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Comparison of Master Steel Leaf Spring with standard leaf spring by Experimental & FEA Analysis

Prof. Rahul Bhakare[1] Prof.V.B.Vakte[2]
[1] *Mechanical Engineering Department, SRE'S K.B.P.Polytechnic, Kopargaon,*
rahulbhakare44@gmail.com
[2] *Mechanical Engineering Department, SRE'S K.B.P.Polytechnic, Kopargaon,*
vikramvakte@gmail.com

Abstract— The automobile manufacturers have been attempting to reduce the weight of vehicles in recent years .The suspension spring is one of most important system in automobile which reduce jerk, vibration and absorb shocks during riding. Steel have been vigorously developed for many applications. Spring fractures caused no damage in other structural components of the buses or accidents of any kind. The suspension component is connected at both ends with the bus chassis and rests on the wheel axle. In this dissertation firstly there is selection of standard leaf spring with EN 47 material. Then there is manufacturing of second leaf spring of SUP 11A material with same dimensions. Testing of material and providing equal hardness to the standard one is done. FEM analysis of both the leaf springs by building 3-D model in CATIA and using ANSYS software and next to that the spring to be tested is examined for any defects like cracks, surface abnormalities etc. The dimensional & material details of the leaf spring are recorded. For both the spring there is experimental analysis is done by using strain gauges and comparison of FEA and experimental analysis between two springs are taken place to validated for conclusion

Keywords- Leaf spring, Master leaf, FEM, Strain gauge, Static loading

I. INTRODUCTION

As the name implies, stress analysis is the complete and comprehensive study of stress distribution of specimen under study. The most important task before design engineer is to maintain the working stresses within predetermined specific limits, in order to avoid the failure of a member. The design has to be economical with adequate mass and inertia. To improve the product quality it is necessary to determine the stresses in various components. It is also necessary to know the stress distribution in order to predict the failure of component. This puts the design engineer into indispensable need for stress analysis. The main cause of failure of leaf spring is due to large bending behavior. The bending stresses on the leaf spring are calculated so far. The approach was based on cantilever beam theory. Using this approach the bending stress must be induced near the support which provides sufficient rigidity to suspension. Hence it is necessary to evaluate the stresses in the leaf spring. The main component of leaf spring is master leaf therefore the stress analysis of master leaf is carried out by different approaches. Comparison of Master Steel Leaf Spring with standard leaf spring by

Experimental & FEA Analysis Paper title 2 | Page In present work stresses in master leaf are evaluated by considering a approach. In this approach the stress on master leaf is carried out by considering one extra full length leave. The analysis is carried out on only half span of leaf. A model of half cantilever spring assembly is developed in ANSYS and finite analysis is carried out in the same software. For the analysis purpose the spring is bolted at the center and static load is applied at the free end i.e. on eye. The results of finite element analysis for both approaches are verified experimentally by using strain gauges.

2. Design parameter and material

The work is carried out in the rear end leaf spring of a commercial vehicle. The leaf spring with

extra full length leave is used for the analysis.

Table 1. Composition of EN 47 Material

Material	C	Si	Mn	Cr	S & P
%	0.49	0.21	0.80	1.04	0.018 & 0.024

Table 2. Composition of SUP 11AMaterials

Material	C	Si	Mn	S&P	Cr
%	0.58/0.64	0.15/0.35	0.70/1.0	0.35 Max	0.70/1.0

Table 3. Steel leaf spring parameters

Parameter	**EN 47**	**SUP 11A**
1) St. length in mm	945	945
2) Leaf thickness in mm	10 mm	10 mm
3) Leaf width in mm	50 mm	50 mm
4) Camber in mm	110 mm	110 mm
6) Strain Gauge locations L1 L2 L3 (From center of leaf spring)	25 230 380	25 230 380

Table 4. Material Properties

Parameter	EN 47	SUP 11A
1) UTSS (N/mm^2)	1158	1962
2) Tensile Strength (N/mm^2)	1034	1470
3) Young's modulus (N/mm^2)	$2.07*10^5$	$2.10*10^5$
4) Poisson's ratio	0.3	0.3
5) Density (Kg/mm^3)	7850	7750

3 Methodologies

3.1 *Experimental work*

In experimental analysis , actual prototype is considered under static loading condition . The stress analysis of leaf spring is carried out by using the strain gauge technique. The instrumentation is developed for this work.

Instrumentation measures only the change in resistance i.e. ΔR. This change in resistance is very small having a magnitude of few millivolts. So it is necessary to convert this small resistance into a equivalent voltage with the help of instrumentation techniques. The instrumentation consist of Strain Gauges ,Wheatstone bridge circuit and Digital multimeter. Or digital strain gauge indicator.

Strain gauge positions from end
Span from load end to strain gauge No.1 L1=447.5mm
Span from load end to strain gauge No.1 L2=242.5mm
Span from load end to strain gauge No.1 L3=92.5mm
The experimental strain is carried out by equation
$dVo = \frac{1}{4} \times Vs \times F \times \varepsilon$
where,
Vs = Supply voltage in volts
dVo=Change in voltage in millivolts
F=Gauge factor=2
ε=Experimental strain
Experimental stress is given is given by
$\sigma b = \varepsilon x E$ (2)
E= Young modulus of material of material

Fig. 1 Experimental Setup

3.2 Finite element analysis

The one model of leaf spring is developed in CATIA V5 R17 . To reduce the complexity for solution, center band and clamp are not modeled together. After generation of model the properties of material are provided and mesh model is developed. Contact conditions are formed where bodies meet. The load is applied on the free end i.e. on eye and constraints are provided at each end of the leaf at center. After solving, the first principle stress counter at nodal region is shown in fig. 2 and 3.

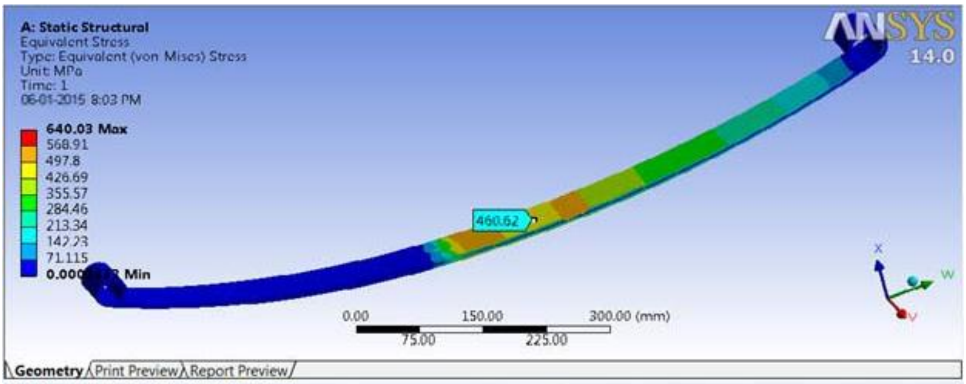

Fig. 2 Von Mises Stress Analysis of EN 47 Leaf Spring at 2047 N

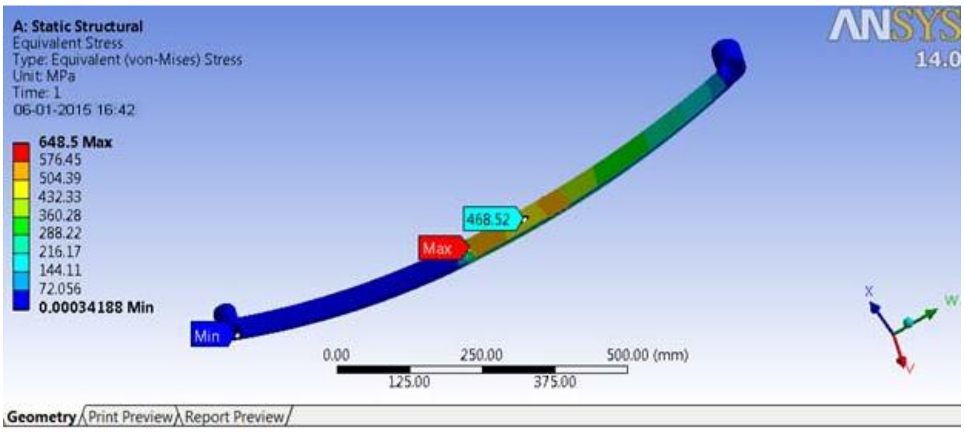

Fig. 3 Von Mises Stress Analysis of SUP 11A steel Leaf Spring at 2077 N

Discussion and conclusion

Though the detailed results are presented in earlier, here an attempt is made to compare the results obtained analytically, by FEM and experimentation. For comparison of stresses first principle stress is considered. The detailed discussion is as

Table 5. Comparison of results for EN 47 steel leaf spring at a Deflection of 55 mm

Location	Parameter	Analytical value	FEM value	Expt. value
L1	Bending stress in N/mm^2	548.58	462.62	413.17
	Load	2048 N	2048 N	2048 N

Table 6. Comparison of results for SUP 11A steel leaf spring at a Deflection of 55 mm

Location	Parameter	Analytical value	FEM value	Expt. value
L1	Bending stress in N/mm^2	556.53	468.51	371.70
	Load	2077	2077	2077

Table 7. Comparison of Stresses in master leaf for graduated leaf spring with 2048N loading for EN47 matrerial.

Sr No.	**Length mm**	**Maximum Stress calculated analytically N/mm2**	**Maximum Stresses By FEM N/mm2**	**Maximum stress with analysis Experimental Analysis N/mm2**
1	447.5	413.17	548.58	413.11
2	242.5	413.58	515.51	402.19
3	92.5	355.41	480.59	389.31

Table 8. Comparison of Stresses in master leaf for graduated leaf spring with 2077N loading for SUP11 matrerial.

Sr No.	Length mm	Maximum Stress calculated analytically N/mm2	Maximum Stresses By FEM N/mm2	Maximum stress with analysis Experimental Analysis N/mm2
1	447.5	371.13	556.29	468
2	242.5	372.55	524.48	470.51
3	92.5	312.99	539.67	434.35

This work involves and comparison of conventional SUP11A and EN 47 material leaf spring under static loading conditions the model is preferred of in CATIA V5 R 16 and ANSYS 14. From the result obtained it is concluded that.

1. Variation of 1.64 % is observed in maximum stress among analytical and FEA values for SUP 11A material.

2. Variation of 1.89 % is observed in maximum stress among analytical and FEA values for EN 47 material.

3. Variation of 11.99 % is observed in maximum stress among analytical and Experimental values for EN 47 material.

4. Variation of 21.91 % is observed in maximum stress among Analytical and Experimental values for SUP 11A material.

5. Variation of 10.30 % is observed in maximum stress among FEA and Experimental values for EN 47 material.

6. Variation of 20.66 % is observed in maximum stress among FEA and Experimental values for SUP 11A material.

7. Stiffness of SUP 11 A Material is higher than En 47 Material.

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