International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Design and Fatigue Analysis of Shot Peened Leaf Spring

K .Hema Latha, Kamran Ahmed Khan, Syed Asim Minhaj, Mohd Shais Khan

Abstract*:*The paper handles the fatigue and failing analysis of serial shot-peened leaf springs of cumbersome vehicles emphasizing on the impact of shot peening on fatigue life, coping with automotive leaf springs, the shot peening method turns into an important step in production.In the situation of leaf spring suspensions, however, asystematic research of the effect of shot peening about fatigue life isstill required. Experimental stress-life curves are determined with the aid of the usage of investigating clean specimen subjected to shot peening. those test consequences are as compared to corresponding ones identified from cyclic three-point test on shot peened serial leaf springs in order to show the influence of applied heat treatment and shot peening approach on fatigue existence of high-strength used to get leaf spring manufacturing, reliant on the load level. Analyses are performed to explain the effects resulting from shot peening practice on the surface features of the high-strength spring steel under examination. The evaluation of fatigue results shows that almost no life improvement due to production highlighting the importance for mutual variation in parameters of shot peening and thermal treatment so that there is sufficient progress in life

Keywords:shot peening; fatigue life; automotive leaf springs; high strength

I. INTRODUCTION

The auto torsion bar system is accountable for the connection between the framework of the automobile and its tires. As a result, it is usually accountable for the absorption of vibrations created by unevenness on the ground, enhancing vehicle transportability and driver contentment. The main parts of the suspension system are the springs, the bumpers, and the stabilizers. Springs for standard vehicles found in different designs (or configurations); coil springs, leaf springs, air springs, or torsion springs. Coil springs are applied to light vehicles, while leaf springsweightier than coil springs, remainprevalent on economic vehicles. The desire for leaf spring suspension in heavyweightautomobile is due to the production of low levelground vibrations during traffic. At present work we restrain the design and assessment to leaf spring. Leaf springs can either be placed longitudinally or laterally depending on type of vehicle. The advantage of leaf springs is that they are simple, cheap and offer reduction in weight. Longitudinal leaf springs are mostly used for live or dead axles. Leaf springs are found in two configurations: semi-elliptical or parabolic. When it comes to both full conditions they are developed by steel leaves, in semi-elliptical spring the thickness along the length of leaf varies, however, in parabolic spring the thickness is identical along the length of leaf spring. Regarding the fatigue life, the largest difference between semi elliptical and parabolic springs is stress distribution along its length. The distribution is constant along the length in parabolic spring whereas, in semi-elliptical springs distribution is functioning under the equivalent work load.

To deliver elastic properties to the springs at excessive loads the components must be submitted to manufacturing process andensuring quenching and tempering will provide sufficient yield strength and ductility.In fact, the surface treatment should be done to increase the fatigue properties. The principal process in this instance can be shot peening, its aim is to create compressive residual stresses on the surface of materials. The shot peening program used in present function was finished with cast steel shot media rather than cast iron shot media. The aim is to model and examine shot peened leaf spring and characterize the different residual stress profiles created simply by different plans and associate these parts fatigue sturdiness.

II. LITRATURE SURVEY

The function of shot peening is creating internal stress in parts surface area, increasing fatigue efficiency. Thus, it is recognized previously. Detailed investigations states, the effect of shot peening (measured by Almen Strip) on fatigue toughness of metal, revealing that an ideal intensity exists. Sever intensity (over-peening) causes deterioration of fatigue strength.

III. METHODOLOGY

Modeling Of Leaf Spring

The commercial Vehicle Dynamics Library [1] happens to be undergoing expansions to suite large vehicles (shape 1),

Revised Manuscript Received on November 30, 2019.

* Correspondence Author

Dr.K.. Hema Latha*, Assistant Professor, Department of Mechanical Engineering, Muffakham Jah College of Engineering and Technology, Hyderabad, India.

Kamran Ahmed Khan , B.E of Mechanical Engineering (Production), Department of Mechanical Engineering, Muffakham Jah College of Engineering and Technology, Hyderabad, India.

Syed Asim Minhaj, B.E of Mechanical Engineering (Production), Department of Mechanical Engineering, Muffakham Jah College of Engineering and Technology, Hyderabad, India.

Mohd Shais Khan, B.E of Mechanical Engineering (Production), Department of Mechanical Engineering, Muffakham Jah College of Engineering and Technology, Hyderabad, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

requiring types of new components such as for example leaf springs.

This paper covers one method to create a leaf spring which has good simulation functionality and still captures the next features: a) The axle attachment placement will deflect within an arc form in the longitudinal-vertical plane under vertical loading circumstances [3], b) Leaf spring suspension styles have two anti-roll bar results. The springs are stiff in roll (twist) which counteracts the automobiles roll movement if the spring is installed to a rigid axle as in figures 7 and 8. If the axle asymmetrically is certainly mounted, that is not devoted to the center of the spring; the axle shall twist as the automobile rolls. This will resist automobile roll as well [4], c) The effective amount of the leaf spring varies with deflection leading to a varying spring price. The versions in this paper need large deflections for the result to be observed, but this effect could be higher for other forms and mounting types of the spring. Modeling is performed using CATIA and evaluation using ANSYS then. Unlike static stress, which is analyzed with calculations for an individual stress condition normally, fatigue harm happens when tension at genuine point changes after a while, and we resolve the problem.

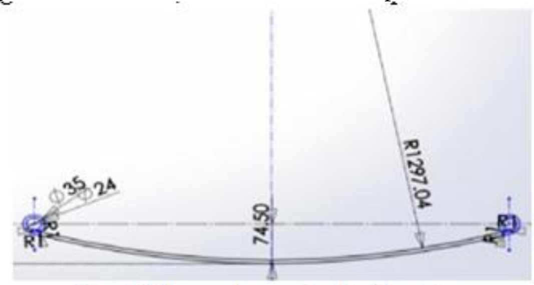

Fig. 1.Dimensions of a leaf spring

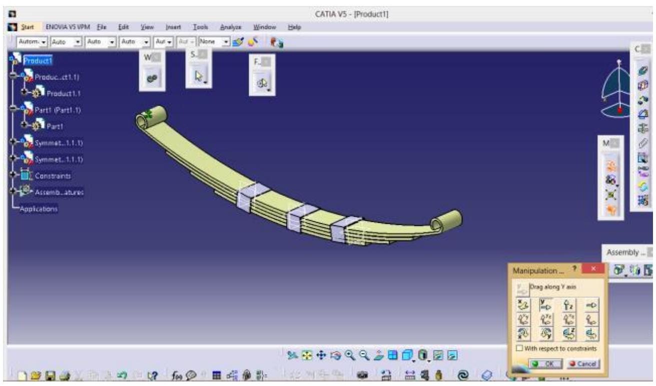

Fig. 2. Modeling in CATIA part modeler

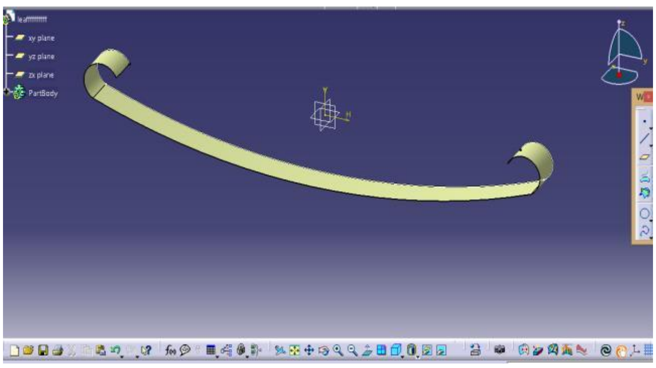

Fig.3. Modeling in CATIA part modeler (single leaf)

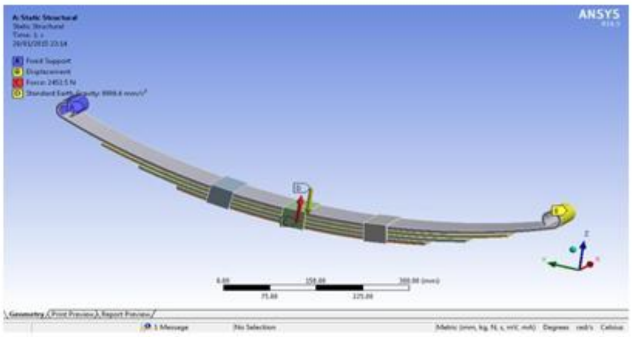

Fig. 4. Boundary condition for steel leaf spring

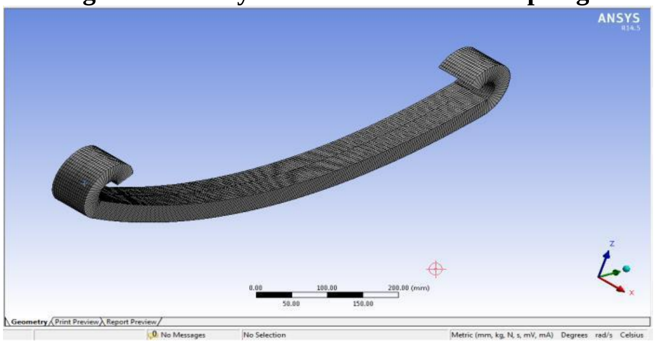

Fig. 5. Meshing of steel leaf spring

IV. SOLUTIONS

Boundary conditions for steel and composite material are same one end has given degree of translation and other end fixed. At the midpoint vertically upward force applied because in TATA ACE there is support at midpoint, acceleration due gravity in downward direction.

Simulation case (1)

Kerb weight= 925 kg

Driver weight = 75 kg

Therefore, Total weight = 925 + 75 = 1000 kg

= 1000 X 9.81 N

= 9810 N

Weight 9810N is on 4 wheels therefore, Weight on one wheel is = 9810/4 = 2452.5N

When 2452.5 N net force applied

Simulation case (2)

Kerb weight= 925 kg

Driver + 1 (weight) = 150 kg

Luggage weight = 250 kg

Therefore, Total weight = 925 + 150 + 250 = 1325 kg = 1325 X 9.81 N

= 12998.25 N

Weight 12998.25N is on 4 wheels therefore, Weight on one wheel is = 12998.25/4 = 3249.56N

When 3249.506 N is net force applied.

Simulation case (3)

Maximum load carrying capacity of TATA ACE = 1550 kg

Therefore, Total weight = 1550 X 9.81 N

= 15205.5 N

= Weight 15205.5N is on 4 wheels, therefore Weight on one wheel is = 15205.5/4 = 3801.375N

When 3801.375N is net force applied.

A. Experimental Plan:

Shot peening of leaf springs:

The 65Si7/SUP9 spring parts in position contains 2 full size leaves and 10 leaves in graduated, four ricochet fasteners of low carbon steel, 4 shim pipes with 4 bolts and nut products, 4 rivets, center nut and bolt and bush of bronze. Components grasp leaf consists of upside-down berlins eye in both the ends. The next leaf will get a military covering in order to prevent mishaps in the event of main leaf failing at its end regions.

Procedure:

1) The complete scale investigation of flat springs was completed within an electric hydro mechanical fixed component testing system.

2) The layered flat springs were positioned within a fitting showing similarities of the conditions of a car. The buildup includes a hydro mechanical equipment to provide a pressure of 20.6 x10Pascal with a discharge of 210 liters each and every minute ,which was delivered to a hydro mechanical actuator to use at a frequency of point three hertz with the displacement specific by the switching weight.

3) This calls for putting on the axial weight upon the flat spring suspension and calculating the deflection and twisting pressure. The standard leaf spring was examined under static load condition through the use of hydro static weight push for load software. Arrangement of the flat spring was carried out by putting it in reversed way over the testing foundation.

4) Gripping tools are used to held the two ends of spring and force was acted via the very best, at the guts of leaf springs. To gauge the force, dial gauge was used that is situated next to the complete scale flat spring screening machine and bending was gauged by strain gauges situated at the holding of the check apparatus. The springs had been loaded from unladed force to maximum force.

5) The bending of the leaves along Y-axis at the unladed force, design force, flat weight, and elastic touching load, and metallic interaction or maximum load was recorded, respectively, according to the ideal recommended process [11].

6) The flat springs had been examined over a complete scale, flat spring screening machine beneath the unladen, rated, smooth, elastic touching load, and metallic to steel load and the corresponding deflection and tension values noted are demonstrated in the Table 3. The trials were carried out two times plus the average worth of the outcomes was considered. The noticed figures are illustrated in Table –III.

V. OBSERVATIONS

The trials were conducted two times and the average worth of the total results was considered. Table 4 depicts the noticed figures of deflection and tension analogous to the loads used on the shorter leaf by a static hydro mechanical push.

TABLE-I: Experiment results for load, deflection and bending stress

SI. NO.	Load type	Load (N)	Deflection (mm)	Bending Stress (Mpa)
1	unladen Load	7661	46.9	262
2	Design/rated load	12959	81.44	446
3	flat load	15754	99	540
4	Rubber touching load	21645.7	136	743
5	Metal to metal contact	28010	176	941

VI. EXPERIMENTAL FATIGUE LIFE DETERMINATION:

To figure out the fatigue life, 4- cart springs work pieces (F-1, F-2, F-3, and F-4) are produced with chosen model parameters. Similar kind of metal treatment process like rolling, heating and dipping in water at 880° C, improving hardness in oil at 80° C, tempering at 410° C. A peening intensity, Brunel hardness No380– 432, and a test by bending at 0.9% of stress at yield point was done for all the work pieces.

1) The range of force acting per area considered for the specimens is 627 x 10^6 Pascal, 1.3 ± 0.7 grams. Altogether the 4 specimens were tested under same stress range and amount of application of a given stress to which a sample of steel can be subjected before failing was determined as depicted in Table 4. The number of loading (stress) cycles that a work pieces F-1, F-2, F-3, F-4 sustains before failure are as follows F-1 is 84212, for F-2 is 81961, and for F-3 and F-4 are 82226 and 85685, respectively.
2) The Average of the number of loading (stress) cycles that a work pieces F-1, F-2, F-3, F-4 sustains before failure, is 83513, can be considered for this study. As per the necessity specified by the automobile producer, the flat springs should be examined on whole scale testing setup according to 1.3 ±0.7 g utmost weight shall be 0.002 kilo grams and the minimum load will be 0.0006 kilo grams. Right here, g represents the layout load [12]:

3) $S_{max} = \frac{P_{max} * L_a * t}{8 * \Sigma I_{total}} = 896\ MPa$

4) $S_{min} = \frac{P_{min} * L_a * t}{8 * \Sigma I_{total}} = 269\ MPa$

A. Study of Iron alloy and shot peened Mono flat spring:

The iron alloy and shot peened flat springs are examined by using flat spring test setup. The experimental setup is proven in Figs. 6, 7 and 8. Test on the flat springs are carried out by following standard procedures recommended by AISI. The specimen before testing is certainly checked for any flaws like cracks, surface irregularities, etc.

Procedure:

1) Loading of spring is carried out from 0 to the mentioned highest deflection then again brought back to 0. Strain is applied along the spring center; the vertical distance between a point from the un deformed axis of the spring and the same point which lies on the deformed axis of the spring center. Strain period of 5.098-kilogram force can be noted.
2) Following its production, the shot peened multiple leafs spring is studied while using electric hydro mechanical equipment. Weight of the leaf spring is 58Kg approx. whereas spring after shot peening balances to 50 kg.
3) In a lighter travelling automobile having a camber elevation measuring 175 mm, load acting to level the flat spring is hypothetically approximated to 3250 N. As a result, a static load of 3250 N must be acting along Y-axis so that it easy to evaluate the load-deflection plots.
4)) Through entire bump spring load check, the study carried out to measure the tension is completed to confirm the full total outcomes of computed analysis

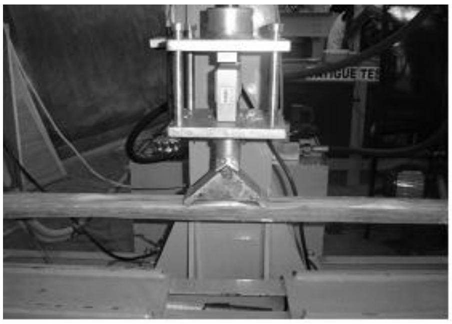

Fig. 6. Static load test for steel cart spring

Fig.7. Static load test for mono leaf spring

Fig. 8. constant load test for maximal deflection

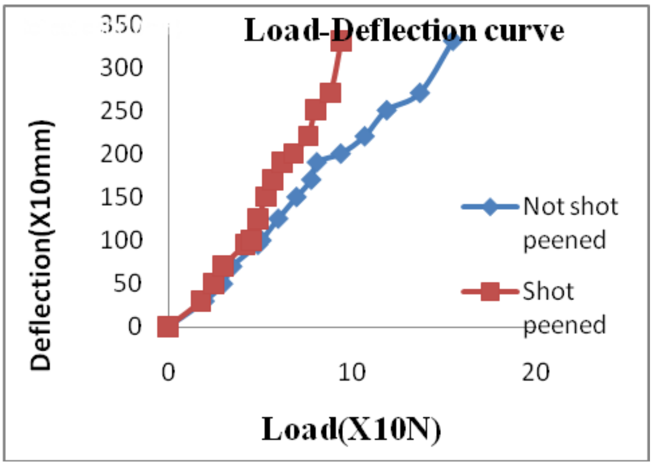

Fig. 9. Load-deflection plot for iron alloy and composite flat springs

VII. FATIGUE ANALYSIS

Outcomes can be plotted from accelerated test carried out to have the actual number of loading (stress) cycles that a work pieces sustains before failure under normal working conditions. Following the method laid out by the references [10, 12], fatigue testing was carried out on shot and metal peened leaf springs

1) Fatigue existence computation involved with laminated steel flat spring has provided this particulars: length of stroke accessible in fatigue calculation machine, 0 cm - 20 cm; preliminary bending of the spring, 100 cm; primary force per area (tested from the experiment), 420 x 10^6Pascal; last bending of the planting section (camber), 17.5 cm; optimum force per area on the ultimate placement (tested from the experiment), 805 x 10^6Pascalactual number of loading (stress) cycles that a work pieces sustains before failure projected for laminated steel flat spring is significantly lower than 10^6 cycles by the task laid out [10].

2) Number of loading (stress) cycles that a shot peened leaf spring sustains before failure, a force is acted a away from the constant load to maximal load by making use of the electric hydro mechanical chuck setup, close to 3250.0 N (17.5 cm bending), in fact it is found in static analysis already.

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

3) In a lighter travelling automobile having a camber elevation of 17.5 cm, the static force to level the laminated flat spring, is valued to end up being 3250.0 N theoretically. As a result, a constant vertical strength of 3250.0 N could be placed on to evaluate the load-deflection plots.
4) The utmost as well as the least force acting per area figures obtained at the initial routine from shot peened leaf spring are 680 x 10^6Pascalas well as 622 x 10^6Pascalcorrespondingly. Considering periods continuously increasing, the strain resolved just after 25*10^3periods of loading stress.
5) Such optimum and minimal tension figures are 750 x10^6 Pa and 640 x10^6Pa correspondingly. Due to decrease in force acting per area, the existence of repeated variation of stress in shot peened laminated flat spring is quite large below the produced computer model of the circumstances
6) The check is executed for almost 1020 minutes to complete 2 x 10^4 periods. The variants of tension region are decreased at a surprisingly low level after 2 x 10^4 periods.

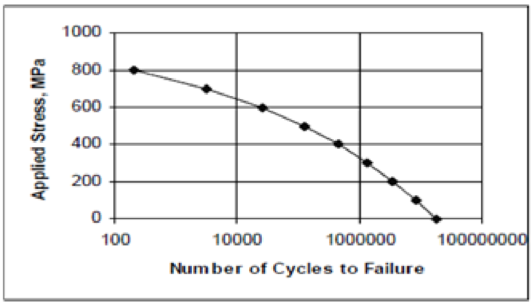

Fig. 10.S-N curve for composite leaf spring

VIII. RESULTS AND DISCUSSION

Results of Analytical analysis

For analytically calculation following formula is used by Assuming leaf spring as a cantilever beam

Max. Stress = 6WL/nb t^2

Max. Deflection = $4WL^3/nEbt^3$

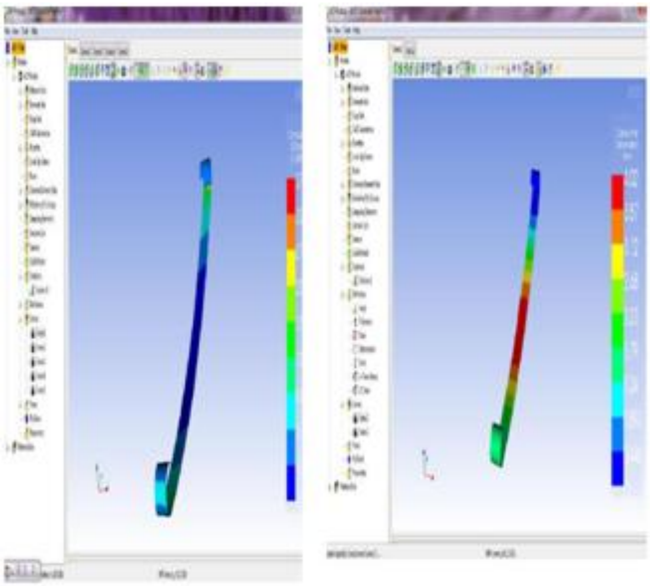

Fig. 11. Stresses in steel leaf spring on F=2452.5 N and F= 3249.506 N

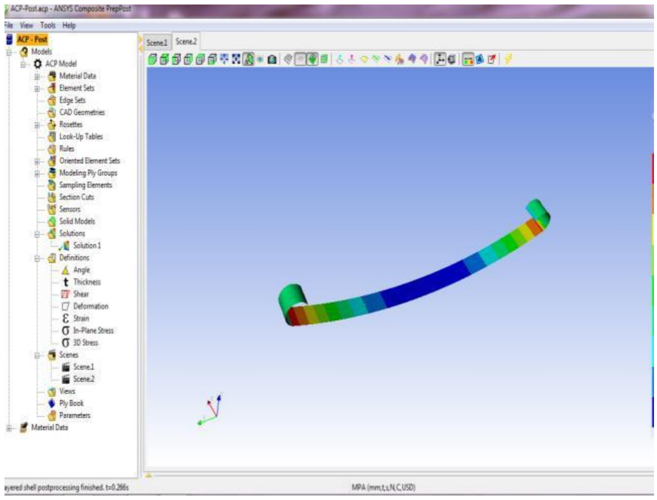

Fig. 12. Stresses in composite leaf spring onF= 3249.506 N

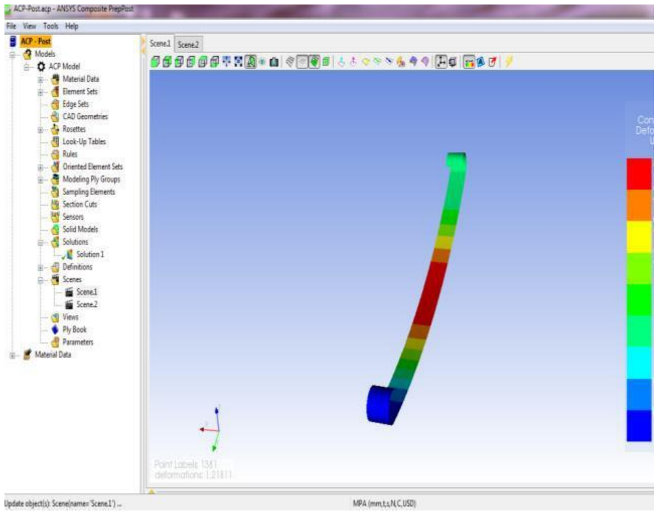

Fig. 13. Deformation in composite leaf spring on F = 3801.37N

TABLE- II: Results at 3801.375 N force

	Steel (conventional) leaf spring	Mono composite leaf spring
Stresses by FEA (Mpa)	299.71	71.5
Stresses by Analytical (Mpa)	310.97	78.65
Deflection by FEA (mm)	23.345	5.92
Deflection by Analytical (mm)	23.95	6.733
Mass (kg)	10.04	5.628
Material Cost (appx) Rs.	800	1200

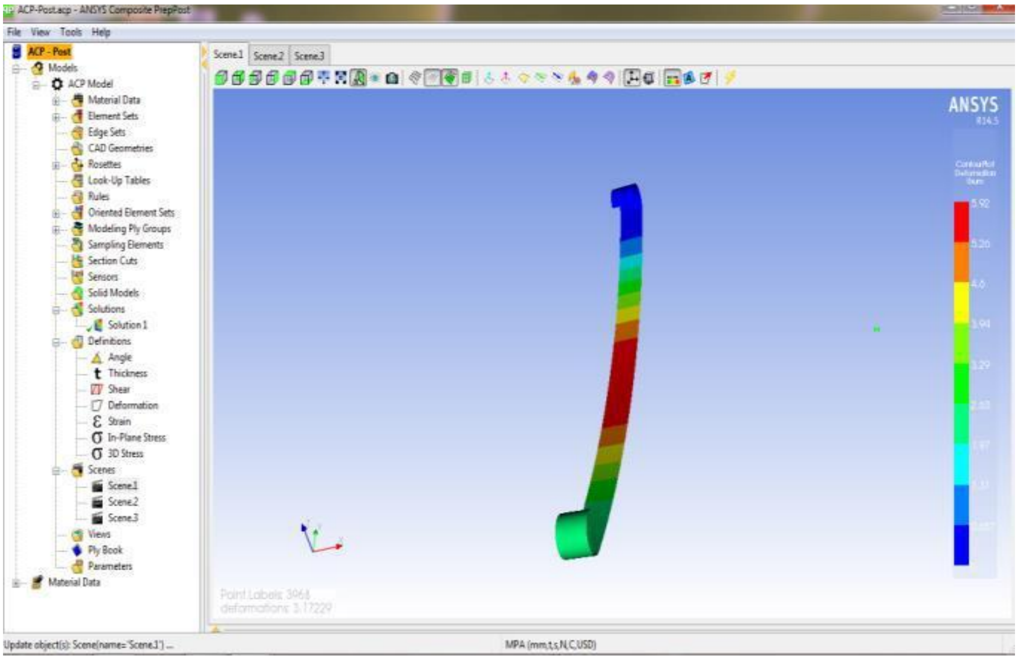

Fig. 14. Deformation in composite leaf spring on F=2452.5 N

TABLE- III: Results at 2452.5 N force

	Steel (conventional) leaf spring	Mono composite leaf spring
Stresses by FEA (Mpa)	197.91	37.6
Stresses by Analytical (Mpa)	197.6	50.3
Deflection by FEA (mm)	15.091	3.23
Deflection by Analytical (mm)	15.23	4.3
Mass (kg)	10.04	5.628
Material Cost (appx) Rs.	800	1200

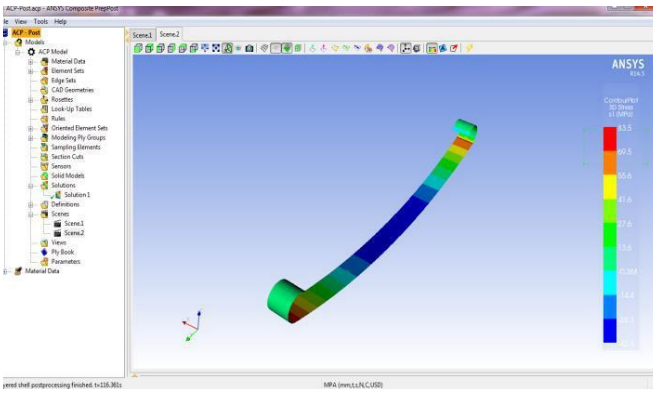

Fig. 15. Stresses in composite leaf spring on F= 3801.375 N

TABLE- IV: Results at 3249.506 N force

	Steel (conventional) leaf spring	Mono composite leaf spring
Stresses by FEA (Mpa)	262.22	71.5
Stresses by Analytical	264.62	67.068
(Mpa) Deflection by FEA (mm)	19.947	4.02
Deflection by Analytical (mm)	15.23	4.3
Mass (kg)	10.04	5.628
Material Cost (appx) Rs.	800	1200

IX. CONCLUSION

The carriage spring model is evaluated for finding out number of loading (stress) cycles that a shot peened leaf spring sustains before failure,byinvestigational and descriptive geometry technique, numerical computation method, AISI spring model manual approach, andengineering analysis task using ANSYS. The concluded points are listed below as follows

- Descriptive geometry technique, numerical computation method, arelong and inclined to faultsyet give outcomes thatdeviates less than 8-9%.

Retrieval Number: A3897119119/2019©BEIESP
DOI: 10.35940/ijitee.A3897.119119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

- Undoubtedly determination of 8 node element, 3D target element contact and 10 nodes quadratic displacement mesh element are used for engineering analysis task,outcomeshappening to be nearer to experimental values.
- The permanent load of laminated flat spring structureis definitely depreciated significantly around50 % by substituting iron alloy carriagespring with composite flat spring.
- Therefore, aimfor unspring weight is usually accomplished towardsa bigger degree.
- Forces per area and deflections in the multiple leaf spring are much equivalent (equal strength) to steel but weight reduced.

REFERENCES

1. Renzhi Wang, Ru Jilai. On the Same Problems In the Surface Strengthening Treatment of Valve Sping for the Automobile Combustion [J]. China Surface Engineering, 2000, 13(2):38-41 (in Chinese)
2. Wuyan Chu, et al. Stress Corrosion Cracking in Mild Steel Under Compressive Stress [J]. ScriptaMetalurgica, 1984,18:579-582
3. Renzhi Wang. Residual Stress and Fatigue Properties of Spring [J]. Physical Testing and Chemical Analysis Part A: Physical Testing. 2005,41 (11)
4. M.T.Todinov. Proceedings of 10^{th} National Spring Scientific Report, 8th National .
5. Spring Failure Analysis and Symposium of Spring Specialities Across the Taiwan Straits, Gueiling China. 2004:94-104
6. Zhang Yinghuai, et al. Spring Handbook [M]. Mechanical Industrial Press.1997:87
7. MargerelO'molley BSC. Stress Relaxation of Spring [J]. Wire Industry. 1988, 12: 88
8. SuDeda, Low Temperature Heat Treatment and Stabilized Treatment of Springs [J]. Spring Engineering, 2002, 3: 4-10
9. Renzhi Wang. Yao Mei, et al. Micro-Meso-Process Theory of Fatigu Crack Initiation and Theory of Internal Fatigue Limit [J]. Transactions of Metals and Heat Treatment, 1995,16(4):26
10. Liu Suo (Renzhi Wang). Fatigue Property of Metals and Shot Peening Strengthening Technology [M]. Defence Industry Press, 1977: 79
11. Xu Jiazhi, et al. The Fatigue Strength and Fracture Morfbology of Leaf Spring Steel After Prestressed Shot Peening [C]. Proceedings of 1th International Conference on Shot Peening, Paris, France, 1981.
12. R.L.Mattson, J.G.Roberts. Internal Stress and Fatigue of Materials [M]. 1959

AUTHORS PROFILE

Dr. K. Hema Latha is assistant professor in Department of Mechanical engineering, MuffakhamJah College of Engineering and Technology, Hyderabad, India. Did M.E in automation and robotics. Has total fourteen years of experience in teaching, area of expertise includes CAD/CAM, Machine Design, Design of Machine elements, Dynamics of Machines and automation. Has published several international journals. Areas of research interest are vibration and design.

Kamran Ahmed Khanis student of Mechanical Engineering (Production),Department of Mechanical Engineering ,Muffakham Jah College of Engineering and Technology, Hyderabad, India. Has published one international journal. Major field of interest are Engineering Design, Material Science, Biomedical Engineering and Manufacturing.

Syed Asim Minhajis student of Mechanical Engineering (Production),Department of Mechanical Engineering, Muffakham Jah College of Engineering and Technology, Hyderabad, India. Major field of interest is Machine Design, Material Science and Biomedical Engineering. Has published two international journals.

Mohd Shais Khanis student of Mechanical Engineering (Production), Department of Mechanical Engineering, MuffakhamJahCollege of Engineering and Technology, Hyderabad, India.Has published more than five International journals in field of design and manufacturing,one patent publication. Was among top seven finalists of ASME E-Fest Design for Social Impact contest. Major filed of interest are CAD/CAM and Material Science.