International Journal of Research in Engineering, Science and Management
Volume-3, Issue-6, June-2020
www.ijresm.com | ISSN (Online): 2581-5792

# Design and Analysis of Suspension System for an All-Terrain Vehicle (ATV)

F. B. Mervin Anand Antony[1*], P. Aiam Pandian[2], T. Sakthivel[3], N. Vasanth[4], P. Yukan[5]
[1,3,4,5]*Student, Department of Mechanical Engineering, KGISL Institute of Technology, Coimbatore, India*
[2]*Assistant Professor, Department of Mechanical Engineering, KGISL Institute of Technology, Coimbatore, India*
*Corresponding author: fbmervinantony@gmail.com

***Abstract*: Designing purpose of this Suspension System is to manufacture an off-road vehicle which should be able to perform well in any terrains and to compete with other ATV'S. In order to accomplish this task, different design aspects of a vehicle have been analyzed, and certain elements of the vehicle were chosen for specific focus. There are many facets to an off-road vehicle, such as the chassis, suspension, steering, drive-train, and braking, all of which require through design concentration. The points of the car we decided to specifically focus is on the suspension system which makes it stable and reliable. The most time and effort were spent to designing and implementing the component of the vehicle because it is the major components and also it causes great effect in the off-road driving experience. During the entire design process, consumer interest through innovative, inexpensive, and effective methods is always the primary goal.**

***Keywords*: Suspension system, Leaf spring.**

## 1. Introduction

Suspension system absorb the vehicle vibrations, shocks and bump loads (induced due to road irregularities) by means of spring deflections, the potential energy is stored in the spring and then relieved slowly. Ability to store and absorb more amount of strain energy ensures the Comfortable suspension system.

Semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. The leaf spring is based upon the theory of a beam of uniform strength. Leaf spring as the name indicates it is made of leaf like structure with rectangular cross section placed one over the above. The main function of leaf spring is not only to support vertical load but also to isolate road induced vibrations. The blades are usually given an initial curvature or cambered so that they will tend to straighten under the load.

## 2. Problem Identification

Failure in an All-terrain Vehicle's Suspension System is mostly catastrophic, which might bring the whole vehicle to halt. If failure happens in between a rally or in a race the vehicle will be subjected to disqualify or to fix the suspension system and reenter the race, but fixing of suspension system is not an easy task. In both cases the vehicle will lose its chance of victory. And the cost of an existing ATV's Suspension System is very high.

## 3. Methodology

The idea is to design a leaf spring suspension system using calculations and modeling it in SOLIDWORKS software, the designed model is analyzed to find Total Deformation, Equivalent (von-Mises) Stress, Equivalent (von-Mises) Strain using ANSYS software.

Designing, modeling and analysis procedure is repeated until obtaining a Factor of Safety above 2.5, the leaf spring is manufactured using cambering process. After Manufacturing, the leaf spring is inspected and mounted on the vehicle for testing. If the suspension system satisfies the needs then it is approved else the procedure is repeated again for higher values.

## 4. Design Calculations of Leaf Spring Suspension System

Total Load, $2P = 20000N$
Number of leaves, $n = 4$
Number of Springs, $N = 4$
Young's Modulus, $E = 2.1 \times 105\ N/mm^2$
Yield strength = $1700\ N/mm^2$
Working Stress, $\sigma b = 850\ N/mm^2$
Total length of the leaf, $2l = 1000mm$
Half-length of the leaf, $l = 500mm$
Load acting on one eye, P = Total load / (No of Springs x 2)
= 20000/4x2 = 2500 N

### A. Thickness of Leaf spring

Working stress, $\sigma b = 12\ Pl / 6t^2(3ne + 2ng)$
Where,
P = Load acting on one eye,
l = Half-length of leaf,
t = Thickness of leaf,
ne = No of main leaf,
ng = No of graduated leaf,
$850 = 12 \times 2500 \times 500 / 50 \times (t^2)(3(1) + 2(3))$
$t^2 = 12 \times 2500 \times 500 / 50 \times 850 \times 9$
$t = 6.26\ mm$

### B. Deflection

$Y = 12\ P\ l^3 / bt^3\ (3ne + 2ng) \times E$

Y=12 x 2500 x $(500)^3$ /50 x $(6.26)^3$ (3(1) +2(3) x 2.1 x $e^5$
Y=161.76 mm

*C. Camber Length*

C = 0.5 x Y
C = 0.5 x 161.76
C = 80.88 mm

*D. Radius of curvature*

R = l2 /2 x Y = 5002 /2 x 162.33 = 772.74 mm

*E. Design of pin (leaf eye pin)*

*1) Load on pin*

Pp = P/cos45 = 2500/cos45 = 3535.55 N

*2) Diameter of pin*

Dp = (Load on pin, Pp) / (Bearing Load x Breadth of leaf, b)
Dp = 3535.55 / (10 x 50) = 7.07mm

*F. Length of the leaf spring*

L1= (Effective length/(n-1)) + ineffective length
=900/4-1+100 = 400mm
L2=Effective length/(n-1) x 2 + ineffective length
=900/4-1 x 2+100 = 700mm
L3=Effective length/(n-1) x 3 + ineffective length
=900/4-1 x 3+100 = 1000mm
L4=Effective length/(n-1) x 4 + ineffective length
=900/4-1 x 4+100 = 1300mm

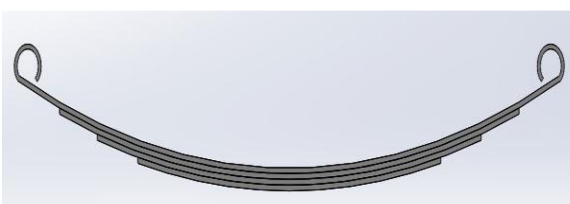

Fig. 1. Front view of Leaf spring

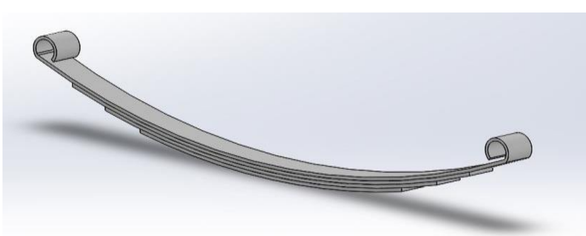

Fig. 2. Side view of Leaf spring

## 5. Analysis of Leaf Spring

Analysis for the leaf spring was done to check whether the suspension system would hold the impact stress of the vehicle and be safe for operation without any failure.

The component is loaded into ANSYS workbench platform and it is meshed with a mesh size of 5 mm. Both the eyes of the leaf springs were fixed in X and Y direction but allowed to rotate along the pivot point (Z direction) and load was applied on the center of the bottom leaf spring, thus the leaf spring moves up compressing and compelled to increase the radius of curvature storing the impact force for later distribution.

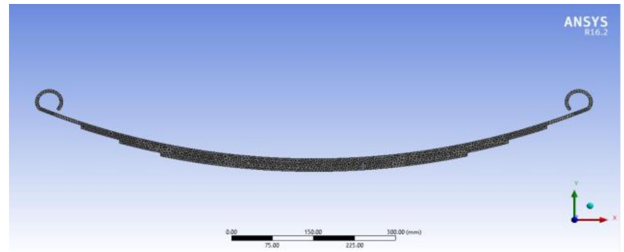


Fig. 3. Meshing of Leaf spring

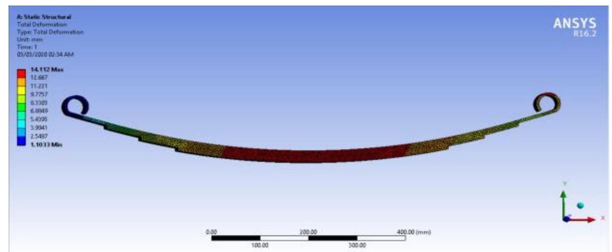


Fig. 4. Total Deformation

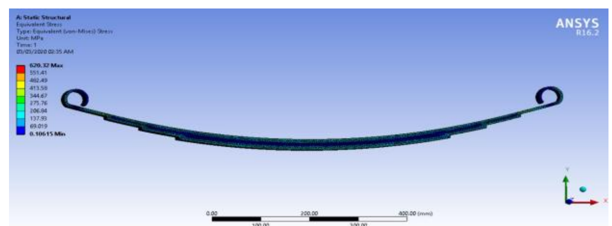


Fig. 5. Equivalent (von-Mises) Stress

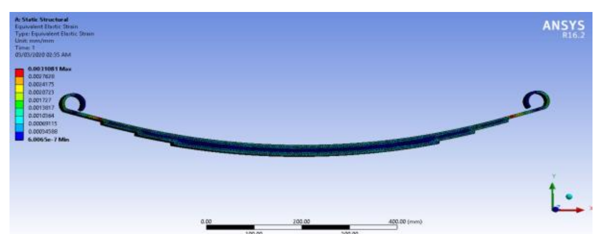


Fig. 6. Equivalent (von-Mises) Strain

*A. Analysis Calculation*

*1) Analytical Results*

Yield strength of 50 Cr 1 Steel = 1700 MPa
Force analyzed for = 7500 N
Maximum Equivalent strength =620.32 MPa

*2) Factor of Safety*

Factor of safety = Yield Stress / Working Stress
= 1700/620.32
Factor of safety = 2.74

Accepted FOS for leaf spring is 2.5, the analytical value obtained is 2.74 therefore the design is safe.

## 6. Mounting of Leaf

The spring is mounted on the axle of the vehicle. The entire vehicle load rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint, while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame.

Fig. 7. Fabricated model of Leaf spring

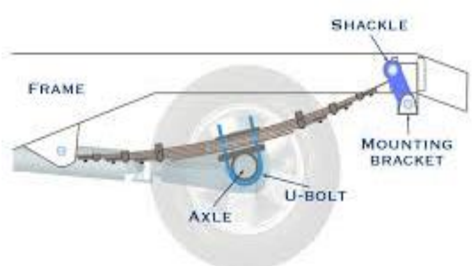


Fig. 8. Mounting of Leaf spring

### 7. Shock Absorber

A shock absorber is a mechanical or hydraulic device designed to absorb and damp shock impulses, the kinetic energy of the shock is transferred into another form of energy which is then dissipated. Shock absorbers reduce the effect of travelling over rough ground, leading to improved ride quality and vehicle handling.

While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations.

### 8. Conclusion

Our vehicle is equipped with Leaf Spring Suspension, due to its reliability than other suspension systems it can withstand for more load cycles and perform constantly without more deviations.

Based on the manufacturing, leaf spring are easier to design and modify which takes lesser time and less man power for design and manufacturing, thus the cost is very low compared to other suspension types.

Comparing to other suspension system it requires less maintenance, easy to service and replace as it is not having any parameters like caster angle, camber angle, etc.

An ATV has to face many tough situations in all kinds of terrain which makes any suspension systems to fail, but unlike with Leaf spring suspension systems the vehicle can move further even after leaf damage with the shock absorber.

### References

[1] Rule book of RCDC 2019.
[2] Kirpal Singh, Standard Publishers Distributors, Vol. I, Vol. II, Edition 12- Automobile Engineering.
[3] John C. Dixon; “Suspension analysis and computation geometry”; October 2009.
[4] V B Bhandari 2004.Springs. “Design of machine elements”. 3rd edition. Tata Mc Graw-hill publications.400-406.
[5] PSG Data Book, Edition 2018.
[6] RCDC 2018 Lecture 1: Motion and dynamic equations for vehicles.