Design and Fabrication of Mono Leaf Spring with Natural Composite Material

[1]P.Jayaraman, [2]N.Ramasamy, [3]G.Sakthivadivazhagan, [4]A.Sarath Kumar, [5]N.Vasanth
[1]Professor, [2]Assistant professor, [3, 4, 5]Student,
Department of Mechanical Engineering, Prathyusha Engineering College, Tiruvallur, Tamilnadu, India.

Abstract: Now days the foremost important problem among the automobiles are fuel efficiency and emission gas regulation. The load of car is very important then the fuel efficiency of the car. So By decreasing the rear load of automobiles is healthier than that of sky rocketing the fuel efficiency. The aim of this project work is optimization of weight by employing of the mono spring within the automotive vehicles. In line with the ASTM standards, style, analyze, fabricate and testing of mono composite spring is that the main goals of the project. The rear load of the machine element is feasible to scale by the material, with no reduction within the load carrying capacity. FRP spring even have excellent fatigue resistance and sturdiness. During this project work, the composite spring is made by the vacuum resign infusion composite fabrication Process. The specimen is tested for the static load carrying capacity on universal testing machine. Here, the steel spring has higher stresses compared to the fiber reinforced composite spring. The fiber reinforced composite spring is a smaller amount than the steel spring. Hence the fuel saving is obtained. This make countries energy independent, hence the fuel is saved and fuel is produced. The optimization of the spring geometry is that the most given consideration. the most target of the project was to induce the mono spring with minimum load, therefore the spring is must capable of carrying the given static external forces or load without failure. Stresses and displacement were look constrains. The specimen is tested for the static load carrying capacity on universal testing machine.

Keywords: **Natural fiber, Composites, Leaf springs, Design constrains, Analysis, CATIA, Resin, Vacuum resin infusion.**

I. INTRODUCTION

In the present, to optimize the use of energy .the all automobiles manufacturers are mainly focuses on the load reduction. The introduction of higher material will achieve the weight reduction .leaf springs are mainly used in suspension system to soak up the shock loads in various automobiles like light cars, trucks heavy duty vehicles and in rail system. If the composite material is employed for suspension spring instead of conventional spring, it will reduce the weight of the conventional spring by nearly 70 and 80%. Spring initially called as laminated or carriage spring. Spring would be a simple kind of spring .spring commonly used in the wheel vehicles for the suspension. This is one of the oldest types of springing, in the ancient times. The top of the spring is also guide along the precise path is one of best advantage of spring over helical spring. In automobiles the most common were leaf spring. In the right up to the 1970's in European countries and late 1970's in America ,when they move to front wheel drive .They mostly use coil spring instead of leaf Spring. In this present ,in heavy commercial vehicles ,such as cars ,heavy cars, trucks and vans and SUV and railway carriages is made up of leaf spring.(1) In the line with the Ravi Kumar . V, Lalitha Nayarana .R, the rear load of the machine is possible to scale by the composite materials with no reduction in the load carrying capacity. (2) In the line with kalyani Sudhir Kulkarni to attain the necessity of natural resources conversation, the automobiles and manufactures are mainly focuses on the load reduction. (3) In the line with M.Manikandan to optimize the use of energy ,the automobile manufacturers are mainly focuses on the load reduction.(4) In the line with the Krushankant R Jani ,Nirav kamdar is to provide a damping action ,it is not well controlled and it will ends in the section with the motion of the suspension of the automobiles.(5) In line with Jagbhooshan Patel , Veerendra Kumar to attain the load carrying capacity, stiffness , deflection and weight saving of composite spring .(6) In line with the Syambabu Nutalapati to optimize the use of energy ,the all automobiles manufacturers are mainly focuses on the load reduction. (7) in line with the Mujawar Ajij I, S.D.Katekar ,in the left spring ,to back load to be scaled , with no reduction in the load carrying capacity and stiffness.(8) in line with the Kiran K.Jadhao Dr.Rajendra S.Dalu to introduction of higher material ,design optimization and better manufacturing process will achieve the height reduction. (9) In line with the M.Sureshkumar, Dr.P.Tamilselvam, G.Tharanitharan the automobiles manufacturers are mainly focuses on the load reduction. (10) In line with the K.Rajesh, S.Vamshi Krishna and Ch.Sushanth to scale back the price and weight of spring.

II. MATERIAL AND EXPERIMENT

2.1 MATERIAL:

2.1.1 VACUUM BAGGING:

The composite to be consolidated is placed on a single-sided mould. The fabric is then covered with an impervious film, which is sealed round the fringe of the part. By evacuating the air between the mould and therefore the dust bag employing a pump, the part is consolidated under gas pressure.The process is commonly performed in an oven to help with the curing of the resin. Because the dust bag material may be readily move size, it's a really flexible process in terms of the scale of the parts that may be consolidated.

In the open mould the material to be combined is placed. It's then covered with a peel ply and a breather fabric. This entire lay-up is then covered with a dust bag and sealed round the edges, except the connection to the air pump. Activating the pump sucks all the air out of the space between the bag and also the mould, causing the composite to be consolidated under 1 bar of pressure. Thiscan often be worn out an oven to help with the curing of the resin. Once the part is fully cured, the pump is disconnected, the bag, breather fabric and peel and take away discarded and also the part off from the mould.

2.1.2 VACUUM GAUGE:

A gauge could even be a pressure instrument that measures pressure during a vacuum. Generally this pressure is usually below force per unit area. These vacuum gauges is utilized either in receivers of air pumps or in steam condensers. Vacuum pressure is that the additional pressure in any system that's relative to the force per unit area. It is also called gauge. Vacuum pressure is zero-referenced against ambient force per unit area and is capable the difference between absolute pressure and force per unit area. The negative signs are generally omitted when measuring vacuum pressure so on live system pressure continuously differing kinds of gauges are combined. Most of the tools that measure pressure give the pressure of system with relevance gage and hostile absolute pressure. Vacuum pressure is stated as positive pressure when it's beyond ambient pressure and a vacuum or negative gauge pressure when below force per unit area.

2.1.3 RESIN TRAP:

A resin trap which is an air tight chamber arranged in the vacuum tubing arrangement between the attachment hence the pump does not leave any excess resin before or after to destroy the pump. When founded properly, the vacuum tubing will emanate of the laminate and connect on to the resin trap.

2.1.4 PEEL PLY

Peel Ply also called “Release Fabric,” is a synthetic cloth that you drape over your epoxy surface as the epoxy sets up. Once cured, you can peel off the fabric, and what's left behind is a perfectly smooth surface that's ready for quick sand.

2.1.5 FIBERGLASS LAYUP:

Cutting fiberglass objects and mixing with short strands of glass from a pneumatic gun is said as spray-up process. This method is employed often when one side of the finished product isn't seen, or when large quantities of a product must be made cheaply and quickly without regards to strength. Corvette fenders and boat dinghies are commonly manufactured this fashion. This process is totally different when compared with hand layup method.

The difference comes from the applying of the fiber and resin material to the mould. In open moulding fabrication process the spray up method is used where the resin and reinforcements are sprayed into a reusable mould. The resin and glass is additionally applied separately or simultaneously "chopped" during a combined stream from a chopper gun. Labors spin out the spray-up part to duct the laminate. Materials that are additionally added are like wood, foam or other core material, then second spray-up layer fix the core within the laminates.

2.1.6 GELCOAT:

Gelcoat or 'Gel Coat' may be a material won’t to provide a high-quality finish on the visible surface of a fiber-reinforced composite. Gelcoats are modified resins which are applied to moulds within the liquid state.Mixtures of polyester resin and fiberglass which are cured to produce cross linked polymers coming backed with thermosetting polymer matrix composite, or resin which is most ordinarily used with carbon fiber for higher specific strength.

The manufactured component, when sufficiently cured and faraway from the mould, presents the gelcoated surface. This is often usually pigmented to produce a coloured, glossy surface which improves the aesthetic appearance of the article, just like the surface of a ship hull.

Specialized gelcoats is made to manufacture the moulds which successively are to make manufacture components. For the curing and demoulding processes the requirement are very high level which is should withstand durability to beat the mechanical and thermal stresses encountered.

2.1.7 GATE VALVE:

A gate valve, also referred to as a floodgate, may be a valve that opens by lifting a barrier gate out of the trail of the fluid. Gate valve need little or no space through the pipe axis and hardly block the flow of fluid when the passage is opened. The gate faces may be parallel but are most typically wedge-shaped so as to be ready to apply pressure on the sealing surface.

2.1.8 EPOXY RESIN:

Epoxy resins form a vital and versatile class of cross-linkable polymers made from monomers containing a minimum of two strained-ring groups called ethylene oxide. These rings contain one oxygen and two carbon atoms and are attached to an outsized quite other aliphatic or aromatic organic molecules. The epoxy resins are used commercially, important applications beginning from high strength adhesives and specialty coating to advanced composites. Altogether of these applications the final word resin formulations also contain a ramification of fillers, hardeners, pigments, and accelerators but the most component is often the epoxy-containing molecule.

Epoxy resin acts as a high-performance bonding strength. Additionally, epoxy is developed to use for any application. It’s often used for metal, glass, and plastics. It are often fabricated as adamantine or flexible, high optical transparent or opaque, and fast or slow setting. Among common adhesives, epoxy is unmatched in heat and chemical resistance.

2.1.9 EPOXY HARDENER:

Hardeners are nearly always necessary to form a synthetic resin useful for its intended purpose. Without a hardener, epoxies don't achieve anywhere near the impressive mechanical and chemical properties that they might with the hardener. The proper kind of hardener must be selected to confirm the epoxy mixture will meet the wants of the applying. Research should be done on both the resin and therefore the hardener to form sure the ultimate epoxy mixture will perform satisfactorily. Common samples of epoxy hardeners are anhydride-based, amine based, polyamide, aliphatic and cycloaliphatic.

Hardeners are made to cure epoxy resins. However, simply adding a hardener to an epoxy might not cause the epoxy mixture to cure quickly enough. If this is often the case a special hardener could also be required. Also, hardeners with certain additives may be used. These hardener additives function catalysts that speed up the curing process.

2.1.10 BANANA FIBER:

Banana fiber, also called musa fiber is one amongst the world's strongest natural fibers. Biodegradable, the fiber is created from the stem of the banana and is incredibly durable. Banana fiber are often made to provide variety of various textiles with different weights and thicknesses, supported what a part of the banana stem the fiber was extracted from.

Fig 1: Banana Fiber

2.2 COMPOSITE FABRICATION:

2.2.1 VACUUM RESIN INFUSION PROCESS:

The Vacuum Resin Infusion Process is to drive the resin into the laminate by using vacuum pressure. Materials are laid dry into the mold and so the vacuum is applied before resin is introduced. After the entire suction process the vacuum is achieved entirely, resin is sucked into the laminate through the placed tubing carefully.

Based on hand lay-up, reinforcements are followed into a mould and manually wet out using brushes, rollers through other means. An improvement thereon method is to use a bag to suck excess resin out of the laminate. Vacuum bagging greatly improves the fiber-to-resin ratio, and eventually finally ends up during an awfully stronger and lighter product. From the above principle the vacuum infusion process is made, providing further improvements to the lamination process.

2.2.2 VACUUM RESIN INFUSION PROCESS SET-UP:

Fig 2: Vacuum resin infusion process setup

2.2.3 FLEXURE TESTING:

Flexural testing measures the force required to bend a beam of plastic material and determines the resistance to flexing or stiffness of a cloth. Flex modulus is indicative of what quantity the material can flex before permanent deformation.

The specimens were prepared with the ASTM 790-03. The Universal Testing Machine (tensile testing machine or tensile tester) is used for testing the specimens with either of three point or four point bend fixture. The main advantage of a three-point flexural test is that the straightforward the specimen preparation and testing. Moreover these methods have some demerits such as the results of the testing method are sensitive to specimen, strain rate and loading geometry. The flexural testing setup was shown in Fig.3. The overall sequence of events that comprises vacuum resin infusion is illustrated in Fig.2.

General set-up idea with the notion that resin are infused into a centre point within the laminate. From there, resin are visiting be pulled outward via vacuum pressure, the ultimate arrangement of materials.

Fig 3: Flexure Testing Machine

Formula used

$\sigma f = 3FL/2bd2$

➢ σf = Stress in outer fibers at midpoint

➢ F = load at a given point on the load deflection curve, (N)

➢ L = Support span, (mm)

➢ b = Width of test beam, (mm)

➢ d = Depth or thickness of tested beam

The speed of the testing machine is round "2mm/min". The test method for conducting the test usually involves a specified test fixture on a universal testing machine. Details of the test preparation, conditioning, and conduct affect the test results. The sample is placed on two supporting pins a set distance apart.

2.4 MODELING:

2.4.1 SOFTWARE USED:

2.4.1.1CATIA V5R20:

CATIA is utilized to enables the creation of 3D parts, from 2D sketches, sheet, composites and moulded, forged or tooling parts up to the definition of mechanical assemblies. The advanced technologies for mechanical surfacing & BIW are obtained by the software.

It provides tools to finish product definition, including functional tolerances also as kinematics definition. This tool is employed within the design of assorted objects like vehicles, buildings, components, etc. it's similar in use to AutoCAD, NX (Formerly called UG), Pro-E (Wildfire), and plenty of others. It basically replaced the multitude of engineers/drafters that won't to design while hunched over their respective drawings on a strategy planning stage. CATIA/NX is especially good for aircraft, automotive, motorcycle design. Other like AutoCAD is good for architecture.

2.4.1.2ANSYS:

ANSYS is getting used by designers across a broad spectrum of industries like aerospace, automotive, manufacturing, nuclear, electronics, biomedical, and lots of more. The designers to simulate design performance directly on desktop by use of ANSYS software.

In this way, it provides fast, efficient and cost-effective development from design concept stage to performance validation stage of the merchandise development cycle. ANSYS package help to accelerate and streamline the merchandise development process by helping designers to resolve issues associated with structural deformation, heat transfer, fluid flow, electromagnetic effect, a mixture of these phenomena action together.

III. RESULT AND DISCUSSION:

3.1 FLEXURE TESTING:

Flexural testing measures the force required to bend a beam of plastic material and determines the resistance to flexing or stiffness of a cloth. Flex modulus is indicative of what quantity the fabric can flex before permanent deformation. The specimens were prepared with the ASTM 790-03. The Universal Testing Machine (tensile testing machine or tensile tester) is used for testing the specimens with either of three point or four point bend fixture.

The most common merit of three point flexure test is that, the specimen preparation is simple for testing. Moreover these methods have some demerits such as the results of the testing method are sensitive to specimen, strain rate and loading geometry are the kinds of demerits.

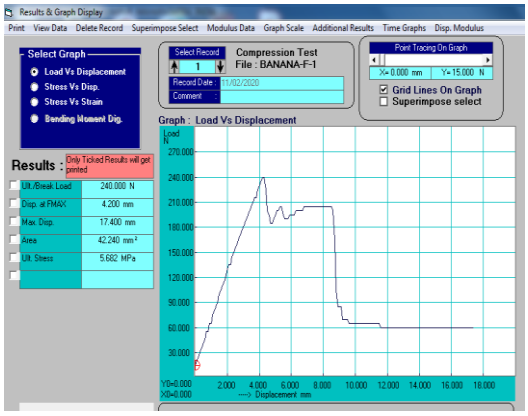

Fig.4.Load versus displacement of banana fiber composite

Young's modulus obtained from the calculation made from the test specimen is
E (bend) = 176.55117 KN/mm^{2}for 3mm thickness specimen
E (bend) =312.189 KN/mm^{2}for 9mm thickness specimen
Force F = 240 N breakage for 3mm thickness specimen

3.2 ANSYS RESULT:

ANSYS is getting used by designers across a broad spectrum of industries like aerospace, automotive, manufacturing, nuclear, electronics, biomedical, and lots of more. The designers to simulate design performance directly on desktop by use of ANSYS software.

In this way, it provides fast, efficient and cost-effective development from design concept stage to performance validation stage of the merchandise development cycle. ANSYS package help to accelerate and streamline the merchandise development process by helping designers to resolve issues associated with structural deformation, heat transfer, fluid flow, electromagnetic effect, a mixture of these phenomena action together.

3.2.1 TOTAL DEFORMATION:

The act of Force (stress) which makes in change in shape of a body caused to it. Deformation is proportional to the stress applied within the elastic limits of the material was illustrated in Fig.5.

Sometimes things can happen in a factory that will cause a deformation and you will need to get it fixed quickly.

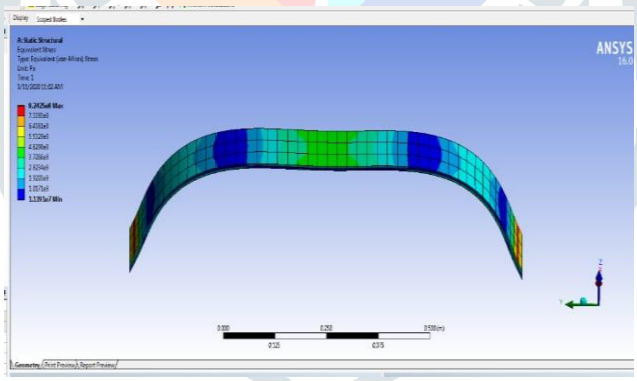

Fig 5: Total Deformation

3.2.2 EQUIVALENT STRESS:

Equivalent stress is used when there is a multi axial stress state with multiple stress components acting at the same time in the structure was shown in Fig.6. Ascribed to Poisson's effect, a principal stress obtained is zero and corresponding normal strain is non-zero.

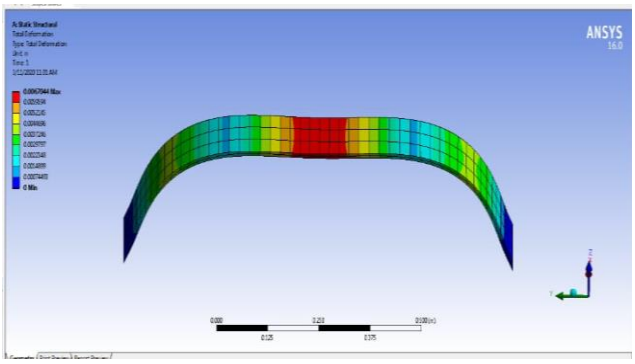

Fig 6: Equivalent Stress

E (bend) =270.0763KN/mm^{2}for 9mm specimen
Force F = 240 N breakage for 3mm thickness specimen

From the result of both flexure and ansys, experimental and theoretical value of young's modulus 312.189kn/mm^2 and 270.0763kn/mm^2.thus from the experimental and theoretical value it is clear that the experimental value shows higher value than the theoretical value.

IV. CONCULSION

The design of leaf spring and fabrication of the leaf spring has been accomplished by the composite materials. The fabrication of the leaf spring is done by the vacuum resign infusion method for the substances of gales fiber and banana fiber.

The high research demands in the world are reducing weight and increasing strength of the products. Composite materials are satisfying these research demands. Design of composite leaf spring and analysis of composite leaf spring using glass fiber and banana fiber has been carried out successfully.

Composite leaf spring is having lesser stress higher stiffness and higher deflection than the steel leaf spring. The weight of the conventional leaf spring is about 8kg, whereas the weight of the composite leaf spring is only 0.95kg. Therefore, load or weight reduction is achieved successfully. Composite leaf spring is observed as a best replacement for the existing steel leaf spring.

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