`Technical Review on Design and Material Selection for Leaf Spring

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Abstract

Reducing weight and stabilising or upgrading the energy is extra crucial. Automotive and related industries are making progress in replacing the conventional metallic leaf spring with composites cloth crafted from glass fibre, natural fibres, and so forth. The mono leaf spring has fabricated the usage of hand lay-up technique, which tends to be clean and price effective. The present dimensions of a traditional Tata Ace leaf spring are decided on for modelling and evaluation. Stress and deflection are examined experimentally by using flexural attempting out. The hardness of the composites is determined with the assist of Rockwell and Brinell hardness trying out the device, and the values are correlated with each distinct. Leaf spring is modelled in CREO Parametric 2.0 and brought in ANSYS for the numerical analysis. The results suggest that the composites have reduced weight up to 75% in evaluation with the conventional one. With decreased element weight and higher performance is done using composite material, replacing traditional cloth with that of the composite is efficient. The efficiency of a vehicle will improve with a reduced thing cost while a composite leaf spring is used.

Keywords: *- Glass fibre, sisal fibre, leaf spring, FEA, FMEA, numerical analysis*

INTRODUCTION

In the present scenario, the strength of the structures has been the main focus of automobile manufacturers. The suspension leaf spring is one of the potential items for higher strength in automobiles as it accounts for more than two times stronger than the conventional steel leaf spring. This helps achieve more damping capacity, less fuel consumption and resistance against impact loads in the vehicle. The introduction of composite materials made it possible to avoid catastrophic damage due to sudden impact loads transferred to the chassis of a light passenger vehicle through the leaf spring. In this work, an attempt has been made in replacing the design of a conventional multiyear leaf spring with a composite multi-leaf leaf spring based on strength ratio without any modification of the existing design of a light passenger vehicle.

The materials adopted in the composite multiyear leaf spring analysis are glass/epoxy, glass jute /epoxy, carbon jute/epoxy. The optimum material combination is determined based on the maximum induced bending stress, material availability and the contact pressure generated between every laminate, which will influence the unsprung weight of the light passenger vehicle (9).

Due to impact loads acting on the multi-leaf spring, damage tolerance work is also carried out in the composite material with minimum contact pressure by creating artificial hemispherical damage for varying proportions. The optimum composite multiyear leaf spring is fabricated using the filament winding technique. Modelling and contact analysis were carried out for both conventional and composite materials using ANSYS software. From the investigations undergone, it is well proved that composite multi-leaf spring made of glass/ epoxy is found to be of higher strength comparing strength ratio, induced bending stress, contact pressure as well as concerning cost, than the conventional leaf spring and the optimum damage radius due to sudden impact loads is also Predicted in the composite multiyear leaf spring.

Springs are unlike other machines/structure components in that they undergo significant deformation when loaded; their compliance enables them to store readily recoverable mechanical energy. It is well known that springs, in general, are designed to absorb and store energy and then release it. Hence, the strain energy of the material and the shape become a major factor in designing the springs. In a vehicle suspension, when the wheel meets an obstacle, the springing allows movement of the wheel over the obstacle and, after that, returns the wheel to its normal position (i.e., to be resilient). The elliptic composite springs described by Mallick represented the first step in introducing fibre-reinforced elliptic springs for automotive applications. Mechanical performance and failure modes of composite elliptical spring elements under static load conditions are reported (2). Key design parameters, such as spring rate and failure load, are measured as a function of spring thickness. Modes of joining spring elements using bolts are investigated by Mallick[6]. Akasaka et al. evaluated the spring constants of elliptic composite springs by using the energy method. Good agreement was obtained between the analytical and experimental results [7]. However, for vehicle suspension, the industry looks for a cost-effective composite spring with minimum mass capable of resisting corrosion and possessing a high degree of durability. Therefore, due to the cost factor, the automobile industry has shown increased interest in replacing steel springs with composite springs, especially glass fibre composites, rather than others, such as carbon fibre.

Design Concept and Methodology for consisting Composite Martial

For composites to compete in vehicle suspension applications, it is essential to control their failure by utilising them. This can be achieved efficiently by employing a new configuration instead of an existing one, such as a leaf spring. It is proven that designing a composite spring in an elliptic configuration will eliminate the delamination and override the weakness of matrix properties [1–4]. In the case of a new configuration spring, the layers experience a self-compression state, and the tensile properties of fibres will dominate the failure. In contrast, for the leaf spring, the layers experience delamination, and the loss will be dominated by matrix quality. This can draw a very important conclusion regarding the cost of elliptic spring since the matrix will only play binding. This study marries between an elliptical configuration and the woven roving composites. (5)

MATERIALS

Most industries manufacture conventional leaf springs with EN 47 steel material, which was broadly employed in producing parabolic and multi-leaf springs. As discussed earlier, leaf spring can absorb abnormal vibrations, shocks and bumps, which occur due to dissimilarities in the road surface. The capacity to restore and absorb greater strain energy guarantees the comfortable suspension system used in automobiles. Composites consist of 'matrix phase', represented as sheets, particles or fibres and implanted in supplementary material known as the 'reinforcing phase'. Most of the composites exhibit good strength and modulus. Composite materials are superior because they possess lower specific gravities and a strength-to-weight ratio to metallic materials. The fatigue properties are exceptional. With those details, fibre composites have arisen as superior structural materials, which can be considered replacements for conventional materials. An additional inimitable characteristic of numerous fibre-reinforced composites is its great internal damping capacity.

Composites generally produce enhanced energy absorption of vibration inside with greater damping capacity, and composite materials have their use in the automotive field, which eventually suppresses noise, vibration, and hardness. Leaf spring material cost offers nearly 70% of automobile price, which donates to the automobile's quality and performance. Reduction in the mass of automobiles induces a broader and greater financial value. Composite materials prove themselves as appropriate alternatives for steel with a decrease in the weight of an automobile. The usually used fibres are carbon, glass, Kevlar, and so on. Amid those, natural fibre such as sisal is also making their progress in replacing an automotive part. Sisal fibre is found abundantly in urban areas of South India, particularly in the southern part of Chennai in Tamil Nadu. The fibre selected in this experiment is woven glass, woven sisal and the combination of both sisal and glass as a hybrid fibre. The selection of glass fibre is because of its low cost. Glass fibre possesses high chemical resistance, excellent strength and decent insulating properties. Limitations that occur while using glass fibres are small modulus of elasticity, reduced adhesion to polymers, high density and low fatigue strength. Crack detection also becomes difficult. The E-glass fibre in woven roving weighs 360 g/m2. The natural fibre selected in this experiment is sisal, which has good strength and corrosion-resistant properties. The limitation of using sisal fibre is that the production of natural fibres in today’s world is limited. The sisal fibre is woven roving weighs 358 g/m2. The hybrid fibre, a combination of both sisal and glass fibres, increases the strength, reduces the weight and possesses good crack arresting property. (7)

Fabrication of composites

The fabrication procedure starts with the preparation of a pattern in which the layers of fibre can be applied with resin to form a laminate of mono leaf spring, and its constraints woven glass fibre and woven sisal fibrerovings are marked at consistent intervals of 50 mm (width of leaf spring), which are then cut into preferred length

From 1 m2 rovings: The weight of one layer of woven glass fibre is 0.030 kg, and that of one layer of woven sisal fibre is 0.010 kg. The pattern is created to accommodate the fibre layers to form the desired camber of length 100 mm with a required thickness of 10 mm. The hand lay-up technique is used for fabrication. (12)

A. Glass fibre laminate Initially, the Mila sheet, that is, polythene sheet of required dimensions, is placed, and then the application of resin is made gently to form the first layer. Additional roving of woven glass fibre is positioned with the help of a hand roller and pressed to eliminate entangled air. Supplementary layers are positioned, and resin is smeared alternatively, and the technique is reiterated for 12 layers of woven glass fibre to acquire the thickness of 10 mm of the leaf spring. The leaf spring is permitted to harden and cure at room temperature. Then, the woven glass fibre laminate is removed from the pattern and trimmed to dimensions. The weight of woven glass fibre laminate is 0.752 kg. (11)

B. Sisal fibre laminate the procedure is similar to woven glass fibre laminate except that woven glass fibre is replaced by woven sisal fibre. The laminate is made of 12 layers of woven sisal fibre to attain the required thickness of 10 mm. The total usage of resin to prepare the laminate is 900 ml. The leaf spring is permitted to stabilise, and then it is detached. The laminate edges are trimmed to the required dimensions. The weight of woven sisal fibre laminate is 0.702 kg.

C. Hybrid fibre laminate once the polythene sheet is placed, the resin application is made gently, and the principal layer of woven glass is positioned shadowed by the epoxy resin. Then, a roving of woven sisal fibre is Supplementary alternate fibrerovings of woven glass and sisal fibre are positioned with the application of resin. The procedure is repeated to obtain the required thickness of 10 mm. The total usage of resin in the hybrid fibre laminate is 650 ml. The hybrid fibre laminate possesses both the combination of woven sisal and glass fibres of stacking sequence.

CONCLUSION

In general, this present investigation verified that composites could be utilised for vehicle suspension and meet the requirements, together with substantial weight saving. It is also believed that hybrid composite elliptical springs have better fatigue than conventional and composite leaf and coil springs. Interestingly, the hybridisation technique can be used effectively to improve weight saving and performance in the automotive industry. Elliptical configuration was employed to eliminate any hypothesis of delamination. The ellipticity ratio significantly influenced the spring rate and failure loads. Composite elliptic spring with ellipticity ratios of a/b 2.0 displayed the highest spring rate. Hence, damage tolerance analysis only uses glass/epoxy for elliptical damages due to sudden impact loads with varying ratios (a/b) and only at a/b = 0.6. Maximum experimental stress is not intolerable range which means that it exceeds fibre fracture loads. Hence the optimum damage size for this design lies only in the range of (0.30.5) with critical damage size after a/b = 0.6.

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