

Effect of ovality problem in cylindrical roller bearing during heat treatment and grinding

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Abstract: Bearing is required for smooth running of machine and support the loads. For that precise manufacturing of bearing is required. There are many possibilities of arising faults in bearing throughout its manufacturing process. This research concerns about ovality problem in bearing outer and inner races rises during heat treatment process and grinding process. Mainly ovality is a metallurgical and geometrical problem in cylindrical roller bearing. Ovality is the degree of deviation from perfect circularity of the cross section of the core. Ovality mainly occur during quenching process due to uneven cooling of inner and outer race of bearing. The high temperature generated during grinding process can also create ovality in both races. Due to ovality the track of the race will not properly traces the path of the roller. Due to this, the friction between roller and races increase which cause the bearing life decrease. This paper comprise possible solution of ovality problem arise majorly during heat treatment process and minorly during grinding process.

Keywords: cylindrical roller bearing, ovality, heat treatment, grinding.

I. INTRODUCTION

Basically, bearing is the machine element, which supports another moving machine element permitting the relative motion between the contact surfaces with minimal friction.

The bearings are classified mainly in two categories: roller bearings and ball bearings. The cylindrical bearings are included in category of roller bearing. The principal types of roller bearings are cylindrical, needle, tapered, and spherical. In general, they have higher load capacities than ball bearings of the same size and are widely used in heavy-duty, moderate-speed applications. However, except for cylindrical bearings, they have lower speed capabilities than ball bearings.

Normally cylindrical roller bearings are used as automotive parts because of its high radial capacity and provide accurate guidance to the rollers. Their low friction permits operation at high speed, and thrust loads of some magnitude can be carried through the flange-roller end contacts.

The main parts of the cylindrical roller bearings are (1) Inner ring and Outer rings: which are made from bearing steel 100Cr6(1.3505) according to SAE52100 and SUJ2 (2) Rolling element: These are the rolling elements that separate the inner and outer ring and permit the bearing to rotate with minimal friction. (3) Cage: The main purpose the cage is the separate the balls, maintaining an even and consistent spacing, to accurately guide the balls in the paths, or raceways, during rotation, and to prevent the balls from falling out.

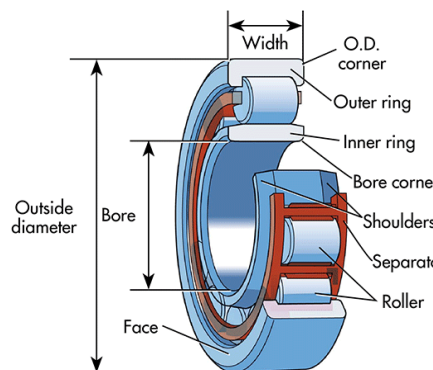


Fig. 1: Cylindrical roller bearing

Chemical composition of bearing steel (in wt. %) according to SAE52100.

C	1.04
Mn	0.35
P	0.01
Si	0.26
Al	0.04
Cr.	1.44
Ti	0.008
Mo	0.001
Ni	0.026
Cu	0.024
S	0.009
O ₂	7 ppm

II. BACKGROUND OF OVALITY PROBLEM IN CYLINDRICAL ROLLER BEARING DURING MANUFACTURING PROCESS.

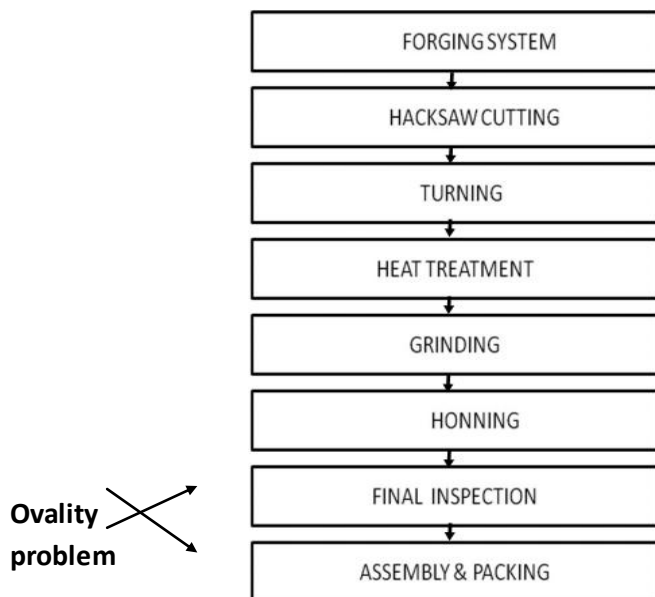


Fig. 2: Steps of manufacturing process

Manufacture of cylindrical roller bearings is a challenging production process. The manufacturing comprises a number of operations needed to produce rings, rolling elements and cages. It includes hammering of forgings at the beginning, turning, heat treatment, cutting, forming, grinding, washing of parts.

A number of preventive, intra-operational and final inspections and dimensional, chemical, metallurgic, endurance and other tests are carried out during the manufacturing process

All cups, cones, rollers and wear rings are heat treated prior to grinding to provide the proper wear and fatigue resistance. The parts are carburized in pits by heating and soaking them in a carbon gas solution. Gas flow, furnace temperature, and process time are regulated to assure accuracy, consistency and maximum efficiency of the operation. After case carburizing, the parts are cooled to room temperature, heated in a rotary furnace, oil quenched and drawn to provide a case-hardened part with controlled dimensions.

Normally problem of ovality is a certain type of circularity deviation which has been occurred during heat treatment process and grinding process.

III. DESCRIPTION ABOUT OVALITY PROBLEM:

During the heat treatment process & grinding process if the temperature of races increase than it's elastic limit, the races will change their shape minorly from circular to oval. This problem is known as ovality problem.

Ovality is the degree of deviation from perfect circularity of the cross section of the core. Ovality is find majorly in heat treatment process and minorly in grinding process. The results of ovality from non-symmetrical distribution of internal stresses before hardening.

Ovality is considered as the difference of diameters measured in one plane those are perpendicular to each other. Means that, the maximum diameter D_{max} is measured first after that the maximum value is found when the ring is turned again, then the ring is rotated by 90° and the second, minimum diameter D_{min} is measured. The outer surface shape of the ring should be close to a circle, but in fact, the outer ring is elliptical in shape. The prime goal is to reduce this ovality as small as possible.

$$\text{Ovality \%} = \frac{(\text{Max OD} - \text{Min OD})}{\text{Nominal OD}} \times 100$$

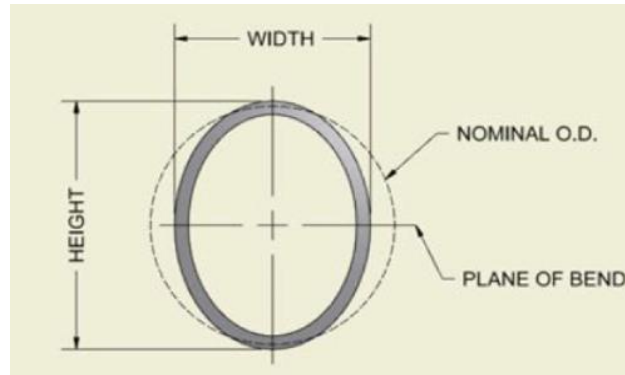


Fig 3 : concept of ovality

IV. OVALITY PROBLEM DURING HEAT TREATMENT PROCESS AND GRINDING:

Heat treatment of bearing cages has the risk of deformations caused by internal tensile stresses. Hardening is followed by tempering process in order to remove the internal stress.

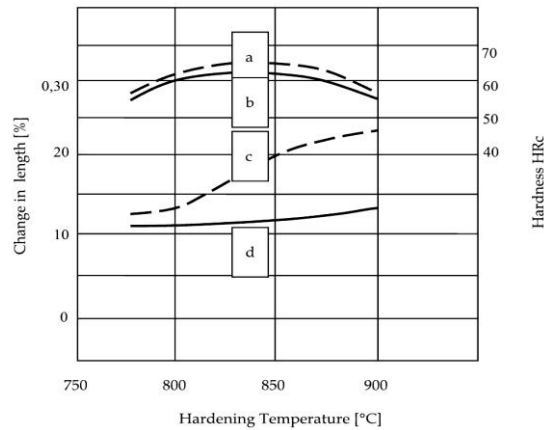


Fig. 4: Change in length Vs. Hardening temperature

Cooling rate in the hardening process has an impact on shape change in bearing components. The higher cooling rate is the deformation.

The dimensional changes (Fig. 4) that occur after heat treatment are caused by the lack of stability of the microstructure of hardened and tempered bearing steel in the given operating conditions. Here, a – hardness after hardening, b – hardness after hardening and tempering 150°C , c – change in length after hardening, d - change in length after hardening and tempering 150°C . This is the result of permanent changes in instable structural stages of martensite and residual austenite. Therefore, stabilization of dimensions in hardened and tempered bearing components depends on the degree of super saturation of a solid solution - martensite and the residual austenite content, i.e. on the microstructure as well as on operating conditions, temperature, time and tensions.

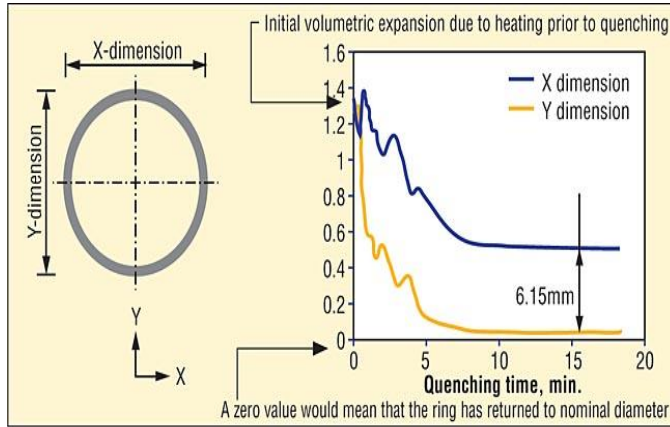


Fig. 5: Relation between ovality and quenching time in hardening process.

The most critical parameter during quenching process is the heat-transfer coefficient, which depends on temperature, agitation and stacking conditions of the bearing cage. Fig. 5 show examples of the distortion evolution through time during quenching and the final estimated distortion after heat-treatment. Here, different values of the heat-transfer coefficient were assumed at various locations in the quenched bearing case.

The various types of quenching technologies available are Gas nozzle field (NFGQ), High pressure gas quenching (HPGQ), Salt bath (SBQ), Oil bath (OBQ). The various technologies have different effect on relative size changes of different bearing rings.

Ovality is also minorly produced in grinding process. The bearing will be fail due to Non-symmetrical distribution of internal tensions and uneven heating and cooling in grinding process. The ovality affect the Produce non confirmative rate in grinding machine. The problem of the ovality during grinding process is removed by providing a tampering between pre grinding and fine grinding. Heat tampering must be done between outer surface grinding and inner surface grinding for stress relieving purpose.

V. Effect of ovality on performance of cylindrical roller bearing.

Due to ovality the track of the race will not properly traces the path of the roller. Due to this, the friction between roller and races increase which cause the bearing life decrease.



Fig. 6: Ovality defect in bearing ring

VI. SOLUTION OF OVALITY PROBLEM IN BEARING.

Ovality mainly happens due to uneven temperature distribution during heat treatment. So following table suggest the specification for hardening and tempering of bearing rings eliminate the ovality problem in bearings.

Parameters	Hardening	Tempering
Device name	Hardening furnace $\phi = 100$	Furnace PP017 / 50
Zonetemperature (°C)	840 ± 5	170 ± 5
Oil temperature (°C)	50 – 80	-

Method of placement	1 row	Freely
Variator	3-5	-
Heating time (min.)	60 – 80	155 ± 5
Ourput (pcs/hour)	1080	1080

Table – 1: *Hardening and tempering specifications for standard bearing rings*

Above specification ensure lower levels of ovality during hardening and tempering process.

Additional method for subsequent grinding of the rings, which would gives the lower internal tensions, deformations and ovality values, whereas the required hardness of the rings should remain unchanged.

Consider the following points for minimum ovality in grinding process.

- (I) Pre-grinding of functional surfaces in bearing rings, but not to reach the final value; only with a partial use of the total allowances for grinding – rough grinding.
- (II) By controlling the Speed of grinding wheel (RPM) in grinding process so that overheating of bearing rings during the grinding operation can be reduced.

VII. CONCLUSION.

Quality of cylindrical roller bearing required for smooth running in automobile. Due to presence of ovality in bearing rings, the friction between rings and roller increases so ultimately bearing life decrease due to friction loss. So it advisable to reduce the ovality in bearing.

The ovality mainly produces due to uneven temperature distribution during heat treatment and grinding process and due to uneven cooling during quenching process. In this paper, standard hardening and tempering parameters has been suggested to reduce the ovality up to minimum level. To reduce ovality in quenching process oil or salt bathing is more preferable compare to conventional water bathing. Also during grinding process speed of the grinding wheel (rpm) should also control to excessive heating which may cause deformation in bearing rings.

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