ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 9, March 2017

DESIGN AND ANALYSIS OF COMBINED SUSPENSION SYSTEM

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Abstract— **Due to the importance of the safe and comfort transportation under every circumstance, the combined suspension systems has been proposed for betterment shock absorbing ability which gives better comfort and increases safety of the vehicle from the failure. A combined leaf spring and air lift suspension particularly for a vechicle,comprises a suspension whose function is to elastically support weight of a vechicle and a double-effect shock absorber which comprises an energy dissipation brake.To avoid failures combination of both leaf spring suspension and air lift suspension is proposed. This is a proposal of the suspension by combining leaf spring and air lift suspension system. Hence it's a reliable system and can provide additional reinforcement to the suspension in case of failure of air lift. This is therefore essential in providing suspension with more efficiency and reliability to overcome vehicular discomfort.**
Keywords:(Combined Suspension, leaf spring, Air lift, Comfort,Safety)

I. INTRODUCTION

1 .SUSPENSION

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and a ride quality reasonably well isolated from road noise, bumps, vibrations etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

An early form of suspension on ox-drawn carts had the platform swing on iron chains attached to the wheeled frame of the carriage. This system remained the basis for all suspension systems until the turn of the 19th century, although the iron chains were replaced with the use of leather straps by the 17th century. No modern automobiles use the 'strap suspension' system.

Automobiles were initially developed as self-propelled versions of horse-drawn vehicles. However, horse-drawn vehicles had been designed for relatively slow speeds, and their suspension was not well suited to the higher speeds permitted by the internal combustion engine.

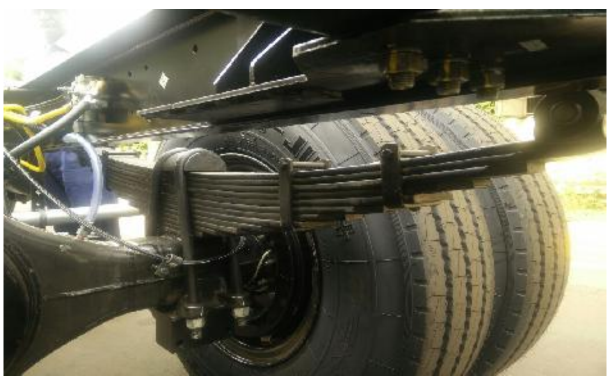
1.1 TYPES OF SUSPENSION
LEAF SPRING

Semi elliptic leaf springs are almost used in commercial vehicles. It is also used in cars for rear suspension. The spring consist of a number of leaves called blades. The blades vary in length and connected together as shown in the figure. These springs based on the theory of beam of uniform strength.
This spring is mounted on the axle by the U bolt and the one end of spring is mounted on the frame and other is connected with a shackle which allow to change in length between eye of spring when the vehicle come across projection of road and upward movement of wheel.
When there is wide range of loading on vehicle helper spring is also provided with the leaf spring which increase the weight loading capacity of vehicle. These springs are made by the Chrome-Vanadium Steel, Silico-Manganese Steel or Carbon Steel as per requirement. These spring are noisy and does not used where luxuriousness is necessary.

A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. In the most common configuration, the center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. For this reason some manufacturers have used mono-leaf springs.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a *spoon end* (seldom used now), to carry a swiveling member.

1.2. EXISTING SYSTEM AND THEIR PROBLEMS
EXISTING OF LEAF SPRING :



Semi elliptic leaf springs are almost used in commercial vehicles. It is also used in trucks for rear suspension. This spring is mounted on the axle by the U bolt and the one end of spring is mounted on the frame and other is connected with a shackle which allow to change in length between eye of spring when the vehicle come across projection of road and upward movement of wheel.

Problem occurs in leaf spring:

- The leaf-spring systems are not easy to install
- The inter-leaf friction between the leaf springs reduces the ride comfort.
- The leaf springs may tend to lose shape and sag over time. If the sag is uneven, it alters the cross weight of the vehicle which changes the handling. It also changes the axle-to-mount angle.
- Acceleration and braking torque cause wind-up and vibration. Also wind-up causes rear-end squat and nose-diving.

1.3. EXISTING AIR SUSPENSION SYSTEM:

Air suspension is a type of vehicle suspension powered by an electric or engine-driven air compressor. This compressor pumps the air into a flexible bellows usually made from textile-reinforced rubber. The air pressure inflates the bellows, and raises the chassis from the axle.

Problems occurred in air suspension:

1.4. LINK ROD:

1.5. Air bellows :

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- V -link rod is used for pulling the entire body, rubber stock in v-link rod is easily damaged due to wear and tear.
- Air suspension parts may fail because rubber dries out.
- Punctures to the airbag may be caused from debris on the road.
- Improper installation may cause the airbags to rub against the vehicle frame or other surrounding parts.
- Airbag failure is usually caused by wet rust, due to old age, or moisture within the air system that damage it from the inside.
- Failure of air spring may also result in complete immobilisation of the vehicle.

II. DESIGN CALCULATION

CALCULATION OF LEAF SPRING:

Full length of leaf spring 2L = 1000mm
L=500mm
Breath b=32mm
Thickness t=14mm
Number of plates = 7

Total load acting on system 2W $=\frac{load}{no\ of\ plate}$

2W= $\frac{75}{7}$ =10.71N
W=5.357KN = 5357KN

$$\sigma = \frac{6WL}{nbt^2}$$

$$\sigma = \frac{6 \times 5357 \times 500}{7 \times 32 \times 14^2}$$

$$\sigma = 366.04N/mm^2$$

Assume Young modulus Y=200KN/mm^2

Deflection $\delta = \frac{\sigma \times L^2}{E \times t}$

$$\delta - \frac{366.04 \times 500^2}{200 \times 10^3}$$

$\boldsymbol{defletion\ \delta}$ **=32.67mm**

DIAMETER OF EYE

$$W = d \times t \times p_b$$

D=$\frac{5357}{32 \times 8}$=20.92mm

Maximum bending moment
m=$\frac{5357 \times 36}{4} = 48213Nmm$

Shear modulus =$\frac{\pi \times d^3 b}{32}$

=$\frac{\pi \times 20.92^3}{32}$

Z=785$\boldsymbol{mm^3}$

BENDING STRESS

$\sigma_b = \frac{maximum\ bending\ moment}{shear\ modulus}$

=$\frac{4821.3}{785}$

$\boldsymbol{\sigma = 61.41N/mm}$

Length of leafs

Ineffective length –length =80mm-l

Length of smallest length =$\frac{effective\ length}{n-1}$+ineffective length

Length of first leaf =$\frac{920}{6} + 80 = 235mm$

Length of second leaf $= 2 + 80 = 385mm$

Length of third leaf $= \frac{920}{6} \times 3 + 80 = 540mm$

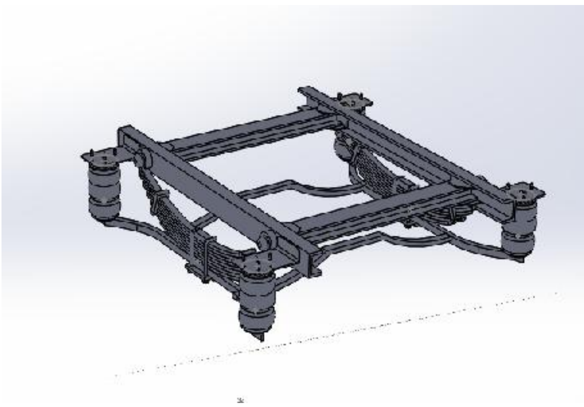
Length of fourth leaf $= \frac{920}{6} \times 4 + 80 = 700mm$

Length of fifth leaf $= \frac{920}{6} \times 5 + 80 = 850mm$

Length of six leaf $= \frac{920}{6} \times 6 + 80 = 1000mm$

There 2 full length leaf spring of 1000mm.

III. DESIGN OF COMBINED SUSPENSION SYSTEM ISOMETRIC VIEW:



IV. ANALYSIS OF LEAF SPRING USING ANSYS:

Static Structural Analysis has been done on the frame for a load of 75KN on the leaf spring on both pins are fixed and load will act on entire system

The following data has been inferred :

- ✓ The total deformation of the frame has undergone negligible deformation indicating that it is well within the factor of safety values of structural C45 steel used in the frame construction.
- ✓ The strain energy is within permissible values for the given material.
- ✓ The shear stress is also found to negligible.

V. TOTAL DEFORMATION:

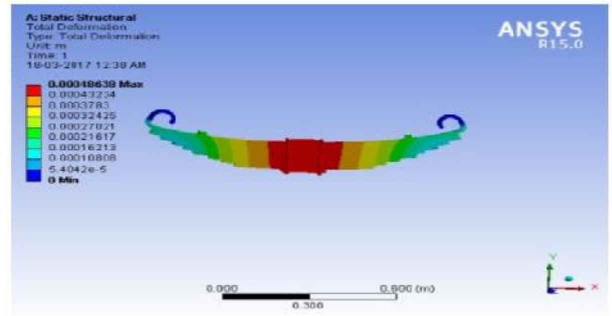


FIG:1

VI. STRAIN ENERGY :

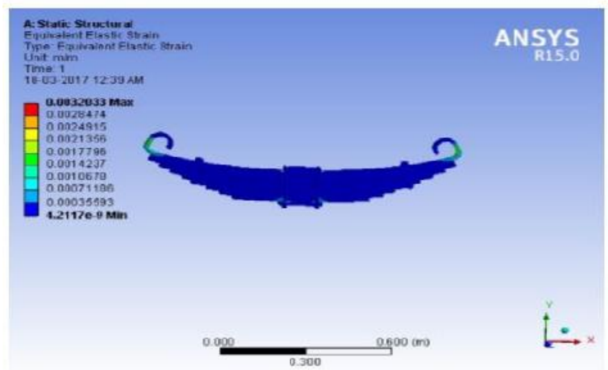


FIG: 2

VII. SHEAR STRESS:

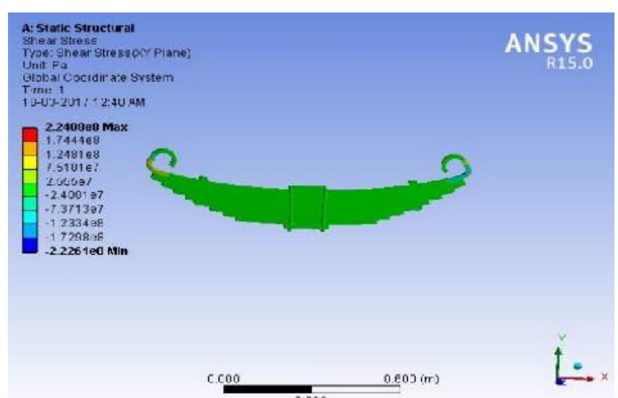


FIG 3

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ISSN (PRINT): 2454-9762
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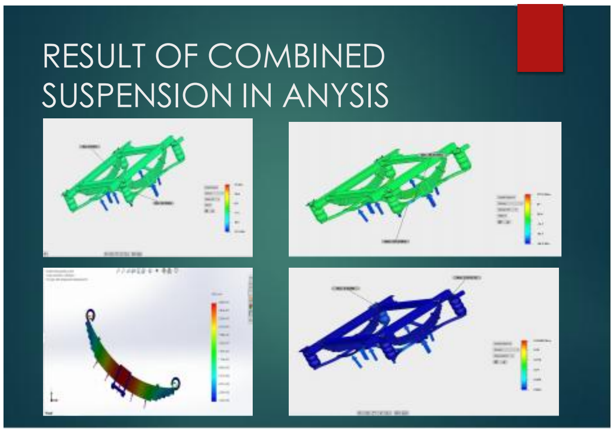
VIII. ANAYLSIS OF COMBINED SUSPENSION :



IX. ADVANTAGES OF COMBINED SUSPENSION:

- Greatly improving the driving comfort of the vehicle.
- Ride height can be artificially controlled to some extent by improving the resistance.
- Reduce fuel consumption and improve vehicle stability.
- Cost of maintenance is less.
- Increase stability of system.
- If anyone spring is fails, we can manage with another system.

X. DISADVANTAGES OF COMBINED SUSPENSION

- Initial cost is high due to addition of rod.
- It is only used high duty vehicle.

XI. FUTURE SCOPE

- Make it work in light duty vehicle by hanging size of air bellows and leaf spring
- Weight of leaf spring and air suspension will be reduced by changing the materials of it.
- We can implement this system in passenger vehicle, so that it increase the comfort of vehicle

XII. CONCLUSION:

The combined leaf spring and air lift suspension will enhance the shock absorbing facility with decrease in maintenance cost, increase the factor of safety of vehicle and strain energy is absorbed by air suspension so that it increase comfort in heavy duty vehicle .

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