A Review on Deep grove ball bearing

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***Abstract*: Bearing is most commonly used important component to be found in all rotating machinery. It is found form bicycle to turbo machinery and helicopter. Bearing is not only providing relative motion between support bodies and rotating part but also transmit the load to the base. So, bearing is very important part of machinery to provide information about the condition of machine. Here in this paper a review was carried out on deep groove ball bearings and their different process parameters.**

***Keywords*: Deep groove ball Bearing, static analysis, Dynamic analysis, materials, contact stress**

1. Introduction

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The invention of the rolling bearing, in the form of wooden rollers supporting, or bearing, an object being moved is of great antiquity, and may predate the invention of the wheel. Though it is often claimed that the Egyptians used roller bearings in the form of tree trunks under sleds, this is modern speculation. They are depicted in their own drawings in the tomb of Djehutihotep as moving massive stone blocks on sledges with liquid-lubricated runners which would constitute a plain bearing. There are also Egyptian drawings of bearings used with hand drills.

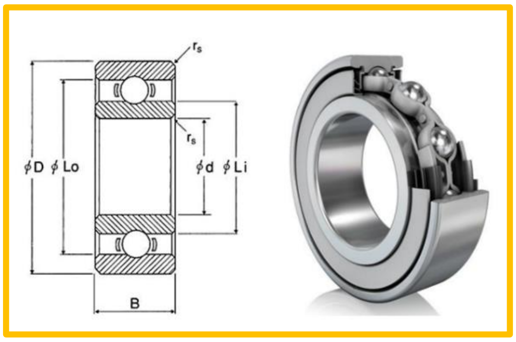

Fig.1 shows different component of deep grove ball bearing and their arrangement. [3]

The earliest recovered example of a rolling element bearing is a wooden ball bearing supporting a rotating table from the remains of the RomanNemi ships in Lake Nemi, Italy. The wrecks were dated to 40 BC. Leonardo da Vinci incorporated drawings of ball bearings in his design for a helicopter around the year 1500. This is the first recorded use of bearings in an aerospace design. However, AgostinoRamelli is the first to have published sketches of roller and thrust bearings. An issue with ball and roller bearings is that the balls or rollers rub against each other causing additional friction which can be reduced by enclosing the balls or rollers within a cage. The captured, or caged, ball bearing was originally described by Galileo in the 17th century' The first practical caged-roller bearing was invented in the mid-1740s by horologist John Harrison for his H3 marine timekeeper. This uses the bearing for a very limited oscillating motion but Harrison also used a similar bearing in a truly rotary application in a contemporaneous regulator clock.

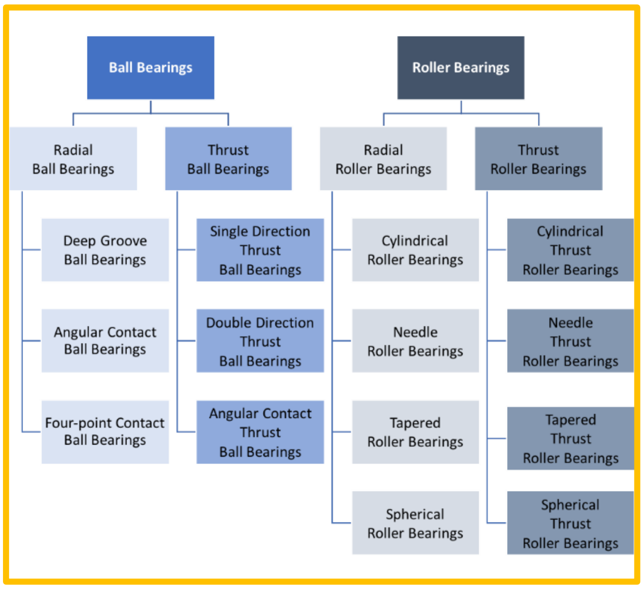

Fig.2 shows the diagram of classification of bearing. [4]

In order to measure the performance and optimization of different parameters of deep groove ball bearing, many researchers have performed different work. Researcher uses different methods to detect the failure of deep grove ball bearing. Some of the research work and methods were mention in this chapter. Vibration technique is one of the methods to detect the failure of deep groove ball bearing. These vibration signals will give us information about the health of bearing. Vibration monitoring is the most popular technique to diagnosis of rolling element bearing faults. Many researchers have been worked on vibration signal analysis techniques and numbers of research papers have been published by them. They reviewed the vibration monitoring of rolling element bearing by High-Frequency Resonance Technique. Some of the research wok is shown here in below section.

2. Existing research work

Han et.al [1] proposed the study to evaluate the effects of bearing's groove factor (GF) with different ball-spacer clearance (CL) and the surface roughness's of the inner and outer raceways on the inception time of bearing element instability arising in the ball-bearing like specimens with grease lubrications. Frictional instabilities in rolling bearings has been an interesting subject in a wide range of applications covering both liquid, solid, and grease lubrication conditions. Rolling element skidding and instabilities in the spacer (cage or retainer) motion have been known to be critical to many advanced and precise lubricated bearings. The instability model is developed for ball-spacer interactions considering the partition of frictional heat and thermal effects on linear expansion of dominant side.

Tiwari et.al [2] have proposed a Multi-objective optimization approach for design optimization of spherical roller bearings. The authors have considered dynamic load capacity and elastohydrodynamic film thickness as the two design objectives along with eight design variables and twenty two constraints. The stated nonlinear constrained optimization problem for spherical roller bearing has been solved by using Elitist Non Dominated Sorting Genetic Algorithm (NSGA-II). The optimum bearing dimension has been selected from the knee point solution on the Pareto Optimal Fronts. The authors have also performed a sensitivity analysis for deciding the manufacturing tolerances of the most important design variables during the manufacturing of the optimized bearing.

Chandran et.al [3] have performed design optimization problem of a deep groove ball bearing by considering three prime objectives, i.e. dynamic load capacity, maximum bearing temperature and the Elasto hydrodynamic minimum film thickness along with twelve realistic constraints based upon geometry, strength and assembly aspect. ABCA was used for solving the proposed nonlinear constrained optimization problem, separately for each objective. The study includes normalized constraint violation study and parameter less penalty approach for efficient constraint formulation and their handling respectively. A sensitivity analysis also has been performed using Monte-Carlo simulation method to study the effect of the variation of design parameters on the objective functions owing to the manufacturing tolerances.

Jilu et.al [4] inspected the optimization of structural parameters for angular contact ball bearing using an approach involving a combination of Particle swarm optimization algorithm and Kriging model for minimization of heat generation in bearing. The constraints are formulated depending on the range of the structural parameters (i.e. Stiffness) of the bearing system. The authors have validated their proposed method by comparing the initial value and optimized value of heat generated. The authors have also observed that the increase in pitch diameter of ball bearing causes an increase in heat generation due to the applied load and viscous friction.

Tiwari et.al [5] have performed multi-objective optimization problem to optimize the standards of needle roller bearing. The authors have considered dynamic load capacity and elastohydrodynamic minimum film thickness as the two design objectives of the nonlinear constrained optimization problem. The NSGA-II based on GA has been found effective for optimum design of the bearing and also for generating nonstandard eedle roller bearing. In this study, the authors have performed a sensitivity analysis to predict the effect of design variables on the objective functions.

Guilbault et.al [6] suggested the optimum design of cylindrical roller profile under EHL regime. The authors have developed a mathematical formulation for establishing crowning and corner rounding radii for rapid design of the optimal roller. The evaluated design variables have also been compared with optimum valued obtained from the multi-objective Particle swarm optimization. The integrated three objective functions are contact pressure uniformity, film thickness stability and maximum load capacity of the bearing. The authors have concluded that the developed algebraic relation represents a powerful design tool for optimal profile correction of cylindrical rolling contacts.

Tiwari et.al [7] have proposed the design optimization of a thrust bearing for minimum power loss and weight of bearing. A multi-objective design optimization approach was used and a Pareto optimal front was obtained under variable load condition. The different imposed constraints are load to be supported, current density in the coil, flux density allowed in coil, flux density flow in the stator and the space available. A parameter less penalty approach was used for constraint handling. Further, the authors have concluded that as the load in bearing increases the Pareto optimal front reduced to a point at the peak load.

Chandran et.al [8] investigated to a design optimization problem in cylindrical roller bearing based on multiple design objectives like dynamic load capacity, the elasto-hydrodynamic lubrication minimum film-thickness and the maximum temperature by using ABCA. In this study, nineteen realistic constraints based on geometry and strength is imposed on the optimum design objective along with nine design variables. A Constraint violation study has been performed after normalization of the equality and inequality constraints. Both the penalty function and the penalty parameter less methods have been applied for constrained optimization formulations.

Singh et.al [9] in this paper focused on a review of literature concerned with the vibration modelling of rolling element bearings that have localized and extended defects. An overview is provided of contact fatigue, which initiates subsurface and surface fatigue spalling and subsequently leads to reducing the useful life of rolling element bearings. To investigate the effects on the vibration characteristics of defective rolling element bearings, a full parametric study could be conducted that could include a matrix of parameters, which can be varied. These parameters may include load (both radial and axial) on a bearing, rotational speed, clearance within a bearing, and various defect types.

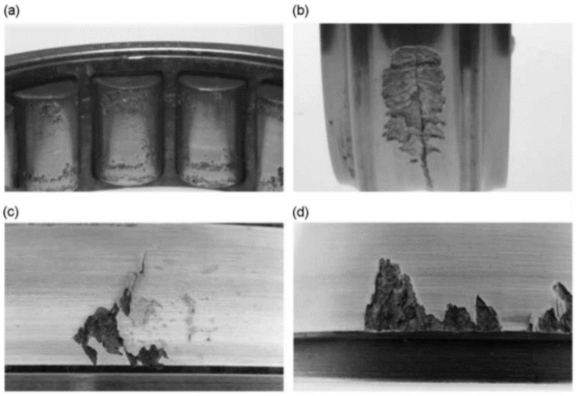

Fig.2.1Fatigue spalls on various elements of rolling element bearings [9]

The types of bearing defects may range from line, to area, to extended area spalls having different profiles of surface roughness, which can be made similar to operational defects observed in real-world applications. A review is described of the development of all analytical and finite element (FE) models available in the literature for predicting the vibration response of rolling element bearings with localized and extended defects.

Dragoni et.al [10] investigated the design optimization of a radial cylindrical roller bearing to obtain maximum values of static and dynamic load rating using the geometrical optimization method. The author graphically illustrated the optimization problem successfully and observed the noticeable impact of the aspect ratio of roller element and the pitch diameter on the load carrying capacity of radial cylindrical roller bearing. Further, it is also reported that width constraint is one of the most potential criteria in the optimum design of a narrow bearing to meet the design objectives.

Tudose et.al [11] used evolution based multi-objective optimization approach for optimization of fatigue life and minimum film thickness by considering some inequality constraints in a single row cylindrical rolling bearing. All the eight constraints based on geometry and strength have been imposed on this design optimization problem. The authors have used the Pareto approach to obtain the Pareto optimal front for the given problem along with the non-dominating set of design variables.

Edwin et.al [12] presented paper on Numerical Model to Study of Contact Force in A Cylindrical Roller Bearing with Technical Mechanical Event Simulation**.** This paper focused on the employed modelling technique makes it applicable for a wide range of ball bearing assemblies using the appropriate presented methods to estimate the critical parameters, such as convection coefficients and contact resistances. However, for a given bearing system in practice one needs to consider the appropriate material properties, boundary conditions etc. nevertheless, the approach remains valid. The model was developed with the finite element method (FEM) for mechanical event simulations (MES) withthe commercial code Algorithm.

Patel et.al [13] formulated a dynamic model for the study of vibrations of deep groove ball bearings having single and multiple defects on surfaces of inner and outer races. The solution was obtained using Runge-Kutta method. And showed the good correlations between the numerically simulated and experimental results, and demonstrated that this dynamic model can be used with confidence for the study and prediction of vibrations of healthy and defective deep groove ball bearings. The model provides the vibrations of shaft, balls, and housing in time and frequency domains. Computed results from the model are validated with experimental results, which are generated using healthy and defective deep groove ball bearings. Characteristic defect frequencies and its harmonics are broadly investigated using both theoretical and experimental results.

3. Conclusion

Here an effort was done to review different parameters that were responsible for the performance of deep groove ball bearing. Here in this work an attempt has been done to summarize the recent research and developments in field of vibration analysis techniques for diagnosis of deep groove ball bearing faults has been made. Different methods were used to measure vibration peaks generate in spectrum at the bearing characteristics frequencies, from that we can easily understand which bearing component was defected. The performance of deep groove ball bearing depends on the type of loading condition and load acting on it. Through literature it is found that the wear out of inner race and outer race is the main cause of deep groove ball bearing failure. So the material used for the manufacturing of deep grove ball bearing plays an important role during the performance of deep groove ball bearing.

REFERENCES

[1] Chang-Fu Han, Chang-Shuo Chang, Cheng-Jyun Wu, Hsiao-Yeh Chu, Jeng-Haur Horng,Chin-Chung Wei, Jen-Fin Lin, “Determinations of thermoelastic instability for ball-bearing-like specimens with spacers and in grease lubrications”, Tribology InternationalVolume 151, November 2020, 106415.

[2] Jat, A., & Tiwari, R. (2018). Multi-objective optimization of spherical roller bearings based on fatigue and wear using evolutionary algorithm. Journal of King Saud University-Engineering Sciences.

[3] Tiwari, R., & Chandran, R. (2018). Optimal design of deep-groove ball bearings based on multitude of objectives using evolutionary algorithms. Multidiscipline Modeling in Materials and Structures.

[4] Jilu, F., Zhili, S., & Hongzhe, S. (2017). Optimization of structure parameters for angular contact ball bearings based on Kriging model and particle swarm optimization algorithm. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 231(23), 4298-4308.

[5] Kalyan, M., & Tiwari, R. (2016). Multi-objective optimization of needle roller bearings based on fatigue and wear using evolutionary algorithm. Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 230(2), 170-185.

[6] Najjari, M., & Guilbault, R. (2015). Formula derived from particle swarm optimization (PSO) for optimum design of cylindrical roller profile under EHL regime. Mechanism and Machine Theory, 90, 162-174.

[7] Rao, J. S., & Tiwari, R. (2015). A Pareto Optimal Design Analysis of Magnetic Thrust Bearings Using Multi-Objective Genetic Algorithms. International Journal for Computational Methods in Engineering Science and Mechanics, 16(2), 71-85.

[8] Tiwari, R., & Chandran, R. M. (2015). Multitude of objectives based optimum designs of cylindrical roller bearings with evolutionary methods. Journal of Tribology, 137(4), 041504.

[9] Sarabjeet Singh, Carl. Howard, An Extensive Review of Vibration Modeling of Rolling Element Bearings with Localized and Extended Defects, Journal of Sound and Vibration, 2015.

[10] Dragoni, E. (2013). Optimal design of radial cylindrical roller bearings for maximum load-carrying capacity. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 227(11), 2393-2401.

[11] Tudose, L., Kulcsar, G., & Stănescu, C. (2013). Pareto approach in multi-objective optimal design of single-row cylindrical rolling bearings. In Power Transmissions (pp. 519-528). Springer, Dordrecht.

[12] Rao, J. S., & Tiwari, R. (2012). Optimum design and analysis of axial hybrid magnetic bearings using multi-objective genetic algorithms. International Journal for Computational Methods in Engineering Science and Mechanics, 13(1), 10-27.

[13] Laniado-Jacome Edwin, Numerical Model to Study of Contact Force in A Cylindrical Roller Bearing with Technical Mechanical Event Simulation, Mechanical engineering department, Carlos III University, Madrid, 28911, Spain.-2011.

[14] V.N. Patel, N. Tandon, R.K.Panday, A Dynamic Model for Vibration studies of Deep Groove Ball Bearings considering Single and Multiple Defects in Races. Journal of Tribology, ASME, 2010