Effect of Variation In Thickness And Width On The Performance of Leaf Springs Used In Heavy Duty Vehicle Applications

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Abstract- Leaf springs are oldest suspension elements they are still frequently used, mainly in commercial vehicles. Weight reduces is the main function in automobile industries. Its present work, existing mono steel leaf spring of a TATA-407 is take for modelling and analysis. Finite element method has been implemented to change the existing leaf spring with considering the dynamic loading. Present work involves design and analysis of a conventional leaf spring under static and dynamic loading condition. The 3D model is prepared in CATIAV5, and then analysis is performed in the ANSYS by considering same load in static and dynamic loading. For the cost reduction in existing leaf spring modification carried out by iteration method consider two cases that is, varying thickness of leaves and varying width. The optimization has been carry out to satisfy the permissible value of factor of safety. The results are verified by comparison of Experimental and Finite Element Method. All Experimentally calculated values of deflection and stresses are closely matching with values obtained from ANSYS software.

Key word- Leaf Spring , FEM Analysis , Thickness and width variation.

1. Introduction

Leaf springs are widely used in railway and in automobile industry. The leaf spring should absorb the impacts and vertical vibrations due to road irregularities by means of variations in the spring deflection so that the potential energy is stored in the form of strain energy and then released slow so increases the energy storage capabilities of a leaf spring and ensures that more compliant suspension system[1]. In order to reduce natural resources and increase efficiency we need to reduce weight. It can be attained by the introduction of better material, design optimization and better manufacturing processes. [2]. The basic idea for the design is to generate the wanted elasticity and maintain the driving comfort. The leaf spring is one of the oldest suspension types. Nowadays it is widely used in heavy duty vehicles and work machines. [3]. Conventional leaf spring has less specific modulus strength. Conventional leaf spring are usually manufactured and assembled by using number of leaf made of steel and hence weight is more. Its corrosion resistance is more compared to composite leaf spring, it has less damping capacity. Hence, composite material becomes a very strong candidate for such applications [4]. The suspension spring is one of most important system in automobile which reduce jerk, vibration and absorb shocks during riding in automobiles like light motor vehicles, heavy duty trucks and in rail systems. It carries lateral loads, brake torque, driving torque in addition to shock absorbing [5]. Finite Element analysis tools offer the tremendous advantage of enabling design teams to consider virtually any molding option without incurring the expense associated with manufacturing and machine time [6]

2 Experimental Work

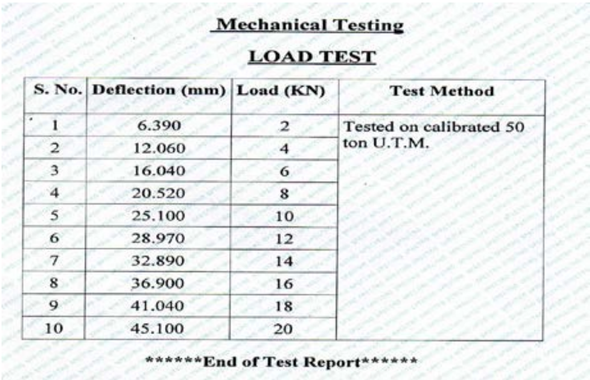
2.1 Load vs. Deflection testing of conventional TATA-407 leaf spring

Experimental and FEM analysis of conventional leaf spring at different loading condition for find out deflection a test was done between load and deflection.

Fig 1: Leaf Spring under loading condition

Leaf spring is placed as shown in the figure upside down and eyes are facing downward which are connected by a movable fixture by the help of bearings. Both fixtures are placed in different position one is fixed and on the other hand second fixture is allowed to move horizontally.

In this position by using UTM machine load is gradually increases on the last leaf of the leaf spring up to 20.14 KN. In computer result is shown which is manually noted down.



Mechanical Testing

LOAD TEST

S. No.	Deflection (mm)	Load (KN)	Test Method
1	6.390	2	Tested on calibrated 50 ton U.T.M.
2	12.060	4	
3	16.040	6	
4	20.520	8	
5	25.100	10	
6	28.970	12	
7	32.890	14	
8	36.900	16	
9	41.040	18	
10	45.100	20	

******End of Test Report******

Table 1 Load vs. deflection

2.2 FEM Analysis of the leaf spring

Leaf spring was design is was created in CATIA V5 mechanical design modular. Dimension from modeling purpose was taken of TATA-407.

Dimension of the conventional leaf spring used are as follows:

Parameter	Value
Camber	**100 mm**
Width of leaf spring	**76 mm**
Thickness of each leaf	**11 mm**
Eye dinner diameter	**30 mm**
No of leafs	**7**
E	**210 Gpa**

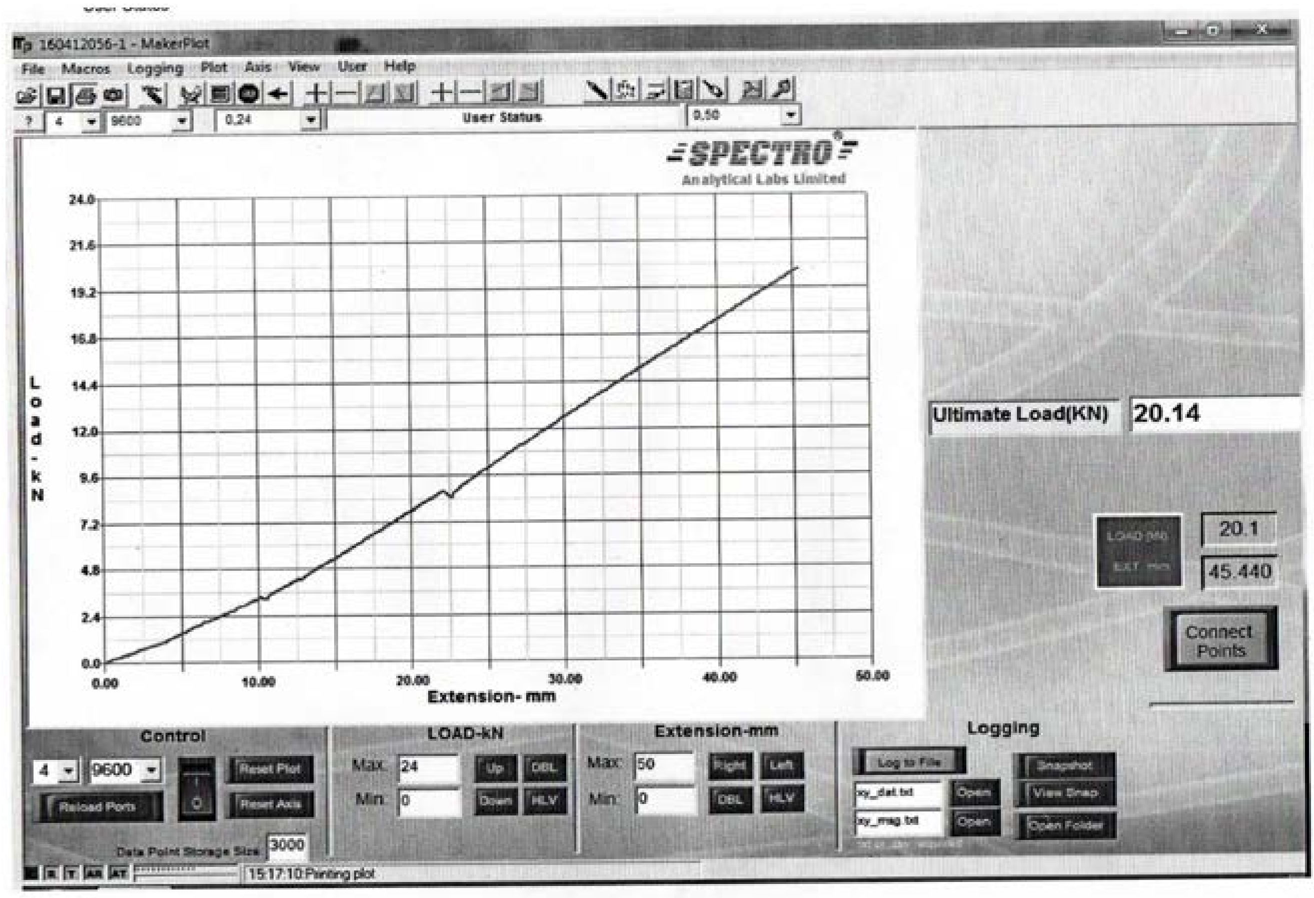


Fig 2 Load vs. deflection plot

Leaf span of leaf spring we have used are as follows:

Leaf	Length (cm)
Leaf span of 1st leaf	**120**
Leaf span of 2nd leaf	**120**
Leaf span of 3rd leaf	**105**
Leaf span of 4th leaf	**85**
Leaf span of 5th leaf	**66**
Leaf span of 6th leaf	**50**
Leaf span of 7th leaf	**30**

To design purpose we have created each leaf individually in CATIA V5. In next step we used assembly modular to create assembly of this leaf spring. Assembly of leaf spring is shown in the figure below.

Leaf spring is now saved in .stp format so we can transfer it into ANSYS.

Now for FEM analysis we imported .stp file into ANSYS. Now for FEM analysis we need to do few step

1) Select material from engineering data
2) Insert coordinate system
3) Insert boundary condition
4) Insert solution Parameter

After this we need to right click and select evaluate all and we get our desired result.

Results we get from FEM analysis and from experiment in lab was almost same. For the loading condition of 20,000N deflection which we get are 45.1 mm from experiment and 42.44 from FEM analysis. FEM analysis is done on ideal case and on the other hand experiment is done on actual condition in which manufacturing defect, material quality, environmental condition cause more deflection compare to ideal condition.

2.3 Comparison of Load vs. Deflection for Test results and ANSYS results

Comparison of results of experiment and FEM analysis are shown below in the form of table for maximum deflection for different loading condition

Test results and ANSYS analysis results are shown below in the table. Maximum deflection

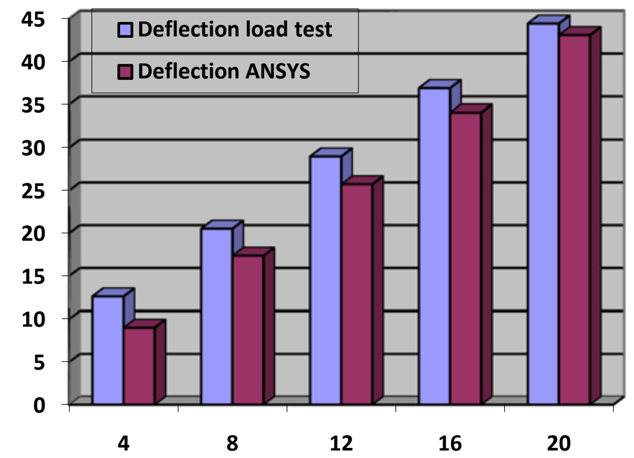


Fig 3: Comparison of deflections for test and analytical results

Blue bar shows deflection under load test in lab and red bar show deflection in FEM analysis . we can see that difference is very less and following a trend. By this we can say that optimization can be done by using analytical method.

2.4 Comparisons of deflection at different thicknesses

For a load of 50 kN deflection in various leaf springs-

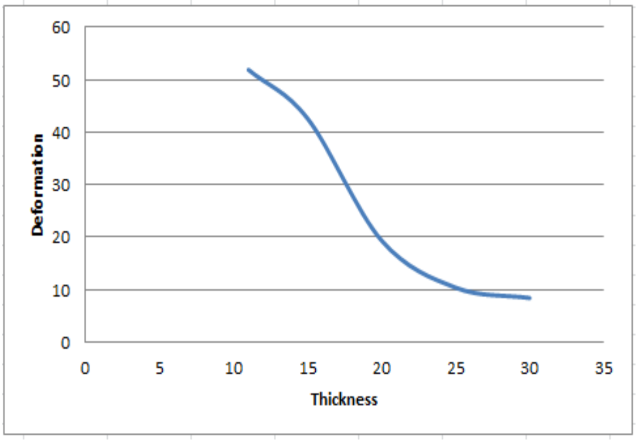


Fig 4: Deflection for different leaf spring thickness

20 mm thickness leaf spring are optimal for practical use because after increasing more thickness deflection decreases is negligible.

2.5 Comparison of deflection with varying width

Table below shows the deflection for different leaf spring assemblies with varying width

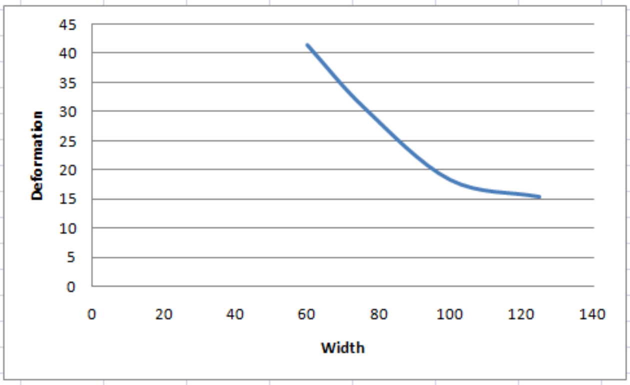


Fig 5: Deflection vs. width in leaf spring assembly.

100mm width leaf spring are optimal for practical use. In leaf spring of 100 mm width assemble slope is very closes to 50KN load condition.

CONCLUSION

In the current work, leaf spring is modeled and Quasi-static analysis is carried out by using ANSYS software and it is concluded that for the given specifications of the leaf spring FEM gives quite accurate prediction of variation of leaf spring Width and Thickness carination. The results of static analysis of the leaf spring using the commercial solver and test results shows better correlation thus further variations in leaf spring parameters and their study will also be close to real life experiment testing.

We have got the following result from our experiment and FEM analysis for variation thickness

Load vs. deflection test is performed on a TATA – 709 rear axle leaf spring manufactured and assembled by TOYO leaf spring manufactures. This test gives deflection of 45 mm for a given maximum load of 20.14 kN. FEM analysis also done for this successfully model of leaf spring was created in CATIA V5 with same dimension used for test lab. This model has a thickness of 15 mm and it gave a deflection of 42.44 mm for 20 kN load. In FEM this model analysis under load of 50 kN . In 20 mm thickness of leaf spring deformation slope are more drastically so grater change in deformation of leaf spring then ride discomfort in some cases, so optimum value of leaf spring thickness is 20 mm.

We have got the following result from our experiment and FEM analysis for variation width

Leaf spring models with varying width were created using CATIA and were analyzed in ANSYS. These results show that with increase in width, deflection reduces significantly.

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