Design of Leaf Spring Shackle Plate in Automobile Vehicle by Using Topological Optimization

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doi: https://doi.org/10.21467/proceedings.118.12

ABSTRACT

An automobile leaf spring suspension shackle is a mechanism which allows the changes in the length of the leaf spring. It is a part of suspension system and helps leaf spring elasticity. The arrangement tends to tensile, shear and static loads. Finite element analysis (FEA) carried out at static conditions with different load conditions with different materials of shackle. Stress, strain and deformation analysis is observed at high stress designs. Solid work model is carried out in the analysis. The analysis is compared with different loading conditions with different materials and observed stress, strain, deformation in overall zones has been studied.

Keywords: Shackle plate, Steel, Titanium, Aluminium materials, Finite element method, Stress-strain-deformation analysis

1 Introduction

A shackle is a modest form of mechanism commonly used for the suspensions wheeled vehicles originally called a laminated spring. The shackle is built on the theory of a beam of unchanging strength. Shackle can serve finding and to some extent damping as well as springing functions. Depends on the damping, static load varies then the leaf spring is not controlled in motion of suspension. So producers noticed to experiment on mono type shackle. In this present work, an attempt is made to replace the steel with other materials like titanium and aluminium in light vehicle at various loads applied conditions and shackle plate is designed to analysis the behaviour of stress, strain and deformation at over all area. Because of various new light vehicles are industrial now a days and also competitions among the cost reduction of producing procedures then all creators are more intensive on life and several materials replacing by regular conventional materials with various load conditions. There is direct proportion between weight of the vehicle and its fuel consumptions. This paper is mainly focused on the analysis by varying different types of material on different light load situations. This paper focused on the analysis regarding stress, strain and deformation as per various static loads.

4 Theoretical Calculation

The leaf spring behaves like a simply supported beam and the simply supported beam is subjected to both bending stress. Strain and deformation as one side fixed. There are static loads carries on four wheeler equally distributed on wheels and design factor of safety considered for theoretical calculations. With kept load 30KN, 40KN & 50KN

4.1 Constant material, varying static load

In this design kept constant material vary different load at all over area one end is fixed.

4.2 Different material, varying static load, varying analysis (stress, strain & deformation)

In this change the different material same varied load with stress, strain and deformation analysis

Proceedings DOI: 10.21467/proceedings.118; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-947843-6-4

5 Problem Statement

In vehicles, weights of the components play an important role in defining the efficiency of the vehicle. We will analyze with different materials of the Leaf Spring suspension Shackle in order to select the right material of Shackle while maintaining the strength and mechanical assets. The Shackle is designed for TATA ACE mini truck suspension Leaf Spring using standard design procedures and the dimensions attained are confirmed with the actual Shackle used in the appearance. The designed Shackle will be analyzed using ANSYS 16.2 software for the maximum and minimum stress, strain regions.

6 Specifications of Shackle

Sr.No.	Parameters	Dimensions
1	Total length of shackle	90
2	Width of shackle	40
3	Maximum load given on shackle	30-50KN
4	Weight of the body	0.74kg

7 Materials For Shackle

Generally shackles are made of various materials like steel, Titanium, composite materials, aluminum, and fibers .The steel, Titanium and Aluminum these materials are selected for experimental investigation .The parabolic shackle is used in the TATA ACE MINI TRUCK for rear suspension.

8 Modelling

Firstly, we generated design for Shackle for TATA ACE and then created 3D model using modeling software CATIA. The 3D model was imported in analysis softwareANSYS and analysed for stresses the designed Shackle will be analysed using ANSYS 16.2 software for the maximum and minimum stress regions.

Figure 1: Meshed model of Leaf SpringFig.2 Base line of Shackle plate

9 Analysis

Material----Steel

The 3D model was imported in analysis software ANSYS and analyzed for stresses the designed Shackle will be analyzed using ANSYS 16.2 software for the maximum and minimum stress regions.

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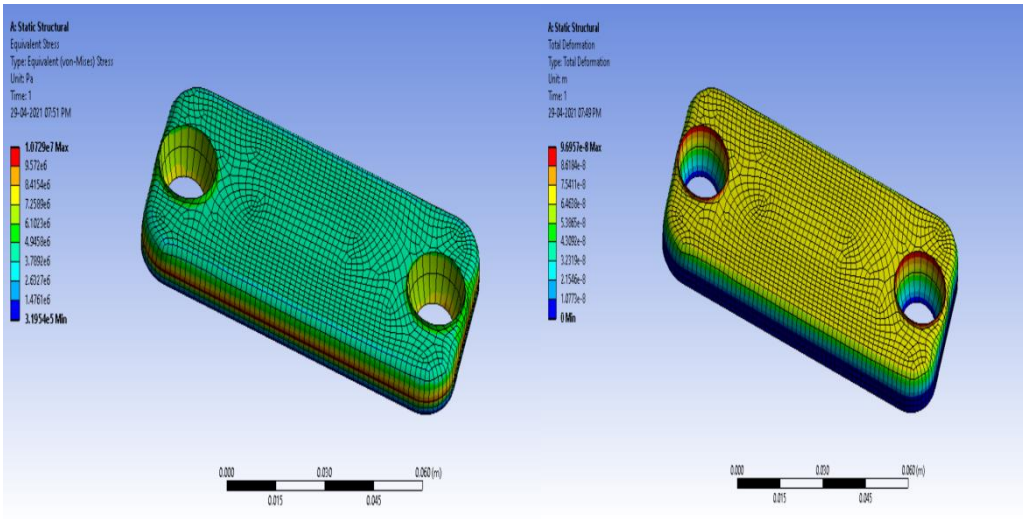

Figure 2: A) Static load 30 KN (Stress)Fig3 B) Static load 30 KN (Deformation)

Material---Titanium

The 3D model was imported in analysis software ANSYS and analyzed for stresses the designed Shackle will be analyzed using ANSYS 16.2 software for the maximum and minimum stress regions.

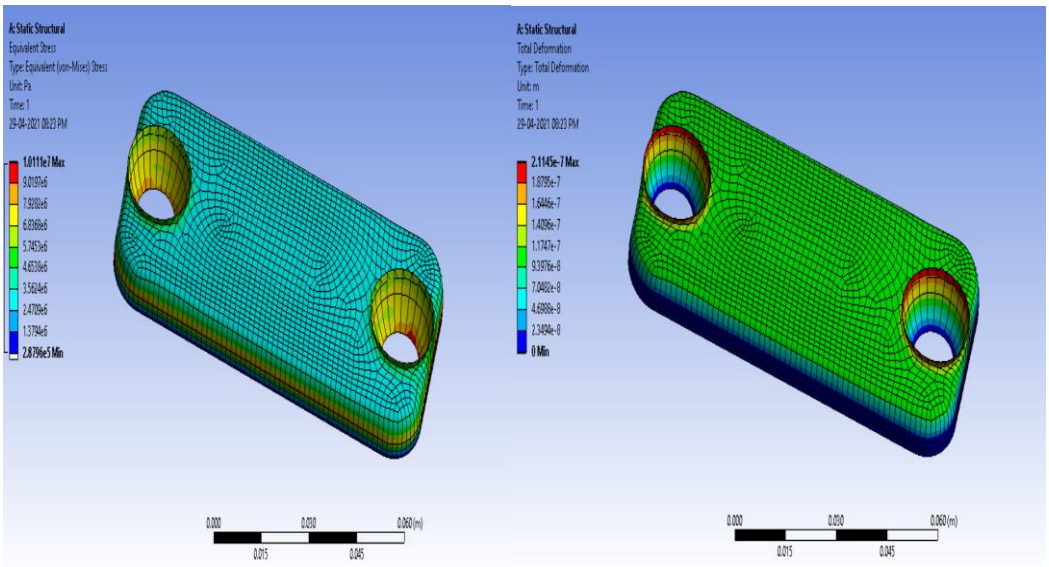

Figure 3: A) Static load 30 KN (Stress)Fig4 B) Static load 30 KN (Deformation)

Material---Aluminum

The 3D model was imported in analysis software ANSYS and analyzed for stresses the designed Shackle will be analyzed using ANSYS 16.2 software for the maximum and minimum stress regions.

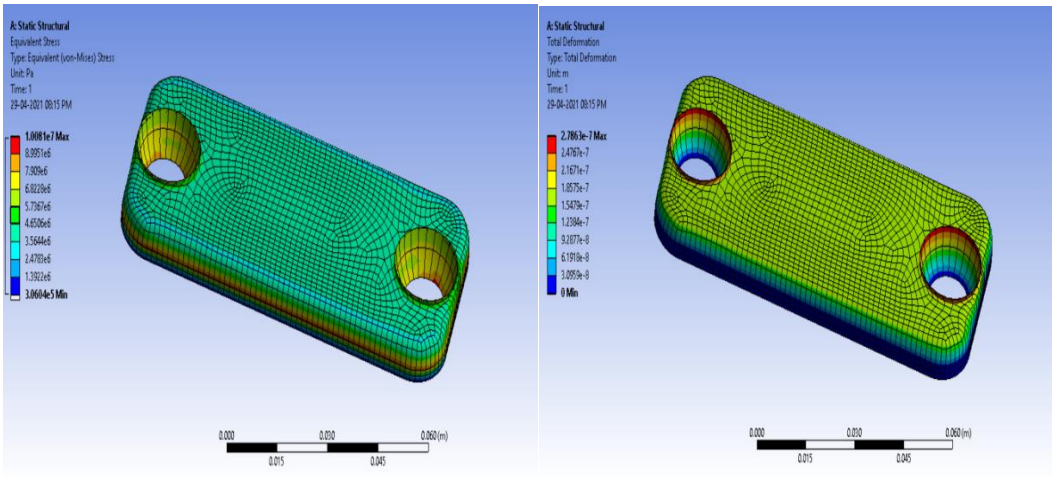

Figure 4: A) Static load 30 KN (Stress)Fig5 B) Static load 30 KN (Deformation)

10 Results and Discussion

From the results of different material and same static load we analyzed the stress, strain and deformation on shackle plates as shown above figures. Comparison of Stress, strain and deformation for different materials. By applying load as per results are observed at different materials are as follows.

10.1 Load applied---30KN

Material	Stress (Pa)	Strain(m/m)	Deformation(m)
Steel	1.0729	5.3643	9.6957
Titanium	1.0111	0.00010	2.1145
Aluminum	1.0081	0.00014	2.7861

10.2 Load applied---40KN

Material	Stress (Pa)	Strain(m/m)	Deformation(m)
Steel	1.4305	7.1524	1.2928
Titanium	1.3482	0.00014	2.8193
Aluminum	1.3442	0.00018	3.7151

10.3 Load applied---50KN

Material	Stress (Pa)	Strain(m/m)	Deformation(m)
Steel	1.7881	8.9405	1.616
Titanium	1.6852	0.00017	3.5241
Aluminum	1.6802	0.00023	4.6438

11 Conclusion

In this present work, the bending stress, strain and deformation analyzed for the conventional steel shackle of TATA ACE Mini truck but we are tried for other materials (Titanium, Aluminium) as shown in above comparison which are taken for various load. As per this comparison Titanium material selected for manufacturing the shackle plate Because titanium is a high-strength and low-density metal, it's very well suited to applications where both weight and strength are critical.

Proceedings DOI: 10.21467/proceedings.118
ISBN: 978-81-947843-6-4

Series: AIJR Proceedings
ISSN: 2582-3922

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