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Modelling and Analysis of Transverse Leaf Spring under the Static Load Condition by using FEA

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Abstract:

Transverse leaf spring and solid axle front suspension and automotive leaf spring is the main load carrier and energy absorbing component in a vehicle. In today's modern world, suspension is considered as a luxury and safe travel issue. Keeping all these constrains in consideration, strong and light weight material and new designs low maintenance should be used for leaf spring design. Composite material would help reducing weight and improve fuel consumption without sacrificing the safety of the vehicle. Modification in the existing leaf spring design and material selection should be done at every stage of the analysis depending upon the simulation results for the safe design. In the present study, leaf spring has been designed using mechanical catia design software and analyzed using a finite element analysis (FEA) programme ANSYS, with different

material stainless steel, titanium, plain carbon steel properties. Results of shear stress, shear strain, deformation von mises stress and weight obtained from ANSYS has been taken into consideration in this study for final conclusion.

Keywords: Transverse leaf spring, composite material, catia , load analysis, FE analysis. plain carbon steel, spring steel, and stainless steel, copper alloy, titanium.

1. INTRODUCTION:

SUSPENSION SYSTEM

The complete suspension system is to isolate the vehicle body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It must also keep the tires in contact with the road, regardless of road surface. A basic suspension system consists of springs, axles, shock absorbers, arms, rods, and ball joints. The spring is the flexible component of the suspension. Basic types are leaf springs, coil springs, and torsion bars.

Modern passenger vehicles usually use light coil springs. Light commercial vehicles have heavier springs than passenger vehicles, and can have coil springs at the front and leaf springs at the rear. Heavy commercial vehicles usually use leaf springs, or air suspension.

1.1 PRINCIPLE OF SUSPENSION SYSTEM

The suspension system isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load. It also must keep the tires in contact with the road. When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly. The sprung mass is that part of the vehicle supported by the springs - such as the body, the frame, the engine, and associated parts. Unsprung mass includes the components that follow the road contours, such as wheels, tires, brake assemblies, and any part of the steering and suspension not supported by the springs.

When a wheel strikes a bump, there is a reaction force, and energy is transferred to the spring which makes it oscillate. Oscillations left uncontrolled can cause loss of traction between the wheel and the road surface. Shock absorbers dampen spring oscillations by forcing oil through small holes. The oil heats up, as it absorbs the energy of the motion. This heat is then transferred through the body of the shock absorber to the air.

When a vehicle hits an obstruction, the size of the reaction force depends on how much unsprung mass is at each wheel assembly. Sprung mass refers to those parts of the vehicle supported on the springs. This includes the body, the frame, the engine, and associated parts.

Unsprung mass includes the wheels, tires, brake assemblies, and suspension parts not supported by the springs. Vehicle ride and handling is improved by keeping unsprung mass as low as possible. Wheel and brake units that are small and light follow the road contours without a large effect on the rest of the vehicle

1.2 Classification of Suspension springs

The Suspension springs may be classified as follows:

(i) **Steel Springs**

- (a) Leaf Spring
- (b) Coil spring
- (c) Torsion bar

(ii) Rubber Springs

- (a) Compression spring

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(b) Compression–shear spring
(c) Steep reinforced spring
(d) Progressive spring
(e) Face Shear Spring
(f) Torsion shear spring

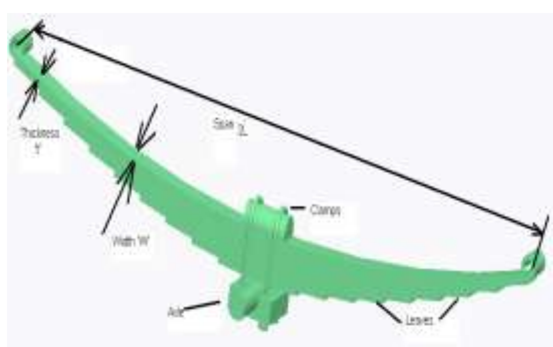
1.3 SUSPENSION SYSTEM OF LEAF SPRING

The leaf spring is one of the oldest forms of springing. It is usually used on rear-wheel-drive vehicles because its simplicity. They can be mounted longitudinally. Leaf springs consist of one or more flat springs, made of tempered steel. A number of leaves of different length are used to form a multi-leaf spring. They are held together by a center bolt that passes through a hole in the center of each leaf. It is also used to locate the axle on the spring. The axle is then clamped to the spring by U-bolts that wrap around the axle housing, and through a spring plate underneath the spring.

Rebound clips are formed at intervals around the leaves. They prevent excessive flexing of the main leaf during rebound, and also keep the leaves in alignment. The longest leaf called the main leaf, is rolled at both ends to form eyes. These eyes are used to mount the spring to the frame of the vehicle. Some springs have the ends of the second leaf rolled around the eyes of the main leaf, as reinforcement. This leaf is called the wrap leaf.

The front of the spring is attached to a rigid spring hanger on the vehicle frame. The rear is connected to the frame by a swinging shackle, which provides a link between the spring eye and a bracket on the sub-frame. This swinging link is needed, because, as the spring flexes, and flattens out under load, the distance between the spring eyes increases.

Some springs have inserts between the leaves, of plastic, nylon, or rubber. They act as insulators, to reduce noise transfer, and friction as the leaves move under load. Some older vehicles completely enclose the leaf springs in grease. The spring eyes are fitted with bushes, usually with a rubber, flexible section, but nylon and urethane bushes are also used, and sometimes bronze for heavy duty applications. Rubber insulating pads between the spring mounting pad and the spring also act as insulators and similarly, between the spring plate and the spring.



Bending Stress of Leaf Spring

Leaf springs (also known as flat 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. Thus the leaf springs may carry lateral loads, brake torque, driving torque etc., in addition to shocks.

Equalized stress in spring leaves (Nipping)

We have already discussed that the stress in the full length leaves is 50% greater than the stress in the graduated leaves. In order to utilize the material to the best advantage, all the leaves should be equally stressed. This condition may be obtained in the following two ways.

1. By making the full length leaves of smaller thickness than the graduated leaves. In this way, the full length leaves will induce smaller bending stress due to small distance from the neutral axis to the edge of the leaf.

2. By giving a greater radius of curvature to the full length leaves than graduated leaves, before the leaves are assembled to form a spring by doing so, a gap or clearance will be left between the leaves. This initial gap is called nip. When the central bolt, holding the various leaves together, is tightened, the full length leaf will bend back and have an initial stress in direction opposite to that of the normal load. The graduated leaves will have an initial stress in the same direction as that of the normal load. The graduated leaves will have an initial stress in the same direction as that of the normal load. When the load is gradually applied to the spring, the full length leaf is first relieved of this initial stress and then stressed in opposite direction. Consequently, the full length leaf will be stressed less than the graduated leaf. The initial gap between the leaves may be adjusted so that under maximum load condition the stress in all the leaves is equal, or if desired, the full length leaves may have the lower stress. This is desirable in automobile springs in which full length leaves are designed for lower stress because the full length leaves carry additional loads caused by the swaying of the car, twisting and in some cases due to driving the car through the rear springs.

Chapter2

Literature review:

C.Madan Mohan Reddy,D.RavindraNaik, Dr M.LakshmiKantha Reddy[1] conducted study on analysis and testing of two wheeler suspension helical compression spring. They focused their study on suspension system springs modelling, analysis and testing. They try to replace the steel helical spring in automobiles. They carried a comparative study. They calculate the stress and deflection of helical spring. They compared their FEA results with experimental values.The found chrome vanadium steel spring has 13-17% less maximum stress and 10% less specific weight compared to steel spring. They validate their FEA results with the experimental values and found excellent similarity of 95% in deflection and of 97% in shear stress pattern.

AjitabhPateriya, Mudassir Khan [2] studied dynamic characteristics of spring loaded using ANSYS. Fluid-solid interaction mesh deformation between the valve disc and surrounding fluid has been used to study the motion of the valve disc for different materials. Differentmaterials have been used considering similar boundary condition for finding the best suitable material. FEM analysis result shows that La2Zr2O7 is best suitable material. Maximum shear stress considered is 0.20395 MPa which is greater for Aluminium alloy. For weight and cost comparison the Aluminiumalloy material should be preferred.

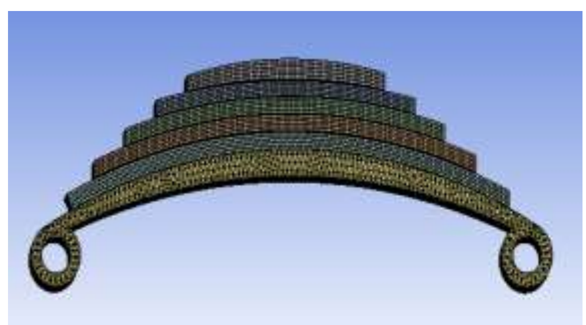
Pozhilarasu V. and T ParameshwaranPillai [3] studied analysis of steel and composite leaf spring. They compared the conventional leaf spring and composite (Glass fibre reinforced plastic – GFRP) leaf spring. They used ANSYS software for studying conventional steel leaf spring and composite leaf spring for similar conditions. They fabricated a glass/epoxy composite leaf spring using hand layup method. The universal testing machine has been used to test the results of conventional steel and composite leaf spring.

Adams and Peppiatt (1974) investigated the significance of transverse stresses and the existence of stress gradients through the thickness of the adhesive layer close to the joint edges were observed.

Admas and Wake (1984) presented the detailed study on structural adhesive joints subjected performed to bending and shear stresses.

Tsai and Morton (1994) presented a 2D elasticity based solution to solve single–lap adhesively bonded joint**.**

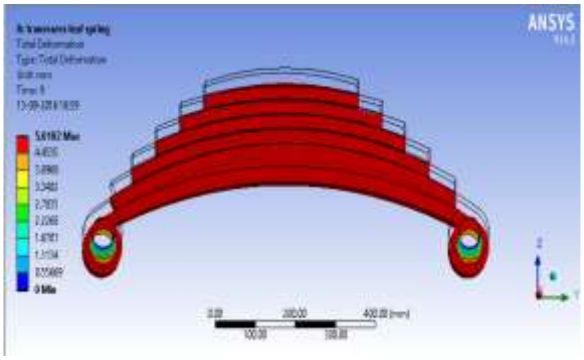
MESH:



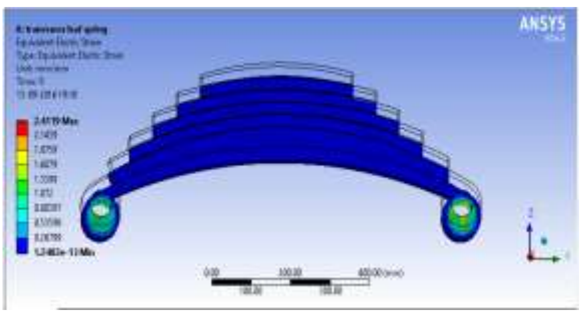
RESULT:-

- **TITANIUM ALLOY:**

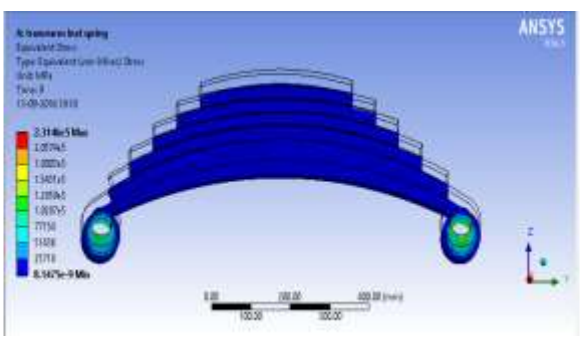
TOTAL DEFORMATION:



EQUIVALNT ELASTIC STRAIN:



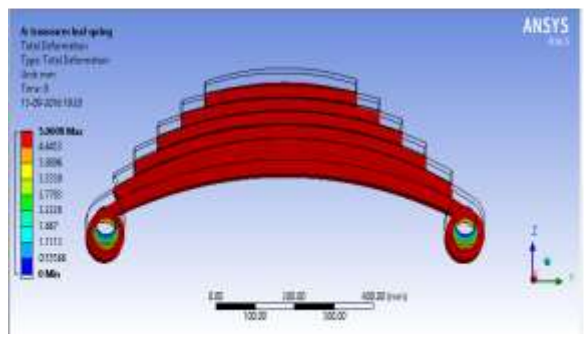
EQUIVALENT (VON-MISES)STRESS:



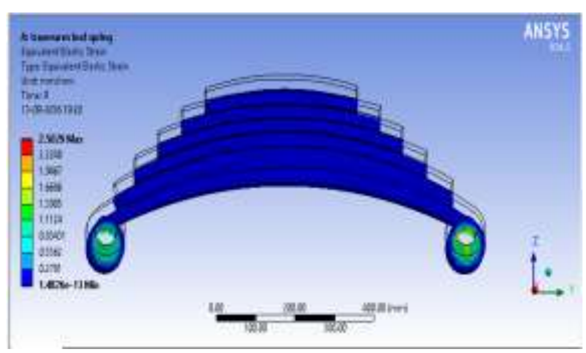
	MINIMU M	MAXIMU M
TOTAL DEFORMATION	0. mm	5.0102 mm
EQUIVALENT ELASTIC STRAIN	1.2402e-013 mm/mm	2.4119 mm/mm
EQUIVALENT(VON-MISES)STRESS	8.1475e-009 MPa	2.3146e+005 MPa

- **STAINLESS STEEL:**

TOTAL DEFORMATION:



EQUIVALENT ELASTIC STRAIN:



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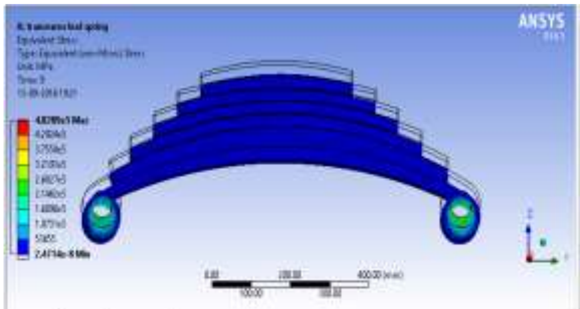
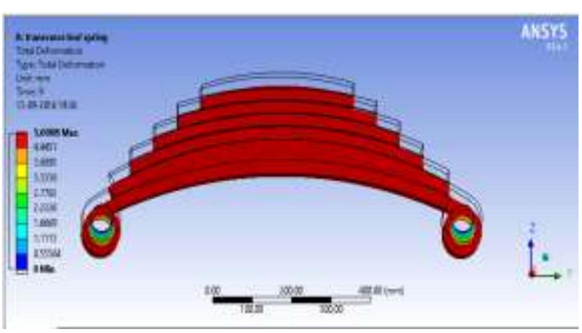
EQUIVALENT(VON-MISES)STRESS:



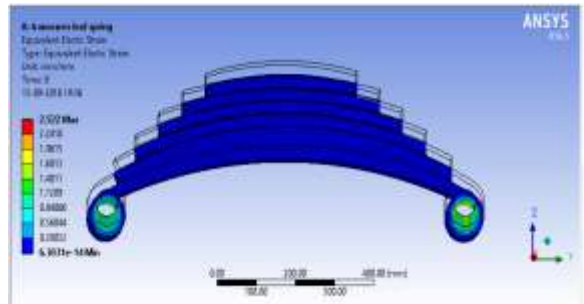
	MINIMUM	MAXIMUM
TOTAL DEFORMATION	0. mm	5.0009 mm
EQUIVALENT ELASTIC STRAIN	1.4826e-013 mm/mm	2.5029 mm/mm
EQUIVALENT(VON-MISES)STRESS	2.4714e-008 MPa	4.8289e+005 MPa

- **AISI 4140- ALLOY STEEL:**

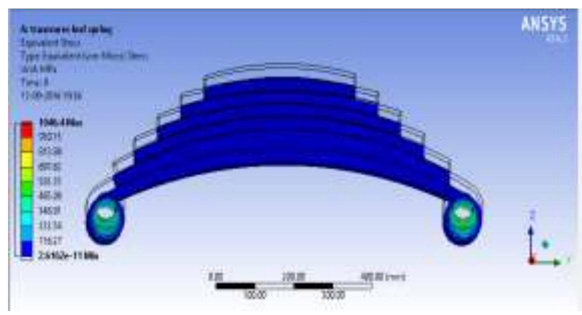
TOTAL DEFORMATION:



EQUIVALENT ELASTIC STRAIN:



EQUIVALENT(VON-MISES)STRESS:



	MINIMUM	MAXIMUM
TOTAL DEFORMATION	0. mm	5.0008 mm
EQUIVALENT ELASTIC STRAIN	6.3031e-014 mm/mm	2.522 mm/mm
EQUIVALENT(VON-MISES)STRESS	2.6162e-011 MPa	1046.4 MPa

CONCLUSION:-

The following conclusions can be drawn from the present work.

- By replacing the material with composites, the weight of the leaf spring is reduced. The strength of the composites is more when compared to that of Stainless Steel.
- It was observed that the deflection in the composite leaf spring was almost equal so we can say that composite spring had the same stiffness as that of steel spring.
- As reducing weight and increasing strength of products are high research demands in the world, composite materials are getting to be up to the mark of satisfying these demands. In this paper reducing weight of vehicles by 68.14% and increasing the strength of their spare parts is considered. The deflection of the leaf spring along its transverse direction, which is very small compared to the considered maximum deflection. Even though it has been noted the material is not that reliable due to chipping problem in a bumpy roads by former studies, it has achieved an acceptable fatigue life of 221 $x10^3$ cycles. This particular design is made specifically for the case study/TATA Ace/light weight vehicles.

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