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Optimization of leaf spring parameters using ANSYS

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Abstract: A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. leaf springs are long and narrow plates attached to the frame of a vehicle that rest above or below vehicle axle. There are mono leaf springs, are single leaf spring that are consists of simply one plate of spring steel. These are usually thick in the middle and tapper out toward the end and they don't typically offer too much strength and suspension .Drivers looking for heavier loads typically used multi leaf springs, which consists of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, springs will fail from fatigue caused by the repeated flexing of the spring. The aim of the project work is to design and model a leaf spring according to the loads applied. Presently used material for leaf springs are mild steel, Epoxy glass and Epoxy fiber. In this project work the leaf spring of TATA ACE (PID - 1415244329) is designed using CREO parametric 4.0 software. The analysis is carried out by varying number of leaves, material and thickness of leaves using ANSYS workbench 18.1 .The deformation and stress for various combination are obtained through analysis using ANSYS and compared.

Keywords—Tata Ace Leaf Spring; Materials; number of leaves; thickness of leaves; ANSYS

1. INTRODUCTION (*Heading 1*)

A spring is defined as an elastic body, whose function is to distort when loaded and recover its original shape when the load is removed. Increasing competition and innovation in automobile sector tends to modify the existing products or replace old products by new and advanced material products. A suspension system of vehicle is also an area where these innovations are carried out regularly. More efforts are taken in order to increase the comfort of user. Appropriate balance of comfort riding qualities and economy in manufacturing of leaf spring becomes an obvious necessity. The leaf spring should absorb the vertical vibrations and impacts due to road irregularities by means of vibrations in the spring and the energy absorbed is stored in spring as strain energy and then released slowly. The strain energy of the material used for spring is the important property to be considered. The specific strain energy is inversely proportional to the density and young's modulus. It can be easily observed that material having lower modulus

and density will have greater specific strain energy capacity. In the present scenario, weight reduction can be achieved primarily by the introduction on better material, design specialization and better manufacturing process. The large vehicles need a good suspension system that can be delivered a good ride and handling. At the same time the component need to be light weight and had an excellent of fatigue life. The fatigue durability testing of the mechanical structure is performed extensively in all industries as one of the part in design process. Hence, seven-leaf steel spring are being replaced by eight-leaf steel spring and other design changes has been made it possible to reduce the weight of the leaf spring without any reduction on load carrying capacity and stiffness. A spring is understood to be a flexible body, whose function would be to distort once the load is taken away its original shape once the load is taken away. Springs are unlike other structure components for the reason that they undergo significant deformation when loaded their compliance permits them to store readily recoverable mechanical energy. In the vehicle leaf spring, once the wheel meets a hurdle, the springing enables movement of wheel within the obstacle and after that returns the wheel to the normal position. Semi-elliptical leaf springs are nearly globally employed for leaf spring. U. S. Ramakant & K .Sowjanya stated that The laminated spring includes quantity of leaves known as blades . The blades are different long curvature so they will have a tendency to straighten underneath the load. The leaf spring is design relies upon the idea of beams of uniforms strength. Initially known as laminated or carriage spring, a leaf spring is a straightforward type of spring, generally employed for the leaf spring in wheeled vehicles. It's also among the earliest types of springing, dating back medieval occasions. Sometimes known as semi-elliptical spring or cart spring, it requires the type of a slender are formed period of spring steel of rectangular mix section. The center from the arc provides place for the axle, while tie holes known as eyes are supplied at either finish for attaching towards the vehicle body. For very heavy vehicles, a leaf spring can be created from the 3 leaves stacked on the top of one another in a number of layers, frequently with progressively shorter leaves.Shishay Amare Gebremeskel states the Leaf springs can serve locating and to some degree damping in addition to springing functions . To commercial vehicles for example vans and trucks, SUVs, and railway carriages. For heavy vehicles, they've the benefit of distributing the burden more broadly within the vehicle's chassis, whereas coil springs transfer it one point. Unlike coil springs, leaf springs also locate the trunk axle, eliminating the requirement for trailing arms along with a Pan hard fishing rod, therefore saving cost and weight inside a simple live axle rear leaf spring. A far more modern implementation may be the parabolic leaf spring... Spacers prevent contact at other points. Apart from fat loss saving, the primary benefit of parabolic springs is the greater versatility, which means vehicle quality of ride that approaches those of coil springs.

Leaf springs were very common on automobiles, right up to the 1970s in Europe and Japan and late 70's in America when the move to front-wheel drive, and more sophisticated suspension designs saw automobile manufacturers use coil springs instead. Today leaf springs are still used in heavy commercial vehicles such and trucks, SUVs, and railway carriages. For heavy vehicles, they have the advantage of spreading the load more widely over the vehicle's chassis, whereas coil springs transfer it to a single point. Unlike coil springs, leaf springs also locate the rear axle, eliminating the need for trailing arms and a Pan hard rod, thereby saving cost and weight in a simple live axle rear suspension. A further advantage of a leaf spring over a helical spring is that the end of the leaf spring may be guided along a definite path.

A more modern implementation is the parabolic leaf spring. This design is characterised by fewer leaves whose thickness varies from centre to ends following a parabolic curve. In this design, inter-leaf friction is unwanted, and therefore there is only contact between the springs at the ends and at the centre where the axle is connected. Spacers prevent contact at other points. Aside from a weight saving, the main advantage of parabolic springs is their greater flexibility, which translates into vehicle ride quality that approaches that of coil springs. There is a trade-off in the form of reduced load carrying capability, however. The characteristic of parabolic springs is better riding comfort and not as "stiff" as conventional "multi-leaf springs". It is widely used on buses for better comfort. A further development by the British GKN company and by Chevrolet with the Corvette amongst others, is the move to composite plastic leaf spring. The structure of leaf spring is shown in Fig.1.

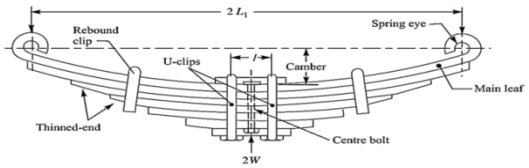

Fig.1 Structure of Leaf Spring

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2. LITERATURE REVIEW

D.V. Ramana Reddy, B.Subbaratnam, E. Manoj Kumar and Perala kalyanpraneeth carried out design and analysis of composite leaf spring. In their paper, the design and analysis a composite leaf spring and compared with a standard steel leaf spring. The materials selected are Epoxy glass. Epoxy carbon, Aluminium Alloy Titanium Alloy is used against conventional steel leaf spring. The design parameters are selected and analyzed with the objective of comparing Stress, Deformation Elastic Strain and Weight of the composite leaf spring as compared to conventional steel leaf spring. The leaf spring was modeled in CATIA and the analysis was done in ANSYS software.

Ganji madhukar and Goroginam santhi carried out design and analysis of leaf spring for heavy commercial vehicle.in their paper describes dynamic and static analysis of steel leaf spring and laminated composite Multi leaf spring. The aim would be to compare displacement, frequencies, deflections and weight savings of composite leaf spring with this of steel leaf spring. The length of a current conventional steel leaf spring of the Light design calculations. Dynamic and static Analysis of three-D type of conventional leaf spring is conducted using ANSYS. Same dimension is utilized in composite multi leaf spring using S2 Glass/Epoxy and Kevlar/Epoxy unidirectional laminates. Analysis is completed by layer stacking way of composites by altering reinforcement angles for several layers, 5 layers and 11 layers. The load of composite leaf spring is in contrast to those of steel leaf spring. The look

Mahmood M. Shokrieh and Davood Rezaei carried out analysis and optimization of a composite leaf spring .in their paper showed that an optimum spring width decreases hyperbolically and the thickness increases linearly from the spring eyes towards the axle seat. Compared to the steel spring, the optimized composite spring has stresses that are much lower, the natural frequency is higher and the spring weight without eye units is nearly 80% lower.

Rupesh N. Kalwaghe', and Prof. K. R. Sontakke carried out design and analysis of composite leaf spring by using FEA and ANSYS. In their paper shown increased interest in the use of composite leaf spring in the place of conventional steel leaf spring due to its high strength to weight ratio. The introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction in load carrying capacity and stiffness. Therefore the objective of this paper describes design and FEA analysis of composite leaf spring made of glass fiber reinforced polymer. The dimension of an existing conventional steel leaf spring of commercial vehicle are taken for evaluation of result.

Pragnesh B. Satasiya', Maulesh Parikh², Darshan Dodiya and Prof. Siddharth Tirole carried out the optimization of a leaf spring by ansys software.in their paper The automobile industry has shown increased interest in the replacement of steel spring with composite leaf spring due to high strength to weight ratio and improved damping. Therefore, the finite element results using ANSYS software showing stresses and deflections with different composite materials

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Ritesh Banpurkar and Bhushan Funde carried out Review Paper on Design & Analysis of Leaf Spring in their lot of research has been done for improving the performance of leaf spring. Lot of materials are used for leaf spring .but it is found that fibre glass material has better strength characteristic and lighter in weight as compare to steel for leaf spring. In this paper the author is reviewed few papers on use of alternate materials and effect of material on leaf spring performance.

Priyanka Kothari and Amit Patel carried out a review paper on Design & Analysis of Leaf Spring in their paper The suspension system in a vehicle significantly affects the behaviour of vehicle, i.e. vibration characteristics including ride comfort, stability etc. Leaf springs are commonly used in the vehicle suspension system and are subjected to millions of varying stress cycles leading to fatigue failure. A lot of research has been done for improving the performance of leaf spring. Lot of materials are used for leaf spring, but it is found that fibre glass material has better strength characteristic and lighter in weight as compare to steel for leaf spring. In this paper the author is reviewed few papers on use of alternate materials and effect of material on leaf spring performance.

Godatha Joshua Jacob and Mr M.Deepak carried out Design And Analysis Of Leaf Spring In A Heavy Truck The aim of the project is to design and model a leaf spring according to the loads applied.

Presently used material for leaf spring are forged steel. In this project we are going to design leaf spring for the materials Mild Steel and composite material Glass Carbon by varying reinforcement angle. We are going to check the strength variations while changing reinforcement angle. For validating this design we are conducting FEA Structural Analysis is done on the leaf spring by using two different materials Mild Steel and Glass Carbon. Modal and fatigue Analysis is also done. Pro/Engineer software is used for modeling and ANSYS is used for analysis.

D. Lydia Mahanthi', and C. Venkata Siva Murali² carried out Design and analysis of composite Leaf Spring for light Weight Vehicle in their paper the suspension leaf spring is one of the potential entities for weight reduction in automobiles as it results in large unstrung mass. The Introduction of fiber reinforced plastics (FRP) is used to reduce the weight of the product without any reduction on load carrying capacity and spring rate. As the materials high strain energy storage capacity and high strength-to- weight ratio compared to steel, multi-leaf springs are being replaced by mono-leaf FRP spring FRP springs also have excellent fatigue resistance and durability

Pragnesh B. Satasiya', Maulesh Parikh², Darshan Dodiya and Prof. Siddharth Tirole carried out the optimization of leaf spring by ansys software.in their paperThe automobile industry has shown increased interest in the replacement of steel spring with composite leaf spring due to high strength to weight ratio and improved damping. Therefore, the finite element results using ANSYS software showing stresses and deflections with different composite materials.

It is found from the literature review that all the authors have done their work for the minimization of deformation and stress in the leaf spring by varying either materials alone or number of leaves alone or by varying thickness of leaf spring. But as a novelty, in this present work, the analysis has been carried out by varying all the three parameters with three levels for the minimization of stress and deformation.

3. MATERIALS AND METHODS

In the present work, leaf spring of TATA ACE model(PID-1415244329) is selected and the specification of the selected models is presented below:

No.of leaf spring = 06

No.of gradual length = 02

Full length of leaf spring = 950mm

Eye diameter = 40mm

Non effective length = 76.2mm

Thickness = 10

Width = 60mm

The two dimensional and three dimensional diagram of the selected leaf spring for the test condition number 24 is shown in Fig. 2 and Fig. 3.

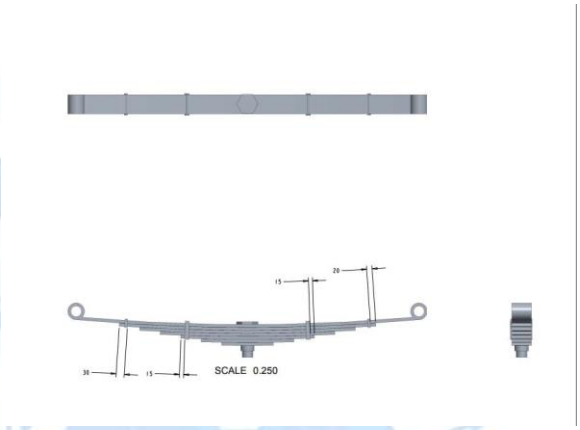

Fig. 2 2D diagram of the selected leaf spring

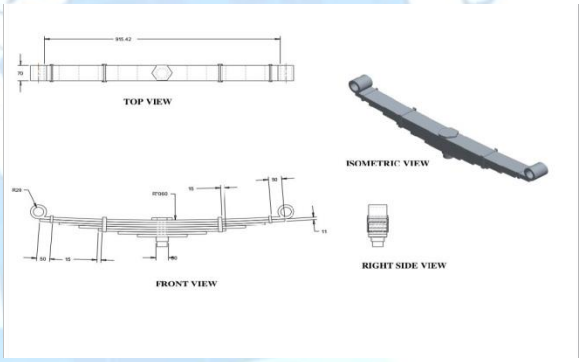

Fig 3. 3D diagram of the selected leaf spring

The properties of the selected materials are presented in Table 1

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Table1 properties of materials

Material	**Young's modulus (Gpa)**	**Poisson's ratio**	**Tensile strength (Mpa)**	**Density (Kg|mm^3)**
Mild steel	198	0.28	572.3	1000
Epoxy E glass	72	0.3	205	1520
Epoxy fiber	127.7	0.33	171	1750

The selected parameters such as materials,no.of.leaves and thickness are varied to the levels and it is shown in table 2

Table.2 Parameters and their levels

Parameters	**level 1**	**level 2**	**level 3**
Materials	Epoxy E Glass	Epoxy Fiber	Mild steel
Thickness	9	10	11
No.of.leaves	5	6	7

The analysis is carried in the ANSYS by varying the selected parameters as shown in Table.3

4. RESULTS

The two dimensional drawing with the required parameters are drawn using modeling software CREO 4.0 and analysis has been carried out using ANSYS Workbench 18.1 for all the test conditions. The output of deformation and stress for all the test conditions are shown in Table 4.

Table.3 Test condition numbers & variation in levels of selected parameters.

S.No	**Material**	**No.of leaves**	**Thickness**
1	E Glass	5	9
2	E Glass	6	9
3	E Glass	7	9
4	E Glass	5	10
5	E Glass	5	11
6	E Glass	6	10
7	E Glass	6	11
8	E Glass	7	10
9	E Glass	7	11
10	Epoxy fiber	5	9
11	Epoxy fiber	6	9
12	Epoxy fiber	7	9
13	Epoxy fiber	5	10
14	Epoxy fiber	5	11
15	Epoxy fiberEpoxy fiber	6	10
16	Epoxy fiber	6	11
17	Epoxy fiber	7	10
18	Epoxy fiber	7	11
19	Mils Steel	5	9
20	Mild Steel	6	9
21	Mild Steel	7	9
22	Mild Steel	5	10
23	Mild Steel	5	11
24	Mild Steel	6	10
25	Mild Steel	6	11
26	Mild Steel	7	10
27	Mild Steel	7	11

Table 4 Output of deformation and stress for all the test conditions

Test condition	Material	No.of,leaves	Thickness (mm)	deformation (mm)	stress (MPa)
1	E Glass	5	9	0.17	17.40
2	E Glass	6	9	0.07	16.73
3	E Glass	7	9	0.06	16.25
4	E Glass	5	10	0.06	12.36
5	E Glass	5	11	0.11	12.14
6	E Glass	6	10	0.105	12.18
7	E Glass	6	11	0.08	27.90
8	E Glass	7	10	0.09	21.56
9	E Glass	7	11	0.34	39.29
10	Epoxy fiber	5	9	0.14	14.97
11	Epoxy fiber	6	9	0.14	14.29
12	Epoxy fiber	7	9	0.13	14.18
13	Epoxy fiber	5	10	0.13	13.89
14	Epoxy fiber	5	11	0.11	12.69
15	Epoxy fiber	6	10	0.10	11.94
16	Epoxy fiber	6	11	0.34	39.29
17	Epoxy fiber	7	10	0.09	21.56
18	Epoxy fiber	7	11	0.15	22.67
19	Mild Steel	5	9	0.09	14.90
20	Mild Steel	6	9	0.07	14.10
21	Mild Steel	7	9	0.06	13.96
22	Mild Steel	5	10	0.06	11.87
23	Mild Steel	5	11	0.05	11.55
24	Mild Steel	6	10	0.05	11.68
25	Mild Steel	6	11	0.04	10.67
26	Mild Steel	7	10	0.04	11.37
27	Mild Steel	7	11	0.03	9.11

The snapshots of ANSYS output for the test condition number27,6,9.for the deformation is shown in Fig 5 Fig 6,Fig 7.

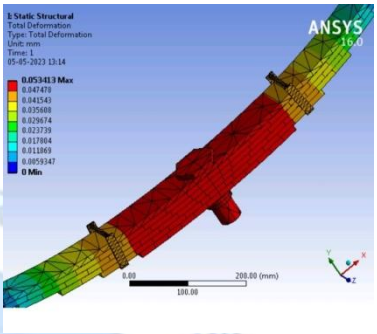

Fig 5

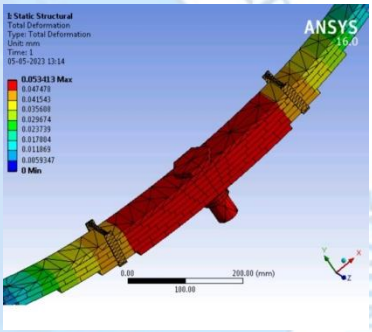

Fig 6

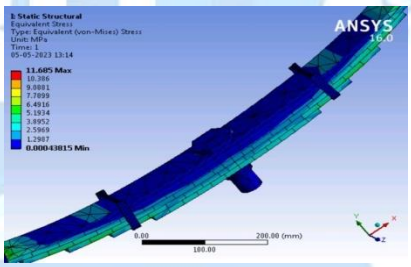

Fig7

The snapshots of ANSYS output for the test condition number 27,8,9.for the stress is shown in Fig 8 Fig 9,Fig 10.

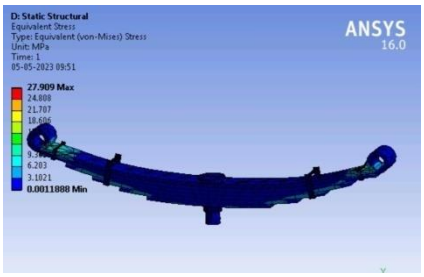

Fig 8

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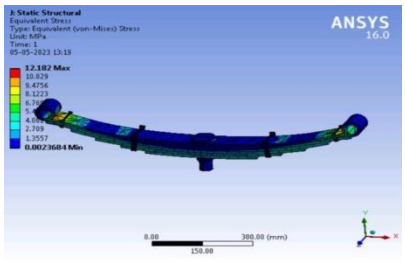

Fig 9

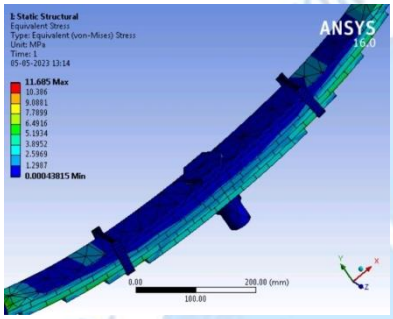

Fig 10

5. CONCLUSION

The leaf spring of TATA ACE (PID - 1415244329) model has been designed using CREO parametric 4.0 software. The modeled diagram for all the test conditions has been imported in the ANSYS software. The analysis has been carried out by varying number of leaves, material and thickness of the leaves using ANSYS workbench 18.1. The selected parameters are varied through three levels. Totally 27 number of analysis has been carried out for the minimization of stress and deformation in the leaf spring. The deformation and stress for various combination are obtained through analysis using ANSYS and compared. It is found that the minimum deformation is obtained for the test condition number 27. Also it is found that the minimum stress is obtained for the test condition number 27. Hence the optimized selected parameters are Mild Steel with 7 number of leaves and 11 mm thickness for the minimization of stress and deformation in the selected leaf spring

REFERENCES

[1] D V Ramanareddy, B. Subbaratnam, E. Manoj Kumar, Perala Kaalyan Praneeth., "Design and Analysis of Composite Leaf Spring", International Journal of Mechanical Engineering and Technology (IJMET) , Volume 08, Issue 06 , June 2017

[2] Ganji Madhukar, Goroginam Santhi., "Design and Analysis of Leaf Spring For Heavy Commercial Vehicle", International Journal of Innovative Technology and Research(IJITR) Volume 04, Issue 05, August - September 2016.

[3] Mahmood M. Shokrieh, Dawood Rezaei., "Analysis and Optimization of a Composite Leaf Spring", Composite Structures 60 (2003) 317-325.

[4] Rupesh N. Kalwaghe, Prof. K.R. Sontakke., "Design and Analysis of Composite Leaf Spring by Using FEA and ANSYS", International Journal of Scientific Engineering and Research (IJSER) Volume 03, Issue 05, May 2015.

[5] Pragnesh B. Satasiya, Maulesh Parikh, Darshan Dodiya, Prof. Siddharth Tirole., "Optimization of a Leaf Spring by Ansys Software", International Journal for Technological Research In Engineering Volume 06, Issue 09, May 2019

[6] Prof. Ritesh Banpurkar, Bhushan Funde., " A Review Paper on Design and Analysis of Leaf Spring", International Journal for Research In Applied Science and Engineering Technology (IJRASET), Volume 10, Issue 05,May 2022.

[7] Priyanka Kothari, Amit Patel., " A Review Paper on Design and Analysis of Leaf Spring", International Journal for Engineering Research and Technology (IJERT), Volume 03, Issue 03, March 2014.

[8] Godatha Joshua Jacob, Mr. M. Deepak., "Design and Analysis of Leaf Spring In a Heavy Truck", International Journal of Innovative Technology and Research(IJITR) , Volume 05, Issue 04, June-July 2017.

[9] D. Lydia Mahanthi , C. Venkata Siva Murali , "Design and Analysis of Composite Leaf Spring for Light Weight Vehicle", International Journal of Advanced Engineering Research and Science (IJAERS), Volume 04, Issue 03, Mar-2017.

[10] Pragnesh B. Satasiya, Maulesh Parikh, Darshan Dodiya, Prof. Siddharth Tirole., "Optimization of a Leaf Spring by Ansys Software", International Journal for Technological Research In Engineering Volume 06, Issue 09, May 2019.