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DESIGN OPTIMIZATION AND ANALYSIS OF AUTOMOTIVE SHACKLE USING ANSYS

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Abstract: The shackles are very significant part in vehicle suspension system and should possess adequate strength to bear loads. The design of shackle could be optimized for weight reduction without much compromise in strength. This optimization could be done using Taguchi response surface method and enable to achieve good strength to weight ratio. The current research is intended to optimized design of shackles using Taguchi response surface method. The CAD modeling and FEA analysis of shackles is conducted in ANSYS software and optimization is conducted using central composite design scheme.

Key Words: Shackles, Leaf Spring, Optimization.

1. INTRODUCTION:

Suspension system constitutes springs, shock absorbers and other linkages connecting vehicle to wheel. Suspensions systems are meant to dampen the vibrations caused in vehicle due to uneven road surfaces or bumps. It conjointly has extra purpose as support weight, enable fast cornering while not extreme rolling. It plays an important role in automobile handling specially in rolling, braking. the upper the suspension is mounted, the upper the CG of the automobile shifts from the bottom that successively result into increase in tendency of rolling. suspension constitutes to regarding 16-21% of UN sprung weight of auto. the load that isn't supported by suspensions like wheel, axles and tires constitutes UN sprung weight. There square measure differing kinds of suspension, however during this analysis, springs square measure being studied. The spring of AN automobile includes the tires and therefore the wheels that permit the car locomote the surface by maintaining the correct quantity of friction to stay it on it surface. The vehicle structure is unbroken integrated by frame whereas supporting engine and alternative body masses. This spring is mounted over a suspension, that conjointly works as a load support for the car.

2. LITERATURE REVIEW

Rupesh N. Kalwaghe, K. R. Sontakke[1] conducted FEA analysis on semi-elliptical spring exploitation ANSYS code. Composite spring used was E-glass/epoxy generated less stress and deformation as compared with steel leaf springs. the burden of E-Glass/Epoxy spring was sixty seven.88% but steel spring.

Manish Parwani1, Vaibhav Jainist [2] conducted study on mono spring exploitation material exploitation Jute/E-glass/Epoxy. exploitation this material weight of spring is reduced by eightieth while not a lot of compromise in strength of spring.

Krishan Kumar, Aggarwal M.L,2017 [3] Have optimize numerous style Parameters for EN45A Flat spring. Leaf springs area unit wide used as suspension in automotive vehicles. within the gift work, optimisation of style parameters of flat leaf springs are carried out: keeping into consideration the impact of shot peening intensity, reduction within the weight of parts and increase in fatigue life at wide selection of operational conditions. A trojan horse exploitation Visual Basics has been ready to predict the fatigue life, thickness and weight of shot peened EN45A spring steel leaf springs, supported stress approach. The results obtained from simulation area unit found in accordance with the experimental results

Ganesan K , Kailasanathan C, et al. 2015 [4].Did analysis of Composite spring increased With Nanoparticles. Weight reduction is currently the most issue in automobile industries. during this work because of scale back the burden of steel spring with composite spring because of high strength quantitative relation is have to be compelled to improve. the most aim is to match to the load carrying capability, stiffness and weight savings of composite spring thereupon of steel spring at rated- load and over-load condition.

Triveni Z, Amara adult male B, et al 2016[5]. Studied finite part analysis on spring made from material. A spring may be a straightforward kind of spring normally used for the suspension in wheeled vehicles. Weight reduction are often achieved by coming up with new materials and complex producing processes.

3. OBJECTIVES

The shackles is very significant part in vehicle suspension system and should possess adequate strength to bear loads. The design of shackle could be optimized for weight reduction without much compromise in strength. This optimization could be done using Taguchi response surface method and enable to achieve good strength to weight ratio. The current research is intended to optimized design of shackles using Taguchi response surface method. The CAD modeling and FEA analysis of shackles is conducted in ANSYS software and optimization is conducted using central composite design scheme.

4. METHODOLOGY

The CAD model of shackles is modelled using dimensions as shown in figure 1 below. The CAD model is developed in ANSYS design modeler using sketch and extrude tools as shown in figure 4.1 below.

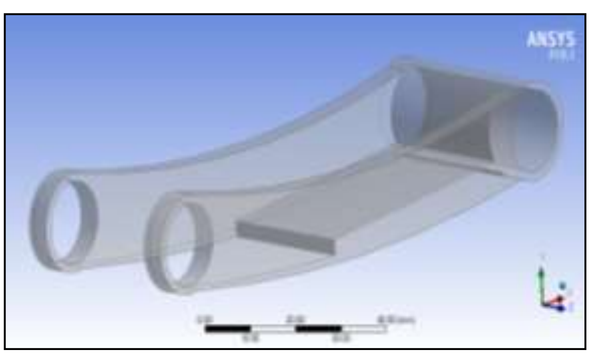

Figure 1: CAD model of shackles

The dimensions of shackles are given below. The length of shackles is 110mm and width of shackles is 40mm.

1. Total Length shackle(body): 110mm
2. Width of shackles: 40mm

The CAD model is meshed with tetrahedral elements. The number of elements generated is 3088 and number of nodes generated is 6317.

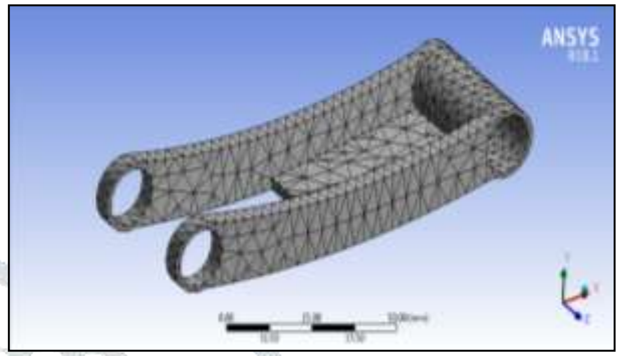

Figure 2: Meshed CAD model in ANSYS

The deformation is applied on one end of cylindrical support and force of 1500N is applied on other cylindrical support. The load is taken from literature [6]

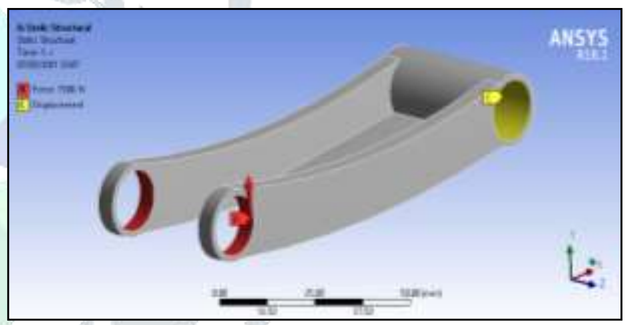

Figure 3: Loads and Boundary conditions

Software carries out matrix formulations, matrix multiplications, formulation of element stiffness matrices, assembly of global stiffness matrix. Results are calculated at nodes and interpolated for entire element edge length. The solver report is attached herewith.

5. RESULTS AND DISCUSSION

The FEA analysis is conducted on CAD model of shackle to determine shear stress, total deformation, fatigue life and safety factor. The shear stress obtained from FEA analysis is shown in figure 4 below. The maximum shear stress is observed on cylindrical support region as shown by red colour contour with magnitude of 110.4MPa.

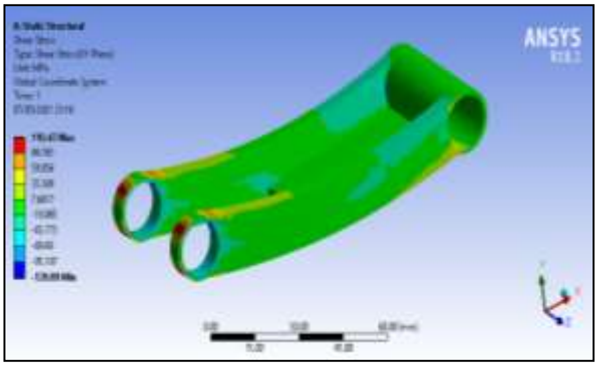

Figure 4: Shear stress in shackles

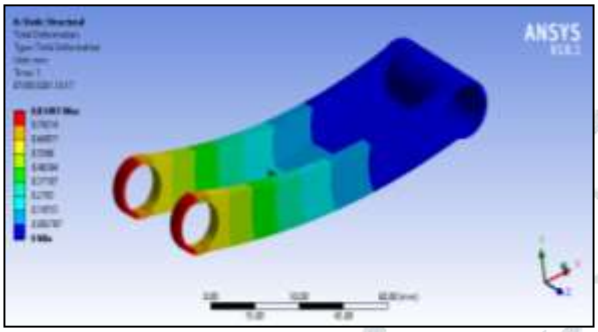

Figure 5: Total deformation observed in shackles

The maximum deformation is observed on cylindrical region as shown by red coloured region with magnitude of .834mm. The deformation decreases as we move away from cylindrical face and reaches minimum as we move towards fixed support end.

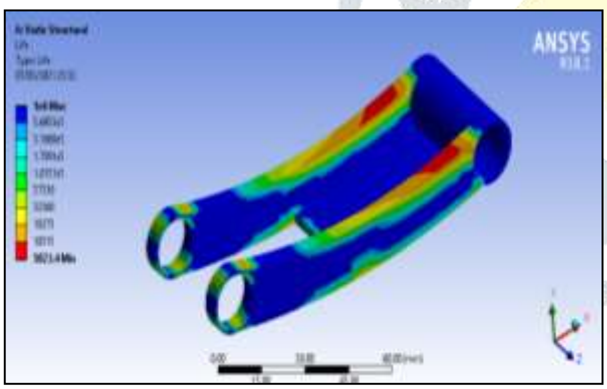

Figure 6: Fatigue life observed in shackles

The fatigue life obtained for shackles is shown in figure 6 above. The fatigue life is different for different regions. The fatigue life of shackle is 5823 in the red colored regions. Similarly, safety factor is obtained for shackles as shown in figure 7 below. The safety factor obtained for shackles is .27 which is low.

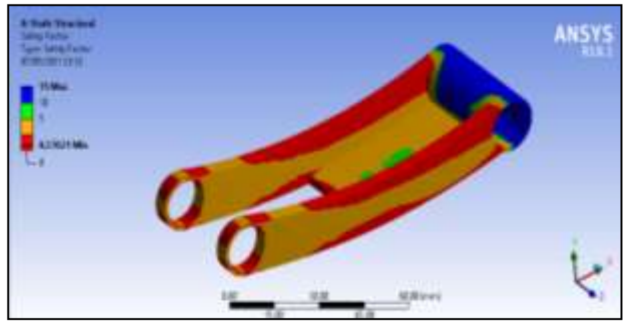

Figure 7: Safety factor of shackles

The design points are generated using Taguchi design of experiments using central composite design scheme. The optimization variables selected for analysis are outer diameter and inner diameter.

Table 1: Design points using Taguchi design of experiments

	A	B	C	D	E	F	G
1	Name	P1-outerdia (mm)	P2-innerdia (mm)	P3-Shear Stress Maximum (MPa)	P4-Total Deformation Maximum (mm)	P5-Life Minimum	P6-Safety Factor Minimum
2	1 DP 0	18	15	118.47	0.83491	5823.4	0.27621
3	2	17.8	15	128.98	0.87235	4461	0.25317
4	3	18.2	15	99.175	0.80176	8549.3	0.31257
5	4	18	14.8	101.09	0.82706	8138.9	0.3078
6	5	18	15.2	121.23	0.84088	6136.8	0.28058
7	6	17.8	14.8	104.56	0.86014	7578.5	0.30079
8	7	18.2	14.8	97.721	0.79491	8289.3	0.31964
9	8	17.8	15.2	135.95	0.88126	4287.7	0.25316
10	9	18.2	15.2	107.78	0.8089	8212	0.31869

The maximum shear stress obtained is 135.95MPa and minimum shear stress obtained from analysis is 97.204MPa. The maximum safety factor is observed for design point 9 with value of .319

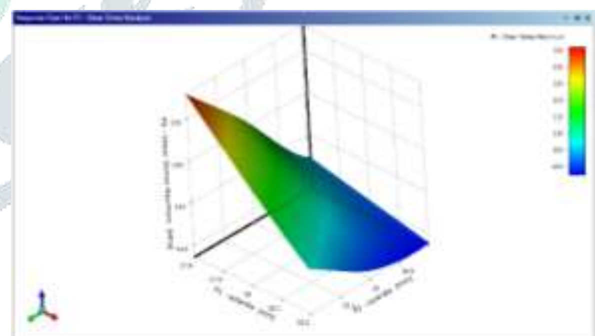

Figure 8: Response surface plot of shear stress

The response surface plot of shear stress is obtained which shows the red coloured with maximum magnitude, blue coloured region with minimum magnitude. The shear stress is maximum for outer diameter ranging from 17.8mm to 17.95mm and inner diameter ranging from 15.15mm to 15.18mm. The shear stress is minimum for regions shown in dark blue colour.

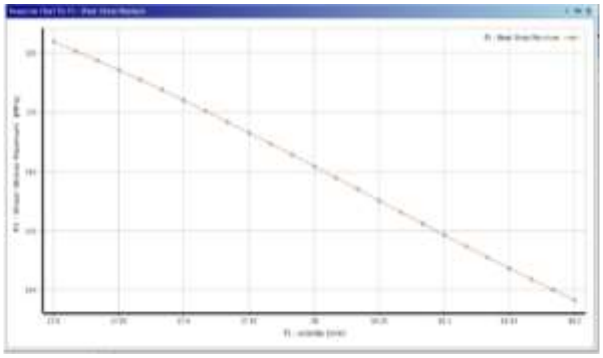

Figure 9: Shear stress vs outer diameter

The graph above shows variation of shear stress vs outer diameter. The curve shows decrease in shear stress with increase in outer diameter. The maximum shear stress is observed for outer dia value of 17.8mm and minimum shear stress is observed for outer diameter value of 18.2mm.

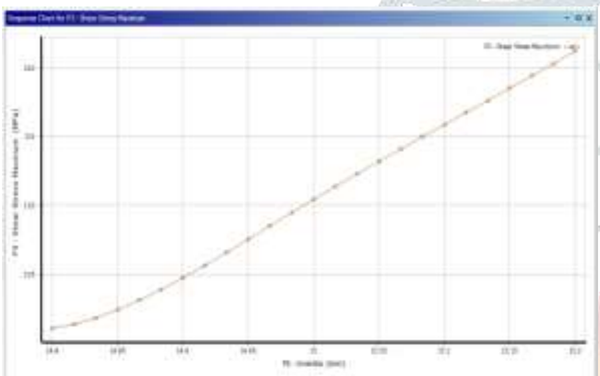

Figure 10: Shear stress vs inner diameter

The graph above shows variation of shear stress vs inner diameter. The curve shows increase in shear stress with increase in inner diameter. The maximum shear stress is observed for inner dia value of 15.2mm and minimum shear stress is observed for inner diameter value of 14.8mm.

6. CONCLUSION

The FEA analysis of shackles used in leaf spring is conducted using ANSYS software. For design optimization of shackles using response surface method the inner radius and outer radius of shackles are selected as parameters for optimization. The response surface plots are generated for deformation and shear stress, deformation, safety factor. From response surface plots the range of magnitude of parameters (inner radius and outer radius) can be determined for which the output parameters are maximum or minimum. The details are as follows:

1. The maximum shear stress is observed on cylindrical support region with magnitude of 110.4MPa.
2. The maximum deformation is observed on cylindrical region on which force is applied with magnitude of .834mm. The deformation decreases as we move away from cylindrical face and reaches minimum as we move towards fixed support end.
3. The fatigue life is different for different regions. The fatigue life of shackle is 5823 cycles and the safety factor obtained for shackles is .27 which is low.
4. The shear stress is maximum for outer diameter ranging from 17.8mm to 17.95mm and inner diameter ranging from 15.15mm to 15.18mm.

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