Design And Analysis of Leaf Spring With A Finite Component Technique By Composite Material Offer High Strength And Light Weight of Small Segmentation

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Abstract- *The mechanics of composite material laid the foundation for the utilization of composites in various fields. The demand of composite materials has been highly augmented in vehicle industry. In this work, I investigated the use of composite material for leaf spring of light weight vehicles. For this purpose, I selected the leaf spring of Suzuki Mehran car for the study. The main goal of this e ort is to obtain optimal geometry for leaf spring with light weight and that can sustain external loading without failure. The analytical and numerical analysis were performed on the leaf spring under static loads. The values of stress and detection obtained from numerical analysis were verified by analytical analysis while optimization was performed on the basis of the results obtained from static stress analysis to decrease the weight of the composite leaf spring while conserving its strength. Also, the dynamic analysis was performed to determine maximum cycles of fail grounder dynamic loads. Moreover, stresses against each dynamic load were also determined. The composites used to design such leaf spring were Kevlar/epoxy and E-glass/Epoxy. The results of values of stresses and detection obtained from analytical and numerical analysis for composite leaf spring were compared and are in compliance. The results of optimization showed a linear variation of width with length and linear variation in thickness along the length from eyes to the axle seat. The proposed optimization method can be efficiently used to reduce the weight of the springs. However, the modal analysis showed that natural frequency of the composite leaf springs was higher than the steel leaf spring. Finally, the result of dynamic analysis shows that Kevlar/Epoxy leaf spring has better tendency to sustain dynamic loads up to 90000 cycles at the speed of 120 km/h as compared to E-glass/Epoxy leaf spring which can sustain dynamic loads up to 60000 cycles at the speed of 120km/h. Furthermore, comparison based on strength and weight among both conventional and composites-based leaf spring was conducted.*

Keywords- Leaf Spring, Finite Element Analysis (FEA), Composite Materials, Structural Design, Weight Reduction, Stress Analysis, High Strength-to-Weight Ratio, Automotive Suspension

I. INTRODUCTION

In automobiles, the leaf spring are crucial components to provide comfortable ride and stability to the vehicle. The requirement to replace leaf spring with more robust and durable leaf spring is the major concern in transport and automotive industry. With this datum it was expected that the vehicle would be more reliable, comfortable and faster. In recent years multiple researches, on metallic and composite materials were carried out to study the application of leaf springs and revealed that the use of composites in vehicle suspension can have accountable significance. This chapter explain brie y about composite and conventional leaf spring.

Background of the Study

The suspension system is significant mechanism to provide strength and protection to the frame of vehicles. However, the suspension system is the area of concern for manufacturers to decrease the load of an automobile by reducing its weight of suspension. The suspension system weights accounts for 15-20 percent of un-sprung weight. Furthermore, the suspension systems of automobiles are also developing regularly to provide protection from impact loading, prevent chassis distortion and damage [1].

Leaf springs and helical springs are major components of suspension system used in vehicles, but in comparison to the helical springs, leaf springs are used more frequently due to their better tendency to absorb shock loads in the vehicles [2]. The leaf spring suspension systems are the key elements for reducing weight in automobiles due to this reason fuel efficiency and riding quality increases. The benefits of leaf spring include its simple and low-cost design. However, variety of leaf springs used in vehicles depending upon the gross weight of the vehicle [3]. The difference between several types of leaf spring depends on their shape. The parabolic leaf spring and normal leaf spring have different number of leaves piled together. Though, normal leaf spring requires a greater number of leaves than parabolic leaf spring. This is due to parabolic shape provides uniform stress distribution [4]. It is well acknowledged that the conventional steel leaf spring provides the necessary strength and sti ness to sustain the weight of the vehicle and appropriately performs its function. But it has some discrepancies during its period of operation. Initially the issue that arises is the weight and the ultimate strength of an ordinary leaf spring. Generally, the eye of the spring close to the shackle and also the curvature of the spring at the centre of the leaf spring gets weaken with the motion of the vehicle causing a reduction in comfort level thus resulting in catastrophic failure. However, this drawback of steel leaf spring can be overcome by enhancing the mechanical properties of steel. Thus, the enhanced material properties help in weight reduction and increased strength, which is also achieved by design optimization and improved manufacturing processesa

II. LITERATURE REVIEW

M.M.Shokrieh et.al worked on the design and optimization of four steel leaf spring. The focus of this study was to replace the conventional leaf spring by optimized composite leaf spring having minimum weight and can withstand peripheral loading without failure. The burglars with epoxy resin was used for the composite leaf spring for the analysis. The analysis was performed in ANSYS V5.4 software. Using FEA analysis the numerical results obtained for stresses and detection are compared and verified with existing analytical and experimental results. The attention was given to the optimization of the leaf spring design. The design constraint are stress and detection. The results obtained after optimization of leaf spring showed that the stresses are much lower in composite leaf spring as compared to steel leaf spring and weight saving of approximately 80% was obtained for composite leaf spring without eyes. Also, the natural frequencies obtained for composite leaf spring are greater than road frequency and steel leaf spring to overcome failure due to resonance.

[2] E. Mahdi a et al. worked on the composite elliptic leaf springs for light weight vehicles. The study was based on the ellipticity ratio of the composite leaf spring. The elliptical conguration for woven roving composites was considered. This pa per studied the impact of using ellipticity ratios extending from one to two on the performance of elliptical leaf spring made from woven roving wrapped composite. The results are examined both numerically and experimentally. The failure mechanisms for these leaf springs were also presented and cited that increasing the wall thickness leads to the increase in the maximum failure and spring rate (k). The results presented that ellipticity ratio has significant effect on the failure loads and spring rate, also the ellipticity ratio (a/b) of 2 for elliptic composite leaf spring exhibited the highest spring rate and demonstrated that these leaf spring can be used for both light and heavy weight vehicles up to significant weight saving and can meet the requirements.

[3] Pankaj Saini et al.[39] presented the work on the design and analysis of composite leaf spring for light vehicles. The objective of this research is to replace the conventional steel leaf spring by composite leaf spring and compare their stresses and weight. In this work, three different type of materials are selected for the composite leaf spring model i.e. E-glass/epoxy, graphite epoxy and carbon epoxy. The static analysis was conducted in ANSYS and results are obtained for the stresses. The stresses for steel leaf spring are higher than composite leaf springs. However, the stresses in graphite/epoxy leaf spring are higher than steel leaf spring among other composite leaf spring. The results demonstrated that E-glass/Epoxy composite leaf spring saves weight up to 81.22% , Graphite/Epoxy saves up to 91.90% and Carbon/Epoxy saves up to 90.50% as compared to steel leaf spring. Also, it was observed that E-glass/Epoxy composite leaf spring has lower stresses and weight as compared to steel leaf spring. Hence, it is considered as replacement of steel leaf spring

[4] Y.N.V Santhosh Kumar et al.[40] studied the design and analysis of composite leaf spring. The main goal of this work is to analyze the Mono composite leaf spring having minimum weight to replace the conventional steel leaf spring. The material used for this purpose is E-glass/Epoxy composite. The leaf spring was analyzed in ANSYS Multiphysics. The weight obtained using E-glass/Epoxy composite leaf spring was 39.4% to that of steel leaf spring. So, a weight saving of 60.48% was achieved. From the results it was obtained that the stresses in composite leaf spring are lower than steel leaf spring and within allowable limits. It was also observed that orientation of fibers in perpendicular direction in composite laminate offered increased strength than other fiber orientations.

III. CONCLUSION

A design and analysis of a leaf spring using finite element techniques and composite materials demonstrate a significant improvement in performance over traditional steel springs. Through the application of composite materials such as E-glass or carbon fiber, the leaf spring achieves a substantial reduction in weight without compromising strength or durability. The segmentation of the spring into smaller, optimally designed components further enhances stress distribution and flexibility. Finite element analysis (FEA) has proven to be a powerful tool in predicting the behavior of the leaf spring under various loading conditions, allowing for efficient material usage and design optimization. Ultimately, this study confirms that the use of composite materials in leaf springs not only contributes to vehicle weight reduction thereby improving fuel efficiency but also maintains or enhances mechanical properties, making it a viable and effective alternative to conventional designs.

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