International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Finite element analysis of Mono leaf spring by using Hybrid composite Material

Vinod Sheshkar[1], Yogesh Yadav[2]

[1]M.tech.Student, Department of mechanical engineering, Millennium institute of technology, Bhopal, MP, India
[2]Asst.Professor, Department of mechanical engineering, Millennium institute of technology, Bhopal, MP, India

***

Abstract - *Leaf springs are made out of flat plates. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite and hybrid materials are one of the material families which are attracting researchers and being solutions of such issue. The attempt is made in the present work to design and analysis of Hybrid composite leaf spring. The design constraints are stress, deflection and stiffness with variable thickness of leaf spring. The main objective of this work is to analyze the equivalent stress, equivalent elastic strain, Deformation, and weight optimization of leaf spring by using a material Hybrid composite.*

Key Words: **Leaf Spring, Hybrid composite material, equivalent stress, equivalent elastic strain, deformation, finite element analysis, Unigraphics NX 6.0, Ansys15.0.**

1. INTRODUCTION

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. 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 un-sprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of Hybrid composite materials has made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. For weight reduction in automobiles as it leads to the reduction of un-sprung weight of automobile. The elements whose weight is not transmitted to the suspension spring are called the un-sprung elements of the automobile.

2. Literature Review

Amal M.K. Esawi et al.(2006) evaluated in their topic named as 'Carbon nanotube reinforced composites: Potential and current challenges' technical and economic feasibility of using carbon nanotubes in reinforcing polymer composites. They concluded that carbon nanotubes can be used in conjunction with carbon fibers in a hybrid composite in order to achieve elastic modulus values in the range 170–450 GPa.

Thippeswamy Ekbote et al. (2012) replaced existing steel spring with composite spring. They found that compared to steel spring, the optimized composite mono leaf spring has much lower stress and the spring weight without eye units is nearly 65% lower than steel spring.

Sagar Manchanda et al. (2015) has been found that carbon polyamide is suitable for mass reduction of 6.1 kg (approx. 80% than steel) moreover, stress, strain and deformations observed are almost similar to other composite, which shows that the vehicle is light weight and can generate more torque and power.

Cristianah O et al. (2016) investigated Design and simulation of fatigue analysis of vehicle suspension system and its effect on global warming. The fatigue life and static analysis of VSS adopting FEA technique provided a reliable design that can be employed in VSS design.

Chen Qian et al. (2017) have analyses the ply scheme design for composites. The production of composite leaf spring samples, on which the fatigue bench test was conducted, was based on the optimized ply scheme. Results indicate that the fatigue life of composite leaf springs can be improved by using the proposed ply scheme design method.

K.Ashwini et al. (2018) have taken review for leaf spring made by different materials. Designing a leaf spring using various composites as the Automobile industries are showing keen interest for replacing steel leaf spring with that of a composite leaf spring to obtain reduction in weight, which is an effective measure for energy conservation as it reduces overall fuel consumption of the vehicle.

3. Problem identification and research objectives

According to the brief study of research paper the fallowing point have been observed:

- Maximum deformation results in the form of failure of leaf spring. Minimize the deformation of leaf spring for long life of suspension system.
- Heavy weight is the major issue in the suspension system. Minimize the weight of leaf spring for good suspension.
- Higher stresses will results in failure of suspension system. Reduce the stresses on leaf spring.

4. Methodology

The following steps are involved in creating a model of mono leaf spring:

A model of mono leaf spring with variable thickness is first created using Unigraphics NX 6.0 Design software. Then the model is imported to ANSYS 15.0 to complete static structural analysis. The entire section deals with the methodology adopted for the analysis of leaf spring for comparison of stress, strain and deformations. The results obtained from analytical method gives very close results as obtained from FEA. The model of the leaf spring has been analyzed using finite element static analysis under the boundary and loading condition. The design model of mono leaf spring is shown below:

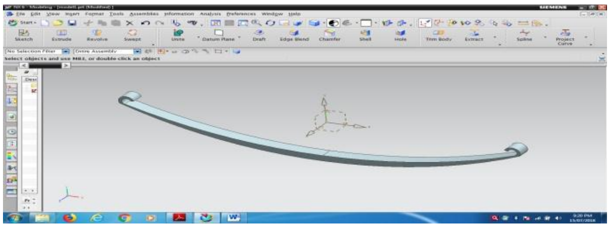

Fig.4.1Model of Leaf spring

4.1 Meshing

The meshing is tetrahedral type. The number of node on the meshing are 17465 and the number of elements are 10182.The meshing diagram has shown below:

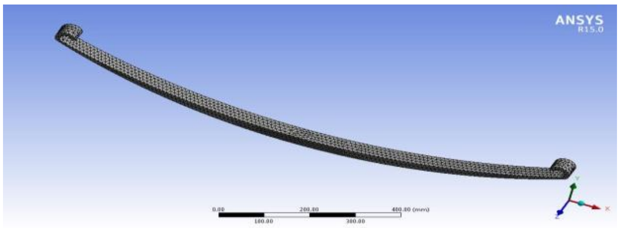

Fig.4.2 meshing diagram of mono leaf spring

The Maximum bending stress and deflection of a non-uniform width and thickness leaf spring is given by

$$\sigma_{Max} = \frac{1.5FL}{bt^2} \quad \& \quad \delta_{Max} = \frac{4FL^3}{Ebt^3}$$

Where, F=force (N), L=length (mm), E=Young's modulus (N/m^2), b-width in (mm), t=thickness of leaf in (mm).

Table 4.1.Dimensions of composite mono leaf spring

Parameters	**At center (mm)**	**At eye end (mm)**
Width	42	42
Thickness	28	16
Total Length of the spring (Eye to Eye)	1165mm	
Free Camber (At no load condition)	165mm	

5. Result & Discussion

From the FEA simulation of steel, e-glass fibre composite and Hybrid composite material mono leaf spring the various results that obtained are as follows:

Equivalent (von-Mises) stresses(ES) acting on mono leaf spring at 15KN loading condition:

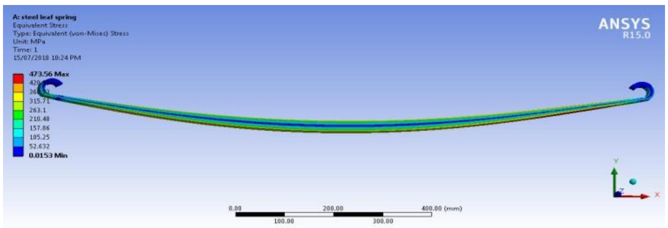

Fig 5.1 ES(von-Mises) of steel leaf spring at 15KN load

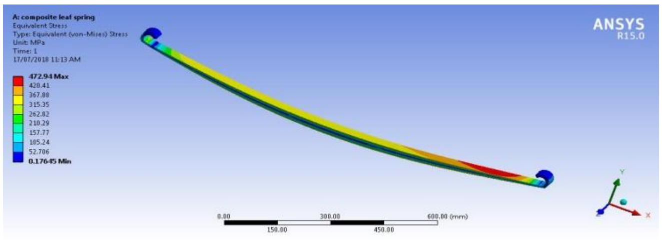

Fig.5.2 ES (von-Mises) of composite leaf at 15KN

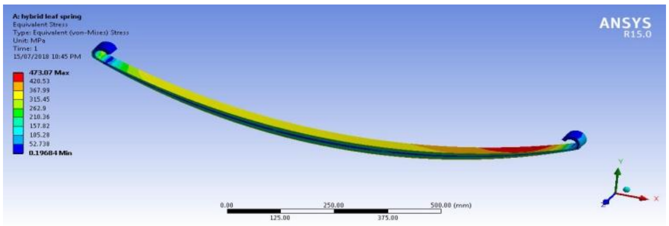

Fig.5.3 ES of hybrid material leaf spring at 15KN load

Equivalent (von-Mises) stresses acting on mono leaf spring at 30KN loading condition:

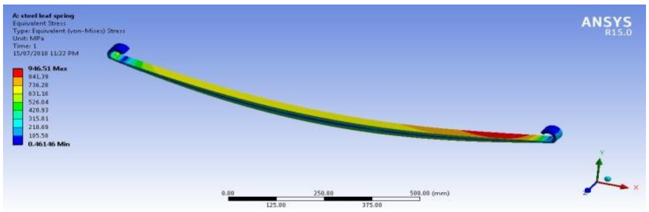

Fig.5.4 ES (von-Mises) of steel material leaf spring at 30KN

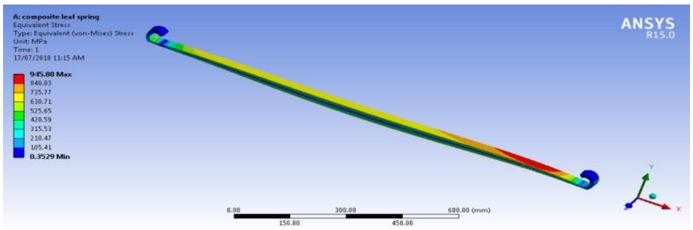

Fig.5.5 ES (von-Mises) stress of composite leaf at 30 KN

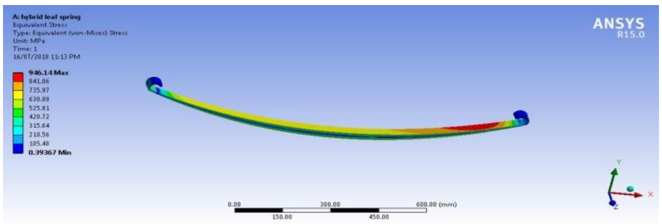

Fig.5.6 ES of Hybrid material leaf spring at 30 KN load

Equivalent (von-Mises) stresses acting on mono leaf spring at 45KN loading condition:

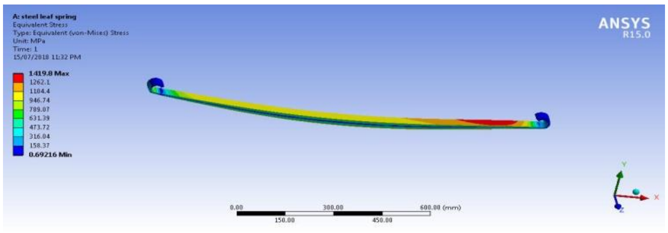

Fig.5.7ES of steel material leaf spring at 45KN

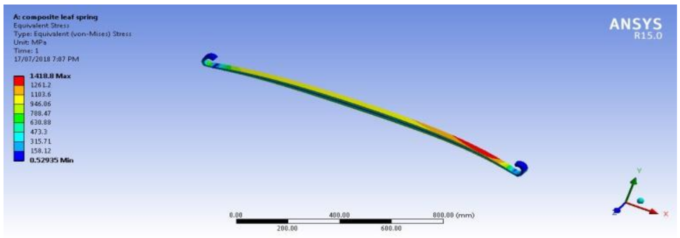

Fig.5.8 ES (von-Mises) of composite material leaf at 45 KN

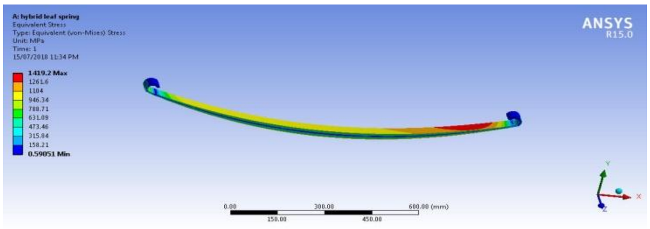

Fig 5.9 ES (von-Mises) of Hybrid leaf at 45 KN load

Equivalent elastic strain(EES) acting on mono leaf spring at 15 KN loading condition:

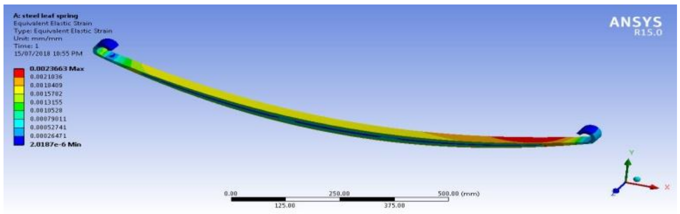

Fig.5.10 EES acting on steel leaf spring at 15 KN load

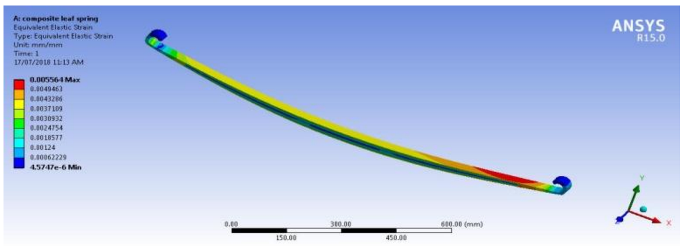

Fig.5.11 EES acting on composite leaf spring at 15 KN load

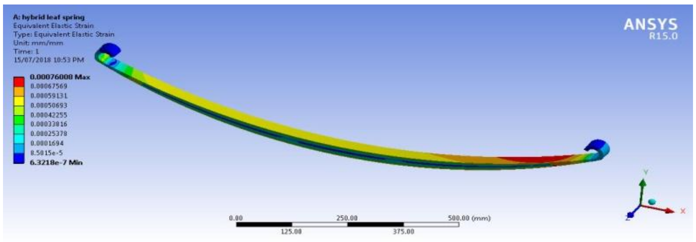

Fig.5.12 EES acting on Hybrid material leaf spring at 15 KN

Equivalent elastic strain acting on mono leaf spring at 30 KN loading condition:

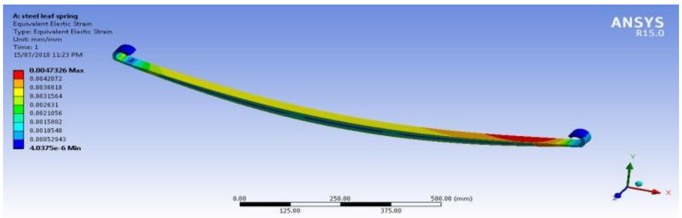

Fig5.13 EES acting on steel leaf spring at 30 KN load

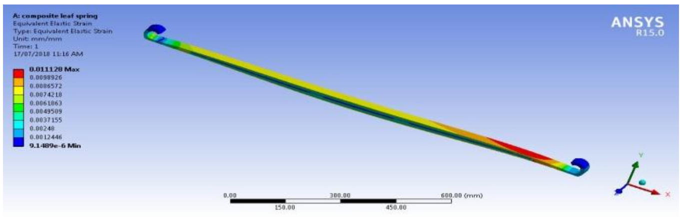

Fig.5.14 EES acting on composite leaf spring at 30 KN load

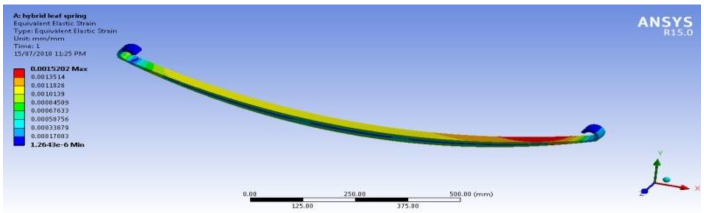

Fig.5.15 EES acting on Hybrid material leaf spring at 30 KN

Equivalent elastic strain acting on mono leaf spring at 45 KN loading condition:

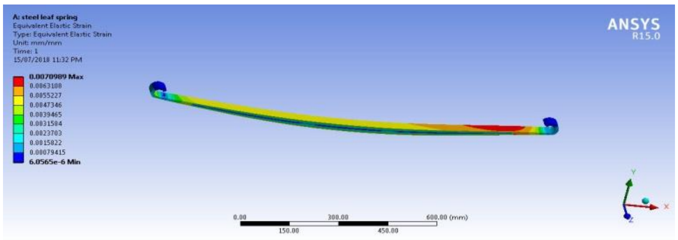

Fig.5.16 EES acting on steel leaf spring at 45 KN load

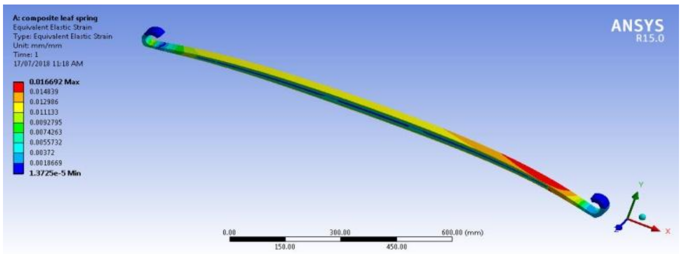

Fig.5.17 EES acting on composite leaf spring at 45 KN load

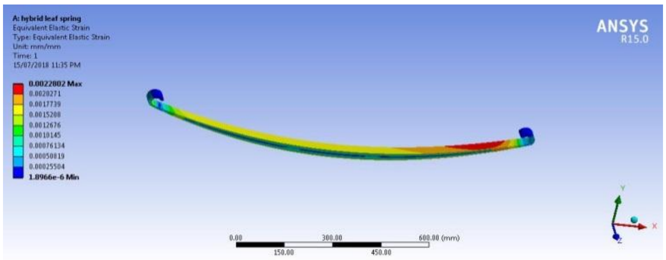

Fig.5.18 EES acting on Hybrid material leaf spring at 45 KN

Total deformation acting on mono leaf spring at 15 KN loading condition:-

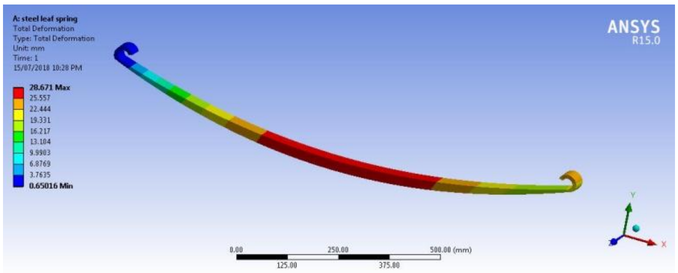

Fig.5.19 Total deformation of steel leaf spring at 15KN

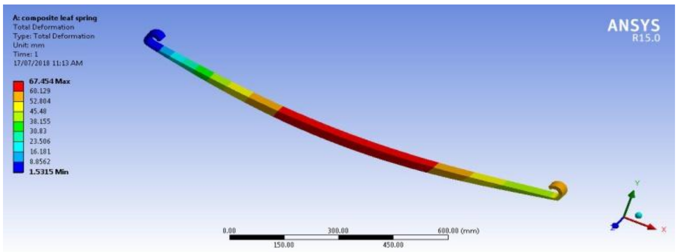

Fig.5.20 Total deformation of composite leaf at 15KN load

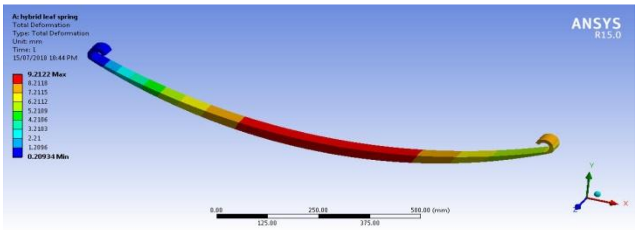

Fig.5.21 Total deformation of Hybrid leaf spring at 15KN

Total deformation acting on mono leaf spring at 30 KN loading condition:-

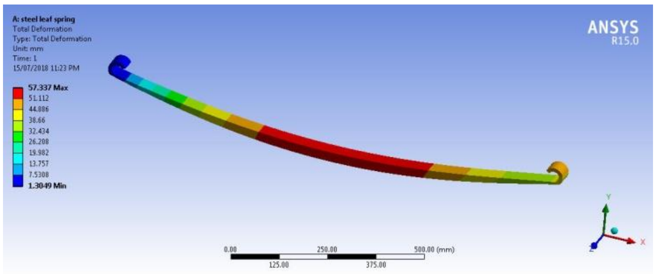

Fig.5.22 Total deformation of steel leaf spring at 30 KN

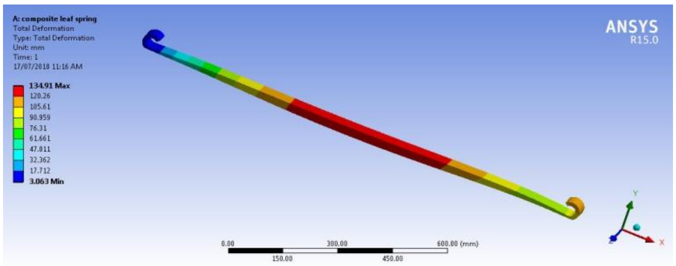

Fig.5.23Total deformation of composite leaf at 30 KN load

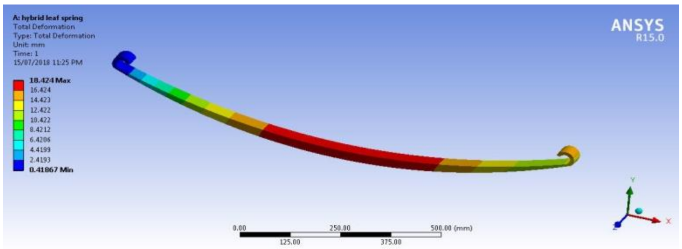

Fig.5.24Total deformation of Hybrid material leaf at 30 KN

Total deformation acting on mono leaf spring at 45 KN loading condition:-

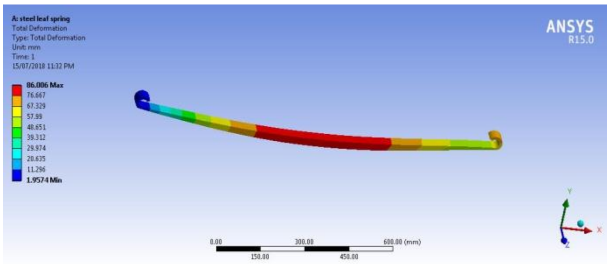

Fig.5.25 Total deformation of steel leaf spring at 45 KN

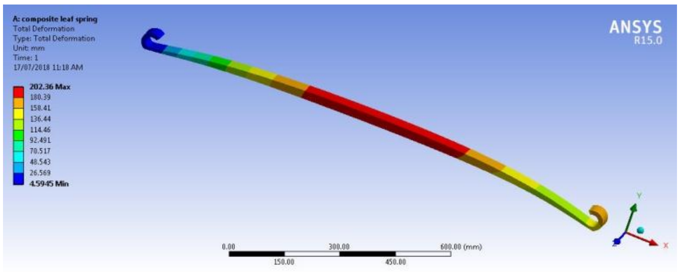

Fig fig.5.26 Total deformation of composite leaf at 45 KN

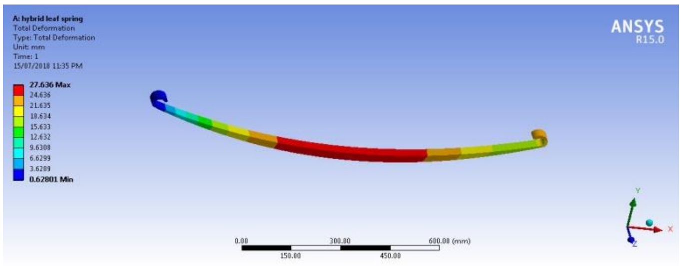

Fig.5.27 Total deformation of Hybrid leaf at 45 KN load

The varying deformations of mono leaf spring on various loading conditions have been shown in graph below:

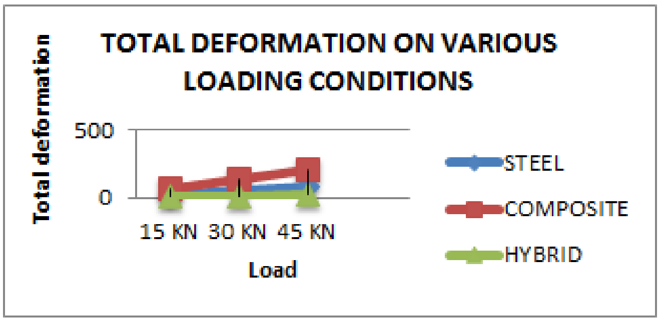

Fig.5.28 Deformation of Steel, E-glass composite and Hybrid Composite leaf spring at varying load.

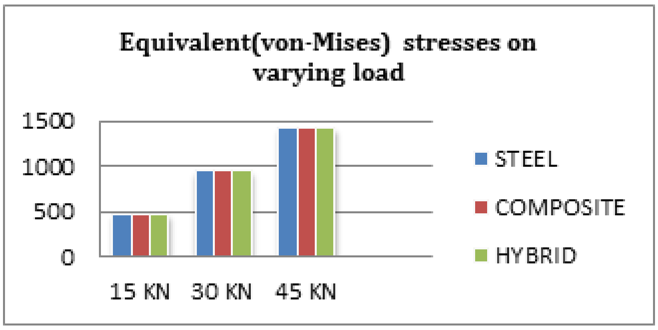

Fig.5.29 Equivalent (von-Mises) stress act on Steel E-glass composite and Hybrid Composite mono leaf spring at varying load.

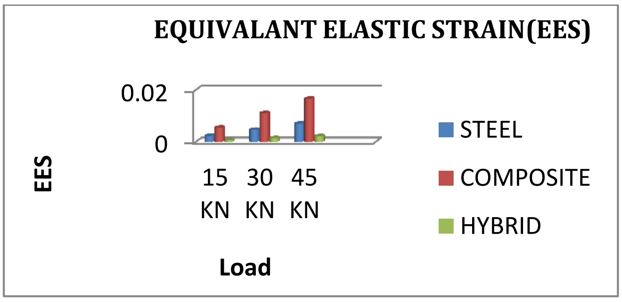

Fig.5.30 EES acting on Steel, E-glass composite and Hybrid Composite mono leaf spring at varying load.

Table 5.4 Results Compression of Mass reduction

Material	Density (Kg/m^3)	Mass (Kg)	mass reduction %
Steel	7850	8.7882	
E-glass Composite	2550	2.9107	66.92 of steel
Hybrid Composite	1858	2.0801	76.33 of steel 28.52ofE-glass composite

6. CONCLUSIONS

From the above analysis and results comparison it can be observed that the best suitable material for the suspension system like as leaf spring have a better replacement of structural steel is available and known as Hybrid Composite. Hybrid Composite is better than steel and other composite material in many criteria. The deformation and equivalent stress occurs on varying loading condition is less than steel which shows that the Hybrid composite is the best suitable material for suspension system. Equivalent elastic strains which are acting on the mono leaf spring are also less than structural steel and E-glass composite materials. Mass reduction in Hybrid composite mono Leaf Spring is nearly 76.33 % of steel and 28.52% of E-glass composite.

Future Scope of work: It has observed from this study the Hybrid Composite is a best available material for leaf spring of suspension system.

- The work that can be done in this field in future is experimental analysis of mono leaf spring by using hybrid composite material.
- Vibration analysis of hybrid composite mono leaf spring.
- Fatigue failure analysis of hybrid composite mono leaf spring.

REFERENCES

[1] K.Ashwini et al. Design and Analysis of Leaf Spring using Various Composites –An Overview. Materials Proceedings 5 (2018) 5716–5721
[2] Chen Qian et al. Fatigue Reliability Design of Composite Leaf Springs Based on Ply Scheme Optimization. Composite Structures (2017)
[3] Cristianah O et al. Design and simulation of fatigue analysis of vehicle suspension system and its effect on global warming. Science direct.com (2016)
[4] Sagar Manchanda*, Beant Singh and Gurmeet Singh, Design and Finite Element Analysis of Leaf Spring Using Different Material Properties, JAIR Volume 4, Issue 7 December 2015
[5] Thippeswamy Ekbote et al. Optimal design and analysis of mono leaf composite spring by finite element analysis. (ICAESM -2012)
[6] E. Mahdi, Light composite elliptic springs for vehicle suspension, science direct, Composite Structures 75 (2006) 24–28
[7] Amal M.K. Esawi, Mahmoud M. Farag, Carbon nanotube reinforced composites: Potential and current challenges, scienceDirect, Materials and Design 28 (2007) 2394–2401.
[8] Textbook of R.S.Khurmi and J.K.Gupta.

BIOGRAPHIE

Vinod sheshkar

M. tech. (Machine Design) final year student in department of mechanical engineering, Millennium Institute of Technology,