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Design And Analysis Of Composite Shaft For A Dc Motor

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Abstract- The purpose of the thesis is to investigate the use of a composite shaft material in place of a traditional shaft material (Carbon steel SAE 1045). Composite structures provide benefits over traditional metallic ones like stronger strength, higher specific stiffness, and reduced density. Applications where weight reduction is crucial without sacrificing quality or safety use composite shafts due to their unique properties. This thesis was created for businesses who produce motors and generators. This thesis intends to provide a composite shaft that is lighter than a normal shaft and will be employed in motors with lighter overall requirements.

Keywords- Carbon steel SAE 1045, stiffness etc.

I. INTRODUCTION

Company in this industry manufacture electric motors, power generators, and motor generator sets. Major US companies include AMETEK, Baldor Electric, Franklin Electric, and Regal Beloit, as well as divisions of Emerson Electric and GE; major companies based outside the US include Nidec (Japan), Panasonic (Japan), and Siemens (Germany). The major leading companies in the production of motors and generators include China, Germany, Japan, Latin America, and the US. In the recent years, countries that have attracted investment in motor and generator factories, in large part because of favorable cost structure include India, China, Brazil, the Czech Republic, Mexico and Thailand. US manufacturing of electric motors and generators involves about 400 companies with combined annual revenue of about $11 billion.

These industries do not include makers of starter motors and battery charging alternators for internal combustion engines or makers of turbine generator sets. Industrial and manufacturing companies drive demand. The profitability of the company is mainly dependent on the efficient production. Small companies can compete by specializing the products and making as per the request from the customers. But large companies like G.E, produce mainly a standard line of products based on the power requirements, smaller companies are more likely to adapt products for customer's special needs. In Indian markets main competitors are G.E, Siemens, ABB, Crompton Greaves, TDPS, Toshiba, and BHEL. Export of motors and generators; go primarily to Mexico and Canada.

1.2 Introduction to concepts

1.2.1 FEM (Finite Element Method)

The finite element method (FEM) is a numerical method used to solve problems of mathematical physics and engineering. Mainly this method is used in heat transfer, fluid flow, mass transport, structural analysis, dynamic analysis, electromagnetic potential. To do the analytical solution it requires boundary value problems for partial differential equations. There are systems of algebraic equations for the formulation of finite element method problems.

This method gives an approximate value of the unknowns at discrete number of points over the domain. In-order to solve the problem, FEM technique sub divides a larger problem into smaller, which are called as finite elements. The finite elements that forms the model is formed with simple equations are then assembled to form a larger equation that models the entire problem. The variational methods are used in the FEM technique which is taken from calculus of variations to approximate a solution by minimizing an associated error function. The advantage of FEM which analyses a component by splitting it into simpler partsare

- Local effects are been identified.
- The total solution can be easily represented.
- The complex geometry can be accurately represented.
- Material properties can be assigned differently

for each segment. In this case the above method involves the problem to be divided into sub- domains, with each subdomain are been represented by a set of element equations to the original problem, gradually the elemental equation are combined together into a global system of equations for the final calculation. In-order to achieve a numerical solution the global system of equations has known solution techniques, and can be calculated from the initial values of the original problem.Firstly the element equations are simple equations which approximate the original complex equations to be studied, in which the partial differential equations are original equations.

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In FEM approximation is used in this process and they are commonly introduced as a special case of Galerkin method. In this case the integral value is set to zero, and main aim is to construct an integral of the inner product of the residual and the weight functions. By fitting the trial functions into the PDE it will minimize the error of approximation. Polynomial functions are weight functions and the residual is the error caused by the trial function. This process will remove all the spatial derivations from the Partial differential function, thus the PDE is locally approximated.

- For transient problems a set of ordinary differential equation is used,
- For steady state problems a set of algebraic equation is used.

The sets of equations are elemental equation. If the PDE is linear then the sets of equations are linear and vice-versa. Numerical linear algebra methods are used to solve the steady state problems in which algebraic equations are involved. The numerical method such as Euler's method or the Runge-Kutta method is used when the ordinary differential equations are used in transient problems.

The sub domain's local nodes are been transformed into domain's global nodes through the global system equations which is generated from the elemental equation. In the reference to the coordinate system the spatial transformation includes the appropriate orientation adjustments. This process is carried out by the software called **Ansys Workbench** using coordinate data generated from the sub domains.

To perform the engineering analysis FEA (Finite Element Analysis) is used. This technique uses mesh generation in-order to divide a complex problem into small elements. The software program coded with FEM algorithm is applied. The FEA divides the complex problem into small elements of the complex problem which involves a physical system with the underlying physics such as the heat equation, Navier-Stockes equations, and the Euler-Bernoulli beam equation. FEA simulations remove multiple instances of creation and testing of hard prototypes for various high fidelity situations.

1.2.2 Mesh Generation

It includes the generation of a polygonal or polyhedral mesh which approximates a geometric domain. The term grid generation is used often. In the finite element method we generally use the mesh generation. The common use model can vary greatly are CAD, NURBS, B-rep, STL or a point cloud.The meshes used in FEM consists of the below types tetrahedral, prisms, pyramids and hexahedra. Those which are used for FEM usually need to have piecewise structured arrays of hexahedra which is known as multi-block structured meshes. So the mesh is otherwise called a discretization of a domain existing in one,two, three dimensions.

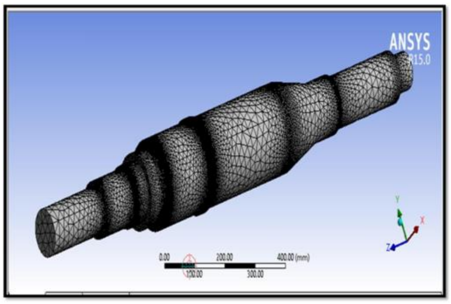

Fig 1. Pictorial representation of mesh

1.2.3 Boundary Condition

Boundary Conditions are the constraints which are necessary in order to have the solution for boundary value problems. The boundary value problem is the differential equation which is to be solved in a domain on whose the set of boundary condition are known. In some cases the initial value of the problem is known in which only the conditions on one extreme is calculated and it is known as "initial value problem". The boundary value problems are all extremely important as they model a vast amount of phenomena and the applications, which covers from solid mechanics to acoustic diffusion. In every problem they arise naturally based on a differential equation to be solved in the space on the other hand the initial value problems usually refer to the problems which are solved based on time. Jocques Charles Francois Strum and Joseph Liouville have been studying mainly on the boundary value problems; they studied mainly on the Eigen values of a linear differential equation of the second order.

1.2.4 Types of boundary condition

Both ordinary and PDE needs the boundary conditions which need to be solved. In the boundary of the domain different types of boundary conditions can be imposed. The correct choice of the boundary condition is fundamental for the resolution of the computational problem. If we apply a bad imposition of the boundary condition it may lead to the divergence of the solution or the convergence to a wrong solution.

1.2.5 Dirichlet Boundary Condition

The Dirichlet boundary condition is a type of boundary condition which is named after Peter Gustav Lejeune Dirichlet. It specifies the value that the unknown function which needs to take along.

1.2.6 Neumann boundary Condition

The Neumann boundary condition, it is a type of boundary condition, which is named after Carl Neumann. This condition when imposed on the ordinary or partial differential equation, which specifies the values that the derivative will take on the value that the derivative of the solution.

1.2.7 Robin Boundary Condition

This boundary condition which is called as robin boundary condition which consists of a linear combination of the values of the field and its derivatives on the boundary.

1.2.8 Mixed boundary condition

This boundary condition consists of applying different types of the boundary conditions which are in different parts of the domain. This boundary conditions must be applied on the whole boundary.

II.METHODOLOGY

2.1 Objective of study

To Finalize the appropriate composite material and motor for the thesis.

The appropriate composite material which is used for the shaft is selected in the project which is carried out by Mr. Arunprasad. The composite material choosen by him is AlSiC. Previously SAE 1045 material was used for the shaft.This thesis is carried out in the motor MGF 400 (Motor Frame size: 400mm(from the base to center of the shaft). M-Master Line, G- Squirrel Cage, F- Air to Air type heat exchanger), Power: 260KW, Supply Voltage: 6,300V, Poles: 4P, Frequency:50Hz.

To model the shaft and apply boundary conditions

The shaft is modelled in solidworks. Since this model is being analyzed in Ansys, the shaft is simplified and all the fillets and champhers are removed. This model is then imported into Ansys and boundary conditions like the Cylindrical support which symbolizes the bearings, Frictionless support on the face where the bearings are seated, shaft is locked in the tangential direction on the face where the coupling is coupled.

To perform the static analysis

In this process the static analysis on the shaft is performed. The mass of the fan and shafts are considered in the model. The static analysis is done inorder to find the deflection on all the direction such as X direction, Y direction and on Z direction. Even the Von-Mises stress is calculation on the model.

To perform the modal analysis

Here it determines the vibration characteristics (both natural frequencies and mode shapes). In this thesis the first 6 mode shapes are plotted from the ANSYS. These natural frequencies are then compared with the running frequencies and electrical frequencies. These natural frequencies should not fallen with the range of running and electrical frequencies which is detremined by the API standard.

To perform the torsional buckling analysis

It is an angular vibration of an object which is commonly a shaft along its axis of rotation. In ANSYS the torsional buckling analysis is done by locking the shaft from rotation and applying the breakdown torque on to it. Here it is noticed where the shaft is falling in torsional.

R Elayaraja investigated to develop a polymer composite with Prosopis juliflora and mango tree as reinforcements of a natural composite epoxy resin matrix. Composite plates were produced using a compression mold method with a composition ratio of 60:40,65:35 and 70:30. The resin and hardener proportions were 10:1 respectively. The manufactured composites were tested following ASTM standards to assess mechanical characteristics such as tensile strength, compressive strength, flexural strength, impact strength, hardness value, and water absorption test[6]

2.2 Problem Statement

This thesis is done in order to manufacture the motor with lesser weight, this is required to capture the market which demands comparatively less weight motor without compromising the quality. In order to do this the weight of the shaft is reduced by replacing the conventional shaft material with composite material and which has the advantages like higher strength, high specific stiffness and lower density. This is ensured by comparing the results got by ansysing the normal shaft with the composite shaft in the ANSYS. Whole process is done without compromising the quality.

2.3 Assumptions and Limitations of Study

Assumptions

- The shaft rotates at a constant speed about its longitudinal axis.
- The shaft material is non-weldable.
- The shaft has a uniform, circular cross section.
- The shaft is perfectly balanced with rotor.
- The composite material is isotropic and it obeys the Hooke’s law.

Limitations

The limitation of the study for this thesis was the motor. Here it was considered one sample motor i.e, MGF 400 (Motor Frame size: 400mm(from the base to center of the shaft). M-Master Line, G- Squirrel Cage, F- Air to Air type heat exchanger), Power: 260KW, Supply Voltage: 6,300V, Poles: 4P, Frequency:50Hz. Since there was constriant in the time and to manufacture the shaft it takes around 3 months time. So only the shaft has been modelled and done the analysis through ANSYS software.

2.4 Research Design

The methods used in the thesis for optimizing the design of the composite shaft is as defined below,

2.4.1 Static analysis in FEA

This type of analysis applicable to a problem where the stresses remain in the linear elastic range of the used material. The Static analysis is an analysis in which there is a linear relation between the displacement and the applied forces. In this type of static analysis the model’s stiffness matrix is constant, and the solving process is relatively short when it is compared to the non-linear analysis on the same model.

Modal Analysis

In the designing of the structure for dynamic loading condition the natural frequencies and the mode shapes are important. Modal Analysis it determines the vibration characteristics (both natural frequencies and mode shapes) of the component or a structure. It can be served as a starting point of another, which is more detailed, and sometimes called as dynamic analysis like the harmonic analysis, spectrum analysis or transient dynamic analysis.

Torsional Analysis

The torsional vibration in power transmission system is often a matter of concern using rotating shafts or couplings which causes uncontrolled failures. In the case of power generation, or transmission, and the system which uses a rotating parts, in which not only the torques are applied or reacted which leads to constant speeds, but which also leads to rotating plane in where the power is generated and the plane is taken out are same.

III.REVIEW OF LITERATURE

1. Classification of Composites

The composites are classified as below

- Metal matrix composites
- Polymer matrix composites
- Ceramic matrix

3.1.1 Metal matrix composite

A metal matrix composite is a composite material with at least two constituent parts, in which one part is metal and other material, is different metal or another material, such as an organic compound or a ceramic. If there is three materials are present, it is called a hybrid composite.

1.Composition

Metal matrix composites are generally made by dispersing reinforcing material into a metal matrix. Here the surface of the reinforcement may be coated with some chemicals into to prevent a chemical reaction with the matrix. For example carbon fibres in the aluminium matrix are coated with either titanium boride or nickel in order to prevent the reaction with aluminium matrix. In aluminium matrix usually carbon fibres are used to synthesize composites which have low density and high strength.

A. Matrix

The matrix is single material into which the reinforcement is dispersed and is completely continuous. It means that there is a path through the matrix to any point in the material. In most of the structural application the matrix is usually a lighter metal such as magnesium, aluminium, or titanium, and provides a complaint support for the reinforcement. In high-temperature applications, cobalt or cobalt- nickel alloys are mainly used as matrices.

B. Reinforcement

In a matrix the reinforcement material is dispersed. The reinforcement always is not used for structural task, but it is mainly used to change the physical properties such to increase the wear resistance, friction coefficient, or thermal conductivity. The reinforcement in the matrix may be either continuous or discontinuous. Discontinuous metal matrix composites can be isotropic, i.e. the orientation is uniform. Also the property varies systematically and it depends on the direction, these can be worked with standard metal working techniques, such as extrusion, rolling, forging.

These can be machined using conventional machining techniques but some may require the use of polycrystalline diamond tooling (PCD).The continuous reinforcement can use fibres or monofilament wires such as silicon carbide or carbon fibre. Since the fibres are dispersed into the matrix in a certain direction, thus the structure is an anisotropic in which the alignment of the material affects its strength. Discontinuous reinforcement is made up of shot fibres, or particles or whiskers. Herethe common reinforcing materials in this category are alumina and silicon carbide.

C. Manufacturing of Metal matrix composites

Metal matrix composites can be differentiated into three types- solid, liquid andvapour.

D. **Vapour deposition**:

Physical vapour deposition: A thick cloud of vaporized metal is passedthrough the fibre, thus it forms coating over the fibre.

E. Semi-solid state methods:

Semi-solid powder processing: The powder mixture is heated up to semi- solidstate and pressure is applied to form the composites.

F. Liquid state methods

Squeeze casting: The fibres are preplaced inside the molten metal.

Pressure infiltration: Molten metal is infiltrated into the reinforcement by usinga kind of pressure such as gas pressure.

Stir casting: The molten metal is allowed to solidify after the discontinuousreinforcement is put into it.

Spray deposition: A continuous fibre substrate is selected and molten metal issprayed into it.

Reactive processing: In this case a chemical reaction occurs with one of thereactants forming the matrix and the other the reinforcement. Electroplating and electroforming: A composite material is formed when thesolution containing metal ions are loaded with reinforcing particles.

G. **Residual stress**- Metal matrix composite usually are manufactured at elevated temperatures, this is required for diffusion of the bond between fibre and matrix interface. These fibre and matrix are allowed to cool down to the ambient temperature, and there may be some residual stresses which are generated within the composite due to the mismatch between the coefficients of the metal metric and fibre. In all loading conditions the mechanical behaviour may be influenced by the manufacturing residual stress. In other cases the thermal residual stress would be high enough to create plastic deformation inside the matrix during the manufacturing process.

Applications of Metal matrix composites are

The Standard aluminium driveshaft which are been used in the race cars arenow replaced with aluminium matrix reinforced with boron carbide, allowing to increase the critical speed of the shaft to be raised beyond the safe speeds of a standard aluminium shaft. This replacement of composite material has been used by Ford. In some of the engines the standard material are been replaced by aluminium metal matrix in composite cylinder liners. This technology has been used by Honda. Specialized bicycles in the bicycle frame used the aluminium metal matrix composite for many years. The metal matrix composite which Griffen Bicycles used is boron carbide-aluminium Metal matrix composite. The metal matrix composite have the below **advantages** as compared to the standard material.

Resistant to fire

- It can operate in wide range of temperatures.
- Moisture will be absorbed by these materials.
- Outgassing is not displayed in these materials so that these does not have inbuiltcracks.

3.1.2 Polymer matrix composites

Fig 2 Example of polymer matrix composite used in the car hood.

The polymer matrix composites have thermoplastic or thermoset matrix resins and these are reinforced by stronger and stiffer fibres than the matrix. These are popular because they are stronger, lighter and stiffer than the conventional polymers in which the reinforcements are not present. They can be used even to replace the conventional metal materials. The application of these fibre reinforcements are of more interest for aerospace and military composite applications. These include carbon fibres and some of the organic fibres such as ultra-light-weight-polythene, liquid crystalline polymers and aramids. While coming to the properties of these composite structures does not only depend on the fibre reinforcement but also on the below criteria’s

1.Manufacturing process used to form the finished structure

2.The characteristics of the interface between the matrix and fibre.

3.The polymer matrix.

3.1.3 Ceramic matrix composites

Ceramic matrix composites are sometimes technical ceramics or else composite materials. The ceramic fibres are placed inside a ceramic matrix to form a ceramic fibre- reinforced material. The constituents of the ceramic matrix composites are brittle; the fibre-matrix interface is tough due to the effective design, this deflects and arrests the crack and its propagation inside the matrix. The fibrous reinforcement is been prevented from failure. Mainly ceramic matrix composites are used in extreme cases.

3. 2 Aluminium Silicon Carbide

AlSiC, it is a metal matrix composite and it has aluminium as matrix and silicon carbide particles as fibre. The thermal conductivity of the Aluminium Silicon Carbide is very high and it is around (180–200 W/m K), the thermal expansion of the Aluminium Silicon Carbide can be adjusted in order to adjust with other materials such as gallium arsenide particles, silicon or with various ceramics. These components are mainly used in high density multi-chip modules, microelectronics, automobile, and shaft.

There are different variants of Aluminium Silicon carbide AlSiC-12 – This composite consists of 63 % of Aluminium alloy and 37 % of the fibre i.e. silicon carbide. The thermal conductivity of this metal matrix composite is 170-180 W/mK. Density of this composite at 25 °C is 2.89 g/cm3. AlSiC-10, it contains 45% of Aluminium alloy and 55% of Silicon Carbide. The density of this component at 25 °C is 2.96 g/cm3. The thermal conductivity is around 190–200 W/m K. The thermal expansion of the component is equal to Duroid. The density of AlSiC-10 is slightly greater than that of AlSiC-12.

AlSiC-9, the volume percentage of aluminium alloy is about 37% and silicon carbide is about 63%. Its density at 25 °C is 3.01 g/cm3. The thermal conductivity of the AlSiC-9 is around 190-200 W/mK. The thermal expansion matches with silicon, alumina, silicon nitride and Bonded copper. The thermal expansion also matches with some co-fired ceramics with low temperature. The Aluminium Silicon Carbide composite can be used in-place of copper- molybdenum and copper-tungsten alloys. Since the density of Aluminium is less when compared to other metals like copper, steel, so they are mainly used as matrix. When compared to the weight of copper it is around 1/3rd, to that of CuMo it is around 1/5th and w.r.t Copper tungsten it is around 1/6th. So AlSiC is mainly used in for the application which demands less weight. These composites are also stronger and stiffer than copper. They are strong, lightweight, and stiff when compared to copper and carbon steel. The usages of these composites are for lids for chips, spreaders, housings for electronics, power electronics. The other application is metal, channels and ceramic inserts for coolant also be included into the parts during manufacture. The manufacturing of AlSiC can be relatively in expensive.

AlSiC can be manufactured by near net shape approach, the SiC can be preform by metal injection moulding of SiC-binder slurry, it is then fired to remove the binder, then under pressure it is infiltrate with molten aluminium. The material can be fully dense, without voids, and is hermetic. These Components are having low density and high stiffness making larger components with thin wall; it can be also used for manufacturing large fins in-order to dissipate the heat. Aluminium Silicon Carbide can be plated with nickel-gold and nickel.

It can be plated with ceramic and metal insets which can be inserted into the preform before aluminium infiltration, resulting in a hermetic seal. AlSiC can be prepared not only with near net shape but also using mechanical alloying. The Aluminium matrix will have high amount of dislocations, which is responsible for the strength of the material. These dislocations are introduced during the cooling by the SiC particles, which is resulted but the difference in their thermal expansion coefficient. There is similar material called Dymalloy, Instead of aluminium they have used copper- silver alloy and silicon carbide inside of diamond. Some of the other composites are diamond-reinforced aluminium, pyrolytic graphite and reinforced carbon-carbon. Near net shape The near net shape is an industrial manufacturing technique. The initial production of the item is very close to the final shape (i.e. net), reducing the need for surface finishing. The final finishing such as machining or grinding eliminates more than two-thirds of the production costs in many industries.
3.3 Stir casting

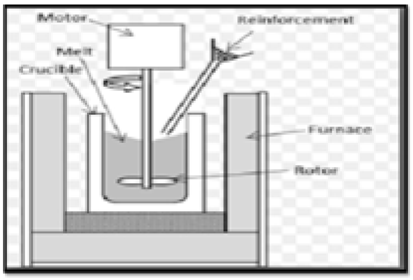

Fig 3 Stir casting

The main process used for fabrication of aluminium matrix composite is Stir casting. This is an economical process. Many parameters are there in this process which affects the final microstructure and mechanical properties of the composites. The SIC is used as fiber and they are used as reinforcement to fabricate Al-3 wt.% SiC composites at two different casting temperatures i.e. 680 and 850 °C and the stirring periods are about 2 and 6 min.

Factors of reaction at ceramic/matrix interface, ceramic incorporation, porosity, and agglomeration of the particles were taken into consideration by using High-resolution transition electron microscope and scanning electron microscope. In-order to achieve proper metal/ceramic interface it is required for shorter stirring period. To have improved ceramic incorporation the stirring temperature should be high (850 °C). There are some cases, where the shrinkage porosity and intensive formation of Al4C3 at the metal/ceramic interface are also observed. At the final stage the mechanical properties of the composites were evaluated, and their relation with the corresponding microstructure and processing parameters of the composites are evaluated. Interaction between Aluminium matrix and SiC particles.

In the furnace when the temperature is from 657 to 827°C, SiC interacts with the matrix called Aluminium this happens due to dissolution-precipitation process. The mechanism involved in this process is that the carbon atoms migrate from the places aluminium is in direct contact with the SiC faces of Al4C3 crystals which are placed close to the Aluminium Silicon carbide interface. The composite so formed can have detrimental influence on the brittle compound Al4C3 and also it reduces the strength and ductility, The moisture in the ambient and the liquid water reacts with the composite formed, which debilitating even more the composite.
Al +3 SiC = Al4C3+3 Si
The above reaction is thermodynamically possible since the standard free energy change for this reactive is not positive and Si , Al4C3 are the two major products of this reaction. In the chemical reaction the migration of carbon atoms happens which leads to bonding movement and wettability.

IV.RESULT AND DISCUSSION

1. Shaft Model

Fig 4. Shaft model

The above design employs the Composite material to analyze stress and strain. The coloured charts of total deformation, strain, stress, and buckling deformation of composite material shown below are common. Because the contour plots for all of the composite materials are the same, one representative contour for each output is shown below. The respective numeric values will be listed in detail.

4.2 Stress Analysis

In the dynamic analysis, the stress response in a laminated composite due to a unit step load applied at the boundary is obtained for points which are a at a finite distance, and b at a large distance, from the impact end. For the case a, the composite may consist of a finite number of layers.

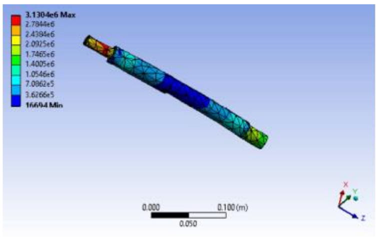

Fig 5 Stress Analysis by using Composite

4.3 Strain Analysis

The modeling constraints are strains, stresses and deflection. Measurements of the present standard steel leaf spring of a light commercial vehicle. Using E-Glass/Epoxy unidirectional covers, indistinguishable measurements from customary leaf spring are used to make a composite multi leaf spring. The 3-D model of traditional leaf spring is also dynamically analyzed using ANSYS 19 Workbench and contrasted with the analytical results.

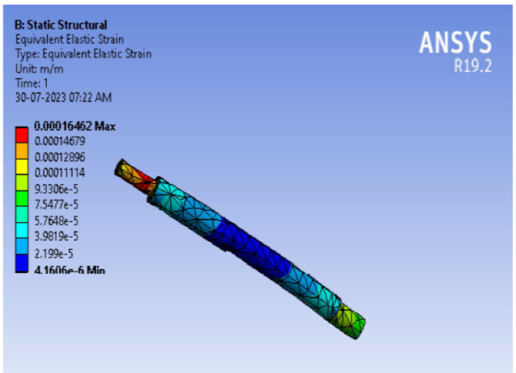

Fig 6 Strain Analysis using Composite

4.4 Deformation using Composite

In ANSYS Workbench deformation are two types' total deformation and directional deformation. Both deformations are used to find displacement through stress. Directional deformation acts in directions like X, Y & Z. In the case of total deformation, it is the square root of the total of the square of X, Y & Z direction

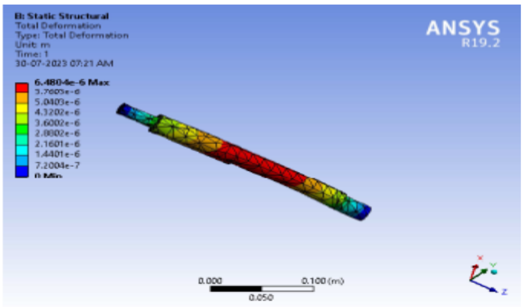

Fig 7 Deformation using Composite

4.5 Stress Analysis using Steel

The reactant forces and bending moments are initially calculated. Based on these parameters, the maximum shear stress, normal stress are calculated. The same values are used then calculated by using ANSYS software. Finally the theoretical and analytical results are compared and verified.

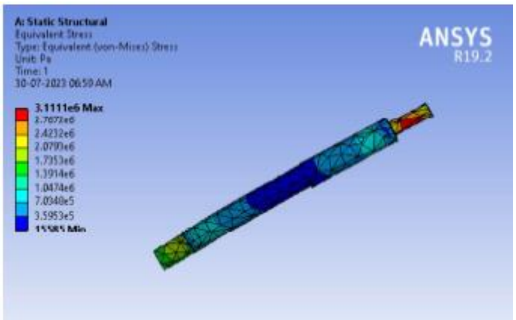

Fig 7 Stress Analysis using Steel

4.6 Strain Analysis using Steel

The shaft which is fixed at one end is selected and forces are given at particular points. The reactant forces acts in opposite directions. Torque acts at two points in opposite directions. The reactant forces and bending moments are initially calculated. Based on these parameters, the maximum shear stress, normal stress are calculated. The same values are used then calculated by using ANSYS software

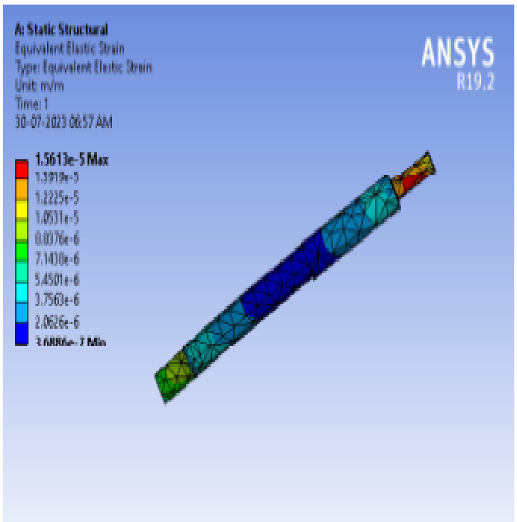

Fig 8 Strain Analysis using Steel

4.7 Deformation using Steel

High-speed electric machines are gaining importance in the field of traction drives and aviation due to their high power density. The evaluation of the mechanical stress in the rotor is one crucial part in the design process for this type of machines. The mechanical stress cannot be measured directly. Accordingly, a validation of the calculated mechanical stress is difficult and normally not performed. Instead of the mechanical stress, the deformation at the rotor surface can be measured using a spin test machine with distance sensors. The deformation can then be used to validate the calculation results.

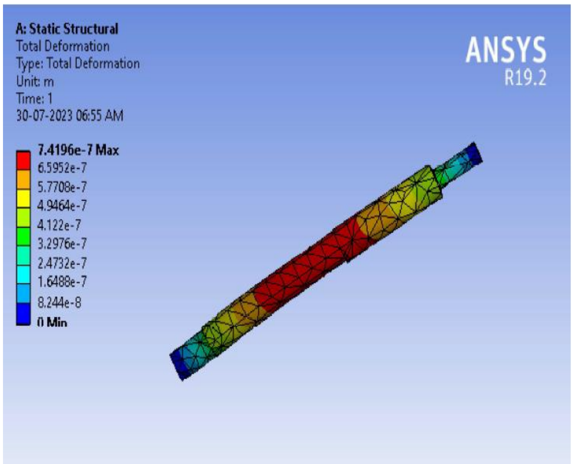

Fig 9 Deformation using Steel

V.CONCLUSION

This study compares steel and composite drive shafts based on maximum deformation, maximum and minimum stresses created in the shaft. Its design technique is investigated, and certain critical parameters are found using finite element analysis. The composite drive shaft was built using high strength carbon, high modulus carbon, and Kevlar / epoxy multilayered composites. When compared to a traditional steel shaft, the use of composite materials has resulted in significant weight savings. Furthermore, the findings show that fibre ply orientation has a significant impact on the static propert

1) The use of composite materials has resulted in significant weight savings, with a weight reduction of over 79% when compared to typical steel shafts.

2) The offered study aims to lower the fuel consumption of a specific automobile or any machine that uses drive shafts. Taking into account weight savings, deformation, and shear stress produced and resonant frequencies, it is clear that a hybrid of high strength carbon, high modulus carbon, and Kevlar/Epoxy composite has the most promising features to operate as a steel replacement.

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