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Off-road Suspension Design and Analysis

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Abstract: The suspension system is used to observe the vibrations from shock loads due to irregularities of the road surface. It performs its function without impairing the stability, steering (or) general handling of the vehicle. An off-road vehicle (BAJA ATV here) has limited power and has to endure through rough tracks so weight reduction of the vehicle becomes an important aspect. This investigation includes comparison of modelling and analyses of primary suspension spring of materials – ASTM a229 and ASTM a227 and suggested the suitability for optimum design. The results show the reduction in overall stress and deflection of spring for chosen materials.

Keywords: Suspension, Coil Spring, Off road, BAJA, CATIA, ANSYS, Simulation, Maneuverability, ASTM.

I. INTRODUCTION

The complete suspension is to observe the vehicle body from road shocks and vibrations otherwise it is transferred to the passengers and load.

It must keep the tires in contact with the road, regardless of road surface. The spring act as an elastic object used to store mechanical energy.

They can twist, pulled (or) stretched by some force and can return to their original shape when the force is released. A coil spring is made from a single length of special wire, which is heated and wound on a former, to produce the required shape.

The load carrying ability of the spring depends on the diameter of the wire, the overall diameter of the spring, its shape, and the spacing of the coils.

Normally, helical spring failure occur due to high cyclic fatigue in which the induced stress should remain below the yield strength level and also with poor material properties.

The static analysis of primary suspension system, their work is carried out on modelling helical spring in CATIA V5 and analysis in ANSYS of primary suspension spring with two materials ASTM A229 and ASTM A227.

Thus the springs are to be designed for higher stresses with small dimensions to have better spring design which leads to save in material and reduction in weight.

II. METHODOLOGY

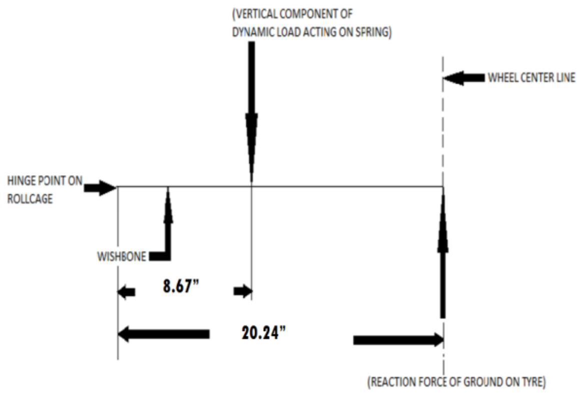
In this work modelling and analysis has been carried out on different materials for helical spring.

The materials chosen are chrome vanadium steel material, low carbon structural steel material; the specifications, modelling and analysis are as follows.

A. Material Properties:

SR NO	PROPERTIES	ASTM A227	ASTM A229
1.	Tensile strength psi*10^3	1350 – 1470 MPa	1420 - 1590 MPa
2.	Density (kg/m^3)	7560	7850
3.	Modulus of elasticity (GPa)	180	200
4.	Bulk modulus (Gpa)	150	160
5.	Poisson's ratio	0.28	0.29
6.	Shear modulus (GPa)	80	80

B. Design Specifications:
1. Mass per wheel = 60 kg
2. Factor for static to dynamic condition: 3



Angle of inclination of the strut
From horizontal = θ = 60^0
Point of attachment of strut from chassis end = 8.67"

1. Reaction force acting from the ground on the wheel = Mass per wheel * 9.81 = 60 * 9.8 = 588.6 N

2. Horizontal distance of reaction force from hinge point = 20.24”
3. By talking moment about hinge points 588.6 * 20.24” = spring force * 8.67” Spring force = 1374.0788 N

- Considering dynamic factor

Dynamic force acting on the spring = 4122.23 N

- Since the spring travel should be 4”
- Required spring stiffness

= Dynamic force / spring deflection
= 4122.23 / 101.6
= 40.57
= 41 N/mm

- Shear stress = 0.5 * Ultimate tensile stress

Shear stress (τ) = 550 N/mm^2

- Taking spring index = 8

By Wahl’s factor,

$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} = 1.184$

So,

$\tau = [8PC/\pi d^2]$

$550 = 1.184 * [\frac{8*1374.0*8}{\pi * d^2}]$

D = 7.76 mm
~10 mm

- Mean coil diameter (D) = c * d

= 80 mm

- No. of active coil (N) $\delta = \frac{8PD^3N}{Gd^4}$

$101.6 = \frac{8*1347.0788*(80)^3*N}{81370*10^4}$

= 14.688
N ~16 coils

Assuming that the spring has square and ground ends.

$N^1 = N + 2 = 18$ coils

- Solid length of spring = N^1 * d
  = 180 mm
- Total axial gap = (N^1 - 1)* 1
  = 17 mm
- Free length = (Solid length + gap +δ)
  = 298.6 mm
- Pitch of coil = $\frac{\text{Free length}}{N^1-1}$
  $= \frac{298.6}{18-1}$
  = 17.56 mm
- $D_o = D + d = 90$ mm
- $D_i = D – d = 70$ mm

C. Modeling Of Helical Spring**:**

A coil spring is designed by using CATIA V5 as per the specifications and analyzed by ANSYS 14.5 software. In this the spring behaviour will be observed by applying different materials loads, to optimum stresses and the result shows best material. Model of the spring will be first created by using CATIA begin by drawing a line of 298.6 mm length and it is the free height of spring. The line is at a distance of 40 mm from vertical axis and it is outer diameter of the coil. Next enter the pitch of spring. Pitch is calculated by free height of coil the spring divided by the number of turns. In this 298.6/16=17.56mm create the circle of wire diameter 10mm of spring and create Solid model of helical spring as shown in figure 1.

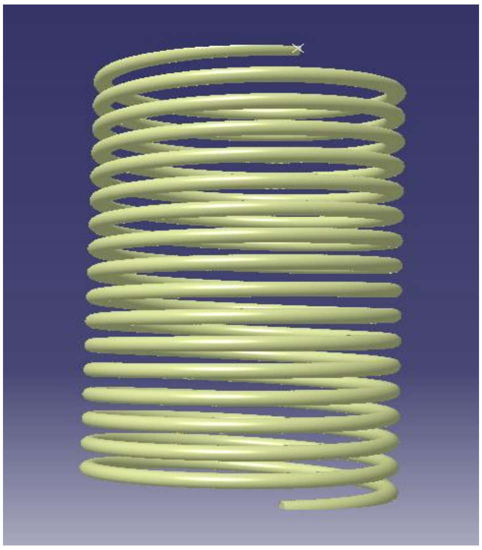


Fig. 1 Design of helical spring

D. Analsys:
Material: ASTM A227
Chemical Composition:
C – 0.45 - 0.85%,Mn – 0.60 – 1.30% Load: 600N

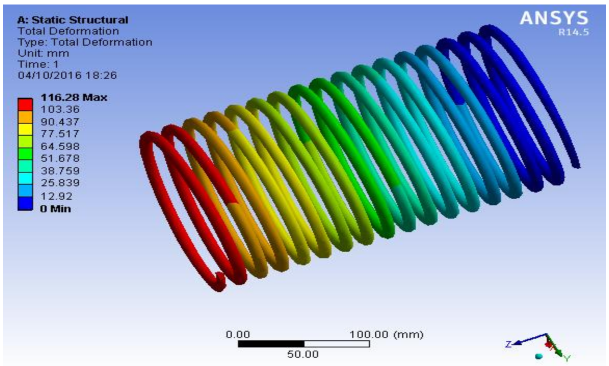


Fig. 2 Total Deformation

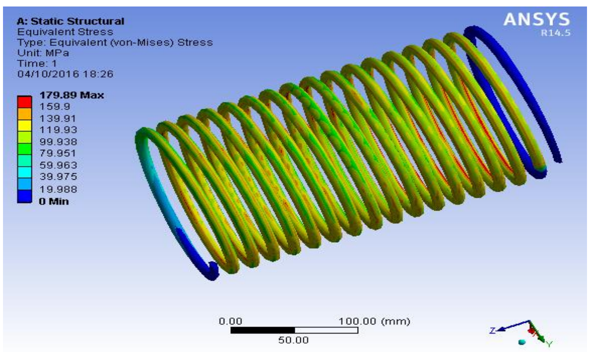


Fig. 3 Equivalent Stress

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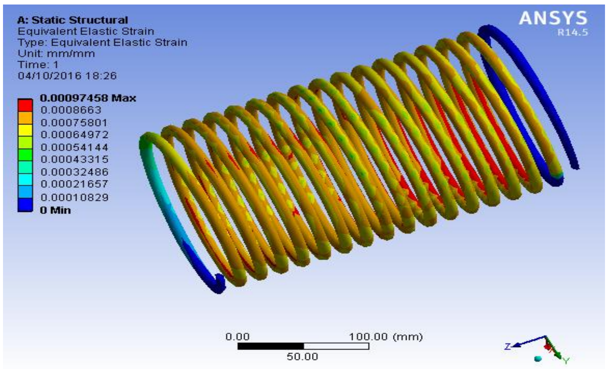

Fig. 4 Equivalent Elastic Strain

LOAD: 1200N

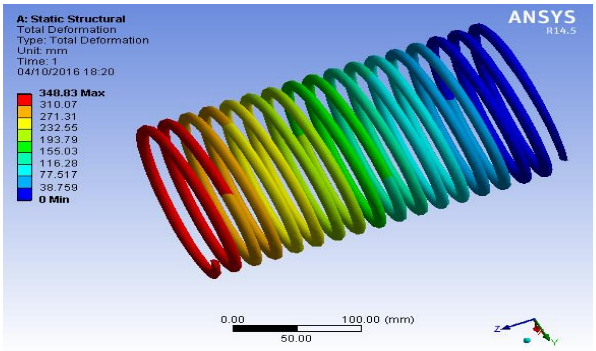

Fig 5 Total Deformation

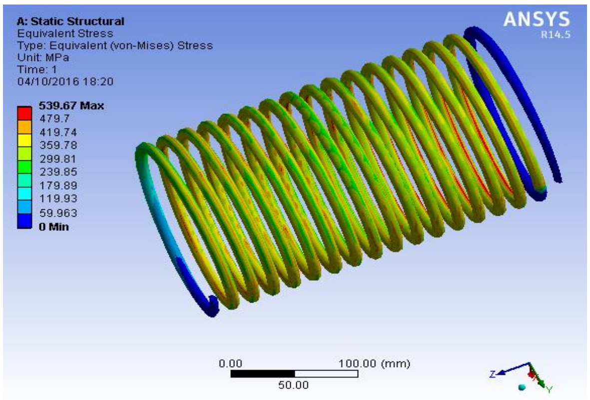

Fig. 6 Equivalent Stress

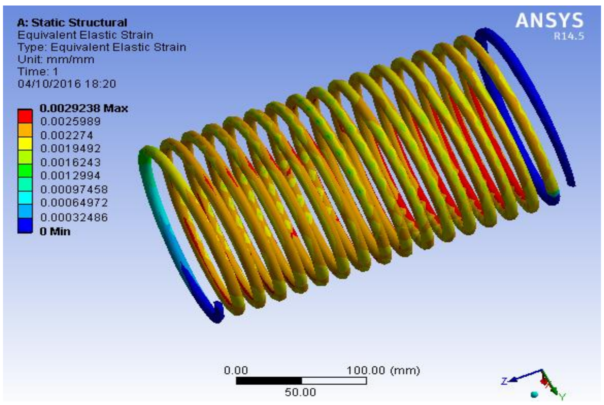

Fig. 7 Equivalent Elastic Strain

LOAD: 2500N

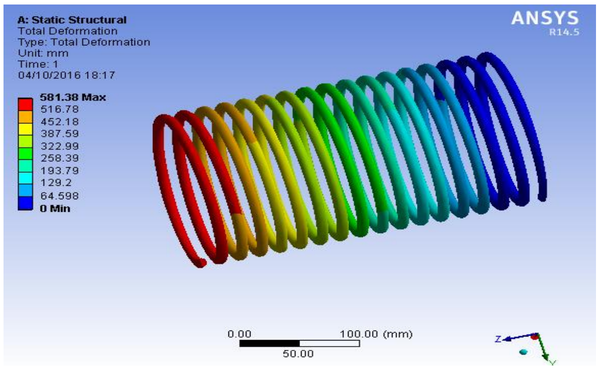

Fig. 8 Total Deformation

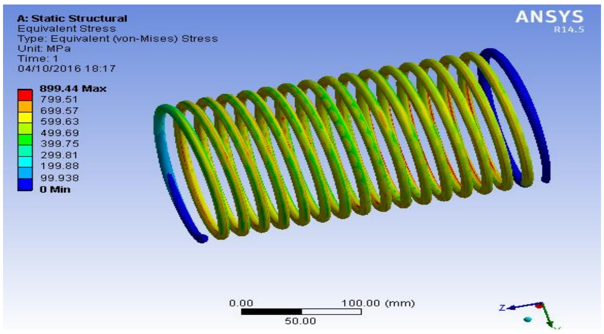

Fig. 9 Equivalent Stress

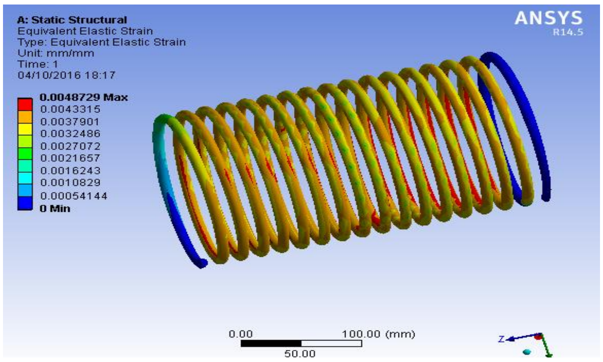

Fig. 10 Equivalent Elastic Strain

Material: ASTM A229
Chemical Composition:
C – 0.55 – 0.85% ,Mn – 0.60 – 1.20% Load: 600N

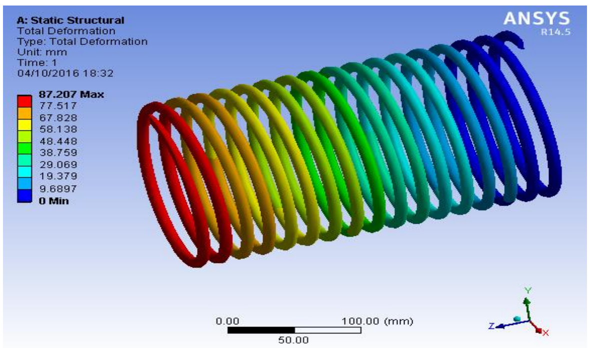

Fig. 11 Total Deformation

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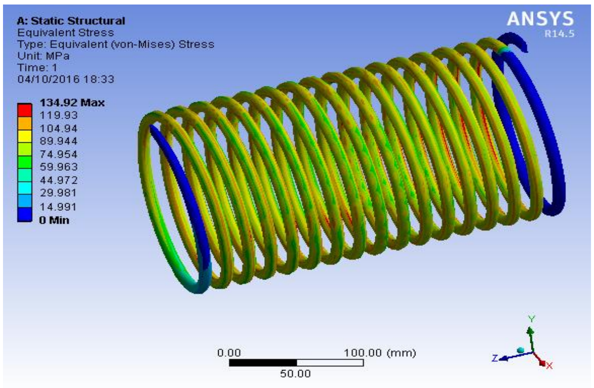

Fig. 12 Equivalent Stress

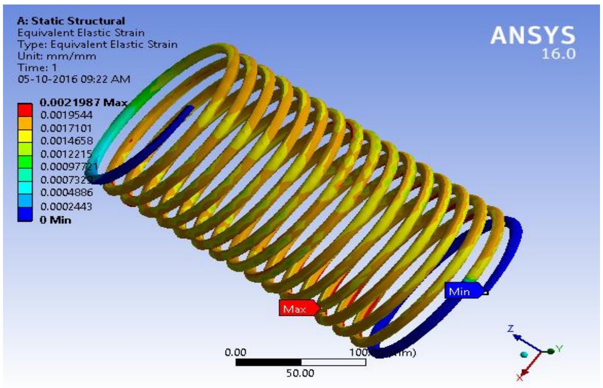

Fig. 16 Equivalent Elastic Strain

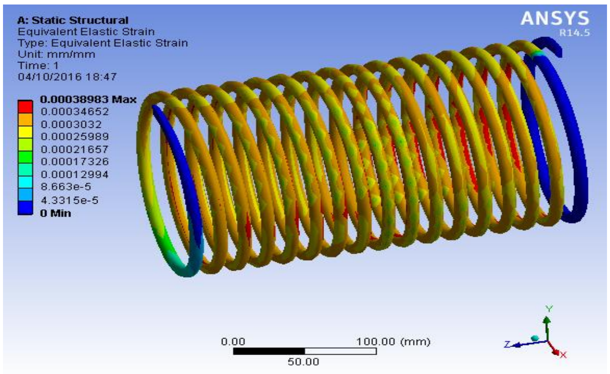

Fig. 13 Equivalent Elastic Strain

LOAD: 2500N

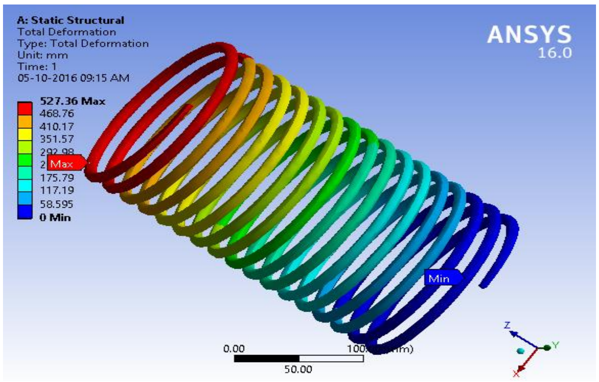

Fig. 17 Total Deformation

LOAD: 1200N

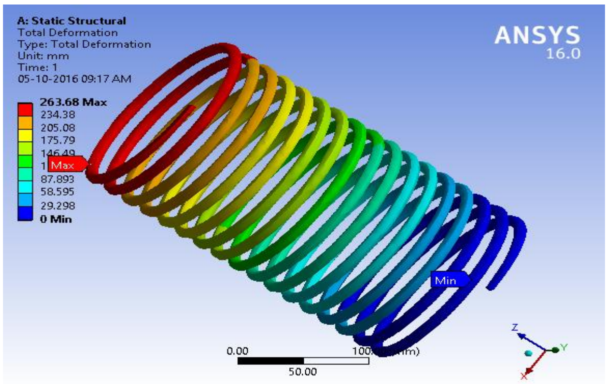

Fig. 14 Total Deformation

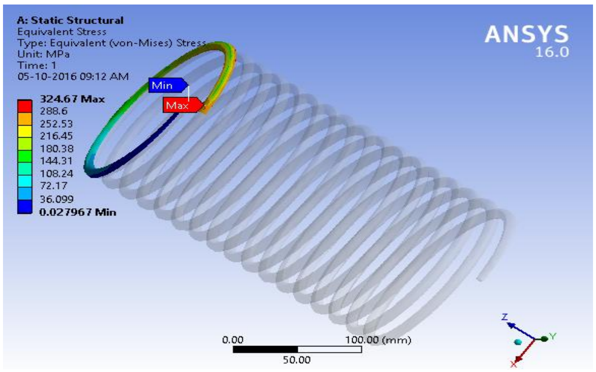

Fig. 18 Equivalent Stress

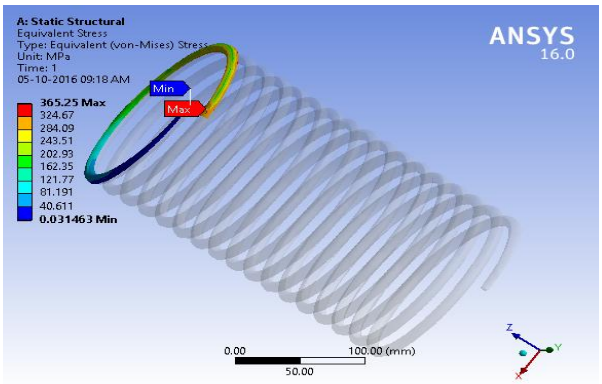

Fig. 15 Equivalent Stress

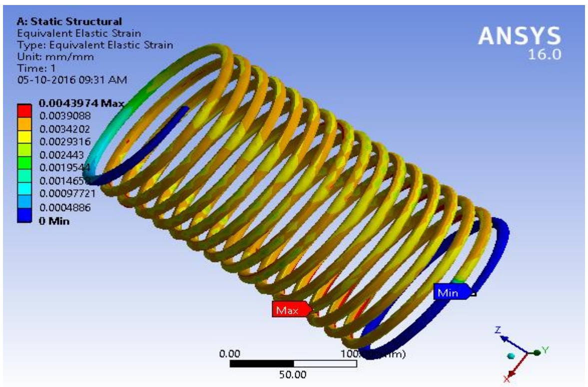

Fig. 19 Equivalent Elastic Strain

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III.CONCLUSION

1. The analysed stress values are less than their respective yield stress values. So our design is **safe**.
2. The stress value is less for **ASTM A229** than ASTM A227.
3. So we can conclude that as per our analysis using material ASTM A229, is best suited for **off-road application**.

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