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Analysis of Mono Leaf Spring Epoxy Carbon Glass Fiber Composite Material

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Abstract

In the automobile sector, the weight of vehicles is increasing due to large-scale use of steel & iron. Due to competition in vehicle manufacturing, all manufacturers try to reduce the weight of automobile components. They search for new materials that can be used for reducing weight. These include fibers, plastics, composite materials etc. In this research paper, we focus on one of these materials, the leaf spring. Generally, leaf spring is manufactured by using MS material with a number of leafs, but we require only one leaf in composite materials as that is sufficient to sustain the entire vehicle's weight. In this research paper, a study of load deflection on single epoxy carbon glass fiber composite material is presented. The objective of this research paper is to compare load carrying capacity and stiffness to weight ratio.

Keywords: *Design, Composite Material, Deflection etc.*

INTRODUCTION

In all automobiles, the suspension is an important component. Due to weight reduction ratio in automobile, it accounts for ten to twenty percent of the unsprung weight. The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness.

Energy conservation is one of the most important objectives in any vehicle design, and reduction of weight is one of the most effective measures for energy conservation as it reduces overall fuel consumption of the vehicle. This is due to composite material's high elastic strain energy storage capacity, and high strength-to-weight ratio compared with that of steel. Springs made of fiber-reinforced plastic (FRP) also have excellent fatigue resistance and durability. The automobile industry has shown increased interest in the replacement of steel leaf spring with fiber glass composite leaf spring because FRP composites has lower Young's modulus, lower density and lesser weight as compared to steel.

PROCEDURE

i. Preparing Leaf spring CAD model by using CATIA software.

ii. This CAD model is imported in ANSYS software.

iii. In ANSYS software, feeding Poissions ratio, Young's modulus value etc.

iv. Applying suitable loading conditions.

v. Perform experimental work by using UTM.

vi. During UTM, we get the values of stress, strain, Young's modulus value, etc.

vii. Compare ANSYS results & experimental results.

PREPARING CAD MODEL OF SPECIMEN

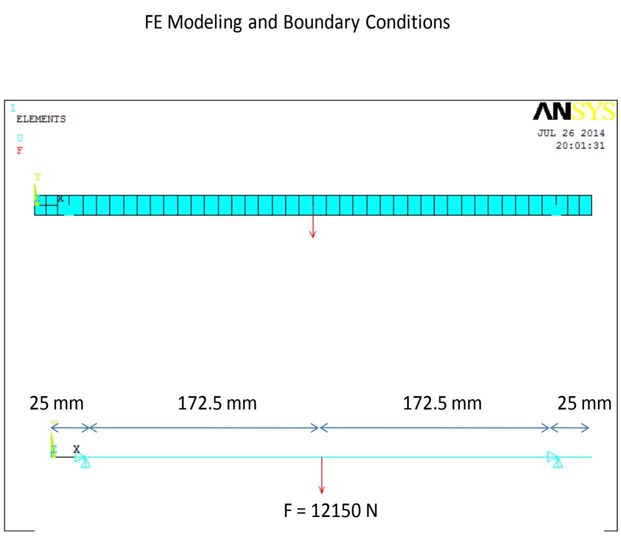

Figure 1 Sample of FEA modeling & showing boundary conditions

ANSYS Simulationsc

Simulation

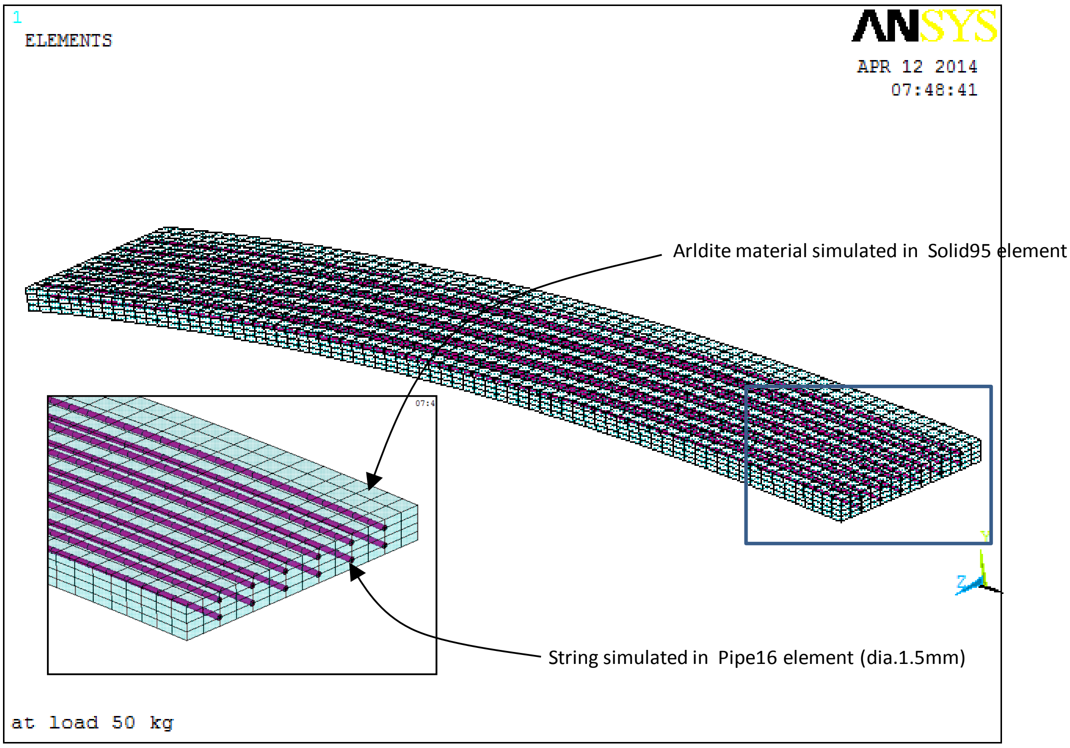

Figure 2 Simulation of composite material leaf spring

EXPERIMENTAL WORK

A specimen leaf glass fiber material is mould & cast for UTM test as per the actual leaf spring dimensions of Maruti 800 car. Density & modulus of elasticity of that material is determined by this test to use these values in FEM analysis. FEM results are validated experimentally using UTM.

Following steps are followed for experimental validation:

i. Arrangement of setup is done on UTM.

ii. Selections of location of deflection measurement.

iii. Deflection measurement at predefined loading conditions.

iv. Comparison of loading/deflection values obtained from FEM analysis and those from experimentation with UTM for sample glass fiber leaf

v. Comparison of loading/deflection Values obtained from FEM

vi. analysis for glass fiber leaf & steel leaf.

Experimentation of loading deflection by UTM

Figure 3

Loading / deflection experimentation of glass fiber specimen leaf at UTM

Figure 4

First end fixed condition

Figure 5

Second end of leaf sliding support similar to application in a car

Figure 6

UTM control panel and display unit

Figure 7

RESULTS

Loading / Deflection Experimentation of Glass Fiber Specimen Sample Rod at UTM

Table 1

SN	LOAD KG	DEFLECTION -MM
1	50	8.4
2	100	15.2
3	150	25.4

Graph 1

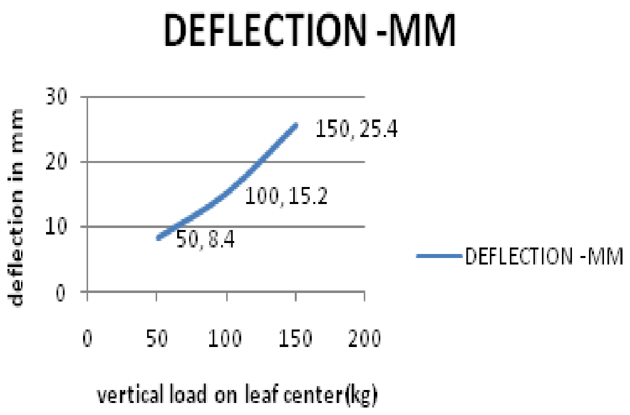

Table 2

SN	LOAD KG	DEFLECTION –MM by UTM	DEFLECTION in MM by ANSYS
1	50	8.4	9.2
2	100	15.2	16.5
3	150	25.4	27.8

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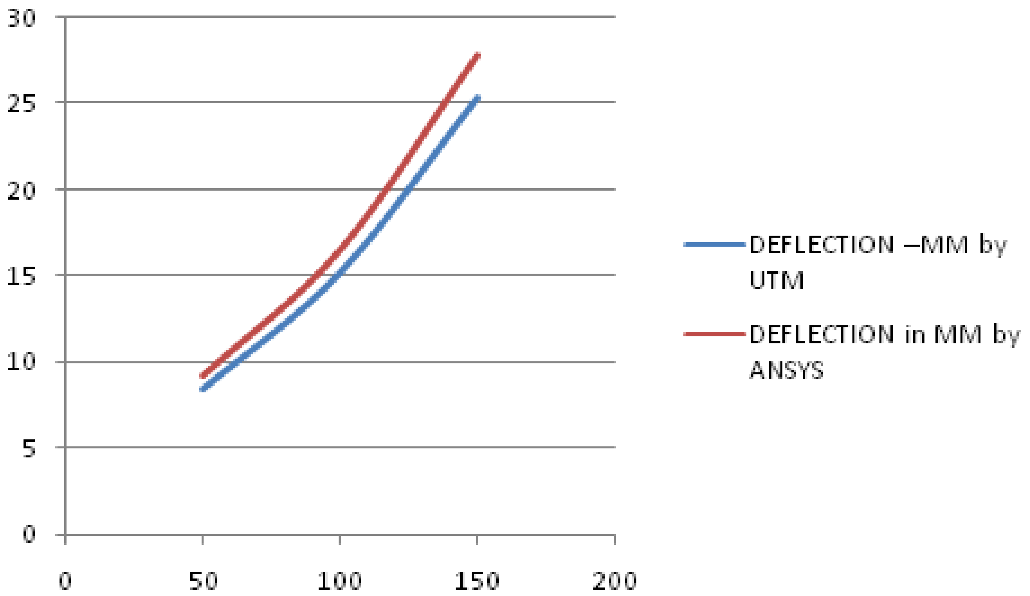
Graph 2



BENEFITS OF USING COMPOSITE LEAF SPRINGS

Composite leaf springs are not new to the automotive industry. In fact, the leaf spring itself dates back to the horse-drawn carriage. By design, leaf springs absorb vertical vibrations caused by irregularities in the road. Variations in the spring deflection allow potential energy to be stored as strain energy and then released more gradually over time. Composites are well suited for leaf-spring applications due to their high strength-to-weight ratio, fatigue resistance and natural frequency. Internal damping in the composite material leads to better vibration energy absorption within the material, resulting in reduced transmission of vibration noise to neighboring structures.

The biggest benefit, however, is mass reduction: Composite leaf springs are up to five times more durable than a steel spring, so when General Motors (GM, Detroit, Mich.) switched to a glass-reinforced epoxy composite transverse leaf spring (supplied by Liteflex LLC, Englewood, Colo.) on the 1981 Chevrolet Corvette C4, a mono-leaf composite spring, weighing 8 lb/3.7 kg, replaced a ten-leaf steel system that weighed 41 lb/18.6 kg. This reportedly enabled GM to shave 15 kg/33 lb of unsprung weight from the Corvette, yet maintain the same spring rates. The leaf spring was transverse-mounted; that is, it ran across the car's width at each axle. This eliminated the coil springs that sit up high in a spring pocket on the frame. Thus, the car can sit lower to the ground, which improves car handling.

Higher speed, greater volume

To date, commercial glass- and carbon-reinforced composite leaf springs have been limited to low-volume production models. “When resins were first being used in the automotive industry, epoxy systems already proven in the aerospace industry were the first to be selected,” explains Scott Simmons, business development specialist for chassis, Henkel Corp. (Madison Heights, Mich.). “While these epoxy systems provide a very high-performing part, the prepreg manufacturing process primarily employed with these resin systems is better suited for the low-volume production associated with aerospace.”

Epoxy prepreg systems weren’t fast reacting because they didn’t need to be for autoclave processing, which, for purposes of quality assurance to high aerospace standards, necessarily involved slow and carefully controlled applications of temperature and pressure. However, much research has gone into expediting the production process through the use of faster molding processes and the development and use of suitably fast-reacting resin systems. These emerging systems show promise for economical mass production of composite leaf springs.

Moving forward with composites

Because transverse composite leaf springs are already in use in lightweight trucks and cargo vans, as well as high-end sports cars, “the main focus for the future of transverse leaf springs,” says Fetscher, “will be the system integration of body-suspension (coil springs) and antiroll bar functions into a multilink leaf spring suspension concept.” These will be a key factor in widespread adoption. “This system will target mainly passenger cars in the C- and D-class segments,” he says, referring to mass-production compact cars and large cars, respectively.

On the longitudinal leaf spring side, composites are used primarily on higher clearance pickup trucks, large cargo vans and heavy-duty trucks. Here, prospects are a bit less promising. “For longitudinal leaf springs, we expect to see more of a component substitution of steel by FRP rather than system integration,” explains Fetscher. That said, the likelihood that composite leaf springs that debuted in the rarified reaches of high-dollar 1950s-era sports cars will reach commercial production in everyday automobiles has, after 50 years of composites research, never been higher.

CONCLUSIONS

i. Experimental results of loading & deflection are matching with the FEM results, hence we can replace steel glass leaf with fiber leaf spring due to advantage of reduction of weight by 67 %.

ii. Stress level is same in both the springs of steel & glass leaf; as cross section area is same.

iii. Due to reduction in mass of glass fiber leaf, suspension performance will be greater than leaf spring.

The longitudinal leaf springs are more exposed to impact from the outside than transverse springs. Because of this, glass fiber-reinforced polymer longitudinal leaf springs are not commonly employed. “There is a level of stiffness that is required in longitudinal leaf springs that is always independent of the width of the spring,” says Fetscher. “You need a flexible width and thickness variation in order to meet the demands of the level of stiffness combined with the main function — the hub stiffness,” he adds. “This is something we hope to achieve with the new process — more flexibility than even with RTM. Filament winding allows flexibility in the width of the spring, and RTM and prepreg allow for alternating thickness change.” Combining these processes and using carbon fiber, he says, could lead to a longitudinal leaf spring design applicable for light commercial trucks and pickup trucks.

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