DESIGN AND ANALYSIS OF FAILURE AND IMPROVEMENT OF REAR AXLE SHAFT BY USING COMPOSITE MATERIAL

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

Shaft is a very important member in automobile vehicles for power transmition .the shaft in vehicle that transmit power from engine to wheel through transmission unit via a differential unit. Our project to analys the failure and improvement of rear axle shaft by using ANSYS software.the rear axle shaft is located in the differential unit which carry the more load and more vibration due to under a load condition. The main failure of axle shaft at fatigue failure of the shaft due to improper hardening process and reduce of wear resistance of the shaft during a running condition.now we intro the new metal in axle such as a AISI 4140 alloy steel.such take a metal as zirconium and aluminium in the way of properties because of the failure of shaft is done by reduction of fatigue strength and wear resistance of shaft material.so the failure is reduced by improve the fatigue strength of the material.the axle shaft strength improved by composition of new material such zirconium and aluminium which replace of chromium in the axle shaft material that analyzing by ANSYS software.

CHAPTER I

Introduction

Thus the project is failure analysis and improve the rear axle shaft by using a composite material.The shaft have a more load when its running condition and also more vibration to be developed during a running condition. The failure of shaft due to lot of ways such as a improper heat treatment,different load condition,reduce of fatigue strength,improper hardening process which is lead to reduce of fatigue strength.we are analyzing the different shaft material such we take the AISI 4140 alloy steel which is composition of "chromium-molybdenum alloy steel" the rear axle shaft which is main power transmission in vehicle.when the failure occur in axle shaft which leads to major problem in power transmission.the shaft material is a standard material so we are intro new material in the axle shaft material such as in AISI 4140 alloy steel.the composition of axle shaft material the chromium is replaced by "zirconium and aluminium" the project is carry out by ANSYS software for analyzing the mechanical property of new composite of rear axle shaft and also analyse failure of rear axle shaft in which point of failure to be occur in the shaft by using analysed ANSYS software.

1.1 REAR AXLE

The rear axle shaft is locating back side of the vehicle that coupled with the differential unit. Which is used to transmit the power to the wheel from developed in the engine. In between the differential and the driving wheels is the rear axle to transmit power from the differential to the driving wheels. It is clear from the construction of the differential that the rear axle is not a single piece.

But it is in two halves connected by the differential, one part is known as half shaft.The inner end of the half shaft is connected to the sun gear of the differential, and the outer end of the shaft driving wheel. In rear wheel drive vehicles, the rear wheel are the driving wheel. Whereas in front wheel drive vehicles, the front wheels are the driving wheels , almost all rear axle on modern passenger cars are live axles,ie they revolve with the wheels. Dead axle simply remain stationary, do not move with the wheels. A housing completely encloses the rear axle and the differential,protecting them from water,dust and injuiry in addition to mounting their inner bearings and providing a container of the lubricant.the rear axle image

Fig 1.1 Rear axle shaft

1.1.1 Rear axle construction

In cases where the rear suspension is non-independent, the type of axle used is either a dead axle or a live axle. The former only has to support the weight of the vehicle, where the latter has to fulfill this task and, in addition, contain a gear and shaft mechanism to drive the road wheels.

Which is connected with differential in it bevel gear for transmitting power to the wheels.

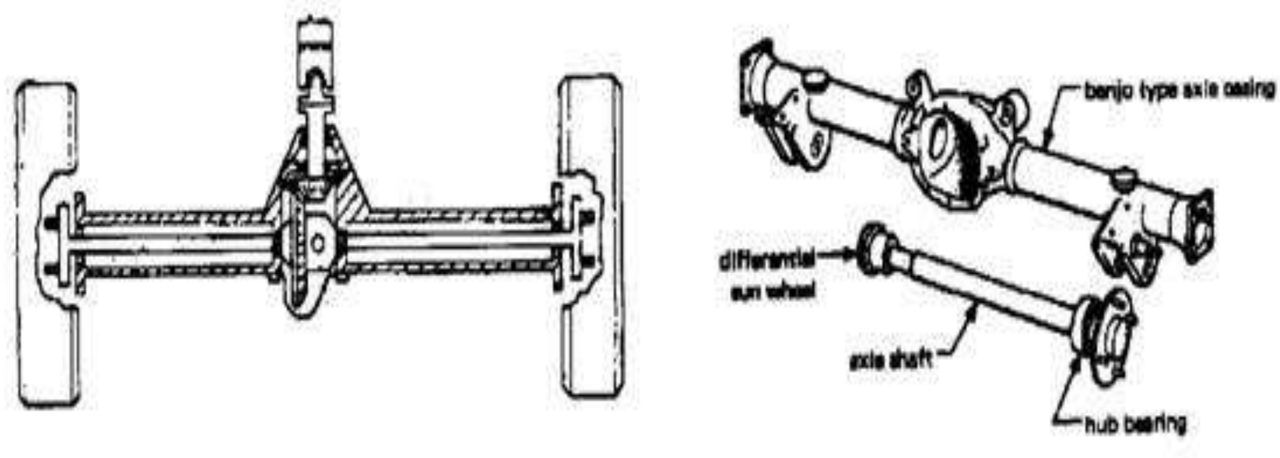

Fig 1.2 Rear axle shaft construction

1.1.2 Axle shafts

The axle shaft (half shaft) transmits the drive from the differential sun wheel to the rear hub. The arrangement of a simple rear axle can be seen in the figure, the road wheel attached to the end of the half shaft, which in turn is supported by bearing located in the axle casing. The diagram illustrates the forces acting on the rear axle assembly under a under different operating conditions.

Operating conditions

The total weight of the rear of the vehicle may exert a bending action on the half shaft. Furthermore, there is a tendency for the overhanging section of the shaft to be subject to a shearing force.

During cornering a side force acts upon the road wheel which imposes a bending load and an end thrust becomes a ‘pull’. A side force also tends to bend the overhanging section of the half shaft. Finally, under driving conditions the half shaft has to transmit the driving torque

1.2 TYPES OF REAR AXLE

There are three types of rear axle to be used, it depending upon the methods of supporting the rear axle and mounting the rear wheels, the three types of rear axle are follows:

- Semi floating axle
- Full floating axle
- Three quarter floating axle

1.2.1 Semi-floating axle

A semi-floating axle has a bearing located on the axle and inside the axle casing. It has a to support all the loads as listed above. Therefore it needs to be of a larger size, for the same torque output, than any other type. The inner end of the rear axle is supported by the differential side gear. It is thus relieved of the job of carrying the weight of the car by the axle housing. The outer end has to support the weight of the car and take end thrust. The inner end of the axle is splined to the differential side gear.The outer end is flanged so that the wheel can be bolted directly to it. In some design, the hub of the wheel is keyed to the outer end of the axle. The vehicle load is transmitted to the axle through the casing and the bearing, which causes the bending and shearing of the axle. The semi-floating axle is the simplest and cheapest of all other types and widely used on cars.

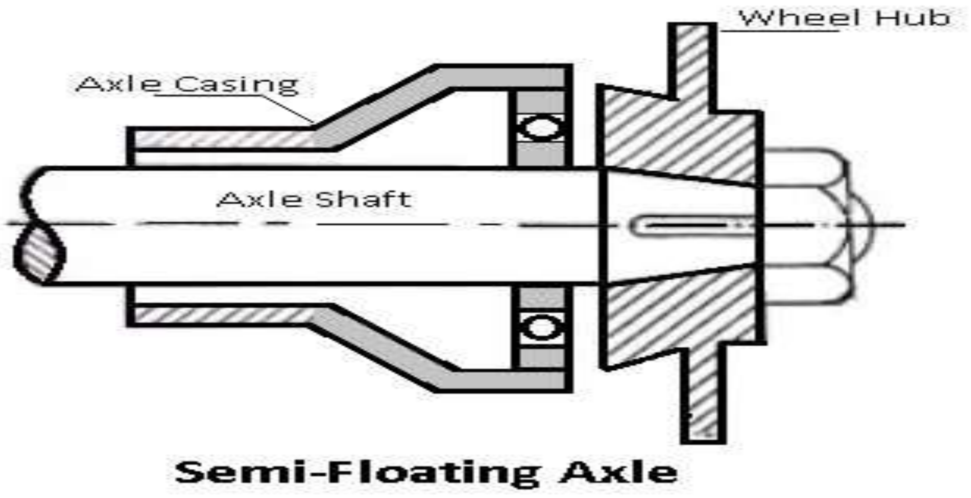

Fig 1.3 semi-floating axle

1.2.2 Full-floating axle

A full floating axle has two deep groove ball or taper roller bearings, located between the axle casing and wheel hub. The outer of an axle is made flanged to which the wheel hub is bolted. The axle is not supported by the bearing at either end, and its position is maintained by the way that it is supported at both ends. Thus the axle is relieved of all strain caused by the weight of the vehicle on the end thrust. It transmits only the driving torque. For this reason ,it is called full-floating. The axle nay be removed from the housing without distributing the wheel byb removing the nuts. An additional advantage of this design is the ability to the vehicle even if it has a broken axle. This type of axle is more expensive and heavier than the outer axle. It is usually fitted on commercial vehicle.

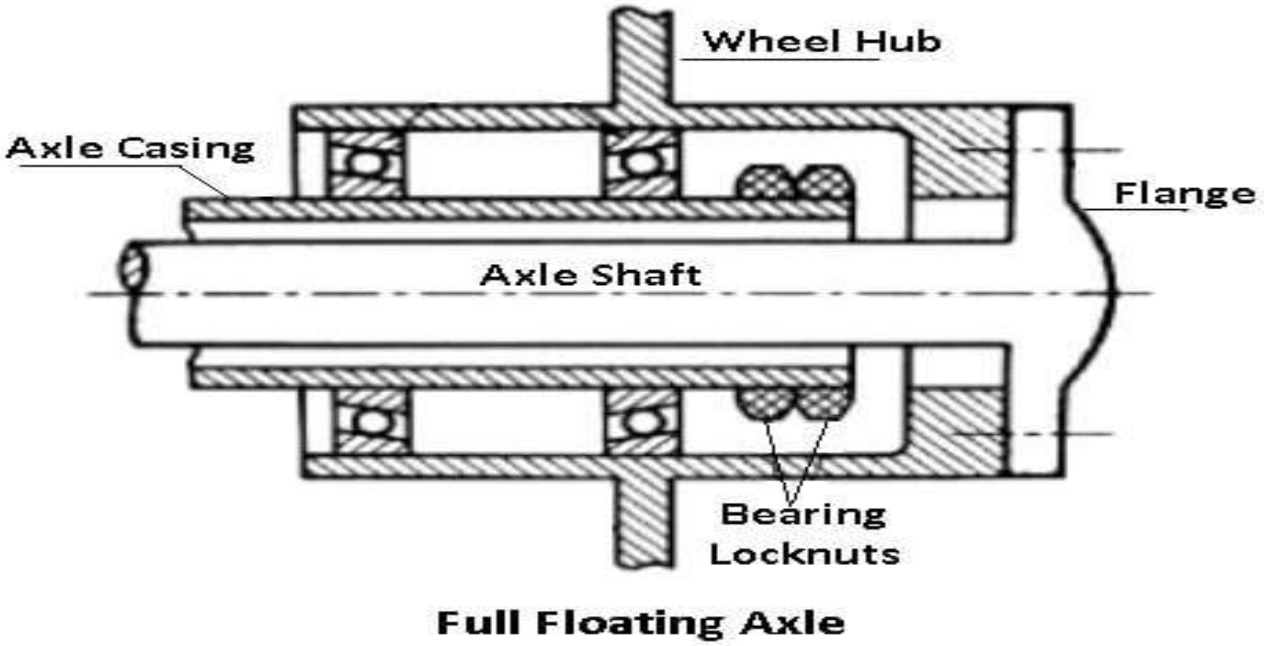

Fig 1.4 full-floating axle

This is generally fitted on commercial vehicles where torque and axle loads are greater.The axle consists independently mounted hub which rotates on two bearings widely spaced on the axle casing. This arrangement relieves the shaft of all stresses except torsional, so the construction is very strong. Studs connecting the shaft to the hub transmit the drive and when the nuts on theses studs are removed, the shaft may be withdrawn without jacking up the vehicle. The shaft is to transmit only the driving torque to the rear wheel.

1.2.3 Three quarter floating axle

This type of axle has a bearing placed the between the hub and the axle casing. Thus, the weight of the vehicle is transferred to the axle casing, and only the side thrust and driving torque are taken by the axle. The axle is keyed rigidly to the hub, thus providing the driving connection and maintaining the alignment of the wheel. The inner end of the axle has the same construction as that of the semi-floating axle.

Although the three quarter floating axle is more reliable it is not as simple the semi floating axle.

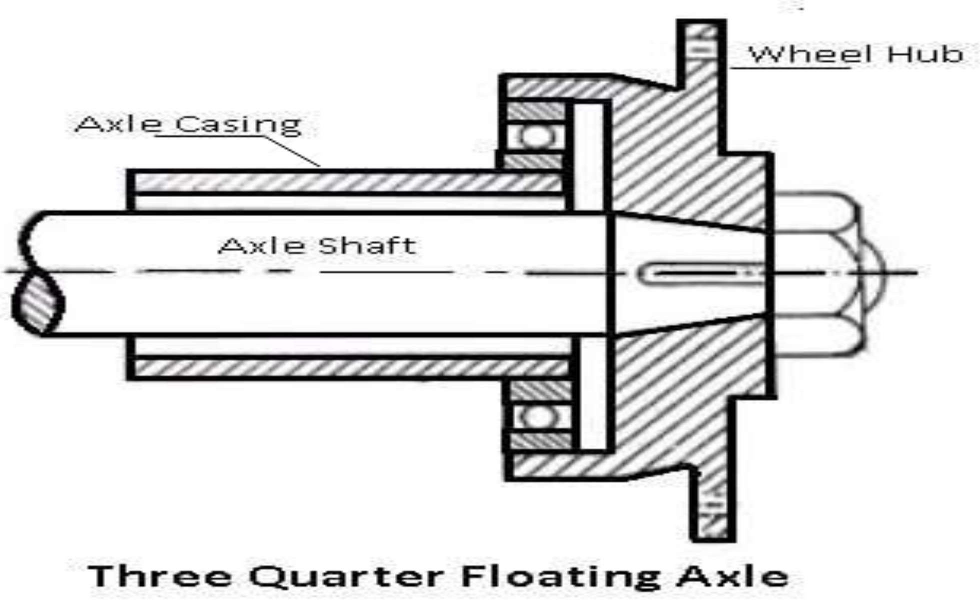

Fig 1.5 Three quarter axle

Having defined the semi-and the fully floating shaft, any alternative between the two may be regarded as a three-quarter floating shaft. Fig. 2b shows a construction which has a single bearing mounted between the hub and the casing. The main
shear stress on the shaft is relieved but all other stresses still have to be resisted. The half shaft must withstand bending loads due to side thrust when cornering and, of course, at the same time transmit driving torque

CHAPTER II

LITERATURE REVIEW

1.J.Sudhakaran, G.Sakthivel ,S.Sheril in the department of mechanical engineering for analysis of "**performance and analysis of tractor rear axle shaft using composite material**" this is analysis of tractor rear axle shaft that can be solve the problems regarding when it breakdown and failure in field of operation. This project improve the rear axle shaft by using composite material. The rear axle shaft subjected to torsional and bending stress due to varying load condition. This review about the performance and failure of tractor rear axle shaft that the member of power transmission in automobile. This involve the modify the shaft design and material strength that analysed by ANSYS software.this project carry out the material of "ductile cast iron,E-glass and carbon fibre" which increasing material property to achieve the mechanical,suspension arms,long service,effective performance are to be achieved. The aim of this project the present work is to design,analyse on existing model and purpose of change in shape and material. This is done by following this design helps in the replacement of conventional rear axle shaft and casing with change of material for better corrosion resistance to be increased and also to achieve substancial stress reduction in the shaft by replacing it with these material. This project carried out the tha analysis of tractor rear axle shaft that improve the performance of the shaft by using the composite material, this using a composition material of ductile cast iron,E-glass and carbon fibre that to introduce the axle shaft foe increasing performance of the shaft. Which also analysis the mechanical property of the shaft.

That may transmit power at critical condition while at time shaft is going to failure condition which form of some failure in a property of the material to be added.

2. Subrata kr mandal,palash kr maji and karmakar, in the CSIR-central mechanical engineering research institute for the "**Analysis of an intermediate rear axle shaft failure**". In this project will modify the design of the shaft such as modify the some mechanical property of the shaft are to be done on it. This involve the process to improve the design of the shaft that shaft diameter and length are to be modified such a way. The shaft design generally done based on the application use of the shaft. Hera in this project the design was made of the keeping the fact that it is will be used in a rear axle shaft transmission system. The wheel shaft has been made from a stainless steel and has been turned down to a central diameter of 25mm and long of 177mm with overall length of 516mm. the ends of the shaft are reduced to 16.5 mm diameter along the 190mm length of the both side. The changes to the design would substantially improve the resulting safe life of the future drive shaft in service. These can be achieved in a number of ways and most effective and simple alternating are followed the shortening the total length of the shaft. This will alternatively reduce the overall length of the different portion of the shaft, increasing the diameter of the shaft. This will also increase the diameter of stepped portion at a ratio increasing the fillet radius the shaft failure at the change of diameter and hence increasing from lowering the stress concentration. The detail design work of the wheel assembly is found wanting the operating under ideal condition the predicted life of relatively short and leaves the no margin for vehicle misuse, a distinct possibility with such an application.

3.Gurkon Irsel, by advance in science and technology,for the project of the "**Analysis of axle shaft fatigue failure and anti- fatigue system design**" in this study an axle shaft subjected to static deformation and fatigue damage was considered by using "computer aided engineering". This shaft system was modeled with CATIA and subjected to dynamic fatigue analysis with ansys workbench. The damaged fracture surface of the shaft have been examined. Thus the fatigue and damage was revealed in greater detail. Foe the present system a design with a minimum cost, short production process, minimum weight was sought together with a minimum construction principle by means of CATIA ana ANSYS, the product development design with reasonable tension and deformation values was formed for endless life fatigue. A design was produced in in a short space with the help of 2D CATIA drawing and field tests were carried out. The design was used through 560.000 cycles and damage was not observed. The fatigue damage that formed because of repetitive stretching of the material or unit shape change. The tension force is mostly cause of fatigue is smaller than yield strength of the material. The cracks are developed by friction between rotating surface. It becomes enables to carry the normal load. Sudden load or fracture occurs and the fracture surface looks granular they are used ANSYS software to calculate and displays stress values generated by the applied force. The anti fatigue design approach such at a nominal stress approach, load stress fatigue approach, stress area density approach, in this approach by adding 20 kg of additional bearing design to a system with a weight of 1400 kg subjected to shaft fatigue damage, the tension strength under a nominal condition was reduced from 131.79Mpa to 49.8 Mpa. The fatigue strength increased from 118200 to $1*10^6$ infinite life limites. In the redesign study the occurred damage was removed within 6 hours of operation including production and installation.

The new design was carried out with CATIA is an effective program for the emergence of new and complex design. The fracture surface contains depth in ductile fatigue. In the case fatigue damage of brittle material there is almost no depth along the axis of the shaft. The design was used on 560.000 cycles and damage did not occur

4.Piyush.C.chaudhan,vimal.D.sonara,Dr.pravin,p.rathore, department of mechanical engineering, in the project of "**Analysis and design of tractor rear axle shaft using finite element analysis method**" in the project that focusing the on the development of vehicles with improve performance, increased stability and enhanced driver pleasure and a premature failure that occurs prior to the excepted load cycles during life of rear axle shaft is studied . during the service,life,dynamic forces caused by the road surface roughness produce dynamic stress and these force lead to fatigue failure og rear axle shaft and its housing which is the main load carrying part load of the assembly. Tractor an off load vehicle is considered to be any type of vehicle which is capable of driving on and off paved or gravel surface the off road condition are uneven agricultural surface the axle position of the wheels relative to each other and to the vehicle body.the dead axle does not transmit any power.the dead axle suspension system is mounted so it called suspension axle.axle generally subjected to torsional stress and bending stress due to weight of components misalignment between journal bearings.the concentration of foe shaft the problem fundamentally fatigue loading.eccentric shaft widely appreciated features like corrosion resistance long service,effective performance and reliability.it based on the particular load spectrum and the boundary condition the axle shaft likely to break at 144233 km whereas the warrenty is for about 150000km.

based on research work within rear axle using following material are SAE1040,SAE 1020,SAE86B45,Al_2O_3 and also mildsteel,cast iron and reinforce aluminium with fly ash and Al_2O_3 thus it is important to analyse rear axle of tractor so that we can solve the problems regarding breakdowns and failure during field operation. In present work finite element analysis approach is used to modify existing rear axle of tractor that point of finite element analysis.

CHAPTER III

LOADS AND FORCES ON SHAFT

The rear axle shaft subjected to point load on acting at both ends of the rear axle shaft. This load depends upon the various factors such as a weight of the of the vehicle, external loads on vehicle and weight of the shaft tends to varying load condition. The shaft has more vibration when more load and power transmitting condition. That the shaft more widely affected by fatigue load on the shaft. Then the shaft is to considered at simply supported beam for assembly and design of shaft which more load acting at both ends of the shaft. There are several loads acting on the shaft as follows:

- Weight of the vehicle body.
- Driving thrust.
- Braking torque.
- Torque reaction.
- Side thrust

3.1 Driving Thrust

Driving torque produced in the engine causes the thrust to be produced in the road wheels, which has to be transmitted from the axle casing to the chassis frame and the body of the vehicle.

3.2 Torque Reaction

If the rear axle is held rigidly when the road wheels are prevented from rotation, (due to driving needs or road conditions) the bevel pinion of the final drive tends to rotate around the crown wheel. It produces a tendency in the whole vehicle to rotate about the rear axle or to lift off the front of the vehicle. This effect is known as torque reaction.

3.3 Braking torque or thrust

The axle casing experiences the brake torque when the brakes are applied to the vehicle.

3.4 Side Thrust

When the vehicle is taking the turn, the rear axle subjected to the side thrust or pulls due to any side load on the wheel.

3.5 Weight of the body

The rear axle may be considered a beam supported at ends loaded.This weight causes bending and shears force in the axle shaft.

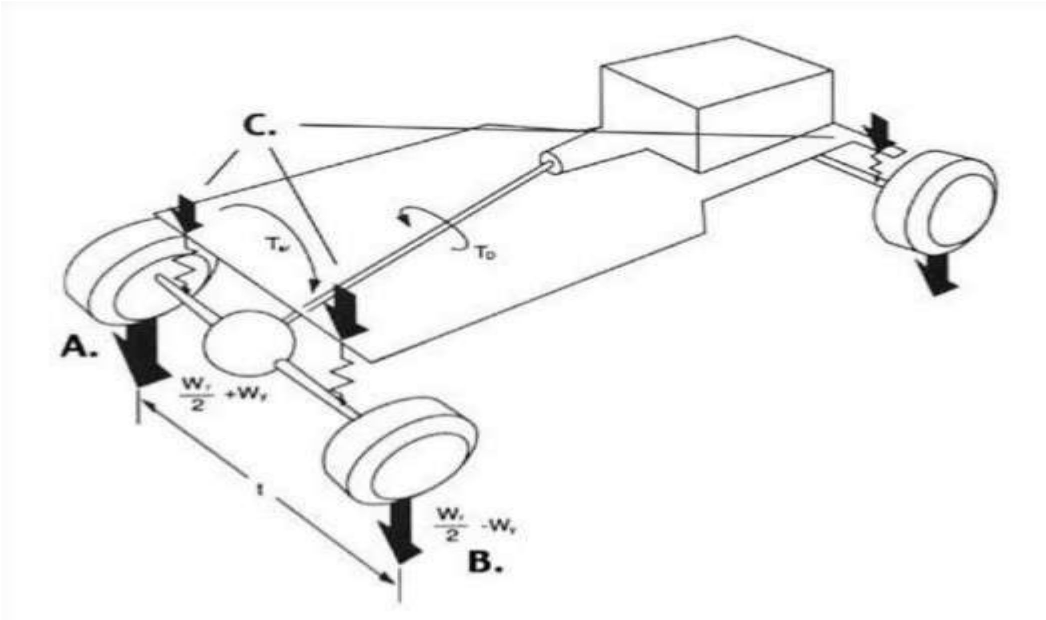

Fig 3.1 load distribution of axle shaf

At the same time the shaft subjected to various stress due to the different loading condition to follows as various Stresses. The various types may be compared by considering the stresses the shaft has to resist

- torsional stress due to driving and braking torque.
- Shear stress due to the weight of the vehicle
- Bending stress due to the weight of the vehicle

CHAPTER IV

MATERIAL SELECTION

4.1 Introduction

This material for our project is the application of composite material based that improvement of rear axle shaft such that the selection of material is based on the material properties for our application. So that our selection of rear axle material is AISI 4140 alloy steel we are try to improve the properties of this by intro the new material in composition in AISI 4140 alloy steel. The grade of this alloy is consist of some alloy elements like that chromium,molybdenum and other catbon etc., the grade is " American Iron And Steel Institute 4140 alloy steel" this is one of the alloy steel material, the selection of new material like the "zirconium and aluminium" it composition in the " chromium-molybdenum alloy steel" for our application of its properties. So know briefly discuss about the selection of materials

The aim of this project is to improve the rear axle shaft. We are selection of materials are follows as a

- zirconium
- aluminium

this materials are composite with the " chromium-molybdenum alloy steel" for the replacement of chromium for composition of its. The chromium is replaced for more expensive, we try to new composition in the shaft material and also of properties of its failure in shaft. Now we briefly discuss the shaft material as "AISI 4140" alloy steel

4.2 AISI 4140 [CHROMIUM-MOLYBDENUM ALLOY STEEL]

1. Introduction
2. Chemical Composition
3. Physical Properties
4. Mechanical Properties
5. Thermal Properties
6. Other Designations
7. Fabrication and Heat Treatment
8. Machinability
9. Forming
10. Welding
11. Heat Treatment
12. Forging
13. Hot Working
14. Cold Working
15. Annealing
16. Tempering
17. Hardening

4.2.1 Introduction

Alloy steels are designated by AISI four-digit numbers. They comprise different kinds of steels having composition exceeding the limitations of B, C, Mn, Mo, Ni, Si, Cr, and Va set for carbon steels.AISI 4140 alloy steel is chromium, molybdenum, manganese containing low alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness, and torsional strength. The following datasheet gives an overview of AISI 4140 alloy steel.

4.2.2Chemical Composition

The following table shows the chemical composition of AISI 4140 alloy steel.

Element	Content (%)
Iron, Fe	96.785-97.77
Chromium, Cr	0.80-1.10
Manganese, Mn	0.75-1.0
Carbon, C	0.380-0.430
Silicon, Si	0.15-0.30
Molybdenum, Mo	0.15-0.25
Sulfur, S	0.040
Phosphorous, P	0.035

Table 4.1 chemical composition

4.2.3 Physical Properties

The physical properties of AISI 4140 alloy steel are highlighted in the following table.

Properties	Metric
Density	7.85 g/cm3
Melting point	1416°C

Table 4.2 physical properties

4.2.4 Mechanical properties

AISI 4140 Alloy Steel (UNS G41400)

The following table outlines the mechanical properties of AISI 4140 alloy steel.

AISI 4140 Alloy Steel (UNS G41400)

Properties	Metric
Tensile strength	655 MPa
Yield strength	415 MPa
Bulk modulus (typical for steel)	140 GPa
Shear modulus (typical for steel)	80 GPa
Elastic modulus	190-210GPa
Poisson's ratio	0.27-0.30
Elongation at break (in 50 mm)	25.70%
Hardness, Brinell	197
Hardness, Knoop (converted from Brinell hardness)	219
Hardness, Rockwell B (converted from Brinell hardness)	92
Hardness, Rockwell C (converted from Brinell hardness Value below normal HRC range, for comparison purposes only)	13
Hardness, Vickers (converted from Brinell hardness)	207
Machinability (based on AISI 1212 as 100 machinability)	65

Table 4.3 mechanical properties

4.2.5 Thermal Properties

The thermal properties of AISI 4140 alloy steel are given in the following table.

Properties	Metric
Thermal expansion co-efficient (@ 0-100°C/32-212°F)	12.µm/m°C
Thermal conductivity (@ 100°C)	42.6W/mK

Table 4.4 thermal properties

4.2.6 Fabrication and Heat Treatment Machinability

AISI 4140 alloy steel has good machinability in the annealed condition.

1)Forming

AISI 4140 alloy steel has high ductility. It can be formed using conventional techniques in the annealed condition. It requires more pressure or force for forming because it is tougher than plain carbon steels.

2) Welding

AISI 4140 alloy steel can be welded using all conventional techniques. However, the mechanical properties of this steel will be affected if it is welded in the heat treated condition, and post weld heat treatment should be performed.

3)Heat Treatment

AISI 4140 alloy steel is heated at 845°C (1550°F) followed by quenching in oil. Before hardening, it can be normalized by heating at 913°C (1675°F) for a long period of time followed by air cooling.

4)Forging

AISI 4140 alloy steel is forged at 926 to 1205°C (1700 to 2200°F)

5)Hot Working

AISI 4140 alloy steel can be hot worked at 816 to 1038°C (1500 to 1900°F)

6)Cold Working

AISI 4140 alloy steel can be cold worked using conventional methods in the annealed condition.

7)Annealing

AISI 4140 alloy steel is annealed at 872°C (1600°F) followed by slowly cooling in the furnace.

8)Tempering

AISI 4140 alloy steel can be tempered at 205 to 649°C (400 to 1200°F) depending upon the desired hardness level. The hardness of the steel can be increased if it has lower tempering temperature. For example, tensile strength of 225 ksi cab be achieved by tempering at 316°C (600°F), and a tensile strength of 130 ksi can be achieved by tempering at 538°C (1000°F).

9)Hardening

AISI 4140 alloy steel can be hardened by cold working, or heating and quenching.

4.3 CHROMIUM

- Introduction
- Chemical properties
- Physical properties
- Mechanical properties
- Thermal properties
- Application

Chromium is a lustrous, brittle, hard metal. Its colour is silver-gray and it can be highly polished. It does not tarnish in air, when heated it borns and forms the green chromic oxide. Chromium is unstable in oxygen, it immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below.

4.3.1 Introduction

Chromium is a chemical element with Cr as its symbol. It belongs to group 6, periodic number 4 of the periodic table. Its atomic number is 24.Chromium is a steely-gray lustrous, brittle, hard metal. It is known to have high corrosion resistance. When polished, it gains a very shiny surface, which is used to plate other metals so as to form a protective and attractive covering.Chromium is mined as chromite ore.

Globally this ore is available in India, South Africa, Finland, Zimbabwe, Kazakihstan and the Philippines. Commercially, chromiumis produced from chromite using silicothermic or aluminothermic reactions. Roasting and leaching processes are also used.

4.3.2 Chemical Properties

The chemical properties of chromium are provided in the table below.

Chemical Data	Metric
CAS number	7440-47-3
Thermal neutron cross section	2.9 barns/atom
Electrode potential	-0.560 V
Ionic radius	0.520 Å
Electronegativity	1.66
X-ray absorption edge	2.07 Å
Electrochemical equivalent	0.971 g/A/h

Table 4.5 chemical properties of chromium

4.3.3 Physical Properties

The following table discusses the physical properties of chromium.

Properties	Metric
Density (@20°C/68°F)	7.19g/cm^3
Melting point	1907
Boiling point	2672

Table 4.6 physical properties of chromium

4.3.4 Mechanical Properties

The mechanical properties of chromium are tabulated below.

Properties	metric
Poison’s ratio	0.31
Modulus of elasticity	248 Gpa
Hardness, Vickers	90
Hardness,Brinell (convt, from Vickers for 500 kg load/10mm,ball)	80
Hardness, Knoop (converted fromvickers)	102
Hardness, Rockwell B (converted from Vickers)	48

Table 4.7 mechanical properties of chromium

4.3.5 Thermal Properties of chromium

Properties	metric
Thermal expansion co-efficient(@ 20-100°C/ 68-212°F	6.20 µm/m°C
Thermal conductivity	69.2w/mk

Table 4.8 thermal properties of chromium

4.3.6 Applications

The following are the application areas of chromium:

- In metal ceramics
- In chrome plating
- As dyes and paints
- To produce synthetic rubies
- In alloys, e.g., stainless steel
- To manufacture molds for the firing of bricks
- As a catalyst in dyeing and tanning of leather
- In metallurgy to provide corrosion resistance and a shiny finish

4.4 Aluminium

Aluminum is a very light metal with a specific weight of 2.7 g/cm^3

Aluminum is ductile and has a low melting point and density . Aluminum naturally generates a protective thin oxide coating which keeps the metal from making further contact with environment

4.4.1 Properties of aluminium

Properties	Metric
Atomic Number	13
Atomic Weight (g/mol)	26.98
Valency	3
Crystal Structure	FCC
Melting Point (°C)	660.2
Boiling Point (°C)	2480
Mean Specific Heat (0-100°C) (cal/g.°C)	0.219
Thermal Conductivity (0-100°C) (cal/cms. °C)	0.57
Co-Efficient of Linear Expansion (0-100°C) ($x10^{-6}$/°C)	23.5
Electrical Resistivity at 20°C (Ω.cm)	2.69
Density (g/cm^3)	2.6898
Modulus of Elasticity (GPa)	68.3
Poissons Ratio	0.34

Table 4.9 properties of aluminium

1) Light weight

Aluminum is a very light metal with a specific weight of 2.7 g/cm^3, about a third of that of steel. This cuts the costs of manufacturing with aluminum. Again, its use in vehicles reduces dead-weight and energy consumption while increasing load

2) Corrosion Resistance

Aluminum naturally generates a protective thin oxide coating which keeps the metal from making further contact with the environment. It is particularly useful for capacity. This also reduces noise.applications where it is exposed to corroding agents, as in kitchen cabinets and in vehicles. Different types of surface treatment such as anodising, painting or lacquering can further improve this property.

3) Electrical and Thermal properties

Aluminum is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum the first choice for major power transmission lines. It is also a superb heat sink for many applications that require heat to be drained away rapidly, such as in computer motherboards and LED lights.

4) Reflectivity

Aluminum is a good reflector of visible light as well as heat, and that together with its low weight, makes it an ideal material for reflectors in, for example, light fittings or rescue blankets. Cool roofs made of coated aluminum are invaluable in reducing internal solar heat within a house, by reflecting up to 95% of sunlight.

5) Ductility

Aluminum is ductile and has a low melting point and density. It can be processed in several ways in a molten condition. Its ductility allows aluminum products to be formed close to the end of the product’s design.

6) Strength at Low Temperatures

In contrast to steel, which rapidly becomes brittle at low temperatures, aluminum shows increased tensile strength as temperatures drop.

7) Impermeable and Odorless

Aluminum foil is only 0.007 mm in thickness, but is still durable and completely impermeable, keeping any food wrapped in it free of external tastes or smells. It keeps out ultraviolet rays as well.Moreover, the metal itself is non-toxic and odorless, which makes it ideal for packaging sensitive products such as food or pharmaceuticals. The fact that recycled aluminum can be used reduces the carbon footprint for this stage of food and beverage manufacturers as well.

8) Non-magnetic

Aluminum is non-magnetic, making it useful for electrical shieldings as in computer disks, dish antennas, busbars or magnet housings.

9) Non-toxic

Aluminum is non-toxic and is used to make woks, pressure cookers and many other cooking utensils without fear. It is easily cleaned and does not contaminate the food at any stage.

10) Sound and Shock Absorption

Aluminum is an excellent sound absorber and is used for constructing ceilings. It is also used in auto bumpers due to its shock-absorbing properties.

11) Non-sparking

Aluminum produces no sparks when it comes into contact with itself or non-ferrous metals.

12) Recyclability

Aluminum is 100% recyclable and recycled aluminum is identical to the virgin product. This makes it a much more cost-effective source material for production runs. The re-melting of aluminum requires little energy: only about 5% of the energy required to produce the primarly to met.

4.5 ZIRCONIUM

Zirconium (Zr) is a chemical element with atomic number 40 and represented with the chemical symbol 'Zr' in the periodic table.It was discovered by Martin Klaproth in the year 1798. This is named after a mineral Zircon as it is the most important source of zirconium.

4.5.1 Physical properties of Zirconium

The element is a gray-white, lustrous, strong transition metal that forms a variety of organometallic and inorganic compounds.

It is highly resistant to corrosion and heat. The hardness of it is similar to that of copper and it is lighter than steel.

Zirconium is available in about 30 mineral species and its major source is Zircon. More than 1.5 million tonnes of Zircon are mined each year, mainly in South Africa and Australia.

Speed of sound thin rod	3800 m/s (at 20 °C)
Thermal expansion	5.7 µm/(m·K) (at 25 °C)
Thermal conductivity	22.6 W/(m·K)
Electrical resistivity	421 nΩ·m (at 20 °C)
Magnetic ordering	paramagnetic
Young's modulus	88 GPa
Shear modulus	33 GPa
Bulk modulus	91.1 GPa
Poisson ratio	0.34
Mohs hardness	5.0
Vickers hardness	820–1800 MPa
Brinell hardness	638–1880 MPa
CAS Number	7440-67-7
Melting point	2128 K (1855 °C, 3371 °F)
Boiling point	4650 K (4377 °C, 7911 °F)
Density	6.52 g/cm3
when liquid (at m.p.)	5.8 g/cm3
Heat of fusion	14 kJ/mol
Heat of vaporization	591 kJ/mol
Molar heat capacity	25.36 J/(mol·K)

Table 4.10 properties of zirconium

4.5.2 Applications and Effects of Zirconium

The element is often used in high-temperature applications as it is highly resistant to heat.

Its main uses are conferring a white, opaque appearance to ceramic metal, opacifier.

It is used as an alloying agent in materials that are exposed to changing environment because of its corrosion resistant property. It has many other uses that include surgical instruments, photographic flashbulbs and in making glass for televisions. Space and aeronautic industries use Zirconium to manufacture high-temperature parts like blades, combustors, and vanes in jet engine

CHAPTER V

FAILURE ANALYSIS OF REAR AXLE SHAFT

5.1 Introduction

Failure analysis of rear axle shaft that is reduce the function or performance of the shaft during a operating condition the failure of the shaft that cause of lot of way for failure occur in the shaft. The shaft tends ti failure by during a rotation and improper lubrication a nd also a fatigue failure which cause of failure of shaft here the reasons the cause of failure to followas

- Fatigue failure
- Improper heat treatment
- Improper loading
- Improper design etc.,

The failure of shaft mainly discussed fatigue failure of shaft which is main cause for failure and also a various types of failure to be occur during the shaft rotation to main cause produce vibration in the shaft such follow as

- Transverse Vibrations.
- Torsional Vibrations.
- Critical Speed Vibrations.
- Component Failure.

Transverse vibrations

They are typically the result of an unbalanced drive shaft. A transverse vibration will occur once per every revolution of the drive shaft. This could be because of damage to the shaft, missing balance weights or foreign material stuck to the drive shaft.

Torsional vibrations

It occur twice per revolution of the drive shaft. They could be due to excessive u-joint angles or a shaft not in phase with its design specifications. A yoke outside of its design phasing by just one spline can cause torsional vibration issues.

Critical speed vibrations

occur when a drive shaft operates at an RPM too high in relation to its length, diameter and mass.

Component failure

The drive shaft or the motor and transmission mounts can cause vibration. A failing u-joint is a prime example.

5.2 FATIGUE FAILURE

The majority of engineering failures are caused by fatigue. Fatigue failure is defined as the tendency of a material to fracture by means of progressive brittle cracking under repeated alternating or cyclic stresses of an intensity considerably below the normal strength. One of the more common causes of shaft failure is due to fatigue. Metal fatigue is caused by repeated cycling of the load . It is a progressive localized damage due to fluctuating stresses and strains on the material. Metal fatigue cracks initiate and propagate in regions where the strain is most sever. There are only four basic failure mechanisms: corrosion, wear, overload and fatigue. The corrosion and wear almost never cause machine shaft

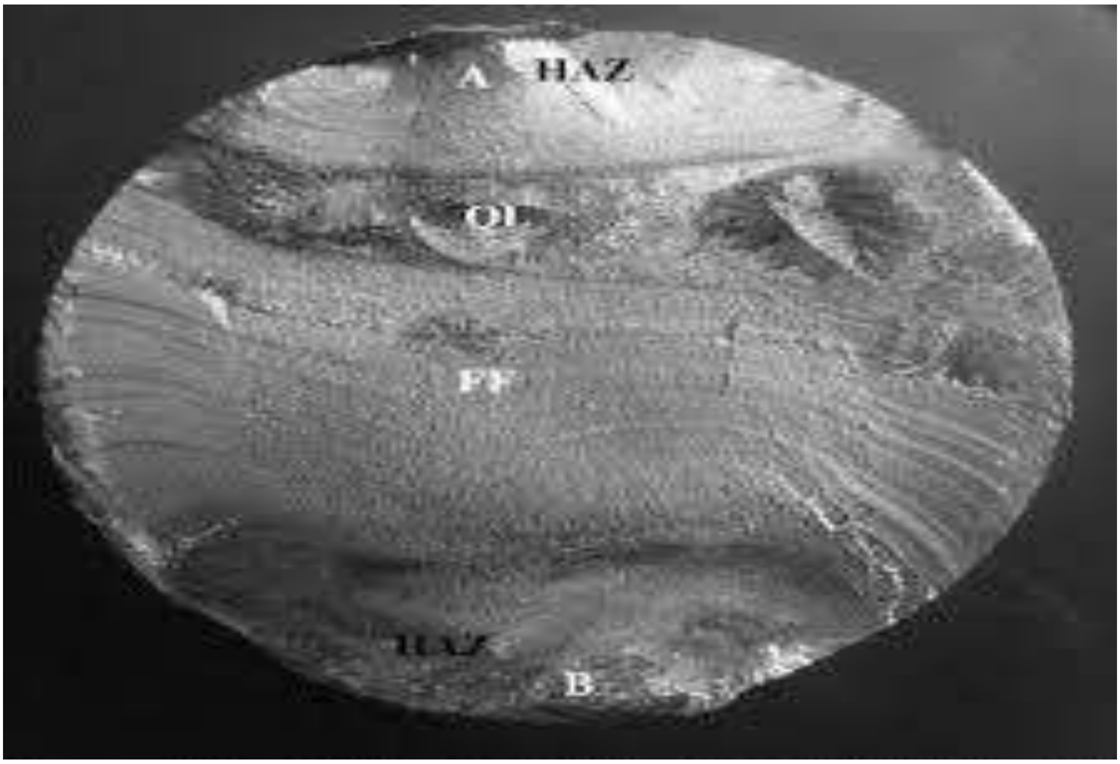

Fig 5.1 fatigue failure of shaft

failures and, on the rare occasions they do, leave clear evidence. Of the other two mechanisms, fatigue is more common than overload

failureFatigue Reduction

Use stronger, more capable materials.

Reduce the margin of errors in assembly and manufacture.

Avoid, soften when inevitable, stress concentrations.

Keep residual stress at surface, if any, in compression

Take service environment into account.

Schedule routine maintenance, firm and thorough

torsonal fatigue

The 45° angle to the central axis is a sure sign of torsional stresses, and the change in surface roughness across the shaft indicates the cause was fatigue forces. failed due to torsional fatigue aggravated by a reduction in strength caused by corrosion

failure due to loading

Many times corrosion will act in conjunction with fatigue loading to cause shaft a failure. One of the more common causes of shaft failure is due to fatigue. Metal fatigue is caused by repeated cycling of the load. It is a progressive localized damage due to fluctuating stresses and strains on the material.

CHAPTER VI

ANALYSIS OF REAR AXLE SHAFT

For design and investigation of engineering difficulties or problem we can solve by using the software is called ANSYS software. The ansys is finite element analysis software for advanced by ansys. It is user friendly graphical user interface package. Many no of CAD programmers have straight interfaces with the ANSYS program through software written by ANSYS or by the CAD venders. Interpreter for the programs like AutoCAD, and pro/engineer are accessible from ANSYS software.

There are following tasks which enable the ANSYS finite element analysis software for engineers to execute the performance on the models

1. Construct the computer models or send CAD models of structures,products components or systems
2. Petition the operating loads or other design production state
3. Examine the physical properties such as stress levels, temperature, disseminate etc
4. Optimize a design early in growth action to diminish manufacture piece
5. Do prototype testing in ambient where it otherwise would be undesirable or impossible

6.1 CATIA 3D MODELING

CATIA software (computer aided three dimensional interactive application) multi-platform for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM and 3D, developed by the CATIA enables the creation of 3D parts, CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scrat. So the ansys process for the project consist the following analysis of material properties such as a

- Static and model analysis of AISI 4140 alloy steel
- Static and modal analysis of composite material

The CATIA 3D modeling shaft done through the suitable dimensions and geometry are need for design of shaft. The shaft are the dimension requirements such length in x and z direction at value of $6.5577e^{-2}$m in both direction of axis, then diameter of shaft in y direction is 0.444m in the y axis to be created in CAD modeling.

6.2 METHODOLOGY

The ansys software done the analysis of rear axle shaft by using a composite material in aisi 4140 alloy steel.this is improve the rear axle shaft by method of composite material that initially investigated by ansys software. The composition of rear axle shaft such a material of AISI 4140 alloy steel. That is improved by the composition with “zirconium and aluminium” with the percentage equal to the composition of chromium in “chromium-molybdenum alloy steel” because of the “zirconium and aluminium” added instead of chromium in AISI 4140 alloy steel in rear axle shaft material. The AISI 4140 alloy steel that analyse the static and model analysis to be carried out and also composite material only the static analysis to be analysed. The chemical composition AISI 4140 alloy steel “chromium-molybdenum alloy steel

6.2.1 Composition of AISI 4140 alloy steel

Element	Content (%)
Iron, Fe	96.785-97.77
Chromium, Cr	0.80-1.10
Manganese, Mn	0.75-1.0
Carbon, C	0.380-0.430
Silicon, Si	0.15-0.30
Molybdenum, Mo	0.15-0.25
Sulfur, S	0.040
Phosphorous, P	0.035

6.2.2 Design of AISI 4140 alloy steel

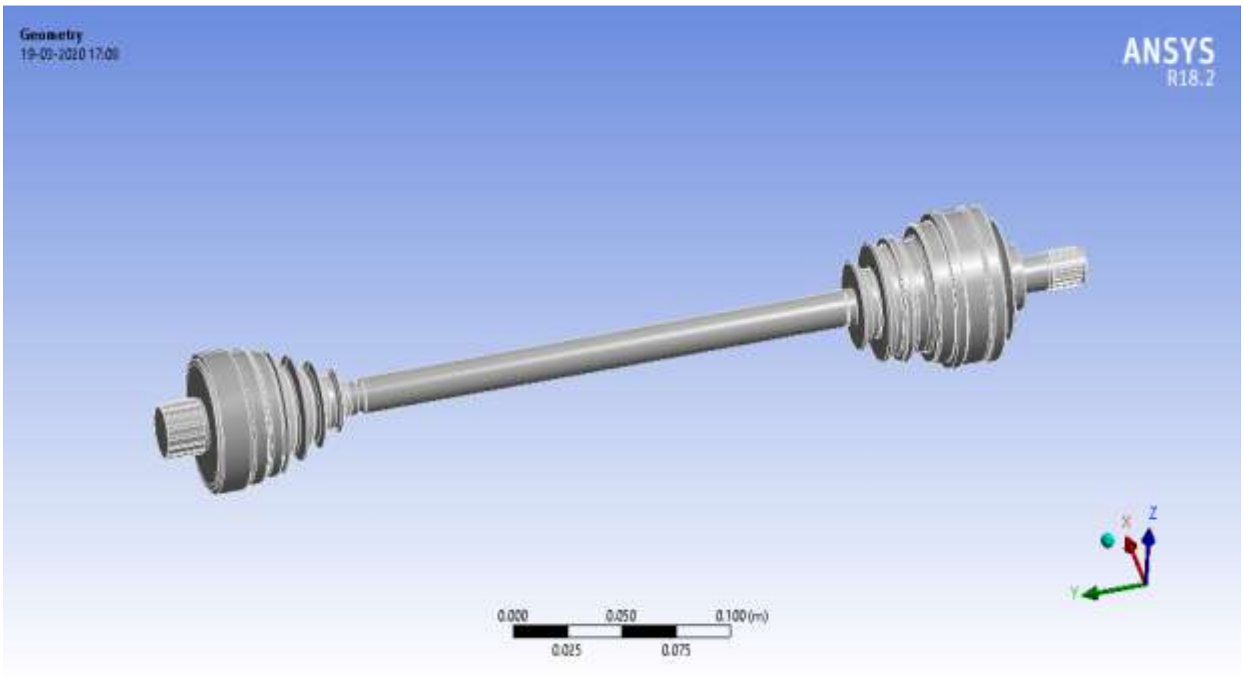

Fig 6.1 AISI 4140 rear axle shaft

The chemical composition that appear the “chromium-molybdenum alloy steel” the our project is to applied the “zirconium and aluminium” to added instead of chromium. The chromium present in AISI 4140 Steel as 0.80% to 1.10% in exact percentage of chromium present in aisi 4140 steel is 1 % to be presented. That we taken the standard percentage of Cr-1% then we add the Zr and Al in the percentage of 0.70% and 0.30% which it equal to percentage of chromium, that new composite material is sample to be tested as per condition of sample material for its mechanical property to be prepared on the following composition of material.

6.2.3 Composition of new material

Element	Content (%)
Iron, Fe	96.785-97.77
Zirconium,Zr	0.60-070
Aluminium,Al	0.20-0.30
Manganese, Mn	0.75-1.0
Carbon, C	0.380-0.430
Silicon, Si	0.15-0.30
Molybdenum, Mo	0.15-0.25
Sulphur, S	0.040
Phosphorous	0.035

Table 6.2 composition of composite material

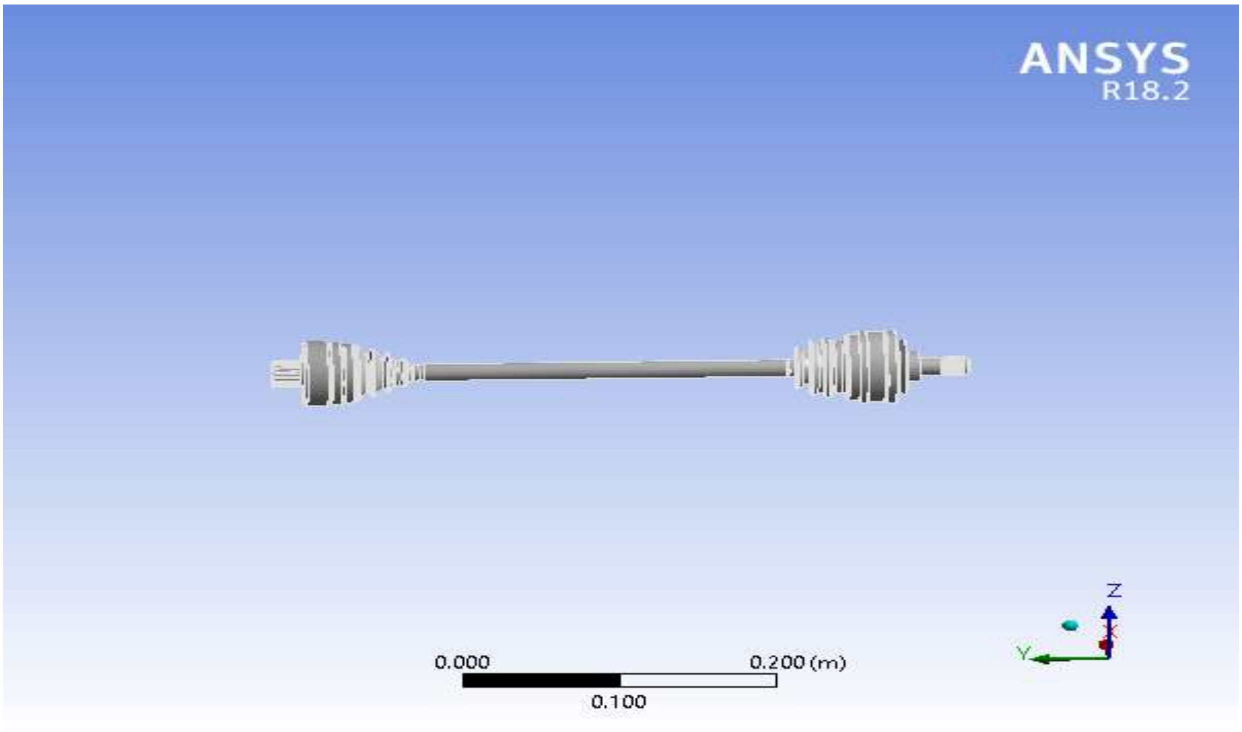

Fig 6.2 rear axle shaft in composite material

6.2.4 Properties of composite material

Property	Metric
Density	7.6 kg /m^3
Modulas of elasticity	209Gpa
Bulk modulus	174,4Gpa
Shear modulus	80.3Gpa
Poisson’s ratio	0.3
Tensile ultimate strength	670 Mpa
Tensile yield strength	450 Mpa

Table 6.3 property of composite material

This the project analysis oriented point of view in the composite material, property and the composition of material for analysis of rear axle shaft in new composite material

6.3 ANALYSIS OF AISI 4140 ALLOY STEEL

The analysis of “ chromium-molybdenum alloy steel” in the ANSYS software version of R18.2 for analysis of material in the property and static and model analysis that taken in the rear axle shaft material. Then the material properties are provide the ansys software as per the analysis of system. The analysis of aisi 4140 steel which consist following analysis

- Static analysis
- Model analysis

6.3.1 SHAFT DESIGN OF AISI 4140 ALLOY STEEL

The rear axle shaft design is basically done in the cad modeling in ansys r 18.2 version. The shaft is done basic requirements of length and diameter are provided for design of solid shaft. The design of aisi 4140 alloy steel shaft that designed by CAD modeling in ansys software by using ansys r18.2 version. CAD modeling shaft is designed at the requirements of rear axle shaft dimensions and its specifications to be followed. That the design specification such as length, diameter, loads and its property of material are to analysed for the design of shaft that the designed shaft to be involved in ansys analysis for the following analysis are done by Static analysis and Model analysis.When design the shaft at provide the dimension requirements such length in x and z direction at value of $6.5577e^{-2}$m in both direction of axis, then diameter of shaft in y direction is 0.444m in the y axis to be created in cad modeling. The volume of designed shaft as $3.372e^{-2}$ that are involved to analyse the total deformation,equivalent stress and equivalent elastic strain for analyse the strength of and mechanical property of the composite material shaft.

6.4 STATIC ANALYSIS OF AISI 4140 ALLOY STEEL

Static analysis deals with the conditions of equilibrium of the bodies acted upon by forces. A static analysis can be either linear or non-linear. All types of non-linearity are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc. A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those carried by time varying loads. A static analysis can however include steady inertia loads such as gravity, spinning and time varying loads. In static analysis loading and response conditions are assumed, that is the loads and the structure responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis includes, Externally applied forces, moments and pressures, Steady state inertial forces such as gravity and spinning, imposed non-zero displacements. A static analysis result of structural displacements, stresses and strains and forces in structures for components caused by loads will give a clear idea about whether the structure or components will withstand for the applied maximum forces. If the stress values obtained in this analysis crosses the allowable values it will result in the failure of the structure in the static condition itself. The static structural analysis of AISI 4140 alloy steel for following properties

Properties	Metric
Density	7.85 g/cm^3
Modulus of elasticity	205Gpa
Bulk modulus	80Gpa
Shear modulus	170Gpa
Poisson’s ratio	0.3
Tensile yield strength	415Mpa
Tensile ultimate strength	655Gpa

The properties of alloy are analysed for total deformation, equivalent stress and equivalent elastic strain in the static structural condition to be analysed

6.4.1 Meshing of shaft

Meshing of shaft for AISI 4140 alloy steel is mesh elements are created with respect to nodes and elements of shaft to be created in shaft by using ansys software. The mesh to be created total no of nodes 35376 and total no of elements 20631 for the shaft in form of FEA analysis The Finite Element Method (FEM) is a procedure for the numerical solution of the equations that govern the problems found in nature. When referred to the analysis of structures the FEM is a powerful method for computing the displacements, stresses and strains in a structure under a set of loads

Statistics	
Nodes	35376
Elements	20631

6.4.2 Total deformation of AISI 4140 alloy steel

Time[s]	Minimum [m]	Maximum [m]
1.	0.	1.1157e-002

6.4.3Equivalent stress of AISI 4140 alloy steel

Time[s]	Minimum [Pa]	Maximum [Pa]
1.	0.14394	5.3702e+009

6.4.4 Equivalent elastic strain of AISI4140 alloy steel

Time [s]	Minimum [m/m]	Maximum [m/m]
1.	1.035e-012	2.7131e-002

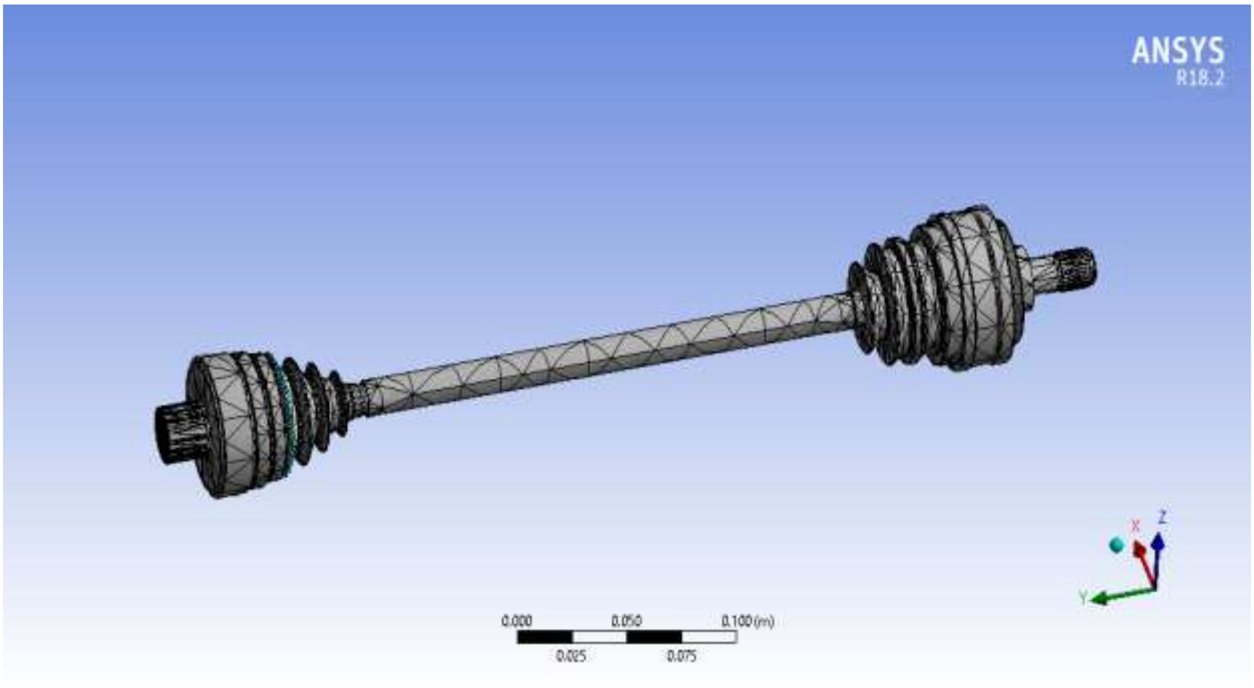

Fig 6.3 mesh of AISI 4140 alloy steel shaft

Total deformation of AISI 4140 alloy steel

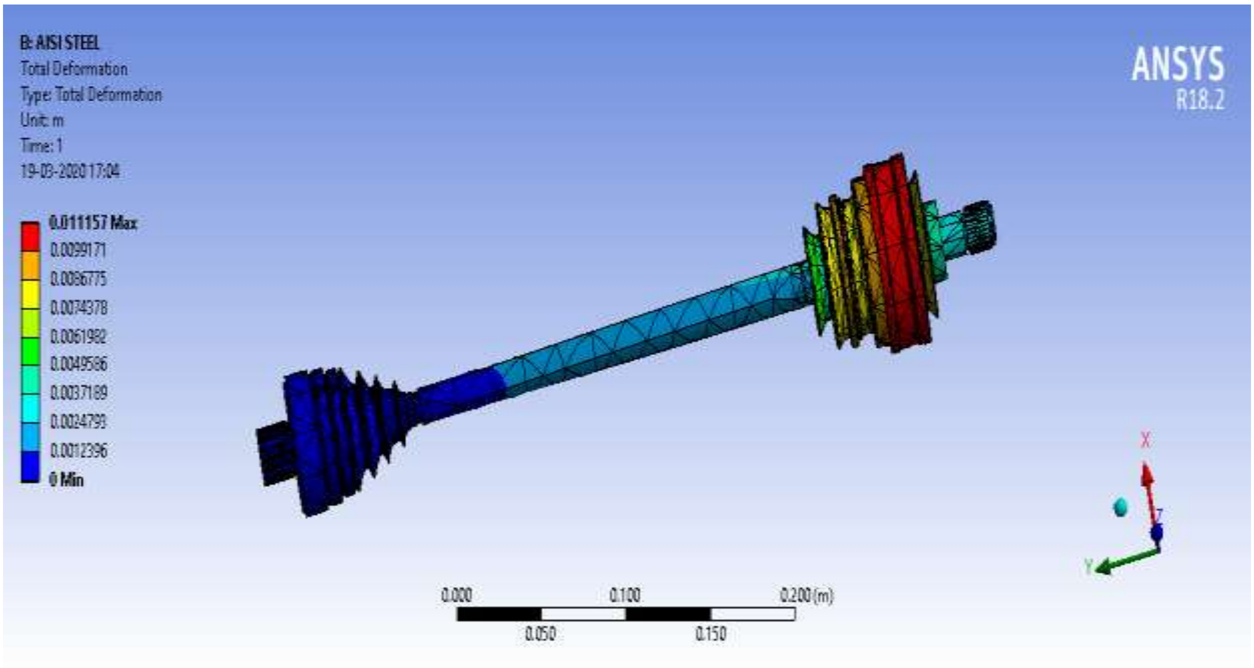

Fig 6.4 total deformation of AISI 4140 alloy steel

Equivalent stress of AISI 4140 alloy steel

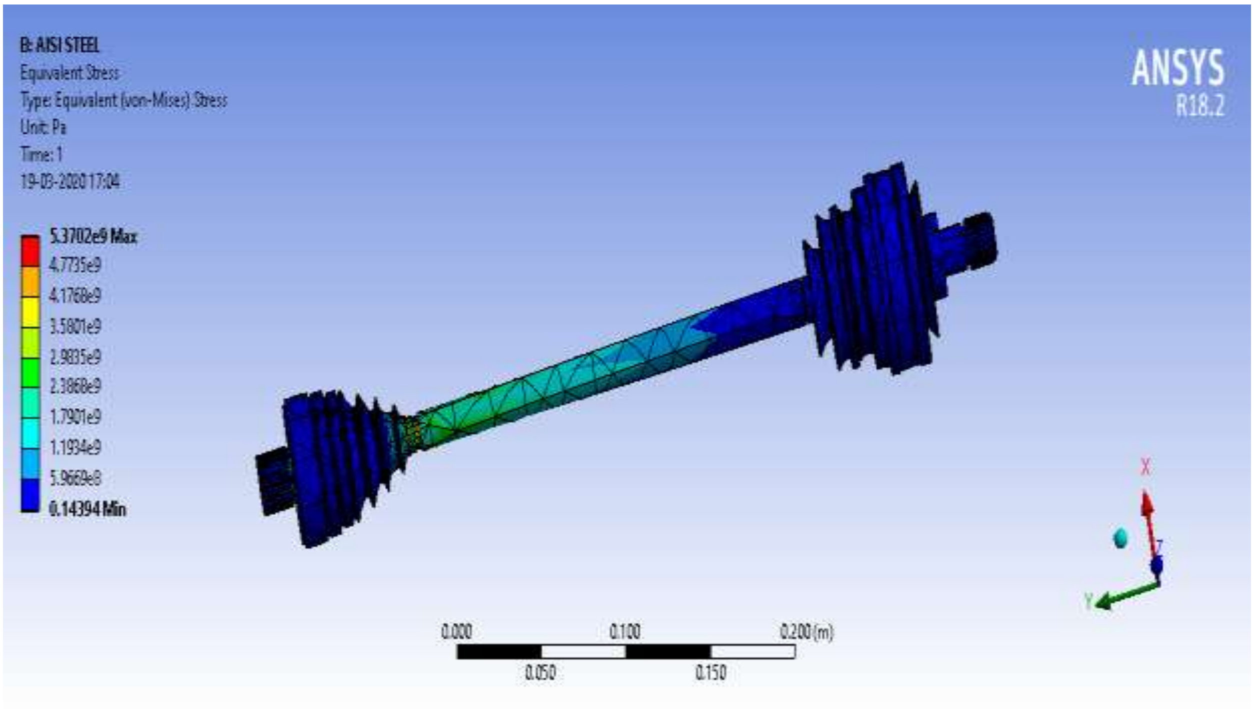

Fig 6.5 equivalent stress of AISI 4140 alloy steel

Equivalent elastic strain of AISI 4140 alloy steel

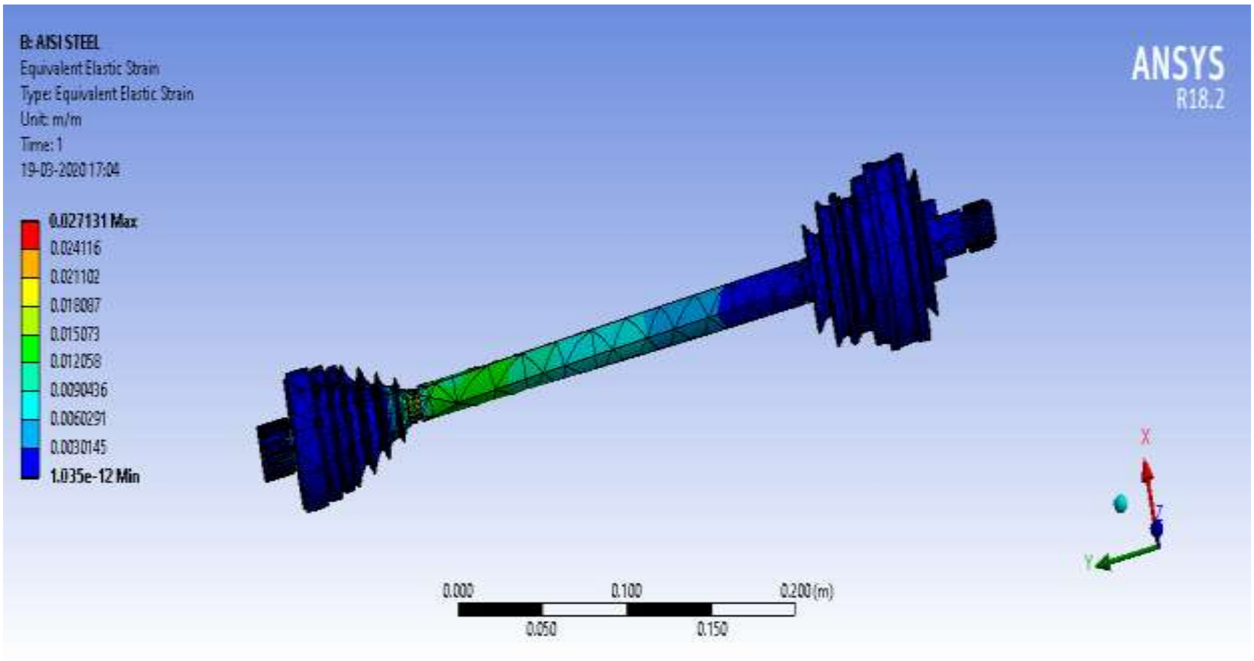

Fig 6.6 Equivalent elastic strain of AIS I4140 alloy steel

6.5 MODAL ANALYSIS OF AISI4140 ALLOY STEEL

Modal analysis of AISI 4140 alloy steel analyse the in which point of displacement, stress and strain, loading and deformation are occur in the point are to be analysed. The analysis of modal analysis is describe the total deformation in rear axle shaft for each and every node points are analysed with respect to frequency range in the each points

Statistics	
Nodes	35376
Elements	20631

That the modal analysis with respect to node point of shaft that also respect to the frequency changes such as 1,2,3,4,5,6,7,8 and 9 for analysis of total deformation of the to be determined. The bar chart describe the change of frequency and node point

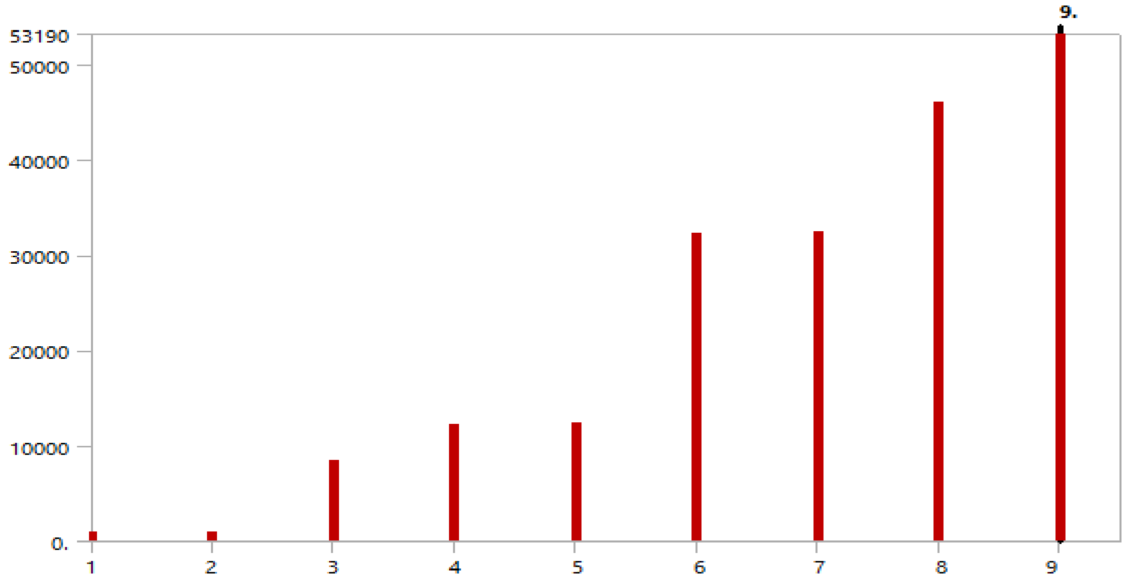

Fig 6.7 node vs frequency

That the frequency variation which respect to the each and every nodal point of shaft, so the frequency will gradually increase the each and every nodal point.

Frequency at different nodal points

Mode	Frequency [Hz]
1.	957.09
2.	992.68
3.	8556.2
4.	12230
5.	12330
6.	32258
7.	32538
8.	45943
9.	53190

Table 6.5 frequency value of shaft

The shaft will be deformed under the loading condition this values are provided below the total deformation of shaft.

Type	Total Deformation								
Mode	1.	2.	3.	4.	5.	6.	7.	8.	9.
Results									
Min	0. m								
Max	34.526 m	34.568 m	44.28 m	54.31 m	54.244 m	59.766 m	59.124 m	26.789 m	54.919 m

Table 6.6 total deformation of AISI 4140 alloy steel

Total deformation at low frequency

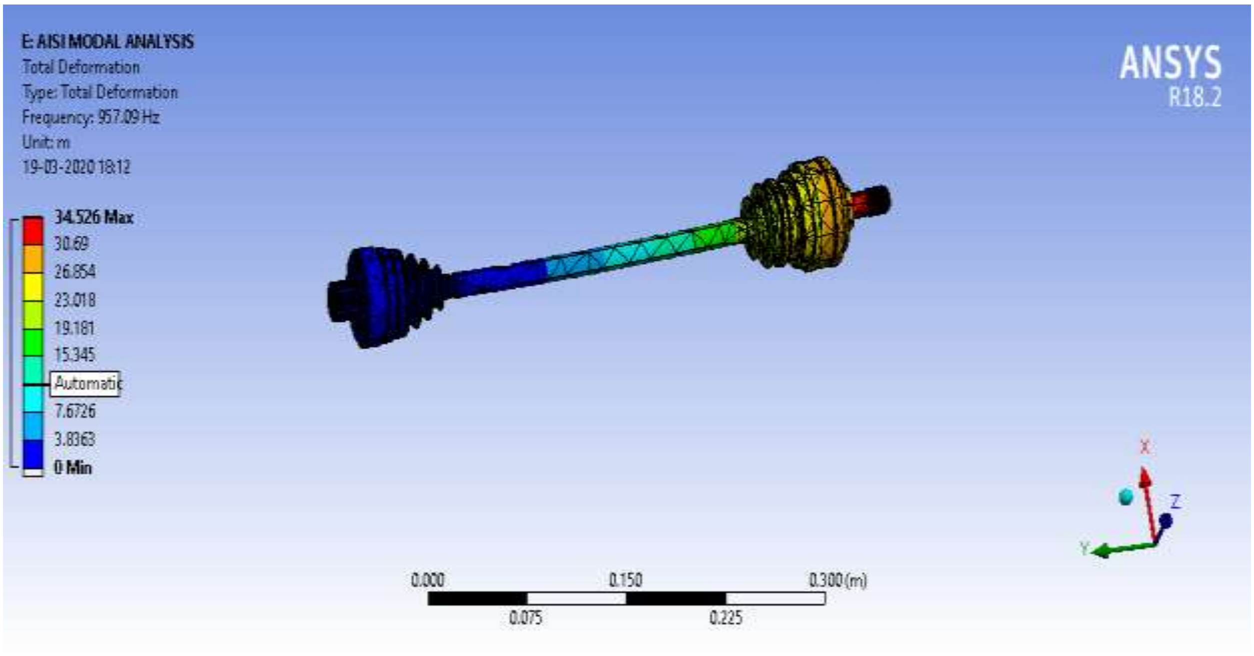

Fig 6.8 total deformation of shaft at low frequency

Total deformation at high frequency

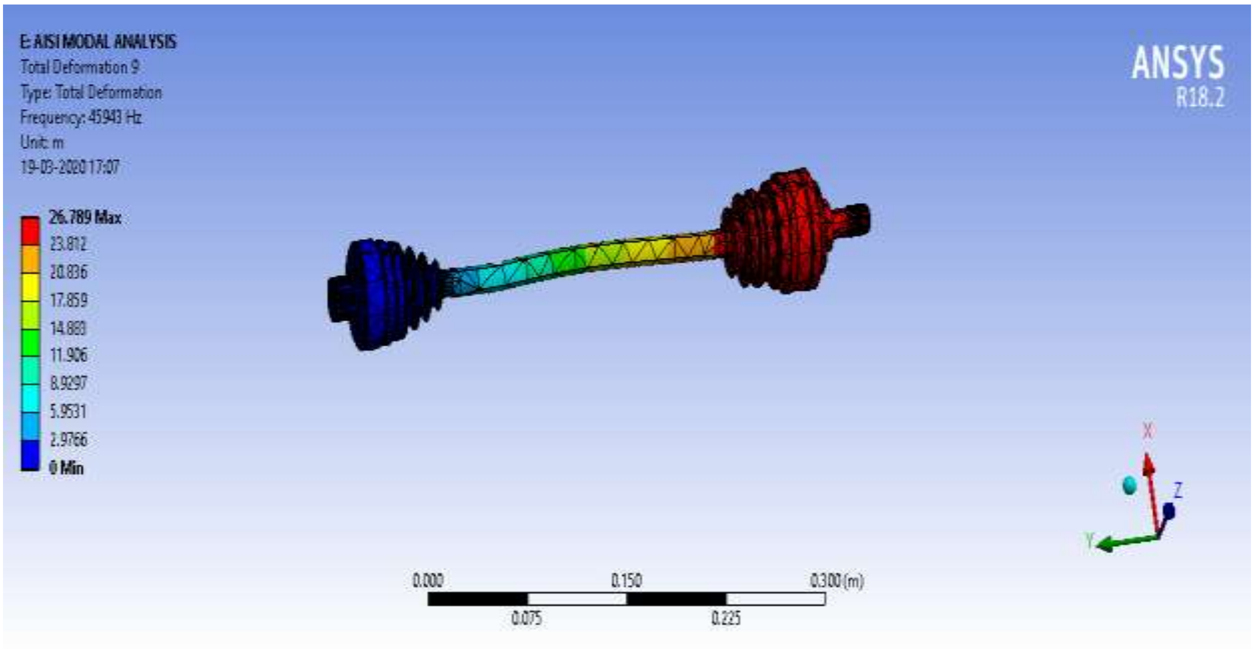

Fig 6.9 total deformation of shaft at high frequency

6.6 ANALYSIS OF COMPOSITE MATERIAL

The analysis of " chromium-molybdenum alloy steel" in the ANSYS software version of R18.2 for analysis of material in the property and static and model analysis that taken in the rear axle shaft material. Then the material properties are provide the ansys software as per the analysis of system. The analysis of composite material which consist following analysis

- Static analysis
- Model analysis

6.6.1 Shaft design of composite material

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6.7 STATIC ANALYSIS OF COMPOSITE MATERIAL

Static analysis deals with the conditions of equilibrium of the bodies acted upon by forces. A static analysis can be either linear or non-linear. All types of non-linearity are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc. A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those carried by time varying loads. A static analysis can however include steady inertia loads such as gravity, spinning and time varying loads. In static analysis loading and response conditions are assumed, that is the loads and the structure responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis includes, Externally applied forces, moments and pressures, Steady state inertial forces such as gravity and spinning, imposed non-zero displacements.A static analysis result of structural displacements, stresses and strains and forces in structures for components caused by loads will give a clear idea about whether the structure or components will withstand for the applied maximum forces.

Properties of composite material

Property	Metric
Density	7.6 kg /m^3
Modulas of elasticity	209Gpa
Bulk modulus	174,4Gpa
Shear modulus	80.3Gpa
Poisson’s ratio	0.3
Tensile ultimate strength	670 Mpa
Tensile yield strength	450 Mpa

The analysis of composite material are to be done the total deformation, stress and strain and also loading and frequency range are to be calculated by using analysis of composite mater.The properties of alloy are analysed for total deformation, equivalent stress and equivalent elastic strain in the static structural condition to be analysed

6.7.1 Meshing of shaft

Meshing of shaft for AISI 4140 alloy steel is mesh elements are created with respect to nodes and elements of shaft to be created in shaft by using ansys software. The mesh to be created total no of nodes 35376 and total no of elements 20631 for the shaft in form of FEA analysis The Finite Element Method (FEM) is a procedure for the numerical solution of the equations that govern the problems found in nature. When referred to the analysis of structures the FEM is a powerful method for computing the displacements, stresses and strains in a structure under a set of loads

Statistics	
Nodes	35376
Elements	20631

6.7.2 Total deformation of composite material

Time [s]	Minimum [m]	Maximum [m]
1.	0.	1.0943e-002

6.7.3 Equivalent elastic strain of composite material

Time [s]	Minimum[m/m]	Maximum [m/m]
1.	1.0181e-012	2.6612e-002

6.7.4 Equivalent stress of composite material

Time [s]	Minimum [Pa]	Maximum [Pa]
1.	0.14485	5.9702e+009

Tables 6.7 analysis of composite material values

Total deformation of composite material

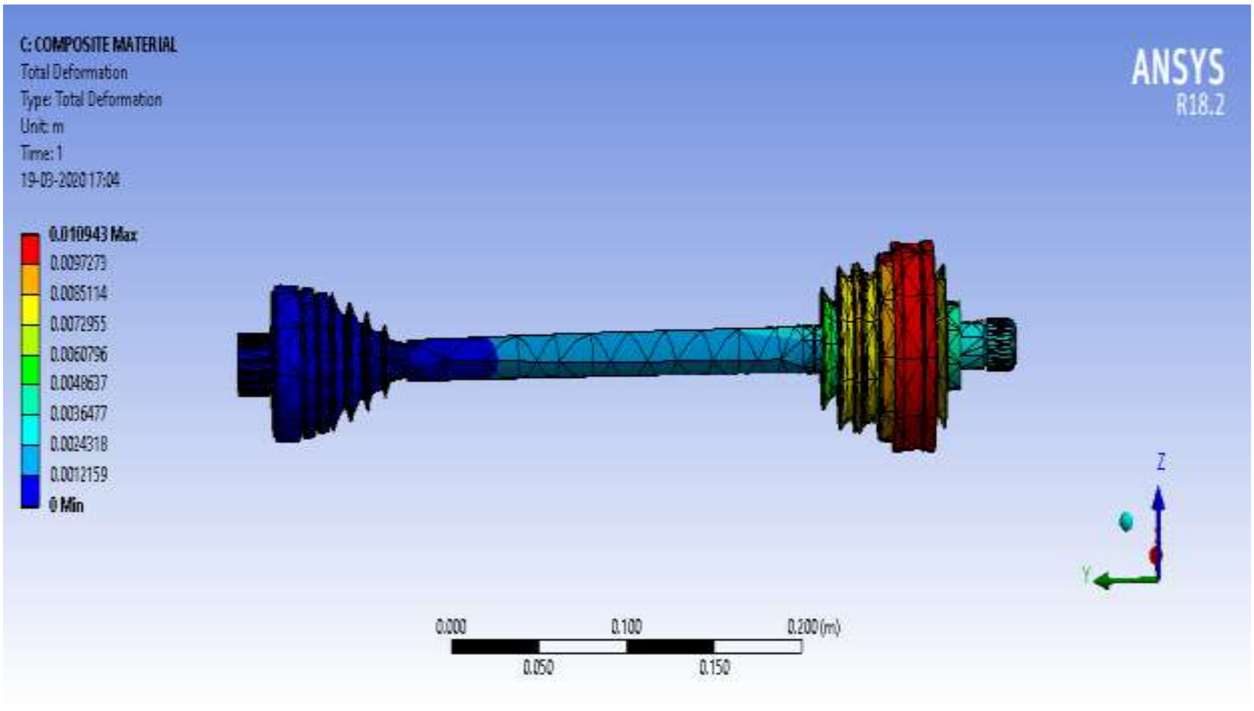

Fig 6.10 total deformation of composite material

Equivalent elastic strain of composite material

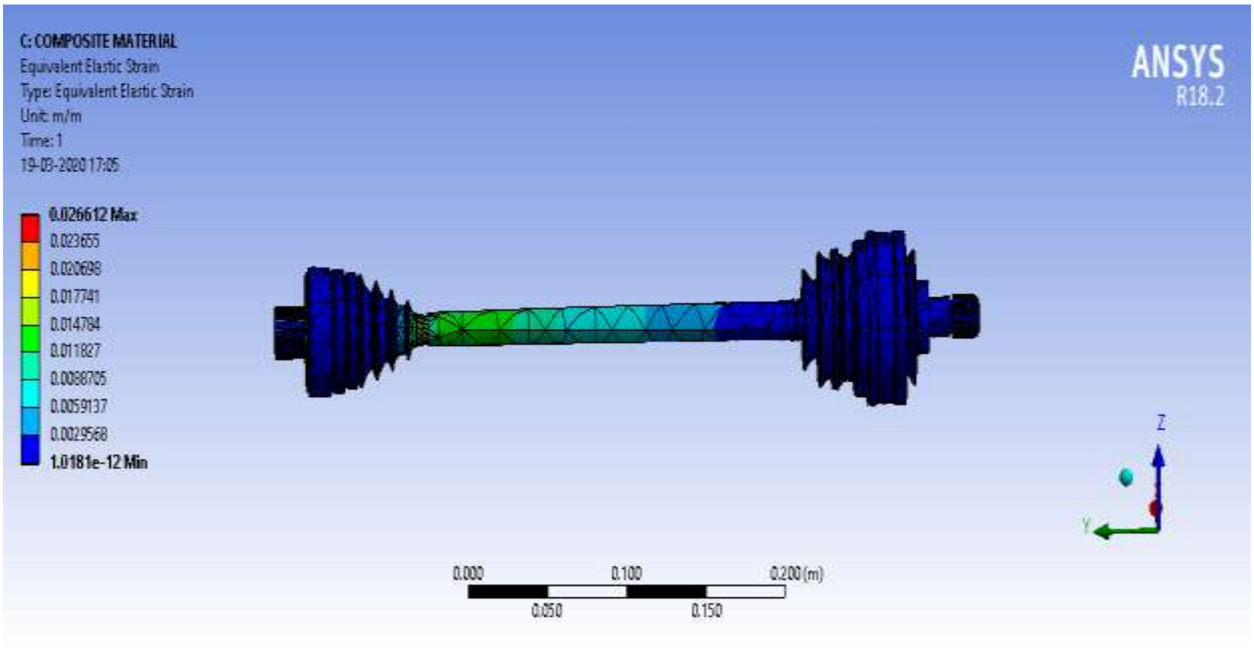

Fig 6.11 equivalent elastic strain of composite material

Equivalent stress of composite material

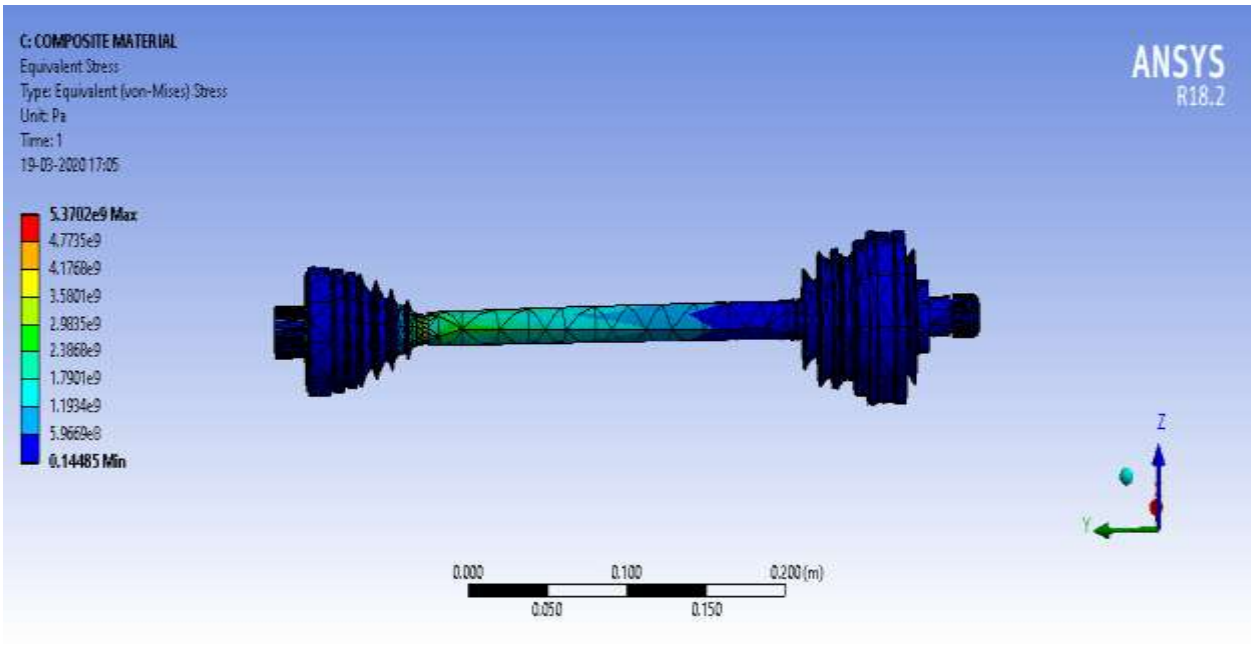

Fig 6.12 equivalent stress of composite material

6.8 MODAL ANALYSIS OF COMPOSITE MATERIAL

Modal analysis of AISI 4140 alloy steel analyse the in which point of displacement, stress and strain, loading and deformation are occur in the point are to be analysed. The analysis of modal analysis is describe the total deformation in rear axle shaft for each and every node points are analysed with respect to frequency range in the each points

Statistics	
Nodes	35376
Elements	20631

That the modal analysis with respect to node point of shaft that also respect to the frequency changes such as 1,2,3,4,5,6,7,8 and 9 for analysis of total deformation of shaft to be determined. Below the bar chart represent the frequency rate at each nodal points

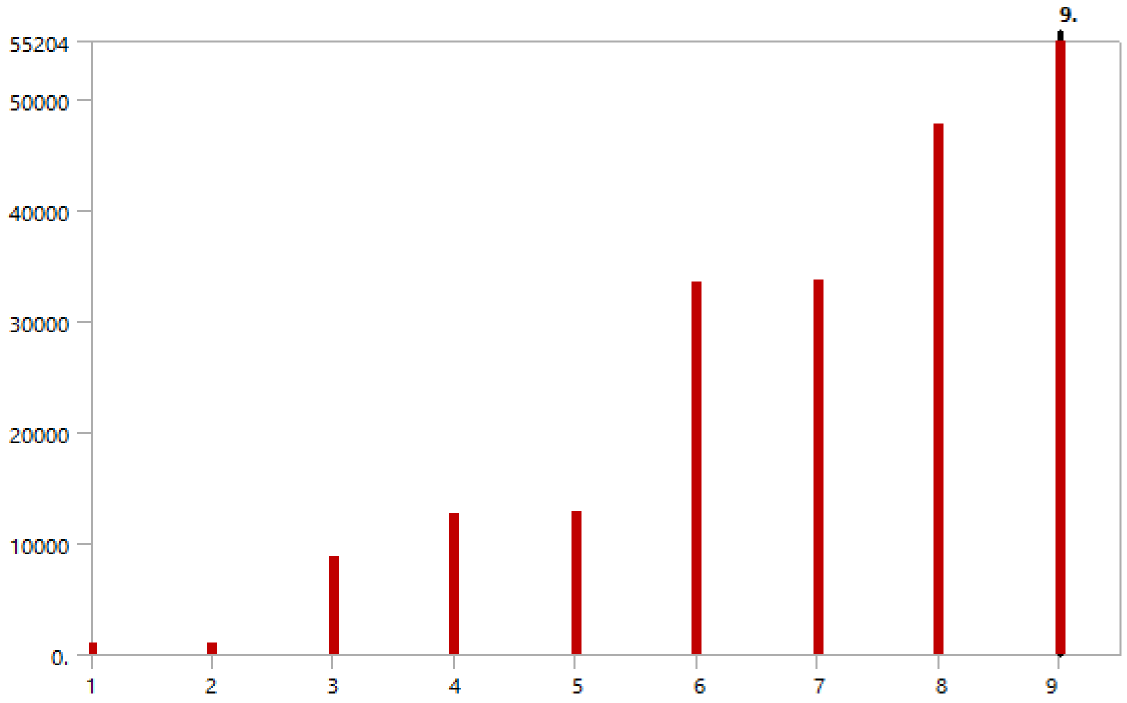

Fig 6.13 node vs frequency

That the frequency variation which respect to the each and every nodal point of shaft, so the frequency will gradually increase the each and every nodal point.

Frequency at different nodal points

Mode	Frequency [Hz]
1.	993.34
2.	1030.3
3.	8880.3
4.	12693
5.	12797
6.	33480
7.	33771
8.	47683
9.	55204

Table 6.8 frequency value of shaft

Total deformation of composite shaft

The shaft will be deformed under the loading condition this values are provided below the total deformation of shaft.

Type	Total Deformation								
Mode	1.	2.	3.	4.	5.	6.	7	8	9
Results									
Min	0. m								
Max	35.49 m	35.532m	45.52 m	55.834 m	55.75 m	61.43 m	62.78 m	35.53 m	68.12 m

Table 6.9 total deformation of composite shaft

Total deformation at low frequency

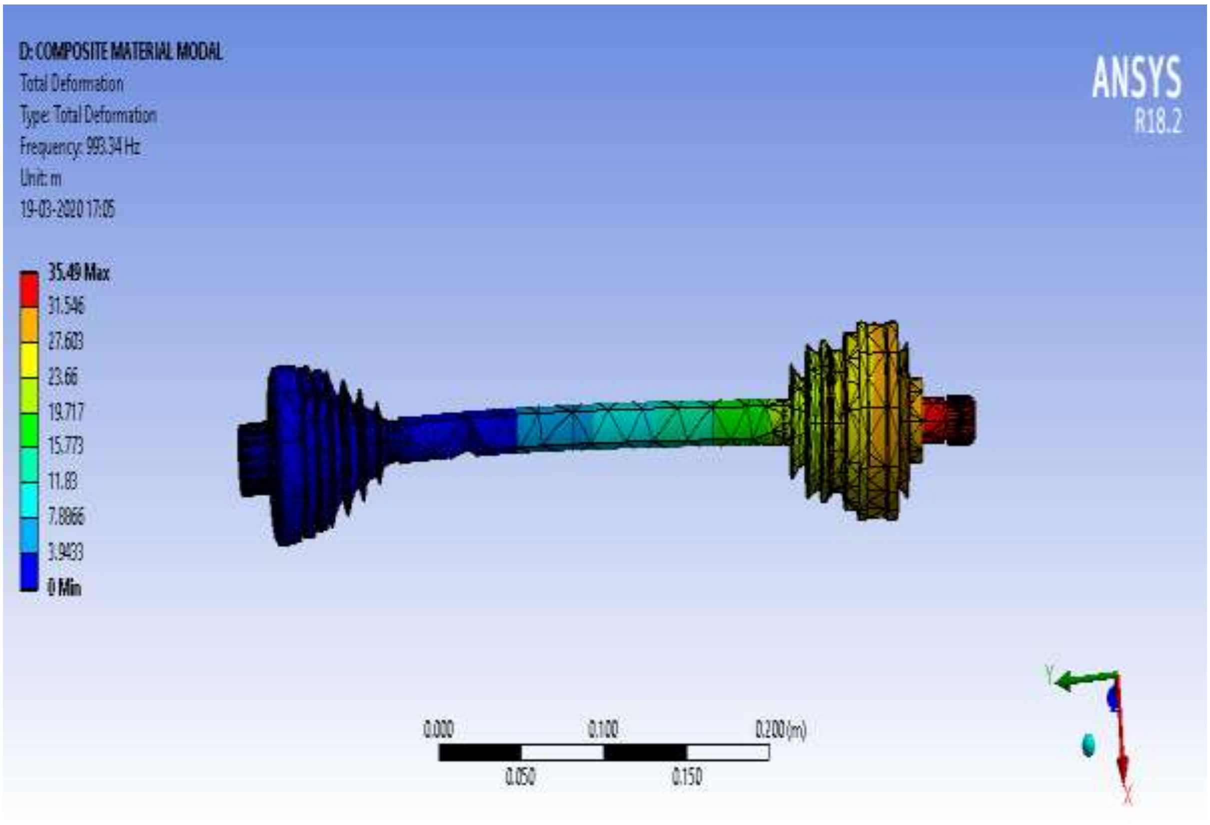

Fig 6.14 total deformation at low frequency

Total deformation at high frequency

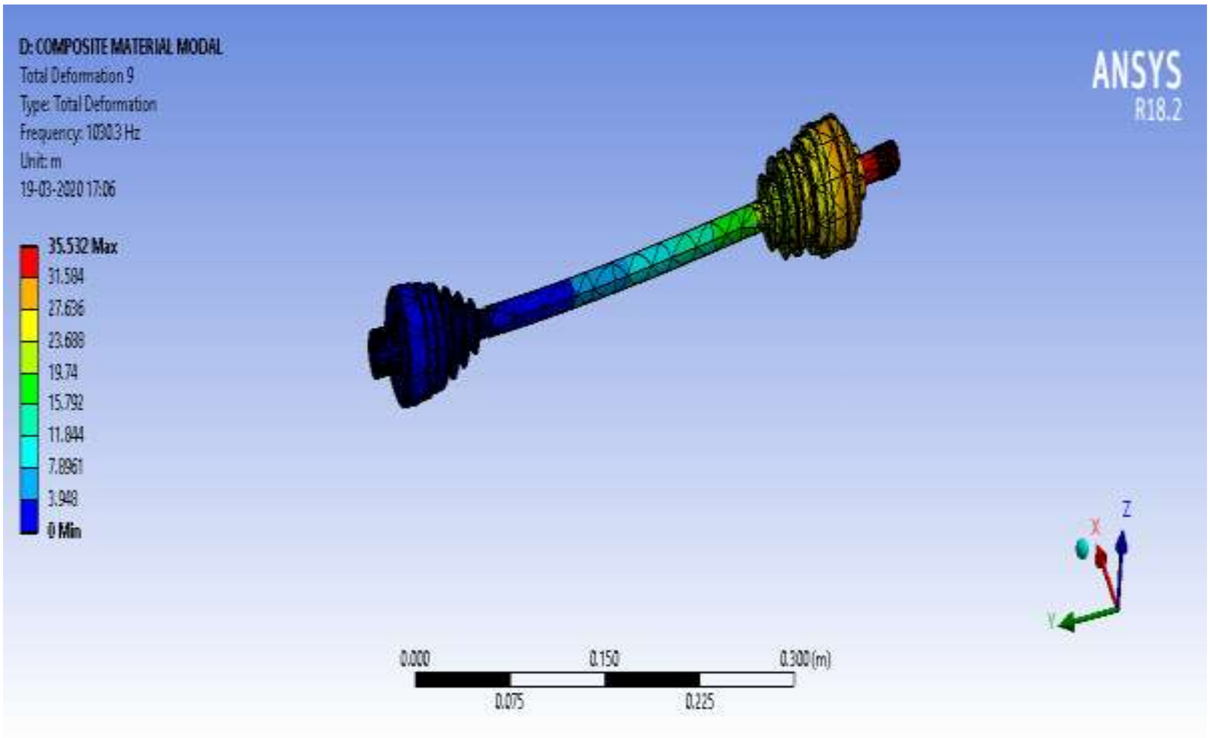

Fig 6.15 total deformation at high frequency

Mode	Frequency [Hz]
1.	993.34
2.	1030.3
3.	8880.3
4.	12693
5.	12797
6.	33480
7.	33771
8.	47683
9.	55204

The total deformation of composite shaft should be determined by ansys software in the nodal analysis of composite material

CHAPTER VII

RESULT AND DISCUSSION

7.1 Static analysis of materials

Static analysis	**AISI 4140 alloy steel**		**Composite material**	
	minimum	maximum	minimum	Maximum
Total deformation[m]	0.	1.1157e-002	0.	1.0943e-002
Equivalent elastic strain[m/m]	1.035e-012	2.7131e-002	1.0181e-012	2.6612e-002
Equivalent stress[pa]	0.14394	5.3702e+009	0.14485	5.9702e+009

Table 7.1 result of static analysis of materials

7.2 Modal analysis of materials

Modal analysis					
AISI 4140 alloy steel			**Composite material**		
Node	Total deform	Frequency	Node	Total deform	Frequency
1	34.526	957.09	1	35.49	993.34
2	34.568	992.68	2	35.39	1030.3
3	44.284	8556.2	3	45.52	8880.3
4	54.318	12230	4	55.839	12693
5	54.244	12330	5	55.757	12797
6	54.766	32258	6	61.434	33480
7	59.124	32538	7	62.784	33771
8	26.789	45943	8	35.259	47683
9	54.919	53190	9	68.12	55204

Table 7.2 result of modal analysis of materials

CHAPTER VIII

CONCLUSION

- The analysis of AISI 4140 alloy steel and composite material for analysis of static and modal analysis was done by using ANSYS software R18.2 version
- The analysis of composite material for static and modal analysis was done using ANSYS software R18.2 version
- The total deformation, equivalent elastic strain and equivalent stress are analysed for both AISI 4140 alloy steel and composite material are to be analysed.
- That also show the total deformation, equivalent elastic strain and equivalent stress of composite material is better than AISI 4140 alloy steel
- The properties of composite material also better than AISI 4140 alloy steel
- So we are improve the material property that is done by ANSYS software for composite materials that we are suggest the more applications of automobiles for using composite material

CHAPTER IX

REFERENCE

- 1.J.Sudhakaran, G.Sakthivel ,S.Sheril in the department of mechanical engineering" performance and analysis of tractor rear axle shaft by using composite material"
- David roylance, department of material science and engineering " fatigue in the shaft" Cambridge, may 1,2001
- Subrata kr mandal,palash kr maji, and s karmakar. CSIR- central mechanical engineering research institute "analysis of an intermediate rear axle shaft failure"
- Deepa ramane, sinhgad technical education society, for "failure analysis of axle shaft using fishbone diagram and image processing" December 2016
- Piyush.c.chaudhan, vimal.d.sonara,Dr.praveen,p.rathod, in international jouranal of advance engineering and research development,volume 2,issue 3, march-2015
- David Roylance, department of material science and engineering for "fatigue analysis" at may 1, 2001
- J.Sudhakaran, G. Sakthivel, S.Sheril , department of mechanical engineering for " performance and analysis of tractor rear axle shaft by using composite materials.
- Piyush C.Chaudhan, Vimal.D. sonara, Dr.Pravin . P. Rathod, department of mechanical engineering for " analysis and design of tractor rear axle shaft using finite element method.
- F.Muahidin, Andoko , department of mechanical engineering for " stress analysis of rear axle pick up using finite element method.

- J.G. Kaufman , for “measuring the effects of properties and charecteristics of aluminium and aluminium alloys.