Principles and Use of Ball and Roller Bearings

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Ball Bearings

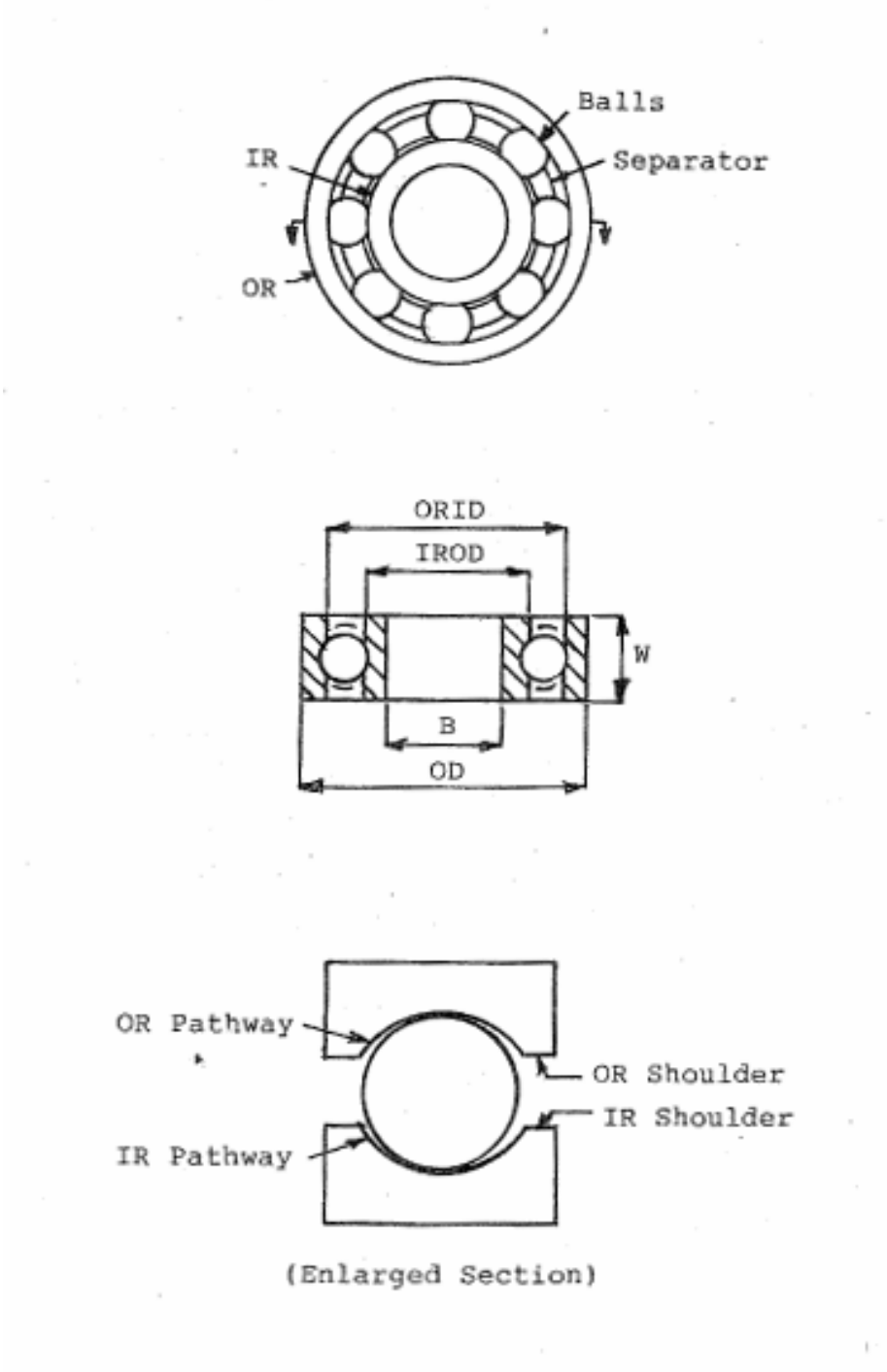
Purpose: Ball Bearings are used primarily to support rotating shafts in mechanical equipment. They can be found in the smallest electric motors to the largest pieces of industrial equipment. They are of simple design and can be precision manufactured in mass production quantities. They can support heavy loads over a wide speed range and do it virtually friction free. They come in many different sizes and shapes, are relatively inexpensive, and require little or no maintenance. They have predictable design lives and operating characteristics and are truly a valuable asset to the rotating equipment industry.

Description: A ball bearing consists of an inner ring (IR), an outer ring (OR), a complement of balls, and a separator. See figure 1. The outer diameter of the inner ring (IROD) and the inner diameter of the outer ring (ORID) have a groove in which the balls roll. The groove is commonly called the pathway. The raised surface on each side of the pathway is called the shoulder. The balls are held equally spaced around the annulus of the bearing by the separator. The basic dimensions of the bearing are the bore (B), outside diameter (OD), and the width (W). The radius of curvature of the pathway must be closely controlled in relation to the ball diameter in order for the bearing to operate satisfactorily. If the radius of curvature is too close to the ball diameter, the bearing will operate with a high amount of friction. If the radius of curvature is too large in relation to the ball diameter, the bearing will operate under a high stress level. Both conditions will contribute to premature bearing failure. The radius of curvature of inner ring and outer rings is normally held to 52 - 53% of ball diameter. See figure 1.

Theory of Operation: In most applications, there are two ball bearings supporting a rotating shaft. The inner ring is a press fit on the shaft while the outer ring is a close push fit into the housing. The shaft and inner ring rotate together while the outer ring remains stationary or undergoes slight rotational creep in the housing. The separator and ball complement rotate around at about half the speed of the inner ring. The balls rotate around their own axis about twice the speed of the inner ring. Loads, or forces, are imposed on the bearings by the equipment that is driving or being driven by the shaft. The loads can be separated into a radial component that acts 90 degrees to the shaft and a thrust component that acts along the centerline of the shaft. Normally the radial component is reacted by just a few balls in the bearing while the thrust

Figure 1

Ball Bearing Terminology



component is supported by all the balls in the bearing. Assume that the radial load is acting in the downward direction. The balls at the top of the bearing are under little or no load. As they rotate to the bottom of the bearing, they are compressed between the rings. As they rotate back to the top, the compressed metal expands back to its original state. This constant compression and expansion of metal after many revolutions of the bearing leads to fatigue failure. The failure usually occurs as a small pit or spall in the inner ring. The bearing then begins to make noise and is replaced. Figure 2 shows h[illegible] calculate individual ball loads in a bearing.

Manufact[illegible]sion level in [illegible]ated starting [illegible] to be taken t[illegible]arbon, high c[illegible]ard grades. H[illegible]hroughout th[illegible] Inner and ou[illegible]

Bal[illegible]

Asser[illegible]

Types: [illegible]g discussed has been the single row radial. [illegible]sed to support loads that are predominantly radial or perpendicular to the bearing axis of rotation. Another type of radial bearing is the maximum capacity bearing. It has a loading groove cut across one shoulder of each ring allowing more balls to be assembled into the bearing.