Design and Fabrication of Composite Leaf Spring for Light Vehicle

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Abstract— In recent year weight reduction is most important research in Automobile industry. Reduction of weight while increasing or maintaining good strength of products is most important in the modern world. And this weight reduction is possible by introducing Composite materials .Therefore composite materials are solution of such type of problems. By using composite material we design a composite leaf spring for suspension system of light weight vehicle. In this we describe design and analysis of composite leaf spring. The objective of our product is to compare the strength and weight of composite leaf spring with that of steel leaf spring. Now a day's industries are interested for replacement of steel leaf spring with that of composite leaf spring, because the composite materials have high strength to weight ratio, good corrosion resistance & low weight. There are different composite materials. The material selection depends upon availability of resource and also depends on its properties. In our project high strength with low weight composite material is required because it is used in suspension system. The composite materials E-glass epoxy, carbon epoxy, graphite epoxy, polythelylene terephthalate, polytetrafluoroethylene are actually used. The most preferable composite material is glass fiber reinforced polymer (E-glass epoxy). The strength of composite multi leaf spring varies in percentage is depending on material selection. If we use E-glass epoxy then about 60-70% weight reduction is possible. The design of model will be done on CATIA & analysis on ANSYS.

Key words: Stiffness, Composite Leaf Spring, Steel Leaf Spring, ANSYS, CATIA

I. INTRODUCTION

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. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unstrung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of variations in the spring deflection so that the potential Energy is stored in spring as strain energy and then released slowly. So, increasing the energy storage capability of a leaf spring ensures a more compliant suspension system. To meet the need of natural resources conservation, automobile manufacturers are attempting to reduce the weight of vehicles in recent years. The suspension leaf spring is one of the potential items for weight reduction in automobiles unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities.

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. Flexural rigidity is an important parameter in the leaf spring design and test out to increase from two ends to the centre. Researchers tried to access three design approaches: I. Constant thickness and varying width, II. Constant width and varying thickness, and III. Constant thickness and constant width design. Out of these mentioned design concepts, the constant cross-section design method is selected due to its capability for mass production and accommodation of continuous reinforcement of fibers. Since the cross-section area is constant throughout the leaf spring, same quantity of reinforcement fiber and resin can be fed continuously during manufacturing. It is also quite suitable for filament winding process.

II. RELATED WORK IN LEAF SPRING

We identify some of the problem which generally occurs in case of leaf spring. The usual steel leaf spring has various problems identified which are listed as follow:

- Maximum deformation: because of continuous running of the vehicle there is a declination in the level of soothed offered by the spring.
- Low strength: It is observed that the leaf springs be likely to break and deteriorate at the eye end segment which is extremely near to the shackle and at the middle.
- High weight: The usual steel leaf spring having more weight, which additionally influences the fuel efficiency.

In the design of springs, strain energy becomes the major factor. The relationship of the specific strain energy can be expressed as

$$U = \sigma^2/\rho E$$

Where σ is the strength,

ρ is the density and E is the Young's Modulus of the spring material

It can be easily observed that material having lower modulus and density will have a greater specific strain energy capacity. The introduction of composite materials made it possible to reduce the weight of the leaf spring without reduction of load carrying capacity and stiffness due to more elastic strain energy storage capacity and High strength to weight ratio.

III. OBJECTIVES

The objective of the present work is to design, analyze and propose a method of fabrication of composite mono-leaf spring for automobile suspension system. This is done to achieve the following-

1) This design helps in the replacement of conventional steel leaf springs with composite multi-leaf spring with better ride quality.
2) To achieve substantial weight reduction in the suspension system by replacing steel leaf spring with composite multi- leaf spring.

A. Proposed Methodology

The flow chart is shown in fig.

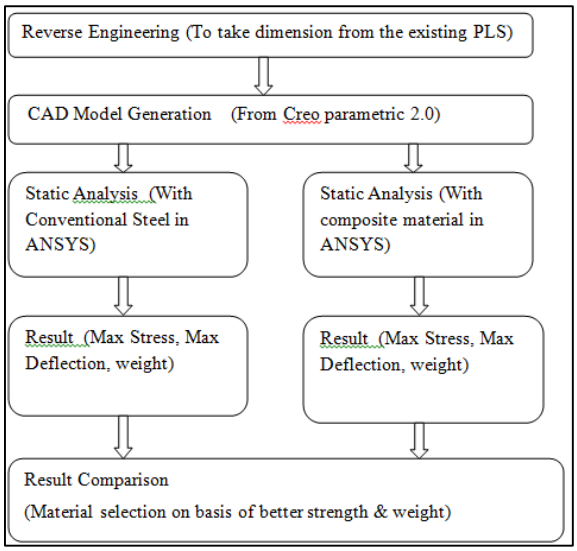

Fig. 1: Flow chart to achieve the objective

IV. CONSTRUCTION OF LEAF SPRING

Multi-leaf spring is constructed of several arc-shaped steel strips of varying lengths that are stacked together with the longest strip at the top, and the shortest strip at the bottom..

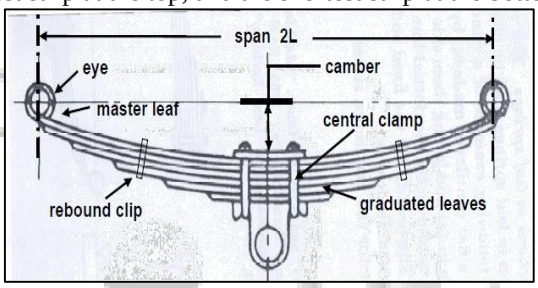

Fig. 2: Construction of Leaf Spring

The top leaf is known as the master leaf. The eye is provided for attaching the spring with another machine member. The amount of bend that is given to the spring from the central line, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member to which it is attached. The camber shown in the figure is known as positive camber. The central clamp is required to hold the leaves of the spring. However, the bolt holes required to engage the bolts to clamp the leaves weaken the spring to some extent. Rebound clips help to share the load from the master leaf to the graduated leaf.

V. SPRING MATERIALS

A. Steel Leaf Spring

The various considerations for the design of semi-elliptical leaf spring of the bus have been presented below.

The different materials are used for the design of leaf spring. The details of which are presented below. Materials for leaf spring are Plain carbon steel, Chromium vanadium steel, Chromium-Nickel- Molybdenum steel, Silicon-manganese steel, are the typical materials that are used in the design of leaf springs.

B. Material Properties of Steel 55si2mn90

Parameter	Value
Yield Strength(N/mm^2)	1470
Youngs Modulus (N/mm^2)	2.1*105
Design Stress(N/mm^2)	388.2
Normal Static Loading(N)	3850
Spring Weight(kg)	280

Table 1: Material Properties of Steel 55Si2Mn90

C. Composite Leaf Spring

1) Glass Fiber Reinforced Polymer (E-Glass/Epoxy)

The matrix material used was medium Epoxy resin widely used in industries due to their strong adhesive properties, chemical resistance and toughness. The reinforcement material employed was E-glass which is a popular fiber primarily made up of silica oxide, along with oxides of aluminum, boron, calcium and other compounds. The hardener HY951is used in the proportion of 1:10. The choice of hardener is governed by the curing temperature and pot life. The experimentation includes fabrication and testing of different % by volume of E-Glass/Epoxy. The composite leaf spring is fabricated using best composition of E-glass/Epoxy. The details of the material combination and percentage are given in table

Matrix	Volume%	Reinforcement	Volume %
Epoxy	50	Glass fiber	50
Epoxy	60	Glass fiber	40
Epoxy	70	Glass fiber	30

Table 2: details of the material combination and percentage

2) Carbon Epoxy

Property	Value
Compressive Strength – Longitudinal	800-1300 MPa
Compressive Strength – Transverse	50-250 MPa
Density	1.6 g cm-3
Flexural modulus – Longitudinal	125 GPa
Flexural strength – Longitudinal	1200 MPa
Tensile strength – Longitudinal	1100-1900 MPa
Tensile strength – Transverse	50 Pa

Table 3: Properties of carbon epoxy

3) Graphite Epoxy

Two different mineral particulates Graphite/Granite filled hybrid composites were prepared by dispersing into the Epoxy as the core material using rule of hybrid mixtures. Mechanical properties like impact strength and hardness, tensile strength and modulus morphological properties were also studied. Composites were prepared using hand layup technique in presence of hot compression molding technique. The impact strength and hardness properties of graphite/granite composites were investigated with reference to the relative weight of graphite and granite. The filler loading was optimized at different weight pattern were investigated. It is found from the impact strength test that all the composites are increased gradually as the granite % increases. From the different filling pattern, the tensile properties were slightly higher for the composites having Graphite as filler and Granite as core material.

4) Polythelylene Terephthalate

The most common thermoplastic polyester, this polymer is often called just “polyester”. This often causes confusion

not only is the chemically similar PBT also a (thermoplastic) polyester, the most common resin system used in GRP is also a polyester system and also often called just "polyester". (in this letter case, however, the polyesters are chemically unsaturated and are "free-radical polymerised" into a thermoset). PET is a hard, stiff, strong, dimensionally stable material that absorbs very little water. It has good gas barrier properties and good chemical resistance except alkalis (which hydrolyse it). Its crystallinity varies from amorphous to fairly high crystalline, it can be highly transparent and colorless but thicker sections are usually opaque and off-white. It is widely known in the form of biaxially oriented and thermally stabilized films usually referred to by their main brand names Mylar, Melinex or Hostaphan. Strictly speaking, these names should be used only for this type of film whose properties are different from, and in several respects superior to, those of "ordinary" PET film.

5) Polytetrafluoroethylene

A totally fluorinated polymer which is semi-crystalline, semi-opaque and white. It has outstanding chemical resistance being unaffected by almost all chemicals and also has a very high oxygen index (i.e. is inherently non-flame). It has a very low coefficient of friction and is stable to high temperatures. It is soft, easily deformed, very prone to creep and low in strength with poor radiation resistance. It is relatively expensive and cannot be melt-processed (although in theory it melts at 327C, the melt viscosity of normal grades is virtually infinite) and so is formed by powder sintering methods.

Industrial applications include bearings, seals, O-rings, high temperature electrical insulations, non-stick coatings and lining for vessels etc. its unusual properties make it invaluable for a wide range of laboratory applications.

VI. CONCLUSION

1) In the present work, a steel leaf spring was replaced by a composite leaf spring due to high strength to weight ratio for the same load carrying capacity and stiffness with same dimension as that of steel leaf spring.
2) Under the same static load conditions the stresses and the deflection in leaf springs are found with great difference. Stresses and deflection in composite leaf springs is found out to be less as compared to the conventional steel leaf springs.
3) A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Composite leaf spring reduces the weight by 67.88% for E-Glass/Epoxy.
4) E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring both from stiffness and stress point of view.
5) Totally it is found that the composite leaf spring is the better that of steel leaf spring. Therefore, it is concluded that composite multi leaf spring is an effective replacement for the existing steel leaf spring in vehicles.

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