FINITE ELEMENT ANALYSIS OF DEEP GROVE BALL BEARING

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***Abstract*: Materials that are used for the manufacturing of bearing play an important role, in terms of their reliability and reduction in friction. In order to reduce the friction and deformation of deep grove ball bearing, in this work effect of using different materials for the manufacturing of bearing was analysed. At static load condition, value of contact stress on inner and outer race and total displacement of ball bearing is calculated at different loading conditio0ns for different materials. In order to analysed the effect of different materials used for the manufacturing of bearing, four different materials were considered in this work that is SUJ2, SUS420J2, FC200 and SUS304.In order to check different conditions of loading on different material here it considered 2000, 4000, 6000 and 10000 N load to perform static analysis on deep groove ball bearing.**

***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 are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts. Rotary 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 simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

This work considered four different materials for the manufacturing of ball bearing. The contact stresses in ball bearing mainly depends on the material properties that are used for the manufacturing of bearing. So, in order to reduce contact stress and deformation in deep groove ball bearing, it analyzed four different types of material used for manufacturing of ball bearing.

2. Development of numerical model of deep groove ball bearing

For analyzing deep groove ball bearing at different material, here first it has to develop the numerical model of deep groove ball bearing. For developing the numerical model of deep groove ball bearing first it has to develop the solid model of ball bearing. Here in this work solid model of deep groove ball bearing were develop on the basis of geometric parameters considered during the experimental analysis performed by shuting li [19]. The geometric parameters considered for manufacturing of deep groove ball bearing were shown in the below table.

Table.1 Geometric parameter of ball bearing

Parameters	Value
Inner race diameter or bore diameter (d)	32 mm
Outer race diameter (D)	75 mm
Width (B)	20 mm
Ball diameter	11.11 mm
Number of balls	8

Base on the above geometric parameters solid model of ball bearing were developed. The solid model of deep groove ball bearing was shown in the below fig.

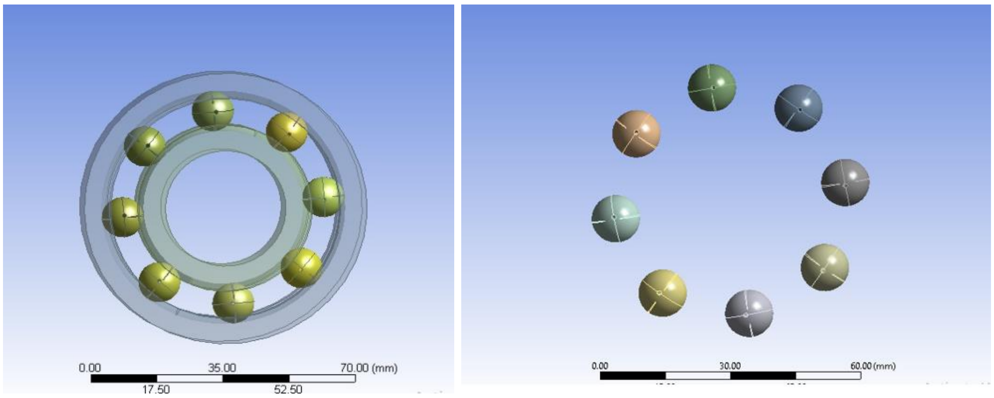


Fig.1 Solid model of deep groove ball bearing considered for numerical analysis

3. Meshing

To perform the numerical analysis first it has to discretize the complete body of ball bearing in to number of nodes and elements. In order calculate the dependency of result on nodes and elements, here in this work it perform mesh of ball bearing with different number of nodes and elements and calculated the value of contact stresses. Through analysis it is found that the contact stress does not depend on the number of nodes and elements. Here in this analysis it discretizes the ball bearing in to 18894 numbers of elements which gives optimum result. The mesh of the ball bearing is shown in the below fig.

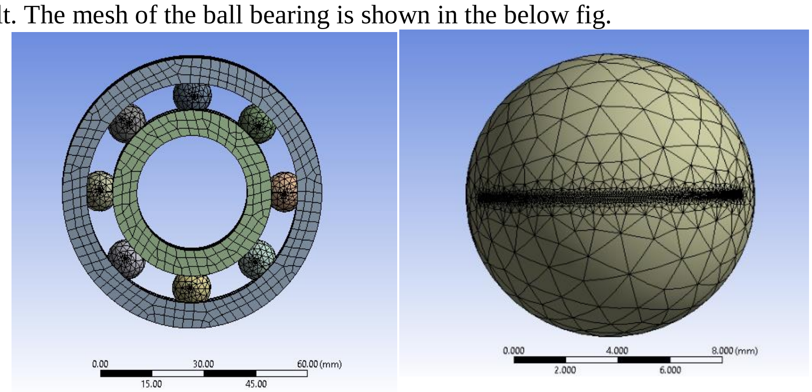


Fig.2 Mesh of the deep groove ball bearing

4. Boundary condition

Here in this work first it performs the static analysis of deep groove ball bearing, to perform the Finite element analysis of ball bearing at static state here we have considered same boundary conditions as considered during the experimental analysis performed by shuting [19]. Here in this work for static analysis it considered outer ring of the ball bearing is in fix condition where different radial load is applied on the ball bearing and calculate the value of contact stresses and total deformation of ball bearing. Here in this work static of deep groove ball bearing were performed in Ansys.

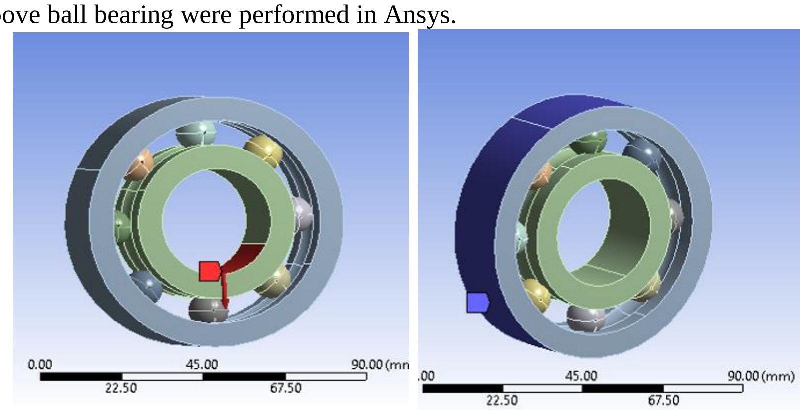


Fig.3 fixing of outer race of ball bearing

5. **Validation of the finite element analysis of deep groove ball bearing**

For validating the numerical analysis of deep groove ball bearing, it performs FEM analysis of deep groove ball bearing considered the boundary conditions as considered during the experimental analysis perform by shuting [19] and calculate the value of contact stresses on the outer and inner race of bearing. During static analysis it considered the same material as considered during the experimental analysis performed by shuting [19] that is SUJ2 and also considered the same boundary condition as considered during the experimental analysis. The value of contact stresses at inner and outer ring of ball bearing for 2000 N static load is shown in the below fig.

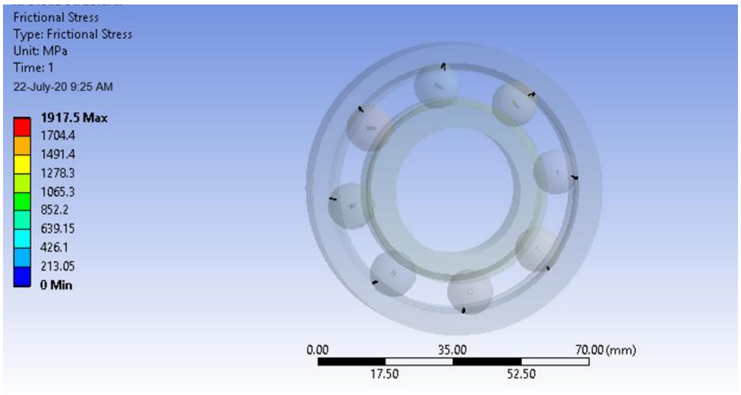


Fig.4 Value of contact stress on lower contact region at 2000 N load

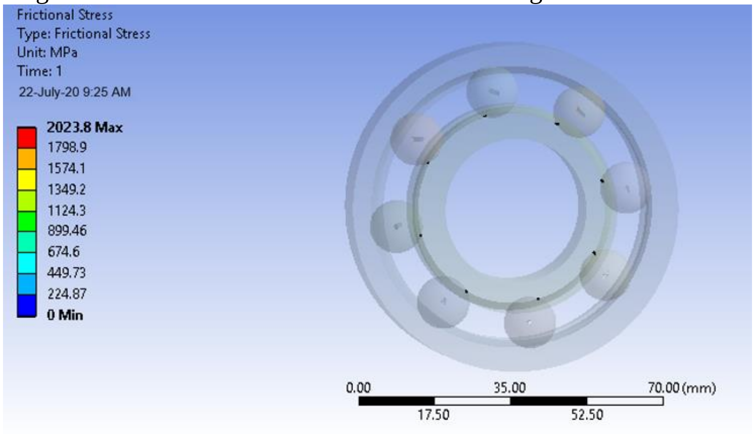


Fig.5 Value of contact stress on upper contact region at 2000 N load

After calculating the value of contact stresses on inner and outer ring here in this work it also calculate the value of total deformation of deep groove ball bearing. The contours of total deformation of bearing at 2000 N load is shown in the below fig.

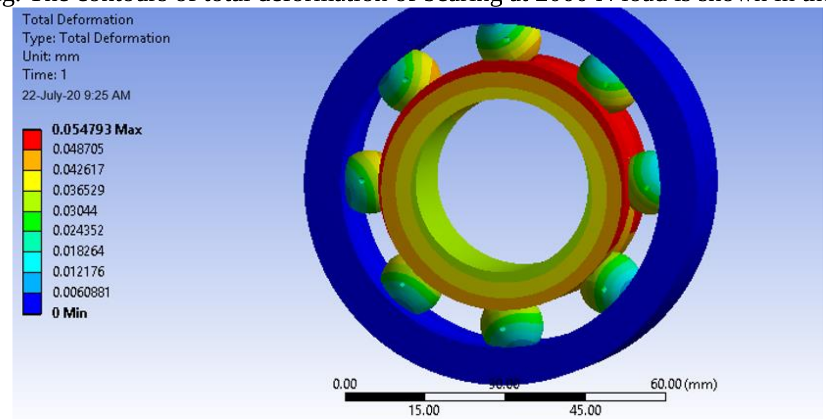


Fig.6 Value of total deformation at 2000 N load

6. Comparison of value of contact stresses

For validating the numerical model of deep groove ball bearing here it compare the value of contact stresses on inner and outer race calculated through numerical analysis with the value of contact stresses obtained from the base paper at same static load.

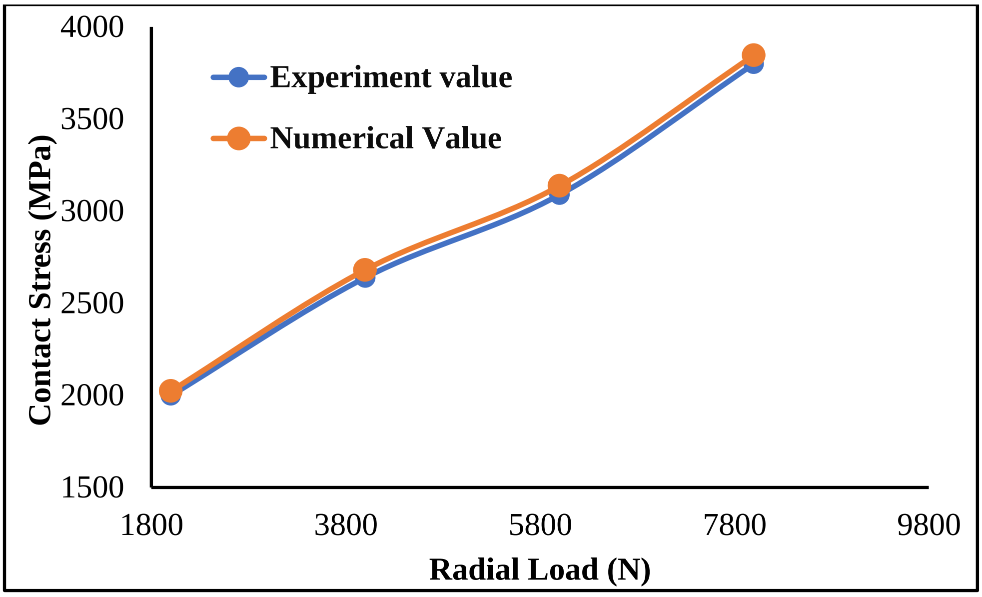


Fig.7 Comparison of value of contact stress in between inner race and ball

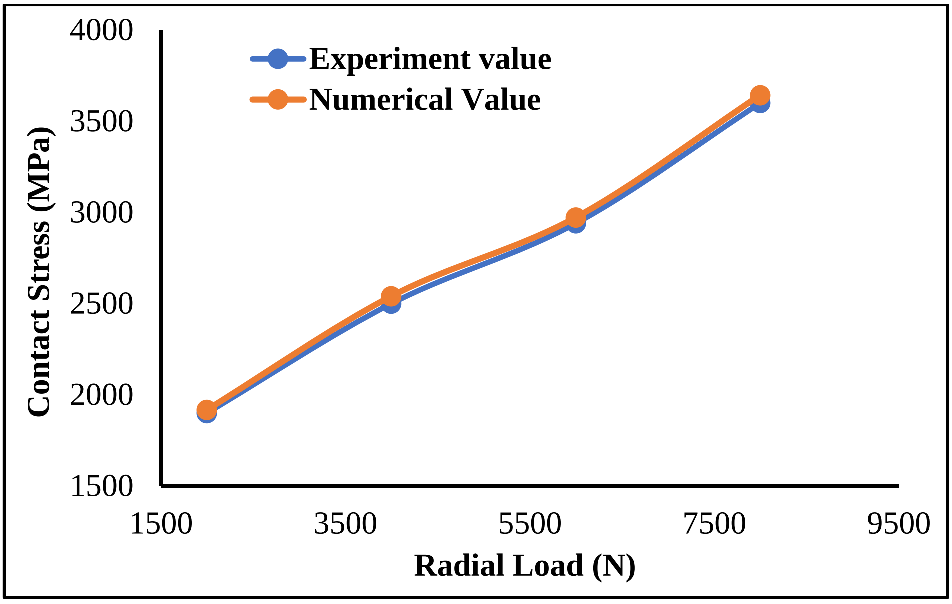
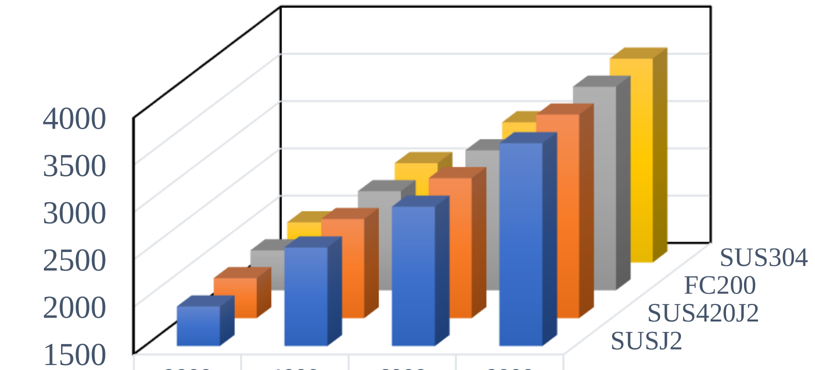


Fig.8 Comparison of value of contact stress in between outer race and ball

From above graph it is found that the value of contact stresses at inner and outer ring is near to the value of contact stresses as given in the base paper so here we can say that the numerical analysis of deep groove ball bearing is correct. After validating the numerical analysis of deep groove ball bearing, here it performs the numerical analysis on different materials used for the manufacturing of deep groove ball bearing and calculate the value of contact stresses on inner and outer ring and also calculate the value of total deformation.

7. **Comparison of Different material**

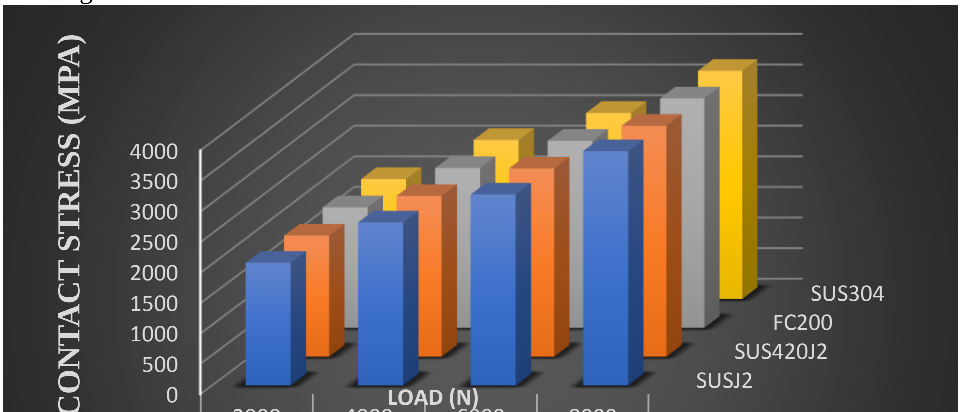
For finding the optimum material for the manufacturing of deep grove ball bearings it is necessary to have low deformation as well as low contact stresses. So, in order to find the optimum material comparison of different materials on the basis of different performance parameters was done. Basically, here it compares three different parameters that is contact stress on outer ring, contact stress on inner ring and total deformation of ball bearing. The comparison of contact stresses on outer ring for different materials at different loading condition is shown in below figure.



	2000	4000	6000	8000
SUSJ2	1917.5	2540.6	2972.1	3643
SUS420J2	1922	2547	2979	3652
FC200	1922.2	2547	2979.5	3652.3
SUS304	1923.7	2548.9	2981.7	3655.1

Fig.9 Shows the comparison of value of contact stresses in between ball and outer race

For better analysis it also compares the value of contact stress on inner race and total deformation of ball bearing for each case of materials at different loading conditions.



	2000	4000	6000	8000
SUSJ2	2023.8	2681.7	3137.3	3846
SUS420J2	1991	2639	3087	3784
FC200	1975.7	2618	3062.8	3754.6
SUS304	1962.5	2600.4	3042.2	3729.4

Fig.10 Shows the comparison of value of contact stresses in between ball and inner race

Above figure shows the comparison of value of contact stresses on inner race at different loading conditions. From graph it is found that the value of stress for SUS304 material is less as compared to other materials at each load condition whereas SUSJ2 shows the highest value of stress as compared to other. With increase in load, the value of contact stress gets also increase and follow same trend as follow in case of upper contact stresses.

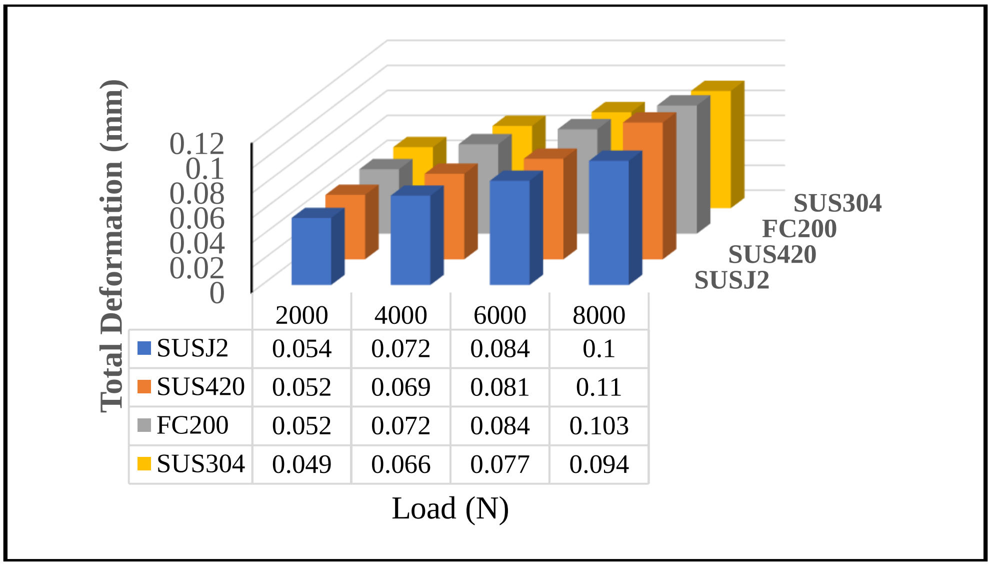


Fig.11 comparison of value of total deformation for different materials at different loading condition

Above figure shows the comparison of value of total deformation for different material at different loading conditions. From graph it is found that the value of total deformation get increases with increase in load which means that, as the load increases the degradation of bearing get also enhanced. Through comparison it is found that SUS304 material shows the minimum deformation in each case of loading condition, which means that it is least affected with increase in load. Here it is concluded with the numerical analysis that SUS304 material shows the optimum properties for the manufacturing of ball bearing.

8. Conclusion

Through numerical analysis, it is found that the value of contact stresses on upper and lower race and total deformation play an important role on the performance and reliability of ball bearings. The value of contact stresses on outer ring is marginally more for material SUS304 during static loading condition as compared to other material. but though the contact stress in high but the total deformation is less as compared to other. Through analysis it is also found that the value of contact stress on inner race is less for SUS304 material as compared to other materials in each case of load. Whereas the total deformation is also less as compared to other, therefore it shows the optimum properties for the manufacturing of ball bearing.

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