

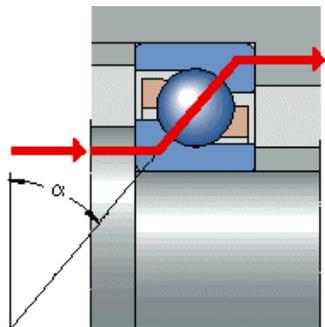
**A REVIEW OF DESIGN AND ANALYSIS OF ANGULAR CONTACT BALL  
BEARING FOR TWO WHEELER CLUTCH**Darshan Adeshara<sup>1</sup>, Dr. Pranav Darji<sup>2</sup><sup>1</sup>Department of Mechanical Engineering, C. U. Shah University, Surendranagar, Gujarat 363-030, India  
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**Abstract** — Angular contact ball bearings are designed to accommodate combined loads, i.e. simultaneously acting radial and axial loads. The axial load carrying capacity of angular contact ball bearings increases with increasing contact angle compare to the deep groove ball bearing. The main objective of this work is to the development of the integrated clutch lifter angular contact ball bearing is enabling two and three wheelers manufacturers to move away from deep groove ball bearing arrangements, helping them to increase bearing fatigue life and reduce assembly times, costs and weight in the process.

**Keywords**-Deep groove ball bearing, Angular contact ball Bearing, radial and axial loads, Integrated clutch lifter, Contact angle, Bearing fatigue life Etc.

**I. INTRODUCTION**

Deep groove ball bearings are widely used in automobile industry for their good caring capacity especially, in the radial direction under the conditions of medium loading. Contact failure and/or wear failure, the typical bearing failure modes, occur on the surface or the subsurface of raceway and ball. Inner and outer raceway failure is characterized by a wear deformation or a plastic deformation.



**Figure 1. Angular contact ball bearing ball contact angle**

Angular contact ball bearings have raceways in the inner and outer rings that are displaced with respect to each other in the direction of the bearing axis. This means that they are designed to accommodate combined loads, i.e. simultaneously acting radial and axial loads. The axial load carrying capacity of angular contact ball bearings increases with increasing contact angle. The contact angle  $\alpha$  is defined as the angle between the line joining the points of contact of the ball and the raceways in the radial plane, along which the load is transmitted from one raceway to another, and a line perpendicular to the bearing axis.

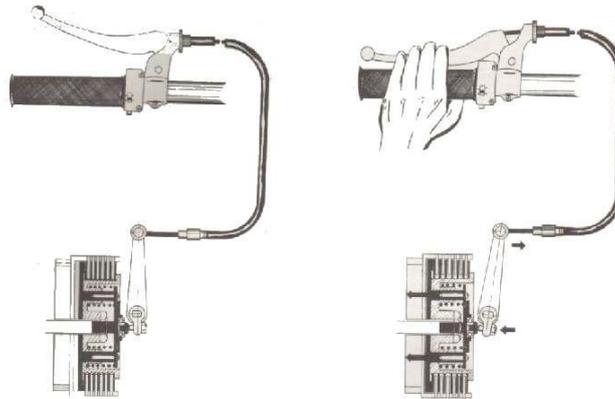


Figure 2. (a) Clutch engaged

(b) Clutch disengaged



Figure 3. Deep groove ball bearing in clutch assembly

Deep groove ball bearing (No. 628) as shown in fig. 3 are used in two wheeler clutch assembly for engaged and disengaged of the clutch as shown in fig. 2.

## II. Hertz Contact Stress Theory

The theory developed by Hertz in 1880 remains the foundation for most contact problems encountered in engineering. It applies to normal contact between two elastic solids that are smooth and can be described locally with orthogonal radii of curvature such as a toroid.

Further, the size of the actual contact area must be small compared to the dimensions of each body and to the radii of curvature.

Hertz made the assumption based on observations that the contact area is elliptical in shape for such three-dimensional bodies.

The equations simplify when the contact area is circular such as with spheres in contact.

### 2.1 Spherical Contact Stresses

For spherical contacts like a ball and socket or ball on a flat plate the pressure distribution is circular and extends out as shown in the hatched region of figure 1. The size of this region depends on the elastic properties and geometries of the parts in contact. Figure 2 gives the equation for calculating the radius of the contact area produced by the deformation of the two spheres from force  $F$ . Where  $E_1$ ,  $\nu_1$ ,  $R_1$  is the elastic modulus, Poisson's Ratio and radius respectively of sphere 1. The same is true respectively for sphere 2.

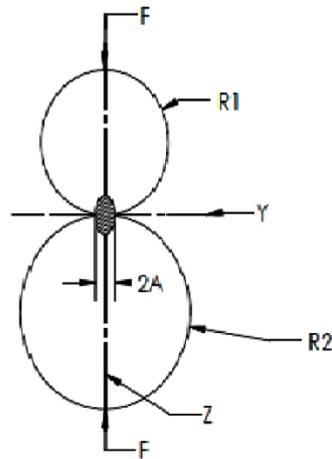


Figure 4. Contact stress between two spheres. (Cross hatched area is the pressure zone)<sup>[1]</sup>

The maximum pressure within the contact area occurs as a compression in the center. For an internal radius like a ball and socket joint a negative radius would be used for the socket. Equation (3) is used for calculating this pressure. Knowing the maximum pressure then allows you to calculate out the principle stresses along the z axis. Equations (4), (5) & (6) shows the principle/normal stresses and the maximum shear stress within the contact region.

## 2.2 The radius of the contact area is given by

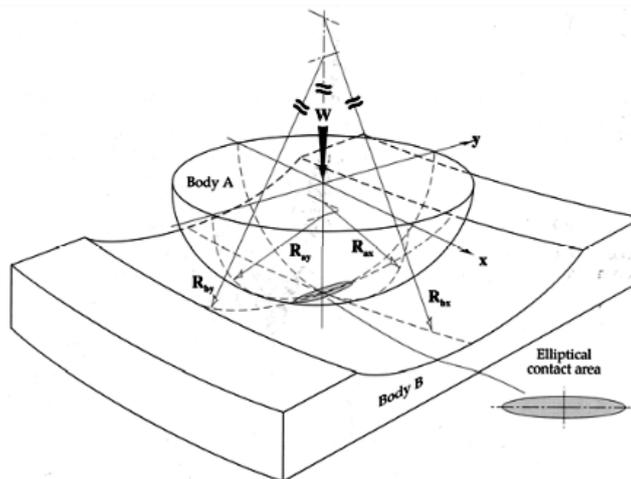


Figure 5. Contact between Ball and Track<sup>[1]</sup>

## 2.3 Reduced Radius of Curvature<sup>[2]</sup>

$$\frac{1}{R'} = \frac{1}{R_x} + \frac{1}{R_y} = \frac{1}{R_{ax}} - \frac{1}{R_{bx}} + \frac{1}{R_{ay}} - \frac{1}{R_{by}} \quad (1)$$

Where  $E_1$  and  $E_2$  are the moduli of elasticity for spheres 1 and 2 and  $\nu_1$  and  $\nu_2$  are the Poisson's ratios, respectively the maximum contact pressure at the center of the circular contact area is given by equation (3):

$$a = \left( \frac{3FR'}{E} \right)^{\frac{1}{3}} \quad (2)$$

$$P_{max} = \frac{3F}{2\pi a^2} \quad (3)$$

## 2.4 Sphere in contact – Principle stresses<sup>[2]</sup>

The principle stress  $\sigma_1, \sigma_2$  and  $\sigma_3$  are generated on z-axis:

$$\sigma_1 = \sigma_2 = \sigma_x = \sigma_y = -P_{max} \left[ (1 + \nu) \left( 1 - \left| \frac{z}{a} \right| \arctan \left| \frac{a}{z} \right| \right) - \frac{1}{2 \left( \frac{z^2}{a^2} + 1 \right)} \right] \quad (4)$$

$$\sigma_3 = \sigma_z = -P_{max} \left( \frac{z^2}{a^2} + 1 \right)^{-1} \quad (5)$$

The principle shear stresses are found as:

$$|T_1| = |T_2| = T_{max} = \left| \frac{\sigma_1 - \sigma_3}{2} \right| \quad (6)$$

### III. Fatigue Failure Progression

#### 3.1 Spall Initiation<sup>[3]</sup>

Operation of a rolling bearing causes fatigue cracks to form within the subsurface material of highly stressed ball–race way contacts. The subsurface cracks propagate and coalesce causing removal of a portion of the contacting surface. Current methods for predicting the life of rolling element bearings are based upon the initiation of the first spall. Typically an equation similar in form to equation (7) is used to predict the life of a ball bearing in Ball Bearings

$$L_{10} = (C/P)^3 \quad (7)$$

Through condition monitoring, the increased vibration and noise associated with the initiation of a fatigue spall can be detected. Generally, the failed component is replaced and operation of the mechanism recommences.

### IV. Solution given by SKF bearing ltd<sup>[3]</sup>



*Figure 6. Clutch lifter bearing<sup>[3]</sup>*

With the development of the integrated clutch lifter, SKF is enabling two and three wheelers manufacturers to move away from conventional bearing arrangements, helping them to reduce assembly times, costs and weight in the process. Featuring a compact design and a push pin that is an integral part of the deep groove ball bearing unit, this unitized SKF clutch lifter bearing solution enables better alignment perpendicularly, allowing for a range of benefits. The integrated clutch lifter bearing is one of a growing number of cost-efficient solutions from SKF.

### V. Advantages for manufacturers and end-users alike<sup>[3]</sup>

Designers are assured of a robust solution that can handle two wheeler clutch conditions reliably and they need not make any changes to current corresponding components. For manufacturers, the reduction in components and weight enables more compact designs, as well as one-stop sourcing for faster, less costly assembly. For end-users, the unit's robust performance and grease-free design provides longer service life with fewer maintenance demands. Conventional assembly components are replaced by a compact, unitized assembly to reduce weight and simplify assembly. The integrated clutch lifter from SKF also provides longer service life with reduced maintenance.



**Figure 7. Clutch lifter bearing vs Standard Deep ball bearing and clutch rod<sup>[3]</sup>**

## **VI. Conclusion**

On the basis of this study it can be concluded that it is aimed at replace the deep groove ball bearing by angular contact ball bearing for two wheeler clutch operates and the research and development conducted to improve technologies that will directly benefit the two or three wheeler clutch operates and other industries.

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