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Design, Analysis and Weight Optimization of leaf spring for light weight vehicle

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Abstract - *In the present scenario, Research and technology move on weight optimization of product with highly sustainability of material strength. Moreover, Now a day many researches are based on mass reduction. One of the oldest component of suspension is leaf spring. Many automobile industries have focused on to replace a material of leaf spring due to various mechanical properties. The aim of this paper is to represent a general study on design and analysis of leaf spring with reduction in weight. The objective of this paper is to get detail on various spring issues such as compare the load carrying capacities, stiffness and weight saving of two different designs of leaf spring. In addition to, this paper carries study of leaf spring on different materials(55Si2Mn90 and 50CrV4). In this study typical leaf springs of light commercial vehicle are used. CREO 2.0 is used for modeling of both the springs and the analysis was done by using HYPERWORKS.*

Key Words: ***leaf spring, weight reduction, CREO 2.0, HYPERWORKS.***

1. INTRODUCTION

Leaf spring is a type of suspension system, whose work is to safeguard the occupants from road shocks. It carries lateral loads, brake torque, driving torque in addition to shock absorption system by means of spring deflections, so that the potential energy is stored in a leaf spring and then relieved slowly. 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 [1].In the modern era, in order to preserve natural resources and also to economize energy, weight reduction has been the centre of attraction for an automobile industry. It can be achieved by change in design or by using different material compositions. In this paper two different designs of master leaf are to be used.

Dr. Amit Pradhan and Yogendra Rathore [2], they have studied that under the same static load conditions deflection and stresses of steel and composite leaf spring were found with great difference. Deflection of composite leaf spring is less as compared to steel leaf spring with same loading conditions. The weight of conventional leaf spring was found to be 23 kg while the weight of composite leaf spring was found to be 3.6 kg. Indicating reduction in weight by 80% in same level of performance.

B. Vijaya Lakshmi, I. Satyanarayana[3] they shows the study of leaf spring with different materials such as mild steel, E-glass, S- glass and C-glass. The static analysis on 8-leafs concluded that E-glass epoxy is better than using Mild-steel as though stresses are little bit higher than mild steel, E-glass epoxy is having good yield strength value (5e+008N/m2) and also epoxy material components are easy to manufacture and this having very low weight while comparing with traditional materials.

Senthilkumar and Mouleeswaran[4], Design and experimental fatigue analysis of composite multi leaf spring using glass fiber reinforced polymer are carried out using life data analysis, in this particular literature. Compared to steel spring, the composite leaf spring is found to have 67.35% lesser stress, 64.95% higher stiffness and 126.98% higher natural frequency than that of existing steel leaf spring. The conventional multi leaf spring weighs about 13.5 kg whereas the E-glass/ Epoxy multi leaf spring weighs only 4.3 kg. Thus the weight reduction of 68.15% is achieved. Besides the reduction of weight, the fatigue life of composite leaf spring is predicted to be higher than that of steel leaf spring.

2. Methodology

Firstly designs are prepared with the help of CREO2.0 software. Only master leaf of light vehicle is designed on standard dimensions[5].

Table -1: Specifications of Leaf spring

S.NO.	Parameter	
1	Total length of spring	1120mm
2	Free Camber (at no load condition)	180mm
3	No. of full length leaves	1
4	Thickness of leaf	6mm
5	Width of leaf	50mm

With the help of this dimension, two different designs of full leaf spring are prepared.

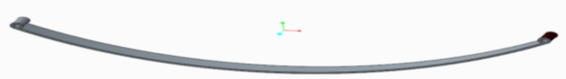

Fig-1: Full length leaf

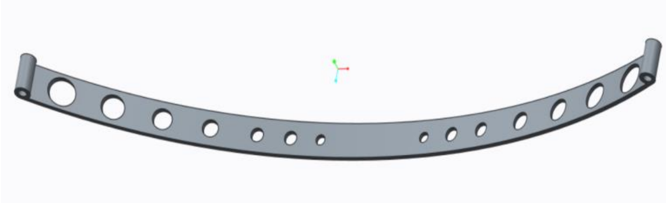

Fig-2: Full length leaf with optimization in design

The diameter of hole is different because of stress formation. Diameter of biggest circle is 40mm because of less stress generation while diameter of smallest circle is 15 mm because of high stress generation.

Table-2: Size of holes

Hole number	Diameter
01 and 14	40mm
02 and 13	35mm
03 and 12	30mm
04 and 11	25mm
05 and 10	20mm
06 and 09	20mm
07 and 08	15mm

Now a days most of automobile industry uses 55Si2Mn90[2] material as well as 50CrV4 [6]. Next table shows mechanical properties of following component.

Table-3: Mechanical Properties of materials

Name\Properties	Young Modulus of elasticity	Poisson's Ratio	Density (Kg/m^3)
55Si2Mn90	200GPa	0.30	7850
50CrV4	210GPa	0.28	7830

The volume of full length leaf spring is 381357mm^3 while the volume of full length leaf spring after weight optimization is 326594mm^3. With the help of these result and mechanical properties, next table shows the total weight reduction.

Table-4: Weight reduction

	55Si2Mn90	50CrV4
Weight of leaf spring	2.993Kg	2.986Kg
Weight after optimization	2.560Kg	2.557Kg
Total reduction	433 gm	429 gm
Change in percentage	14.47%	14.37%

3. Finite Element Analysis

Finite Element Analysis (FEA) is a computer-based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. The power and low cost of modern computers has made Finite Element Analysis available to many disciplines and companies. In the finite element method, a structure is broken down into many small simple blocks or elements. The behavior of an individual element can be described with a relatively simple set of equations. Just as the set of elements would be joined together to build the whole structure, the equations describing the behaviors of the individual elements are joined into an extremely large set of equations that describe the behavior of the whole structure. The computer can solve this large set of simultaneous equations. From the solution, the computer extracts the behavior of the individual elements. From this, it can get the stress and deflection of all the parts of the structure [7].

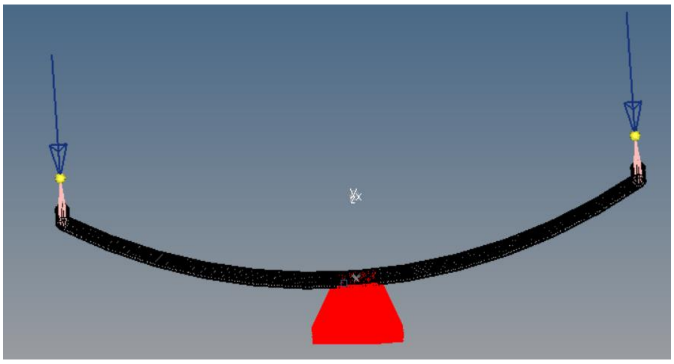

Fig-3: Meshing and boundary condition

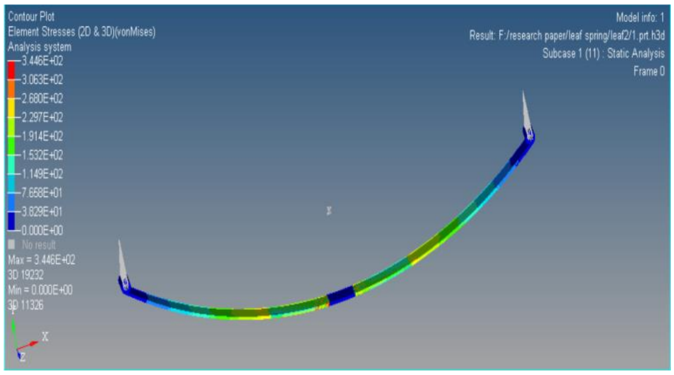

Fig-4: Vonmises stress of full length leaf for 55Si2Mn90 at 1000N

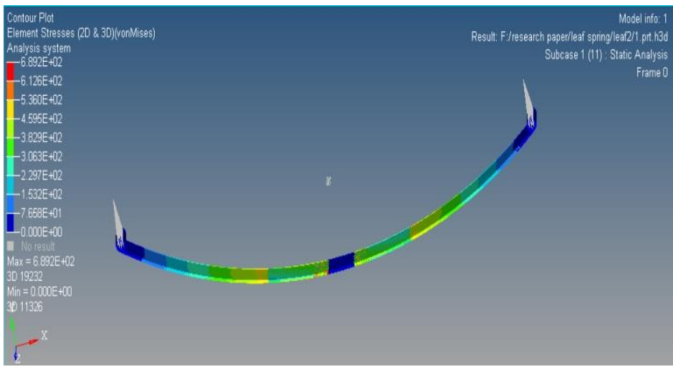

Fig-5: Vonmises stress of full length leaf for 55Si2Mn90 at 2000N

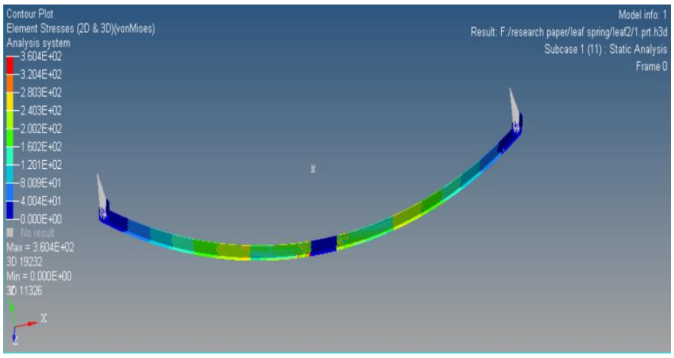

Fig-6: Vonmises stress of full length leaf for 50CrV4 at 1000N

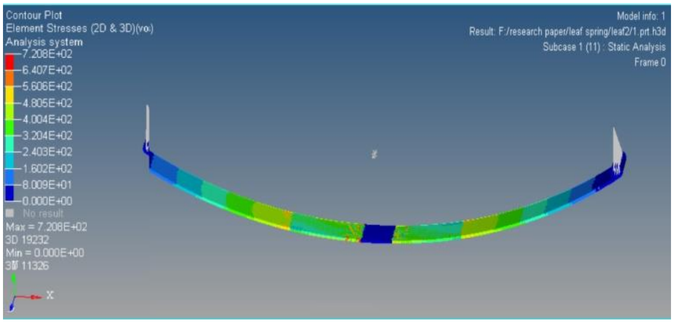

Fig-7: Vonmises stress of full length leaf for 50CrV4 at 2000N

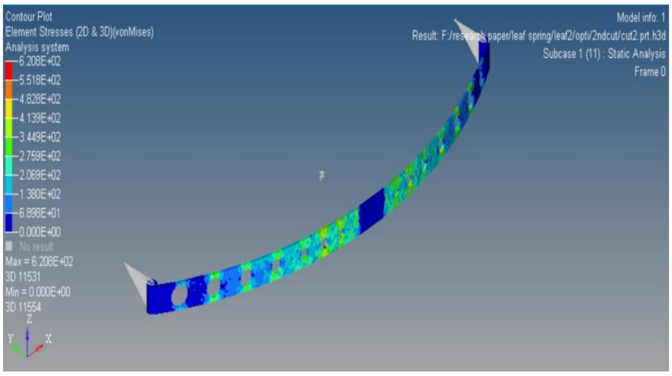

Fig-8: Vonmises stress of full length leaf for 55Si2Mn90 at 1000N after hole

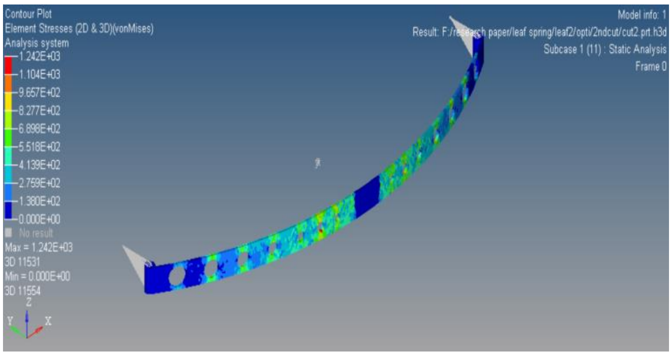

Fig-9: Vonmises stress of full length leaf for 55Si2Mn90 at 2000N after hole

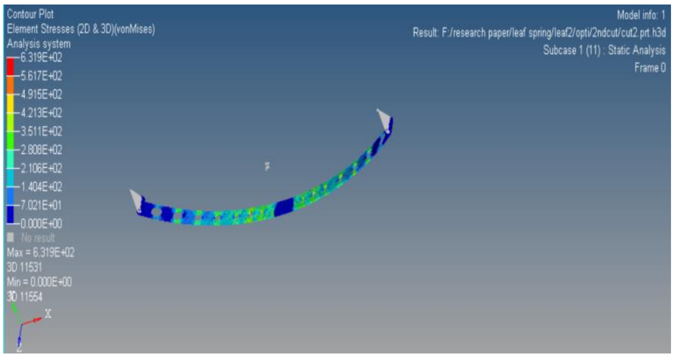

Fig-10: Vonmises stress of full length leaf for 50CrV4 at 1000N after hole

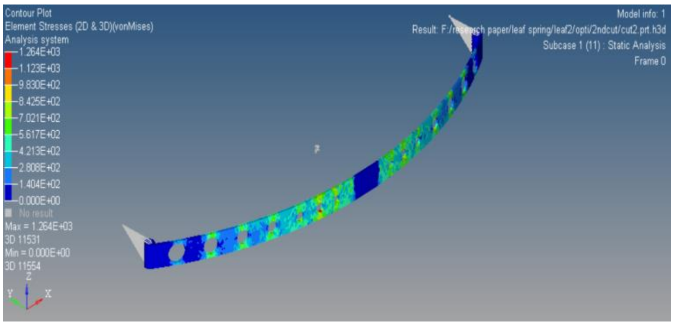

Fig-11: Vonmises stress of full length leaf for 50CrV4 at 1000N after hole

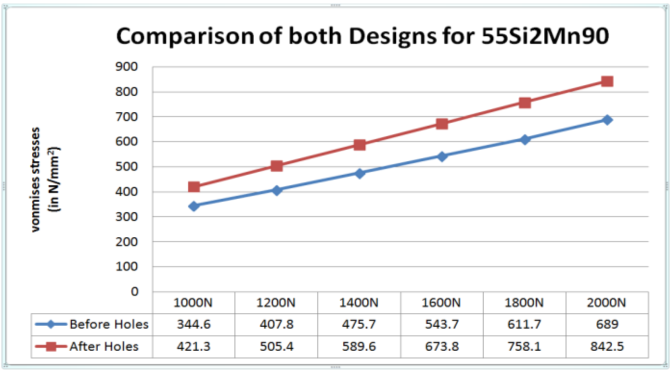

Chart -1: Comparison of both designs for 55Si2Mn90

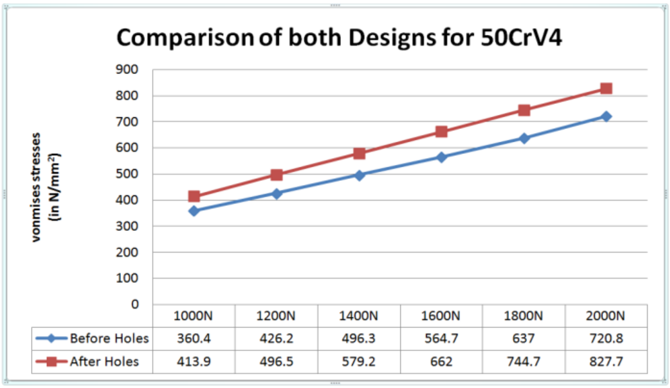

Chart -2: Comparison of both designs for 50CrV4

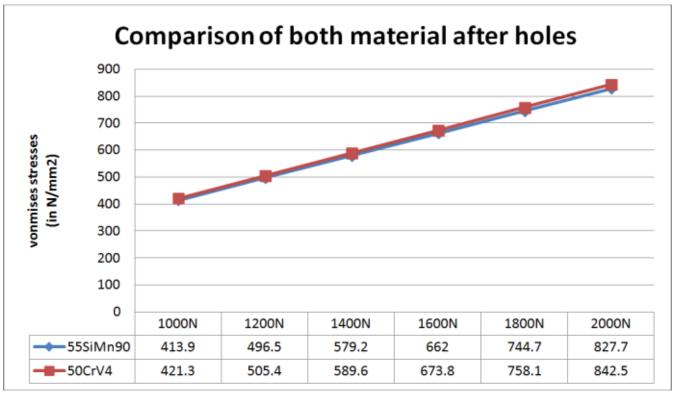

Chart -3: Comparison of both material after holes

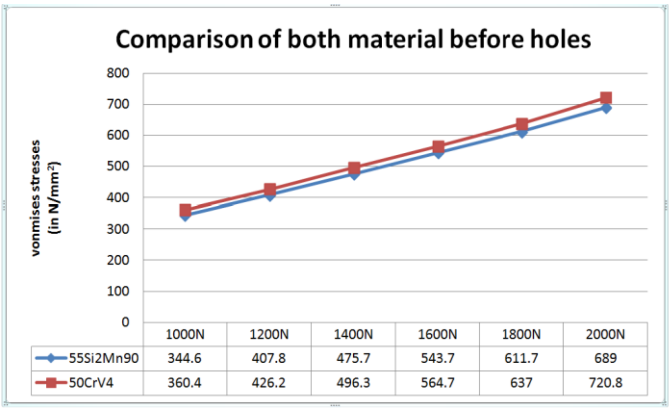

Chart -4: Comparison of both material before holes

4. CONCLUSIONS

This is a general study which is basically concentrate on weight optimization of leaf spring with the help of holes, Moreover comparison of vonmises stresses developed in a full length leaf before and after holes for two different materials such as 55Si2Mn90 and 50CrV4.

From this study we found that the change in the vonmises stress before and after the hole was 12.91% and 18.21% for 50CrV4 and 55Si2Mn90 respectively. It is a general study and only applicable when permissible limit is upto 20% of stress. Furthermore, reduction in weight is 14.37% and 14.47% for 50CrV4 and 55Si2Mn90 respectively.

5. REFRENCE

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