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Meshing and Analysis of Leaf Spring Suspension

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Abstract - *The function of a suspension system is to absorb the bumps in the road and thus maximizing the overall performance of a vehicle. A type of suspension system, the Leaf Spring suspension system, is mainly used in heavy commercial vehicles at present. It is crucial to do a proper fail-proof analysis of these components prior to manufacturing and use. The components are designed and assembled in CAD modelling software. For modeling purposes, Solidworks software is used. For the purpose of meshing software, hypermesh is used and ANSYS for performing analysis.*

Key Words: **Suspension, Leaf spring, FEA, ANSYS, Hypermesh, Solidworks**

1. INTRODUCTION

The function of a suspension system is to absorb the bumps in the road and thus maximizing the overall performance of a vehicle. Leaf springs are a common component of older suspension systems. They consist of metal sheets in various sizes stacked on top of each other. Leaf springs were predominantly used before the late 1970s. You can find them in many vehicles, from horse-drawn carriages to the Model T. Since leaf springs spread the weight of a vehicle over a wider area, they're used on larger vehicles like trucks, vans, and heavy-duty pickups today. This paper focuses on the design and analysis of a leaf spring suspension system that is used in heavy-duty vehicles. For this software like Solidworks, ANSYS and Hypermesh were used.

2. LEAF SPRING

[1]A multi-leaf or laminated spring consists of a series of flat plates, usually of semi-elliptical shape as shown fig-1. The flat plates, called leaves, have varying lengths. The leaves are held together by means of U-bolts and a center clip. The longest leaf, called the master leaf, is bent at the two ends to form spring eyes. Two bolts are inserted through these eyes to fix the leaf spring to the automobile body. The leaves are held together by means of two U-bolts and a center clip. Rebound clips are provided to keep the leaves in alignment and prevent lateral shifting of the leaves during operation. At the center, the leaf spring is supported on the axle. The leaves of multi-leaf springs are subjected to bending stresses. Multi-leaf springs are widely used in automobiles like cars and trucks and railroad suspensions.

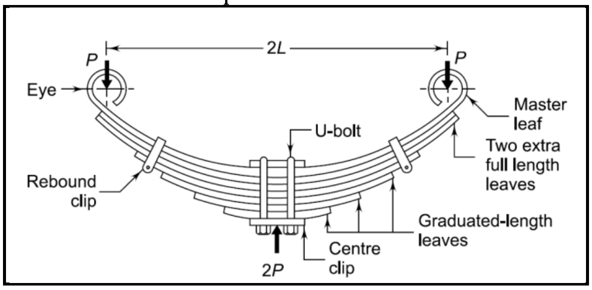

Fig -1: Semi-Elliptic leaf spring [1]

Fig -2: Leaf spring on vehicle [2]

There are 2 ways in which the leaf springs connect to the axle. They are: [3]

1. Overslung - In overslung the leaf is connected on top of the axle. As shown in fig-3.

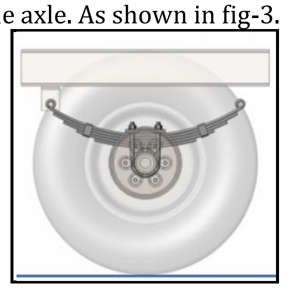

Fig -3: Overslung arrangement

2. Underslung- In underslung the leaf springs are mounted below the axle. In this type of attachment, the U-Bolts carry effective load. As shown in fig-4.

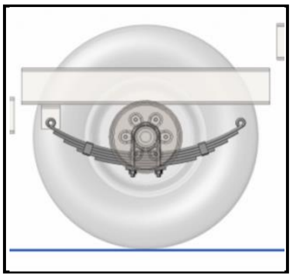

Fig -4: Underslung arrangement

A vehicle can be equipped with either overslung or underslung depending upon the requirement. The underslung setup helps to reduce the deck height of the vehicle which can be advantageous in terms of providing load stability, but on the other hand, having an underslung reduces deck clearance which can expose the vehicle to contact with objects lying on the road/any boulders, etc.

Whereas on the other hand, overslung setup helps increase the deck height of the vehicle which in result provides more clearance to the deck.

3. LEAF SPRING MODEL

The following leaf spring model assembly was built in Solidworks with dimensions:-

Table -1: Dimensions

Eye to eye length	1.08m
Thickness	0.008m
Width	0.06m
Number of Leafs	4

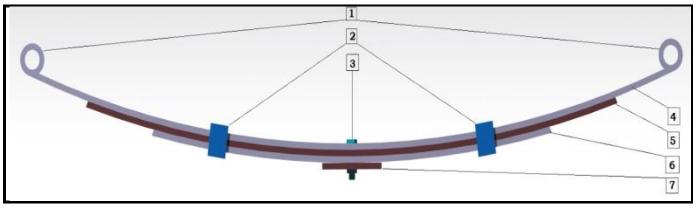

Fig -5: Labeled model

1 - Eye
2 - Rebound Clip
3 - Bolt
4 - Master leaf
5,6,7 - Graduated-Length leaves

4. MESHING

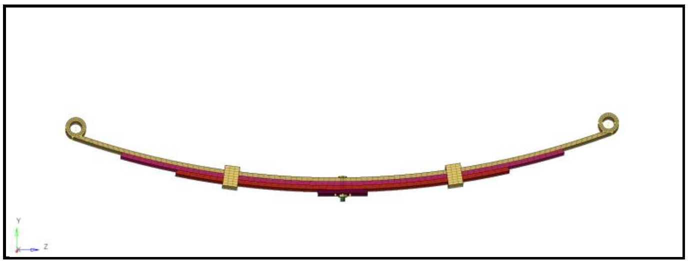

Fig -6: Meshed model- side view

For meshing purposes, Hypermesh software was used to ensure proper meshing in critical areas. The type used was 2D mesh. It is used as two of the dimensions are very large in comparison to the third dimension.

It is necessary to ensure good quality of the mesh, especially in critical regions to ensure proper results while performing analysis. For example, it is necessary to have a quad-type mesh near-circular periphery.

The meshing was performed in the following steps:
(i) At first critical regions were identified. the critical regions noted were - eye section of the master leaf and bolt section and the region surrounding the bolt in the leaves. The face of the part was then splitted in a suitable manner.
(ii) After splitting the faces, meshing was done on the faces of the suitable element size.
(iii) For meshing at the critical portion around the eye of the leaf, a washer of suitable dimension and a 2D mesh of type quad was done(as shown in fig- 7).

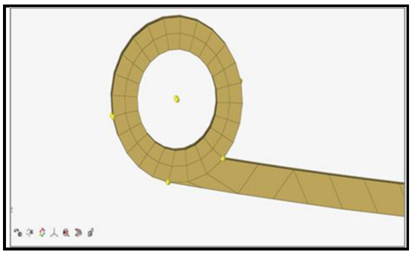

Fig -7: Meshing near eye

(iv) For the base plate region we split the area around the hole by adding nodes and creating a square region around the hole.
This square region was created by transmitting the nodes at eight different locations as shown in the fig- 8 below. These nodes were joined by lines. The regions between this node were split using surface edit and then trim with lines command. We started by meshing a single quarter region and then optimizing the mesh in it. This generated mesh was then transmitted to other similar regions and the regions surrounding it were meshed by using auto meshing using proper mesh size. Further, this entire mesh was transmitted to another side of the base plate.

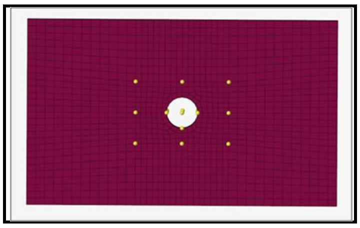

Fig -8: Meshed base plate

(v) In a similar manner all other leaves of the suspension system have been meshed.
(vi) For meshing the rebound clip, each face of the rebound clip was selected individually and the mesh was performed on each face.
(vii) For meshing around the bolt, the shank was selected first, and a mesh with quad type mesh of suitable size and a similar procedure was followed for meshing the head of the bolt.
(viii) After this the model is made ready to be exported to ANSYS for further analysis, this was done by saving the hypermesh file in .cdb format.

5. ANALYSIS

The static analysis was done using ANSYS software. For this study, we used static structural analysis. The material used to perform the analysis: Grey Cast Iron with the following properties:-

Table -2: Material properties

Properties	Value
Young's Modulus	1.1e+5MPa
Density	7.2e-09 tonne/mm^3
Poisson's Ratio	0.28
Yield Stress	420MPa

The model was imported as a meshed model from hypermesh in the form of a .cdb file.

5.1 BOUNDARY CONDITIONS

The leaf spring is suspended by two bolts inserted through these eyes to fix the leaf spring to the automobile body. The leaves are held together by means of two U-bolts and a center clip. The front end is attached to the frame while the other end is attached to a short swinging arm through a shackle. Leaf springs flatten as they encounter force, which helps dampen the bumps and jolts of the road and the metal leaves are perpendicular and curved toward the road. Hence, a load of 2P = 20kN is applied at the base plate in the positive y-direction and fixed support is provided at the inner surface of the eye region. All the contacts between leaf-leaf, leaf-bolt, leaf-nut, and leaf-bracket are made as no separation contacts to facilitate sliding without separation between components.

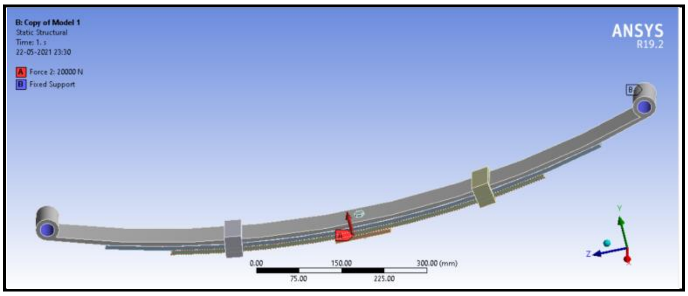

Fig -9: Boundary conditions

5.2 TOTAL DEFORMATION

After performing static analysis of the loaded vehicle of optimum load, the total deformation in suspension was calculated by analysis and a figure showing deformation corresponding to colour code was obtained as shown in fig- 10. From the analysis result it can be inferred that maximum deformation corresponding to colour red is vertically along the bottom most graduated leaf. In contrast to that, the minimum deformation corresponding to colour blue is at the eye of the leaf spring. The deformation is increasingly moving from the eye to the center of the leaf spring.

For a successfully designed leaf spring suspension system is it desired that the maximum deformation that the leaves can undergo is between 1inch - 1.5inch, that is from 25.4mm - 38.1mm.

From fig- 11 it can be observed that the maximum deformation of the leaf spring suspension system is 13.808mm and the average deformation is 5.6236mm. These results are in the range below 1inch (25.4mm). Therefore it can be concluded that the leaf spring is properly designed to sustain the required load.

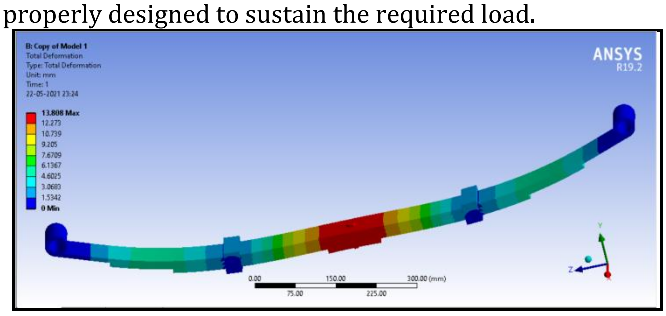

Fig -10: Deformed body

	Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1	1.	0.	13.808	5.6236

Fig -11: Deformation values

5.3 EQUIVALENT STRESS

After the static deformation analysis, the stresses in the leaf spring were calculated by von- mises equivalent stress analysis. The values of the stresses were found to be maximum at the bottom most leaf denoted by the red flag and minimum at the eye of the master leaf due to the fixed support (as shown in fig-12).

The values of the stresses after analysis were obtained as shown in fig- 13. The average stress value obtained in the leaf spring is 119.18 MPa. The minimum stress value is 0.065 MPa and a maximum of 1412 MPa.

The stresses in the leaves gradually decrease from the bottom to the top as we use more material strength.

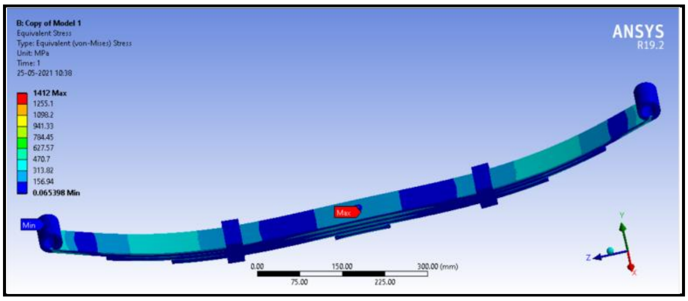

Fig -12: Von- Misses stress contours

	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	1.	6.5398e-002	1412.	119.18

Fig -13: Stress values

6. CONCLUSIONS

1. The user generated mesh was found to be optimum as per requirements.
2. As per analysis results, the deformation of the body is in acceptable range as per safety norms.
3. As per analysis results, the maximum stress of the body is in the vertical direction along the base leaf and the value suggests the design is safe.

Hence, from the design, meshing and analysis, it can be concluded that the leaf spring as designed is meshed optimally and analyzed in the best possible way to simulate real world loads/forces. All these indicate that the body is safe to use in heavy commercial vehicle.

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REFERENCES

[1] Bhandari, V.B. - Design of Machine Elements-Tata McGraw-Hill (2010)
[2] https://philkotse.com/car-buying-and-selling/leaf-spring-vs-coil-spring-9520
[3] https://mechanicalelements.com/overslung-underslung- trailer-springs/