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[ICAME-2018]

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

ANALYSIS OF DEEP GROOVE BALL BEARINGS USING ANSYS

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ABSTRACT

A rolling contact bearing consists of four parts- inner and outer races, a rolling element like ball, roller, or needle and a cage which holds therolling elements together and spaces them evenlyaround the periphery. Depending upon the type of rolling element, the bearings are classified as ball bearings, cylindrical roller bearings, taper roller bearings and needle bearings. This analysis has been done for deep groove ball bearings. Analysis of rolling bearings including stresses induced in the rolling element at the inner and outer race ways, which in turn involves the determination of deformations. In this work Bearing model has been created using ANSYSand Radial load of 0N to 5000 N in steps of 200N. The contact stresses and deformations have been found at each load. The safe working conditions of bearings have been repoted.

Keywords: *Ball bearings, Ansys, Contact stresses and Deformations*

List of symbols:

Symbol	Description	Units
D	The outer diameter of the bearing	m
D_m	The pitch diameter of the bearing	m
D_b	The ball diameter of the bearing	m
d	The bore diameter of the bearing	m
d_i	The inner raceway diameter of the bearing	m
d_o	The outer raceway diameter of the bearing	m
F_r	The radial load on the bearing	N
F_c	The centrifugal force due to rotation of the ball	N
g	The acceleration due to gravity	m/s^2
r_i	The inner raceway groove radius	m
r_o	The outer raceway groove radius	m
Q	the load at the contact point	N
W_b	The width of the bearingof the bearing	m
Z	The total number of balls	
δ	The deformation	m
Subscript		
i	inner ring	
o	outer ring	
j	j-th position of the ball	

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I. INTRODUCTION

Though the concept of rolling motion was known and used for thousands of years , and simple forms of rolling bearings were in use ca,50 AD, during the Roman civilization the general use of rolling bearings did not occur until the industrial revolution. Leonardo da vinci (1452-1519) in his *Codex Madrid* conceived various forms pivot bearings having rolling elements and even ball bearing with a device to space the balls.

The universal acceptance of rolling bearings by design engineers was initially impeded by the inability of manufacturers to supply rolling bearings that could compete in endurance and hydrodynamic sliding bearing. This situation, however has been favorably altered during the twentieth century, and particularly since1960,by developing of superior rolling bearing steels and constant improvement in manufacturing ,providing extremely accurate geometry ,long-lived rolling bearing assemblies. Initially this development was triggered by the bearing requirements high speed air craft gas turbines; however, competition between ball and roller bearing manufacturers for world wide markets in-creased substantially during 1970s,and this has served to consumers with low cost, standard design bearings of out standing endurance. The term *rolling bearings* includes all forms of bearings that utilize the rolling action of balls or rollers to permit minimum friction , constrained motion of one body relative to another. Most rolling bearings are employed to permit rotation of shaft relative to some fixed structure .Some rolling bearings ,however ,permit translation ,that is, relative linear motion, of a fixture in the direction provided by stationary shaft ,and a few rolling bearing designs permit a combination of relative linear and rotary motion.

In this modern age of deep –space exploration and cyber space ,many different kinds of kinds of bearings come in to use ,such as gas film bearings, foil bearings, magnetic bearings and externally pressurized(hydrostatic)bearings. Each of these bearing types excels in some specialized field of application .For example hydrostatic bearings are excellent for applications in which size is no problem, an ample supply of pressurized fluid is available , and extreme rigidly under heavy loading is required . Self acting gas bearings may be used for applications in which loads are light, speeds are high, a gaseous atmosphere exists, and friction must be minimal. Rolling bearings , however are not quite so limited in scope .Miniature ball bearings are found in precision applications such as inertial guidance gyroscopes and high speed dental drills.

II. ANALYSIS OF DEEP-GROOVE BALL BEARING

The deep groove ball bearing is the most popular rolling bearing because of its simplicity in geometry. It performs well at high speeds provided adequate lubrication and cooling are available.In high speed operation ball centrifugal forces are significantly larger as compared to static forces applied to the bearing. In the ball bearing this causes increase in the loading on the outer raceway which results in larger contact deformation in the outer raceway member.

2.1 Bearing Geometry:

A typical deep groove ball bearing is shown in Figure 1. Appendix A gives the nomenclature of symbols used in Figure 3.1.

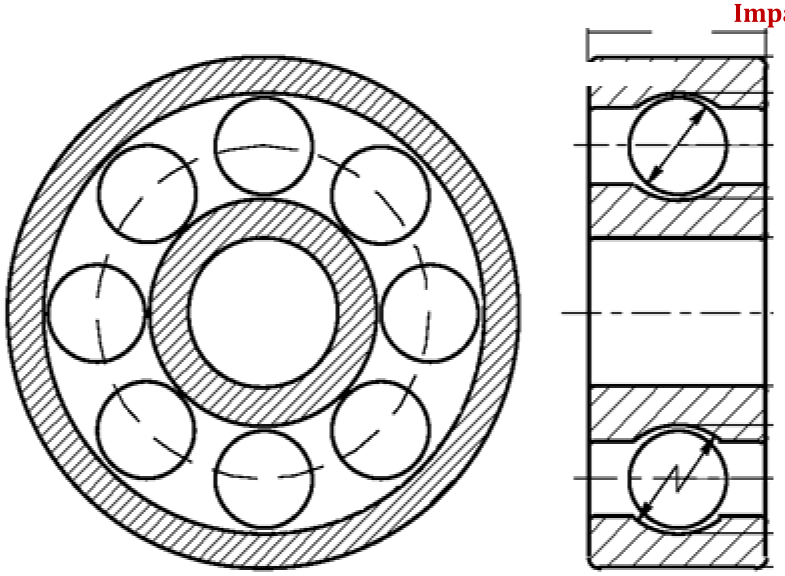

Figure 3.1 A deep groove ball bearing internal geometries

III. BEARING ANALYSIS USING ANSYS

ANSYS Inc. offers a variety of derived products with features blended for a specific Finite Element analysis disciplines.For examples, the ANSYS/Thermal product has steady state and transient thermal analysis capabilities.It allows combined thermal-electric analysis for the elements supported in the product.It provides solution capabilities for a variety of mechanical and electrical engineering applications.

A typical analysis has three distinct steps

- Build the model
- Apply the loads and obtain the solution
- Review the results

Building a Finite Element model requires more of ANSYS user's interactive time with system than any other part of analysis.First, the job name and analysis title should be specified.Then, the preprocessor (PREP7) is used to define the element type, element real constants, material properties and the model geometry.

Specifying the job name and analysis title

The job name is the name that identifies the ANSYS job.When the job name is first defined, it becomes the first part of all the files that are created by the software during the analysis.By using a job name for analysis it can be ensured that no files are overwritten.I have specified our job name.

Defining units

The ANSYS program does not assume a system of units for analysis.Any system of units can be used by the analyst as long as consistency of units is maintained throughout the analysis.I have used SI Units.

Defining element types

The ANSYS element library contains more than 100 different element types.Each element type has a unique number prefixed with an identifier. The identifier implies the element category. An element type is characterized by degree(s) of freedom, directionality (1D, 2D or 3D) and additional feature like capability to take change of phase into account etc.

Eg. PLANE 77 is a 2D plane thermal element. T is element type is identified by the no. 77.For our problem Solid 185 element was used.

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Defining material properties
Depending on the application, the material properties may be linear or non-linear, isotropic or anisotropic, constant with temperature or temperature dependent. For our problem i specified E value as 1.93×10^5 N/mm^2 and poisson's ratio as 0.28.

Creating model geometry
After defining the material properties, the next step in the analysis is to generate a finite element model. There are two methods to create the finite element model.

Solid modeling
Solid modeling involves definition of the location of each element manually. Several convenient operations like copying patterns of the existing nodes and elements symmetry, reflection etc. are available.

Direct generation
Direct generation involves definition of the location of each load and connectivity of each element manually. Several convenient operations like copying patterns of existing nodes and elements, symmetry, reflection, fill etc. are available.

First I created inner & outer race using Annulus command. Later I extruded these two along Z-direction of 19mm.To cut the groove a circle was created and this circle was extruded about Z-axis.This circle was subtracted from above two races.

Balls were created by using Sphere command.

Applying loads and obtaining the solution
This step involves the definition of the analysis type and analysis options, application of loads, specification of load step options and initiation of the finite element solution by the solution processor.

Defining the Analysis type and Analysis options
Analysis type is chosen based on the loading conditions and the required response. For thermal discipline problem, the two available analysis types are static (or steady) analysis type and transient analysis.

Analysis options are used to customize the analysis type. Typical analysis options are the methods of solution, stress stiffening and Newton-Raphson option. The analysis is steady state only.

Applying loads
The main goal of a finite element analysis is to examine how a structure or component responds to certain loading conditions. After giving the analysis type and analysis options, the next step in the analysis is to apply loads.

For our problem, the outer surface of outer race was fixed completely. Centrifugal loads are explained at the center of gravity of ball and a radial load explained on inner surface.

IV. INPUT DATA

Diametral clearence(from static analysis etc),	Pd 0.0150	mm,
Inner Raceway Diameter, d.inner	52.3	mm
Outer Raceway Diameter, d.outer	77.7	mm
ball Diameter, D	12.706	mm
Number of rollers peri row, Z	9	
iner Groove Radius, r.inner	6.6	mm
Outer Groove Radius, r.outer	6.6	mm
Basic Bore Diameter, Basic_Bore_Dia	45.0	mm

Basic Out Diameter, Basic_Out_Dia	85.0	mm
Shaft diameter, D2	45.0	mm
Housing Bore, HB	85.00	mm
Eccentricity, ecc	0	mm
Radial load, Fr	100.0	N
Axial load, Fa	0.000	N
Inner Ring Speed (Shaft), Ni	5000.0	rpm
Outer Ring Speed , Na	0	rpm
Poisson's ratio (inner ring), prir	0.28	
Poisson's ratio (outer ring), pror	0.28	
Young's modulus (inner ring), ymir	193000	N/mm2
Young's modulus (outer ring), ymor	193000	N/mm2
Width of the bearing, Wb	19	mm

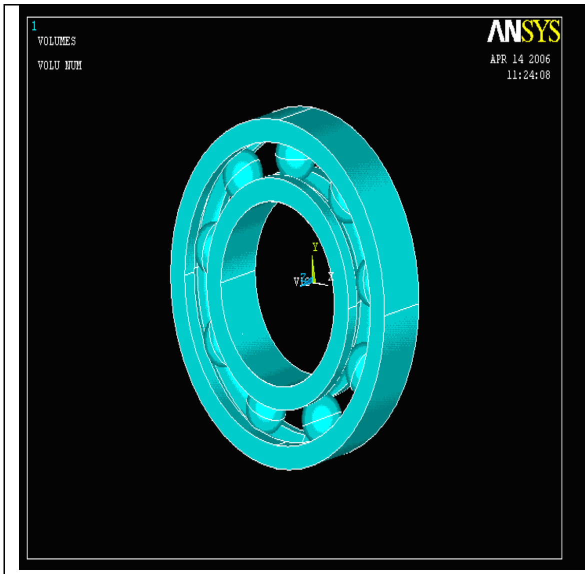


Fig 5.1
Bearing geometry

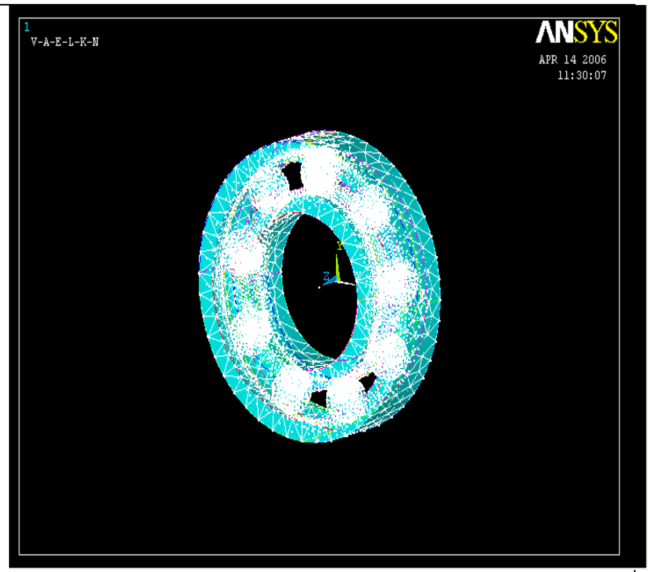
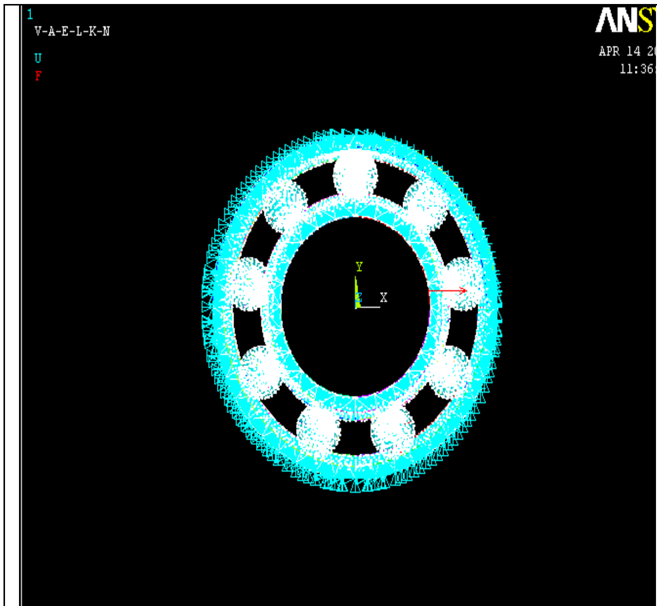
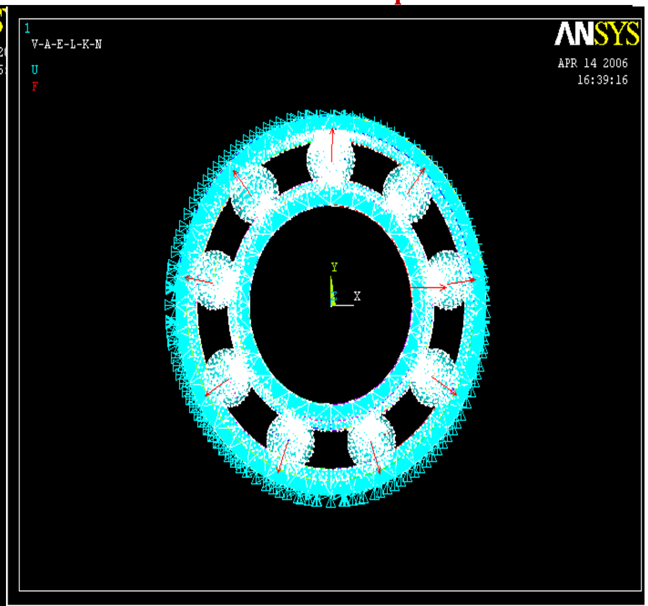


Fig 5.2
Bearing with mesh

ISSN 2348 – 8034
Impact Factor- 5.070

*Fig 5.3* *Bearing with radial load*	*Fig 5.5* *Bearing with radial load and centrifugal forces*

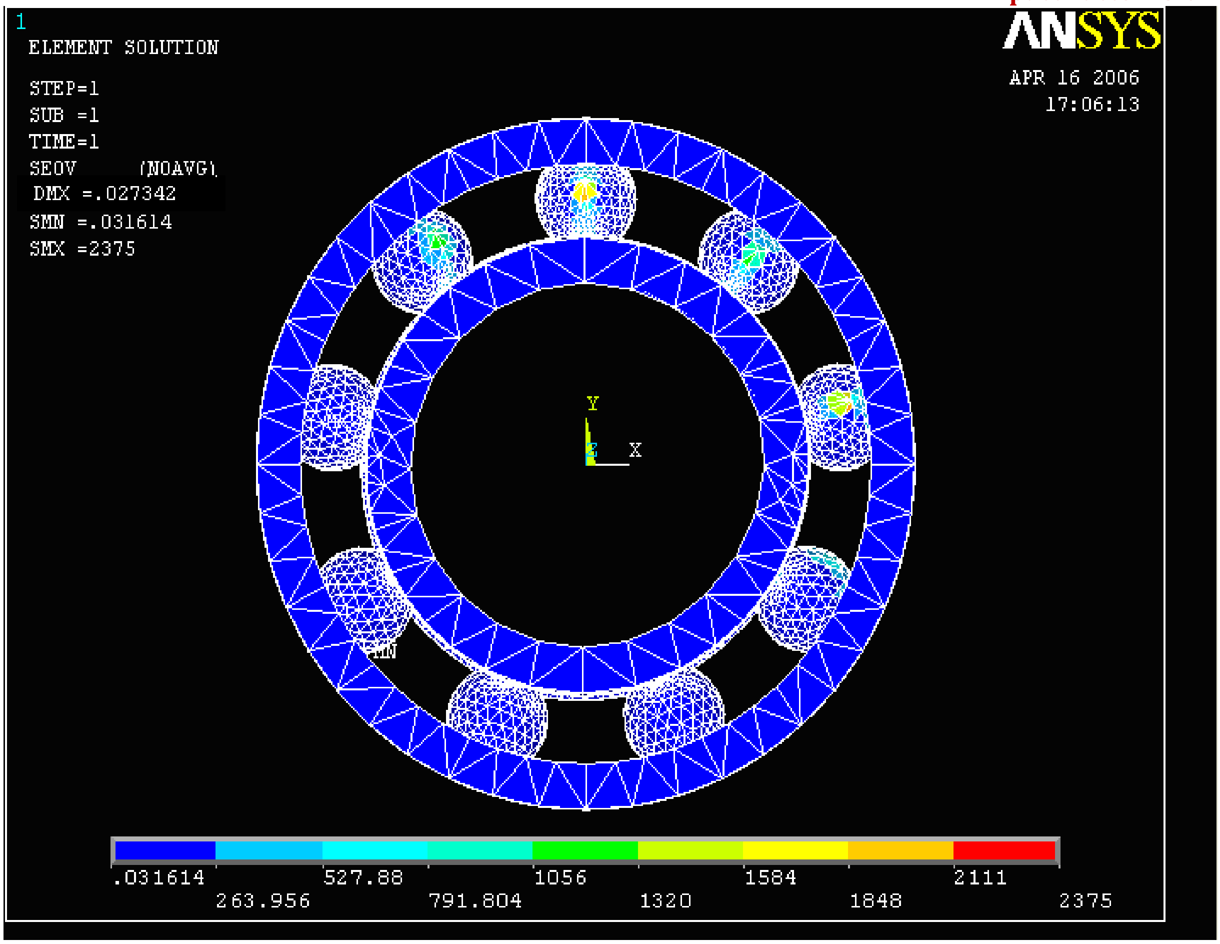


Fig 5.6 Bearing with stresses and deformations

V. RESULTS & CONCLUSIONS

It is not uncommon for rolling bearings to operate continuously with normal stresses exceeding 1380 N/mm^2 compression on the rolling surfaces. In some applications and during endurance testing normal stresses on rolling surfaces, may exceed 3449 N/mm^2. The contact deformations in the contact elements generally low order of magnitude 0.025mm or less in steels.

1. Maximum normal stresses have been calculated for the bearing 45BC02, SKF No.6209 at the speed of 10,000 rpm at different radial loads ranging from 0 to 5000N in the steps of 200N. At the load of 2200 N the maximum stress developed is 1851 N/mm^2. It is exceeding the yield point stress of the material i.e., 1830 N/mm^2.
2. Contact deformations have been calculated at 10000 RPM for all loads ranging from 0 to 5000 N. For the safe working, the deformation should be less than 0.025 mm. At the load of 3600 N the deformation is just crossed the limit.
3. From the results the safe operational conditions for the bearing 45 BC 02 are 2200N at 10000 RPM.

REFERENCES

1. *Analysis Of Rolling Bearings with reduced noof balls and rollers, john.hrambarger ASME Journal of Tribology Vol NO 126 April 24, 2004 page no 407*
2. *New methodology to evaluate the rolling contact fatigue performance of bearing steels with surface dents. Appliacations to 32CrMoV13 (nitrided) and m50 steels by D.Nelas, C.Jacq, G.Lormand, G.Dudragene,and a. Vincent ASME Journal of tribology Vol NO 127 july, 2005*
3. *Effect of surface patterning on contact deformation of eleastic – plastic layered media. By Z.Q.Gong and Klomvopoulos ASME Journal of tribology vol no 125 Jan,2003*
4. *Stability analysis of a rotating system due to the effect of ball bearing waviness by G.H.Jang and S.W.Jeong ASME Journal of tribology vol 125 January,2003*
5. *Palmgren A., Ball and Roller Bearing Engineering,* 3^{rd} *ed., Burbank, Philadelphia, p.34-41(1959).*
6. *Changsen W., Analysis of Rolling Element Bearing, Mechanical Engineering Publications Ltd., London, p.142 (1991).*
7. *Harris T.A., Rolling Bearing Analysis,* 4^{th} *ed., John Wiley & Sons Pub., U.S.A, p.560,(2001).*
8. *Harris T.A and Barnby, Tribological Performance Prediction of Aircraft Gas Turbine Mainshaft Ball Bearings, Tribology Trans 41(1), pp 60-68,(1998).*
9. *Cengel Y.A., Heat Transfer a practical approach, Tata McGraw-Hill Publication, New Delhi, p.358,(2002)*
10. *Design of machine elements by Shiegly McGraw-Hill Publication*
11. *Design of machine elements by Pandya & Shaw*
12. *Machine design by Sundararajamurthy.*