MODELING, ANALYSIS AND MATERIAL COMPARISON OF DOUBLE ROW TAPER ROLLER BEARING

A project report submitted in partial fulfillment of the requirements for
The award of the degree

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the project work entitled *"MODELING, ANALYSIS AND MATERIAL COMPARISION OF DOUBLE ROW TAPER ROLLER BEARING"* is a bonafide work carried out **by T. SAI KUMAR (314126520197), S.V.PRAVALLIKA (314126520152), SK.IMAM KASIM (314126520148), U.BHARAT SAI DHEERAJ (314126520162)** of IV/IV Mechanical Engineering, ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES, Visakhapatnam during the year 2017-2018 in the partial fulfillment of the requirement for the award of Degree of Bachelor of Engineering by ANDHRA UNIVERSITY, VISAKHAPATNAM.

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ABSTRACT

Double row taper roller bearing as a type of roller bearing, can provide the good ability of bearing larger combined load in the directions of radial and axial. It, therefore, has been extensively considered in many aspects of the industry, especially in the domain of rotary machine. And the characteristics of taper roller bearings are highly influenced by different operation conditions. In practice, a double row taper roller bearing may be replaced by an equivalent pair of two Single-row taper roller bearings. However, this simplification may introduce some errors due to the dimensional difference between a double row taper roller bearing and two single row taper bearings and the complexity in modeling and analysis due to the indeterminate problems associated with two single row taper roller bearing. This paper mainly evaluates the bearing with three different material by using finite element method in ANSYS 18.0.

FEM analysis is very efficient method for achieving stresses at different loading condition according to Forces & temperature applied to the component from the static analysis. The use of numerical method such as Finite Element Method now a day commonly used to gives detail information about structure or component. Finite element method (FEM) is a numerical method for solving a differential or integral Equation. It has been applied to a number of physical problems, where the governing differential equations are available. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. The method used in this paper can also be considered to guide the design and manufacturing of taper roller bearing in the practice.

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

1.1 BEARING

It is a device that is used to enable rotational or linear movement, while reducing friction and handling stress. Resembling wheels, bearings literally enable devices to roll, which reduces the friction between the surface of the bearing and the surface it's rolling over. It's significantly easier to move, both in a rotary or linear fashion, when friction is reduced—this also enhances speed and efficiency.

1.2 DESCRIPTION

The inner and outer ring raceways are segments of cones and the rollers are tapered so that the conical surfaces of the raceways, and the roller axes, if projected, would all meet at a common point on the main axis of the bearing. This geometry makes the motion of the cones remain coaxial, with no sliding motion between the raceways and the outer diameter of the rollers.

This conical geometry creates a linear contact patch which permits greater loads to be carried than with spherical (ball) bearings, which have point contact. The geometry means that the tangential speeds of the surfaces of each of the rollers are the same as their raceways along the whole length of the contact patch and no differential scrubbing occurs.

The rollers are stabilized and restrained by a flange on the inner ring, against which their large end slides, which stops the rollers from popping out due to the "pumpkin seed effect" of their conical shape. The larger the half angles of these cones the larger the axial force that the bearing can sustain.

Tapered roller bearings are separable into a cone assembly and a cup. The non-separable cone assembly consists of the inner ring, the rollers, and a cage that retains & evenly spaces the rollers. The cup is simply the outer ring. Internal clearance is established during mounting by the axial position of the cone relative to the cup, although preloaded installations without clearance are common.

1.3 HOW BEARINGS WORKS

In order to serve all these functions, bearings make use of a relatively simple structure: a ball with internal and external smooth metal surfaces, to aid in rolling. The ball itself carries the weight of the load—the force of the load's weight is what drives the bearing's rotation. However, not all loads put force on a bearing in the same manner. There are two different kinds of loading: radial and thrust.

A radial load, as in a pulley, simply puts weight on the bearing in a manner that causes the bearing to roll or rotate as a result of tension. A thrust load is significantly different, and puts stress on the bearing in an entirely different way. If a bearing (think of a tire) is flipped on its side (think now of a tire swing) and subject to complete force at that angle (think of three children sitting on the tire swing), this is called thrust load. A bearing that is used to support a bar stool is an example of a bearing that is subject only to thrust load.

Many bearings are prone to experiencing both radial and thrust loads. Car tires, for example, carry a radial load when driving in a straight line: the tires roll forward in a rotational manner as a result of tension and the weight they are supporting. However, when a car goes around a corner, it is subject to thrust load because the tires are no longer moving solely in a radial fashion and cornering force weighs on the side of the bearing.

1.4 TYPES OF BEARINGS

There are numerous different kinds of bearings that are designed to handle radial load, thrust load, or some combination of the two. Because different applications require bearings that are designed to handle a specific kind of load and different amounts of weight, the differences between types of bearings concern load type and ability to handle weight.

1.4.1 BALL BEARING

Ball bearings are extremely common because they can handle both radial and thrust loads, but can only handle a small amount of weight. They are found in a wide array of applications, such as roller blades and even hard drives, but are prone to deforming if they are overloaded.

1.4.2 ROLLER BEARING

Roller bearings are designed to carry heavy loads—the primary roller is a cylinder, which means the load is distributed over a larger area, enabling the bearing to handle larger amounts of weight. This structure, however, means the bearing can handle primarily radial loads, but is not suited to thrust loads. For applications where space is an issue, a needle bearing can be used. Needle bearings work with small diameter cylinders, so they are easier to fit in smaller applications.

1.4.3 BALL THRUST BEARING

These kinds of bearings are designed to handle almost exclusively thrust loads in low-speed low-weight applications. Bar stools, for example, make use of ball thrust bearings to support the seat.

1.4.4 ROLLER THRUST BEARING

Roller thrust bearings, much like ball thrust bearings, handle thrust loads. The difference, however, lies in the amount of weight the bearing can handle: roller thrust bearings can support significantly larger amounts of thrust load, and are therefore found in car transmissions, where they are used to support helical gears. Gear support in general is a common application for roller thrust bearings.

1.4.5 TAPPER ROLLER BEARING

This style of bearing is designed to handle large radial and thrust loads—as a result of their load versatility, they are found in car hubs due to the extreme amount of both radial and thrust loads that car wheels are expected to carry.

1.4.5.1 TYPES OF TAPER ROLLER BEARING

Fig. 1 SINGLE ROW TAPER ROLLE BEARING

Fig. 2 DOUBLE ROW TAPER ROLLER BEARING

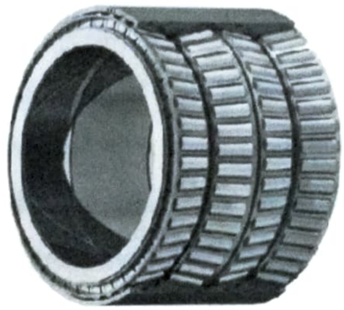

Fig. 3 FOUR-ROW TAPER ROLLER BEARING

1.5 BEARING NOMENCLATURE

The nomenclature of bearing is very simple construction. And in bearing different parts of there such as cup cone, inner ring and outer ring and cage. In bearing is individual parts can assembly. it is not difficult and easy maintained.

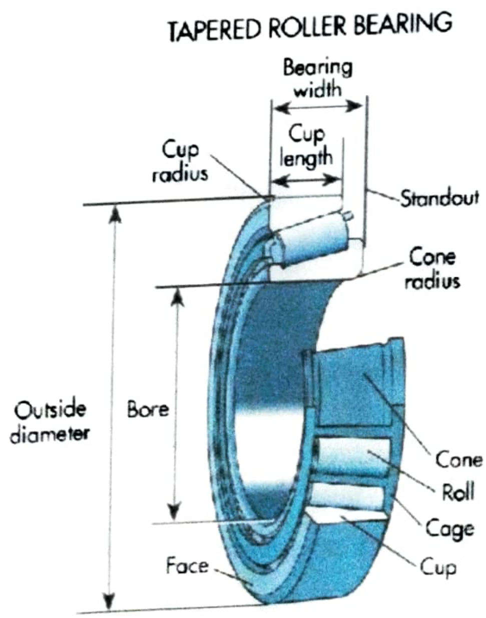

Fig. 4 NOMENCLETURE

1.6 HISTORY

On March 23, 1895, John Lincoln Scott, a farmer and carpenter from Wilmot, Indiana was awarded a patent from the United States Patent Office for his invention of the tapered roller bearing. The purpose of his invention was to improve the performance of wagon wheels used in farming. In 1898, Henry Timken was awarded a patent for the tapered roller bearing. At the time, Timken was a carriage-maker in St. Louis and held three patents for carriage springs. However, it was his patent for tapered roller bearings that allowed his company to become successful.

Tapered roller bearings were a breakthrough at the end of the 19th century because bearings used in wheel axles had not changed much since ancient times. They consisted of a cylindrical seat on the frame and part of the axle enclosed in a case or box that held a lubricant. These were called journal bearings and relied on the lubricant to form a fluid bearing without adequate lubrication, journal bearings would fail due to the excessive heat caused by friction. Timken was able to significantly reduce the friction on his axle bearings by adding tapered elements which actually rolled while transferring the load evenly from axle to frame through the hardened steel inner and outer rings and the rollers - his tapered roller bearing.

The tapered roller bearing in combination with modern lubricants is extremely durable and is used almost universally in applications involving rotating axle and transmission shafts. Bearing durability is such that these shafts often require no maintenance for hundreds of thousands of kilometers of operation.

1.7 APPLICATIONS

In many applications tapered roller bearings are used in back-to-back pairs so that axial forces can be supported equally in either direction.

Pairs of tapered roller bearings are used in car and vehicle wheel bearings where they must cope simultaneously with large vertical (radial) and horizontal (axial) forces. Tapered roller bearings are commonly used for moderate speed, heavy duty applications where durability is required. Common real world applications are in agriculture, construction and mining equipment, sports robot combat, axle systems, gear box, engine motors and reducers, propeller shaft, railroad axle-box, differential, wind turbines, etc.

CHAPTER 2

LITERATURE REVIEW

2 LITERATURE REVIEW

1. Hamrock , et.al. (1983) in their brief status report on bearing technology and present and near-term future problems that warrant research support is presented. For rolling element bearings a material with improved fracture toughness, life data in the low A region, a comprehensive failure theory verified by life data and incorporated into dynamic analyses, and an improved corrosion resistant alloy are perceived as important needs.

2. Schwarz, et.al.(2006) said the purpose of this paper is to present a description of a twin tapered roller bearing assembly and the measurement systems for carrying out an experimental analysis on the thermal behavior of the assembly, taking into account mainly the bearing friction torque and the operating temperatures of the shaft, bearings and housing. The results are obtained for a range of rotational speeds and loading conditions. The temperatures of the bearing are taken for the inner and the outer raceways, simultaneously with the guide flange lip/roller and contact.

3. Kayal , Yusuf, et.al. (2009) said tapered roller bearings, which are also known as angular contact bearing, are suitable for supporting radial and axial loads. The more frequent types of defects in such bearings are caused by contact fatigue in these machine components, and this examination focuses on a contact fatigue failure in a tapered rolling bearing. The examination included visual inspection, microscopic analysis (optical and scanning electron microscope), and micro hardness measurements. These measurements were conducted to help understand the failure mechanisms. Based on the results of visual examination and microstructure and fracture surface analysis, it was determined that the tapered roller bearing failed by contact fatigue that was caused by overloading of the bearing.

4. Ebert et.al. (2010) said the aim is to outline the complex interrelation of all fundamentals with the rolling contact fatigue and the attainable bearing life. Such fundamentals include, amongst others, bearing stressing and life capability. The article shows the different types of rolling bearing stressing and the analysis of the stress distribution (principal stresses and equivalent stresses) in the material under the rolling contact area. It becomes obvious that the contamination of the bearing with foreign particles leads to a drastic reduction in bearing life. Furthermore, it demonstrates the impact of the bearing lubrication and coating as well as the effect of additives on the attainable life and wear. The article reveals the importance of the cleanliness of bearing steels as well as different types of inclusions and their effect on rolling contact fatigue. Additionally the article describes how to optimize the material properties (strength, toughness and residual stress) by the heat treatment processes. The outcome of these investigations is that endurance

life of a rolling element bearing can be achieved if specific operating conditions, an adequate lubrication, good system cleanliness and specific bearing stressing are met.

5. Yong qi et.al.(2012) said taper roller bearings are important part of gear reducers, and their work property affects behavior of the reducers. Pre-tightening of taper- roller bearings affects both meshing contact of the gears and lubrication between the rollers and raceways of the bearings. The influence is analyzed by finite element method in this work. Firstly, a finite element model of roller bearings is established by using Reynolds equation and considering the surface roughness. Then, Stress fields in the roller and the raceway are calculated by adding load and solving, obtaining the maximum stress and strain of the bearings. Finally, effect of the pre-tightening on the work property of the bearings are analyzed by the obtained the maximum stress and strain.

6. Guo Yi et.al.(2012), In this study, a finite element/contact mechanics model is developed for rolling element bearings with the focus of obtaining accurate bearing stiffness for a wide range of bearing types and parameters. A combined surface integral and finite element method is used to solve for the contact mechanics between the rolling elements and races. This model captures the time-dependent characteristics of the bearing contact due to the orbital motion of the rolling elements. A numerical method is developed to determine the full bearing stiffness matrix corresponding to two radial, one axial, and two angular coordinates; the rotation about the shaft axis is free by design. This proposed stiffness determination method is validated against experiments in the literature and compared to existing analytical models and widely used advanced computational methods. The fully populated stiffness matrix demonstrates the coupling between bearing radial, axial, and tilting bearing deflections.

7. R.K. Upadhyay et.al. (2013) stated that rolling Contact Fatigue (RCF) occurs due to the result of cyclic stress developed during operation and mechanism that involve in fretting failure of rolling element bearing. As bearing raceways of non-rotating rolling element bearings exposed to vibration or sliding oscillation false Brinelling occurs. Bearing surface due to false Brinelling tends to damage within a short period, due to cavities created on the bearing raceway. Recommendation towards enhancement of bearing life is also suggested.

8. TANG Zhaoping et.al. (2013) stated that through contact analysis, the changes could be showed in stress, strain, penetration, sliding distance, friction stress among the inner ring, outer ring, rolling elements and cage. Furthermore, the simulation results revealed that the computational values were consistent with theoretical values. The all showed that the model and

boundary conditions were correct and rational, and it would provide a scientific basis for optimum design of rolling bearings under complicated loads.

9. Yan-shuang WANG et al. (2013) said that clearance not only affects the startup torque, rotation precision and stiffness of bearing, but also affects the load distribution, load carrying capacity and life of bearing. A computational model in which the clearance of bearing is first included is presented for determining the contact force distribution and static load-carrying capacity of a double row four-point contact ball bearing which is subjected to the combined radial, axial and overturning moment loadings. The relation between the negative axial clearance and the contact force distribution is analysed. The static load-carrying cyclic autocorrelation have improved the fault detection.

10. M. Prem Kumar et.al (2015) stated that in the railroad industry, troubled bearings in service are primarily identified using wayside hot-box detectors (HBDs). Several bearings set-out for trending and classified as non-verified, due to no visible damage within a cone assembly. Subsequent laboratory experiments were performed to determine a minimum temperature and environment necessary to reproduce these discolorations which are mostly due to roller capacity curves are established, and the effects of the changes in negative axial clearance, curvature radius coefficient of raceway groove and initial contact angle on the static load-carrying capacity are analyzed. The results show that, with the increase in the absolute value of negative clearance, the maximum contact load decreases first and then increases. The clearance values in the range of - 0.2 mm-0 mm have little effect on the static load-carrying capacity of bearing. With the increase in the curvature radius coefficient of raceway groove and the decrease in the initial contact angle, the static load capacity of bearing decreases.

11. H. Saruhan et.al (2014)studied the vibration analysis of rolling element bearings (REBs) defects. The REBs are the most widely used mechanical parts in rotating machinery under high load and high rotational speeds. When the defect in a rolling element comes into contact with another element surface, an impact force is generated which is resulting in an impulsive response of the bearing. A defect at any element of the REB transmits to all other elements such as outer race, inner race, ball and, train cage of the bearing. The defect in rolling elements may lead to serious catastrophic consequences resulting in costly downtime. For this purpose, the vibration analysis technique which is a reliable and accurately detecting defect in the bearing elements is used.

CHAPTER 3

SOLID WORKS & ANSYS

3 . SOLIDWORKS AND ANSYS

3.1 SOLID WORKS INTRODUCTION

The solid works cad software is a mechanical design automation application that lets designers quickly search our ideas, experiment features and dimensions and produce models and detailed drawings.

3.2 SOLIDWORKS FUNDMENTALS

Parts are with basic building blocks in the solid works software. Assemblies contain that parts or other assemblies, called sub-assemblies. A solid works model consists of 3D geometry that defines its edges, faces, surfaces. The solid works software lets you design models quickly and precisely. Solid works models are defined by 3D design, based on components, 3D design.

Solid works uses a 3D design approach. As you design a part, from the initial sketch to the final result, you create 3D model.

Solid Works is a modern computer aided design (CAD) program. It enables designers to create a mathematically correct solid model of an object that can be stored in a database. When the mathematical model of a part or assembly is associated with the properties of the materials used, we get a solid model that can be used to simulate and predict the behavior of the part or model with finite element and other simulation software. The same solid model can be used to manufacture the object and also contains the information necessary to inspect and assemble the product. The marketing organization can produce sales brochures and videos that introduce the product to potential customers. Solid Works and similar CAD programs have made possible concurrent engineering, where all the groups that contribute to the product development process can share information real-time.

3.3 ANSYS INTRODUCTION

ANSYS is a general-purpose finite element modelling package for numerically solving a wide variety of mechanical problems.ANSYS simulation software enables organizations to confidently predict how their products will operate in the real world.

It expands the use of physics. It gains access to any form of engineering field someone may account in. The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis.

A typical ANSYS analysis has three distinct steps:

Build the model.

Apply loads and obtain the solution.

Review the results.

3.3.1 BUILDING A MODEL

Building a finite element model requires more of an ANSYS user's time than any other part of the analysis. First, you specify a job name and analysis title. Then, you use the PREP7 pre-processor to define the element types, element real constants, material properties, and the model geometry.

3.3.2 APPLY LOADS AND OBTAIN THE SOLUTION

In this step, you use the SOLUTION processor to define the analysis type and analysis options, apply loads, specify load step options, and initiate the finite element solution. You also can apply loads using the PREP7 pre-processor.

3.4 LOADING OVERVIEW

The main goal of a finite element analysis is to examine how a structure or component responds to certain loading conditions. Specifying the proper loading conditions is, therefore, a key step in the analysis. The loads can be applied on the model in a variety of ways in the ANSYS program. Also, with the help of load step options, one can control how the loads are actually used during solution.

3.5 SOLUTION

In the solution phase of the analysis, the computer takes over and solves the simultaneous equations that the finite element method generates. The results of the solution are:

- nodal degree-of-freedom values, which form the primary solution
- derived values, which form the element solution.

The element solution is usually calculated at the elements' integration points. The ANSYS program writes the results to the database as well as to the results file (Jobname . RST, RTH, RMG, or RFL).Several methods of solving the simultaneous equations are available in the ANSYS program: frontal solution, sparse direct solution, Jacobi Conjugate Gradient (JCG) solution, Incomplete Cholesky Conjugate Gradient (ICCG) solution, Preconditioned Conjugate Gradient (PCG) solution, and an automatic iterative solver option (ITER).

3.6 MODEL GENERATION

The ultimate purpose of a finite element analysis is to re-create mathematically the behavior of an actual engineering system. In other words, the analysis must be an accurate mathematical model of a physical prototype. In the broadest sense, this model comprises all the nodes, elements, material properties, real constants, boundary conditions, and other features that are used to represent the physical system. In ANSYS terminology, the term model generation usually takes on the narrower meaning of generating the nodes and elements that represent the spatial volume and connectivity of the actual system. Thus, model generation in this discussion will mean the process of defining the geometric configuration of the model's nodes and elements. The ANSYS program offers the following approaches to model generation:

- Creating a solid model within ANSYS.
- Using direct generation.
- Importing a model created in a computer-aided design (CAD) system.

3.7 MESHING

The procedure for generating a mesh of nodes and elements consists of three main steps:

- Set the element attributes.
- Set mesh controls (optional). ANSYS offers a large number of mesh controls, which one can choose from to suit their needs.
- Generate the mesh.

The second step, setting mesh controls, is not always necessary because the default mesh controls are appropriate for many models. If no controls are specified, the program will use the default settings on the DESIZE command to produce a free mesh. As an alternative, one can use the Smart Size feature to produce a better quality free mesh.

3.8 INTRODUCTION TO ANSYS WORKBENCH

ANSYS Workbench is the framework upon which the industry's broadest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user every step of the way. Even complex multi physics analyses can be performed with drag-and-drop simplicity.

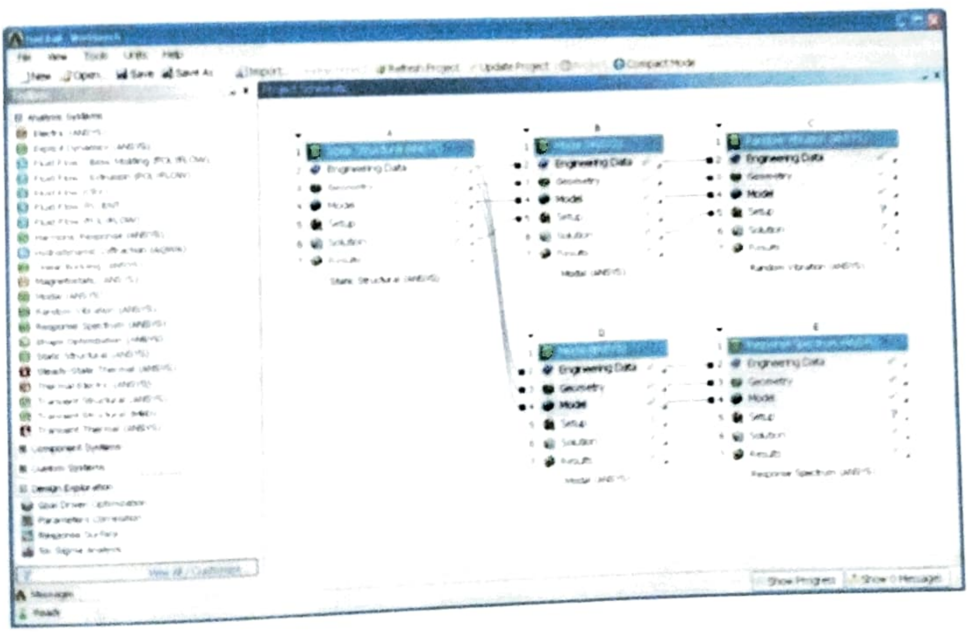

Fig. 5 Workbench 14.5 interface

The ANSYS Workbench platform automatically forms a connection to share the geometry for both the fluid and structural analyses, minimizing data storage and making it easy to study the effects of geometry changes on both analyses. In addition, a connection is formed to automatically transfer pressure loads from the fluid analysis to the structural analysis.

The ANSYS Workbench interface is arranged into two primary areas: The toolbox and the project Schematic. The toolbox contains the system templates that you can use to build a project. The project Schematic is the area if the interface where you will manage your project. The new project schematic view shows an overall view of the entire simulation project. Engineering intent, data relationships and the state of the entire project are visible at a glance, even for complex analyses involving multiple physics. In addition to this, you will see a menu bar and a toolbar with frequently used functions. You can also use context menus, accessible via a right- mouse click, on schematic items, and cells. Context menus provide capabilities to add to and modify projects. The entire process is persistent. Changes can be made to any portion of the analysis and the ANSYS Workbench platform will manage the execution of the required applications to update the project automatically, dramatically reducing the cost of performing design iterations.

3.8.1 ANSYS WORKBENCH FEATURES

- Bidirectional, parametric links with all major CAD systems.
- Integrated, analysis-focused geometry modeling, repair, and simplification via ANSYS Design Modeler.
- Highly-automated, physics-aware meshing.
- Automatic contact detection.
- Unequalled depth of capabilities within individual physics disciplines.
- Unparalleled breadth of simulation technologies.
- Complete analysis systems that guide the user start-to-finish through an analysis.
- Comprehensive multi physics simulation with drag-and-drop ease of use.
- Flexible components enable tools to be deployed to best suit engineering
- intent.
- Innovative project schematic view allows engineering intent, data relationships, and the state of the project to be comprehended at a glance.
- Complex project schematics can be saved for re-use.
- Pervasive, project-level parameter management across all physics.
- Automated what-if analyses with integrated design point capability.
- Adaptive architecture with scripting and journaling capabilities and API`s enabling rapid integration of new and third-party solutions.

3.8.2 STRUCTURAL ANALYSIS

Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

3.8.2.1 TYPES:

The seven types of structural analyses available in the ANSYS family of products are explained below. The primary unknowns (nodal degrees of freedom) calculated in a structural analysis are displacements. Other quantities, such as strains, stresses, and reaction forces, are then derived from the nodal displacements.

3.8.2.1.1 STATIC ANALYSIS-

Used to determine displacements, stresses, etc. under static loading conditions. It comprises of both linear and nonlinear static analysis. Non-linarites can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

3.8.2.1.2 MODAL ANALYSIS-

Used to calculate the natural frequencies and mode shapes of a structure. Different mode extraction methods are available.

3.8.2.1.3 HARMONIC ANALYSIS-

Used to determine the response of a structure to harmonically time-varying loads.

3.8.2.1.4 TRANSIENT DYNAMIC ANALYSIS-

Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

3.8.2.1.5 SPECTRUM ANALYSIS-

An extension of the modal analysis, used to calculate stresses and strains due to a response spectrum or a PSD input (random vibrations).

3.8.2.1.6 BUCKLING ANALYSIS-

Used to calculate the buckling loads and determine the buckling mode shape. Both linear (Eigen value) buckling and nonlinear buckling analyses are possible.

3.8.2.1.7 EXPLICIT DYNAMICS ANALYSIS-

ANSYS provides an interface to the LS-DYNA explicit finite element program and is used to calculate fast solutions for large deformation dynamics and complex contact problems.

In addition to the above analysis types, several special-purpose features are available:

- Fracture mechanics
- Compos Fatigue

CHAPTER 4

BEARING MODELLING

4 BEARING MODELLING

4.1 DESIGN MODELLING

A solid model of the bearing-axle assembly is produced using the three-dimensional graphing software solid works for this study. The axle is rendered as a simple cylinder with a 0.1572 m diameter and a 2.2 m length. The bearing is modeled after an automobile tapered-roller bearing with some minor modifications that simplified the geometry and resulted in a significant reduction to the computational time.

For the first assumption, no lubrication were included in the model; this was done because the thermal resistances of the lubrication are large compared to the rest of the bearing assembly, so the majority of the heat will flow from the rollers to the bearing cup and inner cones. Recent advances in bearing seal technology have resulted in minimal contact low friction seals. Furthermore, these seals constitute a small fraction of the total weight of the bearing and are separated from the rest of the internal bearing components by combination of air and lubrication which both have high thermal resistances. Hence, the omission of the aforementioned components from the FE model will not have a significant effect on the results acquired from this study.

The second assumption is concerned with the contact area between the rollers and the cup and cone raceways. Under normal operating conditions, only the upper hemisphere of an automobile bearing is loaded; therefore, larger contact areas exist between the rollers and the cup and cones in this region. However, since the rollers of a bearing enter and exit the loaded zone continuously as they execute multiple revolutions in a second, an average contact area was applied to all 46 rollers in the bearing. Hence, in the model, the contact area between each roller and the cup and cone raceways is 123.96 mm^2, which represents 3.68% of the total surface area of the roller. The contact area was obtained by first estimating the initial contact area of the rollers with the cup and cones using the Hertz an line contact theory and Harris and Kotzalas., and then using FE analysis to determine the load distribution on the upper hemisphere of a fully-loaded bearing (full load corresponds to a force of

40.2KN per bearing applied through the bearing adapter), which was then used to calculate the amount of roller compression.

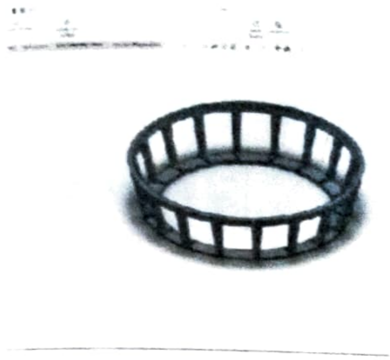

Fig. 6 CAGE

Fig. 7 OUTERRING

Fig. 8 ROLLER

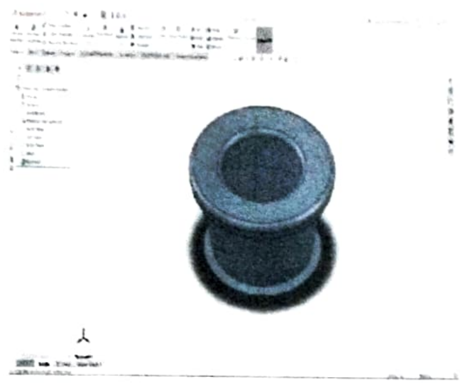

Fig. 9 INNER RING

Fig. 10 ISOMETRIC VIEW

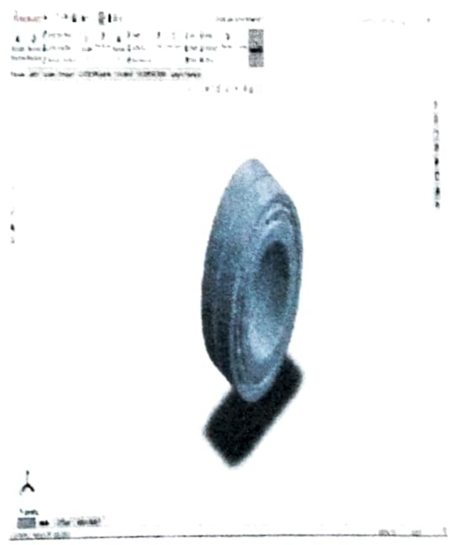

Fig. 11 SECTIONAL VIEW

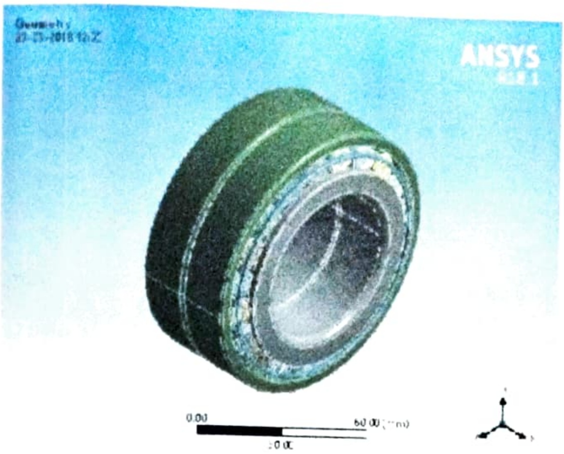

Fig. 12 SOLID MODELLING

Table 1: BEARING MATERIAL PROPERTIES

PROPERTIES	COMBINATION STEEL	STRUCTURAL STEEL	GCr15-YB-9-68
Poission ratio	0.29	0.29	0.29
Ultimate strength (MPa)	440	570	650
Yield strength (MPa)	370	320	415
Density (kg/cm^3)	7.87	7.87	8.03
Shear modules (MPa)	80	73	193

4.2 FINITE ELEMENT ANALYSIS:

FEM analysis is very efficient method for achieving stresses at different loading condition according to Forces & temperature applied to the component from the static analysis. The use of numerical method such as Finite Element Method now a day commonly used to gives detail information about structure or component. Finite element method (FEM) is a numerical method for solving a differential or integral Equation. It has been applied to a number of physical problems, where the governing differential equations are available. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. Here we have to fine maximum stresses in each component of bearing, and to safe design of components material Maximum Stress should be less than Allowable stress.

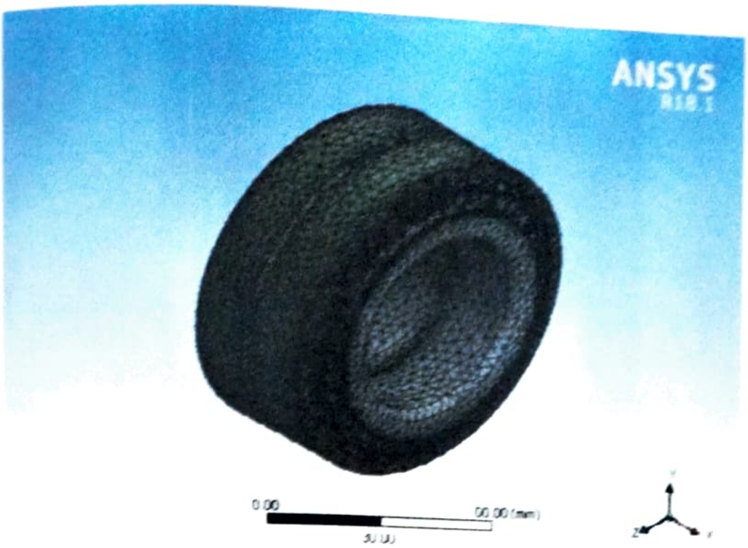

Fig. 13 MESHING

Table 2: FINITE ELEMENT MODEL

NODES AND ELEMENTS	VALUES
NUMBER OF TOTAL NODES	508441
NUMBER OF CONTACT ELEMENTS	63560
NUMBER OF SPRING ELEMENTS	0
NUMBER OF BEARING ELEMENTS	0
NUMBER OF SOLID ELEMENTS	304675
NUMBER OF TOTAL ELEMENTS	368235

4.3 BOUNDARY CONDITIONS:

The validity of the FE model depends significantly on the correctness of the Boundary Conditions applied while running the simulations. In this regard, the Boundary Conditions used for this study were derived from previously conducted experimental work by Tarawneh and from material specifications provided by the bearing manufacturer. The maximum load applied is 40.2 KN radically.

The boundary conditions are taken at cylindrical support (means axial movement is free, radial and tangential movements are fixed) and fully reversal load 40.2 KN is taken at centre of gravity of the bearing. The coupled field result stresses are input load for Fatigue analysis. The fatigue life and damage obtained in the ANSYS are depicted in the figure.

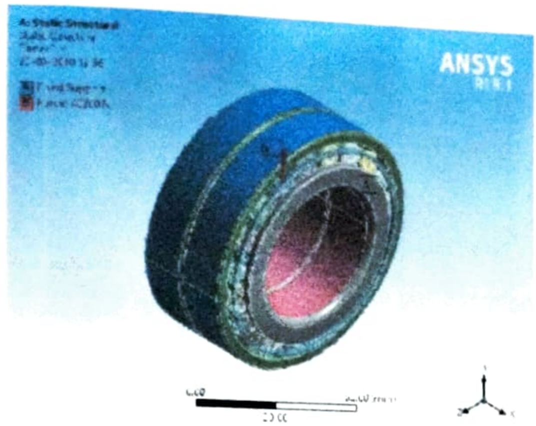

Fig. 14 BOUNDARY CONDITION

Table 3: MATERIAL COMPOSITIONS

MATERIALS	%C	%S	%Mn	%Si	%P	%Cr
Structural steel	0.15 ~ 0.3	0.04 ~ 0.05	0.5 ~ 1.7	<0.4	0.04 ~0.05	8
GCr15-YB9-68	0.95 ~ 1.05	<0.025	0.25~ 0.45	0.15 ~ 0.3	<0.025	1.4 ~ 1.6
SAE4620CASE CARBURIZED	0.17~0.22	0.035	0.45~0.65	0.15~0.35	0.04	1.65~2
HIGHCARBON STEEL	0.75~0.8	0.025	0.6~0.9	0.15~0.35	0.025	0.4

Table 4: NODES AND ELEMENTS VALUE

NODES AND ELEMENTS	VALUES
NUMBER OF TOTAL NODES	508441
NUMBER OF CONTACT ELEMENTS	63560
NUMBER OF SPRING ELEMENTS	0
NUMBER OF BEARING ELEMENTS	0
NUMBER OF SOLID ELEMENTS	304675
NUMBER OF TOTAL ELEMENTS	368235

CHAPTER 5

RESULTS AND COMPARISIONS

5 RESULTS & COMPARISIONS

STATIC STRUCTURAL ANALASYS:

The static structural analysis of DRTRB is carried out in ANSYIS 18.0 under load conditions mentioned in the above chapter for 3 different materials. Among these materials, for static load, Gcr15 gives higher value of FOS compared to other materials. The FOS of the specified materials are shown in following figures and comparison is shown in the table no.4

5.1 FACTOR OF SAFETY:

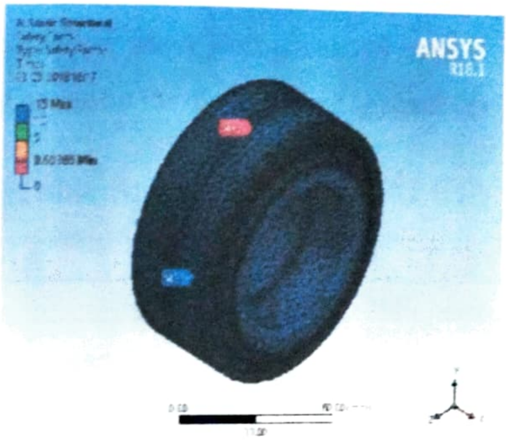

Fig. 15 FOS of Combination material

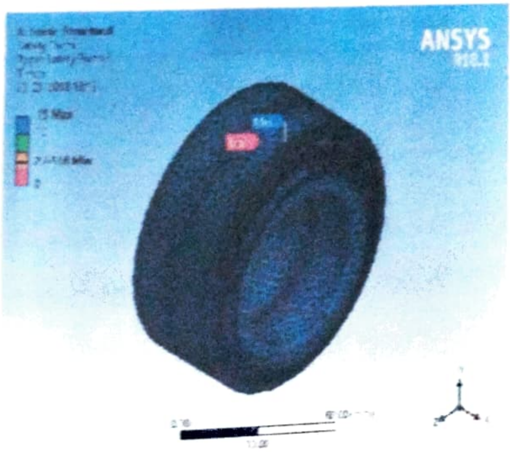

Fig. 16 FOS of GCr15-YB9-68

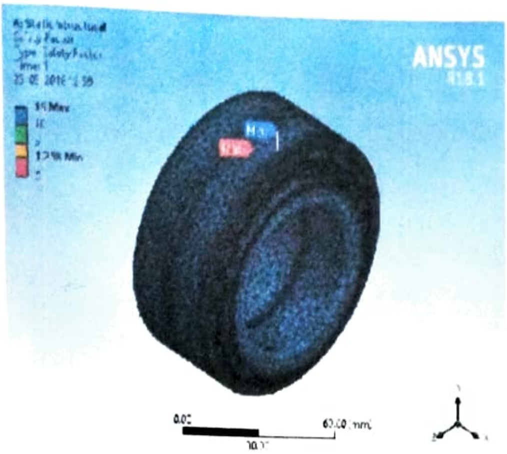

Fig. 17 FOS of Structural steel

For specified load, Gcr15 and structural steel have FOS more than 1, but for combination material the value of FOS less than 1. So the combination material is unsuitable for the applications where load greater or equal to axial load and radial load combined. It may be useful for the light load applications.

Table 5: FACTOR OF SAFETY

Material	Factor of safety	
	Min	Max
Combinational material	0.69386	15
Structural steel	1.258	15
GCr15-YB9-68	2.0518	15

FATIGUE ANALYSIS

The fatigue analysis of double row taper roller bearing is carried out in ANSYIS 18.0 under load conditions mentioned in the above chapter for 3 different materials. Among these materials, for static load, Gcr15 gives higher value of safety factor compared to other materials. The safety factor of the specified materials are shown in following figures and comparison is shown in the table no.5

5.2 FOR 10^3 CYCLES

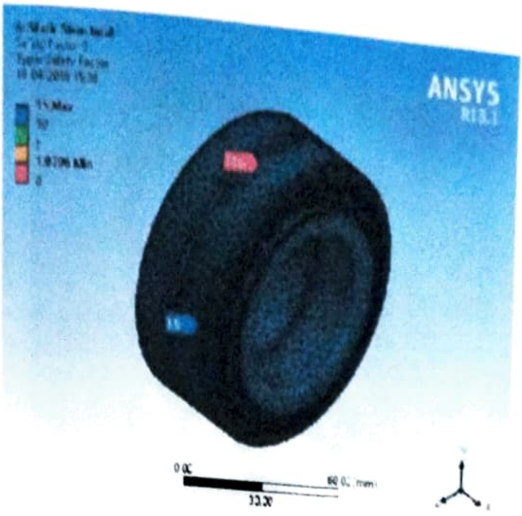

Fig. 18 10^3 cycle of Combination material

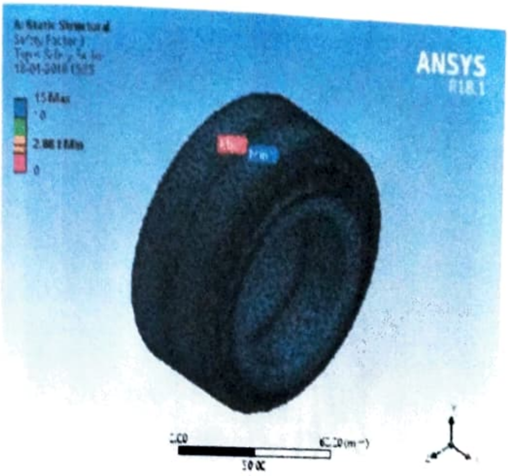

Fig. 19 10^3 cycle of Structural steel

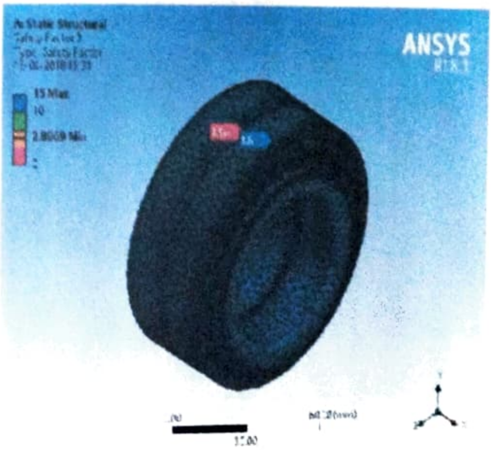

Fig. 20 10^3 cycle of GCr15-YB9-68

5.3 FOR 10^4 CYCLES:

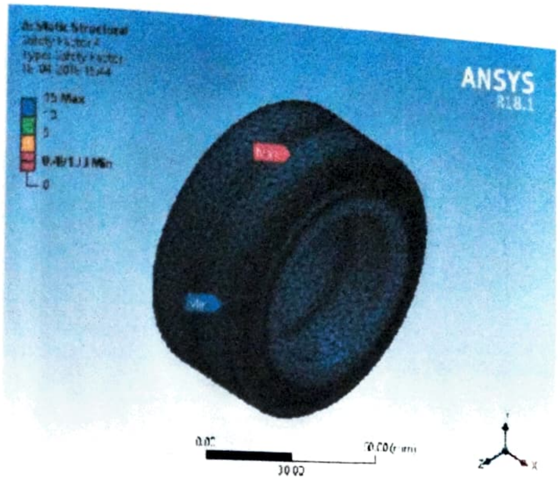

Fig. 21 10^4 cycle of Combination material

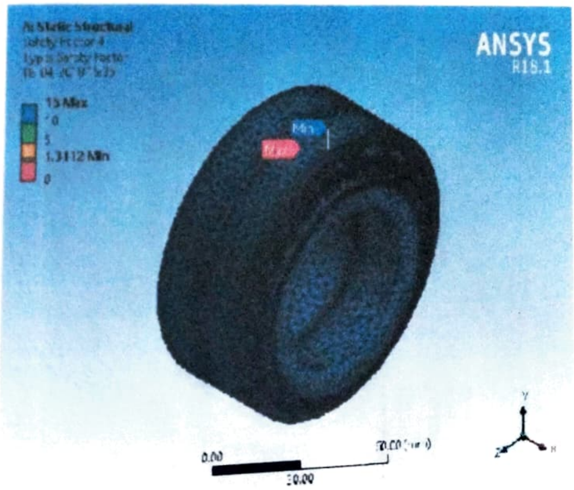

Fig. 22 10^4 cycle for Structural steel

Fig. 23 10^4 cycle for GCr15-YB9-68

5.4 FOR 10^5 CYCLES:

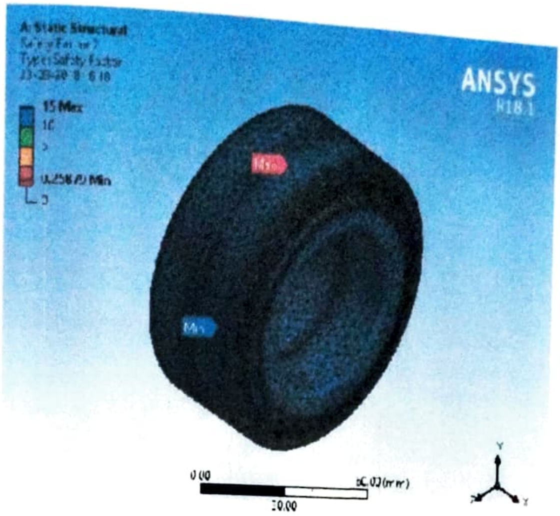

Fig. 24 10^5 cycle for Combination material

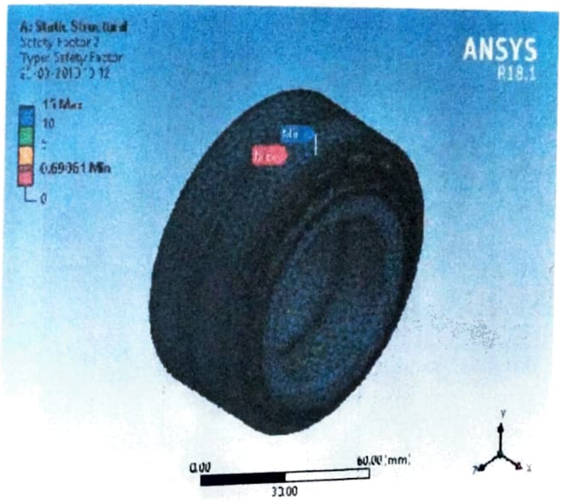

Fig. 25 10^5 cycle for Structural steel

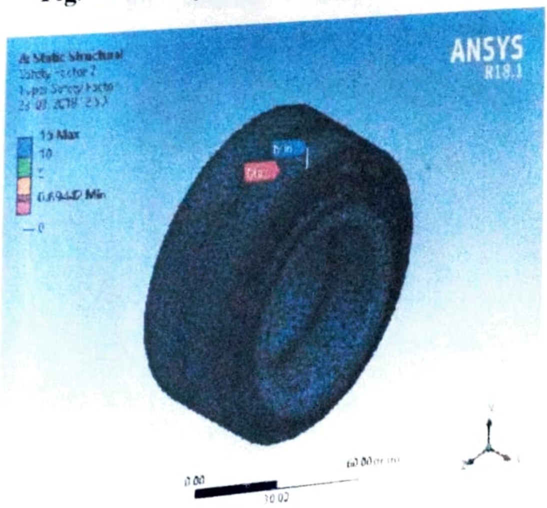

Fig. 26 10^5 cycle for GCr15-YB9-68

5.5 FOR 10^6 CYCLES:

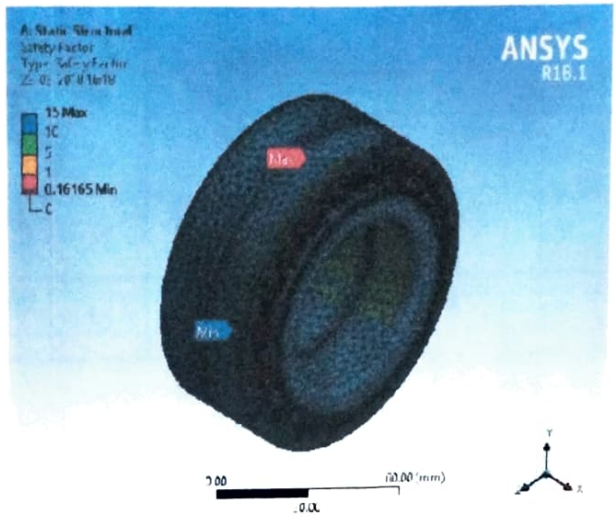

Fig. 27 10^6 cycle for Combination material

Fig 5.1 Combination material

Fig. 28 GCr15-YB9-68

Table 6 : CYCLES

MATERIAL	For 10^3 cycles		For 10^4 cycles		For 10^5 cycles		For 10^6 cycles	
	Min	Max	Min	Max	Min	Max	Min	Max
Combinational material	1.0796	15	0.49133	15	0.25879	15	0.16165	15
Structural steel	2.881	15	1.3112	15	0.69061	15	0.43138	15
GCr15-YB9-68	2.8969	15	1.3184	15	0.69442	15	0.43376	15

From the above table we can clearly observe that increasing of cycles leads to decrease in the life of bearing.

5.6 MAXIMUM PRINCIPAL STRESSES :

The maximum principal stress should not exceed the ultimate strength, if it exceeds the ultimate strength then we can say that the condition is failed. The maximum principal stresses for 3 different materials is shown in the figures below and comparisions are also shown in the table 6.

Maximum principal stress 472.88 > 400(ultimate strength)

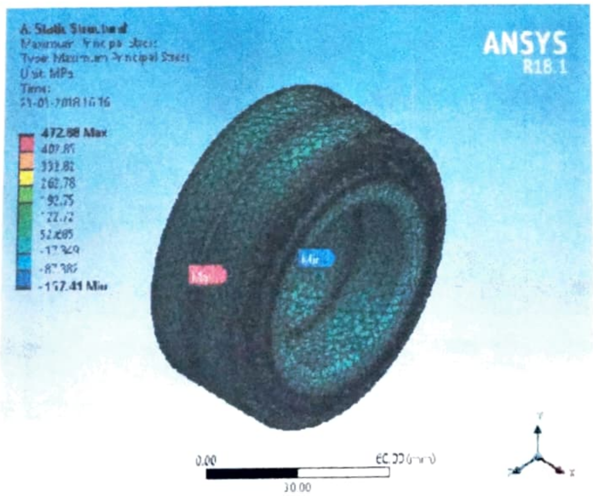

Fig. 29 max principal stress for Combination material

Maximum principal stress 168.44 < 400(ultimate strength)

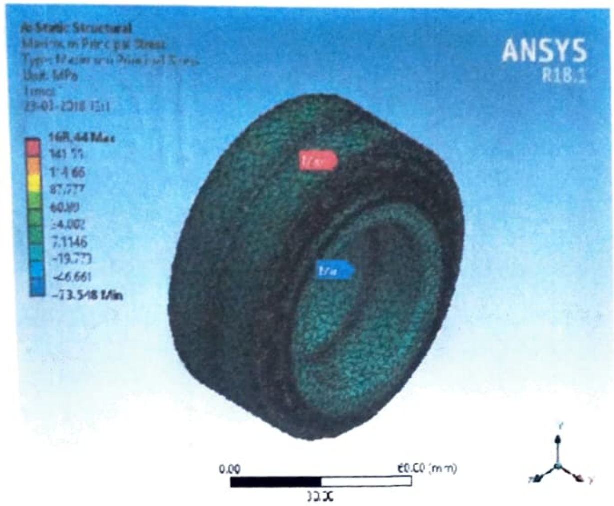

Fig. 30 Structural steel

Maximum principal stress 167.95 < 400(ultimate strength)

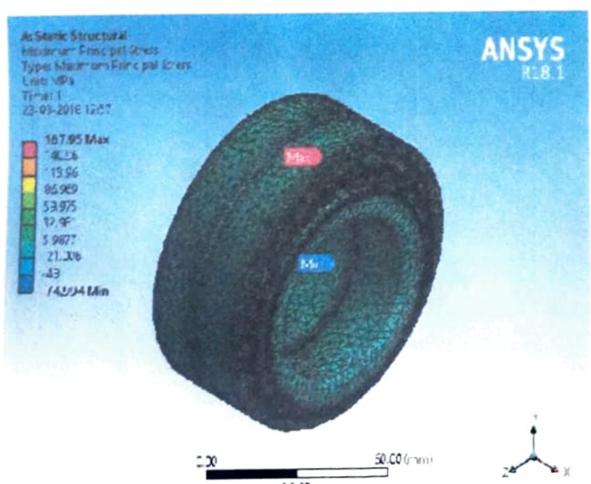

Fig. 31 GCr15-YB9-68

From the above conditions,GCr15-YB9-68 gives better results when compared to other 2 materials. For combinational material, the maximum principal stresses are greater than ultimate strength so condition is failed, so we are eliminating this material.

5.7 MINIMUM PRINCIPAL STRESSES :

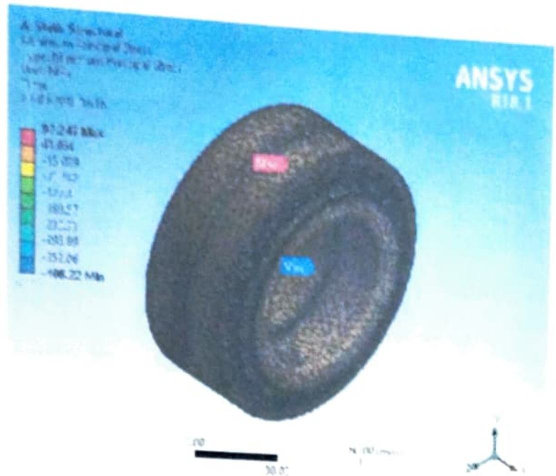

Fig. 32 min stress for Combination material

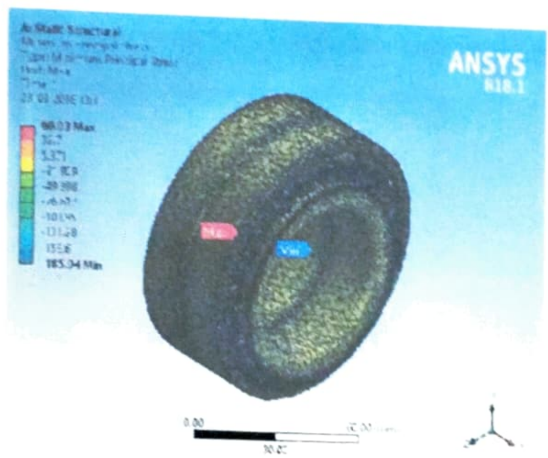

Fig. 33 Structural steel

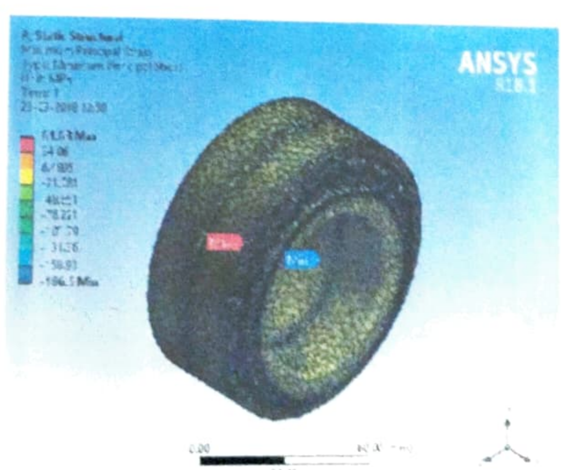

Fig. 34 GCr15-YB9-68

5.8 SHEAR STRESSES :

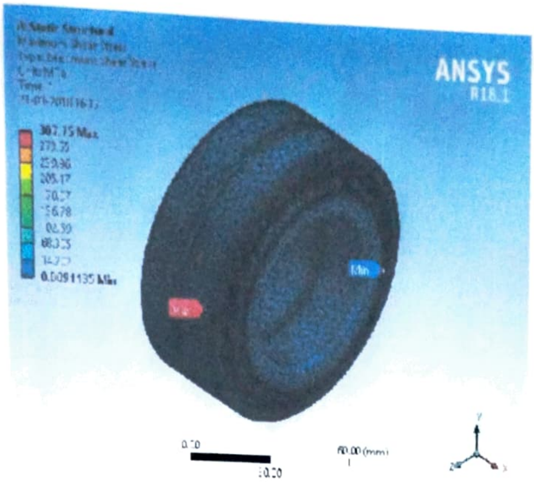

Fig. 35 shear stress for Combination material

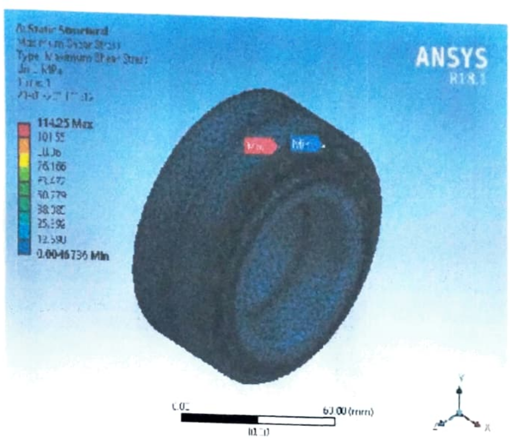

Fig. 36 Structural steel

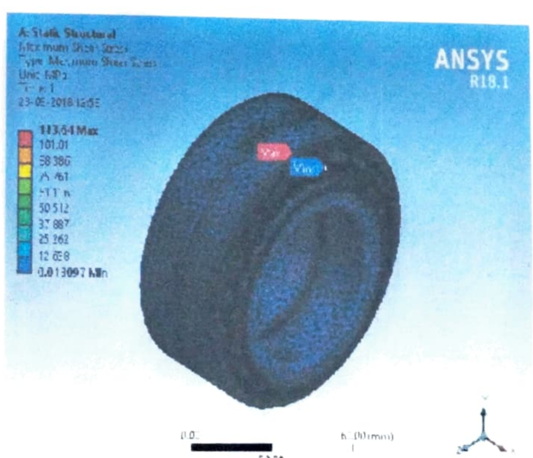

Fig. 37 GCr15-YB9-68

5.9 STRAIN:

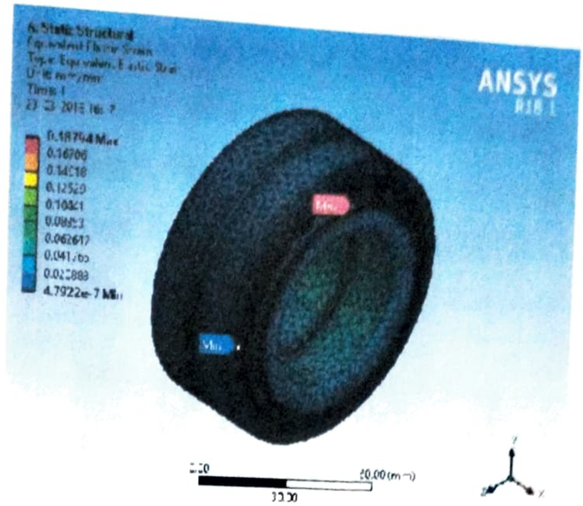

Fig. 38 strain for Combination material

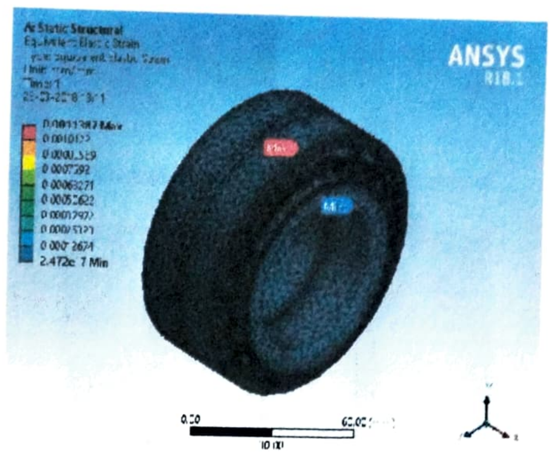

Fig. 39 Structural steel

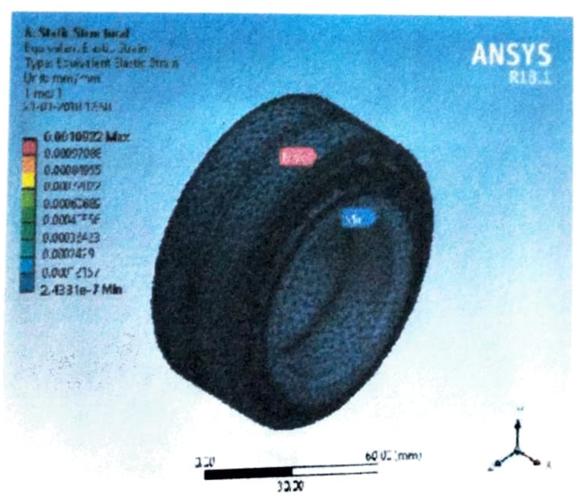

Fig. 40 GCr15-YB9-68

5.10 TOTAL DEFORMATION:

The static structural analysis of double row taper roller bearing is carried out in ANSYIS 18.0 under load mentioned in above chapter for 3 different materials. Among these materials, for static load, Gcr15 gives lower value of total deformation compared to other materials. The total deformation of the specified materials are shown in following figures and comparison is shown in the table no.7

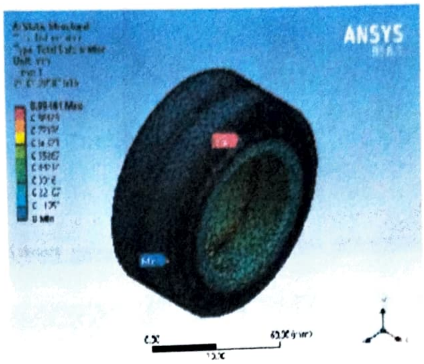

Fig. 41 deformation for Combination material

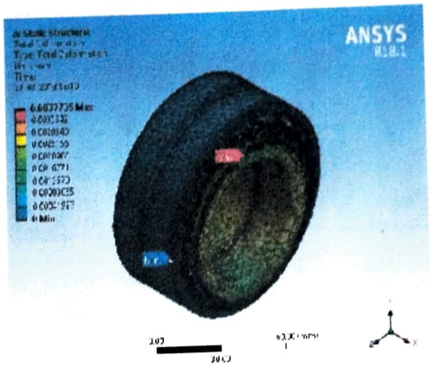

Fig. 42 Structural steel

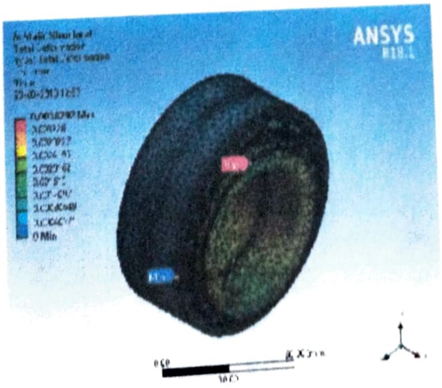

Fig. 43 GCr15-YB9-68

But from the figures total deformation is high in combinational material so this material is not suitable for design purpose

5.11 Von MISES STRESSES:

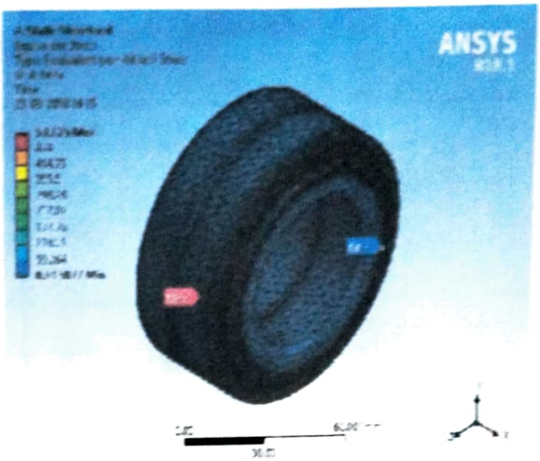

Fig. 44 von misses for Combination material

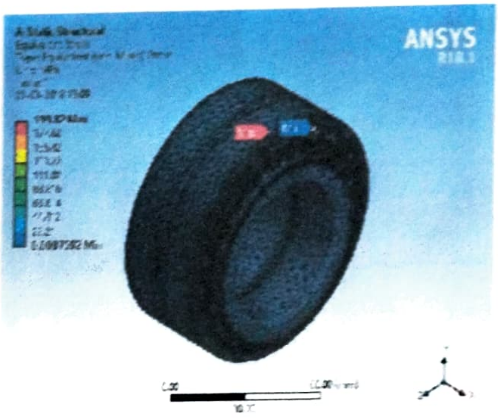

Fig. 45 Structural steel

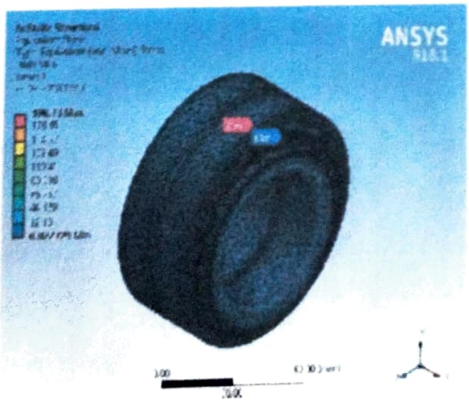

Fig. 46 GCr15-YB9-68

Table 7: STRESSES

MATERIAL	MAXIMUM PRINCIPLE STRESSES		MINIMUM PRINCIPLE STRESSES		SHEAR STRESSES		VON MISES STRESSES	
	Min	Max	Min	Max	Min	Max	Min	Max
COMBINATIONAL MATERIAL	-157.41	472.88	-408.22	97.247	0.0091135	307.75	0.015877	533.25
STRUCTURAL STEEL	-73.548	168.44	-185.94	60.03	0.0046736	114.25	0.0087592	199.82
GCR15-YB9-68	-74.994	167.95	-186.5	61.63	0.013097	113.64	0.022729	198.73

Table 8: STRAIN AND TOTAL DEFORMATION

Material	Strain		Total deformation	
	Min	Max	Min	Max
Combinational material	4.79*e-7	0.18794	0	0.99481
Structural steel	2.47*e-7	0.0011387	0	0.0037735
GCr15-YB9-68	2.43*e-7	0.0010922	0	0.0036292

CHAPTER 6
CONCLUSION

6 . CONCLUSION

Taper roller bearings are made of different material like AISI 8260 Steels (Bearing steels), Structural steels, Gcr15-Y-B9-68 material etc., depending on applications. In this work, it is shown that comparison of factor of safety, static stresses, strains, allowable life and von-misses stresses of bearing which is made of three different materials at one particular application. The conclusions derived from the present work are discussed below.

1. Modeling of double row taper roller bearing has been done by solid works based designer specification.
2. Factor of safety of Gcr15-Y-B9-68 is more than other materials like structural steel and combination material in static as well as fluctuating loading.
3. All bearings what we analysis above are only safe at limited number of cycles as per designer load condition, it is not suitable at infinite number of cycles. So the failure of the component may be high cycle fatigue if number cycles crosses 10^6 cycles. Gcr15-Y-B9-68 material can withstand for more number of cycles than other two materials.
4. Analysis has been carried out on the double row Taper Roller bearing. The Principles stress obtained in static structural analysis are below the yield strength and ultimate strength as per designer specifications. So the Taper Roller bearing stresses are in safe limit. Gcr15-Y-B9-68 shows least values of stress and strains than structural steel and combination material.
5. It is observed that Equivalent (Von-Misses) Stress is least for Gcr15-Y-B9-68 material and this value is below the yield stress value. From this we conclude that double row taper roller bearing is safe.

REFERENCES

1. Ham rock, Bernard J., and William J. Anderson ,"Rolling-element bearings",
2. National Aeronautics and Space Administration, Vol. 1105, 1983.
3. Schwarz, Vilmar Arthur, "Experimental studies of the thermal behavior of a tapered roller bearing assembly", Proceedings of the 11th Brazilian Congress of Thermal Sciences and Engineering, 2006.
4. Kayalı , Yusuf, Ismail Ucun , and Kubilay Aslantaş, "Contact fatigue failure of a tapered roller bearing used in a lorry wheel", Journal of failure analysis and prevention 9.3,pp.288-294. (2009)
5. Ebert, Franz-Josef, "Fundamentals of design and technology of rolling element bearings", Chinese Journal of Aeronautics 23.1, 123-136, (2010):
6. Yongqi, Zhang, "Analysis of Stress and Strain of the Rolling Bearing by FEA method", Physics professor24 19-24 (2012)
7. Guo, Yi, and Robert G. Parker, "Stiffness matrix calculation of rolling element bearings using a finite element/contact mechanics model, "Mechanism and Machine Theory 51, 32-45, (2012).
8. TANG Zhaopinga, SUN Jianping, "The Contact Analysis for Deep Groove Ball Bearing Based on ANSYS" ,Defence Technology 9, 229e236, (2013)
9. R.K. Upadhyay, L.A. Kumara swamidhas, Md. Sikandar Azam, "Rolling element bearing failure analysis: A case study", Case Studies in Engineering Failure Analysis 1, 15–17, (2013)
10. Yan-shuang WANG, Qian-qian YUAN, "Contact Force Distribution and Static Load- carrying Capacity of Large Size Double Row Four-point Contact Ball Bearing",Procedia Engineering 64, 1582 – 1591, (2013)
11. H. Saruhan, S. Sardemir, A. Çiçek and Uygur,"Vibration Analysis of Rolling Element Bearings Defects", Vol.12, June2014
12. Shah, Dipen S., and Vinod N. Patel, "A Review of Dynamic Modeling and Fault Identifications Methods for Rolling Element Bearing", Procedia Technology 14, 447-456, (2014).
13. M. Prem Kumar, Dr.C.J.Rao, "Structural and Thermal Analysis on a Tapered Roller Bearing", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 1, January 2015