ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Design and Analysis of Automated Truck Cabin Suspension System

Sainath Kasuba
Associate Professor,
Thermal Engineering,
Sreyas Institute of Science & Technology.

Mohammed Sameer
M.Tech Scholar,
Department of Mechanical,
Sreyas Institute of Science & Technology.

Abstract:

Leaf springs are unique kind of springs used in automobile suspension systems. The benefit of leaf spring over helical spring is that the ends of the spring may be leaded along a definite path as it deflects to act as a structural member in addition to energy absorbing device. The main work of leaf spring is not only to give support to vertical load but also to isolate road induced vibrations. It is subjected to millions of load cycles leading to fatigue failure. Static analysis gives the safe stress and with corresponding pay load of the leaf spring and also to research the behavior of structures under practical situations. The existing work attempts to examine the safe load of the leaf spring, which will represent the speed at which a comfortable speed and safe drive is available. A typical leaf spring configuration of TATA-407 light commercial vehicle is selected for research. Finite element analysis has been carried out to determine the safe stresses and pay loads.

I. IN T RO D U C T I O N:

A spring is explored in the form of elastic body, where the working criterion alters when it is loaded then used for recovering its original shape and then load is flushed out. Leaf springs absorb the vehicle vibrations, shocks and bump loads by means of spring deflections, so that the potential energy is kept in stock in the leaf spring and then explored slowly. Capability to store and absorb more amount of strain energy ensures the availability suspension system. Semi-elliptic leaf springs are most universally used for break in all type of vehicles. In case of cars also, these are widely used in rear suspension. The spring consists of a number of leaves known as blades. The blades are differs in length. The blades are normally given an initial curvature then it will be set to straight.

The leaf spring is based on theory of a beam of uniform strength. The largest blade has eyes on its ends. This blade is referred master leaf; the rest are known as graduated leaves. All the blades are bound together by means of steel straps. The spring is placed on vehicle's axle. The complete vehicle load rests on the leaf spring. The front end of the spring is attached to the frame with a simple pin joint, while the rear end of the spring is attached with a shackle. Shackle is the flexible link one that which connects between leaf spring rear eye and frame. And when vehicle comes across a projection on the road surface, the wheel moves up, leading to deflection of the spring. This modifications the length between the spring eyes. If two ends are fixed, the spring will not be able to accommodate this change of length.

So, to accommodate this change in length shackle is given at one end, which gives a flexible connection. The leaf spring's front eye is constrained in every direction, where as rear eye is not in X-direction. This rare eye is linked to the shackle. While loading the spring deflects and moves in the direction perpendicular to the load applied. When the leaf spring deflects, the upper side of each leaf tips slides against the lower side of the leaf. This gives some damping which reduces spring vibrations, but since this available damping may change with time, it is not advised to avail of the same. Moreover, it produces squeaking sound. In any further if moisture is also present, such inter-leaf friction will gives fretting corrosion which reduces the fatigue Strength of the spring, phosphate paint may reduce this problem fairly of the load W from the cantilever end.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

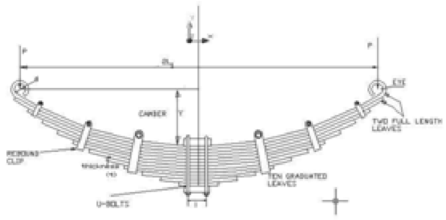

Fig No.1 The leaf spring's

II. MANUFACTURING PROCESS OF LEAF SPRINGS:

Step-1: By identifying your specific requirements, our sales department firstly picks up the appropriate specification sheet, which is then issued to the production team to proceed with the Manufacturing process. We give a unique reference number to each specification sheet so that we can track the process all through the working life cycle of sundry item or spring.

Step – 2: Spring steel to BS970 is then cut off along the length and made to go through required operations incorporating eye-forming, nibbing, beating, taper-rolling and wrapping. Then, the leaves are heated up at temperature 1000 to 1, 0500 C, oil quenched in order to provide the temperature 8900C, or above. Once the draining is done, they are re heated at about 500 to 5600C so as to obtain the Brinell solidity reading of 356 to 440 HBS 10/3000, before the closing alterations are made to give adequate arc and shape.

Step – 3: When assembling the entire unit, the required components including center bolts, clips and bushes are added. The final unit manufactured is again evaluated against the specifications given in specs sheet. To complete the spring, it is coated with a protective covering, and then goes through final inspection according to quality control standards.

Fig No.2quality control standards

III. SYSTEM DEVELOPMENT:

In computer-aided design, geometric modeling is concerned with the computer compatible mathematical description of the geometry of an object. The mathematical description allows the Model of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by the computer and the human designer.

Usage of geometric modeling, the designer develops the graphical model taking object as a lead on CRT screen which was part of ICG system It gives three types of inputs of commands system. The first one among those commands creates static geometric elements which includes points, lines, and circles. And second command which was used to achieve scaling, rotation, or other transformations of these elements. The third command results the different elements have to get attached into the referred shape of the object which was developed on the ICG system.

While geometric process, system automatically alters the commands into a math level, stored in computer data files, and then shows it form of image on CRT screen. The model can consequently call as from the data files for analysis or alteration. The advanced method of geometric modeling is solid one in three dimensions.

Modeling flow for Leaf Spring:

1. Initially have to create the key point 100 at origin. x, y, z = (0, 0, 0).

2. Next to make another key point 200 where arbitrary distance in Z-direction. x, y, z = (0, 0, 200).

3. Attach above two key points 100 and 200 for reference axis.

4. With the usage of data from math analysis develop the key point one according to distance of radius of curvature R1 in vertically decreasing down direction. x, y, z = (0, -R1, 0).

5. In that way only key points 2 and 3 according to R2. x, y, z = (0, -R2, 0) Key points 4 and 5 correspond to R3. x, y, z = (0, -R3, 0).

6. Key point 20 according to R11. i.e. x, y, z = (0, -R11, 0).

7. Attach the pair of key point's sequentially as follows Key points above.

8. Line1 created by key points 1 and 2, line2 created by key points 2 and 3 and line10 created by the key points 19 and 20.

9. Dismiss the above lines with respect to reference axis stated in step3 as follows:
Extrude line1 with an angle Φ1, will get area1 Extrude line2 with an angle Φ2, will get area2 …and
Extrude line10 with an angle Φ10, will get area10.

10. After discarding all the lines, the semi area of the spring without eye will form on XY- plane with significant degeneracy.

11. To avoid degeneracy, extend the right side line of smallest area i.e. area 10 to some extent such that it cross the top most area i.e. area1.Now divide area by line. For this, select the areas left to extended line1and divide with that line. Similarly, extend the right side line of second smallest area i.e. area9 to some extent such that it cross the top most area i.e. area1. Again divide area by line. For this select the areas left to extended line2 and divide with that line.

12. The above process is to be done up to extension of line of area9 and divide area by extension line9.

13. Now perfect half area of leaf spring without eye will form.

14. Eye construction: Extend the right side line of top most area i.e. area1 to the length equal to the radius of eye. Delete lines only, so that key point of that line will remain. Shift the origin to that key point. Create another key point say some key point300 in Z-direction. Join the above two key points to get reference axis to rotate the right side line of area1. Extrude the line with respect to reference axis to an angle 2750 to 2800. Delete all reference lines. So half area of leaf spring with eye is created.

15. For gaining full area of the leaf spring. Shift the origin to the top left most area key point i.e. key point1. Reflect the complete area with respect to YZ – plane.

16. And also to retrieve the solid model of the leaf spring, extrude the area by Z-offset to a length equal to the width of the leaf spring..

STATIC ANALYSIS:

For the above given requirement of the leaf spring, the static analysis is performed using ANSYS to find the maximum safe stress and the corresponding pay load. After geometric modeling of the leaf spring with given requirements it is subjected to analysis. The Analysis involves the following discritization known as meshing, boundary conditions and loading. For this model analysis loading is not needed.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Meshing:

Meshing involves division of the complete of model into small pieces known as elements. This was made of meshing. Thos was flexible to choose the free mesh because the leaf spring has sharp curves, so that shape of the object will not get modify. For meshing the leaf spring the element type have to select first. It is represented; the element type is solid 72. The element edge length is taken as 15 and is refined the area of centre bolt to 2. Fig 7.2 shows the meshed model of the leaf spring. The following are the material properties of the given leaf spring. Material = Manganese Silicon Steel, Young's Modulus E = 2.1E5 N/mm2, Density ρ = 7.86E-6 kg/mm3, Poisson's ratio = 0.3 and Yield stress = 1680 N/mm2.

Boundary Limitations:

The spring is placed on vehicle's axle. The complete vehicle load rests on the leaf spring. The front end of the spring is attached to the frame with a simple pin joint, while the rear end of the spring is attached with a shackle. Shackle is the flexible link one that which connects between leaf spring rear eye and frame. And when vehicle comes across a projection on the road surface, the wheel moves up, leading to deflection of the spring. This modifications the length between the spring eyes. If two ends are fixed, the spring will not be able to accommodate this change of length. So, to accommodate this change in length shackle is given at one end, which gives a flexible connection. The leaf spring's front eye is constrained in every direction, where as rear eye is not in X-direction. This rare eye is linked to the shackle. While loading the spring deflects and moves in the direction perpendicular to the load applied. When the leaf spring deflects, the upper side of each leaf tips slides against the lower side of the leaf. This gives some damping which reduces spring vibrations, but since this available damping may change with time, it is not advised to avail of the same The link oscillates during load applied and flushed out. Therefore the nodes of rear eye of the leaf spring are constrained in all translational degrees of freedom, and constrained the two rotational degrees of freedom.

So the front eye is constrained as UX, UY, UZ, ROTX, ROTY and the nodes of the rear eye are constrained as UY, UZ, and ROTX, ROTY. Figure 4 shows the boundary conditions of the leaf spring.

Loads Applied:

The load is distributed equally by all the nodes associated with the center bolt. The load is applied along FY direction as shown in Figure 4. To apply load, it is necessary to select the circumference of the bolt hole and consequently the nodes associated with it. It is necessary to observe the number of nodes associated with the circumference of the bolt hole, because the applied load need to divide with the number of nodes associated with the circumference of the center bolt.

IV. RE L A T E D WO R K:

Research results from testing the leaf springs under static loading containing the stresses and deflection are placed in the Table 4. These are compared with FEA. Testing done for unidirectional Epoxy mono composite leaf spring only. From where composite leaf spring is able to withstand the static load, it is finales that there is no argument from strength point of view also, in the process of replacing the conventional leaf spring by composite leaf spring. From the time composite spring is designed for same stiffness as that of steel leaf spring, both the springs are considered to be almost equal in vehicle stability. The main drawbacks of composite leaf spring are of chipping resistance. The matrix one is likely to chip off when it is for bad environments which causes breakage some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. Case is it depends on the condition of the road. In casual road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have good strength retention on ageing at critical environments. A composite one replaces with steel leaf spring. Theme was to get a spring with minimum weight which is capable of carrying given static external forces by constraints limiting stresses

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

and displacements. The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring. Thus, the objective of the UN sprung mass is achieved to a larger extent. The stresses in the Composite leaf springs are much lower than that of the steel spring.

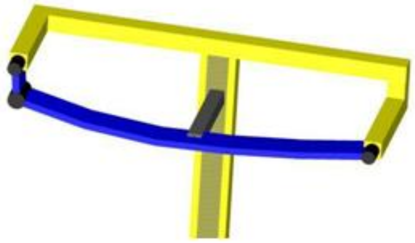

Fig No.3Leaf spring test rig

The validation of the standard leaf spring has been carried out by comparing the model to a reference multi-body model. A test rig, from above figure, has been used to generate the dynamic and kinematic comparison.

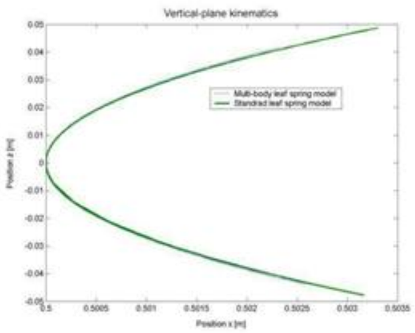

Fig No4: Vertical plane kinematics comparison

The vertical plane kinematics of the leaf spring modeled with rigid elements are virtually the same as for the model described by Lagrange's equation. Both models are damped via viscous damping over each generalized coordinate and corresponding revolute joint for the multi-body model. The vertical plane dynamics for the different models are very similar to each other as long as the excitation does not consist of high frequency components. The fact that the standard model has both stiffness and damping in the mount positions makes it a bit complicated to compare these results, but without fine tuning of the stiffness and damping they perform. The differences can easily be related to the bushings in the mount positions and the mass less approximation used in the standard leaf spring. A suspension assembled as in figure 10 simulates approximately 18 times faster than the reference suspension. A comparison of the kinematic and dynamic behavior of two multi body leaf springs with five versus nine links. The differences between the models are small which implies that the five link leaf spring meets the requirements for vehicle handling simulations. The shackle has big influence on the leaf spring's kinematics. The shape of the leaf spring in the comparison results in larger deflection in bounce than in rebound. This because the shackle's lower mount towards the spring always moves upwards with deflection. Other geometries would give different results. And as per different case studies the differences of deflections and bending stresses in E-Glass/Epoxy finish mono leaf spring and spring with bonded attachments. Adhesively bonded end joints impacts the performance level of composite leaf spring in comparing with bolted joints since, delamination; matrix cracking and stress ability at the holes are observed in bolted joints.

Scarf type of bonded joints enhances the strength considerably without peel splitting compared to the lap type of bonded joints. Induced peel and shear stresses are under yield limits. FEA results give the necessary link between mechanical properties, component design and fabrication to achieve performance optimization. Composite mono leaf spring with integral eye is economical and explored good performance. Harmonic analysis has been done on composite leaf spring to know the modal frequency. The first five natural frequencies are explored. The natural frequency of composite leaf spring is higher than that of the steel leaf spring and is far enough from the road frequency to avoid the resonance. The construction of a composite mono leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring is considered constant due to the parabolic type of the thickness of the spring, has

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

proved to be very effective. The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings.

V. CONCLUSION:

The automobile chassis is placed on the axles, which is not direct but with some form of springs. This is to isolate the vehicle body from the road shocks which might be in the form of bounce, pitch, etc. These tendencies give rise to an uncomfortable ride and also cause extra stress in the automobile frame and body. Every part which performs the function of isolating the automobile from the road shocks are bunch of collection referred as a suspension system. Leaf spring is a device which is used in suspension system to keep safe the vehicle and the occupants. For safe and comfortable riding in the sense to prevent the road shocks from being transmitted to the vehicle components and to guard for safety the occupants from road shocks it is mandatory to determine the maximum safe load of a leaf spring. So in the present work, leaf spring is developed and static analysis is moved out by using ANSYS software and it is for the given requirements of the leaf spring, the max safe load is 7700N. Observation gives that the maximum stress is developed at the inner side of the eye sections, so have to take care in eye design and fabrication and also material selection. The selected material should contain good ductility, resilience and toughness to reduce sudden fracture for providing safety and comfort.

REFERENCES:

[1]Senthil Kumar and Vijayarangan, ―Analytical and Experimental studies on Fatigue life Prediction of steel leaf soring and composite leaf multi leaf spring for Light passenger veicles using life data analysis‖ ISSN 1392 1320 material science Vol. 13 No.2 2007.

[2]Shiva Shankar and Vijayarangan ―Mono Composite Leaf Spring for Light Weight Vehicle Design, End Joint, Analysis and Testing‖ ISSN 1392 Material Science Vol. 12, No.3, 2006.

[3]Niklas Philipson and Modelan AB ―Leaf spring modelling‖ ideon Science Park SE-22370 Lund, Sweden

[4]Zhi'an Yang and et al ―Cyclic Creep and Cyclic Deformation of High-Strength Spring Steels and the Evaluation of the Sag Effect: Part I. Cyclic Plastic Deformation Behavior‖ Material and Material Transaction A Vol 32A, July 2001—1697.

[5] Muhammad Ashiqur Rahman and et al ―Inelastic deformations of stainless steel leaf springs-experiment and nonlinear analysis‖ Meccanica Springer Science Business Media B.V. 2009.

[6]C.K. Clarke and G.E. Borowski ―Evaluation of Leaf Spring Failure‖ ASM International, Journal of Failure Analysis and Prevention, Vol5 (6) Pg. No. (54-63).

[7]J.J. Fuentes and et al ―Premature Fracture in Automobile Leaf Springs‖ Journal of Science Direct, Engineering Failure Analysis Vol. 16 (2009) Pg. No. 648-655.

[8] Mouleeswaran Senthil Kumar and Sabapathy Vijayarangan (2007). Analytical and experimental studies on fatigue life prediction of steel and composite multi-leaf spring for light passenger vehicles using life data analysis. Materials Science 13(2) 141-146.

[9]HA Al-Qureshi (2001). Automobile leaf springs from composite materials. Journal of Material Processing Technology 118 58-61.

[10]JJ Fuentes, HJ Agulilar, JA Rodriguez and EJ Herrera (2008). Premature fracture in automobile leaf springs. Engineering Failure Analysis 16 648-655.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

[11]I Rajendran and S Vijayarangan (2002). Design and Analysis of a Composite Leaf Spring. Journal of Institute of Engineers India 82 180 –187.

[12]RM Mayer, JP Hou, JY Cherruault, I Nairne and G Jeronimidis (2007). Evolution of the eye-end design of a composite leaf spring for heavy axle loads. Composite Structures 64 351-358

[13]A Skrtz, T.Paszek, (1992) ―Three dimensional contact analysis of the car leaf spring‖, Numerical methods in continuum mechanics 2003, Zilina, Skrtz republic.

[14]Cheng Wang, (1999) ―Design and Synthesis of Active and Passive vehicle suspensions.

Second Author:
Mohammed Sameer
Completed his B.Tech (Mechanical Engineering) degree from JAYA PRAKASH NARAYAN ENGINEERING COLLEGE. in the year 2015. He completed his M.Tech in CAD/CAM Mechanical Engineering department fromSreyas Institute of Science & Technology in the year 2016-2017, Hyderabad.312sameer@gmail.com

Firsts Author:
Mr.Sainath Kasuba
Associate Professor, Thermal Engineering (Ph.D) Sreyas Institute of Science & Technology Hyderabad.