



Roller Bearing Application: A Case Study

An Online Continuing Education Course for Engineers

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Introduction

This course is unique in that it goes through the step-by-step procedure of how to select the correct anti-friction bearings for a mechanical power transmission device. It begins with a fundamental analysis of rolling contact bearings. Next, a step-by-step narrative of the selection process used in determining which type and size of rolling contact bearings are to be used in supporting a gear in a gearbox. Finally, drawings of a number of different design configurations, retention methods, and applications of rolling contact bearings in mechanical equipment are presented including expert analysis of each.

Rolling Contact Bearings

Rolling contact bearings are composed of ball bearings and roller bearings. Ball bearings, as the name suggests, have rolling elements that are spherical in shape. Roller bearings consist of cylindrical roller bearings and tapered roller bearings also named for the shape of their rolling elements.

Figure 1 has sketches showing how loads are imposed on bearings. The top sketch shows that “radial” loads act perpendicular to the bearing centerline and that “thrust” loads act parallel to the bearing centerline. The second sketch illustrates how two radial loads are combined into one resultant load using the “Pythagorean” theorem. The third sketch depicts the radial load acting between two bearings. This is referred to as “straddle mounting”. Simple beam formula will show that the bearing located closer to the point of load application supports a greater portion of the load while the opposite bearing supports the remainder of the load. The fourth sketch illustrates an “overhung” load. Beam calculations will show that the bearing located closer to the point of load application actually supports more than the load itself.

Figure 2 has a drawing of a ball bearing. Ball bearings are comprised of an inner ring, an outer ring, a complement of balls, and a separator. There is a groove in the inner and outer rings in which the balls revolve called the “pathway”. The rise of material on each side of the grooves are the shoulders. The basic dimensions are the inner ring inside diameter or the “Bore”, the outer

ring outside diameter or the “OD”, and the width or “W”. Because of their unique construction, ball bearings are able to support both radial and two-direction thrust loading.

Figure 3 is a sketch of a cylindrical roller bearing. The nomenclature and components are the same except that the rolling elements are cylindrical shaped rather than spherical as they are in a ball bearing. Notice that the rollers are retained by outer ring members called “ribs” and the cylinder shaped inner ring is free to float axially with respect to the rollers. There are other cylindrical roller bearing configurations with one or two ribs located on one or both rings (shown later). Roller bearings are able to support higher radial loads than ball bearings but lack the capacity to support substantial thrust loading as explained later.

Figure 4 has a drawing of a tapered roller bearing. Tapered roller bearing outer and inner rings are sometimes called “cups and cones” respectively. Because of their angular construction, tapered roller bearings are able to support both substantial radial and one-direction thrust loading. The cup pathway angle can be either increased or decreased somewhat to change the ratio of thrust to radial load that a tapered roller bearing is able to support. Tapered roller bearings are frequently used in pairs in heavy duty power transmission applications.

In a ball bearing, the contact pattern between the balls and ring pathways begins as a point and then, under increasing load, expands into an ellipse. This is in comparison to roller bearings where the contact begins as a line and, under load, grows into a rectangle. This feature enables the larger contact area of roller bearings to support more radial load than similar sized ball bearings. Although roller bearings can support more radial load than ball bearings, they are limited to the amount of thrust load they can support. Flat roller ends support a limited amount of thrust load in the sliding contact mode while ball bearings support thrust as they do radial load and, that is, in the more efficient rolling contact mode.

The sketch at the top of Figure 5 illustrates how edge loading of roller bearing components can create a “dog bone” shaped stress pattern with the stress peaking at the roller ends. The lower sketch shows how an operation called “crowning” can relieve the high stress condition and change the load contact pattern to a rectangular shape.

Figure 6 gives an example of the contoured shape of the crowned surfaces that eliminate the high stress levels at the ends of the contact pattern.

Figure 7 shows the elliptical contact pattern of a ball bearing. The ellipse is slightly smaller for the ball-outer ring contact pattern than the ball-inner ring contact pattern because the inner ring presents a convex surface to the ball while the outer ring presents a concave surface.

Figure 1
Bearing Loads

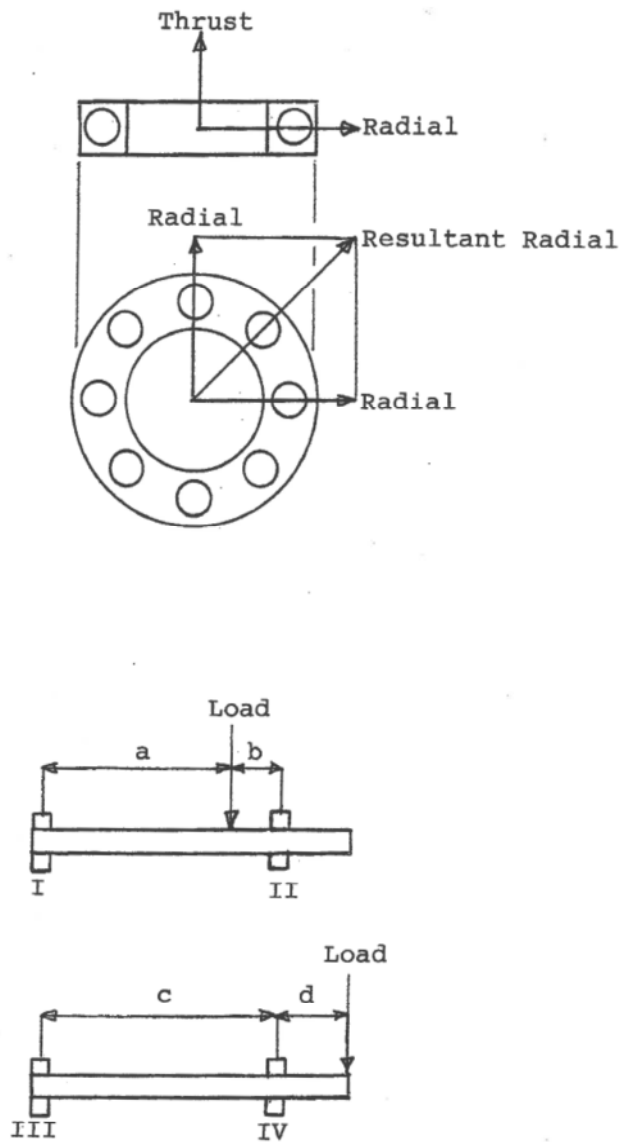


Figure 2

Ball Bearing Terminology

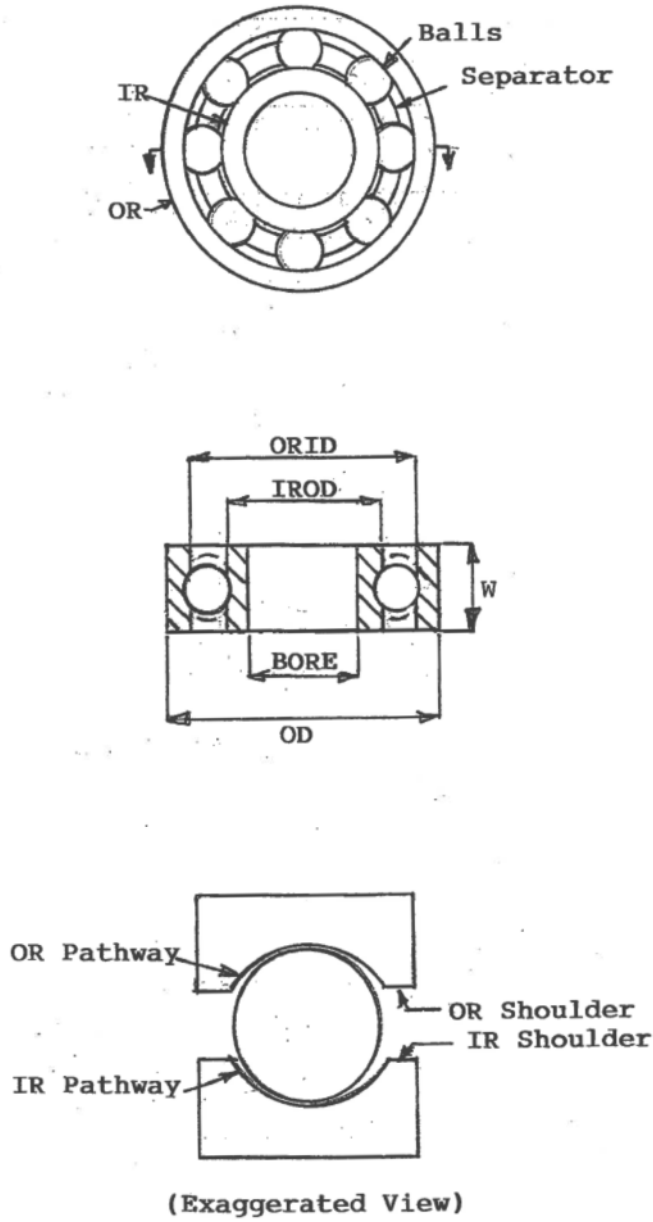
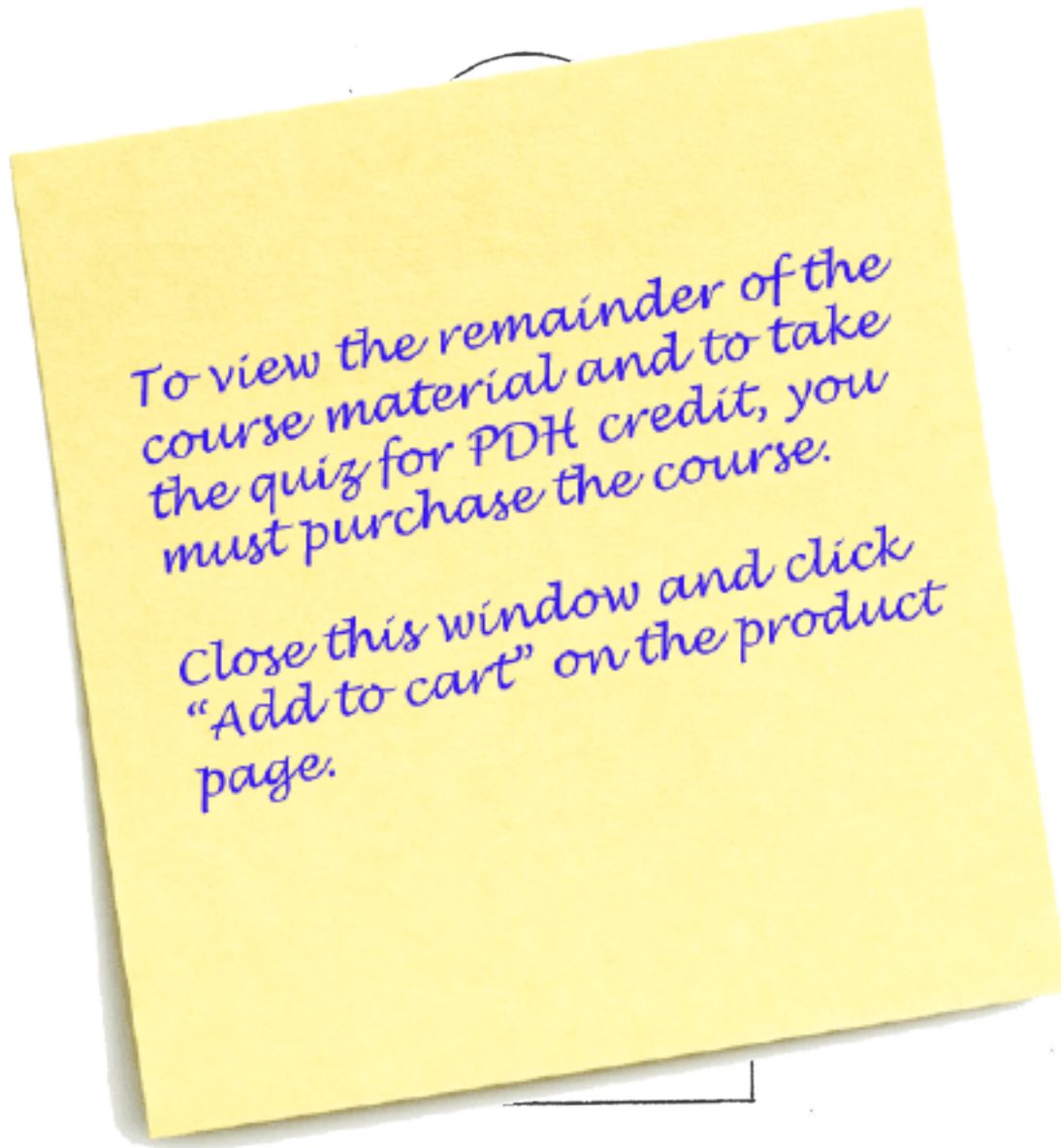


Figure 3

Cylindrical Roller Bearing



(Enlarged Section)