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EXPERIMENTAL ANALYSIS OF STEEL AND E-GLASS FIBER/EPOXY COMPOSITE MATERIAL V SHAPE SPRING USED IN AUTOMOTIVE

Pavan Subhash Baravkar PhD Scholar Sandip University Trambakeshwar Rd, Nashik, Maharashtra 422213 pavanbaravkar49@gmail.com
Dr Amol D Lokhande Principal, Professor S.M.E.S. Sanghavi College of Engineering, Nashik, Maharashtra 422213. amollokhande3@gmail.com

ABSTRACT

This study reviews the initial development of the suspension system, the need for automotive system suspension, the concept of vibration, its causes, causes and effects of vibration in the automotive system. These updates include important information about advanced vehicle parking systems, standard and standard parking systems. The suspension system also helps absorb bumps on the road and provides a safe and comfortable ride. The leaf spring is a simple spring type, often used for suspension in wheeled vehicles. Leaf Springs long and small plates are attached to the frame of the trailer that sits above or below the trailer axis. There are springs of mono leaves, or single-leaf springs, that cover just one plate of spring metal. These are usually dense in the middle and come out at the end, and do not provide too much power and suspension for towing vehicles. Leaf spring is widely used in heavy vehicles such as tractor's trolly, buses, fruight trucks. For the purpose of increasing strength, strength, elasticity, we use V-Strip suspension spring instead of leaf spring. The V-Strip suspension spring, which we review, is a specially designed leaf spring used for Tractor Trolley.

Keywords: Suspension System, , FEA, Modern Type Of Suspension, , V Shape Spring. Composite Material, , E-Glass/ Epoxy, Re-Manufacturing, Effort Factors, CSFS, Critical Factors.

I. INTRODUCTION

The modern car has been around since the days when “just walking” was enough to satisfy the car owner. Improvements in suspension, increased strength and durability of parts, and improvements in tire design and construction have played a major role in talking about the comfort and safety of driving. Basically, suspension means the use of front and rear springs to stabilize the car's frame, body, engine and power train over wheels. These relatively complex assemblies make up what is known as the Sprung weight. Non-slip weight, on the other hand, includes wheels and wheels, break assemblies and other structural elements that are not supported by springs. The springs used in modern cars and trucks are made of a variety of shapes, shapes, sizes, prices and strengths. Types include leaf springs, coil springs, wind springs and torsion bars. These are used in four sets per car, or paired with various combinations and attached to the car with many different mounting techniques. The car frame and body are attached to the front and rear not directly but through springs and shock absorbers. The combination of parts, which makes the separation of the parts from the roadmap, may be in the form of a jump, pitch and roll is called a suspension system. The car’s suspension system separates the tire and the car’s integrated axis from its body. The main function of the suspension system is to separate the body of the vehicle from shock and vibration produced due to road instability. Cars are provided with shock absorbers for this purpose. It is in a state of spring and humidity. The suspension system is provided both at the end and back of the vehicle. The suspension system also maintains the vehicle's stability in turning or rolling when the vehicle is moving. The ability to try new designs or ideas on a computer gives you the opportunity to eliminate problems before you start producing. Additionally, designers can quickly and easily determine the sensitivity of certain molding parameters to the quality and production of the final component. The main leaf spring and V-shape spring strip were created with modeling software such as Pro-E and imported into the ANSYS 15 analysis software, loading, boundary conditions are provided for the imported model and the result is tested by the post processor. Different comparative results of the main steel spring and the V-strip suspension spring are available

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to predict the benefits of the V-Strip Suspension spring to load the continuous level of a small tractor's trolley used on the farm to carry quality imported fruit.

Analytical Design of Composite V- spring

The V shape strip springs, which consist of a straight strip of composite E-Glass / Epoxy material, bend in V form. As design point of view it is considered as the double cantilever spring because it is assumed that the spring is fixed at the clamp.

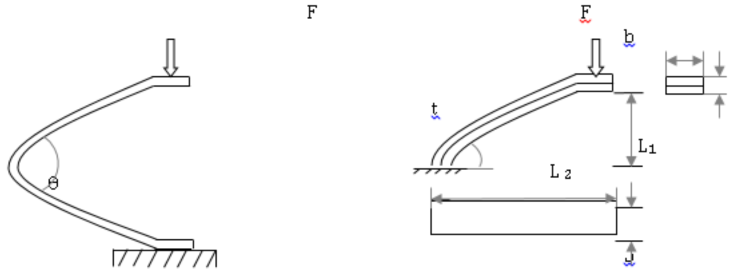

Figure 1.1: Graphical representation of V-spring

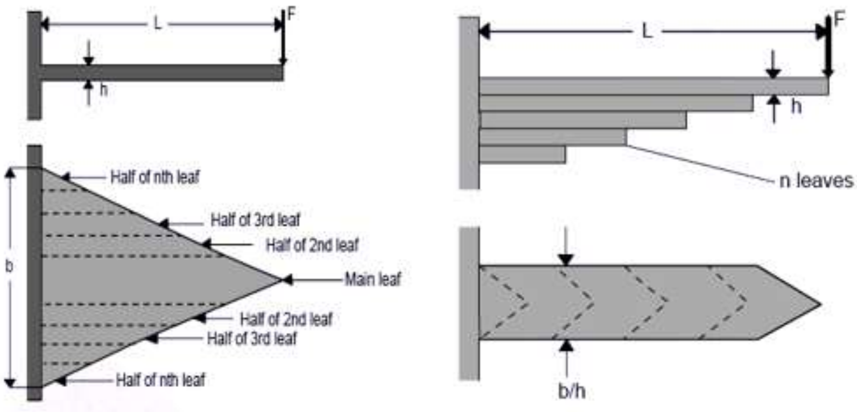

Figure 1.2: V-spring representation as triangular plate

Fig : *Model Mini Tractor-Trailer*

II. LITERATURE REVIEW

FEM Comparison and Leaf Fountains Improved Suspension with Performance Component

Finite Element analysis tools offer the great advantage of allowing design teams to consider almost any design option without incurring the costs associated with production and machine time. The ability to try new designs or ideas on a computer gives you the opportunity to eliminate problems before you start producing. Additionally, designers can quickly and easily determine the sensitivity of certain molding parameters to the quality and production of the final component. The main leaf model of the leaf and the V-shaped V-line were created with modeling software such as Pro-E and imported into ANSYS12 analysis software, uploads, border conditions are provided for the imported model and the result is tested by post processor. Different comparative results of spring steel and V-shape strip spring are available to predict the benefits of V-shape strip spring continuous loading of small trailer used on the farm to bear fruit for export quality.

Design And Analysis Of Leaf Spring In A Heavy Truck GODATHA JOSHUA JACOB, Mr. M.DEEPAK

The leaf spring is a simple spring type, often used for suspension in wheeled vehicles. Leaf Springs plates long and small are attached to the frame of the trailer that sits above or below the trailer axis. There are monoleaf springs, or single leaf springs, that cover one plate of spring metal. These tend to squeeze in and out at the end, and do not provide much power and suspension for towing vehicles. Drivers who want to pull heavy loads often have to use springs, which include several springs of varying lengths mounted on top of one another. When the leaf leaf is short, it will be close to the ground, giving the same semielliptical shape the spring of one leaf becomes larger in the middle. The springs will fail due to fatigue caused by repeated spring fluctuations. The aim of the project is to design and model the leaf spring according to the loads used. The materials currently used in the spring of the leaves are stainless steel. In this project we will design a leaf spring for Mild Steel building materials and Glass Carbon compositions by changing the reinforcement angle. We will explore power differences as we change the reinforcement angle. To validate this design we have done a FeA Building Analysis performed on the spring leaf using two different Mild Steel and Glass Carbon materials. Modal and Fatiuge analysis is also ongoing. Pro / Engineer software is used for modeling and ANSYS is used for analysis.

Read and Update on Leaf Spring analysis PULKIT SOLANKI1 , DR. AJAY KUMAR KAVITI2

We know that the spring plays very essential part of every automobile for suspension point of view. Leaf spring is the main type of suspension system which is used in many light and heavy vehicles. Leaf spring used in many vehicles due to having some main characteristics which are shown below.

1) Uniformly load distribution
2) Lower cost
3) Rough used
4) Easier in Isolation

And tightly attached with working frame Today every automobile company has been working on increasing the efficiency with reducing the weight without having any load carrying capacity. In this paper we would like to review some previous research work performed on the leaf spring by previous researchers for increasing the working condition and capacity with load reduction. The paper based on material composition, experimental testing and load (Steady, Dynamic) study etc.

III. METHEDOLOGY

Materials for V-strip suspension spring :

Plain carbon steel, Chromium vanadium steel, Chromium-Nickel-Molybdenum steel, silicon manganese steel, common materials used in the construction of leaf springs. Items selected for V-strip suspension are 65Si7. The design parameters selected for the V-strip suspension are listed in the table.

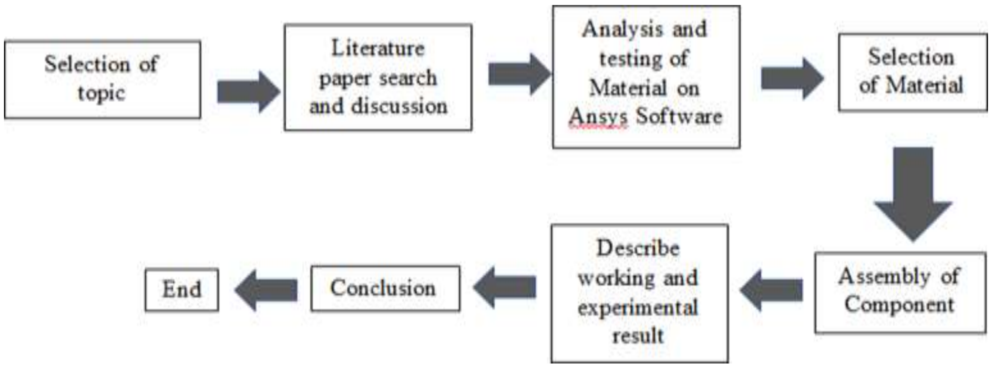

Fig 2: Material for V-Strip Suspension Spring

Design Parameters	Values
Material selected	Stainless steel
Tensile Strength	440 N/mm^2
Field Strength	250 Mpa
Young's modulus	210 Gpa
Length(before bending)	290 mm
Length (after bending)	145 mm
Width	30 mm
Thickness	4 mm
Angle between v-carrying due to spring	Around 40 °
Load Carrying Capacity	150 kg
Number Of Strips	4

A. FEA PROCEDURE

FEA tool is the mathematical idealization of real system. Is a computer based method that breaks geometry into element and link a series of equation to each, which are then solved simultaneously to evaluate the behavior of the entire system. It is useful for problem with complicated geometry, loading, and material properties where exact analytical solution are difficult to obtain. Most often used for structural, thermal, fluid analysis, but widely applicable for other type of analysis and simulation.[6]

Figure 1 shows procedure of FEA.

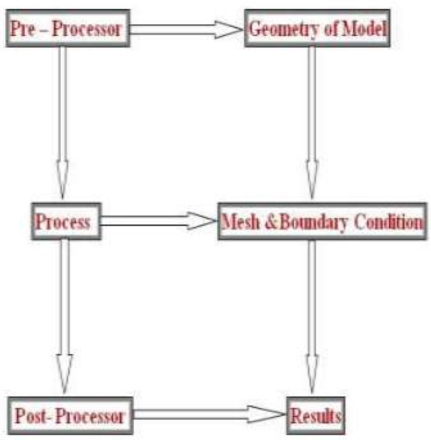

Fig. 1 Typical FEA procedures by commercial software (ANSYS-12)[6]

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B. Materials for Spring

Plain carbon steel, Chromium vanadium steel, Chromium- Nickel- Molybdenum steel, Silicon manganese steel, are the typical materials that are used in the design of leaf springs. The material selected for steel leaf spring is 65Si7 and for composite sring is E-Glass/ Epoxy. The design parameters selected for spring are listed in table I, II, III.

Table I

Parameters	Values
Material selected Steel	65Si7
Tensile strength	1962 N/mm2
Yield strength	1470 N/mm2
Young's modulus(E)	2e5 N/mm2
Total length	650 mm
Arc height at axle seat	76 mm
Normal static loading (max)	2500 N
Available space for spring width	50 mm X 6 mm
Number of leaves	02

Table II.

Parameters	Values
Material selected Steel	65Si7
Tensile strength	1962 N/mm2
Yield strength	1470 N/mm2
Young's modulus(E)	2e5 N/mm2
Total length between V end	100 mm
Included angle of V- shape	450
Normal static loading (max)	2500 N

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Available space for spring width	30 mm X 4 mm
Number of strip	01

Table III.

Parameters	Values
Tensile modulus along X-direction (Ex), MPa	34000
Tensile modulus along Y-direction (Ey), MPa	6530
Tensile modulus along Z-direction (Ez), MPa	6530
Tensile strength of the material, MPa	900
Compressive strength of the material, MPa	450
Shear modulus along XY-direction (Gxy), MPa	2433
Shear modulus along YZ-direction (Gyz), MPa	1698
Shear modulus along ZX-direction (Gzx), MPa	2433
Poisson ratio along XY-direction (NUxy)	0.217
Poisson ratio along YZ-direction (NUyz)	0.366
Poisson ratio along ZX-direction (NUzx)	0.217
Mass density of the material (ρ), kg/mm3	2.6e6

C. Geometry of Main Leaf Spring & V- Shape Strip Spring

Figure 2 shows the imported geometry of mono leaf spring & figure 3 shows the imported geometry of V-shape strip spring. This geometry has been created in Pro-E. Figure shows the 3D model of leaf spring with camber of leaf spring. Total length of mono leaf is 650mm and 76mm is the arc height at axel seat.

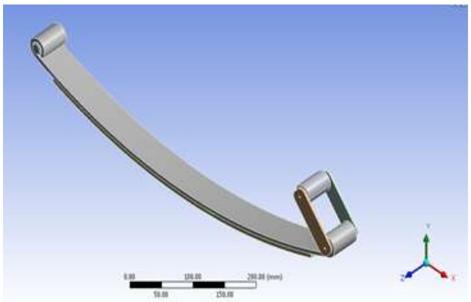

Fig. 2 Geometry of Main Leaf Spring.

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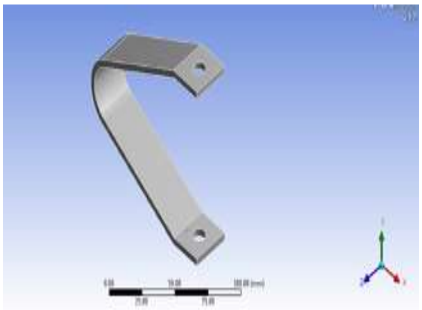

Fig. 3 Geometry of V- Shape Strip Spring.

D. Meshed Model of Main Leaf Spring & V- Shape Strip Spring

Meshing is nothing but the descritization of object into the small parts called as the element. Figure 4 & figure 5 shows the meshed model of both spring with brick and triangular elements are used. Previous Studies show that the best results are obtained using brick mesh.

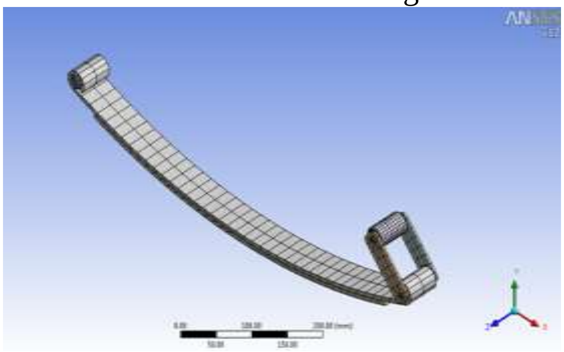

Fig. 4 Meshed Model of Main Leaf Spring.

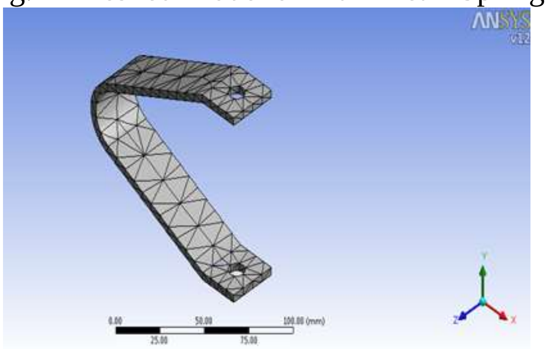

Fig. 5 Meshed Model of V- Shape Strip Spring.

E. Loading & Boundary Conditions Main Leaf Spring & V- Shape Strip Spring

1) Fixed Support

Fixed support has restriction to move in X and Y direction as well as rotation about that particular point. For the leaf spring analysis one eye end of the leaf spring is fixed to the chassis of the vehicle. So this eye end of the leaf spring cannot move in any of the directions i.e. all the degrees of freedom are blocked. V- shape strip spring expands & compress in up and down direction so it has no any fixed support but it firmly attached with main leaf spring at up side & bracket at down side in assembly of whole unit.

2) Displacement support

As there is shackle provided at other end of the leaf spring because of which the leaf spring only translates in one plane and other movements i.e. degree of freedom are blocked. So with the reference of this a displacement support is applied to the other eye end of leaf spring model. This support allows the movement of the leaf spring in X axis, rotation about Z axis and fixed along Y axis.[6] Also for V- shape strip spring curvature end having free movement in X & Y axis Direction but constant in Z axis.

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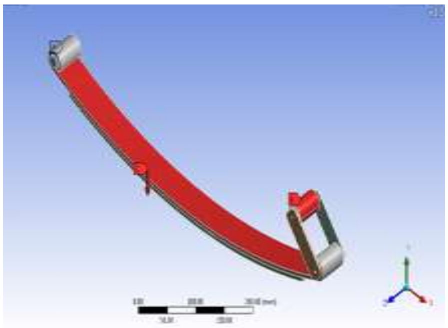

Fig. 6 Loading & Boundary Conditions

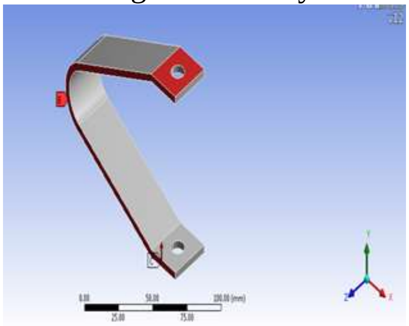

Fig. 7 Loading & Boundary Conditions of Main Leaf Spring of V-Shape Spring.

Since the load is uniformly distributed on the leaf spring, here in this study uniformly distributed load 1380N which is 20% more of the unladen weight of trailer. For V- shape strip spring it uniformly distributed load 690N that is applied on doth side from upward and downward of spring model. The uniformly distributed load is shown in figure 6 & figure 7.

F. Results and Discussion

1) Total Deflection of Main Leaf Spring & V- Shape Strip Spring.

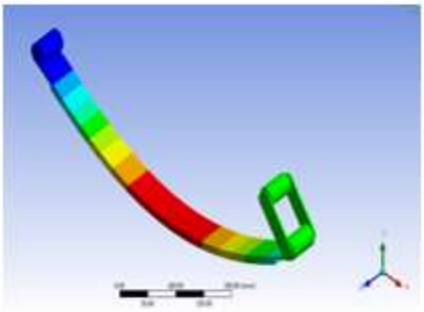

Fig. 8 Total Deflection of Main Leaf Spring.

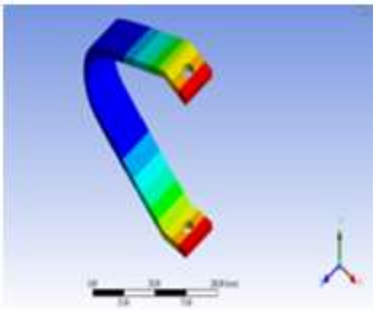

Fig. 9 Total Deflection of V- Shape Strip Spring

Figure 8 shows the deflection of steel leaf spring & Figure 9 shows the deflection of steel V- shape strip spring with leaf spring under the application of 1380N total load. The maximum deflection is at the centre of the leaf spring is 1.71 mm and V- shape strip spring its maximum value is 10.10mm from both side. Red zone indicates the area of maximum deflection and blue zone indicates the area of minimum deflection, which are shown by color band. According to this v- shape spring shows the 16.93 % more deflection than leaf spring.

2) Stress for Main Leaf Spring & V- Shape Strip Spring.

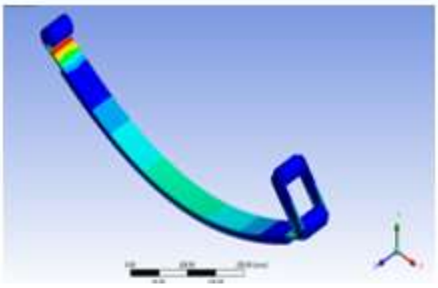

Fig. 10 Stress for Main Leaf Spring.

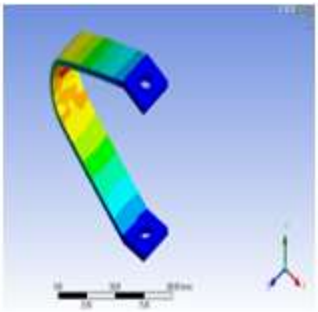

Fig. 11 Stress for V- Shape Strip Spring

Figure 10 & figure 11 shows the equivalent von-miss stress induced in steel leaf spring and V- shape strip spring under the action of 1380N load. The maximum stress is induced at nearer to fixed eye end of leaf spring and the curvature end of V- shape strip spring its maximum value is 150.8N/mm2 & 870.42N/mm2 respectively. Red zone indicates the area of maximum stress and blue zone indicates the area of minimum stress.

3) Strain Energy for Main Leaf Spring & V- Shape Strip Spring:

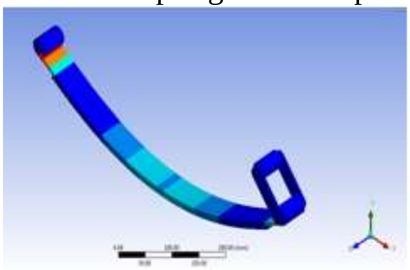

Fig. 12 Strain for Main Leaf Spring.

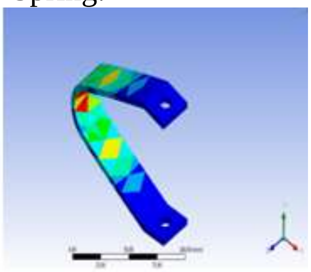

Fig. 13 Strain for V- Shape Strip Spring.

Figure 12 & figure 13 shows the strain energy induced in steel leaf spring and V- shape strip spring under the action of 1380N load. The maximum strain energy is induced at nearer to fixed eye end of leaf spring and the curvature end of V-shape strip spring its maximum value is 27.998MJ & 73.283MJ respectively. Red zone indicates the area of maximum stress and blue zone indicates the area of minimum stress.

Fig 3: V-Strip Suspension spring

Experimental Testing of V spring with Constant Thickness

Figure : Mounting of V- spring

IV. RESULT AND DISCUSSION

4.1 COMPARATIVE RESULT OF COMPOSITE V-SPRINGS

During the course of work, the Analytical and software work has been carried out for the Composite V- shape strip spring with constant and variable thickness and result. The analytical work carried out and numerical analysis (FEA) carried on ANSYS15. In this chapter the comparison of Composite V-spring (with constant and variable thickness) and Composite V-spring spring concern with Deflection and Stress, those are shown graphically and discussed.

4.1.1 Deflection for Constant Thickness Composite V-Spring, Variable Thickness Composite V-Spring.

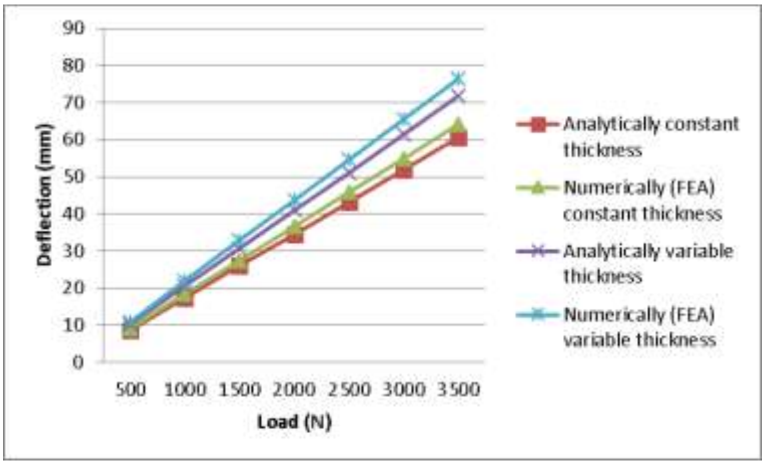

Figure 4.1: Comparative load Vs deflection

Figure 4.1 shows the comparative results of load Vs deflection of V-spring (with constant thickness), V-spring (with variable thickness). The above graph clearly shows the V- spring (with constant thickness) has maximum deflection for concern load and minimum deflection for concern load. V-Spring (with variable thickness) has optimum result of deflection for concern load.Therefore V-spring (with variable thickness) is best suitable for part loading

4.2 COMPARATIVE RESULT OF DEFLECTION

4.2.1 Constant Thickness V-Spring under Analytical, Numerical (FEA),

Table 4.1: Load and deflection value for Composite V-spring (with constant thickness)

Load (N)		500	1000	1500	2000	2500	3000	3500
Deflection (mm)	Analytically	8.64	17.29	25.93	34.58	43.22	51.87	60.52
	Numerically (FEA)	9.15	18.32	27.47	36.63	45.79	54.95	64.11

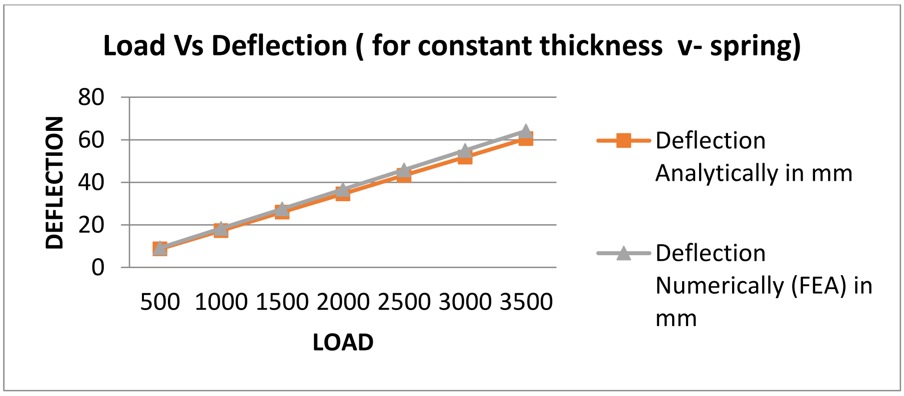

Figure 4.2: Comparative load vs deflection of V- spring (with constant thickness)

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Figure 4.2 shows the comparative results of load Vs deflection of V-spring (with constant thickness). The above graph clearly shows the V- spring (with constant thickness) has nearly closest result. So this is meaning, it satisfies analytical, numerical (FEA).

4.2.2 Variable Thickness V-Spring under Analytical, Numerical (FEA)

Table 4.2: Load and deflection value for V-spring (with variable thickness)

Load (N)		500	1000	1500	2000	2500	3000	3500
Deflection (mm)	Analytically	10.24	20.49	30.74	40.98	51.23	61.48	71.72
	Numerically (FEA)	10.91	21.83	32.74	43.65	54.57	65.48	76.40

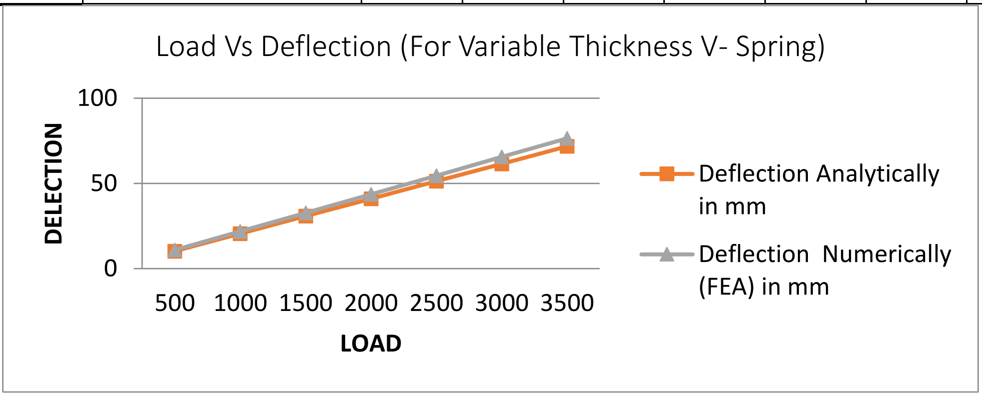

Figure 4.3: Comparative load vs deflection of V- spring (with variable thickness)

Figure 4.3 shows the comparative results of load Vs deflection of V-spring (with variable thickness). The above graph clearly shows the V- spring (with variable thickness) has nearly closest result. So this is meaning, it satisfies analytical, numerical (FEA). Therefore the derived analytical formulation for finding the deflection of V-spring has completely validated.

4.3 COMPARATIVE RESULT OF STRESS INDUCED IN COMPOSITE V-SPRING

4.3.1 Constant Thickness V-Spring under Analytical, Numerical (FEA)

Table 4.3: Load and stress value for V- spring (with constant thickness)

Load (N)		500	1000	1500	2000	2500	3000	3500
Stress (N/mm^2)	Analytically	11.78	23.57	35.36	47.15	58.94	70.72	82.51
	Numerically (FEA)	13.01	26.02	39.03	52.04	65.05	78.06	91.07

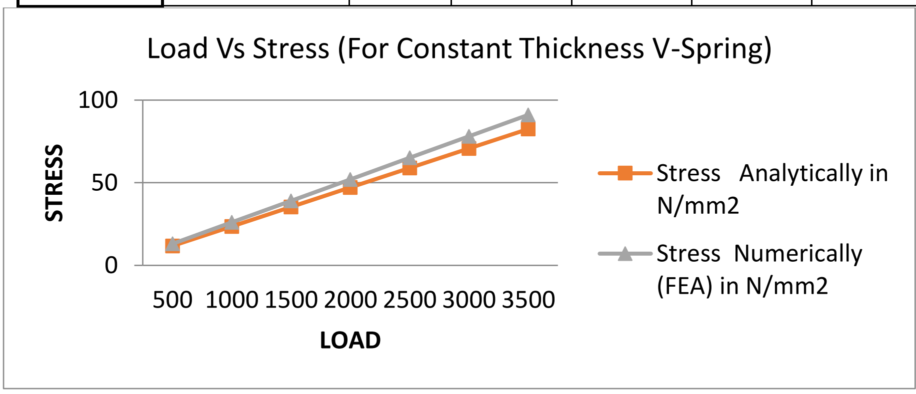

Figure 4.4: Comparative load vs stress of V- spring (with constant thickness)

Figure 6.4 shows the comparative results of load vs stress of V-spring (with constant thickness). The above graph clearly shows the V- spring (with constant thickness) has nearly closest result. So this is mean, derived analytical method for finding bending stress of V-spring satisfy with numerical (FEA) result.

4.3.2 Variable Thickness V-Spring under Analytical, Numerical (FEA)

Load (N)		500	1000	1500	2000	2500	3000	3500
Stress (N/mm^2)	Analytically	18.861	37.72	56.58	75.44	94.30	113.1	132.0
	Numerically (FEA)	24.88	49.76	74.64	99.52	124.4	149.2	174.16

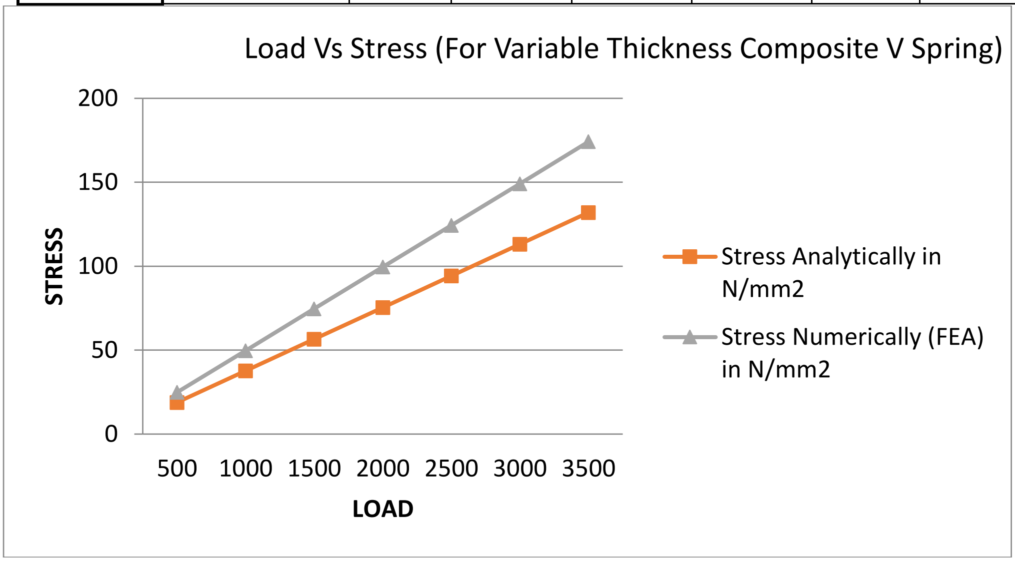

Figure 4.5: Comparative load vs stress of V- spring (with variable thickness)

Figure 4.5 shows the comparative results of load vs stress of V-spring (with variable thickness). The above graph clearly shows the V- spring (with variable thickness) has nearly closest result of analytical & FEA. So this is mean, derived analytical method for finding bending stress of V-spring satisfy with numerical (FEA) result.

4.4 Analysis Result

Table 4.5: Load, Deflection, Stress, Strain Energy, Elastic Strain value for Composite V spring with variable thickness

Sr.No	Load Value	Deflection	Stress	Strain Energy	Elastic Strain
1.	500	10.9	24.88	104.32	0.0029
2.	1000	21.83	49.76	417.28	0.0059
3.	1500	32.74	74.64	938.87	0.0088
4.	2000	43.65	99.52	1669.1	0.0118
5.	2500	54.57	124.4	2608	0.0148
6.	3000	65.48	149.28	3755.5	0.0177
7.	3500	76.4	174.16	5111.6	0.0207

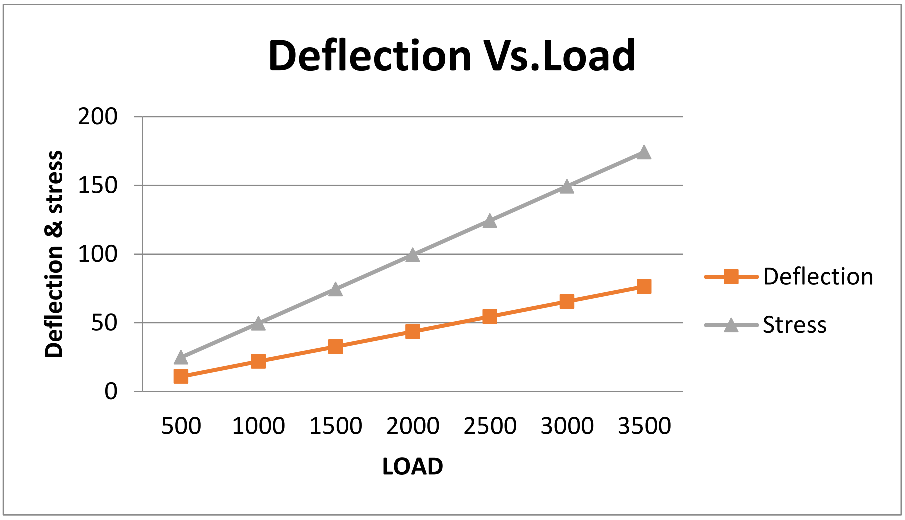

Figure 4.6: Comparative load vs stress of V- spring (with variable thickness)

Table 4.6: Load, Deflection, Stress, Strain Energy, Elastic Strain value for Composite V spring with constant thickness

Sr.No	Load Value	Deflection	Stress	Strain Energy	Elastic Strain
1.	500	9.15	13.01	28.55	0.0023
2.	1000	18.32	26.02	114.24	0.0047
3.	1500	27.47	39.03	257.03	0.007
4.	2000	36.63	52.04	456.95	0.0094
5.	2500	45.79	65.05	713.98	0.0117
6.	3000	54.95	78.06	1028.1	0.0141
7.	3500	64.11	91.07	1399.41	0.0164

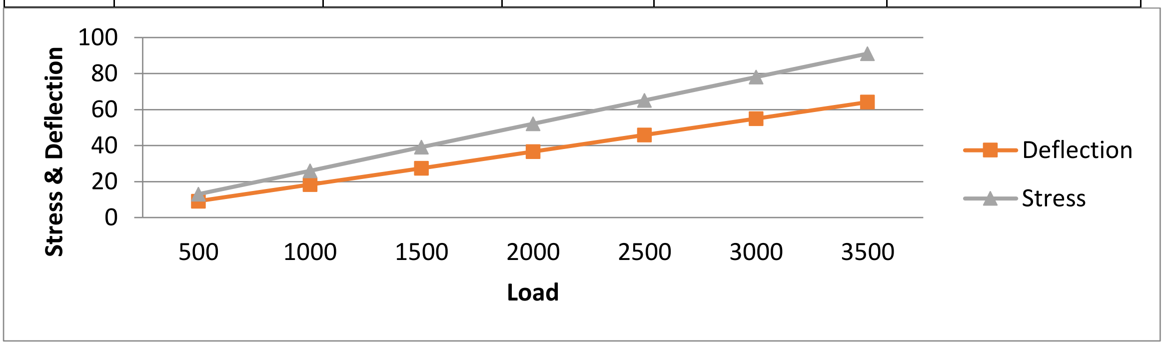

Figure 4.7. Comparative load vs stress and deflection of V- spring (with constant thickness)

V. ADVANTAGE

- It is light in weight and strong.
- Provides good mitigation action.
- Provides good support for axle and chassis.
- Easy to build.
- It can withstand a large amount of load compared to helical springs.

VI. DISADVANTAGES

- The comfort of the ride is not good because of the collision of the leaves between each leaf.
- Over time, springs often lose shape and may collapse.
- If the sag is uneven, it can change the contrasting weight of the car which can affect the handling less.

VII. CONCLUSION

From this project, we conclude that the V-Strip suspension spring has more strength, stiffness and elasticity as compare to leaf spring. The material of V-strip suspension spring also lighter in weight and durable. This suspension spring is most suitable and useful for Mini Tractor's trolley for carrying fruits and can transport it safely from farm to market or other places. This work is concerned with recent research in suspension system design. In the introduced innovations, advanced mechanical mechanisms were designed analyzed and implemented into the start to be applied to real vehicles. The application of the composite V shape spring as a shock absorber device to enhances performance of suspension. With its advantages, axle-less suspension with progressive rate spring unit should be extensively applied in future for all vehicle suspension systems. This unit gets replaced with dead axle.

This suspension unit is used as a sole suspension which provides high performance per unit weight. The V- spring unit with composite material is gradually brought into operation according to the load being applied and progressively increases in proportion to the load being carried. Initial take-up is very smooth and the spring rate increase is progressive, resulting in a greatly improved ride, improved load handling, greater load stability and longer spring life. This suspensions unit undergoes reversible elastic deformation and act as vibration isolators. It can withstand or severe shock loads at minimum to maximum capacity without bottoming out which greatly reduces forces transmitted to the frame.

In this work core part that is mathematical derivation of Total Deflection and Maximum Stress for concern load. Therefore in the present work, V-Spring is design by using derived formulas and it satisfied with the FEA result.

The 3-D modeling of both steel spring is done and analyzed A comparative study has been made between V- shape strip spring and leaf spring with respect to Total deflection, von-miss stresses and strain energy. From the results, It is observed that the V- shape strip spring shows more deflection i.e 16 % and strain energy 38.20 % than that of steel leaf spring material. It is observed that the V- shape strip spring is great under part loading i.e. minimum loading action and main leaf spring is superior for maximum loading condition so that the whole unit of this progressive rate spring is best suitable for fruit carrying trailer and mini ambulance vehicle. The V- spring unit is gradually brought into operation according to the load being applied and progressively increases in proportion to the load being carried and also it is more economical than the conventional steel spring with similar design specifications.

This spring unit is best suitable for fruit carrying trailer and regular trailer used in agricultural field and also it is more economical than the conventional steel spring with similar design specifications.

Future developments and scope

This work is concerned with recent research of Composite V-Spring design used as suspension system for mini trailer in agriculture sector. In the introduced innovations, advanced mechanical mechanisms were designed analyzed and implemented. The application of the shock absorber devices to be continuously controlled therefore apparently enhances its performance. With its advantages, V-Spring suspension with progressive rate spring unit and damper should be extensively applied in future for all vehicle suspension systems.

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