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Design and Analysis of Mono Leaf Spring for Automobile Applications

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Abstract- **The aim of this paper is to fabricate a low cost mono leaf spring and apply it in the place of common conventional multi leaf springs. Leaf springs are one of the oldest suspension systems and they are used in various automobiles even today. Their use is inevitable and many researches are done to improve their functionality. This paper aims in reducing the material usage which would reduce the weight of the leaf spring and also its cost, thus proving productive from the manufacturer point of view. Also, no compromise is done in the functionality or reliability of the spring, instead the strength is improved. The finite element analysis is done using ANSYS Workbench and the design constraints are stress and displacement.**

Keywords – Monoleaf spring, Constant width varying thickness, Von Mises stress, Material reduction, Cost efficient.

I. INTRODUCTION

The suspension system is the one that helps the vehicle roll on the road at its smoothest best and surmount the irregularities. Springs are elastic bodies (generally metal) that can be twisted, pulled, or stretched by some force. They can return to their original shape when the force is released. In other words it is also termed as a resilient member. Damping is the control of motion or oscillation, as seen with the use of hydraulic gates and valves in a vehicles shock absorber. This may also vary, intentionally or unintentionally. Like spring rate, the optimal damping for comfort may be less than for control. A leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times.

Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions.

The main aim of this research is to design a mono leaf spring (a single leaf that acts as both the master leaf as well as the spring) and prove that it can be used as a replacement for the existing conventional leaf spring (the commonly used leaf spring that has multiple number of leaves). The analysis is done by finite element methods.

II. MATERIAL SELECTION

The material used for leaf springs is usually a plain carbon steel having 0.90 to1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel produces greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties. According to Indian standards, the recommended materials are: For automobiles : 50 Cr 1, 50 Cr 1 V 23, and 55 Si 2 Mn 90 all used in hardened and tempered state. For rail road springs: C 55 (water-hardened), C 75 (oil-hardened), 40 Si 2 Mn 90(water hardened) and 55 Si 2 Mn 90 (oil-hardened).

Table 1 Physical Properties of Commonly used Steel

MATERIAL	CONDITION	ULTIMATE TENSILE STRENGTH (MPa)	TENSILE YIELD STRENGTH (MPa)	BRINELL HARDNESS NUMBER
50 Cr 1	Hardened and Tempered	1680 – 2200	1540 - 1750	461 – 601
50 Cr 1V23		1900 – 2200	1680 – 1890	534 – 601
55 Si 2Mn 90		1820 – 2060	1680 - 1920	534 - 601

For our application, we choose spring steel. Spring steel is a low alloy, medium carbon steel with very high yield strength. This allows objects made of spring steel to return to their original shape despite significant bending or twisting.

Table 2 Chemical Compositions of Spring Steel

ELEMENTS	% OF ELEMENTS
Carbon	0.5~0.65
Silicon	0.15~0.35
Manganese	0.65~0.95
Phosphorous	0.035
Chromium	0.65~0.95

Depending on the type of application, springs are made of carbon steels, silicon and manganese containing

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steels, silicon-manganese steels, alloyed steels, stainless steels. Springs must be capable of storing and releasing the energy. After repeated applications of load, they must retain their original shape and dimensions. This property may be attained by the use of a highly elastic material and by proper design because the allowable stress values determine the choice of material and design.

III. DESIGN AND ANALYSIS

The design of mono leaf spring is done in such a way that the impact bearing capacity of the spring is enhanced and the strain energy of an ordinary conventional leaf spring is matched by the mono leaf spring. The concept of uniform width and varying thickness is introduced. No material changes are done. As discussed earlier, spring steel is used for analysis. The dimensions and constraints are discussed below. The thickness varies gradually from the edge till the midpoint and then gradually increases to the other edge. The thickness is maximum at the center and minimum at edges.

Table 3 Dimensions of mono leaf spring

<table>
<tr><th rowspan="2">GEOMETRY</th><th colspan="5">DIMENSIONS OF LEAF SPRING IN MM</th></tr>
<tr><th colspan="2">Thickness at center mm</th><th>Thickness at ends mm</th><th>Width mm</th><th>Camber mm</th></tr>
<tr><td rowspan="3">Constant width and varying thickness</td><td>Model 1</td><td>12</td><td rowspan="3">8</td><td rowspan="3">50</td><td rowspan="3">90</td></tr>
<tr><td>Model 2</td><td>16</td></tr>
<tr><td>Model 3</td><td>20</td></tr>
</table>

For experimental purpose, the center thickness is varied by 4mm from 12mm to 20mm. Three specimens are designed with center thickness 12mm, 16mm and 20mm respectively. Since it is a mono leaf, no U-bolts or clips are used.

For comparison, a conventional leaf spring with a master leaf, one graduated leaf and a base plate is designed and analyzed and compared with the analysis results of mono leaf springs.

Table 4 Dimensions of conventional leaf spring

LEAVES	LENGTH mm	WIDTH mm	THICKNESS mm	CAMBER mm
1	660	50	8	137
2	890	50	8	150
3	110	50	8	161

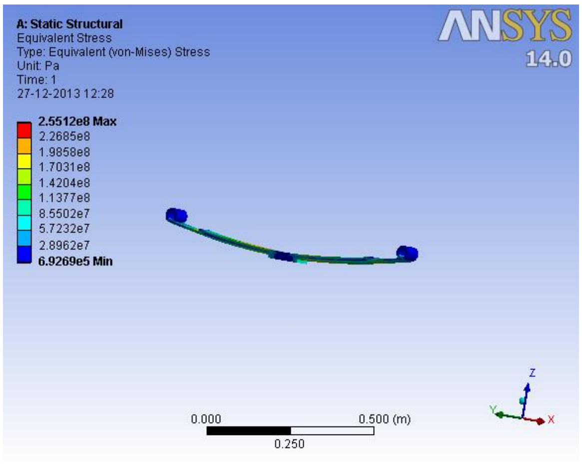

Fig 1 Stress analysis of multi leaf spring

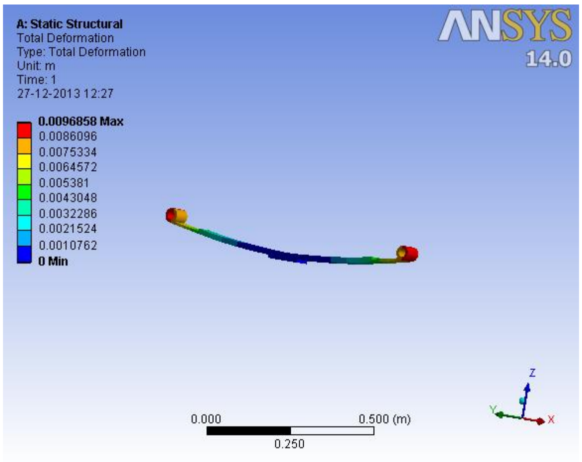

Fig 2 Total deformation of multi leaf spring

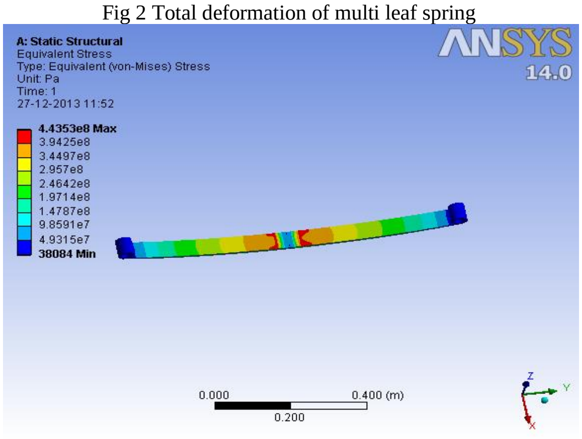

Fig 3 Stress analysis of model 1 mono leaf spring

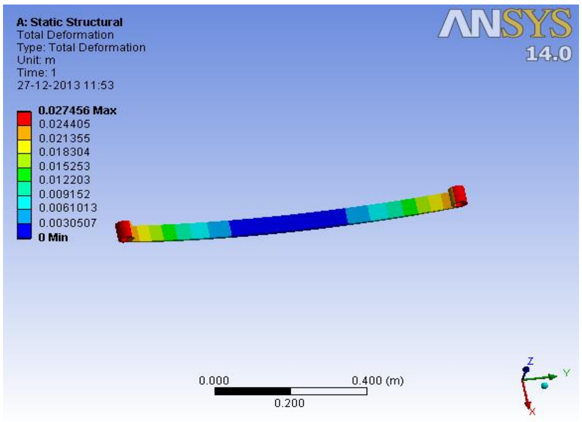

Fig 4 Total deformation of model 1 leaf spring

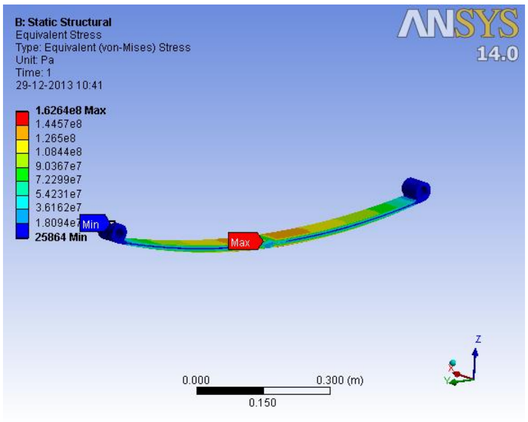

Fig 7 Stress analysis of model 3 mono leaf spring

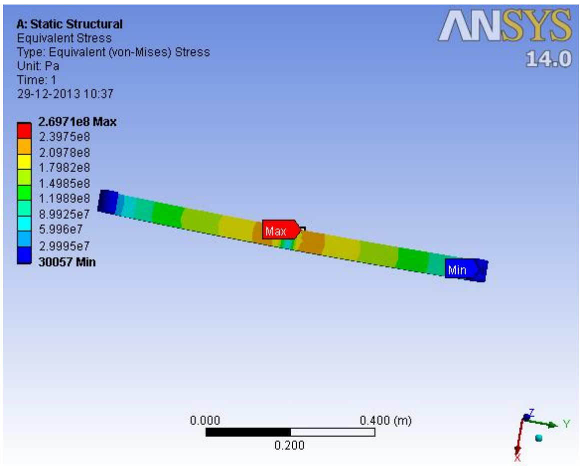

Fig 5 Stress analysis of model 2 mono leaf spring

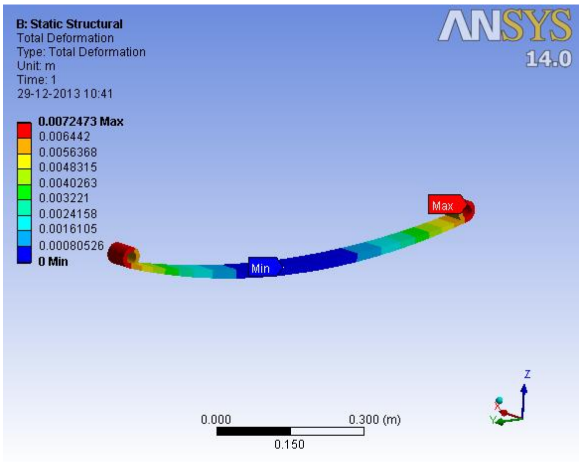

Fig 8 Total deformation of model 3 leaf spring

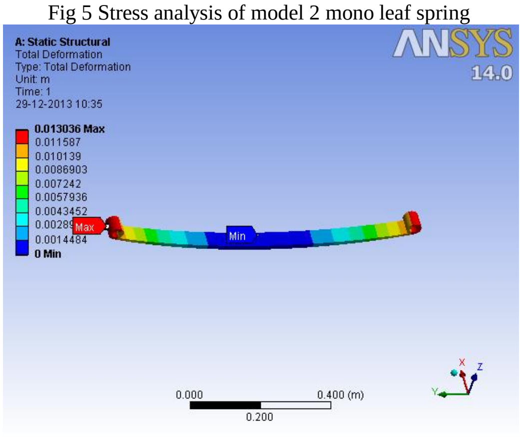

Fig 6 Total deformation of model 2 leaf spring

Stress and deflection calculation for conventional leaf spring:

Total Load	= 2500 N (assumed maximum load)
Bending Stress (Sbg)	$= 12Pl / bt^2 (3nf+2ng)$
	$= 12*1250*445 / 50*8^2 [3(1)+2(3)]$
	$= 231.77$ N/mm²
Deflection (δ)	$= 12 Pl^3 / Ebt^3 (3nf+2ng)$
	$= 12*1250*445^3 / 210000 *50*8^3 [3(1)+2(3)]$
	$= 27.31$ mm

Stress and deflection calculation for mono leaf spring:

Model 1-

Center thickness	= 12 mm
End thickness	= 8 mm
Load	= 2500 N

Bending Stress (Sbg) = 6Pl / ngbt²
= 6*1250*445 / 50*12²
= 463.54 N/mm²

Deflection (δ) = Sbg l² / Et
= 463.54*445²* / 210000*50
= 70.72 mm

Model 2-
Centre thickness = 16 mm
End thickness = 8 mm
Load = 2500 N
Bending Stress (Sbg) = 6Pl / ngbt²
= 6*1250*445 / 50*16²
= 260.742 N/mm²

Deflection (δ) = Sbg l² / Et
= 260.742*445²* / 210000*50
= 34.532 mm

Model 3-
Centre thickness = 20 mm
End thickness = 8 mm
Load = 2500 N
Bending Stress (Sbg) = 6Pl / ngbt²
= 6*1250*445 / 50*20²
= 166.875 N/mm²

Deflection (δ) = Sbg l² / Et
= 166.875*445²* / 210000*50
= 19.6 mm

Table 5 Comparison of Ansys Results and Analytical Results

TYPE OF LEAF SPRING		ANSYS RESULTS		ANALYTICAL RESULTS	
		Stress N/mm²	**Deformation** mm	**Stress** N/mm²	**Deflection** mm
Conventional leaf spring		255.12	9.6	231.77	27.31
Mono Leaf Spring	Model 1	443.5	27.4	463.54	70.72
	Model 2	269.7	13.03	260.74	34.53
	Model 3	162.6	7.24	166.87	19.6

IV. CONCLUSION

A comparative study has been made between conventional leaf spring and mono leaf spring with respect to weight and strength.

The study demonstrated that mono leaf springs can be used for the light weight vehicles and meets the requirements, together with substantial weight savings. The modeling of composite leaf spring is done and analyzed using ANSYS.

From the results, it is observed that the mono leaf springs are more effective compared with the conventional leaf springs. The mono leaf springs also have an advantage of not demanding for clamps and bolts to keep it as a single unit.

REFERENCE

1. R.S. Khurmi, J.K. Kupta. A text book of Machine Design, 2000.
2. P. Beardmore, Composite structure for automobiles, 1986.
3. V.B. Bhandari (1994), “Design of machine elements”, New York, Tata McGraw-Hill.
4. R.S. Khurmi & J.K Gupta (2003), “A textbook of machine design”, S. Chand & company.
5. J. Shigley (1989), “Mechanical engineering design”, New York, McGraw-Hill; Fifth Edition.
6. P.C. Sharma and D.K. Aggarwal, (2005), “Machine design”, S.K. Kataria & Sons.
7. T.D. Gillespie (1992), “Suspensions in fundamentals of vehicle dynamics”, society of automotive engineers, USA, pp.97-117 & pp.237-247.
8. Niranjan Singh, General Review Of Mechanical Springs Used In Automobiles Suspension System, International Journal Of Advanced Engineering Research And Studies, E-ISSN2249–8974