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Experimental Investigation on Leaf Spring using Luffa Cylindrical, Pine Apple and E-Glass Fiber with Resin

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Abstract - This chapter discuss the different loading conditions and a suitable composites is selected for the research of luffa cylindrica, pineapple and e-glass fiber with epoxy composite for leaf spring. Our attempt is to test the mechanical properties of composites reinforce by varying strudy are tensile strength, hardness and toughness. In present year's natural and synthetic fiber composite material locale a major role in industries like aerospace and automobile. The composites formed by fibers gained attention due to their low cost, light weight, low density, high specific strength, non abrasivity, non toxicity etc. in this project discussed the Composite material plate by using luffa cylindrical, pineapple and e-glass fiber with Epoxy composite and to evaluate the Mechanical properties of leaf spring (Tensile strength, Impact and Hardness test).

Keywords: Natural fiber, Synthetic fiber, Resin, Composite material.

1 INTRODUCTION

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix.

The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes.

The primary reason composites are chosen is improved specific strength / stiffness (strength / stiffness specific per unit weight).This helps to reduce fuel use, or increase acceleration or range in transport. It allows for easier, faster installation or faster movement of robot arms and reduces supporting structures or foundations. It improves topside stability in vessels and offshore structures and buoyancy for deep sea applications. Composites don't rust, which is crucial, especially in marine and chemical environments. The need for maintenance and painting is reduced or eliminated. Composite bearings for marine engines and bridges need no lubrication and don't corrode. Combine the excellent fatigue resistance, and composites can increase product lifespan by several times in many applications. Composites are thermal insulators which is good for fire and blast protection or cryogenic applications.

But the weight reduction of the leaf spring is achieved not only by material replacement but also by design optimization. Weight reduction has been the main focus of automobile manufacturers in the present scenario. The replacement of steel with optimally designed composite leaf spring can provide 92% weight reduction. Moreover the composite leaf spring has lower stresses compared to steel spring. All these will result in fuel saving which will make countries energy independent because fuel saved is fuel produced.

2 SELECTION OF FIBERS

This chapter describes the details of processing of the composites for their mechanical characterization. The materials used in this work are

- LUFFA CYLINDRICA FIBER
- PINE APPLE FIBER
- E-GLASS FIBER

2.1 LUFFA CYLINDRICA FIBER

Luffa cylindrical fiber used in this present study was collected in the local market. The outer layer (bark) and seeds of luffa fruit were removed carefully. Then the luffa fibers were cut carefully to separate the outer core from inner core (central core). Only the outer core was used in this study. The outer core of luffa fibers were rolled to make mat like structure after washing them thoroughly with distilled water and air dried for 72h at room temperature. Then the outer core were cut to rectangular mat of size 140 mm x 100 mm by neglecting the end portion to keep the thickness same in all directions and have been used for manufacturing the layered composite.

Fig 1. Luffa cylindrical fiber

2.1.1 ALKALINE TREATMENT

For alkali treatment, the luffa cylindrical fiber were soaked in a 5% NaOH solution at room temperature maintaining a liquor ratio of 15:1. Prior to alkali treatment, the luffa fibers were washed thoroughly with fresh water to remove the any foreign matter/particle that adhere the fiber surface. The luffa cylindrical fiber mats were then dried in sun light. After complete drying the fibers were kept immersed inthe alkali solution for 4 hours. Washing of fibers were then carried for several time swith fresh water to remove any NaOH sticking to the fiber surface, neutralized with dilute acetic acid and finally washed again with distilled water. A final pH of 7 was maintained. The fibers were then allowed to dried at room temperature for 48 hours followed by oven drying at 100°C for 6 hours.

2.1.2 PROPERTIES OF LUFFA CYLINDRICA FIBER

PROPERTIES	**VALUES**
Density	0.56 g/cm³
Tensile strength (Mpa)	12.50
Young's Modulus (Mpa)	521.00
Vickers Hardness (Hv)	17.90

Table 1 Properties of luffa cylindrical fiber

2.2 PINEAPPLE LEAF FIBER

Pineapple leaf fiber is one kind of fiber derived from plants (vegetable fiber) which is derived from the leaves of the pineapple plant.

The pineapple leaf shape resembles a sword that tapper at the ends with black and green colors on the edges of the leaves are sharp thorns. Depending on the species or type of plant, pineapple leaf length is between 55cm to75cm by 3.1cm to 5.3 cm wide and 0.18cm thick leaves of up to 0.27cm. In addition pineapple species, spacing and distribution of sunlight will affect the growth of leaf length and strength properties of the resulting fiber. Distribution of sunlight is not too much (partly hidden) generally will produce a strong fiber, refined, and similar to silk.

Fig 2. Pine apple Fiber

Pineapple leaf fiber intake is generally done at the age of 1 to 1.5 years. A fiber derived from the leaves of the young pineapple generally is not long and strong. For fiber produced from pineapple that is too old, exposed to sunlight without protection will produce short fibers, coarse, and brittle. Therefore, to obtain a strong fiber, soft and smooth, the selection should be done in pineapple leaves enough and protected from the sun

2.2.1 ALKALINE TREATMENT

The pineapple fibers were washed thoroughly in water and subsequently sun dried. The pineapple leaf fibers (PALF) were immersed in a 5% alkaline solution. (NaOH) prepared using a ratio of 1.5 liters to 100 g (liquid: fiber) for 30 minutes. To neutralize the effect of the alkali and further strengthen the PALF, a solution of 2% acetic acid solution was used to treat the PALF for 1 hr. After treatment, the pH of the solution was determined using a pH meter and the pH was found to be 4. The fibers were further washed thoroughly in water to remove embedded chemicals, sun dried, and subsequently dried in an oven at 70°C for 4 hours to finally obtain continuous pineapple leaf fiber.

2.2.2 PROPERTIES OF PINEAPPLE FIBER

PROPERTIES	**VALUE**
Density	1.526 g/cm³
Tensile strength	170 MPa
Young’s modulus	6260 MPa
Elongation	3 %

Table 2 Properties of pineapple fiber

2.3 E-GLASS FIBER

E-Glass fiber (“E” stands for electric) is made of alumina borosilicate glass with less than 1 weight% alkali oxides.

Fig 3. E-glass fiber

Some other elements may also be present at low impurity levels. A typical nominal chemical composition of E-glass fibers is SiO2 54 weight%, Al2O3 14 wt%, CaO + MgO 22 wt%, B2O3 10 wt% and Na2O+K2O less than 2 weight%. Some reported advantages and disadvantages of E-glass fibers.

2.3.1 E-GLASS CHEMICAL PROPERTIES

E-Glass - the most popular and inexpensive. The designation letter "E" means "electrical implies that the it is an electrical insulator". The composition of E-glass ranges from

CHEMICAL COMPOSITION	**RANGE**
Sio_2	52-56%
Al_2O_3	12-16%
CaO	16-25%
B_2O_3	5-10%

Table 3 Chemical properties of E-glass

2.3.2 PROPERTIES OF E-GLASS FIBER

STANDARD	**VALUE**
Specific gravity	2.52-2.62
Tensile strength	3100-3800 MPa
Elastic modulus	72.5-75.5Gpa
Elongation at break	4.7 %

Table 4 Properties of E-glass fiber

3 EPOXY RESIN

Epoxy resins have been commercially available since the early 1950’s and are now used in a wide range of industries and applications.

Fig 4. Epoxy Resin

High adhesive strength and high mechanical properties are also enhanced by high electrical insulation and good chemical resistance. The epoxy molecule also contains two ring groups at its centre which are able to absorb both mechanical and thermal stresses better than linear groups and therefore give the epoxy resin very good stiffness, toughness and heat resistant properties.

3.1 PROPERTIES OF EPOXY RESIN

PROPERTY	EPOXY
Viscosity at 25°C μ (cP)	12000-13000
Density (g cm^{-3})	1.16
Heat Distortion Temperature HDT (°C)	50
Modulus of elasticity E (GPa)	5.0
Flexural strength (MPa)	60
Tensile strength (MPa)	73
Maximum elongation	4

Table 5 Properties of Epoxy Resin

4 METHODS

4.1 MATERIAL PREPARATION

The luffa cylindrica, e-glass fiber and pine apple fiber which is taken as reinforcement in this study is collected from local sources. The epoxy resin and the hardener are supplied. Wooden mould having been first manufactured for composite fabrication. The fiber material is mixed epoxyresin by simple mechanical stirring and the mixture was poured into various moulds.

4.2 MIXING RATIO

The composite sample of different composition are prepared .the composite of mixing ratio luffa cylindrical fiber 10%, e-glassfiber 25% and pineapple fiber (10%) with mixing of epoxy **resin 55%.** The different type of fiber is used, while keeping the length of the fiber constant. The detailed composition and designation of composite materials is a releasing age on the mould release sheets to facilitate easy removal of the composite from the mould after curing. The entrapped air bubbles are removed carefully with a sliding roller and the mould is closed for curing at a temperature Of 30 degree C for 24 hours at a constant load of 50kg .after curing the specimen of suitable dimension is cut using a diamond cutter for mechanical test as per the ASTM standards

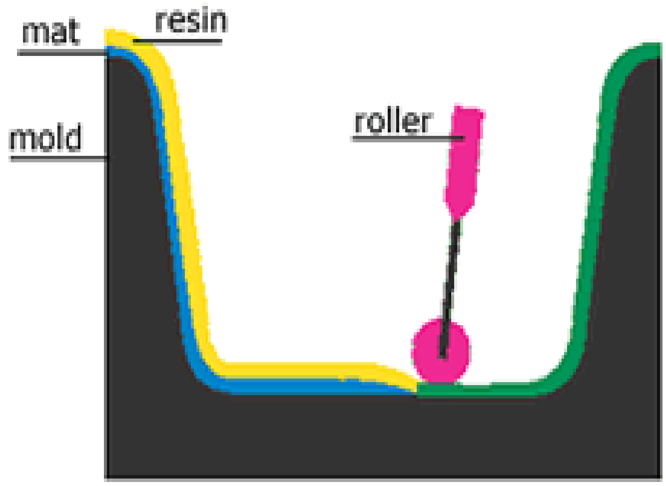


Fig 5 Hand lay-up

5 PHOTOGRAPH

Fig 6 composite leaf spring

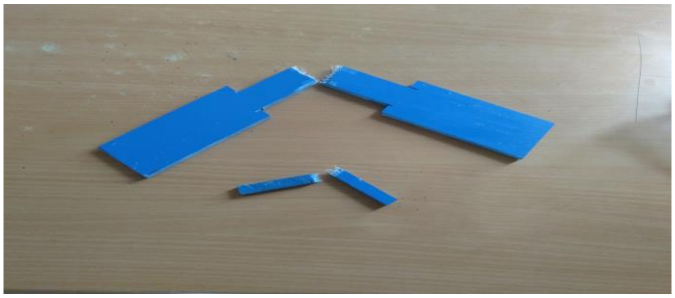
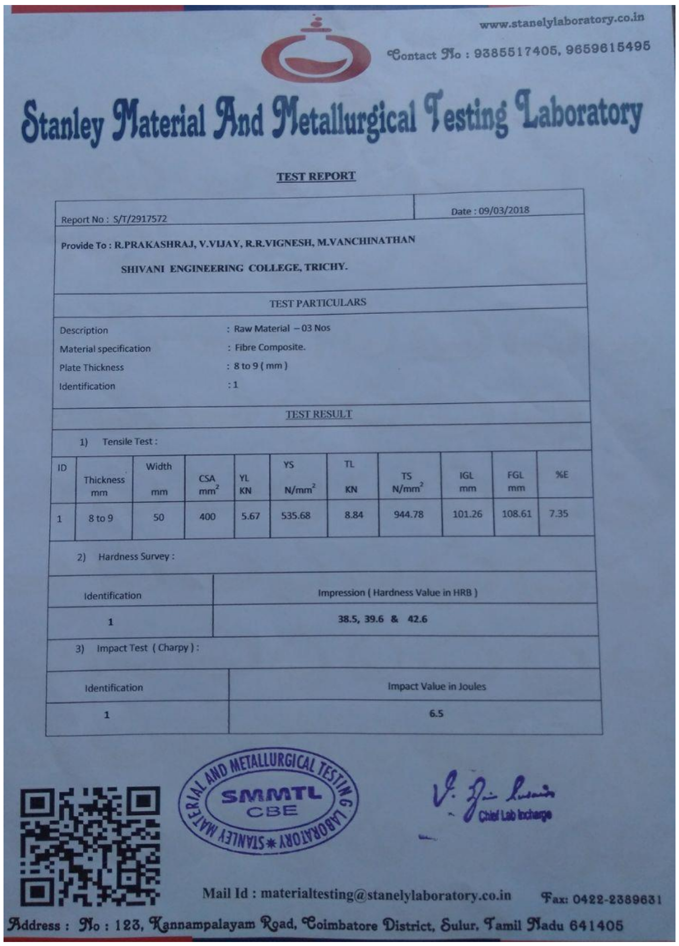


Fig 7 Test piece

6 TESTING REPORT



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Contact No : 9385517405, 9659615495

Stanley Material And Metallurgical Testing Laboratory

TEST REPORT

Report No : S/T/2917572 Date : 09/03/2018

Provide To : R.PRAKASHRAJ, V.VIJAY, R.R.VIGNESH, M.VANCHINATHAN

SHIVANI ENGINEERING COLLEGE, TRICHY.

TEST PARTICULARS

Description : Raw Material – 03 Nos
Material specification : Fibre Composite.
Plate Thickness : 8 to 9 (mm)
Identification : 1

TEST RESULT

1) Tensile Test :

ID	Thickness mm	Width mm	CSA mm^2	YL KN	YS N/mm^2	TL KN	TS N/mm^2	IGL mm	FGL mm	%E
1	8 to 9	50	400	5.67	535.68	8.84	944.78	101.26	108.61	7.35

2) Hardness Survey :

Identification	Impression (Hardness Value in HRB)
1	38.5, 39.6 & 42.6

3) Impact Test (Charpy) :

Identification	Impact Value in Joules
1	6.5

SMMTL CBE
STANLEY MATERIAL AND METALLURGICAL TESTING LABORATORY

Chief Lab Incharge

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Fig 8 Test result

7 COMPARISON TABLE FOR STAINLESS STEEL AND COMPOSITE MATERIAL BASED ON TESTING REPORT

CONTENT	COMPOSITE MATERIAL	STAINLESS STEEL
Tensile Strength (MPa)	755	944.78
Yield Strength (N/mm^2)	310	535.68
Elongation %	20	7.35
Rockwell Brinell Hardness (HRB)	83	40.23
Impact Toughness Test (Joules)	13	6.5

Table 6 Comparison table based on report

8 COMPARISON CHART BETWEEN COMPOSITE MATERIAL AND STAINLESS STEEL BASED ON REPORT

8.1 FOR TENSILE AND YIELD STRENGTH

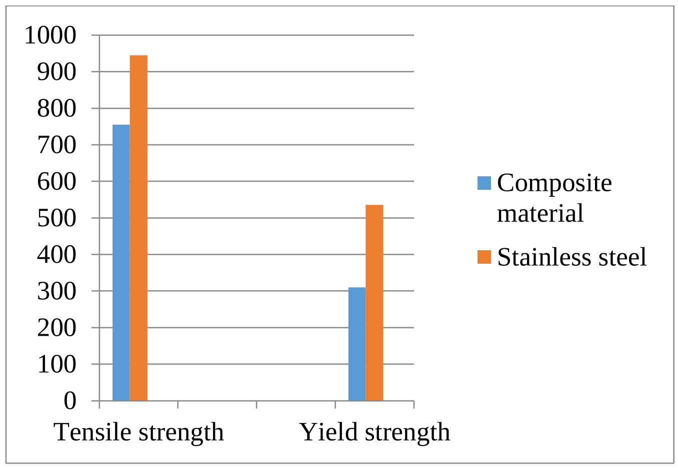

Fig 9 Tensile and yield strength in MPa

8.2 FOR ELONGATION AT BREAK

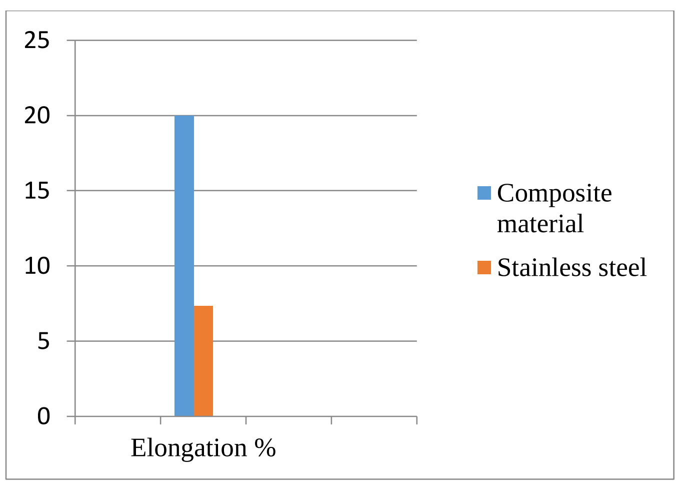

Fig 10 Elongation at break in %

8.3 FOR ROCKWELL BRINELL HARNDESS TEST

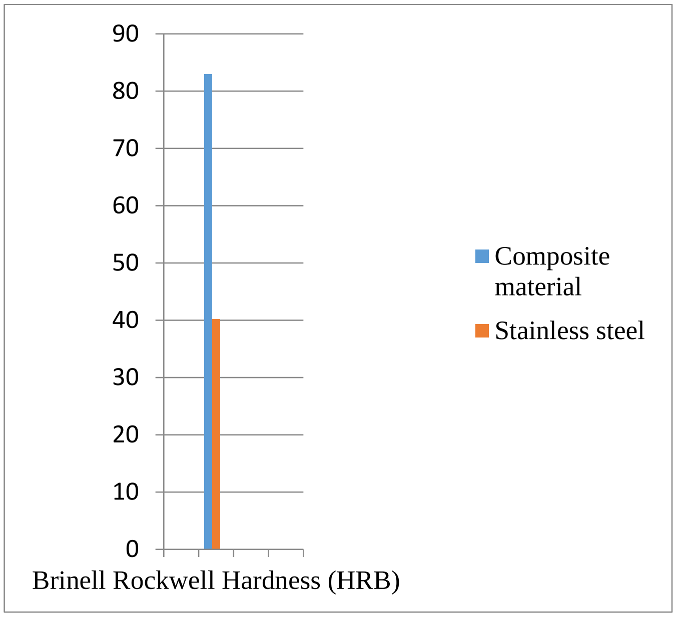

Fig 11 Hardness test in HRB

8.4 FOR IMPACT TOUGHNESS TEST

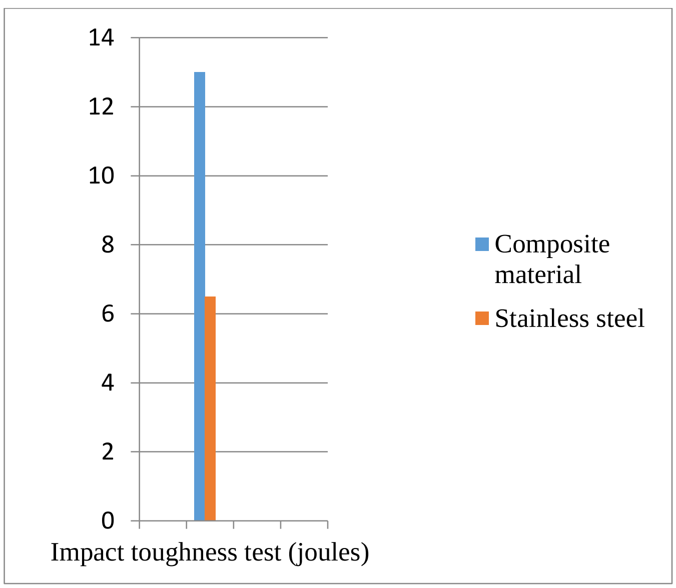

Fig 12 Toughness test in joule

9 CONCLUSION

As a lot of work has been done in designing of leaf springs which is discussed briefly in this text, on the basis of this study, problems in overall weight reduction by using composite materials are identified. Many of the authors suggested various methods of designing, manufacturing and analyses of composite leaf springs. After studying all the available literature it is found that weight reduction can be easily achieved by using composite materials instead of conventional steel, but there occurs a problem during the operation while using the composite leaf spring i.e. chip formation when the vehicle goes off road. Therefore there is an immense scope for the future work regarding use of (luffa cylindrica, pineapple and e-glass fiber) composite materials in leaf springs to reduce the overall weight of the vehicle as well as the cost of the vehicle.

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