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Design ,Improvement and manufacturing Of Four Wheeler Leaf Spring By Using **Fiber Reinforced Plastic** Materials With Application Of Pro-E & Ansys

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ABSTRACT

The objective of this project is to design and develop a prototype for a four wheeler suspension (leaf spring using fiber reinforced plastics) system with the application of pro-e software to design the leaf spring model and ansys software for analysis of designed model. The epoxy based composite material reinforced with glass or carbon fibers are becoming the material of choice in particular for load-bearing structures. These plastic components become integrated into structural design of automobiles compared to other thermosetting plastics. The chosen FRP (fiber reinforced plastic) material replaces metallic material of leaf spring system by delivering best overall strength performance at affordable costs to achieve significant weight reductions.

The process technologies of choice for preparing prototype of leaf spring are Resin transfer molding and Pre pregging. Since these processes enable fast cycles, excellent surface appearance and have a potential for automation.

Keywords: Bearing[1], Design[2], Leaf spring[3], prototype[4], Thermosetting plastics[5]

1.INTRODUCTION:

Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unstrung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. Many past recorded data shows that steel leaf springs are manufactured by EN45,EN45A, 60Si7, EN47 and 50CrMoCV etc these materials are widely used for the manufacture of the conventional multi leaf springs. Originally called laminated or carriage spring, a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times.

2.LITERATURE SURVEY

Composite leaf spring in the early 60 failed to yield the production facility because of inconsistent fatigue performance and absence of strong need for mass reduction.Researches in the area of automobile components have been receiving considerable attention now. Particularly the automobile manufacturers and parts makers have been attempting to reduce the weight of the vehicles in recent years. Emphasis of vehicles weight reduction in 1978 justified taking a new look at composite springs. Studies are made to demonstrate viability and potential of FRP in automotive structural application. The development of a lit flex suspension leaf spring is first achieved. Based on consideration of chipping resistance base part resistance and fatigue resistance, a carbon glass fiber hybrid laminated spring is constructed. A general discussion on analysis and design of constant width, variable thickness, and composite leaf spring is presented.

3.MANUFACTURING OF A FIBRE REINFORCED PLASTIC (FRP) LEAF SPRING

FRP manufacturing process are:

1. Resin transfer molding
2. Hand lay-up process
3. Spray up process
4. Pultrusion process
5. Filament winding process

3.1 Material selection:

The composite material chosen for the manufacturing of composite leaf spring is Fiber reinforced plastics.The major constituents in it are

- Reinforcement
- Matrices

3.2.Reinforcement (Fibre)

The fiber material that is selected for the manufacturing of the composite leaf spring is

E glass fibers (improved electrical resistance fibers)

A) Rovings 400 density which are 0.75 mm thick.
B) Chopped strand mat (CSM) 450 density which are 0.35 to 0.4mm thick.

3.3 Matrices (Resins)

The resin which is selected in the manufacturing of composite leaf spring is

Epoxy resin (a thermo set resin) of grade lapox L-12 and hardener of grade for it is K-6

Because we are using a long fiber we selected a thermo set resin

The epoxy resin of particular grade uses the hardener which suits to the resin grade.

Fig 1. Resin L-12 and hardener K-6

The chemical formula of these two materials is as follows

constituent	Trade name	Chemical name	Density(gm/cm^3)
Resin	Lapox L12	Diglycydyl ether besphenol (DGEBA)	1120
Hardener	-6	Tri ethyl tetra amine (TETA)	954

Table 1 Chemical formulas for resin and hardener

Epoxy resin is almost totally transparent when cured. In the aerospace industry, epoxy is used as a structural matrix material or as structural glue.

3.4.Wax polish

This is used for the easy removal of FRP leaf spring from the profile. If the wax polish not applied then the frp material over the mold or profile does not come out freely from its surface and further get sticked tightly to profile as the resin get hardened.

3.5.Poly vinyl

This is used to form a smooth surface of frp material. It is used in combination with wax polish (i.e.) after wax polish is applied then the poly vinyl is applied over the mold or profile

4. METHOD OF MANUFACTURING A COMPOSITE LEAF SPRING:

Generally the resin transfer molding, filament winding process and hand lay-up process is used for manufacturing a composite leaf spring. Any of the method needs a mould to form a product, but we selected a hand lay-up process among other processes because it is simple and easy. Instead of mould we used a steel leaf spring as a profile to manufacture a leaf spring because to prepare a mould it takes a long period of time.

The manufacturing of composite leaf spring is as follows:

- The profile of leaf spring used to manufacture a FRP leaf spring is shown below

Fig 2. Profile of leaf spring

Fig 3. Cutting of fibers to required length

- First the fibres (roving's and CSM) are cut into required sizes as per dimensions of leaf spring The wax polish is applied

over the profile of leaf spring. This is applied for easy removal of frp leaf spring from the profile. After applying within 5 minutes the applied wax polish is rubbed away from the profile. This is done because the wax polish is sticky, if it remains as a sticky over the profile it becomes another problem for removal of frp. So, just to the have a free removal contact the wax polish is applied over the profile.

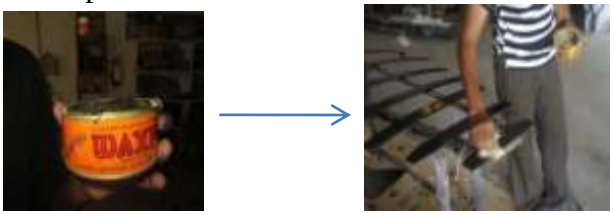


Fig 3 Applying waxes polish over profile
Fig 4 Applying poly vinyl over profile

- Apply a poly vinyl to form a smooth surface of FRP leaf spring
- After applying wax polish and poly vinyl allow to dry for certain period of time.
- A mixture of epoxy resin (L12) and hardener (K6) is prepared

For 1kg of resin, 100 ml of hardener is used, until and unless the hardener is mixed with the resin, the resin remains in the liquid phase only.

The hardener k-6 is used for epoxy resin of grade L12 to harden the resin, by mixing 100ml of hardener in 1 kg of resin the hardening time of resin hardener mixture is 40 minutes. Suppose we mix the hardener more quantity in the resin the time period for hardening the resin hardener mixture reduces.

Fig 5 Mixing of rein and hardener

- Now the resin hardener mixture is applied over the leaf spring profile
- Depending upon thickness to be formed, Respective number of alternative layers of fiber is to be used.

We used rovings of 0.75mm thickness and CSM of 0.38mm. To form a thickness of 8mm, we used 7 layers of rovings and 7 layers of CSM fibers. First the CSM layer is places over the resin coating on profile. After that again resin coating is applied over the CSM layer which is placed over the profile. Next the rovings layer is placed over the resin coating which is applied on CSM. The procedure is repeated till the required thickness is obtained.

- Finally the wax polish is applied over the glass cloth and placed over the FRP leaf spring made on profile and place small weights over it to have a proper contact between and each layer of fiber to get cured and hardened. Curing means allowing hardening and forming a stiff contact between layer and layer.

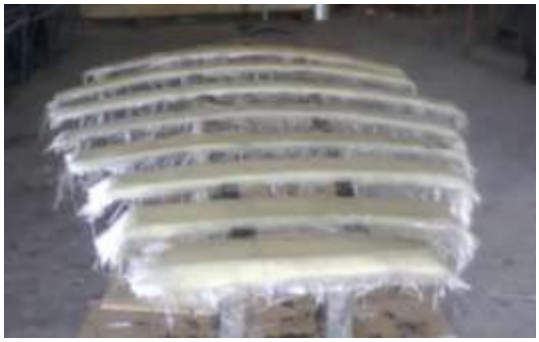


Fig 6 Placing of fiber layers over profile

Fig 7 Finished FRP leaves over profile

- Removal of FRP leaf springs from the profile

Fig 8 Removal of frp leaves from profile

Generally we can remove the FRP leaf spring from the profile used, after 3 hours from the time of completion of leaf spring.

After removing the FRP leaf spring from the profile, it should be cutted to proper shape of leaf spring with the help of hacksaw blade. The coarse teeth blade is used.

- After cutting the leaf spring, the grinding operation is carried over leaf spring for the smooth finishing. For grinding the 36 grade 5 inch sand paper is used.

Fig 9 cutting the leaves to proper shape

Fig 10 Grinding the leaves for finishing

Hardness is checked for all the leaf Springs. If the hardness value is about 75, it indicates the material is properly cured and hardened. Below show the hardness values for all leaves.

Leaf no.	Average Value
1	75
2	80
3	80
4	75
5	82
6	78
7	80
8	82

Table 2 Hardness values of leaves

Fig 11 Hardness testing

- Then the drilling is carried out over the leaf springs for fixing the centre bolt.

The sensitive drilling machine is used for drilling the hole of 10mm dia for accommodating the centre bolt


Fig 12 drilling a hole on frp leaves

- A final view of leaf springs after assembled.


Fig 13. A view of assembled leaf springs:

5. COMPARISION OF STEEL LEAF SPRING AND FRP LEAF SPRING

One of the objectives of this project is to evaluate the applicability of a composite leaf spring in automobiles by considering cost – effectiveness and strength. The comparison between steel multi leaf spring and FRP leaf spring is made for the same requirements and loading condition. The comparison is based on three major aspects such as weight, cost and strength.

5.1 Comparison of weight:

The total weight of composite leaf spring is 7.5 kg including the metal clamps. The weight of conventional steel spring assembly is around 25 kg. So, around 70% of weight reduction is achieved. Thus the objective of reducing the unsprung mass is achieved to a larger extent.

5.2 Comparison of cost:

The cost estimation of composite leaf spring provides a clear economic viability of the product in comparison to that of a convectional leaf spring.

Material quantity used for the manufacturing the FRP leaf spring

E glass fibers – 6mts each (CSM and roving's) = 1500 Rs

Epoxy resin – 6kgs = 2000 Rs

Resin hardener – 600gms = 250 Rs

Wax polish -200gms = 250 Rs

We have not manufactured a mould, but we used a profile of the leaf springs = 1000 Rs

The labour cost is negligible.

Total amount is 5000 Rs to manufacture a leaf spring with FRP material

The cost of steel leaf spring in the market today is from 1500 onwards depending upon the number of leaves and to the vehicle to which it is used. the leaf springs of Swaraj Mazda is around 5000 Rs. Almost the cost of both the springs is same, but in case of mass production the cost of the FRP leaf spring can be reduced to large extent (i.e.) 20 to 30% when compared to steel.


Fig:14.Leaf spring assembled in pro-e software

The procedure is repeated for the various loads till max load of 15942N. The deflection and the stresses generated are as follows

Load N	2500	5000	10000	15000	15942
Bending stress N/mm^2	450.20	569.63	676.206	788.906	810
Deflection mm	23.12	35.24	47.79	55.76	65

Table 3 Deflection and stress values of steel leaf spring

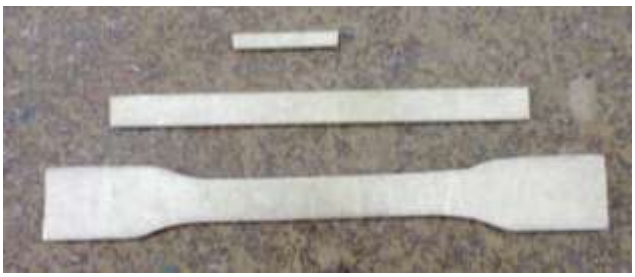


Fig 15 Testing specimens of frp material

Depending upon the testing results we calculated the Young's modulus and Poisson ratio of epoxy fiber reinforced plastic material

Calculation of Young's modulus and Poisson's ratio:

On the basis of results obtained by testing these calculations are performed.

Length of the specimen used for tensile test [L] = 230mm

Width of the specimen used for tensile test [b] = 19.86mm

Thickness of the specimen used for tensile test [t] = 5.8mm

Maximum load applied on specimen [P] = 2354.74kgf = 23099.99N

The elongation of specimen at that load is 0.57mm

As per the relation E = PL/Aδl

E = 23099.99*230/ (19.86*5.8)*0.57 = **$80*10^3$ N/mm^2**

Poisson ratio [μ] = lateral strain / linear strain

= (δd/d) / (δl/l) where δd = 0.013mm and δl = 0.57mm

= (0.013/19.86) / (0.57/230) = **0.27**

The values of Young's modulus of epoxy frp material = **$80*10^3$ N/mm^2**

The values of Poisson ratio of epoxy frp material = **0.27**

These two values are given in the material properties for analyzing the composite leaf spring

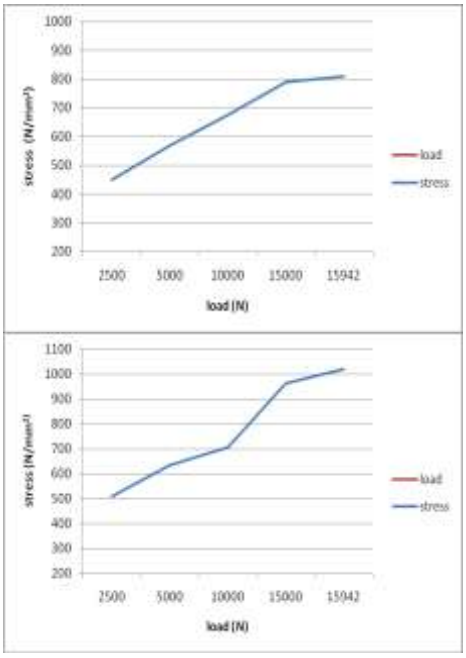
- The procedure is repeated for the various loads till max load of 15942N. The deflection and the stresses generated are as follows

Load N	2500	5000	10000	15000	15942
Bending stress N/mm^2	510.12	634.70	706.48	962.42	1020
Deflection mm	11.02	12.20	13.76	14.30	15.87

Table 4.Deflection and stress values of composite leaf spring

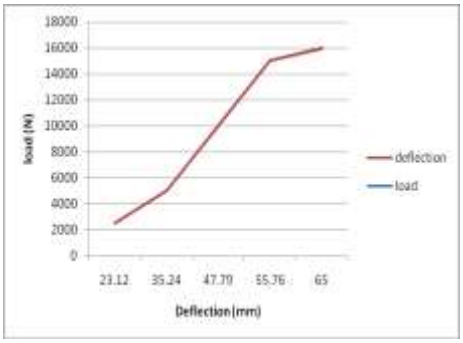
Based on the stress and deflection values obtained at various loads for the composite leaf and steel leaf spring the graphs are been drawn as

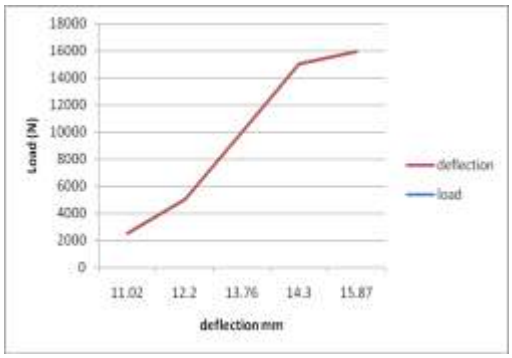
- Load vs deflection
- Load vs stress



Graph 1 load vs stress for the steel leaf spring

Graph 2 load vs stress for the composite leaf spring





Graph 3 load vs deflection for the stress leaf spring
Graph 4 load vs deflection for the composite leaf spring

ANALYSIS RESULTS:

The results that are obtained by analyzing the performance of steel and composite leaf spring in ansys are:

Load N	Stress in steel leaf spring	Stress in FRP leaf spring
2500	450.20	510.12
5000	569.63	634.70
10000	676.206	706.48
15000	788.906	962.42
15942	810	1020

Table 5 **Stress analysis using Ansys software**

Load N	Deflection steel leaf spring	Deflection in FRP leaf spring
2500	23.12	11.02
5000	35.24	12.20
10000	47.79	13.76
15000	55.76	14.30
15942	65	15.87

Table 6. **Deflection analysis using Ansys software**

CONCLUSION

In our project, a leaf spring is designed for Swaraj Mazda van. The data is collected from original leaf springs of the Swaraj Mazda vehicle for the specifications of the model. The leaf spring is designed for the load of 15941.25N. We have also calculated leaf spring dimensions
The 3-D modeling of composite leaf spring is done and analyzed using ANSYS.A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength.

From the results, it is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications.

Under the same static load conditions deflection and stresses of steel leaf spring and composite leaf spring are found with the great difference.

Deflection of Composite leaf spring is less as compared to steel leaf spring with the same loading condition.

FUTURE SCOPE:

Presently leaf springs of the automobile are undergoing a lot of research work in order to bring the composite leaf springs in to the usage. But due to arrival of some difficulties in utilizing the composite leaf springs in real applications these not yet came into existence. To overcome these difficulties different types of composite materials and its combinations are using to produce leaf springs which can be suitable for real application.

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