Study of Vibration Generated in Steel Balls Creating Noise in Ball Bearings

Chirag Ashokkumar Gandhi[1], Dr. K. N. Vijaykumar[2], Frank Crasta[3]

[1] *M.E. Student, Mechanical Engineering, Dwarkadas J. Sanghvi College of Engineering, Mumbai University, Mumbai, India,*
[2] *Professor and Head, Mechanical Engineering, Dwarkadas J. Sanghvi College of Engineering, India,*
[3] *Assistant Professor, Mechanical Engineering, Dwarkadas J. Sanghvi College of Engineering, Mumbai, India.*

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Abstract - *Vibration produced by bearings can be complex and can result from geometrical imperfections during the manufacturing process, defects on the rolling surfaces or geometrical errors in associated components. Noise and vibration is becoming more critical in all types of equipment since it is often perceived to be synonymous with quality. In this paper the different parameters of bearing vibration were considered.*

Key Words: Brinelling, flatten, oversize, spalling, waviness.

1. INTRODUCTION

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other. Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races.

1.1 Standard Ball Bearing Components

The essential components of a ball bearing are defined as follows:

- The Inner Ring

This is the smaller of the two bearing rings and gets its name from the position it holds. It has a groove on its outside diameter to form a path for the balls. The surface of this path is precision finished to extremely tight tolerances and is honed to a very smooth, mirror-like surface finish. The inner ring is mounted on the shaft and is usually the rotating element.

- The Outer Ring

This is the larger of the two rings and, like its counterpart the inner ring, its name is derived from the position it holds. Conversely, there is a groove on its inside diameter to form a pathway for the balls. This surface also has the same high precision finish of the inner ring. The outer ring is normally placed into housing and is usually held stationary.

- The Balls

These are the rolling elements that separate the inner and outer ring and permit the bearing to rotate with minimal friction. The ball radius is slightly smaller than the grooved ball track on the inner and outer rings. This allows the balls to contact the rings at a single point, appropriately called point contact. Ball dimensions are controlled to very tight tolerances. Ball roundness, size variations, and surface finish are very important attributes and are controlled to a micro inch level (1 micro inch = 1/1,000,000th, or one-millionth of an inch).

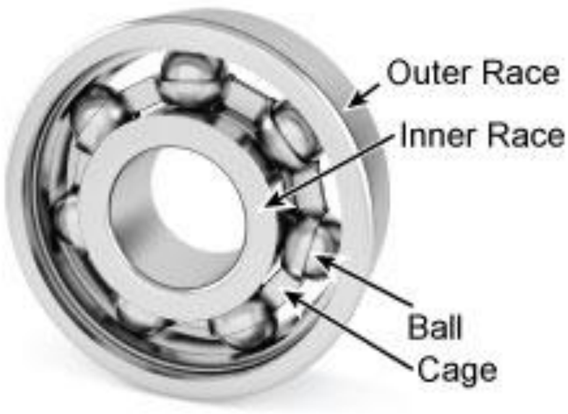

Fig. -1: Main components of ball bearing

- The Cage (Retainer)

The main purpose of the cage is to 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.

2. LITERATURE REVIEW

Ball bearings are used to provide smooth, low friction motion in rotary applications. Ball bearings are able to provide high performance and long lifetime in order to transfer the load from the balls to the inner races. The balls have minimal contact with the inner and outer races due to their spherical shape and this allows them to spin smoothly [1].

A disadvantage of ball bearings is that the balls can become "flattened" over time with too much pressure on the outer races leading to eventual failure. Therefore it is very important that the load ratings and other parameters are monitored regularly [1, 5].

Eschmann et al (1958) stated that when bearings operate under normal conditions of well balanced load and good alignment, fatigue failure begins with small fissures. These fissures are located between the surface of the raceway and the rolling elements, which then gradually propagate to the surface, generating detectable vibrations and increasing noise levels. Riddle (1955) observed the fatigue phenomena, known as flaking or spalling and suggested that continued stress causes fragments of the material to break or loose, and produce a localized fatigue. Once fatigue gets started, the affected area expands rapidly contaminating the lubricant and causing localized overloading over the entire circumference of the raceway, noticed by Eschmann et al (1958). Eventually, the failure results in rough running of the bearing. This is the initiation of failure in rolling element bearings which reduce the life of the bearing [2, 3].

According to Riddle (1995) external sources include contamination and corrosion. Improper lubrication also affects the life of the bearing. The dirt and foreign matter that is commonly present in most of the industrial environment and the abrasive nature of these miniature particles, whose hardness can vary from soft to hard like diamond, cause pitting and sanding action responsible for measurable wear of the balls and raceways [4, 6].

Riddle (1955) stated that improperly installed bearings are often caused by forcing the bearing onto the shaft or in the housing. This produces physical damage in the form of brinelling or false brinelling of the raceways which leads to an early failure. Brinelling is the formation of indentations in the raceways as a result of deformation caused by static overloading [6].

Su et al (1993) dealt with the effect of surface irregularities on roller bearing vibrations. The frequency characteristics of normal roller bearing vibrations, induced by manufacturing errors of components, have been investigated. Ohta and Kobayashi (1996) dealt with the vibration of hybrid ceramic ball bearings. In hybrid ceramic ball bearings, ceramic balls and steel rings have been widely used in high speed spindles for machine tools, replacing conventional steel ball bearings. Radivoje Mitrovi and Tatjana Lazovi (2002) investigated upon the frictional sliding which follows rolling of balls along the rings raceways. This one causes rolling bearing to wear [4].

The main class of bearing problems can be characterized as “distributed” defects, which involve the entire structure of the bearing. It includes surface roughness, waviness, misaligned races, and off-size rolling elements. These defects often give rise to excessive contact forces, which in turn result in premature surface fatigue and ultimate failure. Tallion and Gustafsson (1965) experimentally explored spectral properties of bearings outer ring vibration as a function of speed, load, waviness, and other geometrical parameters. A mathematical model for ball bearing vibrations was proposed by Meyer et al (1980). The model allows a family of distributed defects to be simulated and the spectral components resulting from these defects to be predicted. Sunnersjo (1985) studied the vibration characteristics of the bearings having inner race waviness and varying ball diameter and found that significant peaks occur at the cage speed for a non uniform ball diameter [7, 9].

Yhland (1992) proposed a linear model for the vibrations of the shaft bearing system caused by ball bearing geometric imperfections. These imperfections covered are radial and axial waviness of outer and inner rings, ball waviness, and ball diameter oversize. Choudhury and Tandon (1998) extended the model proposed by Meyer to predict the vibration response of radially loaded bearings with distributed defects. Aktürk (1999) simulated the effect of bearings surface waviness on the vibration by a computer program [8].

3. KEY FINDINGS FROM LITERATURE REVIEW

Rolling bearings have to meet demanding quality requirements. They must be able to support high loads and have a long operating life. Extremely high accuracy is required during bearing manufacture to ensure that bearings run smoothly and save energy in the application. All components must match very precisely. The only permissible deviations are in the micron range.

For this purpose, a safety net is included in every manufacturing operation – integrated quality control.

Many machine tools perform inspections automatically during manufacturing.

To ensure the highest quality each and every parameter of the balls is thoroughly inspected before packing and dispatch. All precision, hardness, material features, etc. are tested at every stage of the production and again before shipping, at the end of the manufacturing process, in order to assure and guarantee the quality. Each lot of balls is inspected with optical machines affecting a surface visual test, where the defective ball gets rejected at the same time a test of physical integrity of balls is effected by eddy current probes, if required. Therefore, ball quality is the key factor in ball bearing manufacturing.

4. CONCLUSION

Vibration and noise do not negatively affect the bearing itself and are a natural consequence of the bearing's design. Bearing rings and balls are not perfectly round and the balls and raceways, even after extensive fine grinding and polishing, are not perfectly smooth. There are machining imperfections in the form of rough or uneven surfaces which will cause one ring to move or oscillate radially in relation to the other. The amount and speed of this movement contributes to the amount of bearing vibration and bearing noise.

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