Analysis of E-Glass/Epoxy Composite Mono leaf Spring for Light Vehicle

P.K.Sharma [1] and Lohitashav Sharma [2]
Department of mechanical engineering, NRI-IST, Bhopal (M.P.), India[1, 2]
lohitashav786@gmail.com[2]

Abstract: *In today's situation, the fundamental weight age of examination is to lessen the heaviness of item while maintaining its quality. To take care of issue in such manner composite materials assume a critical part. In this paperDiminishing the heaviness of light vehicle is considered. The principal segment of the suspension arrangement of vehicle is leaf spring, it has significant measure of weight, and it is vital it would have adequate quality since it needs to oppose vibrations and shocks amid its working. The unmistakable quality of the paper is to lessen the general weight of suspension framework and enhance stack conveying limit of the leaf spring by utilizing the composite material. The outline contemplations for this review are stress and diversion. The work additionally gives concentrate on the use of FEA idea to think about two materials for leaf spring and propose the one having higher quality to weight proportion. Two materials utilized for examinations are; ordinary steel and composite E-Glass/Epoxy. In the present work diversion and twisting Stresses prompted in the two leaf springs are looked at the strong displaying of leaf spring is done in CATIA V5 and investigated utilizing ANSYS 14.5.*

Keywords: *E-Glass/Epoxy, CATIA V5R20, Leaf Spring, ANSYS 14.5.*

1. INTRODUCTION

Overall automobile structure today is much ameliorated version of the pristinely invented conveyances. In case of most full sized, light –passenger conveyances, the structure are composed of three modules or substructure i.e. frame and the front end sheet metal. The body provides three-quarters of the conveyances total rigidity in bending and in chassis frame accommodates as a carriage to which engine, transmission, power train, suspension and adjuncts are firmly annexed. In the earlier conveyances, beam type of suspension was employed. These beam type of suspensions were very stiff. This history of leaf spring suspension system goes back to horse driven carriages. These carriages used Full- elliptic or three-quarter elliptic leaf springs in their suspension system. The credit of inventing the leaf springs goes to Englishman Obadiah Elliot (1805). It superseded the antecedently used leather straps and elbow or C- shaped springs. This spring represented a consequential advance. The leaf spring installation between the axle and the box or cab eliminated the desideratum of a perch between the two axles. This reduced the weight, the step up height and amended springing comfort. The inception of the automobile chassis traces back to these horse driven carriages and bicycles. The earliest kenned conveyance driven by internal combustion engine is that of Siegfried Marcus, an Austrian, who built and engine driven handcraft. However, the automobile structure as such originated in the hands of F.W.Lanchester, in 1895. Full-elliptic springs were utilized as a suspension system of these conveyances, than just a spring element. Variants of leaf springs were utilized on horse driven carriages and automotives. After the LAN Chester model, which was powered by the internal combustion engine, the maximum speed of the conveyance became a consequential attribute of the conveyance. The conveyance is safer to run at higher speeds if the centre of gravity of the conveyance is more proximate to ground. That signifies the ride height of the conveyance is lower. The Full-elliptic and three-quarter elliptic springs provide the conveyance with higher ride height than the semi-elliptic springs. Secondly, advances in the material science engendered more incipient materials. These materials have higher strengths and life. This triggered the supersession of Full-elliptic and three quarter springs by the mono composite leaf springs.

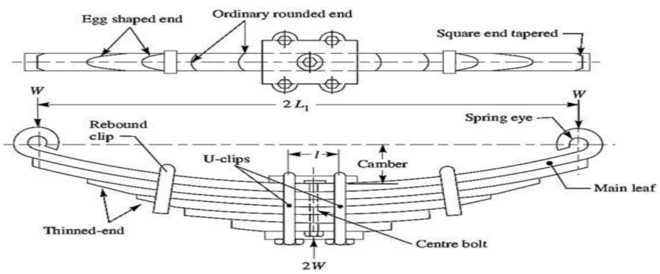


Fig 1: Semi-elliptical leaf spring

Suspension arrangement of any vehicles contains leaf spring to assimilate shocks. The vehicles must have a decent suspension framework that can convey a decent ride and good human comfort. It is watched that the disappointment of steel leaf springs is normally disastrous. [1]According to concentrates made for leaf spring the material with greatest quality and least modulus of versatility in the longitudinal bearing is the most reasonable material. [2,6] with a specific end goal to lessen the mischance's, emerging out of such disappointments traditional steel leaf spring can be supplanted with slowly coming up short composite leaf springs. By doing this, the heaviness of the vehicle may likewise be diminished while keeping up the quality of the leaf spring. A composite material is only stage of two materials that deliver an impact so that the mix produces consolidated properties that are not quite the same as any of those of its constituents. This is done deliberately in today's situation to accomplish diverse outline, fabricating and also benefit favorable circumstances of item. In this paper leaf spring is illustrative of those items, for which vehicle producers are attempting to get best composite material that meets the present prerequisite of quality and weight decrease in one, to supplant the current steel leaf spring. [1] The target of the paper is to configuration leaf springs for avoidance and twisting anxiety made of steel and composite materials. The vehicle considered is four-wheeled light vehicle. Strong Modeling of leaf spring is done in CATIA V5R20 and investigation of the same is finished by utilizing ANSYS 14.5.Specific goal is to propose appropriate material for leaf spring among two expressed above by contrasting the logical outcomes and FEA comes about. The investigation of leaf spring is restricted to static stacking as it were.

2. OBJECTIVE OF WORK

With a specific end goal to defend regular assets and conserve vitality, weight diminishment has been the primary concentration of vehicle producers in the present development. The presentation of better material, outline enhancement and better producing procedures can bring about weight lessening in vehicle .The leaf spring is one of the potential things for weight lessening in vehicle as it records for ten to twenty percent of the un-sprung weight. [2]Work in this paper has taking after targets

1. Static investigation of standard Steel leaf spring and composite E-glass/Epoxy leaf spring utilizing FEA. Discovering the redirection and twisting worry for the same.
2. Comparison of the consequences of standard Steel leaf spring and composite leaf springs.
3. Validation of results by hypothetical counts

A. MATERIAL FOR CONVENTIONAL LEAF SPRING

The material utilized for regular leaf spring is normally a plain carbon steel having 0.90 to 1.0% carbon. [2, 3] EN47 is appropriate for oil solidifying and hardening. At the point when EN47 is solidified it offers fabulous sturdiness and stun resistance which make it an appropriate compound spring steel for parts presented to stress, stun and vibrations.

B. Filaments SELECTION FOR COMPOSITE SPRING

The usually utilized filaments are carbon, glass, and so forth. The primary preferred standpoint of glass strands is minimal effort. It has high quality, high synthetic resistance and great protecting properties. The hindrances are low modulus of flexibility, poor attachment to polymer, low exhaustion quality and high thickness which increment spring weight and size. [3] The sorts of glass strands are C-glass, S-glass and E-glass. The E-glass fiber is a superb glass, which is utilized as standard support fiber for all the present frameworks well conforming to mechanical property prerequisites. Therefore, E-glass fiber was discovered proper for this application.

C. Suppositions

1. Every Nonlinear impact are avoided
2. The anxiety strain relationship for composite material is direct and versatile; henceforth snare's law is relevant to composite material
3. The leaf spring has uniform cross area

D. Determination OF CROSS-SECTION

In the present work, just steady cross-segment plan strategy is chosen. Since the cross-segment, territory is consistent all through the leaf spring, same amount of support fiber and pitch can be bolstered persistently amid fabricating.

3. MATERIAL SELECTION & METHODLOGY

MATERIALS OF LEAF SPRINGS

In leaf springs made of solid materials, the energy is stored as elastic strain energy. Further, since a portion of the spring s mass is associated with vertical kineticism of the wheel, it is desirable to reduce its mass, as well as other contributing unsprung mass, to maximize conveyance control. Consequently, the spring configuration and material of mass without exceeding stress levels consistent with reliable, long life operation.

Materials for Steel Leaf Spring

The material used for steel leaf springs is usually plain carbon steel having 0.90 to 1.0 % carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel produces greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties.

Chemical Composition of EN47 Leaf Spring

From the test report of Neptune laboratories following chemical composition are to be find for the existing leaf spring that composition is exactly shows the existing leaf spring is of EN47 material.

Chemical Composition of EN47 material

Sr. No	Element	Result	Required Value
1	Carbon %	0.49	0.45-0.55
2	Manganese %	0.8	0.50-0.80
3	Silicon %	0.21	0.50 Max
4	Chromium %	1.04	0.80-1.20
5	Nickel %	Nil	-
6	Molybdenum%	Nil	-
7	Sulphur %	0.018	0.050 Max
8	Phosphorus %	0.024	0.050 Max

Materials for Composite Leaf Spring

Many of modern technologies require material with unwonted amalgamation of properties that can be made by metals, conventional metallic alloys, ceramics, and polymeric materials, e.g. materials needed for aerospace, submerged and conveyance applications. For example engineers working in aircraft industry are looking and probing for structural material that have low densities, are vigorous, stiff and abrasion and impact resistance, and are not facilely corroded. Conspicuously, this is a rather formidable coalescence of characteristics. Conventionally vigorous materials are relatively dense; withal incrementing the vigor or stiffness generally components, where two materials cumulate to reinforce and bind together. Composites include multiphase metal alloys, ceramic and polymers. A composite is considered to be any multiphase material that exhibits a paramount proportion of the properties of both constitutes phases such that a better amalgamation of properties is realized. This is termed as the principle of amalgamated action. According to this principle, better amalgamations are fashioned by the judicious accumulation of two or more distinct materials.

Cull of Material

The suspension leaf spring is one of the potential items for weight reduction in automobile as it accounts for ten to twenty percent of the unsparing weight. This avails in achieving the conveyance with amended riding qualities. It is prominent that springs, are achieving the conveyance with amended riding qualities. It is prominent that springs, are material becomes a major factor in designing the springs. The relationship of the categorical strain energy can be expressed as,

$$U=2\rho/ E$$

Where, ρ the density and E the Young's modulus of the spring material. It can be facilely observed that material having lower modulus and density will have a more preponderant concrete strain energy capacity. The prelude of composite materials was made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. Since; the composite materials have more elastic strain energy storage capacity and high vigor-to-weight ratio as compared to those of steel.

It is predicated on the details of processing of the composites and the experimental procedures followed for their characterization and process evaluation. Materials constitute proximately 60%-70% of the conveyance cost and contribute to the quality and the performance of the conveyance. Even an iota in weight reduction of the conveyance, may have a wider economic impact. Composite materials are proved as congruous substitutes for in connection with weight reduction of the conveyance. Hence, the composite material has been culled for leaf spring design.

Fibre Reinforced Composites (FRP) composites are defined as the materials that consist of fibers embedded in a resin matrix. The aim of amalgamating fibers and resins that are different in nature is to take advantage of the distinctive material features of either component to result in an engineered material with desired overall composite action for concrete applications. Perpetual fiber reinforced composites contain reinforcements having lengths much more preponderant than their cross sectional dimensions. Such a composite is considered to be a discontinuous fiber or short fiber composite if its properties vary with fiber length. Engineering properties of FRP composites for structural applications, in most cases, are dominated by fiber reinforcements. More fibers customarily give elevate to higher vigor and stiffness. Exorbitantly high fiber/matrix ratios may, however, lead to vigor reduction or premature failure due to internal fracture. Fiber lengths and orientation additionally affect the properties considerably Performance Analysis of E-Glass Fiber with Epoxy Resin Predicated Composite Leaf Spring.

Fibers Selection

The designer or material specialist has a wide range of fibers from which to make a cull. Often a fiber is culled because of physical properties. For example, graphite or carbon fibers are electrically and thermally conductive, while agamid (Kevlar) and glass fibers are non-conductive. In certain applications, such as an antenna reflector, electrical conduction is required. Hence, graphite (carbon) fibers are generally culled for reflector-type applications. In other applications, for example readme, radar transmissibility is desired. Here, Kevlar and glass fibers are the materials of cull. Fiber cull should additionally consider mechanical and thermal properties. The salient mechanical properties are modulus and vigor. Those for thermal properties include coefficient of thermal expansion (CTE) and thermal conductivity. Table presents typical properties of some commercially available fibers presently utilized for space and spacecraft structures.

Fig 2 : E-Glass fiber

Resin Selection:

In a FRP leaf spring, the inter laminar shear strengths are controlled by the matrix system utilized. Since these are reinforcement fibers in the thickness direction, fiber do not influence inter laminar shear vigor. Ergo, the matrix system should have good inter laminar shear vigor characteristics compatibility to the culled reinforcement fiber. Many thermo set resins such as polyester, vinyl ester, epoxy resin are being utilized for fiber reinforcement plastics (FRP) fabrication.

Dovecot 520 F, Hardener 758 combinations is characterized by

1. Good mechanical and electrical properties
2. Faster curing at room temperature
3. Good chemical resistance properties

Chemical Composition of composite material:

Chemical analysis method IS-1998-1962

Resin content =40.64%

Glass content=59.16%

Manufacturing of Fiber Reinforced Composites

A number of processes have been developed to engender and shape the fiber reinforced composites. Variations are predicated primarily on the orientation of the fibers, the length of perpetual filaments and the property of the final product. Each seeks to embed the fibers in a culled matrix with the opportune alignment and spacing indispensable to engender the desired properties. Discontinuous fibers can be cumulated with a matrix to engender either an arbitrary or preferred orientation. Perpetual fibers are mundanely aligned in a unidirectional fashion in rods or tapes, woven into fabric layers, wound around a mandrel, or woven into a three dimensional shape.

TYPES OF MANUFACTURING PROCESSES

1. Pultrusion
2. Filament Winding
3. Hand Lay-up Technique

Pultrusion

Pultrusion is a perpetual process as shown in the figure 3.3 that is utilized to engender relatively simple shapes of uniform cases such as round, rectangular, tabular, plate, sheet and structural products. As shown in fig.5.1 bundles of perpetual reinforcing fibers are drawn through a bath of thermo set polymer resin and the impregnated material is then amassed to engender a desired cross– sectional shape. This material is then pulled through one or more heated dies, which further shape the product and remedy the resin. Upon emergence from the heated dies, the product is cooled by air or dehydrogenate monoxide, cut to length prodigiously high strengths are possible (since the reinforcement can be as much as 75% of the final structure) with densities @ 20% that of steel or 60% that of aluminum, cross – sections can be as much as 60 inch wide and 12 inch thick

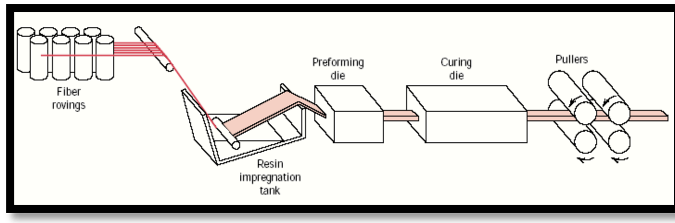
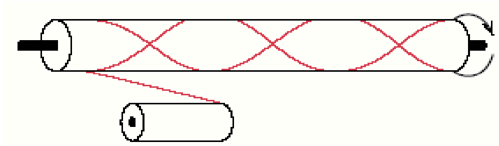


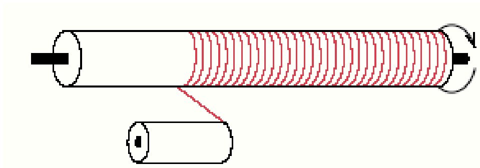
Fig 3 : Schematic diagram of the Pultrusion process

Filament winding

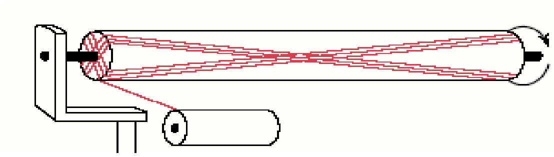
The availability of resin-coated or resin–impregnated, vigor, perpetual filaments bundles or tapes composed of materials such as glass, graphite, or boron has made it possible to engender container–type shapes that have experimental vigor to weight ratios. The filaments are wound over a form, utilizing longitudinal, circumferential or helical patterns or a cumulating of these, designed to capitalize on their highly directional vigor properties. The sundry types of windings are as shown below in the figure 3.4. By adjusting the density of the filaments in sundry locations and culling the orientation of the wraps, products can be designed to have vigor where needed and lighter weight in the less critical regions. After the resin has been remedied, the product can be divested from the form. The matrix, often an epoxy type polymer, binds the structure together and transmits the stresses to the fibers. Moderate engenderment quantities are feasible and because the process can be highly mechanized, uniform quality can be maintained. The process offers tremendous potential for cost savings and high flexibility.



a) Helical winding



b) Circumferential winding



c) Polar winding

Fig 4 : Types of Winding

Hand Lay-up Technique

The work is carried out in a female mould with a polished gel coat surface on the inside. Having acquired and set up the mould at a convenient working height in the workshop, the following procedure should be adopted:

1. Wash the mould meticulously with warm dehydrogenate monoxide and soft soap to abstract any old PVC release agent, dust, grease, finger marks, etc.
2. Dry the mould exhaustively.
3. Check the mould surface for chips or blemishes. These should be rehabilitated by filling with polyester filler and cutting back with wet/dry paper. The eccentric minuscule chip can be transitorily rehabilitated by filling with filler material.
4. If the mould surface is in good condition the mould release wax is now applied, with a circular kinetic's, utilizing a scintilla of cloth. Three coats of wax are ample for a mould surface which has been antecedently, broken in but an incipient mould surface will require at least six applications. Each application is polished up to a high shine with a sizably voluminous piece of cheese cloth, after being left to harden for 15-20 minutes. Care must be taken to abstract all streaks of wax. Be sure that the wax is polished and not abstracted by truculent buffing. Failure to take care at this stage can result in stick up. Check application with manufacturer s injuctive authorizations.
5. Apply the polyvinyl alcohol (PVA – blue or clear) solution punctiliously with a piece of sponge or foam rubber. Evade going over the mould surface more than once with the sponge as this may hoist the layer of PVA aforetime applied. PVA solution must be sanctioned to dry plenarily afore the gel coat is applied. At mundane room temperature approx 21°C this takes about 20 minutes. A dry and dust free area is required.
6. The gel coat is weighed out and the correct quantity of catalyst stirred in. In industry the gel coat is customarily sprayed onto the mould surface or applied by brush or immensely colossal lamb s wool roller (50-120mm) brush is the most opportune. Care must be taken to ascertain an even coverage of gel coat, liberate from blobs, deep ridges, shallow furrows and air bubbles.

The general method for manufacturing of leaf spring is as shown in the figure:

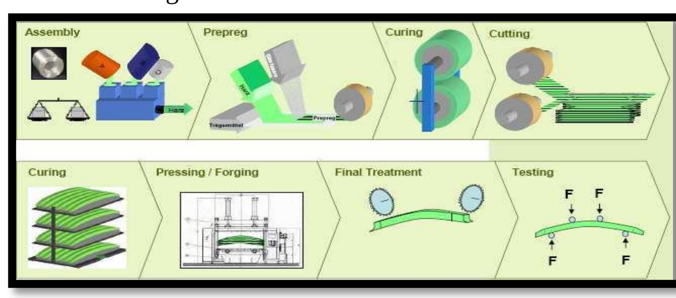


Fig 5 : The leaf spring manufacturing process of Composite material

4. CONCLUSION

In addition, composite leaf spring offers significant advantages over traditional steel multi leaf springs as mentioned below

1. Not requiring special mounting adaption or control arms for replacement.
2. Weight reduction of an equivalent spring rate leaf of 20 to 40 % in light vehicle applications.
3. Balanced compression and tensile strength than steel multi leaf springs.
4. The spring geometry is closer to a true constant stress

beam.

REFERENCES

[1] Shishy Amare Ebremeskel "Design, Simulation and prototyping of single composite leaf spring for light vehicle" Global journal of Researches in engineering./volume 12 Issue 7 Version 1.0 Year 2012.
[2] PankajSaini,AshishGoel, Dushyant Kumar "Design and analysis of composite leaf spring for light vehicles", International journal of innovative research in science , Engineering and Technology/Vol2/issue 5 may 2013.
[3] William D. Callister, "Material science and engineering".
[4] GulurSiddramanna, Shiva Shankar SambagamVijaya-rangan,"Mono Composite Leaf Spring For Light Weight Vehicle – Design, End Joint Analysis And Testing"Issn 1392–1320 Materials Science (Medžiagotyra).Vol.12,No. 3. 2006, Mechanical Engineering Department, PSG College of Technology, Coimbatore-641004, India Received 20 June 2005; Accepted 07 April 2006
[5] Kumar Krishan and Aggarwal M.L. "A finite element approach for analysis of multi leaf Spring using CAE tools" research journal of recentsciences/vol 1,(2)/92,96/feb 2012.
[6] U.S.Ramakant& K. Sowjanya , " Design and Analysis of Automotive Multi Leaf Spring using Composite Material".IJMPERD2249-6890 Vol. 3,Issue 1,pp.155-162,March 2013
[7] K.K.JADHAO, DR.R.S.DALU, "Experimental Investigation & Numerical Analysis ofComposite Leaf Spring" , K. K. Jadhao et al. / International Journal of Engineering Science and Technology (IJEST) ISSN :0975-5462 Vol. 3 No. 6 June 2011
[8] M.Venkatesan And D.HelmenDevaraj,"Design And Analysis Of Composite Leaf Spring In Light Vehicle", International Journal of Modern Engineering Research (IJMER)Vol.2, Issue.1, Jan-Feb 2012 pp-213-218.