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COMPLETE EFFECTIVE PERFORMANCE ANALYSIS OF THE CRACKED BALL BEARING BY FINITE ELEMENT METHOD USING ANSYS SOFTWARE

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ABSTRACT

In the Current highly mechanized industrial world, bearings can be found in a wide variety of applications, but their primary job is to limit relative motion to only the required direction. This makes them extremely versatile. To put it another way, this method provides support for rotating applications in some fashion. Rolling bearings can be utilized in a wide variety of applications, some of the more particular examples of which are dental drills, huge crushers, and windmills. There are many different types of bearings available to do the work, and each one must be selected carefully based on the size and the loading requirements. The majority of machines rely on ball bearings, which are among the most essential components. These bearings must meet exact essential requirements for load capacity and dependability. Ball bearings have been utilized for a significant amount of work across a wide variety of contexts for a significant amount of time. Additionally, bearings provide an accurate position of the rotation axis and have the capacity to withstand very high loads, particularly in the axial direction. The purpose of this research is to investigate the impact that a cracked ball bearing surface has on a bearing's ability to operate well when subjected to dynamic load by using CATIA 5.1 and ANSYS 2021R1. It was discovered that the simulation of the complete Ball Bearing process takes too much time to be useful in the engineering work that is done daily. However, it is possible to successfully estimate different properties such as Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Internal Energy, Temperature, and Pressure etc. with simplified mechanical CAD models

Key Words: Ball Bearing; Simulation; Finite Element Analysis; CATIA; ANSYS.

I. INTRODUCTION

The majority of machines rely on ball bearings, which are among the most essential components. These bearings must meet stringent requirements for load capacity and dependability. Therefore, it is not surprising that placentas play such an essential function, nor is it surprising that they have been the subject of a significant number of studies over the course of human history. Ball bearings have been utilized for a significant amount of work across a wide variety of contexts for a significant amount of time. Ball bearings are used in pretty much every system that consists of a rotor and a stator and has a requirement for either high speed rotation or low friction torque. Ball bearings can be used singly or in multiples. Additionally, bearings provide an accurate position of the rotation axis and have the capacity to withstand very high loads, particularly in the axial direction.

Ball Bearing

Bearings can be found in a wide variety of applications, but their primary job is to limit relative motion to only the required direction. This makes them extremely versatile. To put it another way, this method provides support for rotating applications in some fashion. Rolling bearings can be utilized in a wide variety of applications, some of the more particular examples of which are dental drills, huge crushers, and windmills. There are many different types of bearings available to do the work, and each one must be selected carefully based on the size and the loading requirements. During normal use, the performance of the bearing as well as its lifespan are both affected by a variety of other elements.

Purpose of a Ball Bearing

When transmitting weight between two structures, typically the shaft and the housing, the bearing's job is to ensure that neither structure is compromised in terms of its relative position nor its ability to rotate freely. When the rolling elements are positioned between the sliding elements, the action can be made to be more effectively aided by the rolling elements. This is true in the event that the loads are transmitted between the surfaces in relative motion. Rolling resistance, which is substantially smaller, more or less takes the place of the frictional resistance that is experienced throughout the transition.

Ball Bearing Material

High-grade 100 CR 6 chromium steel is typically used in the manufacturing process of bearings. This material provides the optimal conditions for great load carrying capacity as well as an extended life span when in operation. Bearings made of stainless steel, ceramic, or even surface bearing may be necessary for certain specialized applications.

Bearing lifetime

Bearing life is the metric that is most frequently referred to when making a selection of bearings to employ for a particular application. This is due to the fact that the bearing's lifetime can be converted into the number of rotations that the client will use to select a bearing that meets the requirements of the application. The lifetime can be estimated in one of two fundamentally different ways: either by mathematical calculations or through the use of computer simulations.

Uses of the Bearings

More than 60 different types of businesses can take use of the extensive selection of unrivalled ball bearings. These goods include, for instance, small bearings that are several millimeters broad and are designed for use in wind turbines and dentistry drills. In addition to being utilized in textile machinery and machine tools, INA and FAG bearings can also be found in railway tracks, rollers, bicycles, drills, bridges, and mines.

Bearing Failures

Bearings are one of the most crucial sections of most machines, and because of this, there are stringent standards pertaining to both its capacity and their reliability. Because of this, it should not come as much of a surprise that ball bearings play such a vital part and that researchers have focused a significant amount of attention on them over the years. Regrettably, there are some instances in which the bearing does not reach the expected duration of use. This could be the result of a number of factors, including a higher load than was anticipated, inadequate or insufficient lubrication, negligent handling, inefficient sealing, or excessively tight settings that result in looseness because of the inner bearing. Bearing failure can be caused by a wide variety of factors, each of which results in a particular kind of damage. These imperfections, often referred to as initial damage, are what lead to the development of flaking and secondary cracks, both of which are flaws. The following is a list of the various kinds of defects: Surface wear, smearing, indentation, flaking, and cracking. Wear and surface distress. Shear stresses that take place in a cyclical manner directly under the load surface are what cause fatigue to develop. These stresses, after some period of time, generate cracks, which then progressively develop to the surface. The release of material fragments, known as flaking or spelling, occurs when rolling elements move through fissures in a material.

II. LITERATURE REVIEW

Jing Liu (2015) introduced a brand-new model that demonstrated the relationship between the vibration characteristics that are brought on by the stiffness of the contact between the deep grove ball bearing and the size of the defect as it grew over the course of its lifetime. The vibrational properties of a deep groove ball bearing are discussed in this document. Carl R. Wassgren conducted research on the instability of roller bearings in 2009 for his project. An investigation was conducted to determine the influence that variability on the internal speed, misalignment, asymmetry of cages, and variable size on one of the rolls had. In addition, three distinct roll profiles were used to investigate the influence that each had on the dynamics of the cage. Lars Holland (2016) undertook research on several algorithms for the acquisition of images and the processing of images in order to analyze the movements of bearing cages. This article gives an examination of the movement of ball bearings in connection to the stable and unstable behavior of the movement in the cage. This type of study is frequently carried out by means of simulation, and it typically involves looking at the whirl of a cage. An essay titled "A Novel Approach to Taking into Consideration the Flexibility of Cages in Dynamic Bearing Models" was presented by AnkurAshtekar (2012). It was about a new way to take into account the flexibility of cages in dynamic bearing models. The primary focus of this work was on the development of a novel method that was used to investigate the effect that the flexibility of the cage has on the dynamics of the inner and outer races of the ball bearing. A finite element model of the cages has been built; this model has been integrated with a dynamic bearing model and discrete element (DBM); additionally, six degrees of freedom have been utilized.

III. PROBLEM DEFINITION

This work utilizes two distinct methods, which, when combined, have the potential to supply essential data regarding the performance characteristics of the Ball Bearing, which ultimately results in a more precise assessment of the fatigue strength. The generation of a three-dimensional model of the cracked ball bearing is done in the software CATIA 5.1, numerical analysis of the cracked ball bearing in the software ANSYS 2021 R1.

The initial goal is to develop and construct a three-dimensional model of the cracked ball bearing so that its functionality may be evaluated. We create the model in the CATIA 5.1 by drawing inspiration from the work of a large number of researchers as well as from industry standards and guidelines. The second objective of this work is to do a numerical analysis of a cracked ball bearing to understand the effect of a broken ball bearing surface on its performance. In order to do the finite element analysis of the Cracked Ball Bearing geometry, we will be making use of the commercial programmed ANSYS 2021 R1. In this part of this research, we will discuss the process that was used, as well as the findings of the static analysis of the bearing revolution while it was under load. We may observe the Cracked Ball Bearing's Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Internal Energy, Temperature, and Pressure.

IV. MODELING & ANALYSIS OF THE BALL BEARING

Modeling- Software used: CATIA

Tools used: Modeling, Assembly

CATIA is a suite of configuration programming that provides discrete manufacturers with support for item outlines. The suite consists of applications, each of which provides a unique set of capabilities tailored to a specific customer part within the product development process. CATIA is an application suite that runs on Microsoft Windows and provides applications for 2D configuration, 3D CAD parametric component strong demonstrating, 3D immediate displaying, Finite Component Analysis and reproduction, schematic design, technical outlines, as well as survey and representation. FEM Analysis in the ANSYS Software After a Cracked ball bearing has been designed, prior to the actual manufacture of the bodies, it is essential to have an understanding of the typical behavior of the component parts when subjected to simulated operating conditions. An analysis using static finite elements has the potential to detect probable design faults, such as stress concentrations, validate the component stiffness, and provide information that will assist in the validation of calibration results. By carefully selecting the right boundary conditions, we are able to make predictions about the performance and determine whether or not they fall within the acceptable range for the hardware that is currently available. In this section, we discuss the dynamic finite element analyses that were carried out with ANSYS 2021 R1. We analyze the convergence of the mesh in order to get the most precise results possible, and we talk about the outcomes.

Dynamic analysis

methods and findings of the dynamic study of the cracked ball bearing under loading conditions are presented in this section. When we examine the Cracked Ball Bearing, we observed the Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Internal Energy, Temperature, and Pressure.

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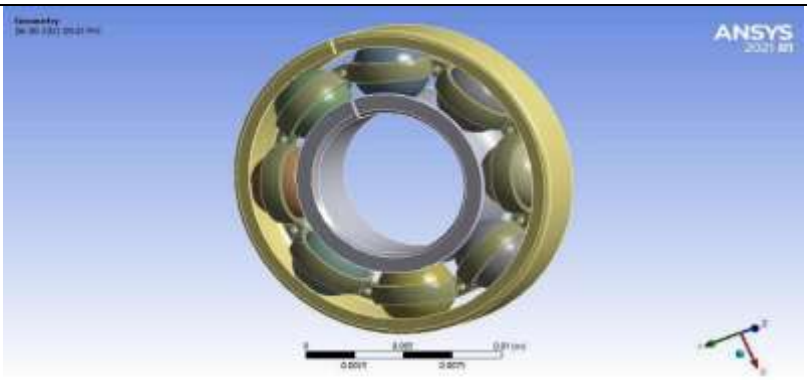

Figure 1: Cracked Ball Bearing model generated in the CATIA software

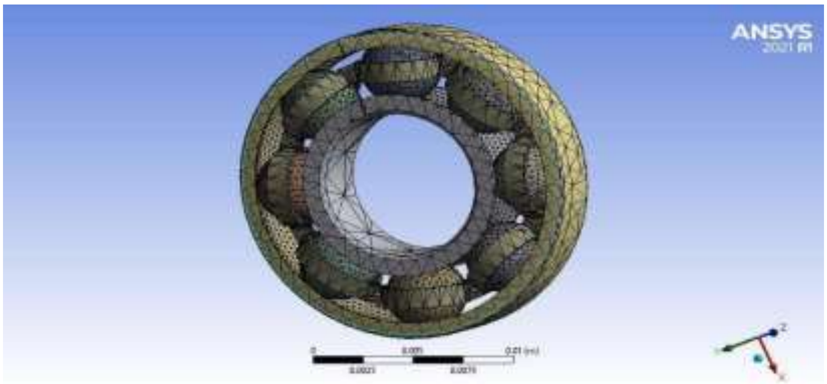

Figure 2: After modeling in CATIA software, triangular type of meshing Cracked Ball Bearing is done in ANSYS software

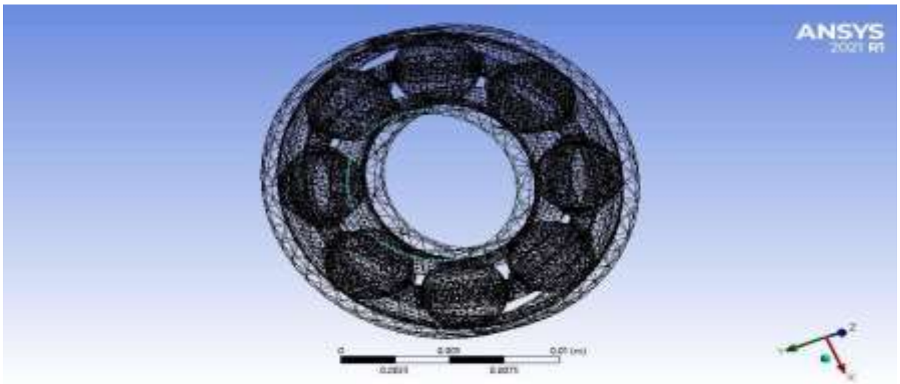

Figure 3: Triangular type of meshing for the Cracked Ball Bearing is done in ANSYS software.

V. RESULTS FOR FINITE ELEMENT ANALYSIS

The modeling of the proposed design is done by using CATIA 5.1 software & static analysis is done in ANSYS 2020 R1 software.

- Equivalent Stress maximum generated in Cracked Ball Bearing is $2.7273 \times 10^{+8}$ Pa
- Equivalent Stress maximum generated in Cracked Ball Bearing Surface is 2.2269×10^{8} Pa
- Equivalent Stress maximum generated in Balls of Cracked Ball Bearing is 2.7273×10^{8} Pa
- Equivalent Elastic Strain maximum generated in Cracked Ball Bearing is 0.12277 m/m
- Directional Deformation maximum generated in Cracked Ball Bearing is 1.1896×10^{-2} m
- Total Pressure maximum generated in Cracked Ball Bearing is 7.3343×10^{8} Pa
- Compression maximum generated in Cracked Ball Bearing is 4.3322×10^{-3}

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VI. CONCLUSION

Following are the conclusions of ANSYS research:

In this study, Cracked Ball Bearing has been analyzed by the Finite Element Method. A simplified and idealized finite element model by using symmetry assumption and a non- simplified finite element model of the process have been used in the analyses. Ball Bearing has been examined. The Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Internal Energy, Temperature, and Pressure exerted by the Cracked Ball Bearing during one complete revolution have been identified. The aim of the study is to predict the effects of the crack surface on the performance of the Ball Bearing during one complete revolution.

1. Ball Bearing has been examined.
2. The Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Internal Energy, Temperature, and Pressure exerted by the Cracked Ball Bearing during one complete revolution have been identified.
3. The aim of the study is to predict the effects of the crack surface on the performance of the Ball Bearing during one complete revolution.

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