COMPARATIVE ANALYSIS OF C45 AND GFRP LEAF SPRING

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ABSTRACT

A leaf spring is a persistent element in auto- motive suspension systems. In the previous, extensive investigations have been carried out on the design and development aspects of high grade carbon steel and composite materials. Multi leaf is designed with all similar characteristics. The present work comprises detailed analysis of leaf spring with C45 steel and glass fiber reinforced plastic with different grades. The results are to be compared for high efficiency, loading by using ANSYS software.

Keyword :- *Glass fibre reinforced plastic, leaf spring, C45 steel*

1. INTRODUCTION

Leaf spring is a simple form of spring commonly used in the suspension vehicles. Sometimes it is also called as semi-elliptical spring. Thus depending upon the load bearing capacity of the vehicle the leaf spring is designed with graduated and ungraduated leaves. Unlike coil springs, these springs also locate the rear axle, eliminating the need for trailing arms and a Pan hard rod. As a general rule, the leaf spring must be regarded as a safety component as failure could lead to severe accidents. For this reason, experimental or computational stress analysis of the leaf spring has been of continuous interest for many years.

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 un sprung weight. This helps in achieving the vehicle with improved riding qualities. This helps in achieving the vehicle with improved riding qualities. It is well known that springs, are designed to absorb and store energy and then release it.

2. STATEMENT OF PROBLEM

The previous work has been done only for single leaf with out considering the materials behavior. Now in this present work the gap is fulfilled by creating different models and contact pairs between the leafs. The objectives of this work is to design and analysis of unidirectional leaf spring without end joints and composite leaf spring using bonded end joints by hand-layup technique. This is an alternative, efficient and economical method over wet filament-winding techniques.

In this design methodology all the stems are done in a computer and simulation is carried out. Initially the analysis is done for a minimum load of 2000N and extended to 7500N. The coordinates are defined to the cantilever beam and three beams models. The work has been extended beyond the elastic limit. It clearly shows that how the material properties are contributed for designing the leaf spring to withstand the max load up to its fracture and also the behavior of material beyond this limit.

3. MATERIAL CHARACTERISTICS

3.1 HIGH GRADE CARBON STEEL C-45

The carbon percentage usually ranges from 0.6 to 1.70%. They have higher tensile strength and are harder than other plain carbon steel. They have a hardness of about 500 BHN. High carbon steel responds readily to heat treatment and hence their hardness can be further increased to desired values. Their tensile strength varies from 600-750 N/mm^2 and yield strength is 380 N/mm^2. The youngs modulus and poissons ratio are 2.1x 10^5 N/mm^2 and 0.3.some of the other properties are tabulated below.

Table 1: Properties of C45 Steel

Quantity	Value	Unit
Youngs modulus	2.1 x 10^5	N/mm^2
Tensile strength	600-800	Mpa
Yield strength	380	Mpa
Poissons ratio	0.3	

3.2 GLASS FIBRE REINFORCED PLASTIC

Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time all fiberglass had been manufactured as staple.

Glass-reinforced plastic (GRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers. Like graphite-reinforced plastic, the composite material is commonly referred to by the name of its reinforcing fibers (fiberglass). Thermosetting plastics are normally used for GRP production—most often unsaturated polyester (using 2-butanone peroxide aka MEK peroxide as a catalyst), but vinyl ester or epoxy are also used. As with many other composite materials.GRP becomes a material that resists both compressive and tensile forces well. The two materials may be used uniformly or the glass may be specifically placed in those portions of the structure that will experience tensile loads.

Table 2: Properties of GFRP

Material	Youngs Modulus(Gpa)	Poisson's ratio	Yield strength Mpa
A-glass	70	0.183	1500-1800
C-glass	69	0.276	1300-1900
D-glass	51	0.2	1200-1500
E-glass	72.4	0.2	850-1200

4. DESIGN OF LEAF SPRING

4.1 CALCULATION

Width of the leaf spring, b = 50mm

Thickness of the leaf, t = 25mm

Length of the cantilever beam (spring), L= 520mm

No. of leaves in the spring, n = 3

Let us consider Loads of 1000N,2000N,3000N

Y_{steel} = $(6*3000*520^3)/(2.1*10^5*3*50*25^3)$

=5.14 mm

The Calculation is done for C45 steel for load of 3000N

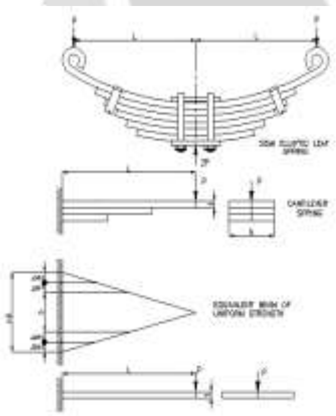
$Y_{C\text{-}GFRP}$ =$(6*3000*520^3)/70*10^3*3*50*25^3)$

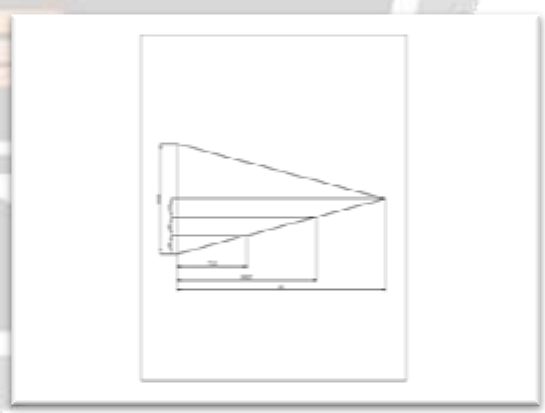
=15.42mm

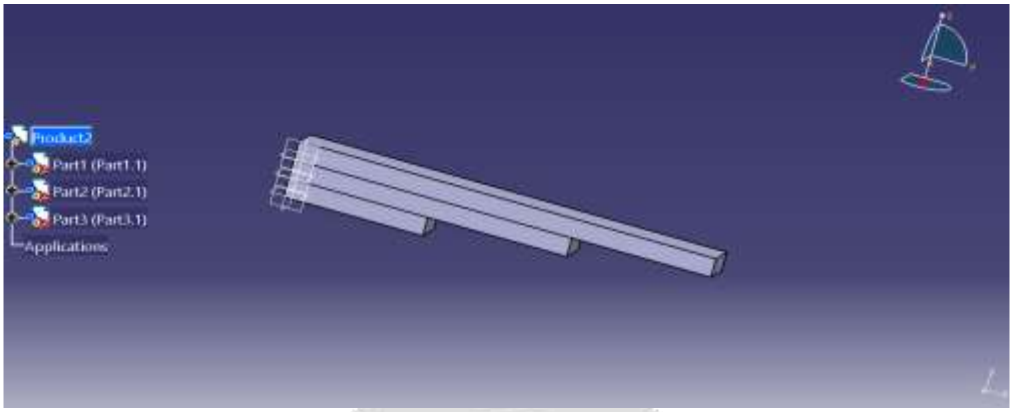
Calculation is done for C-Grade GFRP for load of 3000N

4.2 MODELLING

The first phase of design is cantilever solid triangle which represents the plan view of a leaf spring with three leaf spring, ie, the master leaf which is of 520mm and rest is graduated leaf of considerable length with respect to the width 'b'. The modeling is done in CATIA V5 software.







4.3 ANALYSIS OF LEAF SPRING

The assembled saved file of CATIA V5 as in STEP fomat(.stp file) or IGES (.igs)format imported in ANSYS.

Analysed for High carbon C45 steel and C-Grade, D-Grade Glass fibre reinforced plastic for variable loads of 1000N,2000N,3000N

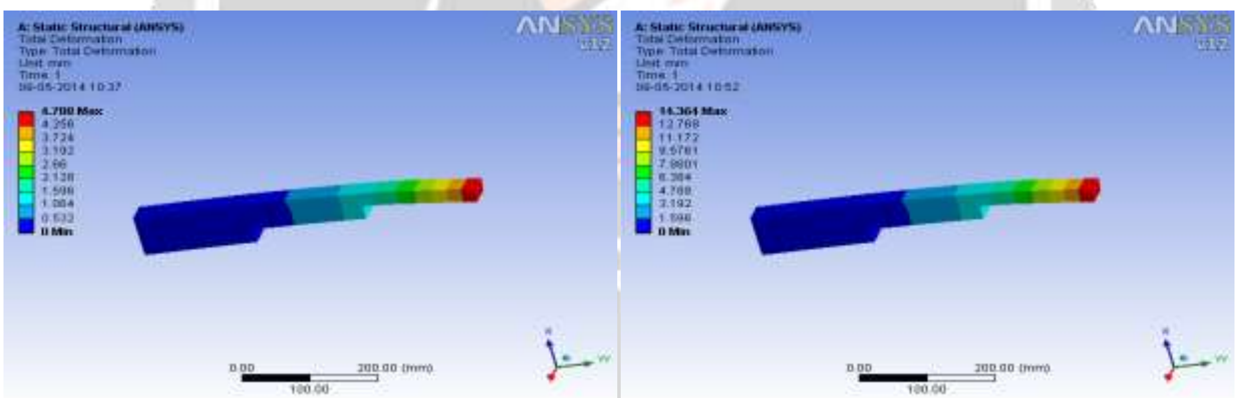


Fig 1. Deformation of C45 Steel and GFRP

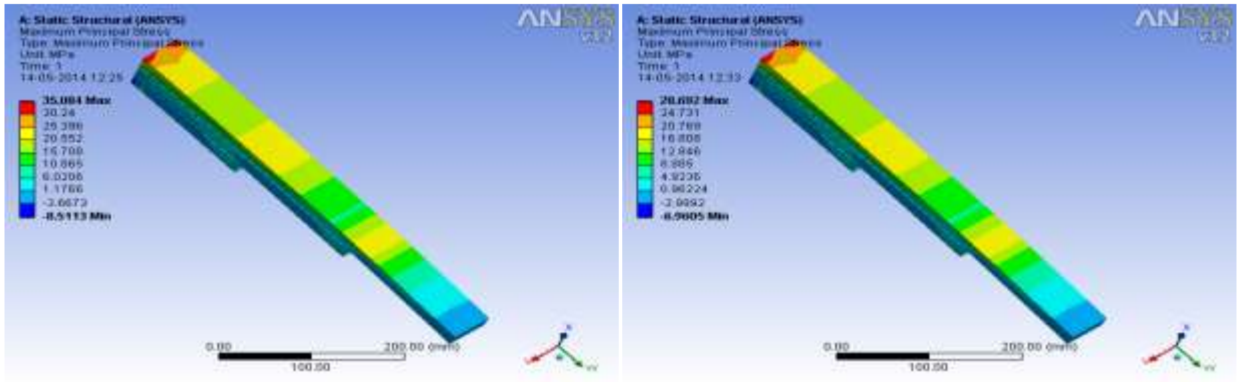


Fig 2. Maximum Principal stress of C45 steel and GFRP

5. RESULTS AND DISCUSSIONS

Table 3. Deformation of C45 steel and GFRP

S.NO	Material Types	Deformation by FEA Mm	Deformation by Analytical method mm
1	C45 Steel	4.732	5.16
2	C-GFRP	14.630	15.42

Table 4. Maximum Principal stress of C45 steel and GFRP

S.NO	Material Types	Max Principal stress by Ansys mm
1	C45 Steel	35.084
2	C-GFRP	28.692

Experimental results from testing the leaf springs under static loading containing the deflection are listed. These results are also compared with FEA. Testing has been done for Glass fibre reinforced plastic (GFRP) of C-grade and D-grade composite leaf spring only. Since the composite leaf spring is able to withstand the Dynamic load, it is concluded that there is no objection from strength point of view also, in the process of replacing the conventional steel leaf spring by composite leaf spring. Since, the composite spring is designed for same stiffness as that of steel leaf spring, both the springs are considered to be almost equal in vehicle stability. The major disadvantages of composite leaf spring are chipping resistance. The matrix material is likely to chip off when it is subjected to a poor road environments (that is, if some stone hit the composite leaf spring then it may produce chipping) which may break some fibres in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. But this depends on the condition of the road. In normal road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments. The steel leaf spring was replaced with an composite one. The objective was to obtain a spring with minimum weight which is capable of carrying given static external forces by constraints limiting displacements. The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring. Thus, the objective of the unsprung mass is achieved to a larger extent. The stresses in the composite leaf spring are much lower than that of the steel.

6. REFERENCES

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