# Parametric Designing and Simulation of Mono Leaf spring using Solidworks

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**Abstract- Designing of particular component for different PARAMETERS is time consuming PROCESS. So to reduce Redesigning time of components for different specifications, parametric modeling can be used. The objective of this paper is to find an optimized design of component by varying the values of its dimensions. In this project parametric designing has been used to design a mono leaf spring by defining its width and thickness as a varying parameter. SolidWorks is used for Modeling of leaf spring which has in-built strong simulation compatibility. An alloy steel is considered as material for mono leaf spring and it is tested for different combinations of width and thickness. The comparisons of theoretical and analytical results shows that parametric concept is successfully implemented in designing of mono leaf spring.**

**Keywords – Parametric Design, Leaf Spring, Simulation**

## I. INTRODUCTION TO PARAMETRIC MODELING

Parametric modeling is a concept in which a relationship is developed between different variables of a component with the modelling software. The following methods are used for parametric modeling. Parametric Modelling in Solidworks can be achieved by following two methods.

- By using Equation table: In this method, Variables of a component are defined in terms of parameters in Equation table by assuming ideal dimensions for model. These parameters can be changed as per design specifications or user requirement and Model will get automatically updated to given changes.

- By using Excel sheet: In this method, initially excel sheet is designed by defining all the variables of the component. This excel sheet is used as a input parameter for modelling of component. Any desired specifications of component can be achieved by defining required inputs in excel sheet.

Parametric modelling using Solidworks reduces the time of redesigning same components for different specifications. In Addition to this, Solidworks simulation produces analytical results for each specification, reducing the time of performing individual analysis for different specifications.

## II. LEAF SPRING

### *A. INTRODUCTION:*

Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. Leaf spring consists of flat bars of varying lengths clamped together and supported at both ends, thus acting as a simply supported beam. This can also be referred to as a semi-elliptical spring or cart spring; it has 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.

### *B. TYPES OF LEAF SPRING:*

There are two types of leaf springs based on Number of leaves, mono leaf springs and multi leaf springs. The mono leaf spring or single-leaf spring consist of only one plate of spring steel. On the other hand, Multi leaf spring consists of several leaf springs with varying length placed on top of each other. The shorter plates are placed at the bottom and the longer plates are placed at the top.

## III. DESIGN OF MONO LEAF SPRING

The eye is provided for attaching the spring with another machine member. The amount of bend that is given to the spring from the central line, passing through the eyes, is known as camber. The camber is provided so that even at the maximum load the deflected spring should not touch the machine member to which it is attached.

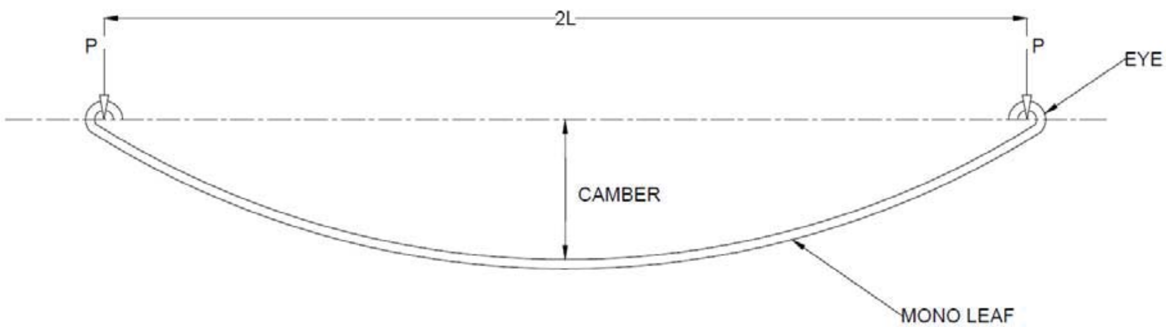


Fig 3: Mono Leaf Spring profile

### *A. SPECIFIC DESIGN DATA*

Consider a Mono Leaf spring of Mahindra Model "Commander 650 di" for analysis. This leaf spring is subjected to following working conditions.

Gross vehicle weight = 2150 kg
Unsprung weight = 240 kg
Total sprung weight = 1910 kg
Taking factor of safety (FS) = 1.4
Acceleration due to gravity (g) = 10 m/s$^2$
There for; Total Weight (W) = 1910*10*1.4 = 26740 N
Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one fourth of the total weight.
F = 26740/4 = 6685 N

| Parameter | Dimension (mm) |
|---|---|
| Total length | 1120 |
| Camber | 180 |
| Thickness | 30 |
| Width | 50 |
| Diameter of eye | 23 |

Table 3: Mono Leaf spring Profile

*B. STRENGTH CALCULATION*

Assuming:

Width b = 50mm
Thickness t = 30mm
Number of Leafs n=1

And leaf spring is made of alloy steel having Young modules E= $2.1*10^5 N/mm^2$

Formula for calculating stress in quartered mono leaf spring is given below

Bending stress

$$\sigma = \frac{6\,WL}{nbt^2}$$

$$\sigma = \frac{6 * 3342.5 * 560}{1 * 50 * 30^2}$$

$\sigma$ = 249.57N/mm$^2$

Deflection of spring

$$y = \frac{6\,WL^3}{nEt^3}$$

$$y = \frac{6 * 3342.5 * 560^3}{1 * 2.1 * 10^5 * 30^3}$$

y = 12.42mm

IV. MODELING OF LEAF SPRING USING SOLIDWORKS

SolidWorks developed by Dassault systems, is a solid modeling computer-aided design (CAD), and computer-aided engineering (CAE) software that utilizes parametric feature-based approach to create models and assemblies. The solid model of the leaf spring can be created by using Solidworks equations feature that allows user to define dimensions using global variables and mathematical functions. While designing the leaf spring in Solidworks, thickness is termed as ‘t’ and width as ‘b’ and length of spring as ‘l’. Solid modelling is carried out by keeping parameters like width and thickness as variable and eye to eye length as a constant. In given design, global variables like thickness of leaf is taken as “thick”=30mm and width as “width”=50mm. This model is easily editable to get customized products as per user requirement.

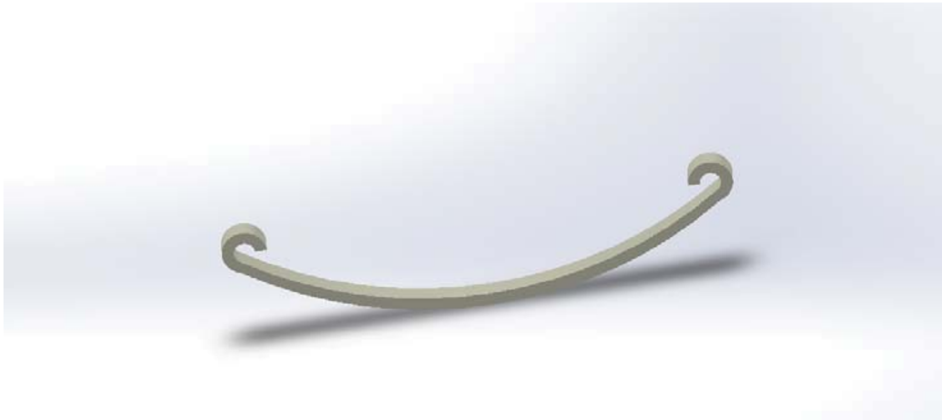

Fig 4. 3D Model of Mono Leaf Spring Using Solidworks

## V. SIMULATION OF MONO LEAF SPRING

Simulation is the imitation of the operation of a real-world process or system over time. Here simulation of leaf spring is done in Solidworks software, to check whether the spring design is safe or not for given load. Generally leaf spring is made of alloy steel. Analysis of spring can be considered as a cantilever beam subjected to point load at its free end. One end of semi elliptical leaf spring is kept fixed so that it constraint in all direction and eye end is free to move. Load of 3342.5N is applied along FY in downward direction at Eye end as shown in Figure. Meshing involves division of the entire of model into small pieces called elements.

Fig 5.a: Loading and Boundary conditions of Mono Leaf Spring

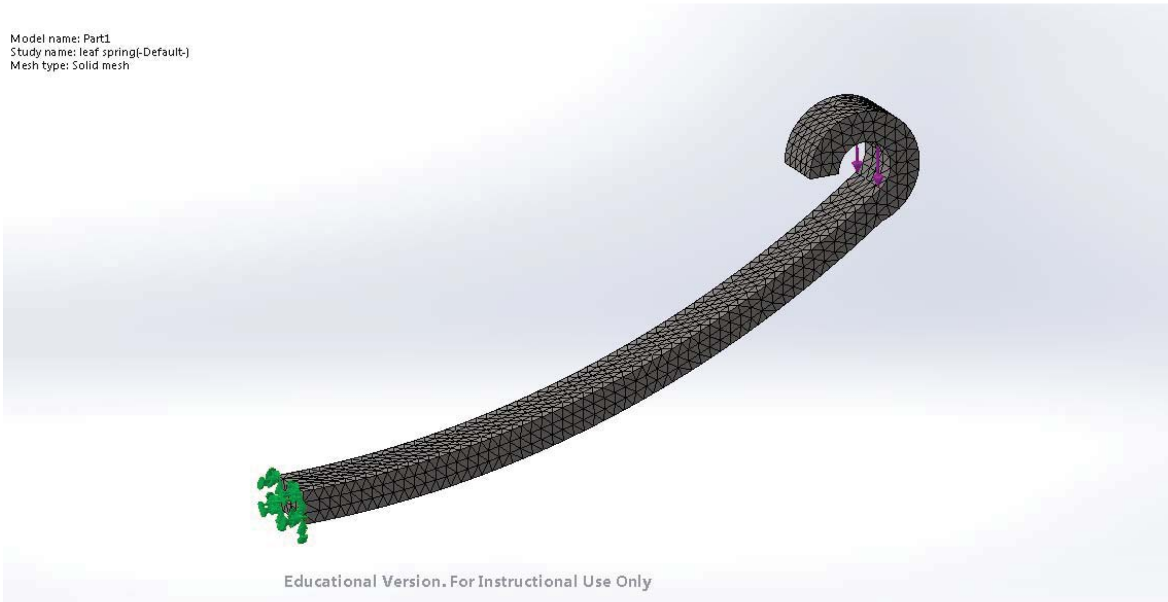


Fig 5.b: Coarse Mesh Mono Leaf Spring


Fig 5.c: Static Stress analysis of Mono leaf Spring

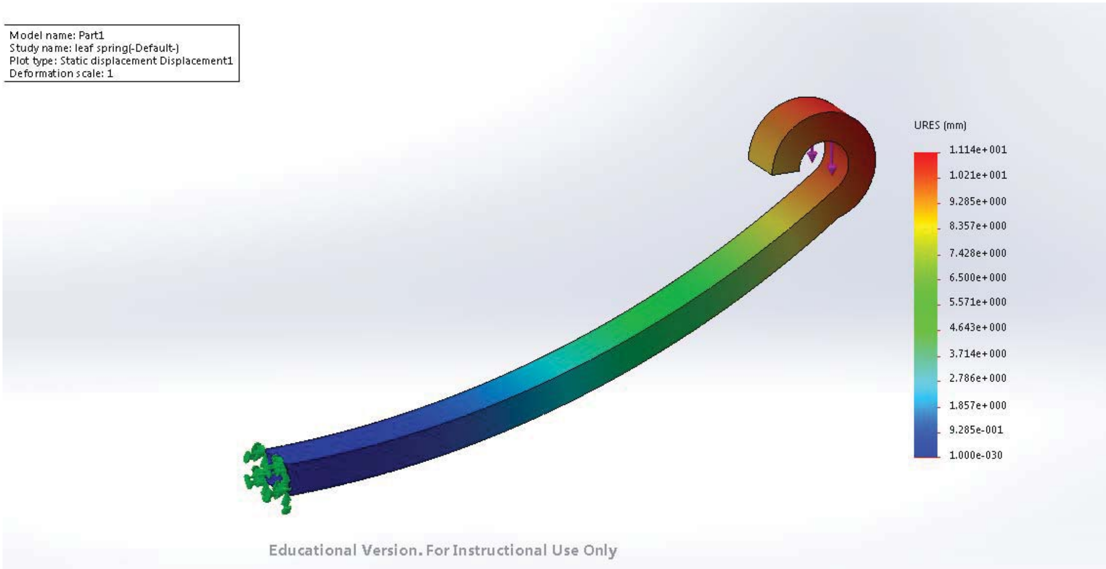


Fig 5.d: Static Deflection analysis of Mono leaf Spring

## VI. RESULTS AND CONCLUSION

The optimized design can be found by simulating parametric modeling for various combinations. In parametric modeling, modeling of object is done only once and it permanently available for modifications according to specifications, hence it reduces time and efforts of the user. In present work we implemented parametric modeling on mono leaf spring by using equation table feature in Solidworks by taking thickness and width as a parameters. Analytical Results calculated from leaf spring equations shows Static stress value and Deflection value for given mono leaf spring. These values are compared with Simulation results done on Solidworks, both were converge to each other with fraction of error. Analysis of spring is repeated for different thickness by keeping width constant and by varying both thickness and width to find the best suited spring. This parametric designing and simulations helps customers to find customized spring with their simulation results by reducing the time of redesign.

| Parameters | Analytical | Solidworks Simulation |
|---|---|---|
| Stress ( MPa) | 249.57 | 255.7 |
| Deflection ( mm) | 12.42 | 11.14 |

Table 6.a: Results obtained for thickness 30mm and width 50mm.

| Thickness | Tensile stress | | Deflection | |
|---|---|---|---|---|
| | STATICAL | ANALYTICAL | STATICAL | ANALYTICAL |
| 20mm | 573.1 | 561.54 | 33.82 | 41.92 |
| 21mm | 509.1 | 509.33 | 29.31 | 36.21 |
| 22mm | 463.6 | 464.08 | 25.56 | 31.5 |
| 23mm | 424 | 424.6 | 22.43 | 27.56 |
| 24mm | 385.6 | 389.96 | 19.81 | 24.26 |
| 25mm | 357.8 | 359.38 | 17.57 | 21.46 |
| 26mm | 330.8 | 332.27 | 15.67 | 19.08 |
| 27mm | 308.4 | 308.11 | 14.04 | 17.04 |
| 28mm | 290.1 | 286.5 | 12.62 | 15.28 |
| 29mm | 267.6 | 267.08 | 11.39 | 13.75 |
| 30mm | 249.8 | 249.57 | 10.32 | 12.42 |

Table 6.b: Results obtained by keeping width constant and varying Thickness

| Thickness | Width | Tensile stress( MPa) | | Deflection (mm) | |
|---|---|---|---|---|---|
| | | STATICAL | ANALYTICAL | STATICAL | ANALYTICAL |
| 20mm | 52mm | 551 | 539.94 | 32.51 | 40.31 |
| 22mm | 52mm | 445.5 | 446.22 | 24.57 | 30.29 |
| 22mm | 54mm | 437.5 | 429.7 | 23.65 | 29.17 |
| 23mm | 55mm | 386.8 | 386 | 20.38 | 25.06 |
| 24mm | 58mm | 337.5 | 336.17 | 17.06 | 20.91 |
| 26mm | 60mm | 275.8 | 276.89 | 13.04 | 15.9 |
| 28mm | 63mm | 221.2 | 227.38 | 9.99 | 12.12 |
| 30mm | 65mm | 188.8 | 191.97 | 7.92 | 9.55 |

Table 6.c: Results obtained by varying both Thickness and Width

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