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EXPERIMENTAL INVESTIGATION & ANALYSIS OF COMPOSITE MATERIAL OF LEAF SPRING MADE BY COMPOSITE MATERIAL

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Abstract :

The Automobile Industry has shown keen interest for replacement of steel leaf spring with that of glass fiber composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance and tailor-able properties. The design and experimental analysis of composite leaf spring made of glass fibre reinforced polymer. The objective of present study was to replace material for leaf spring. The main aim is to compare the load-carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. The design constraints are stress and deflection. In present study the material selected was glass fiber reinforced plastic (GFRP) . A spring with constant width and thickness was fabricated by hand lay-up technique which was very simple and economical. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle were considered for the present work. A traditional composite leaf spring was fabricated with the same dimensions using E- Glass/Epoxy unidirectional laminates. The experiments were conducted on UTM and numerical analysis was done via (FEA) using ANSYS software. Stresses and deflection results were verified for analytical and experimental results. Result shows that, the composite spring has stresses much lower than steel leaf spring and weight of composite spring was nearly reduced up to 90%. Static analysis of conventional leaf spring has also been performed using ANSYS and compared with experimental results. Finite element analysis with a full load on the 3-D model of composite multi leaf spring was performed using ANSYS, and the analytical results were compared with experimental results.

Keywords: Composite materials, composite leaf springs, FEA , E-Glass/Epoxy, ANSYS

1.INTRODUCTION

Ever increasing demands of high performance together with long life and light weight necessitate consistent development of almost every part of automobile. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. A suspension system of vehicle is also an area where these innovations are carried out regularly. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems.

The leaf performs the following functions:

1. Supports the chassis weight.
2. Controls chassis roll more efficiently`-high rear moment centre and wide spring base.
3. Controls rear end wrap-up.
4. Controls axle damping.
5. Controls lateral forces much the same way a hard bar does.

6. Controls braking forces.
7. Regulates wheelbase lengths (rear steers) under acceleration and braking.

Leaf spring is a simple form of a spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times. Just for the common form of its conception in Italian language a leaf spring suspension is called “balestra” (cross bow).an advantages of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path. 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.

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. 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.

The matrix material surrounds and supports the reinforcement or the fibre materials by maintaining their relative positions. The reinforcing material impart their special mechanical and physical properties to enhance the matrix properties. In general terms composite are explained as the following:

Fig1. Components of a composite

Objectives

1. Investigation and Static analysis of standard Steel leaf spring and composite E-glass/Epoxy leaf spring.
2. Finding out the deflection and compressive strength for the same.
3. Comparison of the results of standard Steel leaf spring and composite leaf springs.
4. Validation of results by theoretical calculations of standard Steel leaf spring and composite E-glass/Epoxy leaf spring.

2.LITERATURE VIEW

Compare the load carrying capacity, stiffness and weight saving of composite leaf spring and conventional steel leaf spring. He calculate and compare mechanical properties like Young’s modulus, Ultimate Tensile Strength, Yield Tensile Strength, Density and Thermal Expansion between conventional leaf spring of material 55si2Mn90 steel and composite leaf spring of material E glass/ Epoxy. He analyzed both the conventional steel leaf spring and composite material leaf spring on ANSYS 14.0 software by giving boundary and loading conditions. Dr. Amit Pradhan et.al. [1]

Analysis, design and fabrication of GFRP composite leaf spring and laminated mild steel leaf spring. CATIA software is used for modelling and static analysis of 3-D model of conventional leaf spring is performed using ANSYS14.0. The composite leaf spring is manufactured by Hand lay- up process using vacuum press. For surface finishing of mold releasing agent gel/wax is used. Practical test is carried out on UTM machine. Akhil Mehndiratta et.al. [2]

A study on the use of glass fibre reinforced composite leaf spring for commercial vehicle particularly for heavy tank trailer suspension system. The combination of Dobeckot 520F and hardener 758 hardeners are used. The materials used because of better inter laminar shear strength, good mechanical and thermal properties. A general discussion on the analysis and design of constant width, variable thickness composite spring is prepared.P. Vivek and A. Mohankrishnan. [3]

To reduce the overall weight of suspension system and improve load carrying capacity of the leaf spring by using composite material. Two materials are used to comparison are: conventional spring and composite E-glass/Epoxy material. The deflection and bending stresses induced in the two leaf springs are compared. The solid modelling of leaf spring is done in CATIA V5 and analysed using ANSYS14.5. Sushil B.Chopade et.al. [4].Primary objective is to compare their load carrying capacity stiffness and weight savings of composite leaf spring and conventional leaf spring. Modelling of spring is done on AUTO CAD and CATIA. Analysis

of spring by using ANSYS-12 with workbench journaling and scripting is carried out. Prashant Kuyate et.al. [5].To present a general study on the performance comparison of Composite (Glass Fibre Reinforced plastic - GFRP) leaf spring and conventional leaf spring. Leaf spring is modelled in Unigraphics NX4 software and it is imported in ANSYS 11.0. The Conventional steel leaf spring and the composite leaf spring were analysed under similar Conditions using ANSYS software and the results are presented. An E-glass/Epoxy composite leaf spring is fabricated using hand layup method. The composite and steel leaf spring is tested using universal testing machine and the results are compared. This leaf spring is used in Ambassador Car. Material used for steel leaf spring is 55 Si 2 Mn90 steel. V. Pozhilarasu et.al. [6]

For replacement of steel leaf spring with that of glass fibre composite leaf spring. The composite material have a high strength to weight ratio and good corrosion resistant. In this paper firstly study & understanding about the material & properties of steel leaf spring like tensile strength, Yield strength young's Modulus etc. Then similarly he find out & selected the composite material for the leaf spring based on the strain energy i.e. E glass/ Epoxy. Ghodake A. P. et.al. [7].The brief look on the suitability of composite leaf spring on vehicles and their advantages. The objective of the present work is design, analysis and fabrication of mono composite leaf spring. The design constraints are stress and deflections. The finite element analysis is done using ANSYS software. Dr. Santosh B. Jaju et.al. [8].A three-leaf steel spring used in passenger cars is replaced with a composite spring made of fiber glass/epoxy composite. Hand lay-up vacuum bagging process of composite fabrication is used. Experimental tests are performed to compare the load carrying capacity and stiffness of composite leaf spring with metallic one and also the fabricated composite leaf spring is fitted to the vehicle and its performance under actual working conditions are studied.R M Patil, S M Hatrote [9]. Steel leaf spring was replaced with an optimized composite one. Using the results of the steel leaf spring, a composite one made from fiberglass with epoxy resin is designed and optimized using ANSYS. Compared to the steel leaf spring (9.2 kg) the optimized composite leaf spring without eye units weights nearly 80% less than the steel spring. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the resonance.Mahmood M. Shokrieh et.al [10]

3.METHODOLOGY

3.1] Selection of Standard Leaf Spring of Light Motor Vehicle.

The material used for conventional leaf spring is usually a plain carbon steel having 0.90 to 1.0% carbon. EN47 is suitable for oil hardening and tempering.

3.2] Study of mechanical properties and dimensions of selected standard leaf spring.

Table3.2.1 Mechanical properties of EN 47 Steel

Properties	Values	Unit
Young's modulus	200000	MPa
Tensile strength	650-880	MPa
Elongation	8-25	%
Fatigue	275-275	MPa
Yield strength	350-550	MPa
Density	7700	kg/m3

Table3.2.2 Dimensions of Steel Leaf Spring

Parameter	Dimension	Units
Total length of spring (Eye to Eye) 2L	940	mm
Free Camber (At no load)	136	mm
No. of leaves	1	-
Thickness of leaf	6	mm
Width of leaf spring	60	mm

3.3]Leaf Spring Calculation for Maruti suzuki Omni:

The specifications regarding load on leaf spring of Maruti Suzuki Omni Van is as follows:
Omni 5 seater has weight = 800kg
The carrying capacity is = 5
Let, the average weight of person is 70kg so 70×5 = 350kg
So gross weight of vehicle = 800+350 =1150kg
Total weight acting downward = 1150×9.81×1.5 =16922 = 17000 N
The Omani has four leaf spring so the weight distribution on each leaf spring = 17000/4 = 4230 N.
But each conventional leaf spring has one master leaf spring & three graduated leaf springs. So load carrying capacity for only master leaf spring will be less than 4230 N.

3.4]Study and selection of composite material for leaf spring.

Materials constitute nearly 60%-70% of the vehicle cost and contribute to the quality and the performance of the vehicle.

The commonly used fibres are

1. Carbon fibre
2. Boron fibre
3. Glass fibre.

3.5]Selection of Resins

In a FRP leaf spring, the inter laminar shear strengths is controlled by the matrix system used. Since these are reinforcement fibers in the thickness direction, fibre do not influence inter laminar shear strength. Araldyte LY556 is a solvent less epoxy resin. Which in combination with hardener HY951 cures into hard resin. Hardener HY951 is a low viscosity polymer .

4.Modelling and Analysis

Modelling of both springs on CATIA V5 Software.

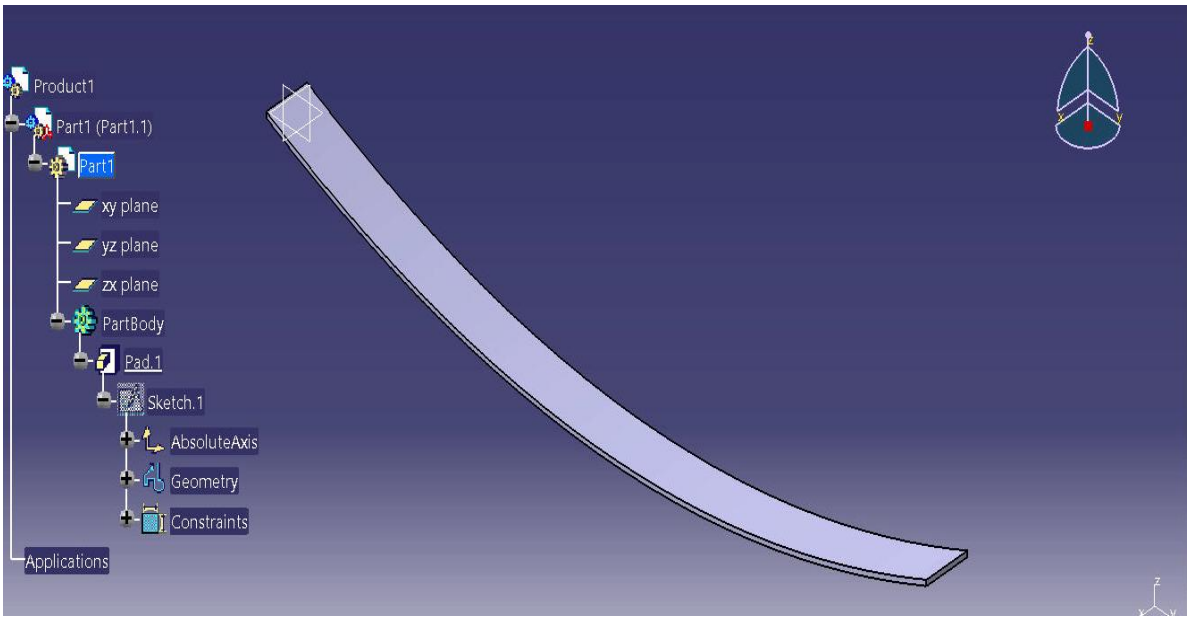

Fig.4.1 Steel Leaf Spring Model on CATIA

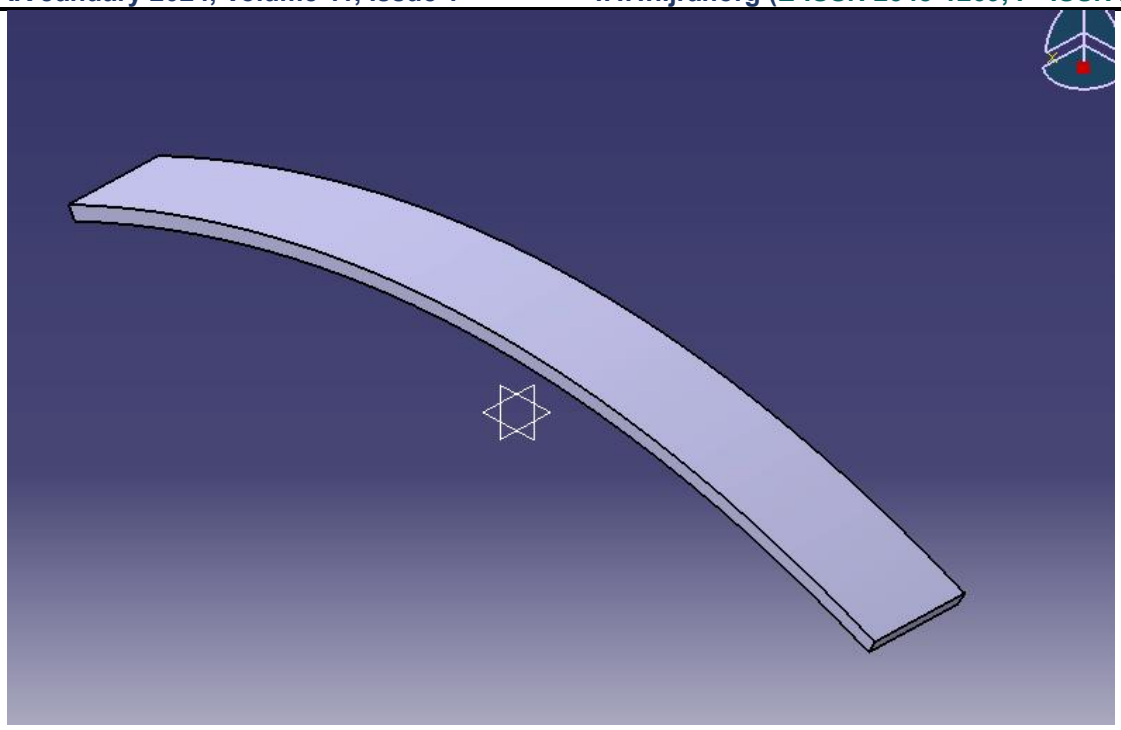

Fig.4.2 CATIA Modelling of Composite Leaf Spring

4.1] Analysis of both springs on the ANSYS 14.0 analysis software for load and Deflection criteria.
4.2] Manufacturing of leaf spring with selected composite material.

Fig.4.3 Material

Fig.4.4 Final Composite Leaf Spring

4.3] Testing of both the spring on Universal Testing Machine (UTM). [2]

4.4]Testing on UTM Machine:

Testing of leaf springs is done on UTM machine at Annasaheb Dange College of Engineering and Technology. The capacity of UTM machine is 1000 KN. We applied 2250 N load on both steel and composite leaf spring & load vs deflection readings noted.

Fig.4.4.1 Testing o UTM Machine

4.4.1] Comparison of both the spring for load vs deflection & stress criteria.

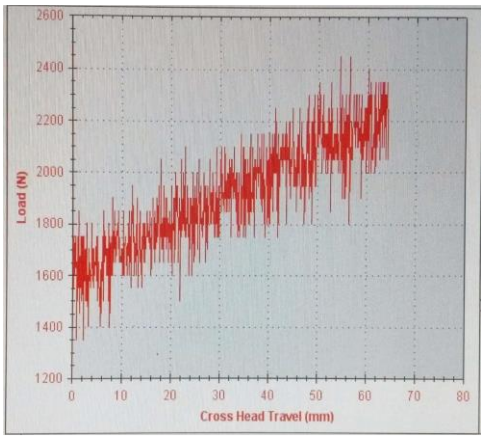

Fig.4.4.2.Load Vs Deflection Graph Of Steel Spring

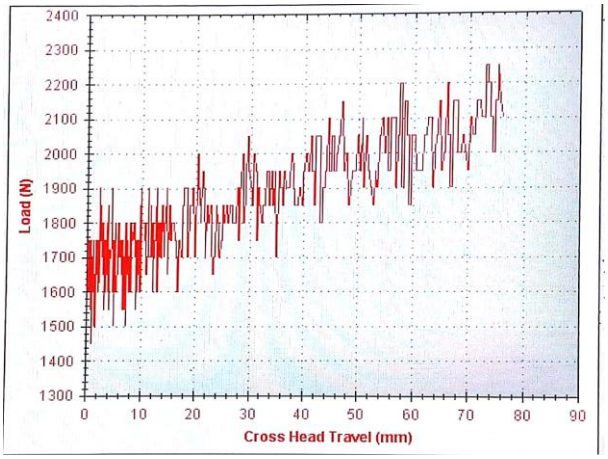

Fig.4.4.3.Load Vs Deflection Graph of Composite Leaf Spring

4.5]Load Vs Deflection

The both manufactured composite leaf spring and steel leaf spring are tested on UTM machine. The load is applied gradually from 0 to 2250N is applied at the centre of leaf spring. The deflections at various loads is measured and load vs deflection graph is generated by the computer connected to UTM machine. The comparative result of both steel and composite leaf spring are as follows

Table4.5.1. Result of Both Leaf Spring

Load (N)	**Deflection (mm)**	
	Steel	**Composite**
1650	2	2
1800	18	21
2000	46	56
2150	60	72
2200	62	74
2250	64	76

Table.4.5.2 Weight of Steel and Composite Leaf Spring

Leaf spring type	Steel	Composite
Weight (Kg)	2.8	2

4.6 Calculation

Table: 4.6.1 comparison of load and stresses between both leaf spring

Load	Stress	(N/mm2)
	Steel	Composite
1650	1077	44.74
1800	1175	48.80
2000	1305	54.23
2150	1403	58.29
2200	1436	59.65
2250	1468	62

$$\text{Stress} = \frac{3FL}{2bt^2 n}$$

Where,

F = Applied Load
L = Total Length
n = No. Of Leaves
b = Width of Leaf Spring
t = Thickness of Spring

The maximum bending stress for the both spring are as follows

1) Bending stress for steel leaf spring
   L= 940 mm
   N= 1
   B= 60mm
   t = 6 mm

Max bending stress for load 1650N $= \frac{3FL}{2bt^2}$

$$= \frac{3 \times 1650 \times 940}{2 \times 60 \times 6^2} = 1077 \text{ N/mm}^2$$

2) Bending stress for composite leaf spring

L= 940 mm

N= 1

B= 130mm

t = 20 mm

Max bending stress for load 1650N $= \frac{3FL}{2bt^2}$

$$= \frac{3 \times 1650 \times 940}{2 \times 130 \times 20^2} = 44.74 \text{ N/mm}^2$$

5.Conclusion:

The 3-D modelling of both steel and composite leaf spring is done and analyzed. A comparative study has been done between steel and composite leaf spring with respect to deflection and weight. It is observed that the composite leaf spring is lighter than conventional leaf spring.

The introduction of composite materials was made to reduce weight of leaf spring without not more reduction in load carrying capacity. It is observed that the composite material shows more deflection than that of steel leaf spring.

At load 2250N the deflection of composite leaf is 76mm and steel leaf spring is 66mm. It is observed that the composite material shows more deflection than that of steel leaf spring.

The stresses in both leaf spring are calculated at 2250 N load. The stress in composite leaf spring is 61 N/mm² and that of steel leaf spring is 1468 N/mm². It is observed that the stresses in composite leaf spring are less as compared to the steel leaf spring.

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