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# Minimization Of Stress In A Parabolic Leaf Spring By Local Algorithm For Constant & Priorities

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## ABSTRACT

**A leaf spring is simple form of spring, generally used for the suspension in automotives. Earlier it was like a slender arc-shaped having length of a spring steel of rectangular cross-section. In this paper analysis is done for leaf spring whose thickness varies from the center to the outer side following a parabolic pattern. The development of a parabolic tapered leaf spring enabled the springs to become lighter, but also provides a much improved ride to the vehicle through a reduction on interleaf friction. To move further, authors take an opportunity to perform a Finite element analysis (FEA) on the spring model so that stress and damage distribution can be observed. In this paper, initially the magnitude of stress pertaining to parabolic leaf spring is computed by finite element method and then the approach to minimizing the stress has been carried out effectively with help of Local Algorithm for Constants and Priorities.**

**Keywords – Camber, Computer aided engineering (CAE), Finite element analysis, Eye distance, Parabolic leaf spring, Static loading,**

## 1. INTRODUCTION

The parabolic leaf spring which we have taken into consideration is that of a mini loader truck. To begin with, the CAD model of the spring was developed in CATIA V5R20. In this paper work is carried out on the leaf spring's front axle. The objective of this work is to analyze the spring under the existing static load conditions and determining the amount of stress developed. The values of stress will be computed with the help of finite element method and this process will be performed in static structural workbench of CATIA V5R20. Any physical experimentation takes a lot of time and work setting. In this paper an approach has been shown as to how physical experimentation can be reduced by the use of finite element method and how stress values can be computed. After computing max stress, it is imperative to reduce its magnitude further so that the life of the parabolic leaf spring increases. This is the point where optimization plays its role effectively.

## 2. MATERIAL TYPE, MECHNICAL PROPERTIES

The material used for the experimental work is 55Si2Mn90. The other designation of this material is shown in Table-1 and its chemical compositions are shown below in Table -2.

**Table – 1**

| International Standard | Equivalent Grades | | | |
|---|---|---|---|---|
| | **IS** | **DIN** | **BS** | **AISI** |
| EN45 | 55Si2Mn90 | 55Si7 | 250A53 | 9255 |

**Table – 2**

| Grade | C % | Si % | Mn % | Cr % | Mo % | P % | S % |
|---|---|---|---|---|---|---|---|
| 55Si2Mn90 | 0.55 | 1.74 | 0.87 | 0.1 | 0.02 | 0.05 | 0.05 |

Mechanical properties and spring dimensions pertaining to 55Si2Mn90 are shown in Table – 3 below.

**Table - 3**

| PARAMETER | VALUE |
|---|---|
| Material selected - steel | 55Si2Mn90 |
| Young's Modulus (E) | 200GPa |
| Poission's Ratio | 0.3 |
| Tensile Strength Ultimate | 1962 MPa |
| Tensile Strength Yield | 1500 MPa |
| Density | 7850 $kg/m^3$ |
| Thermal Expansion | $11x10^{-6}$ / °C |

The existing parabolic leaf spring has the following dimensions showed in Fig. 1 where camber is 90.81mm and leaf span or distance between eyes is 1025mm.

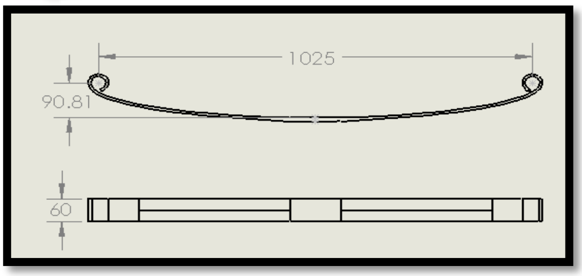


Fig.1 Front and Top View

## 3. CAD MODELING

Computer model of parabolic leaf spring forms the basis of our work. It is very essential that the developed computer model is exactly a replica of the physical specimen. The parabolic leaf spring has been modeled in CATIA V5 R20 in Part Design workbench. The computer model is shown in Fig.2.

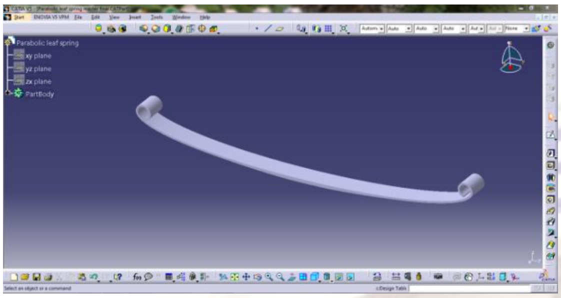

Fig.3 CAD Model of Parabolic Leaf Spring

## 4. FINITE ELEMENT ANALYSIS

### 4.1 Meshing

Meshing is basically the process of breaking the CAD model into very small elements. It is also known as piecewise approximation. Meshing are of different types, it may be comprising of 1D, 2D or 3D elements. In our case we have selected the following element for analysis mentioned in Table-4 below:

**Table-4**

| Mesh | | | Element type | |
|---|---|---|---|---|
| S. N. | Entity | Size | | |
| 1 | Nodes | 12084 | Connectivity | Statistics |
| 2 | Elements | 5905 | TE10(Tetra hedron element) | 5905 ( 100.00 % ) |

### 4.2 Applying Load and Restraints

It has been mathematically calculated that the maximum load which the spring will be subjected to 3800 N. This particular calculation has been done on the basis of GVW (Gross Vehicle Weight), which may be defined as the total weight of the loaded vehicle. This includes the vehicle itself and the cargo that is loaded within that vehicle.

In order to perform static structural analysis it is very essential to restraint the CAD model in the same manner as it is done physically. As far as parabolic leaf springs are concerned it has two eye ends, one of which is fixed with the upper body of the mini loader truck, while the other end is attached to a shackle which allows the spring to expand along its leaf span thereby causing some degree of rotation in the shackle.

After performing finite element analysis the following results are obtained as shown below :-

i. Max Displacement = 16.3079mm
ii. Max Von-Misses stress = 5.11017e+008 N_m2
iii. Energy = 30.008 J
vi. Mass = 4.549kg

The maximum Von mises stress and maximum displacement is shown in Fig. 4 and Fig. 5.

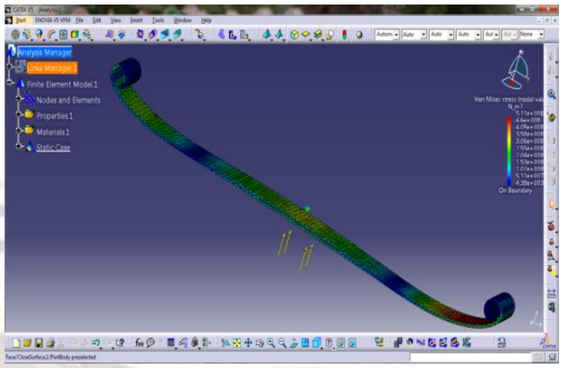

Fig.4 Maximum Von Mises stress

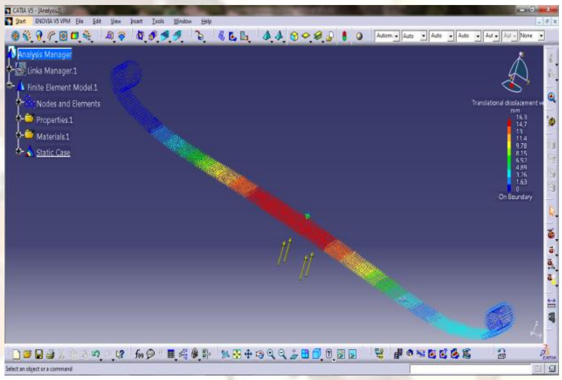

Fig.5 Maximum Displacement

The different zones from red to blue in Fig. 4 and Fig.5 indicate the maximum and minimum values of the respective output parameters.

## 5. MINIMIZATION OF STRESS BY LOCAL ALGORITHM

After the results obtained from finite element analysis it is learned that stress concentration near the right eye of the parabolic leaf spring is maximum, hence in order to minimize the stress generated, local algorithm for constants and priorities is applied.

Mathematical representation of the minimization problem:

Objective Function: Minimization of existing stress.

Variables: Camber (Ranges from 90mm to 95mm) and Eye Distance (Ranges from 1020mm to 1030mm)

Subject to constraint: Maximum displacement < 15mm

After running the algorithm we achieved the following results as shown in Fig.6

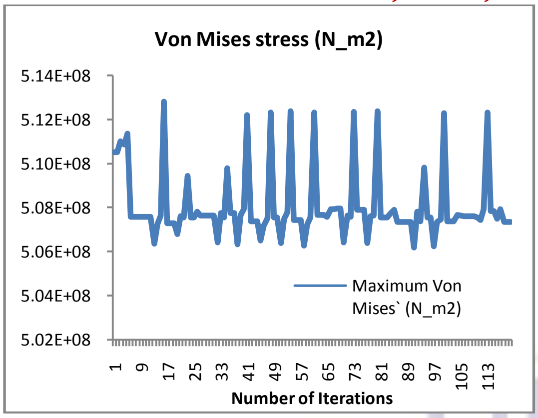


Fig.6 Changes in von mises stress

On the basis of results obtained from the applied algorithm, we founded that iteration number 91 indicates the minimum value of stress generated as shown in Table-5 below

**Table-5**

| Iteration No. | Best (N_m2) | Maximum Von Mises` (N_m2) | Camber (mm) | `Eye Distance` (mm) |
|---|---|---|---|---|
| 91 | 506191744 | 506191744 | 90.001 | 1020 |

## 6. RESULTS AND DISCUSSIONS

A comparison has been made in order to show the reduction in amount of stress by varying the camber and eye distance in Table-6. Hence eye distance and camber both have an important role to play as far as the computation of stress is concerned.

**Table-6**

| | |
|---|---|
| Minimum / Modified stress(N/m$^2$) | 506191744 |
| Existing stress(N/m$^2$) | 510538816 |
| Difference(N/m$^2$) | 4347072.00 |
| % Decrease | 0.851467482 |

## 7. CONCLUSION

The analysis carried out in the current work suggested that search algorithms may be implemented as far as minimization or maximization of an objective function is concerned. The paper suggests an approach as to how stress can be minimized by the help of local algorithm.

From the graph of Fig.6 regarding the variation in von mises stress, we conclude that stress has been minimized and the corresponding input parameters namely camber and eye distance should be 90.001mm and 1020mm respectively.

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