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Structural Design And Analysis On Various Profile

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Abstract

Bearings, essential machine components enabling relative motion in commercial devices, can be categorized into contact and non-contact types, with contact bearings, including sliding, rolling, and flexural varieties. This study's core objective is to assess the impact of different bearing shapes on speed and weight considerations. Employing Finite Element Analysis (FEA) techniques, the research evaluates the mechanical properties of these bearings while accounting for diverse operating frequencies and their consequences on bearing deformation under varying vibration and surface conditions. The study's findings significantly enhance our understanding of the intricate interplay between bearing shape, speed, weight, and mechanical performance in commercial applications.

Keywords: Bearings, Mechanical performance, Bearing shapes, Finite Element Analysis (FEA)

1. Introduction

Bearings are vital machine components that enable relative motion within commercial devices, categorized into contact and non-contact types. Contact-type bearings, such as sliding, rolling, and flexural bearings, involve mechanical contact between elements. Conversely, non-contact bearings, including externally pressurized, hydrodynamic fluid-film (liquid, air, mixed phase), and magnetic bearings, lack mechanical contact but may incur high maintenance costs due to the viscosity of the liquid medium. Consequently, contact-type bearings are prevalent in industries with high axial loads, despite the potential for unscheduled downtime and equipment wear. Vibration analysis, particularly at specific frequencies, proves valuable for identifying issues like defects, misalignment, unbalance, and deterioration in equipment, aiding in maintenance and condition monitoring. This technique is commonly applied to rotating machinery like turbines, pumps, compressors, and gearboxes, with recent technological advances extending its utility to reciprocating equipment like large diesel engines and compressors. This paper employs Finite Element Analysis (FEA) in CATIA software to assess the structural and mechanical properties of various bearing designs in a simulated environment using ANSYS Workbench. It focuses on the influence of bearing shape modifications on deformation and mechanical properties, with the literature review summarizing relevant vibration analysis studies on different bearing types in various machinery. Section 3 outlines the research objectives and methodology involving FEA for vibration analysis of diverse bearing shapes, while Section 4 presents simulation results using ANSYS software concerning material properties. Finally, Section 5 offers the study's conclusions.

2. Related Work

In this section, we conduct finite element analysis of contact-type bearings using CATIA [5], exploring various bearing shapes. Additionally, we assess the properties of these shapes through simulation analysis using ANSYS software [6].

2.1 Material Properties:

- The properties of STAINLESS STEELS are given as follows.
- density = 7.85 g/ cm^3
- coefficient of thermal expansion = 13.0 x 10-6 m/m-deg C
- Thermal Conductive = 16.63 (W/mK) at 20°C
- Young’s modulus = 200 GPa
- Poisson’s ratio = 0.30–0.31

2.2. Finite Element Analysis of stress and vibration of rolling bearing

In this literature review, Finite Element Analysis is employed to investigate the stress and vibration behavior of rolling bearings. The study focuses on the initial surface condition of the rolling element with the aim of extending the bearing's lifespan while reducing the size and weight of the material. The research also examines the vibration excitation method using contact theory as a means to achieve these objectives. Monitoring the bearing is considered a significant method for assessing its performance. The analysis includes an evaluation of the contact stress conditions under various vibration scenarios, as well as an investigation into the contact characteristics of stress conditions in relation to vibration and surface deformation. The design properties and boundary conditions used for the simulations are adapted from literature sources [7].

3.1. Design Objectives of the bearing on various shapes

• To reduce the weight and friction of the radial and axial loads.

• To increase the load-bearing capacity and stiffness.

• To enhance the boundary conditions of the bearing.

• To determine the optimal input parameters for the bearing's shape.

• To assess the impact of vibration under working conditions.

3.2. Structural Design of the Bearing on shapes of the material through CATIA

Structural Design of bearing [9] using various structures is designed using various shapes and contact and surface conditions to meet the above-mentioned objectives. Design is carried out using CATIA software on modeling the design specification tree. Optimal Parameter to the material shape determines the model efficiency to withstand the bearing contact of shaft and gear various road conditions and deformations. Bearing undergone shape modification to produce less weight and increase the speed 10]. Specification and design calculation of the bearing on the condition using Catia is as follows.

TABLE 1 SPECIFICATION OF BEARING

Parameter	**Ball bearing**	**Taper roller bearing**	**Thrust bearing**
Part number	6002 RS	30202	51202
Bore diameter (mm)	15	15	15
Outside diameter (mm)	32	35	32

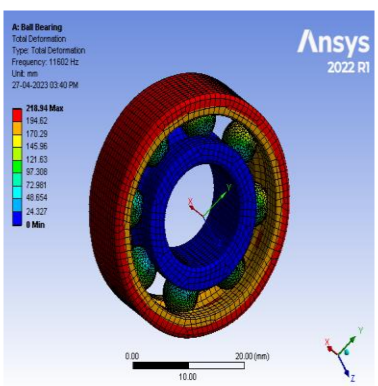
4. Simulation Analysis

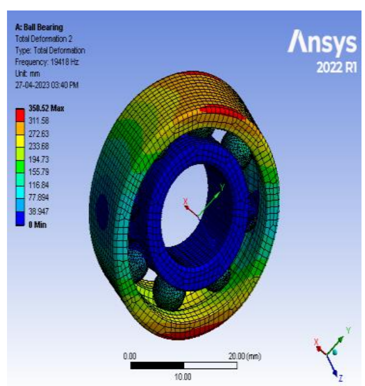
In this section, we conduct a finite element analysis of diverse bearing material designs featuring various shapes. This analysis is carried out using ANSYS software and focuses primarily on evaluating speed and weight considerations [8]. The process entails selecting shapes through finite element methods to assess the mechanical properties at the interface between the bearing, gear, and shaft [9]. These assessments span a range of frequencies, taking into account the operational modes of the bearing, and the results provide insights into how the bearing deforms under different vibration and surface conditions.

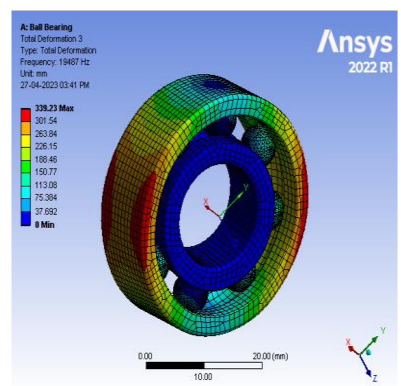
Table 1: Finite Element Analysis of the bearing with various shapes

Mode Shape	**Ball Bearing**			**Tapered Bearing**		**Thrust Bearing**	
	Frequency		Deformation	Frequency	Deformation	Frequency	Deformation
1	11602	218.94	27228	224.07 mm	46667	365.82	
2	19418	350.54	39250	334.74	46975	492.56	
3	19487	339.24	39322	332.38	46989	508.99	
4	20336	389.13	42818	411.43	48723	522.86	
5	20378	389.27	42907	383.36	48733	529.54	
6	23457	233.98	43247	295.13	52636	589.82	

Table 1 illustrates the results of finite element analysis conducted on different bearing shapes, including ball bearings, tapered bearings, and thrust bearings. Figure 1 depicts the operational behaviour of the ball.

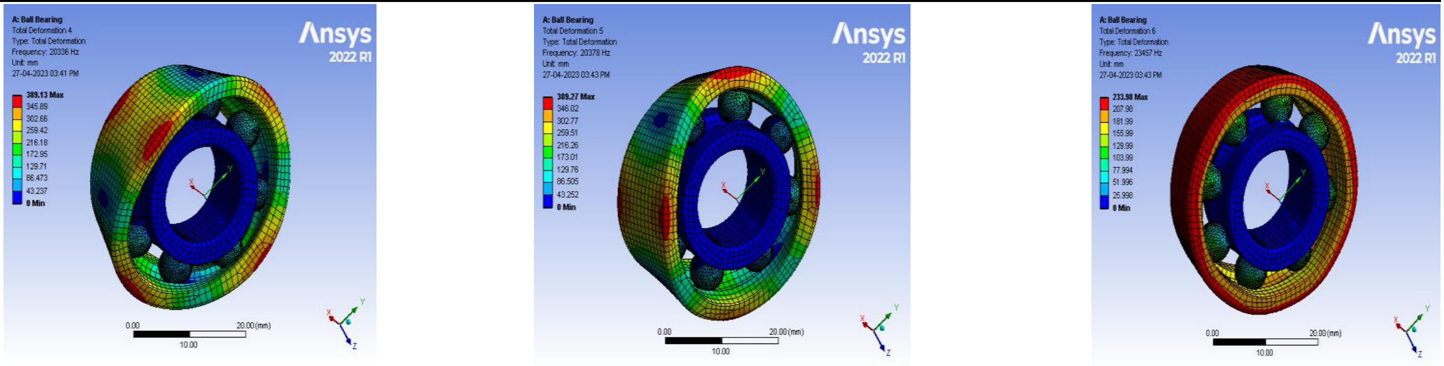






(a) Frequency -11602 Hz **(b)** Frequency - 19418 Hz **(c)** Frequency – 19487 Hz

Max Deformation – 218.94 mm Max Deformation – 339.23 mm Max Deformation – 339.23 mm

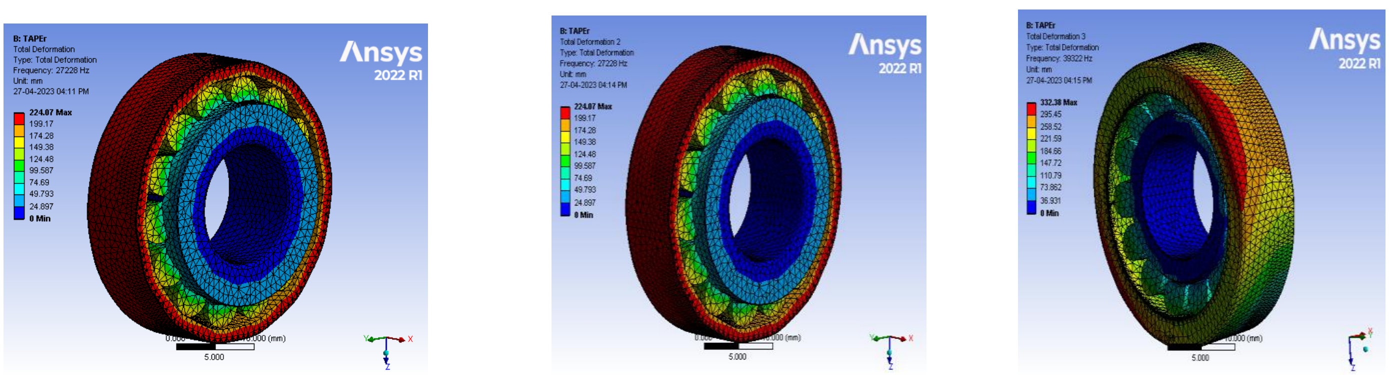


(d) Frequency-20336Hz **(e)** Frequency-20378Hz **(f)** Frequency- 20457Hz

Max deformation – 389.13 mm Max deformation – 389.27 mm Max deformation – 333.15 mm

Figure 2: Design of the ball bearing on the various modes

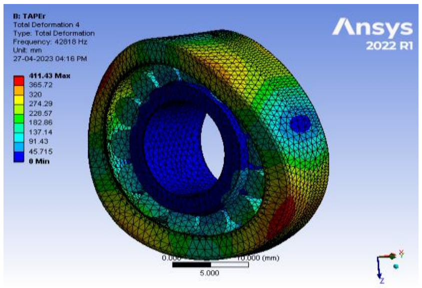
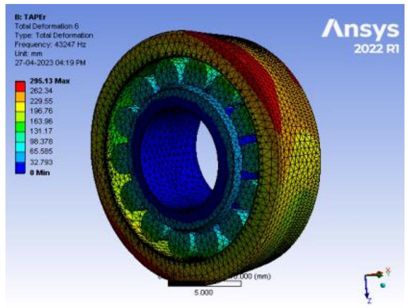
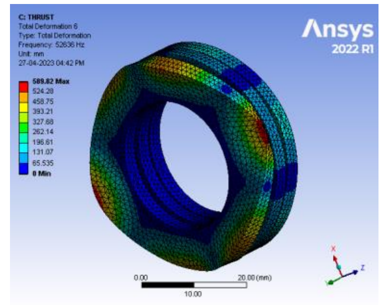
We're evaluated the material used in the ball bearing, taking into account vibrations and the conditions at the interface where the shaft and gear meet. The goal here is to increase speed while reducing weight. As part of our analysis, we're closely examined how the model deforms, paying attention to both the minimum and maximum



deformation values. Figure 2 visually illustrates how the bearing responds under various modes and frequencies.

(a) Frequency-27228 Hz **(b)** Frequency-27220 Hz **(c)** Frequency-30222 Hz

Max deformation – 224.87 mm Max deformation – 224.87 mm Max deformation – 332.38 mm

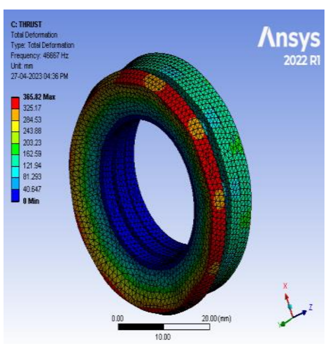
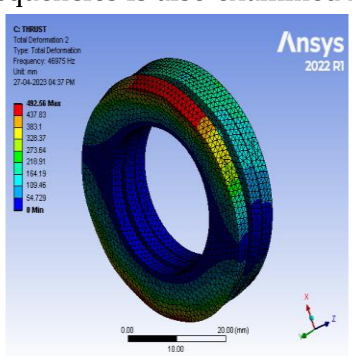
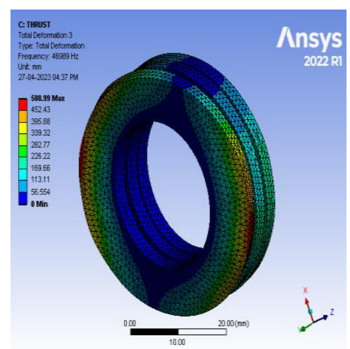




(d) Frequency-42818Hz **(e)** Frequency-43247Hz **(f)** Frequency-52838Hz

Max deformation – 411.13 Max deformation – 286.13 Max deformation – 588.6

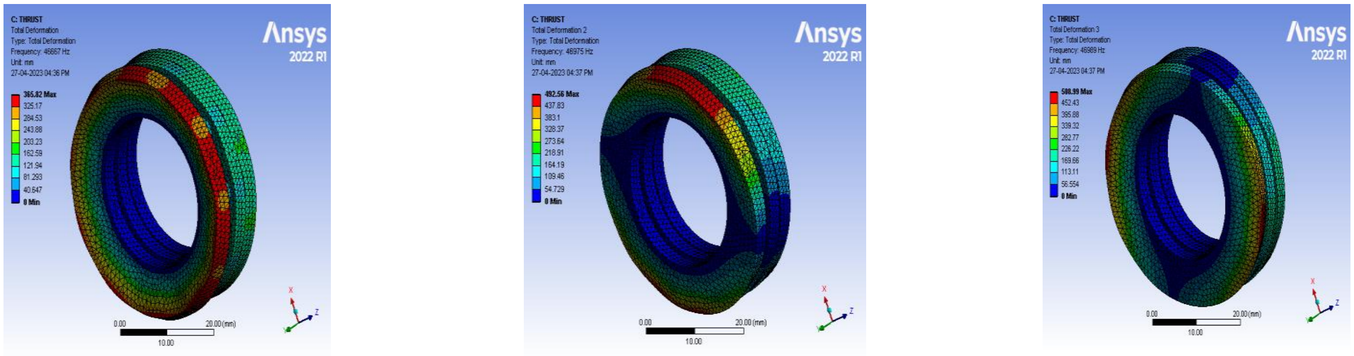
Figure 3: Design of the tapered bearing geometry on the various modes

The evaluation of the tapered bearing material, along with the analysis of vibration and boundary conditions at the shaft and gear interface, is employed to achieve speed and reduce weight. This analysis is carried out to determine the minimum and maximum deformation of the model, as represented in Figure 3. The deformation of the bearing under various modes and frequencies is also examined in the analysis.

(a) Frequency-46667Hz **(b)** Frequency-48075Hz **(c)** Frequency-48999Hz

Max deformation – 389.13 Max deformation – 389.27 Max deformation – 333.15



(d) Frequency-48723Hz **(e)** Frequency-48733Hz **(f)** Frequency-42907Hz

Max deformation – 522.05 Max deformation – 529.54 Max deformation – 383.36

Figure 4: Design of the Thrust bearing geometry on the various modes

In our analysis, we're diving deep into thrust bearing materials and their performance in the context of vibrations and the specific conditions found at the interface between the shaft and gear. Our main objectives are to enhance speed and reduce overall weight. The crux of our investigation revolves around understanding the extent of deformation in the model, as illustrated in Figure 4, across various modes and frequencies.

When it comes to thrust bearings, there are two key types to consider: plain bearings and anti-friction bearings. These are engineered to minimize friction while handling axial loads. And then there are tapered roller bearings, featuring inner and outer tapered ring raceways and rollers, designed to efficiently support combined loads, encompassing both radial and axial forces simultaneously.

Conclusion

In this experiment, we have explored the consequences of distinct bearing silhouettes on rapidity, heftiness, and mechanical capability via finite element analysis (FEA) methods. Using FEA assessments, we can gauge the mechanical traits and dissect its behaviors under sundry operating frequencies along with its retort to quivering and surface conditions. Our aspiration is assessing the interplay amidst bearing contour, pace, heaviness and mechanical performance with a view to perfecting bearing blueprints towards heightened productivity while minimizing risk of malfunction. This research's findings provide precious insights into influence stemming from bearing shape on overall operation. The FEA scrutiny allowed us to assess deformation of bearing amidst diverse operating frequencies empowering us in spotting the most advantageous form which minimizes deformation while preserving required mechanical characteristics. By considering velocity and bulk aspects we are able to devise bearings geared towards specific applications thus optimizing their abilities and efficiency levels.

Reference

[1] Tapered Roller Bearing Damage Detection Using Decision Fusion Analysis by Paula J. Dempsey

[2] Dynamic Analysis of a High-Load Capacity Tapered Roller Bearing by Kazuyoshi HARADA, Tomoya SAKAGUCHI

[3] TAPER ROLLER BEARINGS LUBRICATED WITH BIO-GREASES by B. M. Graça , A .J. V. Campos , J. H. O.Seabra

[4]. Overstam, H., 2006, “The Influence of Bearing Geometry on the Residual Stress State in Cold Drawn Wire Analyzed by the FEM,” J. Mater. Process. Technol., 171(3), pp. 446–450.

[5]. Wei, Y., Qin, Y., Balendra, R., and Jiang, Q., 2004, “FE Analysis of a Novel Roller Form: A Deep End-Cavity Roller for Roller-Type Bearings,” J. Mater. Process. Technol., 145(2), pp. 233–241.

[6]. Demirhan, N., and Kanber, B., 2008, “Stress and Displacement Distributions on Cylindrical Roller Bearing Rings Using FEM,” Mech. Based Des. Struct. Mach., 36(1), pp. 86–102.

[7]. Vernersson, T., 2007, “Temperatures at Railway Tread Braking. Part 1: Modeling,” Proc. Inst. Mech. Eng., F J. Rail Rapid Transit. 221(2), pp. 167–182.

8]. Schmidt, E., and Weiland, T., 2006, “Application of a Computationally Efficient Air-Gap Element within the Finite Element Analysis of Magnetic Bearings,” IEEE Trans. Magn., 42(4), pp.1263–1266.

[9]. Awasthi, R. K., Jain, S. C., and Sharma, S. C.,2006, “Finite Element Analysis of Orifice-Compensated Multiple Hole-Entry Worn Hybrid Journal Bearing,” Finite Elem. Anal. Des., 42(14/15), pp.1291–1303.

[10]. Sukumaran Nair, V. P., and Prabhakaran Nair, K.,2004,“FiniteElementAnalysisofElastohydrodynam ic Circular Journal Bearing With Micropolar Lubricants,” Finite Elem. Anal. Des.,41(1), pp.75–89. Dunnuck D. L., 1992, “Steady-State Temperature and Stack-Up Force Distributions in a Railroad Roller.