A REVIEW PAPER ON DESIGN, MANUFACTURING AND ANALYSIS OFCOMPOSITE AXLE FOR FOUR WHEELER

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ABSTRACT

This paper represents the review on the importance of composite materials in modern world can be realized from the fact that much of the research is being done to apply new materials to different components. Fuel efficiency and weight of the automobile are two important parameters considered during design and manufacturing of automobile. Most of the industries are using composite materials such as Epoxy resin, glass fiber and epoxy carbon..In this paper, the objective is to manufacture the composite wheel axle to replace the conventional steel axle to reduce the vehicle weight without compromising the strength and safety of the vehicle. The composite axle will be compared the results with conventional steel axle under different mechanical testing with evaluating of different mechanical properties such as tensile strength, bending strength, impact strength, fatigue strength by using appropriate experimental technique.

Keywords: ***Axle, Composite, Glass Fiber Reinforced plastic (GFRP),Tensile test, Bending test, Impact test, Fatigue test, Pultrusion.***

I. INTRODUCTION

Composite materials are commonly used in structures that demand a high level of mechanical performance. Their high strength to weight and stiffness to weight ratios has facilitated the development of lighter structures[1]which often replace conventional metal structures. Glass fibers are used to increase the mechanical and physical properties of the material. Particulate glass fiber tend to be much weaker and less stiff than continuous glass fibers, so pultrusion process is used to manufacture the component which creates continuous composite profile. In glass fiber material damage can easily detect which is important to identify the factor that contributes to permanent deformation, it would be very dangerous in some application such as automobiles. Because of all these factors, comparative test has to be carried out. Epoxy resin is one of the excellent thermosetting polymer resins. The cost-to-performance ratio of epoxy resin is outstanding. Epoxy resins possess characteristics such as high strength, low creep, good adhesion to most of the substrate materials, low shrinkage during curing and low viscosity. Bisphenol A, more commonly known as BPA, is a chemical widely used to make epoxy resin . This resin uses a 2:1 hardener. Mixing 2 parts epoxy to 1 part hardener will give you the appropriate final mixture. The 2:1 hardener has a pot life of 35-40 minutes at 80 0 F, set time of 5-6 hours and a drying time of 24-48 hours.

1.1 Problem statement

Manufacture the composite axle using composite material of epoxy resin and glass fiber and compare the results with conventional steel axle under different mechanical testing with evaluating of different mechanical properties such as tensile strength, bending strength, impact strength, fatigue strength by using appropriate experimental technique.

1.2 Objective

- To create a model of existing axle.
- To check the model by using FEM with existing material and at normal operating conditions.
- To study the behaviour of composite material.
- To suggest new and improved material for the same axle.
- To design a composite axle
- To manufacture a composite axle.
- To compare the results of composite axle and conventional steel alloy axle.

II. LITERATURE REVIEW

Mr. P. A. Pandav, Dr. V. R. Naik, [1]"Use of composite material for replacement of steel in conventional two wheeler axle", In this paper, the aim is to manufacture the composite wheel axle and compare the results with conventional steel axle under different mechanical testing with evaluating of different mechanical properties such as tensile strength, bending strength, impact strength, fatigue strength by using appropriate experimental technique. The replacement of composite materials has resulted inconsiderable amount of weight reduction about 64% when compared to conventional mild steel shaft.Parshuram D, Sunil Mangsetty,[2] " Design and Analysis of Composite/Hybrid Drive Shaft for Automotives" The main concept of our project is to reduce the weight of automotive drive shaft with the utilization of composite material. Composite materials have been used in automotive components because of their properties such as low weight, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength and high impact energy absorption etc.By using advanced composite materials, the weight of the drive shaft assembly can be tremendously reduced. This also allows the use of a single drive shaft (instead of a two piece drive shaft) for transmission of power to the differential parts of the assembly. Juvvi Siva Nagarju, HariBabu, [3]"Design and structural analysis of heavy vehicle chassis frame made of composite material by varying reinforcement angles of layers". In this work, modelled a chassis used in a heavy vehicle using Unigraphics. Structural and modal analysis are done on the chassis using ANSYS. The analysis is done using three materials Steel, Carbon Epoxy and E-glass Epoxy. And done using different layers 3, 5 and 11 without and with damping material Rubber. Present used material for chassis is steel. I have considered composites Carbon Epoxy and E – Glass Epoxy for chassis material. By observing structural analysis results, the stress values for Carbon Epoxy and E–Glass Epoxy are less than their respective allowable stress values. So using composites for chassis is safe.Vinodh Kumar S, Sampath V, Baskar P,[4] " Analysis of Propeller Shaft for Composite Materials".The main objective of this paper is to reduce the weight of an automobile drive shaft assembly by using the composite materials such as Epoxy/E-glass and

Epoxy carbon. Conventional Drive shaft has having less strength, less specific modulus and increased weight. Composite materials are having advantages like high strength, free corrosion resistance, high specific modulus, high impact energy and reduced weight. Pro-E wildfire 4.0 is used to model the drive shaft assembly and ANSYS 11.0 is the analysis package used to carry out analysis. It is concluded that from the analysis, the E-carbon composite material can be used as drive shaft material instead of the E-glass composite material and conventional steel.Amol B. Rindhe, S. R. Wagh,[5] " Evaluation of a Composite Material Automotive Drive Shaft by Using Fem".In this paper work are deals with the replacement of conventional composite material drive shaft with a E-glass carbon /Epoxy, High strength carbon /Epoxy and High module carbon /Epoxy to overcome the drawback of conventional composite material drive shaft. In this paper we are work for suggesting the best composite material for drive shaft and improve the life of drive shaft and also saving the percentage of material. In this work it is concluded that, a one-piece composite drive shaft for rear wheel drive automobile has been designed for E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy composites with the objective of minimization of weight and increase life of the shaft which was subjected to the constraints such as torsional buckling capacities and natural bending frequency. Sagar R Dharmadhikari, Sachin G Mahakalkar, Jayant P Giri, Nilesh D Khutafale,[6]**"**Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm". This study deals with the review of optimization of drive shaft using the Genetic Algorithm and ANSYS. Here the replacement of the conventional steel is done by the composite materials of glass fiber of carbon fiber and optimization is done for further selection of most effective material Genetic algorithm technique is used. Substitution of composite material over the conventional steel material for drive shaft has increasing the advantages of design due to its high specific stiffness and strength.

2.1 Outcome from literature review

From literature review we found that the composite materials are used for various applications of automotive such as drive shaft, chassis, two wheeler axle. They have performed composite materials study for higher stiffness, high fatigue strength, impact strength, increased life and flexibility of the components.

III. INTRODUCTION OF COMPOSITE MATERIAL

Composite material

The advanced composite materials such as graphite, carbon, Kevlar and Glass with Suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density). Advanced composite materials seem ideally suited for long, power driver shaft (propeller shaft) applications. Their elastic properties can be tailored to increase the torque they can carry as well as the rotational speed at which they operate. The drive shafts are used in automotive, aircraft and aerospace applications. The automotive industry is exploiting composite material technology for structural components construction in order to obtain the reduction of the weight without decrease in vehicle quality and reliability. It is known that energy conservation is one of the most important objectives in vehicle design and reduction of weight is one of the most effective measures to obtain this result. Actually, there is almost a direct proportionality between the weight of a vehicle and its fuel consumption, particularly in city driving. Composites consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents.

The constituents are combined at a macroscopic level and or not soluble in each other. The main difference between composites, where as in alloys, constituent materials are soluble in each other and form a new material which has different properties from their constituents.

3.1 Classification Of Composite Materials

Composite materials can be classified as

- Polymer matrix composites
- Metal matrix composites
- Ceramic Matrix

Technologically, the most important composites are those in which the dispersed phase is in the form of a fiber. The Design of fiber-reinforced composites is based on the high strength is the ratio between strength and density. Specific modulus is the ratio between strength and density. Specific modulus is the ratio between modulus and density. Fiber length has a great influence on the mechanical characteristics of a material. The fibers can be either long or short. Long continuous fibers are easy to orient and process, while short fibers cannot be controlled fully for proper orientation. Long fibers provide many benefits over short fibers. These include impact resistant, low shrinkage, improved surface finish and dimensional stability. However short fiber provide low cost are easy to work with and have fast cycle time fabrication procedures. The principal fibers in commercial use are various types of glass, carbon, graphite, Kevlar. All these fibers can be incorporated into a matrix either in continuous lengths or in discontinuous lengths as shown in the Fig. The matrix material may be a plastic or rubber polymer, metal or ceramic. Laminate is obtained by stacking a number of thin layers of fibers and matrix consolidating them to the desired thickness. Fiber orientation in each layer can be controlled to generate a wide range of physical and mechanical properties for the composite laminate.

3.2 Properties Of Composite Materials

The physical properties of composite materials are generally not isotropic(independent of direction of applied force or load) in nature, but rather are typically orthotropic (depends on the direction of the applied force or load). For instance, the stiffness of a composite panel will often depend upon the orientation of the applied forces and/or moments. Panel stiffness is also dependent on the design of the panel. In contrast, isotropic materials (for example, aluminium or steel), in standard wrought forms, typically have the same stiffness regardless of the directional orientation of the applied forces and/or moments. While, composite materials exhibit different properties in different directions. The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties: Young's Modulus, the Shear Modulus and the Poisson's ratio, in relatively simple mathematical relationships. For the anisotropic material, it requires the mathematics of a second order tensor and up to 21 material property constants. For the special case of orthogonal isotropy, there are three different material property constants for each of Young's Modulus, Shear Modulus and Poisson's ratio -a total of 9 constants to describe the relationship between forces/moments and strains/curvatures.

3.3 Advantages Of Composites Over The Conventional Materials

- High strength to weight ratio
- High stiffness to weight ratio

- High impact resistance
- Better fatigue resistance
- Improved corrosion resistance
- Good thermal conductivity
- Low coefficient of thermal expansion. As a result, composite structures may exhibit a better dimensional stability over a wide temperature range.
- High damping capacity.

3.4. LIMITATIONS OF COMPOSITES

- Mechanical characterization of a composite structure is more complex than that of metallic structure
- The design of fiber reinforced structure is difficult compared to a metallic structure, mainly due to the difference in properties in directions
- The fabrication cost of composites is high
- Rework and repairing are difficult
- They do not have a high combination of strength and fracture toughness as compared to metals
- They do not necessarily give higher performance in all properties used for material Selection.

3.5. APPLICATIONS OF COMPOSITES

The common applications of composites are extending day by day. Nowadays they are used in medical applications too. The other fields of applications are,

- Automotive : Drive shafts, clutch plates, engine blocks, push rods, frames, Valve guides, automotive racing brakes, filament–wound fuel tanks, fiber Glass/Epoxy leaf springs for heavy trucks and trailers, rocker arm covers, suspension arms and bearings for steering system, bumpers, body panels and doors
- Aircraft: Drive shafts, rudders, elevators, bearings, landing gear doors, panels and floorings of airplanes etc.
- Space: payload bay doors, remote manipulator arm, high gain antenna, antenna ribs and struts etc.
- Marine: Propeller vanes, fans & blowers, gear cases, valves &strainers, condenser shells.
- Chemical Industries: Composite vessels for liquid natural gas for alternative fuel vehicle, racked bottles for fire service, mountain climbing, underground storage tanks, ducts and stacks etc.
- Electrical & Electronics: Structures for overhead transmission lines for railways, Power line insulators, Lighting poles, Fiber optics tensile members etc

IV. Material Selection Criteria

4.1 High strength

While not for corrosion resistant equipment high strength does play an important role in the design of FRP equipment for such applications as missiles, protruded shapes, etc. For filament wound pipe and duct the high strength gives the lightweight features discussed earlier. You will often see FRP equipment especially filament wound equipment, FRP's high strength properties can be a major advantages.

4.2 Economy:

Often a major advantage of FRP is its lower cost. When comparing materials for corrosion service rubber lining and exotic stainless material are very frequently alternatives to FRP .In these cases FRP may offer both a satisfactory solution to corrosion problems on lowest cost.There is no rule of thumb for comparing costs of FRP with other material. These costs depend entirely upon the application, the design considerations, the pressures involved and the product configurations.FRP is not competitive, however if you simply try to substitute it for a carbon steel in a particular use with minimum design changes. Design for FRP as a material of its own not as substitute for another material of its own not as a substitutes for another material.

4.3 Versatility & flexibility:

Too many people overlook the versatility of FRP. It is best for many applications because you can do things with it that cannot be done economically with other materials. You mold almost any configuration of equipment for which you can build a temporary or permanent mold. On ductwork it is also possible to use FRP to line existing structures.

4.4 Corrosion resistance:

Prime reason behind using FRP is due to their inherent corrosion resistance. In many cases they are the only materials that will handle a given service environment. In other cases, their corrosion resistance is combined with their economy to make them the most economical acceptable solution.

Corrosion resistance of FRP is a function of both the resin content & the specific resin used in the laminate. Generally higher the resin content the more corrosion resistant the laminate. This is why when building the laminate, the surface nearest the corrosive medium is made of layer that is 90% resin and 10% glass (i.e. the surfacing veil layer). For the most corrosive media, this is followed by a layer of approximately 75% resin and 25% glass. High glass content layers such as are achieved with woven roving or by filament winding, are usually limited to those applications where the corrosive service is less severe or where the corrosion medium is separated by means of a layer high in resin .

4.5 Weight advantages:

Another very distinct advantage of FRP is its low weight to strength ratio. As a rule thumb, for the same strength, FRP will weigh approximately one seventh as much as steel and half as much as aluminium. Light weight properties are important when considering the cost & ease of installation especially for pipe & tanks. FRP’s inherent light weight is an advantage when equipment must be mounted on existing structures such as scrubbers on mezzanines or rooftops and for specialty applications such as FRP tank trailers .

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V. METHODOLOGY

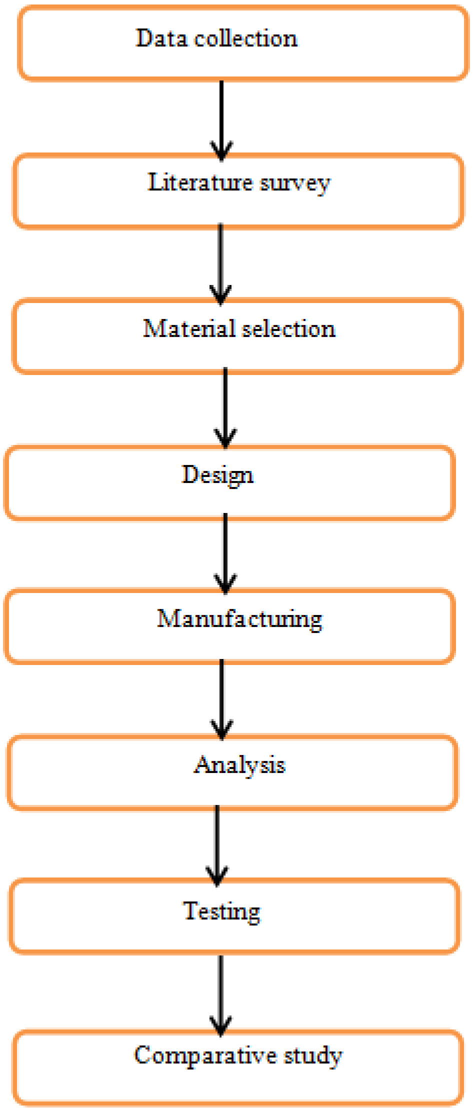

Figure 5.1 Process flow chart

VI. CONCLUSION

- Weight of composite axle should be less than conventional steel axle by 40% to 60%.
- Life of axle should be increased.
- Composite axle should possess high bending strength, impact strength, and higher stiffness.

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