International Journal of Engineering & Technology, 7 (2.33) (2018) 1298-1301

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Analysis and Conversion of Air Suspension System to Parabolic Leaf Spring Suspension System

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Abstract:

Nowadays competition among automobile industries has been increasing rapidly. Hence to retain the existing customers and to make new customers cost and quality of products plays is a rubric one.To do so value engineering plays a vital role. Our project deals with the conversion of air suspension system with parabolic spring suspension system and to prove that it is efficient and economic one compared to air suspension system. It should also be noted that basic functions should be preserved and not to be reduced as a consequence of pursuing value improvements. The aim of the project is to design a parabolic leaf spring for an air suspension system. Parabolic leaf spring is modelled in CATIA software and deformation analysis is done using Ansys 14.

Keywords: *More comfort, Cost reduction, Easy to repair*

1. Introduction

The suspension is a mechanical system which absorbs the impact forces and other forces created due to variation in road levels. Generally, it absorbs the available energy during the elastic force is being released and returns back when there is a demand. Major things to consider when designing a spring are its stiffness, deflection, stress, materials. The strength characteristics are determined according to the type of suspension and type of loading. The design of spring starts with fluctuation and vibration. The leaf spring is the conventional type of suspension. Presently it is used in heavy-duty vehicles and work machines.

It is crucial for the springs to maintain the tyre in contact with the road in so far as possible. The suspension avoids damages to the vehicles by absorbing the shocks produced during the vibrations in the system caused by the improper road conditions. The design of front and rear suspension of a car may be typical in setup. A leaf spring is mainly used for the suspension in heavy vehicles.

Suspension system supports the whole weight of the vehicle. Without it, smooth movement is almost not possible. The basic parts are the Control arm and steering knuckle. The control arm is a movable lever that is used to fasten the steering knuckle to the body or frame of the vehicle. Shock absorbers or dampener's which is used to keep the suspension from continuing bounce after spring deflection (elongation and compression).

Leaf spring is used in heavy machines and automobiles due to its internal friction that provides damping with other components compared to another type of springs. One side of the leaf spring is placed over a hanger and fixed to the frame. The other side of the parabolic leaf spring is fitted to the frame with shackles. Spring alignment clips prevent the separation of the leaf spring rebounding from hitting a bump. Mono leaf springs are used in some vehicles which consist of only one leaf spring. Mono leaf spring is tapered along the edges to produce a variable deflection rate. Helper leaves are extra leaf springs that are used during extra load conditions or when the vibrations are higher than usual. Leaf spring rate increases when the thickness increases, and decreases as the length increases. To improve the value of products, goods and services by using the examination of function value engineering is used. Value can, therefore, be increased either increasing the function or reducing the cost.

2. Suspension System

Three types of suspension system include leaf spring suspension system, air suspension system and parabolic leaf spring suspension system

3. Air Suspension System:

Air suspension system provides smooth, constant ride quality, by absorbing shocks smoothly. Modern air suspension systems use electronically controlled systems which have good accuracy and precision in absorbing shocks and vibrations thereby features self-levelling along with jumping actions take place in the vehicle. Automobile height can be maintained at a certain range regardless of the load by adjusting the air pressure in the master bed cylinder. To increase range over the average ride height range to originally aid loading and unloading the automobile on and off ferries ferry lifts are used.

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4. Parabolic Leaf Spring Suspension System

A parabolic spring is a leaf or a set of leaves spring which are having different cross-section rather than the tapered spring in a parabolic mode. The cross-section will be maximum in the middle section and will be minimum at the two ends of the spring. Force distribution from the machine or automobile to the axle and will be dealt with by the tapered part of the leaf spring.

Multi-leaf spring applies pressure from the axle to the adjacent leaves simultaneously and the forces transmitted will be eventually absorbed by the individual leaf. Vibration produced will be absorbed by the largest spring first, and when the vibration energy exceeds the spring energy absorption capacity, the remaining vibration energy will be transferred to the next leaf which is second largest in size and it further goes on until all the vibration energy is absorbed by the suspension system. The changes in the shape of the leaf spring allow forces acting on it to change the shape easier (by absorbing the shock) than with a standard leaf spring which has a uniform cross-section. The tapering steps down in a parabolic manner, i.e.

$Y=X^2+ n$

Where Y is the thickness of the leaf spring and the X is the longitudinal length of the leaf. During the application of force, instead of flexing, the spring stays rigid and the vibration energy is sent back through the system

The interleaf friction is considerably reduced when having few leaf springs in the suspension system when compared to a non-parabolic leaf pack. This enables the leaf spring to flexible enough for the applied load to deform easier.

5. Material Properties, Calculation, Design and Analysis:

Material: 55Si2Mn90Composition of various element materials:55Si2Mn90

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

Materials Properties of 55Si2Mn90:

SL.NO.	PARAMETER	VALUE
1	Young's Modulus (E)	200×10^3 N/mm^2
2	Poisson's Ratio	0.3
3	Tensile strength ultimate	1962N/mm^2
4	Tensile strength yield	1500N/mm^2
5	Density	7850 Kg/m^3
6	Thermal Expansion	11 x 10^{-6} / ^{o}c

Calculation:

FORMULA USED:

$\sigma = \frac{6 X f X l}{n X b X t^2}$ $\delta = \frac{6 X f X l^3}{E X n X b X t^3}$

$\frac{C}{L} = 0.089$

Where,

σ = Stress

δ = Deflection

Here the weight and initial measurement of the passenger vehicle which is considered is given,

Weight in the vehicle= 8150 kg

Taking average weight of the passenger as 65 kg

Taking number of seats= 38

Number of standees= 22

Total number of passenger= 60

Average weight of 60 person= 3900 kg

Additional weight= 200 kg

Total weight = 8150+3900+200

= 12200 kg

Acceleration due to gravity (g) = 9.81 m/s²

Therefore, Total weight= 12200x9.81

= 119682N

Since the vehicle is 4-wheeler a single leaf spring corresponding to one of the wheels takes up one-fourth of the total weight

$\frac{119682}{4}$ = 29920.5N

But, 2F=29920.5N

F=14960.25N

Span length, 2L= 1200 mm

L = 600 mm

Thickness And Breadth:

Now the maximum bending stress of a leaf spring is given by,

$\sigma = \frac{6 X f X l}{n X b X t^2}$

$723.10 = \frac{6 X 14960.25 X 600}{n X b X t^2}$

$n X b X t^2 = 74480.56$

Total deflection of the leaf spring is given by

$\delta = \frac{6 X f X l^3}{E X n X b X t^3}$

$92.97 = \frac{6 X 14960.25 X 600^3}{2 X 10^5 X\ n X b X t^3}$

$n X b X t^3 = 1042727.97$

Dividing the two equations

$\frac{n X b X t^3}{n X b X t^2} = \frac{1042727.97}{74480.56}$

t = 14 mm

From equation 1, we have

$b = \frac{74480.56}{n X t^2}$

$= \frac{74480.56}{4 X 14^2}$

b = 95 mm

From equation 2, we have

$b = \frac{1042727.97}{n X t^3}$

$= \frac{1042727.97}{4 X 14^3}$

b = 95 mm

Taking the average of the two width values, the width of the leaves is,

b = 95 mm

CHAMBER LENGTH:

The straight length of the parabolic leaf spring(L)= 1200mm

The ratio of chamber length of parabolic leaf spring is given by,

$\frac{C}{L} = 0.089$

C = 0.089 X 1200

=106.8mm

PARABOLIC SPRING DIMENSIONS:

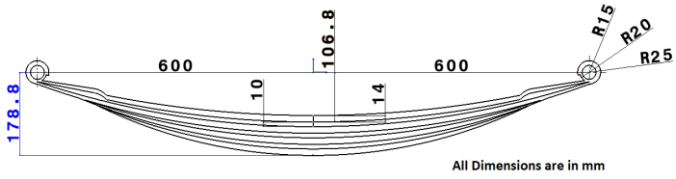


Fig1: Parabolic spring dimensions

5.1. Catia Model:

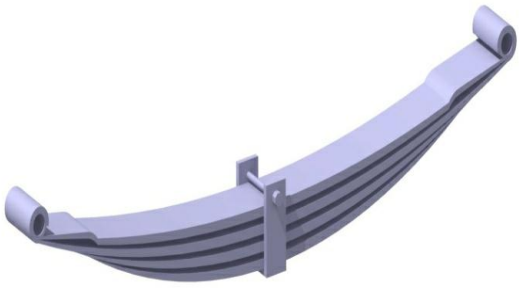


Fig 2: Catia model of parabolic leaf spring

5.2. Ansys:

The model made in CATIA is analyzed for deformation using Ansys 16.0 The maximum deflections occur on the mid-range of the parabolic leaf spring even though it has more cross section compared to the other ends of the leaf spring.

5.3. Coordinate Systems:

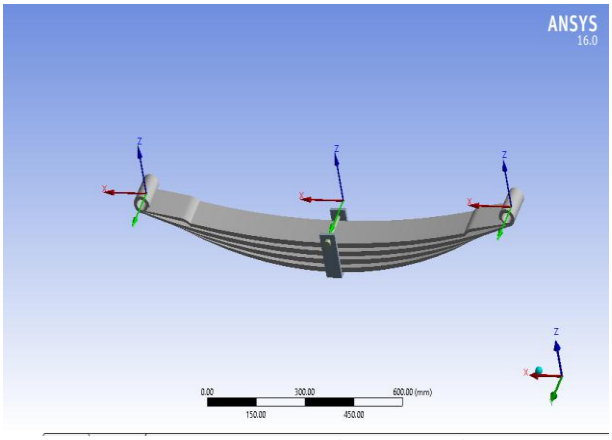
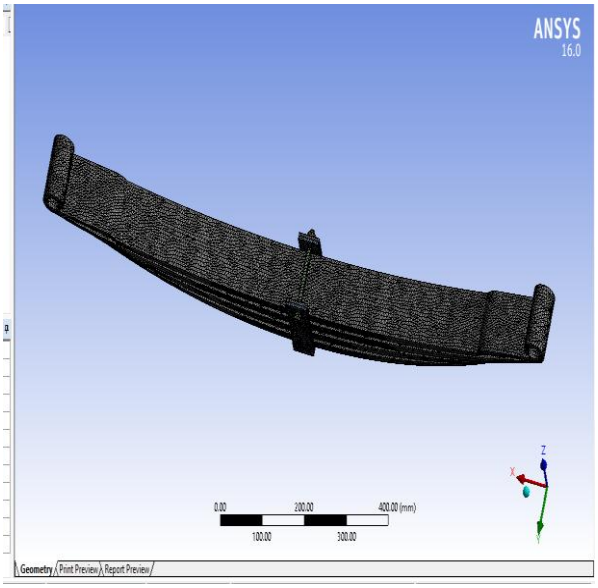
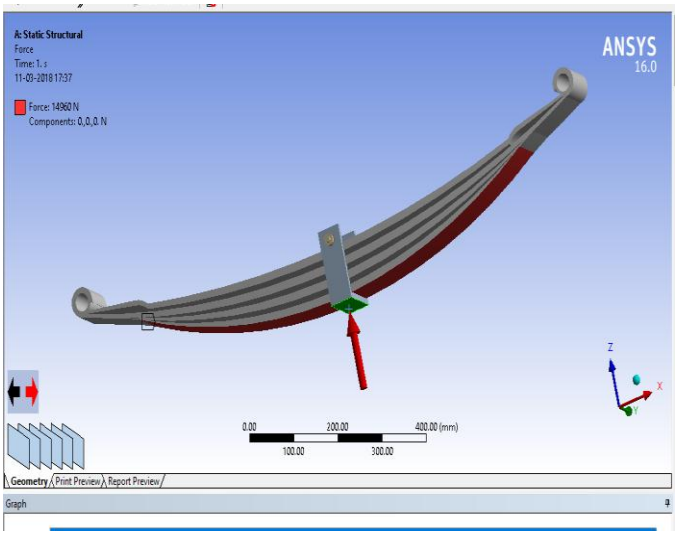


Fig 3: Coordinate systems of parabolic leaf spring

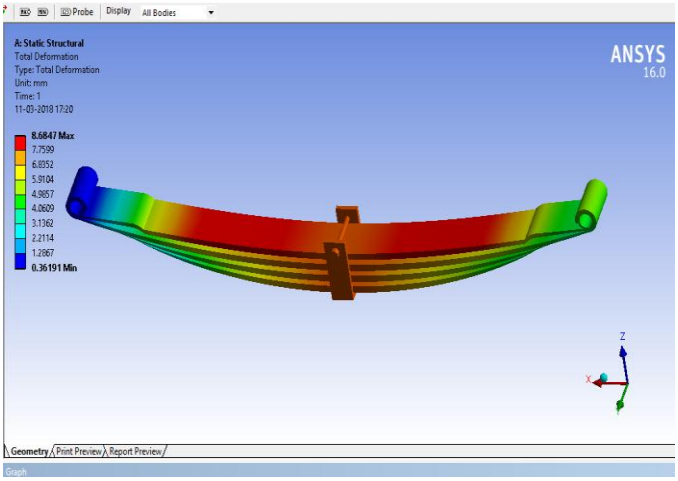
5.4. Meshing:



5.5. Force Acting:



5.6. Deformation:



6. Results

The required parabolic leaf spring was designed by manual calculations as per the taken loads. The model leaf spring was modelled using CATIA software and imported to Ansys 16 for analysis. Deformation analysis was done using Ansys 16.0 and the results were calculated and analysed. The maximum deformation produced in the parabolic leaf spring for the applied 14960N force is 8.6847 mm and the lowest deformation is found at the ends of the leaf spring as 0.36191mm

7. Conclusion

The parabolic leaf spring is designed to overcome the disadvantages of air suspension. The parabolic leaf spring provides better ride comfort than air suspension which is also called as semi-elliptical leaf spring and reduces friction between leaves which decreases material wear. This increases the life of the spring. Air suspension system is used to provide furthermore comfort. But, it has the disadvantage of more cost and punctures to the airbag caused by debris on the road and due to old age. So, to overcome these defects parabolic leaf spring is used

References

[1] Abhitosh Chauhan, Francis John (2002) ‘lower arc, hence its name. "Quarter-elliptic" springs often had the thickest part of the stack of leaves stuck into the rear end of the side pieces of a short ladder frame'-International Journal of Science and Technology. Vol.8, PP. 203-220.

[2] Edward Nikhil Karlus, Rakesh L. Himteand Ram Krishna Rathore (2014) ‘Optimization of mono parabolic leaf spring’-International Journal of Advances in Engineering & Technology.Vol. 7, Issue 1, PP. 283-291

[3] G. Savaidis, L Riebeck, K Feitzelmayer (2009) ‘The characteristic of parabolic springs is better riding comfort and not as "stiff" as conventional "multi-leaf springs-International journal of Process of simultaneous engineering-Vol.3, PP.96-118.

[4] Gao Zepeng a, Nan Jinruia b, Liu Liana, Xu Xiaolina(2016) ‘thickness varies from centre to ends following a parabolic curve' –International Journal of Applied Energy. Vol. 10, PP.230-245.

[5] I.K.Karathanassis, E.Papanicolaou, V.Belessiotis, G.C.Bergeles (2017) ‘main advantage of parabolic springs is their greater flexibility'- International Journal of Renewable Energy. Vol. 9, PP.265-283.

[6] M. P. Palaskar (2014) ‘Optimization of Mono Leaf Spring by Parabolic Variation of Thickness along the Length’ – International Journal of Scientific and Research Publications, Volume 4, Issue 5, PP.68-82.

[7] M. Z. Omar, Y. S. Kong, 3 L. B. Chua, and S. Abdullah (2014) ‘multiple leaf springs over its differential that was curved in the shape of a yoke’-International journal of Department of Mechanical & Materials Engineering. Vol. 4, PP.110-125.

[8] Narendra Yadav, Mr Praveen Tandon and Mr S.A.K. Jilani (2014) ‘Material optimization of leaf spring of tractor trolley by FEA’-International journal of modern engineering research. Vol. 4, Iss. 4, Apr. 2014, PP.253-264.

[9] Ritesh Kumar Dewangan, Manas Patnaik and Narendra Yadav (2012) ‘Minimization of Stress of a Parabolic Leaf Spring by Simulated Annealing Algorithm’ -International Journal of Engineering Research and Applications Vol. 2, Issue 4, pp.457-460, PP.117-136.

[10] Subhash Chandrabose, C. Thamotharan, P. Naveenchandran and R. Anbazhagan (2005) ‘variety of leaf springs, usually employing the word "elliptical". "Elliptical" or "full elliptical" leaf springs referred to two circular arcs linked at their tips’-International journal of Department of Automobile Engineering. Vol. 5, PP.69-84.