A Review Paper on Analysis of Ball Bearing Cage

[1]Kataria Mahendra B, [2] Harshal V. Pandyal., [3]Dr. J.P. Mehta, [4]Dr. Dipesh Kundaliya

[1]Assistant Professor, [2]Student, [3,4]Associate Professor
[1]Mechanical Engineering Department
[1]Aditya silver Oak Inst. Of Tech, Ahmedabad, India, [2,3,4]VVP Engineering College, Rajkot, India

Abstract: **Centrifugal pump is a hydraulic machine which converts the mechanical energy into the hydraulic energy. Its miles one of the mechanical devices which play the critical role inside the water area in addition to the business sector. Also its miles very beneficial in human life. Water is life so pump plays critical position in bringing the water from deep region up to the needy lives door. So it's miles vital, the pump must be dependable and sturdy over the numerous years from set up. However there are many elements which can be accountable for the damage to the pumps and end its existence before it completes his life. Hence in this paper a few factors are highlighted that are answerable for the damage to the bearings and accordingly to pump. At the same time as operating of pump there are two kinds of forces are appearing at the pump that are radial and axial thrust. The pressure generated in lateral direction is due to dissimilar stress generated in volute is known as Radial thrust. The pressure generated in longitudinal direction icon account of different regions of impeller exposed to trapped pressurized liquid known as axial thrust.**

***Index Terms*— Deep groove ball bearing, Fatigue life, ANSYS, Stress, Deformation**

I. INTRODUCTION:

A "Bearing" is a machine element which is permit constrains relative motion and reduces friction between two surfaces. Bearing is a device that supports, guides, and reduces the friction of motion between fixed and moving machine parts. The term "Bearing" is derived from the verb "to bear" it means "to support another".
All type Bearing has a mainly four parts 1) Outer race (Outer ring) 2) Inner race (Inner ring) 3) Rolling element (i.e. ball, roller, needle, sleeve) 4) Cage/ separator (retainer). **[8]**

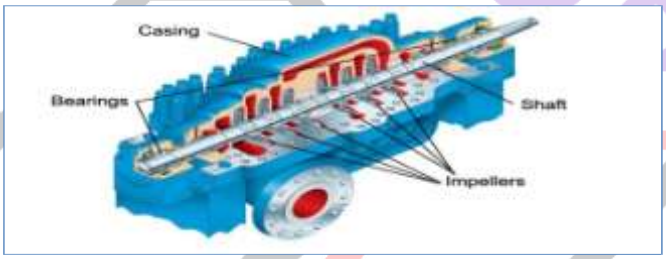

Figure-1. Mechanical System.

The reason why bearing is used is that first it can transfer moment or force. Secondly and maybe more important is that it can be interchanged easily and conveniently when it's broken. In the mechanical system shown in Figure-1, it is also possible to amount the shaft directly with housing. However,

When this system has some problem, really the only probability to recuperate the function of the system is to displace the enclosure or the shaft. Through the mechanical engineer perspective, both of these aren't only very costly but also frustrating to manufacture a fresh cover or shaft with the same guidelines.

But when the bearings are being used between them, the problem changes. Normally there is absolutely no relative movement between shaft and internal ring or the outside ring with cover. So that it has less opportunity for the shaft or enclosure to be exhausted. Usually the bearing first breaks and then your shaft or property is broken. In the event the above situation happens it is absolutely easy to find it out: just buy a fresh bearing from the marketplace with the same parameter and replace it. That is why bearings are frequently used.

II. OBJECTIVE OF RESEARCH PROJECT:

The objective of the Research project is to:

- **A.** To understand the basics of deep groove ball bearing for Centrifugal Pump.
- **B.** To make a 2D/3D ax symmetric model with modified design data of ball bearing.
- **C.** To carry out the FEA (Analysis)using ANSYS.
- **D.** And then compare FEA result with Analytical method.

To improvement on efficiency & life of the ball bearing. And also, Determine the safe stress level of the specimen and it is help to improving performance of ball bearing.

III. NEED OF CHANGE CAGE MATERIAL

Main Goal of this study is that increase the fatigue life of bearing. One of the goals of this study is to find the reasonable reference reaction force from the outer ring to the inner ring by means of FEM simulation. Fatigue failure occurs when metal is subjected to repetitive and fluctuating load.

That is the reason why changing the material of cage comes into investigation where fatigue failure occur without any plastic deformation. The greater the applied stress rang, the shorter life. Fatigue life is affected by verify of factors such as Temperature, Surface Finishing, Material of using for bearings, Surface finishing, Surface Contact, Overloading etc

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IV. P LITERATURE REVIEW:

A. **Jing Liu (2015)** Presented paper on *A New Model for the Relationship Between Vibration Characteristics Caused by the Time-Varying Contact Stiffness of a Deep Groove Ball Bearing and Defect Sizes* **[1].** This paper presents the Vibration characteristics of a deep groove ball bearing caused by a localized surface defect are greatly affected by defect sizes, such as the length, width, and depth. However, effects of the defect depth, the time-varying contact stiffness between the ball and defect, and the relationship between the time-varying contact stiffness and defect sizes have not been considered in previous defect models. In this work, a new defect model considering a new force–deflection relationship is presented to replace the Hertzian force–deflection relationship to describe the ball-line contact between the ball and defect edge. The results show that the model developed can predict a more realistic impulse caused by a localized surface defect for dynamic simulation of the deep groove ball bearing. An experimental investigation is also presented to validate the proposed model.

B. **Carl R. Wassgren (2009)** Presented paper on *Cage Instabilities in Cylindrical Roller Bearings* **[2].** A six-degree-of-freedom model was developed and used to simulate the motion of all elements in a cylindrical roller bearing. Cage instability has been studied as a function of the roller-race and roller-cage pocket clearances for light-load and high-speed conditions. The effects of variation in inner race speed, misalignment, cage asymmetry, and varying size of one of the rollers have been investigated. In addition, three different roller profiles have been used to study their impact on cage dynamics. The results indicate that the cage exhibits stable motion for small values of roller-race and roller-cage pocket Clearances. A rise in instability leads to discrete cage-race collisions with high force magnitudes. Race misalignment leads to a rise in instability for small roller-cage pocket clearances since skew control is provided by the sides of the cage pocket. One roller of larger size than the others causes inner race whirl and leads to stable cage motion for small roller-race clearances without any variation in roller-cage pocket clearance. Cage asymmetry and different roller profiles have a negligible impact on cage.

C. **Lars Holland (2016)** Presented paper on *Image Acquisition and Image Processing Algorithms for Movement Analysis of Bearing Cages* **[3].** This paper presents Movement analyses of ball bearings with regard to stable and unstable cage motion behavior are often conducted by simulations, typically by investigating the cage whirl. Some experimental studies exist in which the cage is modified in order to capture its movement with sensors. This paper presents an image-based approach for investigating the cage motion without modifications, which in turn allows a cage motion analysis of an angular contact ball bearing under operation condition. Two new image evaluation algorithms are presented in detail and their suitability is verified by experiments on a bearing test rig.

D. **Ankur Ashtekar (2012)** Presented paper on *A New Approach for Including Cage Flexibility in Dynamic Bearing Models by Using Combined Explicit Finite and Discrete Element Methods* **[4].** This paper focused on a new approach was developed to study the influence of cage flexibility on the dynamics of inner and outer races and balls in a bearing. A 3D explicit finite element model (EFEM) of the cage was developed and combined with an existing discrete element dynamic bearing model (DBM) with six degrees of freedom. The EFEM was used to determine the cage dynamics, deformation, and resulting stresses in a ball bearing under various operating conditions. A novel algorithm was developed to determine the contact forces between the rigid balls and the flexible (deformable) cage. In this new flexible Cage dynamic bearing model, the discrete and finite element models interact at each time step to determine the position, velocity, acceleration, and forces of all bearing components. The combined model was applied to investigate the influence of cage flexibility on ball-cage interactions and the resulting ball motion, cage whirl, and the effects of shaft misalignment. The model demonstrates that cage flexibility (deflection) has a significant influence on the ball-cage interaction.

E. **Tomoya Sakaguchi (2006),** Presented paper on *Dynamic Analysis of Cage Behavior in a Tapered Roller Bearing* **[5].** This paper focused on a three-dimensional dynamic simulation analysis of a tapered roller bearing was performed using commercially available software. Without cage pocket shape simplification, the dynamic motion of the cage and rollers was calculated in six degrees of freedom. The motion of the cage and rollers was measured experimentally to verify the analysis. Under all axially loaded conditions, cage whirl was analytically predicted and experimentally confirmed.Whirl amplitude increased as the inner-ring rotational speed and axial-load magnitude increased. The maximum whirl amplitude reached the radial clearance between a roller and its pocket. Under combined load conditions, the cage also

whirled. However, the whirl amplitude was smaller than only under axial load. Load distribution due to the addition of radial load to axial load equalized roller distribution. Equally distributed rollers limited the cage's movable distance to circumferential clearance between a roller and its pocket.

F. **J. V. Poplawski (2015),** Presented paper on *Slip and Cage Forces in a High-Speed Roller Bearing* **[6].** This paper present A roller bearing model, which includes the effects of full film lubrication at the race contacts, was developed for use in estimating cage slip, roller slip, film thickness, and cage forces for a given bearing geometry and operating condition. The model includes churning loss, cage pilot surface friction, roller pocket friction, cage unbalance as well as the drag due to the unloaded rolling elements. Roller skew and misalignment have been neglected, however these effects could be introduced if desired. The description of the lubricant film thickness, traction, and pressure forces are based upon assumptions introduced by Dowson, which reduce the complex numerical procedure required for a rigorous solution to the isothermal elastohydrodynamics problem to a set of nonlinear equations. A parametric study on a 1907 basic roller bearing is included to illustrate the use of such a model as a design tool.

I.P LITERATURE THEORETICAL CONSTRUCTION OF CENTRIFUGAL PUMP BEARING

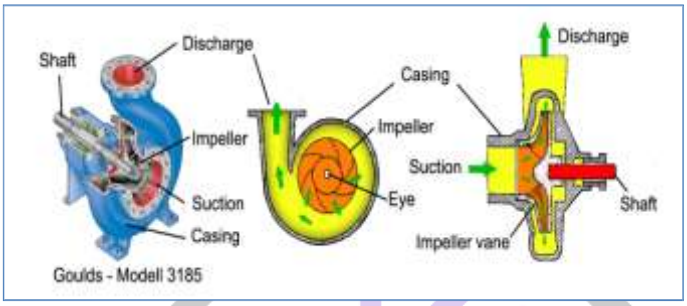

Figure-2. Centrifugal pump Bearing

A centrifugal pump is a roto dynamic pump that uses a rotating impeller to increase the pressure of a fluid, fluid enters the pump near the rotating axis, streaming into the rotating impeller. The impeller consists of a rotating disc with several vanes attached, vanes normally slope backwards, away from the direction of rotation. When the fluid enters the impeller at a certain velocity due to the suction system, it is captured by the rotating impeller vanes. The fluid is accelerated by pulse transmission following the curvature of the impeller vanes from the impeller center (eye) outwards. It reaches its maximum velocity at the impeller's outer diameter and leaves the impeller into a diffuser in Figure-2.

Centrifugal force assists accelerating the fluid individual particles because the radius at which the particles enter is smaller, it will leave the impeller. Now the fluid's energy is converted into static pressure, assisted by the shape of the diffuser or volute chamber. The process of energy conversation in fluids mechanics follows the Bernoulli principle which states that the sum of all forms of energy along a streamline is the same on two points of the path. The total head energy in a pump system is the sum of potential head energy, static pressure head energy and velocity head energy as a centrifugal pump increases the velocity of the fluid, it is essentially a velocity machine, fluid has left the impeller, it flows at a higher velocity from a smaller area into an increasing area, velocity is decreasing & so the pressure increases as described by Bernoulli's principle resulted in an increased pressure & fluid displacement at the discharge side of the pump.

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$$\alpha + \beta = \varkappa \qquad (1)$$

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There is no period after the "et" in the Latin abbreviation "et al.".
The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".
An excellent style manual for science writers is given by Young [7].

V.APPLICATION

Centrifugal Pump bearings are mainly used in Injection Molding machine, Crane Hook, And In vertical pumps. Due to their versatile design, the ready-to-fit units are suitable for many other applications. They can be used, for example in power generation, Ground Water pumps, Aerospace, Sewage and in grinder pumps.

VI.CONCLUSION

Both Radial and Axial thrusts during running of the pump influenced highly in life of the bearing and also different methods stated by various researchers so it's difficult to predict the correct value of axial thrust. If we predicted correctly then and then we can easily predicted life of bearing. Also different bearing life parameters also depends to be a part of major contribution for predicting life of the bearing in a centrifugal pump. This in turn will improve the reliability of the centrifugal pumps.

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