Fabrication and Simulation of Composite Sandwich Leaf Spring for Light Commercial Vehicle

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***Abstract*—In today's automobile world weight reduction is one of the major role to increase the vehicle efficiency. Which can be achieved by use Glass-fibre reinforced composite (GFRC) instead of steel. Moreover, the composite materials have more elastic strain energy storage capacity and high strength to weight ratio compared to steel. Due to increased trend in using composite materials in manufacturing. In this research work an attempt has been made to predict the structural behaviour of composite coated steel leaf spring and we too have adopted our own model of sandwiching a steel leaf spring(55Si2Mn90) with composite materials(E-Glass epoxy composite) as it would possess increase in strength and life cycle of that particular model of leaf spring. Surface pre-treatment of steel leaf spring in conducted to achieve maximum adhesion strength between steel and composite materials. Fabrication is carried by hand lay-up technique and tested. The simulated and analytical results comparison of both mono steel leaf spring and mono composite coated steel leaf spring are to be carried. The testing was performed experimentally with the help of Universal Testing Machine (UTM) and by Finite Element Analysis (FEA) using ANSYS.**

Keywords—composite, sandwiched, leaf spring, Eglass-epoxy, ANSYS.

INTRODUCTION:

Composite materials consist of two or more physically dissimilar and instinctively separable components called reinforcement and matrix. These two components can be mixed in a restricted way to achieve optimum properties, which are superior to the properties of each individual component.

Composite materials have been widely used in automobile industry because of its high strength and modulus to weight ratio, low cost and flexibility in material and structure design. 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 unsprung weight. This helps in achieving the vehicle with improved riding qualities.

Since the strain energy in the spring is inversely proportional to density and young's modulus of the material, it is always suggested that the material for leaf spring must have low density and modulus of elasticity. Many research have been carried out in the direction to replace conventional steel leaf spring by composites.

Material constitute nearly 60-70% of the vehicle cost and contribute to quality and the performance of the vehicle. Even a small amount in weight reduction of the vehicle, may have a wider economic impact. Composite materials are proved as suitable substitutes for steel in connection with weight reduction of the vehicle.

Design and consideration

In this research work TATA ACE mono composite leaf spring with constant width and constant thickness with constant cross section is considered. In the design point of view weight reduction is the key point to make the vehicle overall efficient and without affecting load carrying capacity. In our project TATA-ACE steel leaf spring is selected for composite coating and testing. Weight of master leaf spring is 2.95kg.

By coating the master steel leaf by composite material, we neglect the graduated leaf and the weight is almost reduced by 60%. The composite coated leaf spring has increased fatigue due to the steel core.

Surface pre-treatment:

To obtain the optimum performance from an adhesive joint, pre-treatment is required. The suitable surface pre-treatment gives

- Enhanced mechanical performance of joint
- Improved joint durability in aggressive environments
- Increased service-life of component
- Ability to bond difficult adherends.

There is wide range of surface treatments available, based on the ISO4588 for metal, leaf spring surface are pre-treated for strong adhesion. Following pre-treatment process are carried out.

- Cleaning/degreasing to remove the loose solids can be accomplished with a clean brush. Organic solvent are used remove materials such as grease, oil and wax from adherend surfaces.
- Surface roughening are done by abrasive materials using medium grit(120-200 mesh) are employed to remove unwanted layers and generate a roughened surface texture and following thus chemical treatment are carried out to remove oxidized layer.

Leaf spring specification of TATA-ACE

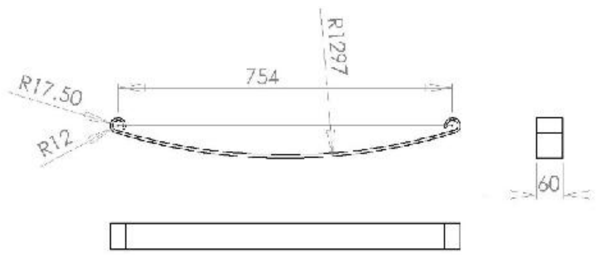

Figure 1 2D drawing of TATA-ACE master leaf spring

Table 1 Leaf spring specification of TATA-ACE

Total Length (L)	930mm
Length of leaf spring from Eye to Eye	754mm
Thickness (t)	8mm
Width (b)	60mm

Table 2 Material properties of 55Si2Mn90 steel

Ultimate tensile strength Su (Mpa)	1962
Yield tensile strength Su (Mpa)	1470
Modulus of elasticity E (Gpa)	210
Poisson ratio	0.3

Considered three specimens

1. Steel leaf spring
2. Composite coated steel leaf spring(4 layup above and 6 layup at bottom)
3. Composite coated steel leaf spring(3 layup above and 4 layup at bottom)

Specific design data

Gross vehicle weight: 1550Kgs
Kerb weight:840 Kgs
Payload: 710 Kgs
Acceleration due to gravity(g)=9.813m/s^2

Total weight acting downwards (i.e at full load)
= Gross Vehicle Weight × gravity
= 1550 x 9.81
= 15205.5 N

There are four suspensions two at the front and two at the back. So, Load on one suspension
= 15205.5/4
= 3801.4 N or 3800 N approx.

But 2F=3800
F=1900N

Span length, 2L=754mm
L= 377mm

Bending stress, $\sigma_b = 6FL/bh^2$
σ_b= 1119.21N/mm^2

Total deflection,
$\delta = 4FL^3/Ebh^3$
δ =63.12mm

where,
F= Force (N)
L=span length
σ_b=bending stress (N/mm^2)
b= breadth of leaf spring (mm)
h = thickness of leaf spring (mm)
E = modulus of elasticity

Material selection for composite coating

Uni-directional e-glass fibre is selected as reinforcement and fabricated.

Fibre: E-glass fibre (uni-directional)
Resin: Epoxy

Fabrication of composite coated steel leaf spring

Fabrication of composite coating is carried by hand lay-up technique. The surface pre-treated steel leaf spring is placed on the table then mixed epoxy and hardener is layered over the steel surface and glass fibre is placed over it. This process is repeated until desired thickness is achieved.

Composite layer is lay-up on both sides of steel spring i.e (top and bottom of leaf spring). And allowing to cure for 24hours.

Testing

Composite coated steel leaf spring is to be tested in UTM (Universal Testing Machine). Front eye end of the leaf spring usually attached to the vehicle chassis and rear eye end are fixed to the chassis through the rigid link called shackle. From this front eye is translational constrained and free rotation about eye axis. The rear eye are translated horizontally as well as vertically and free rotation about eye. Flexural test conducted to obtain the deflection value until it brakes. Deflection values are to be noted for every interval of 50kg. Corresponding stiffness value should be calculated.

CONCLUSION

Due to increasing competition in automobile industry the weight of the vehicle are reduced for the increase in overall efficiency of some particular vehicle. Composite materials which has set a footmark and has been employed in manufacturing the light weight parts for the commercial vehicles.

As the leaf spring which thus constitute more amount of total vehicle weight which needs to be strong and weight bearable such that a conservative study is conducted between conventional normal leaf spring and sandwiched composite leaf spring which is fabricated. And weight and strength of these leaf springs are compared.

And even simulated result in ansys are also to be compared with actual results.

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