract

For global sourcing of bearings, quality control of regular deliveries as well as evaluation of new suppliers are highly important. Thorough metallurgical and geometrical inspections which are most common methods for quality control require significant time and effort. Therefore, life testing of at least four samples can be significantly cheaper and quicker for especially small bearings.

Motivation

During global sourcing of bearings, one permanently gets in contact with potential new suppliers that offer interesting commercial conditions; however, during visiting the related production facilities, one quickly realizes that a lot of them will not be able to fulfil the requirements. Since such trips require a lot of time and money, a quick and efficient test on samples could significantly reduce the number of candidates which then shall be subjected to thorough quality audits and product testing for final approval.

Apart from that, once having approved suppliers, stability of quality can still be questionable. Therefore, incoming inspection of goods is essential for identification of non-qualified products prior to using them.

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Standard sample inspection

Typical sample inspection refers especially to:

- Outer dimensions
- Microgeometry of raceways
- Noise and vibrations
- Material quality

Especially metallurgical inspection of at least three specimens per bearing (inner ring, outer ring, rolling element) can be highly expensive while checking only one sample provides very limited information on a whole delivery batch; especially if one considers the risk that the vendor might have mixed goods of different quality.

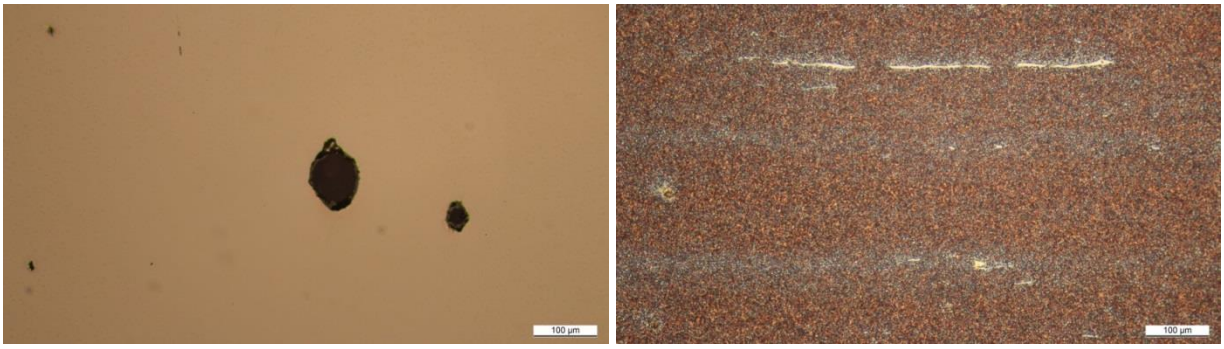

Figure 1: example of non-qualified bearing material

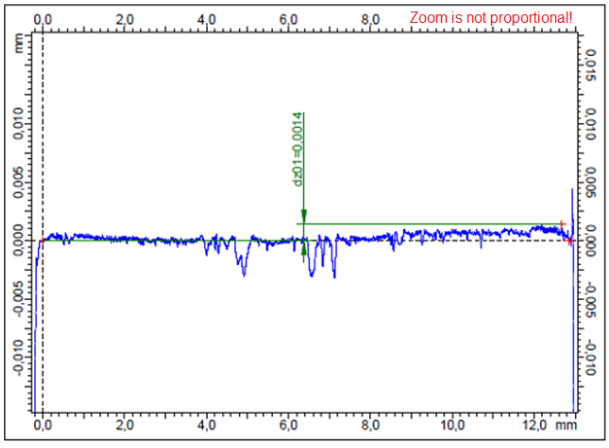

Figure 2: example of improper raceway crowning

Simplified life testing as alternative approach

For deep groove ball bearings, like e. g. 6208, test conditions could lead to modified lifetime expectation according to ISO 281 of 120 hours for which purpose a test run on four samples which have to be installed on one shaft shall be suspended for the same time in order to quickly detect possible major defects.
Such quick test will not be sufficient for a general evaluation of bearing performance; nevertheless, assuming that four samples are randomly picked from a container of a particular production batch, most common production faults or transportation defects are likely to cause premature failure, conspicuous noise or problems during mounting (dimensional deviations) into the test rig by which these could be detected. Such possible faults are especially:

- Highly non-qualified material (only significant deviation)
- Improper raceway geometry (only significant deviation)
- Improper heat treatment
- Hardening cracks
- Grinding burns
- Raceway corrosion
- Faulty radial clearance
- Dimensional deviation
- Contamination
- Different size of rolling elements

Figure 3 shows the setup for four deep groove ball bearings on one shaft which are radially loaded. For cylindrical roller bearings, however, one would be likely to install only two test bearings and two slave bearings as shaft bending is different at different positions which might have an influence. Tapered roller and one row angular contact bearings could be most efficiently tested by pure axial loading which also would mean to have only two test bearings.
For double row angular contact bearings it could make sense to choose a three bearings setup with combined radial and axial load. Then, the middle bearing would face the full radial load of the cylinder, the outer bearings only half the radial load. Accordingly, one could define axial load which only applies to the outer bearings to a value which leads to the same life expectation for all three bearings. The strong point of this approach is that any deviation of contact angle would lead to reduced lifetime for either the middle or the outer bearings.
In case of a four test bearings setup, it can be sufficient to carry out one test run; for the other cases, two test runs would be recommended in order to have some minimum statistical evidence.

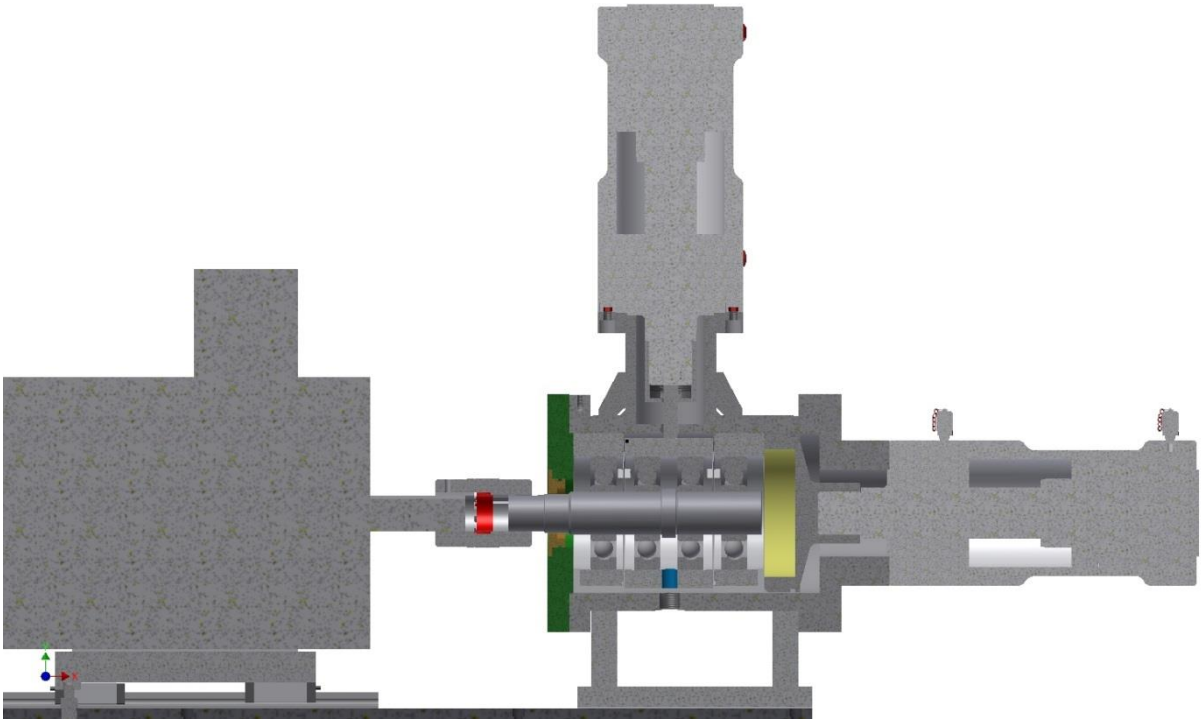

Figure 3: test setup

Test rig

Bearings up to 80 mm outer diameter can be tested on a two station bearing test rig type EELPRAAX-80, which can be seen in Figure 4 while for bigger bearings, larger but similar machines are available. This test rig is designed to determine bearing lifetime in different operation conditions for any kind of bearings. The bearings are mounted on a horizontal shaft while the non-rotating outer rings are radial or/and axial loaded by controlled hydraulic cylinders. The shaft is driven by an electric motor which is supplied by a frequency converter so that both variable and controlled rotational speeds are possible.

The motor and the test head shaft are connected by a flexible coupling which not only compensates certain misalignment but also separates motor vibrations from the test bearings. For the same reason, the stiff base plate on which motor and test head are mounted is supported by flexible buffers on the frame so that the test bearings are hardly influenced by any external vibrations, especially from the opposite test station on the same frame.

The temperature, as the third testing parameter, is controlled by the lubrication system. The oil flows through an air cooler and a filter into the test head and finally back to the tank. The fan speed of the air cooler and the speed of the oil pump are each controlled by frequency converters. This configuration allows adjusting both the oil temperature and the oil flow rate.

In order to observe testing conditions, temperatures are continuously measured and recorded on every outer ring as well as at oil inlet and oil outlet next to the test head. The average of the latter two values is approximately equal the mean oil temperature inside the test head which is the target quantity of the temperature control. Further, the motor torque is monitored by the frequency converter. Finally, the vibration level is measured by a piezo sensor at the test head housing which is able to detect bearing failure.

Figure 4: EELPRAAX 80

Conclusion

For bearings smaller than 200 mm outer diameter, quick lifetime testing on minimum four samples can be carried out within one week and will be significantly cheaper than thorough metallurgical geometrical inspection of only one sample. Therefore, this method is suitable for quality control of incoming goods prior to release of each container. Apart from that, this method is helpful to get a first impression on potential new suppliers without visiting the related factories.