Static Analysis of Spherical Roller Bearing by ANSYS

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Abstract — This study presents a finite element analysis (FEA) of the static structural behavior of a spherical roller bearing (SKF 22218 EK) using ANSYS. Spherical roller bearings are critical components in heavy industrial machinery such as sugar mill equipment and heavy-duty gearboxes due to their high load-carrying capacity and self-aligning capabilities. However, under high operational loads, they undergo significant contact stresses and localized deformations that can lead to early fatigue failure. To evaluate these effects, a detailed 3D finite element model incorporating non-linear contact pairs, material properties for AISI 52100 bearing steel, and fine quadratic meshing was subjected to incremental static radial loads ranging from 1,000 N to 10,000N. The simulation results indicate that both equivalent (von Misses) stress and total deformation increase linearly with load, reaching maximum values of 23.952MPa and 0.0029385 mm, respectively, at the peak load of 10,000N. The observed stresses remain well within safe yield limits, confirming the structural integrity of the bearing design and offering valuable insights for reliability enhancement and industrial applications.

Keywords: Spherical Roller Bearing, Static Structural Analysis, Finite Element Analysis (FEA), ANSYS, von Mises Stress, Total Deformation

I. Introduction

Rolling element bearings, which carry significant radial and axial stresses while supporting rotating shafts, are essential parts of heavy industrial equipment. Because of its great load-carrying capacity and ability to self-align, spherical roller bearings are often used in demanding applications including heavy-duty gearboxes and sugar mill equipment. However, these bearings undergo significant contact stresses and localized deformations under high working loads, which may result in early fatigue failure. Hertzian contact theory-based analytical methods have historically produced basic contact pressure estimates, but they often fail to account for intricate geometries, rib interactions, and multi-row load sharing. Finite Element Analysis (FEA) utilizing programs like ANSYS has become crucial for modeling realistic contact mechanics due to developments in computational mechanics. The static structural study of a spherical roller bearing using ANSYS is the main topic of this research article. This study attempts to assess the distribution of von-Mises stress and total deformation under rated operating loads by building a 3D finite element model that incorporates non-linear contact pairs, material properties, and boundary conditions. This will provide insights for improved bearing design and reliability enhancement.

II. Literature Review

The recent literature on bearing mechanics and performance analysis encompasses three major domains: advanced finite element modeling, condition monitoring, fluid film behavior, and novel material applications. In the areas of contact mechanics and finite element (FE) modeling, researchers have focused their attention on replicating the non-linear contact dynamics, stress concentrations, and deformation behaviors for different operating conditions. To address the convergence problems and the variation of contact pressure under higher internal clearance in wind turbine spherical roller bearings (SRBs), Dai et al. [1] proposed a finite element (FE) modeling strategy with spring constraints to track the pressure evolution. Unnikrishnan et al. [6] developed a spring-element methodology in MATLAB based on Hertzian theory, providing a computationally inexpensive option for the static analysis of SRBs. Similarly, Li et al. [2] solved non-Hertzian contact gaps using a 3D FEM framework with deformation influence coefficients, and showed that Johnson-Gohar crowning curves are effective in eliminating edge-load stress spikes in cylindrical roller bearings. These contact studies were supplemented by the work of P. Šulka et al. [3], who compared ANSYS Workbench FEA simulations with classical Hertzian theory, and the work of Blanco-Lorenzo et al. [5], who demonstrated the applicability of Kalker's Conformal Exact Contact Theory to roller-raceway contacts under friction and identified different steady equilibrium positions. Yan et al. [8] studied advanced materials beyond traditional geometries and materials; they showed that TiAl-based alloy plain bearings deform much less than GCr15 steel. Condition monitoring and fault diagnosis strategies have been developed by numerical modeling, data-driven feature extraction, scaling laws and vibration signal processing. Jadhav et al. [4] combined Dimensional Analysis (DA) and K-Nearest Neighbor (KNN) classification for high-accuracy fault detection from vibrational data and Jamadar et al. [11] and Desavale et al. [14] used Buckingham's Pi Theorem along with multivariable regression and dimensional scaling laws for prediction of defect frequencies and dynamic vibration signatures in high-speed industrial fan bearings. Practical implementations of condition-based maintenance (CBM) have proven crucial in industrial settings; Upadhyay et al. [7] outlined mechanisms to mitigate false Brinelling and rolling contact fatigue, while Dhamande [12], Joshi et al. [13], and Joshi et al. [15] demonstrated that MATLAB-assisted signal analysis and time-frequency vibration monitoring effectively diagnose unbalance, misalignment, and early-stage component defects to minimize unscheduled machine downtime. Finally, research into dynamic system response and lubrication theory provides critical insight into fluid-structure interactions and machine dynamics, and Goenka et al. [9] developed a triangular element FEM solver incorporating Reynolds boundary conditions for fluid-lubricated spherical bearings, and Wang et al. [10] solved the general Reynolds equation using finite difference schemes to reveal complex cross-coupling effects among oil pressure, speed, and clearance in spherical hybrid sliding bearings. Together, these studies form a

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comprehensive foundation for modern bearing design, diagnostics, and tribological optimization.

III. METHODOLOGY

It consists of the following steps

A. Geometry Preparation & Simplification

A three-dimensional model of Spherical roller bearings (22218 EK) SKF was created in AutoCAD 2026. The details are as given below

Symbol	Parameter	Value
d	Bore diameter	90 mm
D	Outside diameter	160 mm
B	Width	40 mm
d_2	Shoulder diameter inner ring	106 mm
D_1	Shoulder diameter outer ring	141 mm
b	Width of lubrication groove (outer ring)	6 mm
K	Diameter of lubrication hole (outer ring)	3 mm
$r_{1,2}$	Corner radius	min. 2 mm

Table 1: Bearing dimensions

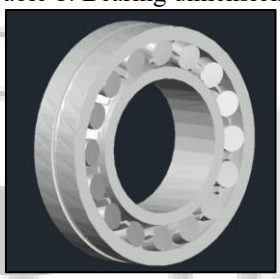


Fig. 1: CAD model of Spherical roller bearing (22218 EK)

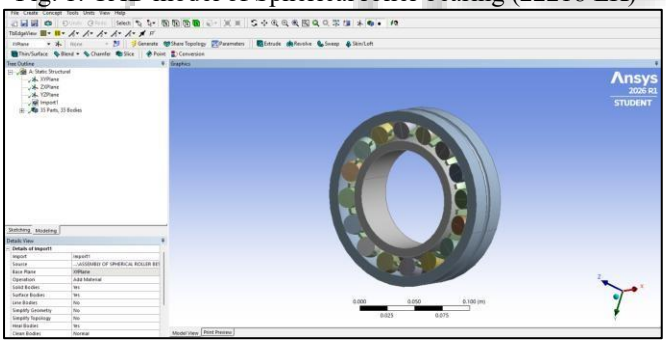


Fig. 2: Spherical roller bearing in ANSYS

B. Material Property:

Bearing Steel (e.g., AISI 52100): Young's Modulus (E=210 GPa), Poisson's Ratio (0.3), and Density (780 kg/m^3).

C. Meshing

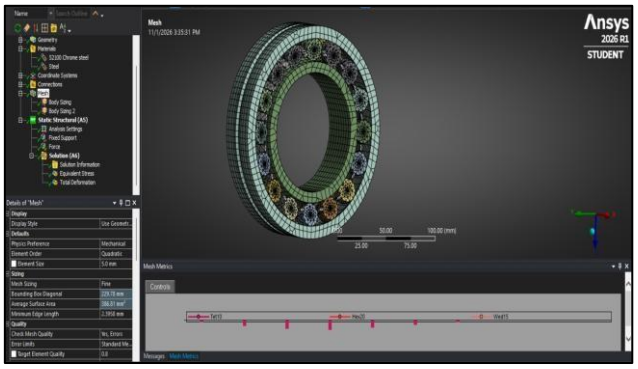


Fig. 3: Meshing of Spherical roller bearing

Meshing is as shown in Figure 3. Under mechanical physics settings, the finite element mesh for the bearing assembly in ANSYS. Mechanical is set up with a "Fine" mesh size and quadratic element order. With a bounding box diagonal of 229.78 mm, an average surface area of 386.81 mm², and a minimum edge length of 2.3958 mm, the model has certain body size parameters. The mesh metrics show a distribution of higher-order 3D elements, such as Tet10, Hex20, and Wed15, and mesh quality checking is enabled with a target element quality of 0.8.

D. Boundary Conditions & Load Application

ANSYS Static Structural was used to put up the rolling element bearing assembly's finite element analysis (FEA) model in order to assess the structural behavior under triaxial loading. While contact surfaces between the rolling components, inner ring, and outer ring raceways were preserved to transmit loads throughout the assembly, the outer ring geometry remained fixed to restrict rigid body motion, emulating its firmly fitting attachment inside the housing. Ten different load scenarios, ranging from 1,000 N to 10,000 N applied in incremental 1,000 N increments, were used to assess load application.

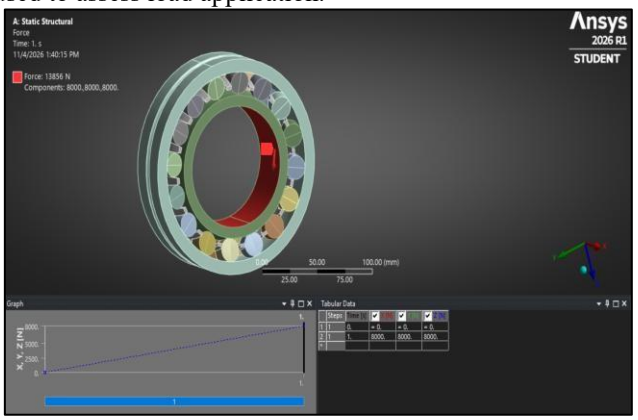


Fig. 4: Load of 8000 N applied in X, Y, Z directions

IV. RESULTS AND DISCUSSION

The variation of stress and total deformation for various as shown in following figure 5 to 24.

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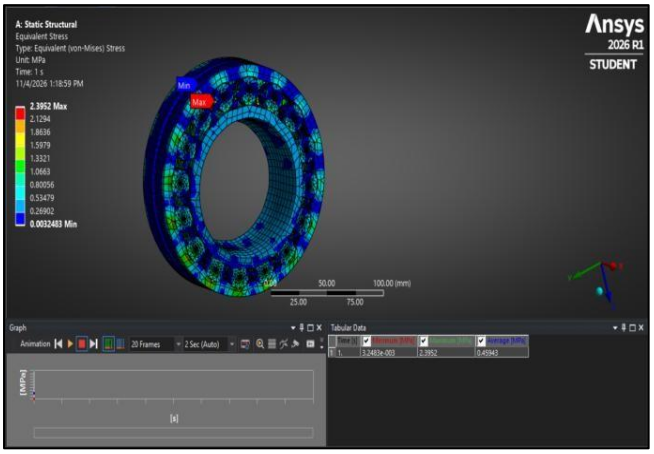


Fig. 5: Vonmiss stress for load 1000 N

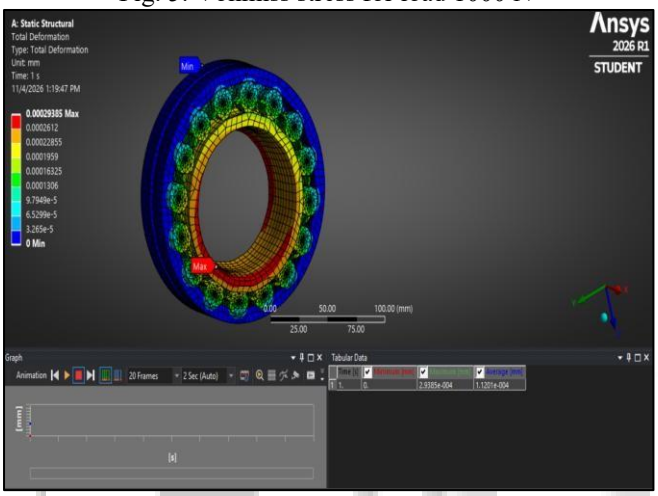


Fig. 6: total deformation for load 1000 N

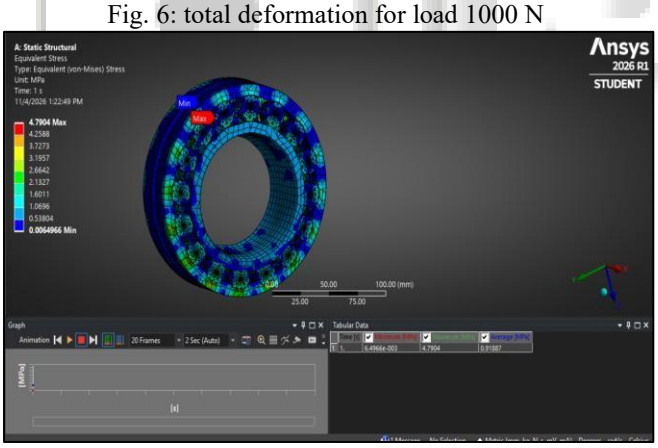


Fig. 7: Vonmiss stress for load 2000 N

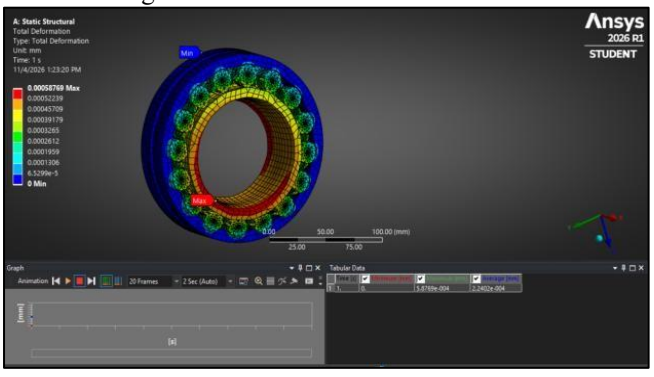


Fig. 8: Total Deformation for 2000 N

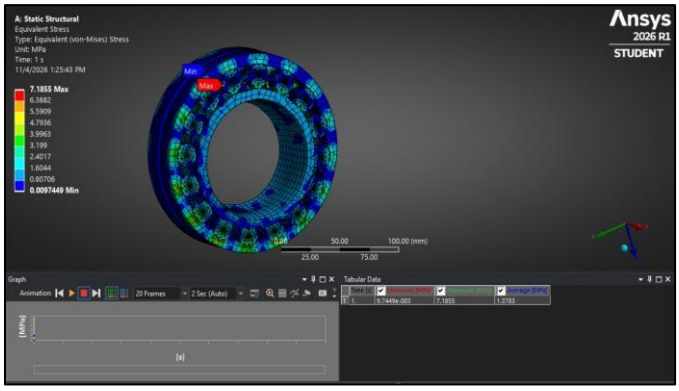


Fig. 9: Vonmiss stress for load 3000 N

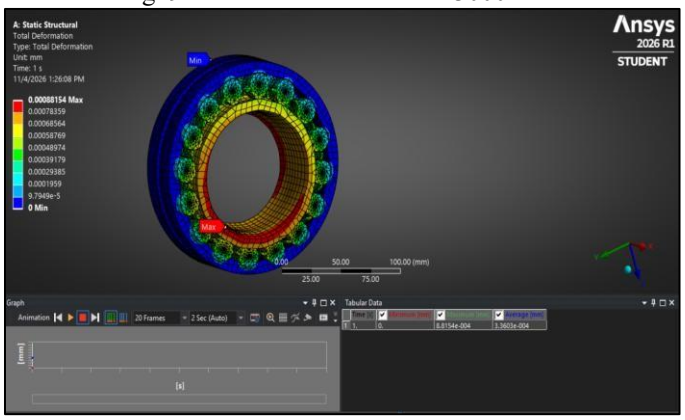


Fig. 10: Total Deformation for 3000 N

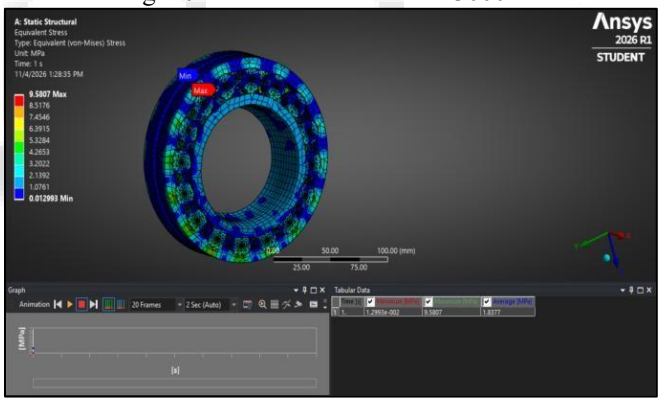


Fig. 11: Vonmiss stress for load 4000 N

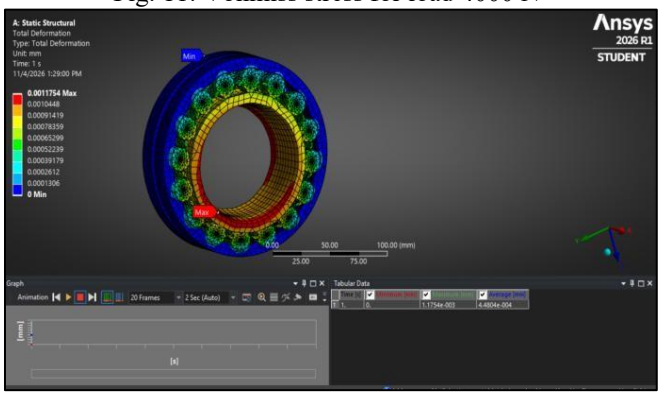


Fig. 12: Total Deformation for 4000 N

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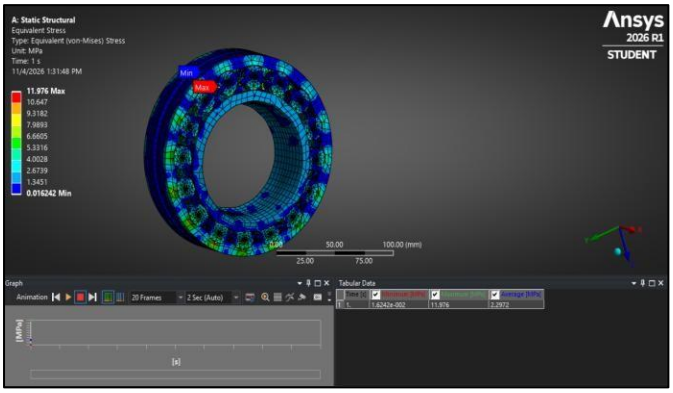


Fig. 13: Vonmiss stress for load 5000 N

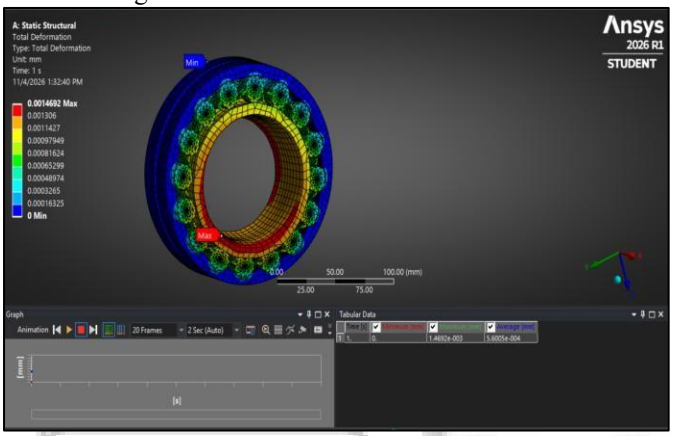


Fig. 14. Total Deformation for 5000

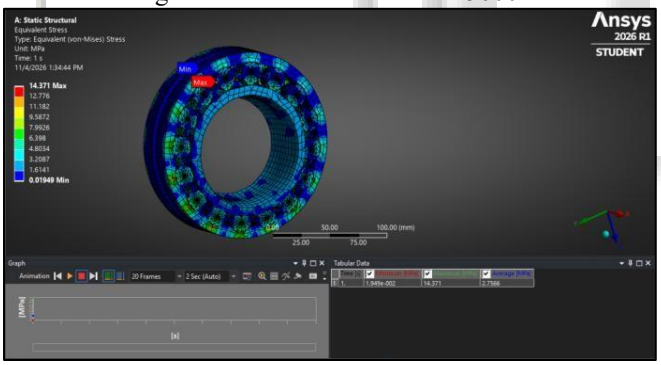


Fig. 15: Vonmiss stress for load 6000 N

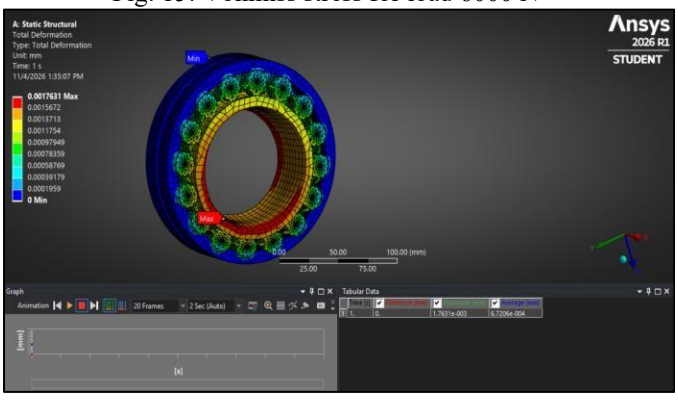


Fig. 16: Total Deformation for 6000 N

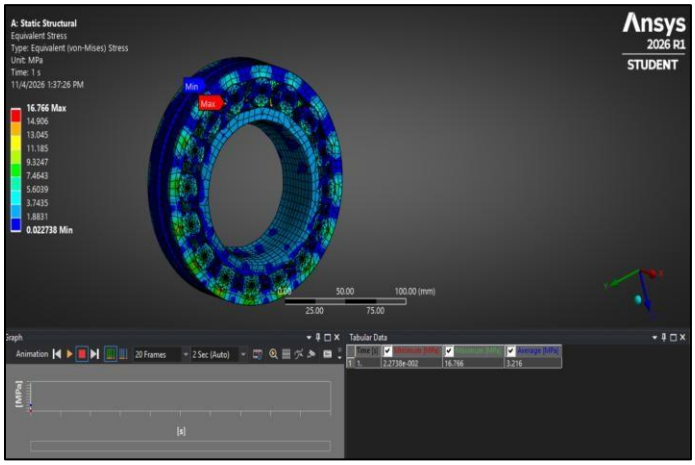


Fig. 17. Vonmiss stress for load 7000 N

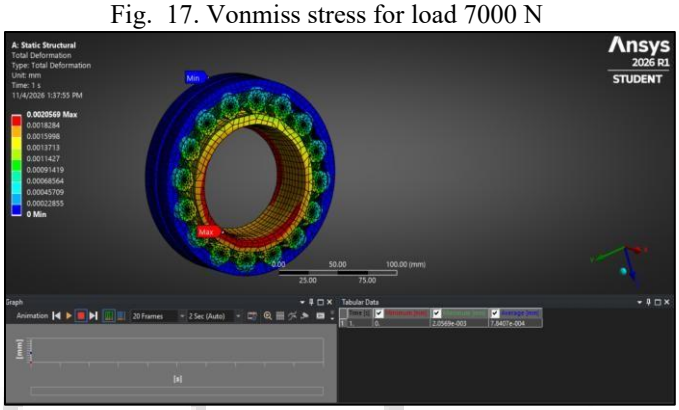


Fig. 18. Total Deformation for 7000 N

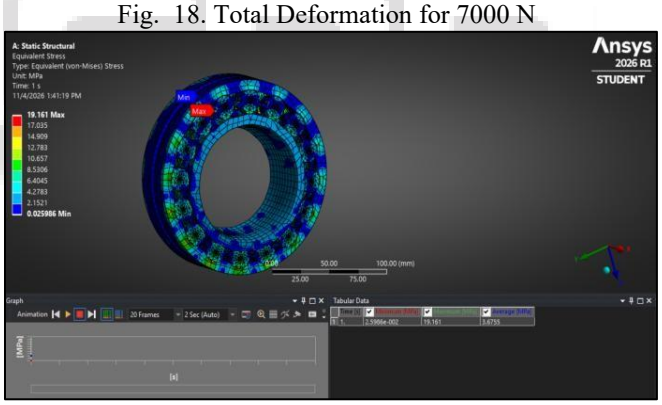


Fig. 19: Vonmiss stress for load 8000 N

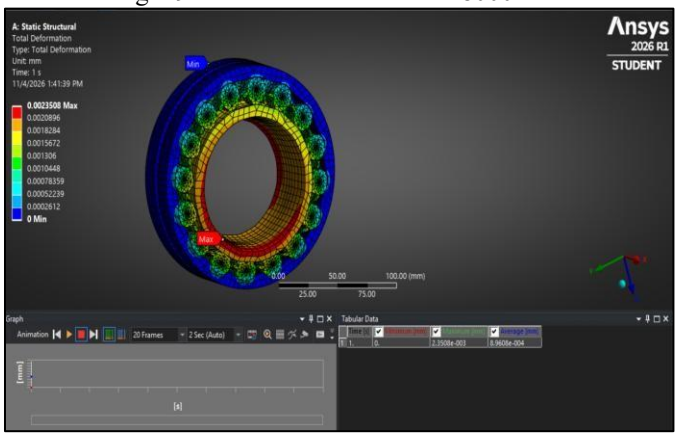


Fig. 20: Total Deformation for 8000N

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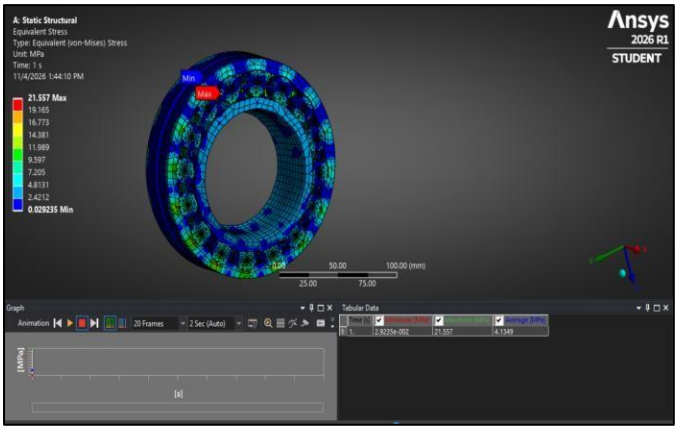


Fig. 21: Vonmiss stress for load 9000 N

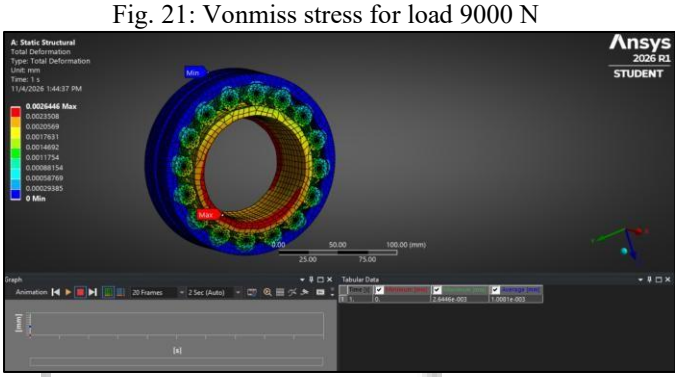


Fig. 22: Total Deformation for 9000N

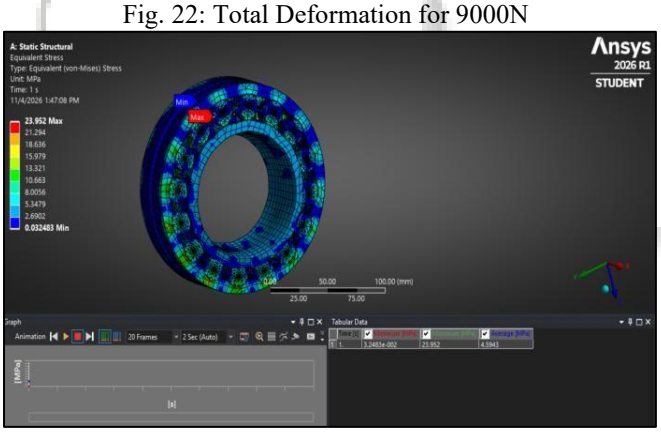


Fig. 23: Vonmiss stress for load 10000 N

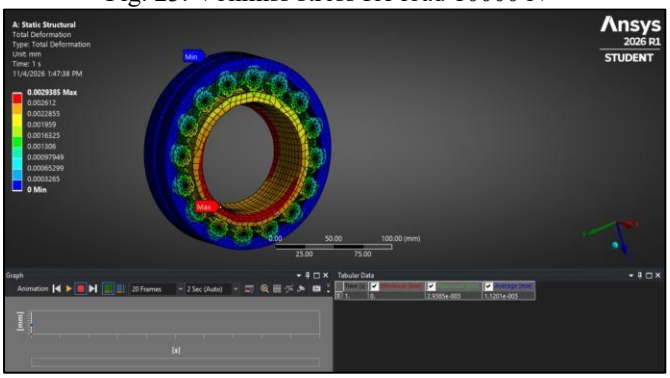


Fig. 24: Total Deformation for 10000 N

The following table 2 shows all the values of stress and total deformations for all loads.

Sr. no.	Load in N	Stress in Mpa	Deflection
1.	1000N	2.3952	0.00029385
2.	2000N	4.7904	0.00058769
3.	3000N	7.01855	0.00088154
4.	4000N	9.5807	0.00011754
5.	5000N	11.976	0.0014692
6.	6000N	14.371	0.0017631
7.	7000N	16.766	0.0020569
8.	8000N	19.161	0.0023508
9.	9000N	21.557	0.0026446
10.	10000N	23.952	0.0029385

Table 2: Stress and total deformation for all loads

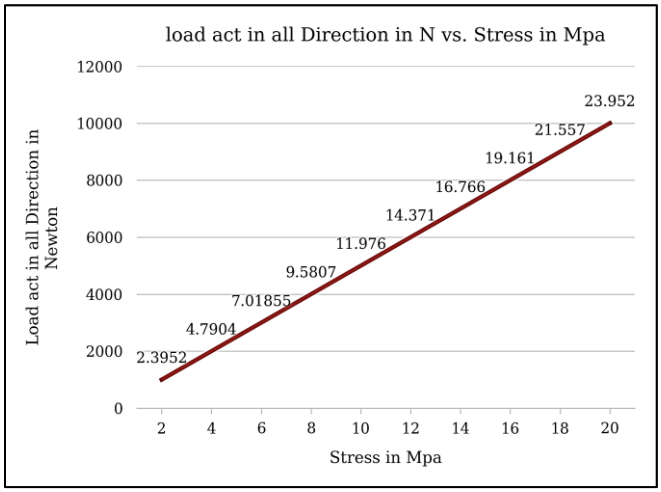


Fig. 25: Load vs. stress

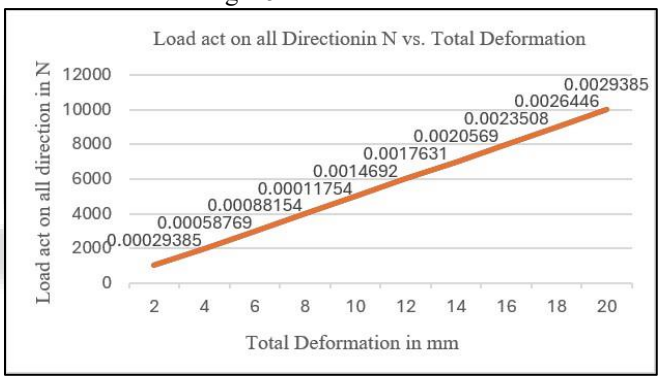


Fig. 26: Load vs. Total deformation

V. CONCLUSION AND FUTURE SCOPE

In this study, static structural analysis of a spherical roller bearing (SKF 22218 EK) was successfully conducted using ANSYS to evaluate its mechanical behavior under incremental radial loads ranging from 1,000 N to 10,000 N. The finite element results demonstrate that:

- Stress Proportionality: The equivalent (von Mises) stress increases linearly with the applied load, rising from 2.3952 MPa at 1,000 N to a maximum of 23.952 MPa at the peak load of 10,000 N.
- Deformation Characteristics: Total deformation exhibits a direct, proportional correlation with load intensity, increasing from 0.00029385 mm at 1,000 N to 0.0029385 mm at 10,000 N.

A. Future Scope

The current static finite element model can be extended in several directions to better capture real-world operational complexities: Dynamic and Transient Loading: Future work can incorporate rotational speeds, centrifugal forces, and dynamic load cycles to evaluate high-speed performance in

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heavy-duty machinery such as sugar mill centrifuges and gearboxes.

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