International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 6, September-October 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Finite Element Analysis of Ball Bearing for Different Materials

Pushpendra Tiwari[1], N. V. Saxena[2]

[1]M Tech Scholar, [2]Assistant Professor,

[1,2]Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal, Madhya Pradesh, India

ABSTRACT

Bearing is an important part of a moving machine which is used for relative motion between the contact surfaces. Wear and tear of bearing is a common problem due to friction between the moving parts. A lot of researchers have done work for improving the life of the bearing. In the present work, traditionally used ball bearing has been modeled and analysed using FEM. Parameters such as Equivalent (Von-Misses) Stress, Maximum Principal Stress, Equivalent Elastic Strain, Maximum Shear Stress and Total Deformation have been found out. Analysis has also been carried for finding out the effect of material of bearing: steel, Structural Steel, Si3N4 and SiC on its performance along with elastic strain, stiffness and total deformation for various materials. It can be concluded that the Deformation and Elastic Strain induced in the SiC is less than the steel, structural steel and Si3N4 for the present investigation and the Stiffness of SiC is maximum as compared to steel, structural steel and Si3N4 hence SiC is the best material for ball bearing.

KEYWORDS: *Finite Element Analysis, Ball bearing, materials, Structural Steel, SiC, Si_3N_4*

How to cite this paper: Pushpendra Tiwari | N. V. Saxena "Finite Element Analysis of Ball Bearing for Different Materials" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-6, October 2020, pp.964-968, URL: www.ijtsrd.com/papers/ijtsrd33541.pdf

IJTSRD33541

INTRODUCTION

A bearing is a machine element which supports another moving machine element. It is used for relative motion between the contact surfaces of the members, while carrying the load. Due to relative motion between the contact surfaces, a certain amount of power is wasted in overcoming frictional resistance. Also if the resist surfaces are in direct contact, there is rapid wear. To reduce frictional resistance a layer of fluid (known as lubricant) may be provided.

In the present work, traditionally used ball bearing has been modeled and analysed using FEM. Equivalent (Von-Misses) Stress, Maximum Principal Stress, Equivalent Elastic Strain, Maximum Shear Stress and Total Deformation have been found out. Also analysis has been carried for finding out the effect of material of bearing: steel, Structural Steel, Si3N4 and SiC on its performance along with elastic strain, stiffness and total deformation for various materials.

LITERATURE REVIEW

Jiazhi Hea and Yibao Chenb analysed about the sleeve joint structure in cantilever. R. Pandiyarajan et al. 2016 determined the contact stress of large diameter ball bearings using analytical and numerical methods. C. Akgu¨ner, M. Kirkit, 2016 cmpared the axial bearing capacities estimated with pile load tests and empirical methods for seven rock-socketed single cast-in-place piles constructed in Turkey. František Pochylý et al 2015 presented a modified Reynolds equation for studying the effect of fluid slipping at partially hydrophobic surface. Zhang Yongqi et al. 2015 developed FEM of roller bearings by using Reynolds equation and considering the surface roughness. Many researchers have worked for life enhancement of bearings. FEM analysis can be used for analysis of bearings.

GEOMETRIC MODELING AND MESHING

Geometric Modeling

A model of the ball bearing is first created using UNIGRAPHICS (NX8.5) software. Then the model is imported to ANSYS 14.5 to complete static structural analysis; the finite element analysis and mechanical properties.

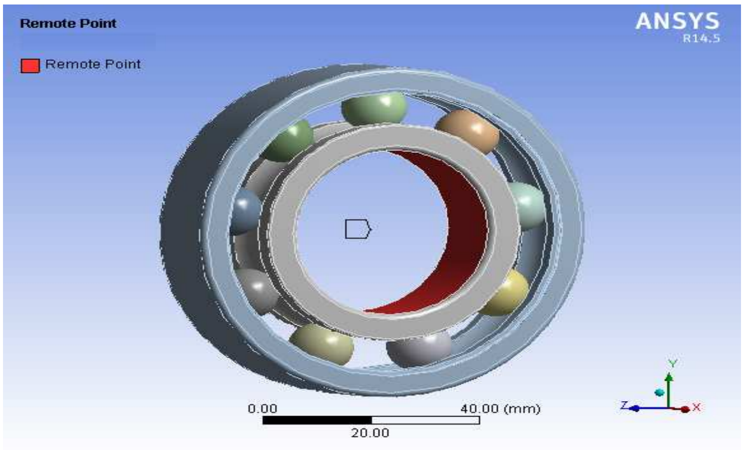

Fig 1: Model of ball bearing.

Meshing

In the present thesis work meshing of the model has been done using default meshing type tetrahedral method of contact size 1 mm and body size 5mm. Number of nodes and elements are 8000 and 2100 are being created respectively.

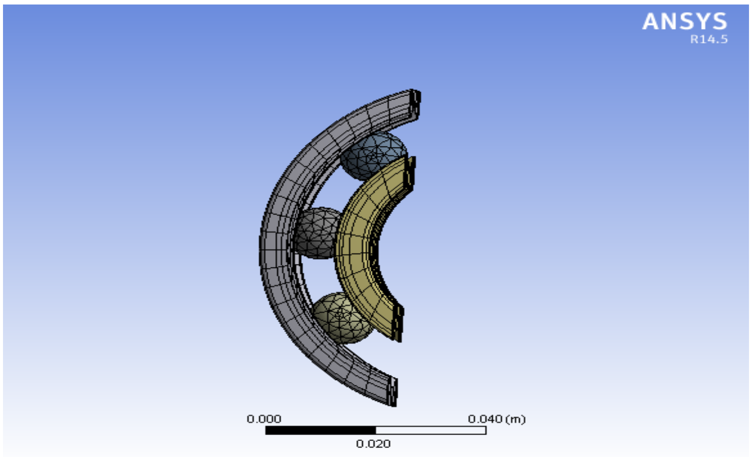

Fig 2: Mesh model of ball bearing.

BOUNDARY CONDITIONS

During analysis two boundary conditions has been considered which on ball bearing are as follows:

Applying Force of 1000 N on inner case at inner surface of ball bearing, which is calculated, stress, strain and deformation from FEA.

Fixed support of outer case of ball bearing.

The analysis has been done for steel, Stainless Steel, Si_3N_4, SiC

RESULTS AND DISCUSSION

Analysis is carried out under static structural module of ANSYS workbench The Equivalent (Von-Misses) Stress, Maximum Principal Stress, Equivalent Elastic Strain, Maximum Shear Stress and Total Deformation are calculated using ANSYS. Bearing steel, Structural Steel, Si3N4 and SiC are used as the ball bearing material for analysis and its mechanical properties are provided as the input to the ANSYS.

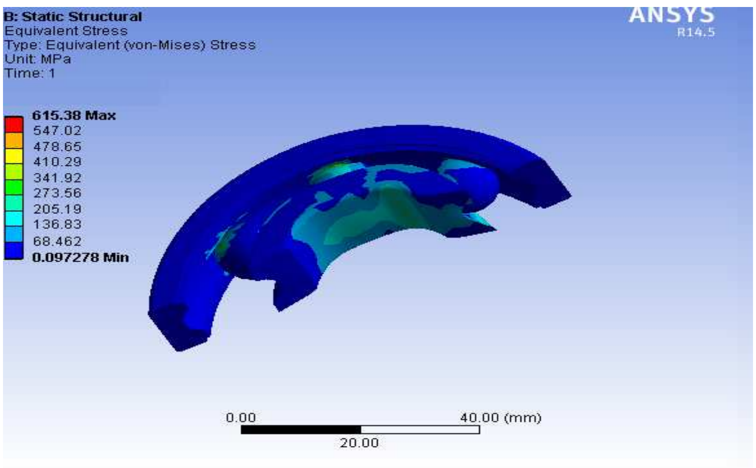

Fig 3: Von-misses stress of steel ball bearing

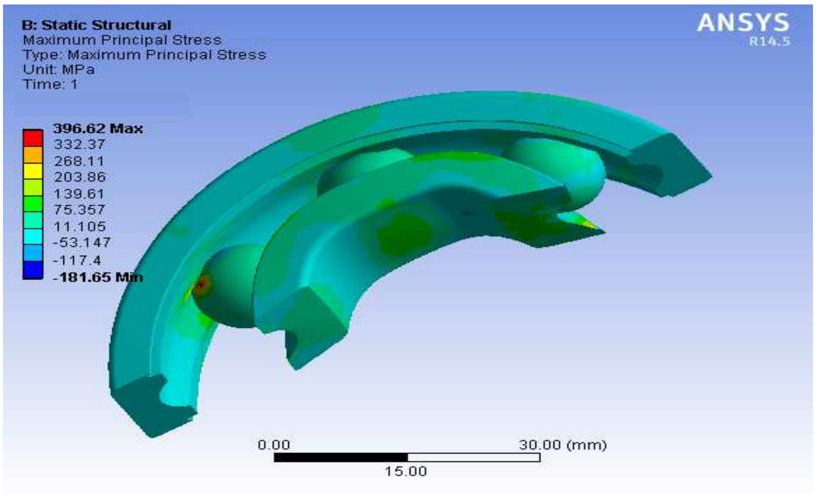

Fig 4: Principal stress of steel ball bearing.

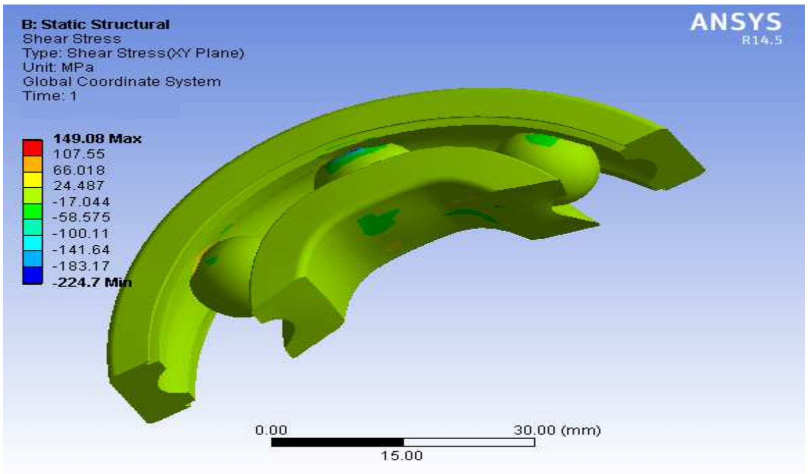

Fig 5: Shear stress of steel ball bearing.

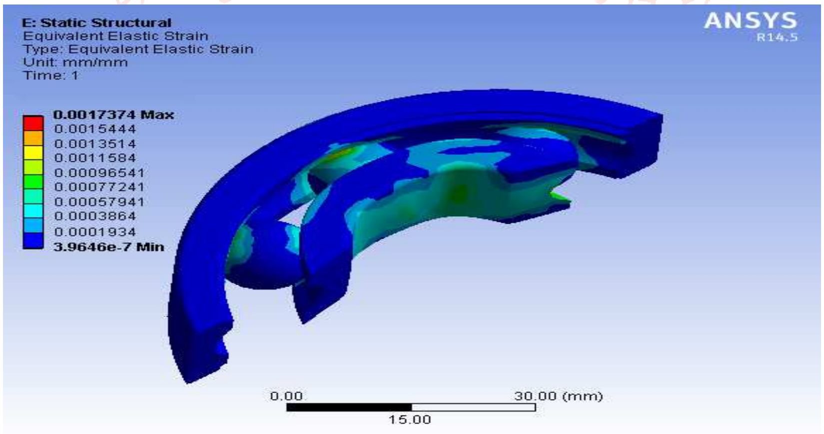

Fig 6: Elastic strain of SiC ball bearing.

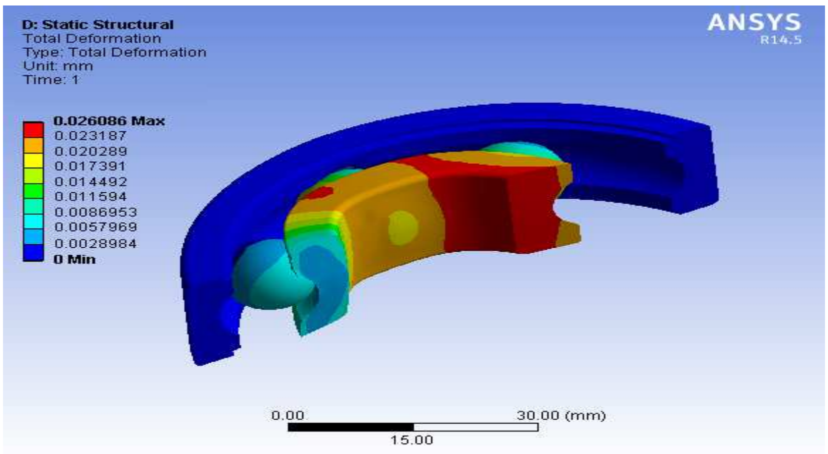

Fig 7: Total deformation of Si_3N_4ball bearing

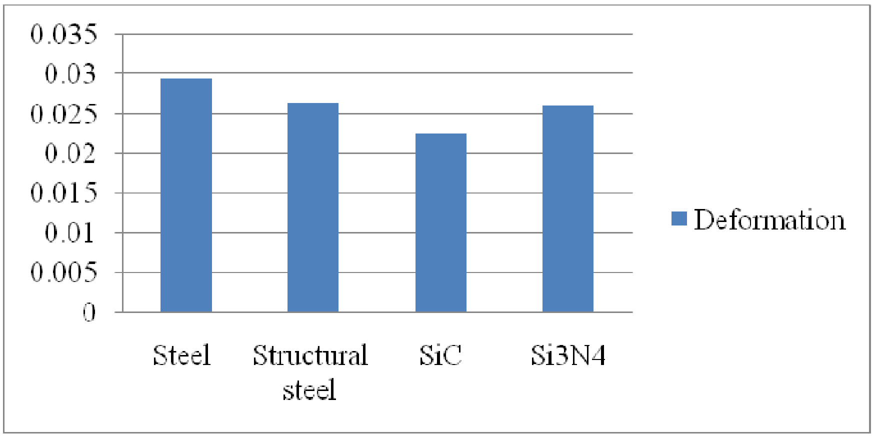

Fig 9: Total deformation

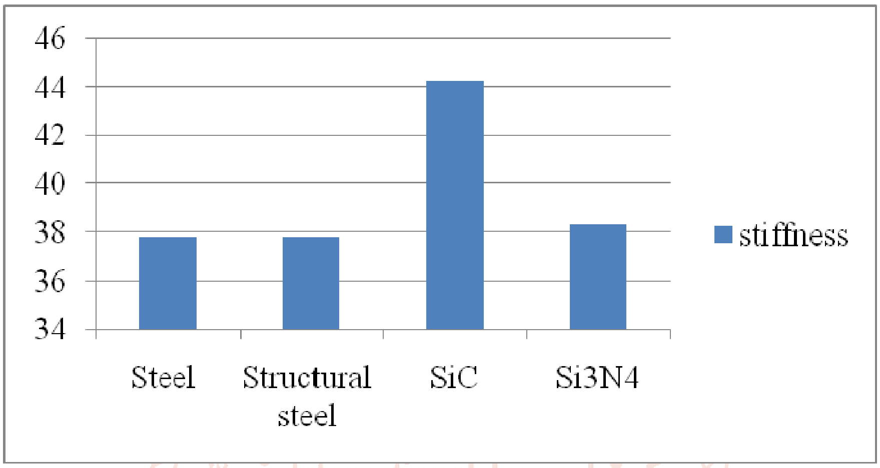

Fig 10: Stiffness

CONCLUSIONS

Finite element analysis of four different materials: Steel, Structural Steel, Si_3N_4 and SiC have been carried out. Ball bearing is 3D solid modeled with UNIGRAPHICS (NX8.5) and static analysis is carried out by using ANSYS software to understand the Structural response of the ball bearing. Finite element analysis of the ball bearing has been done using FEA tool ANSYS Workbench. It can be concluded that the maximum Von-misses stress is 615.38MPa, Principal stress is 396.62MPa, Shear stress is 149.08MPa and the minimum Von-misses stress is $97.278*10^{-3}$MPa, Principal stress is -181.65 MPa, Shear stress is -224.7 MPa respectively for steel. Deformation occurs in steel (23.26%), structural steel (14.58%) and Si_3N_4 (13.36%) ball bearing are higher as compared to the SiC ball bearing. Elastic Strain occurs in steel (48.58%), structural steel (23.56%) and Si_3N_4 (11.18%) ball bearing are higher as compared to the SiC ball bearing. It is concluded that the Deformation and Elastic Strain induced in the SiC is less than the steel, structural steel and Si3N4 for the present investigation and the Stiffness of SiC is maximum as compared to steel, structural steel and Si3N4 hence SiC is the best material for ball bearing.

REFERENCES

[1] A. Eslami et al. "Evaluating CPT and CPTu based pile bearing capacity estimation me-thods using Urmiyeh Lake Causeway piling records" Scientia Iranica, Civil Engineering 18pp 1009–1019, 2091.

[2] Ayao E. Azianou et al. "Modeling of the behavior of a deep groove ball bearing in its housing" Journal of Applied Mathematics and Physics, volume 1pp 45-50, 2019.

[3] C. Akgu¨ner, M. Kirkit "Axial bearing capacity of socketed single cast-in-place piles" Soils and Foundations 52pp 59–68, 2018.

[4] Chan-hee Nam et al. "Finite element analysis model of rotary forging for assembling wheel hub bearing assembly" Procedia Engineering 81pp 2475 – 2480, 2018.

[5] František Pochylý et al. "Journal Bearings with Hydrophobic Surface" Procedia Engineering 39pp 76 – 83, 2017.

[6] HU Qinghua et al. "A 5-DOF Model for Aero engine Spindle Dual-rotor System Analysis" Chinese Journal of Aeronautics 24pp 224-234, 2017.

[7] Hui Xing, Qili Wu,et al. "Elastohydrodynamic Lubrication Analysis of Marine Sterntube Bearing Based on Multi-body Dynamics" Energy Procedia 16pp 1046 – 1051, 2016.

[8] J. Ghorbanian et al. "Design predictive tool and optimization of journal bearing using neural network model and multi-objective genetic algorithm" Scientia Iranica, Mechanical Engineering 18pp 1095–1105,2016.

[9] Jiazhi Hea and Yibao Chenb "Analysis and Optimal Design about a kind of Bearing Beam with Sleeve Joint Structure" Procedia Environmental Sciences 11pp 275 – 280, 2015.

[10] Ju Yan-zhong et al. "Theoretical Calculation of Ultimate Bearing Capacity and Fatigue of Safety Pin of

Transmission Tower" Energy Procedia 17pp 1057 – 1063, 2015.

[11] M. Imani et al. "Bearing failure modes of rock foundations with consideration of joint spacing" Scientia Iranica, Civil Engineering 19pp 1411–1421, 2014.

[12] M. Mehdizadeh, F. Khodabakhshi "An investigation into failure analysis of interfering part of a steam turbine journal bearing" Case Studies in Engineering Failure Analysis 2pp 61–68, 2014.

[13] M. Veiskarami et al. Prediction of the bearing capacity and load–displacement behavior of shallow foundations by the stress-level-based ZEL method" Scientia Iranica, Civil Engineering 18pp 16–27, 2013.

[14] Michele Cerullo "Sub-surface fatigue crack growth at alumina inclusions in AISI 52100 roller bearings" Procedia Engineering 74pp 333 – 338, 2013.

[15] 15. N.A. Branch et al. "A new reverse analysis to determine the constitutive response of plastically graded case hardened bearing steels" International Journal of Solids and Structures 48pp 584–591, 2012.