DESIGN & ANALYSIS OF MONO LEAF SPRING

Miss. Payal S. Tajanpure[1] Dr. S. N. Shelke[2]

[1] *P. G. Student, in Mechanical (Design) Engineering Department, R. H. SAPAT COE, Nashik, Maharashtra, India.*
[2] *Professor, in Mechanical Engineering Department, R. H. SAPAT COE, Nashik, Maharashtra, India.*

ABSTRACT

The fuel efficiency and emission gas regulation of automobiles are two important issues now a day. The best way to increase the fuel efficiency is to reduce the weight of the automobile. This project work focus on weight optimization of mono leaf spring used in the automotive vehicles. The goal of the present work is to design, analyze, fabricate and testing of unidirectional E-Glass Fiber / Epoxy / Kevlar mono composite leaf spring as per ASTM standards. Determine through structural analysis the Load vs. Deflection of Composite Leaf Spring. Initially the compression test is carried out to determine the deflection at the design load. Spring is chemically tested, its composition is found out and it found that the spring is made up of chromium vanadium EN-47 steel. Further the analysis is carried out for the composite spring of same dimensions to achieve the stated objective.

Keywords- *Composite leaf spring, Deflection, analysis.*

1. INTRODUCTION

Now a day the fuel efficiency and emission gas regulation of automobiles are two important issues. To fulfill this problem the automobile industries are trying to make new vehicle which can provide high efficiency with low cost. The best way to increase the fuel efficiency is to reduce the weight of the automobile. The weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel. In automobile car out of many components one of the components of automobile accounts for 10 to 20% of unsprung weight. which can be easily replaced is leaf spring. A leaf spring is a simple form of spring, commonly used for the suspension wheeled vehicles. The suspension of leaf spring is the area which needs to focus to improve the suspensions of the vehicle for comfort ride. The suspension leaf spring is one of the potential items for weight reduction automobile as it

Fig.1: Mono leaf spring

2. LITERATURE SURVEY

Al-Qureshi presented a general study on the analysis, design and fabrication of composite leaf spring. A single leaf, variable thickness spring of glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf steel spring, was designed fabricated (molded and hoop wound) and tested. Comparison between the performance of the GFRP and the multi leaf steel spring was presented. Shokrieh & Rezaei analyzed four leaf steel spring used in the rear suspension system of light vehicles using the ANSYS V 5.4 software. The finite element results showing stresses and deflections verified the existing analytical and experimental solutions. The objective was to obtain a spring with minimum weight that is capable of carrying given static external forces without failure. Shankar and Vijayarangan described a low cost fabrication of complete mono composite leaf spring and mono composite leaf spring with bonded end joints. A single leaf with variable thickness and width for constant cross sectional area of unidirectional GFRP with similar mechanical and geometrical properties to the multi leaf spring, was designed, fabricated (hand-layup technique) and tested. The results showed that an spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. Jadhao and Dalu described that the composite material has high strength to weight ratio, good corrosion resistance

properties. The objective of present study was to replace material for leaf spring. The material selected was glass fiber reinforced plastic (GFRP) and the polyester resin (NETPOL 1011) can be used which will reduce total cost of composite leaf spring. The experiments were conducted on UTM and numerical analysis was done via (FEA) using ANSYS software. Result shows that, the composite spring has stresses much lower than steel leaf spring and weight of composite spring was nearly reduced up to 85% Abdul Rahim Abu Talib et al. have worked on developing a composite based elliptic spring for automotive applications. The objective is to compare the load carrying capacity, fatigue behavior and weight savings of composite leaf spring with that of steel leaf spring P They concluded that composite elliptical springs have better fatigue behavior than the conventional steel leaf spring and weight reduction ratio is static load condition achieved. patunkar and Dolas in their research paper discussed the analysis of composite mono leaf spring made of glass fiber reinforced plastic. Then simulation was done for the composite spring of glass fiber under the same. From the above literature it can be observed that there is need of experimental investigation of mono leaf spring for light duty/passenger vehicle. The conventional mono leaf spring then can be replaced with the composite spring.

3. PROBLEM DEFINATION

This project work focus on weight optimization of mono leaf spring used in the automotive vehicles. The goal of the present work is to design, analyze, fabricate and testing of unidirectional E-Glass Fiber/Epoxy/Kevlar mono composite leaf spring.

3.1. Objective of Study

1. To develop a composite material fiber particulate for application of leaf spring.
2. To test the spring as per ASTM standards.
3. Determine through structural analysis the Load vs. Deflection of Composite Leaf Spring.

4. METHODOLOGY

In order to achieve desired objective. From the website of Maruti we have connected the data related to the maximum power and speed which is used to find out the maximum load shared by each spring. In this work we are going to conduct test on the rear mono leaf spring of Maruti Omni. In order to determine the deflection at the design load the spring is tested on the UTM. From the Ansys we can determine total deformation in order to optimize in the existing leaf spring. Later on the composite material is taken for fabrication of leaf spring.

5. LEAF SPRING CALCULATIONS FOR MARUTI OMNI

The Maruti Omni van is basically a Japanese commercial van that has been converted with some modification into a passenger vehicle. Gross weight of Vehicle=Weight of vehicle +Weight of person

- Omni 8 Seater has Weight of 800kg
- The carrying capacity is 8(7+1)
- Let the average weight of person is 70kg so 70*8=560kg
- So Gross weight of Vehicle=800+560=1360Kg
- Total weight acting downward=1360×9.81×1.5
- Total weight=200012.4N=20000N
- The Vehicle has 4 springs, two at front and 2 at rear.
- So Weight on spring=20000/4=5000N

Fig 2: Experimental Setup

B. Chemical Testing

Component	C	Mn	Si	S	P	Cr	V
Percentage	0.45	0.75	0.24	0.018	0.016	0.97	0.16

TABLE 2: CHEMICAL COMPOSITION

C. Hardness Testing

- Hardness test is carried out which confirms hardness of 454/459HV-30(Hardness of 45/46HRC).From the above the test the EN-47 Chromium vanadium spring steel confirms.

6. ANALYSIS

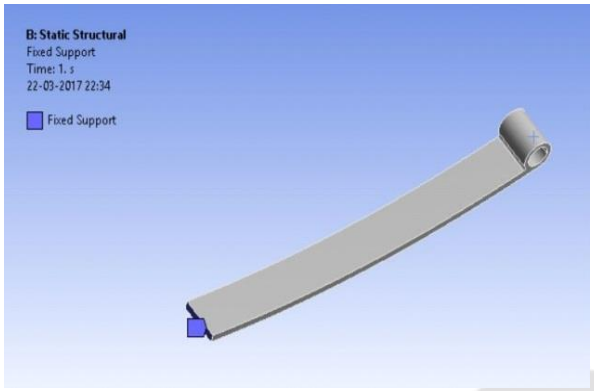

Fig. 3: Leaf spring modeled as Cantilever Beam

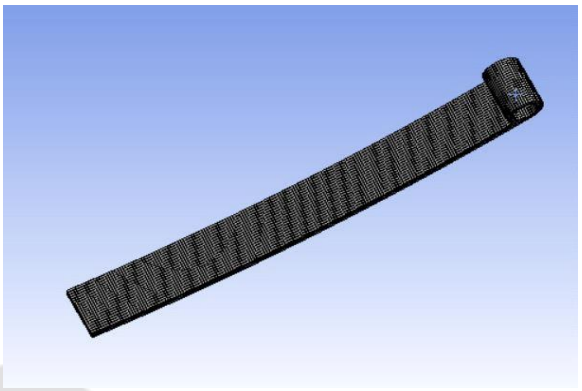

Fig. 4: Meshing of Leaf Spring

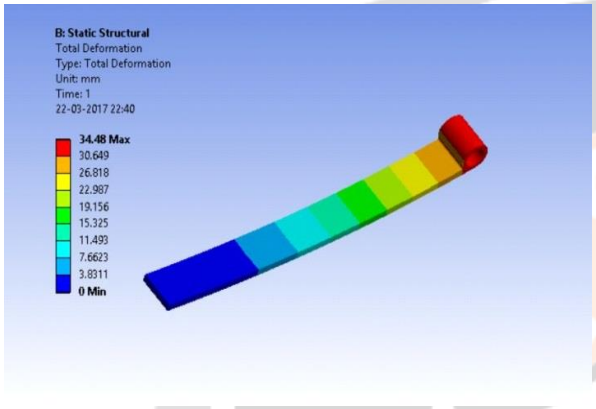

Fig. 5: Deformation at 1000N

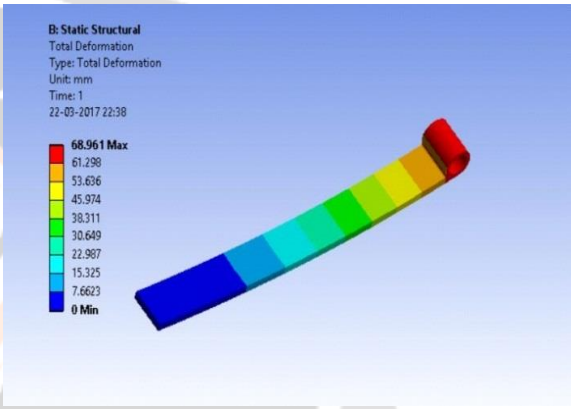

Fig. 6: Deformation at 2000N

7. COMPOSITE LEAF SPRING

7.1 Fabrication of Composite Spring

For fabrication of composite leaf spring the pattern is required. The pattern required is made up of plywood. The dimensions of pattern are calculated from the dimensions of the designed composite leaf spring.

1. Cutting of fibers: The fiber sheets of both carbon fiber an glass fiber are cut into dimensions 990mm×50.13mm.
2. Preparation of matrix: The matrix used is polyester. Polyester contains all the properties of resin, hardener and accelerator. By using polyester the layers of fiber are stacked over one another.
3. Fabrication: The fiber sheets are layered one over another with the help of matrix. The sheet of carbon fiber over glass fiber is layered. 24Hrs.time is required for setting of composite material.

Fig. 7: Final Component

Sr	Load (N)	Deflection(mm)
1	1000	13.10
2	1520	23.80
3	2000	36.90
4	2520	50.90
5	3000	64.60
6	3520	78.60
7	4000	95.80
8	4520	115
9	5000	131.40

TABLE 2: LOAD VS DEFLECTION (MARUTI OMNI)

Sr. No.	Load(N)	Deflection(mm)
1	1000	35.3
2	2000	70.6
3	2800	80.3
4	3000	101.44
5	3200	106.48
6	3600	136.69
7	4000	154.12

TABLE 3: LOAD VS DEFLECTION (COMPOSITE)

8. ANALYSIS OF COMPOSITE MONO SUSPENSION SPRING

The analysis of newly fabricated composite mono suspension spring is carried out in ANSYS Workbench

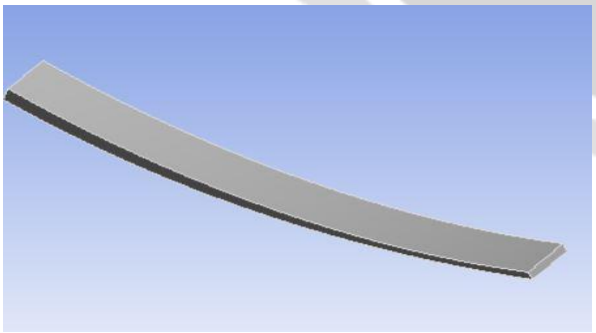

Fig. 8: Geometry

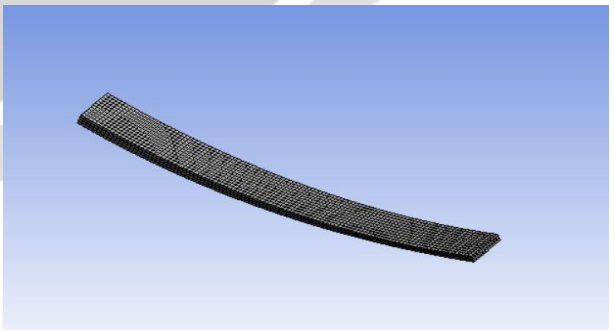

Fig. 9: Meshing of spring

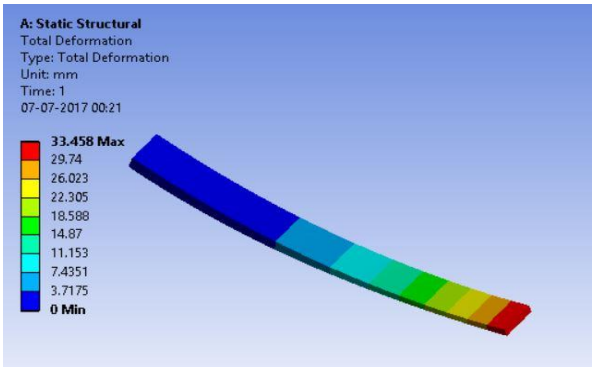

Fig. 10: Deformation at 1000N

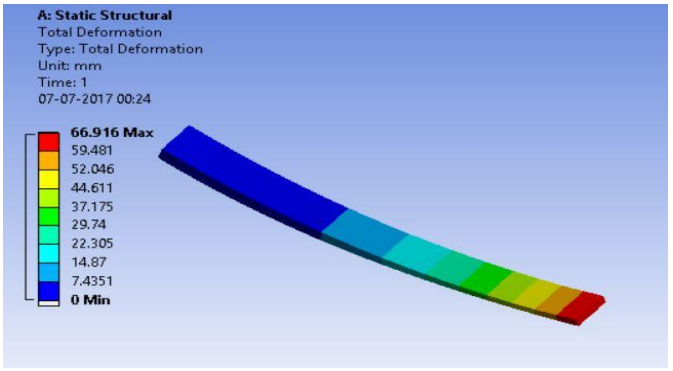

Fig. 11: Deformation at 2000N

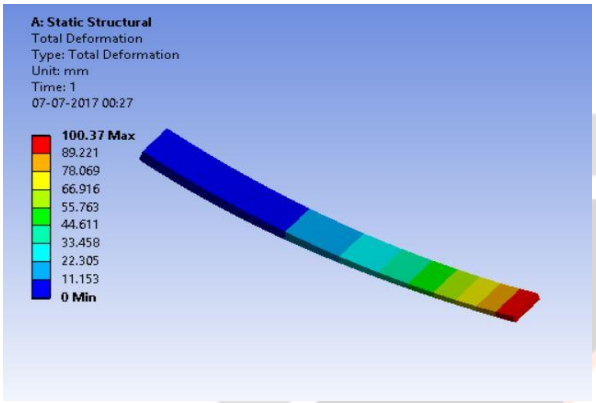

Fig. 12: Deformation at 3000N

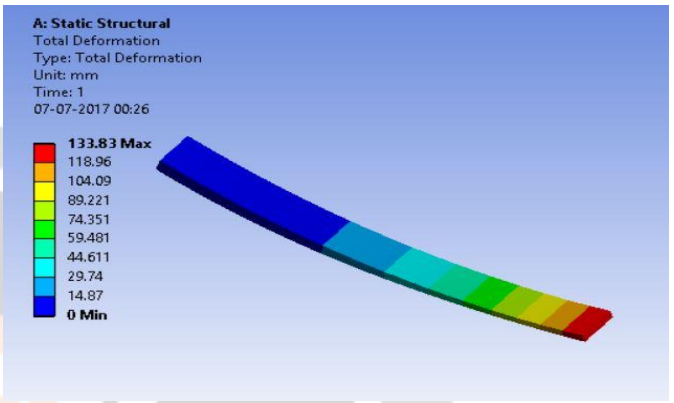

Fig. 13: Deformation at 4000N

9. RESULTS AND DISCUSSION

From the above experiment it can be observed that

1. Material for the current spring is chromium vanadium E-47 steel, the analytical and experimental modeling for which is carried out successfully.
2. Composite with 70:30 combination of glass fiber is selected based on flexural strength and spring is manufactured of which is 2.9Kg as compared to 3.684 kg for conventional spring and 21.28%weightreduction is observed.
3. As compared to conventional spring more deflections is observed but good ductility is observed in new fabricated spring.
4. From the analytical and experimental analysis it is observed that the deformation for new material for same loading condition is less as compared to conventional material so the composite material can be used for the automotive applications.

Sr. No.	EN -47				Composite Spring			
	Load	Deformation Expt. (mm)	Deformation in Ansys(mm)	Bending Stress(MPa)	Load	Deformation Expt.(mm)	Deformation in Ansys(mm)	Bending Stress(MPa)
1	1000	13.10	34.48	833.94	1000	35.3	33.45	130.38
2	2000	36.90	68.96	1668.53	2000	70.6	66.91	260.77
3	3000	64.60	103.44	2502.81	3000	101.44	100.37	391.16
4	4000	95.80	137.92	3337.07	4000	154.12	133.83	521.55
5	5000	131.40	174.4	4171.34				

TABLE 4: Comparative Results (All Parameters)

10. VALIDATION

Sr. No.	Composite Spring			Error Percentage
	Load	Deformation	Analytical Deformation(mm)	
1	1000	35.3	33.45	5.24
3	2000	70.6	66.91	5.22
3	3000	101.44	100.37	1.06

4	4000	154.12	133.83	13.14
Average Error				6.24

TABLE 5: Validation

Thus the analytical and experimental comparison is done which indicates 93.75% accuracy based on above results. Thus composite material for the spring can be used for the automotive suspension application.

11. CONCLUSION

- Thus this work focuses on the experimental investigation of mono suspension leaf spring of Maruti Omni which is tested mechanically for compression test on UTM.
- From the chemical test the chemical composition is determined which confirms the existing material for spring is EN47 chromium vanadium steel.
- With Hand layup method the composite spring carbon glass fibre is manufactured and tested successfully.
- From the Analytical Analysis it is observed that the deformation for new composite leaf spring is less as compared to conventional spring.
- Thus the new material can be used in automotive suspension application.

12. ACKNOWLEDGMENT

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