DESIGN And STATIC ANALYSIS Of TWO WHEELER SUSPENSION

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ABSTRACT- A SUSPENSION SYSTEM OR SHOCK ABSORBER IS A MECHANICAL DEVICE DESIGNED TO SMOOTH OUT OR DAMP SHOCK IMPULSE, AND DISSIPATE KINETIC ENERGY. THE SHOCK ABSORBERS DUTY IS TO ABSORB OR DISSIPATE ENERGY. IN A VEHICLE, IT REDUCES THE EFFECT OF TRAVELING OVER ROUGH GROUND, LEADING TO IMPROVED RIDE QUALITY, AND INCREASE IN COMFORT DUE TO SUBSTANTIALLY REDUCED AMPLITUDE OF DISTURBANCES. WHEN A VEHICLE IS TRAVELING ON A LEVEL ROAD AND THE WHEELS STRIKE A BUMP, THE SPRING IS COMPRESSED QUICKLY. THE COMPRESSED SPRING WILL ATTEMPT TO RETURN TO ITS NORMAL LOADED LENGTH AND, IN SO DOING, WILL REBOUND PAST ITS NORMAL HEIGHT, CAUSING THE BODY TO BE LIFTED. THE WEIGHT OF THE VEHICLE WILL THEN PUSH THE SPRING DOWN BELOW ITS NORMAL LOADED HEIGHT. THIS, IN TURN, CAUSES THE SPRING TO REBOUND AGAIN. THIS BOUNCING PROCESS IS REPEATED OVER AND OVER, A LITTLE LESS EACH TIME, UNTIL THE UP-AND-DOWN MOVEMENT FINALLY STOPS. IF BOUNCING IS ALLOWED TO GO UNCONTROLLED, IT WILL NOT ONLY CAUSE AN UNCOMFORTABLE RIDE BUT WILL MAKE HANDLING OF THE VEHICLE VERY DIFFICULT. THE DESIGN OF SPRING IN SUSPENSION SYSTEM IS VERY IMPORTANT.

IN THIS PROJECT, SPRING IS DESIGNED AND THE 3D MODEL IS CREATED USING MODELLING SOFTWARE. STATIC ANALYSIS IN DONE ON THE SPRING BY VARYING MATERIALS. THE ANALYSIS IS DONE BY CONSIDERING LOADS AND BIKE WEIGHT. IN THIS ANALYSIS, MAXIMUM SHEAR STRESS AND TOTAL DEFORMATION IS CALCULATED USING ANSYS SOFTWARE. AND THE COMPARISON IS DONE ON ALL MATERIALS.

Keywords— Spring Materials, Spring Design, Deflection, Shear Stress, Analysis.

I. INTRODUCTION

The suspension system is the integral part of the vehicle. The purpose of the suspension system is to isolate the vehicle body from the irregular bad roads and maintain the contact of the wheel with the road. Efficient suspension system should provide the highest comfort to the rider with absorbing all the road disturbances. Today we can see the simple leaf spring suspension system to the complicated independent algorithm suspension systems in the various types of vehicle. Depending on the vehicle and type of load it carries i.e. passengers; goods etc. suspension system will be designed. An efficient suspension system should absorb road disturbances as well as load disturbances. Road disturbances include hill type large magnitude in low frequency and road roughness low magnitude of high frequency. Load disturbances include external loads, braking loads, turning loads, accelerating loads crash loads etc. 2-Wheeler suspension is an important category where comfort, ride quality, handling is decided by the suspension system. In India 2-wheeler market is growing in vertical direction and India has the highest number of the 2-wheelers. Indian roads are very bad in nature. Reliability of the vehicle, handling and ride comfort will be greatly decided by the suspension system. So a lot of research is going on to improve the suspension system of 2-wheelers.

II. Spring Design Process

A) Spring Material

Commonly used spring materials-

One of the important considerations in spring design is the choice of the spring material. Some of the common spring materials are given below.

Comparison Of Materials -

Properties	Materials		
	Cold-drawn Carbon Steel	Chrome-silicone Steel	Titanium Alloy
1. ASTM designation or composition	ASTM A228	ASTM A410	Ti-5Al-4V
2. Properties-			
I. Ultimate Tensile Strength	3000 MPa	1800Mpa	1210MPa
II. Density	7.85	7.9	4.65
III. Modulus of Elasticity	$30x10^3$ GPa	$29x10^3$ Gpa	$10x10^3$ Gpa
3. Common Uses	Most popular material for all types of spring manufacturing.	Used for spring application in heavy and high temperature environment.	Due to light weight, it is used in race cars and bikes.
4. Approx. Cost per kg	100 Rupees/kg.	360 Rupees/kg.	1600 Rupees/kg.

Table 1. Comparison of materials

B) *Spring manufacturing processes-*

If springs are of very small diameter and the wire diameter is also small then the springs are normally manufactured by a cold drawn process through a mangle. However, for very large springs having also large coil diameter and wire diameter one has to go for manufacture by hot processes. First one has to heat the wire and then use a proper mangle to wind the coils. Two types of springs which are mainly used are, helical springs and leaf springs. We shall consider in this course the design aspects of two types of springs.

III. DESIGN OF PROPOSED WORK

Design Calculations-

Calculations for spring-

Materials to be used for Analysis-

Materials	S (ut)	Young's Modulus	Density	Poisson's Ratio
Cold drawn Carbon Steel	3000MPa	207	7.85	0.31
Crome-Silicone Steel	1800Mpa	200	7.9	0.28
Grade5 Titanium alloy	1210Mpa	112	4.65	0.3

Table 2:Materials for spring

Terminology-

d= Wire diameter of spring (mm)

D= Mean diameter of spring coil (mm)

C= Spring Index

N= total no. of coils

K=spring stiffness

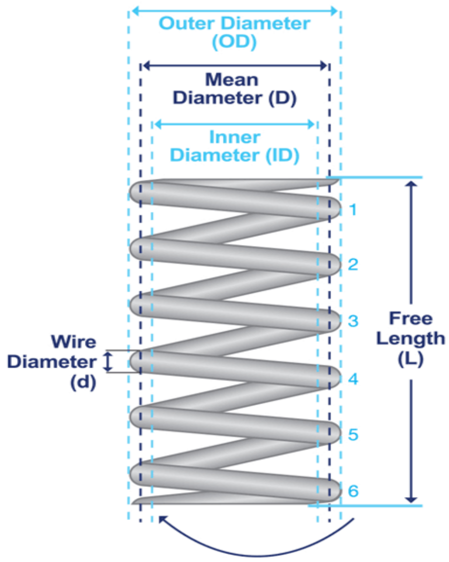

Fig.Dimensions Of Spring

Lets assume total weight of bike is 150kg,

Weight of passenger=80kg

Total weight=230kg

If we consider 60-40 weight distribution, weight on rear wheel=138kg

But due to weight transfer and other conditions, W=160kg

So, Load on Rear suspension = 160x9.81=1569.6N

And Total Length = 172 mm.

1.Standard values of d&C,

d = 10mm

C= 6

As,

$$C = \frac{D}{d}$$

D=10X6

D=60mm

2.Wahl's Stress Factor,

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

Kc=1.35

3.Stress on spring,

$$\tau = K \times \frac{8PC}{\pi d^2}$$

$\tau = 1.35 \text{ x } \frac{8 \, x \, 1569.6 \, x \, 6}{\pi \, x \, (10)^2}$

τ=323.753 N/mm2

For safe design,

$$\tau \leq 0.5Sut$$

$\tau \leq 0.5 \times (1210MPa)$ ………. design is safe.

4.Deflection of spring-

$\delta = \frac{8 \, x \, P \, x \, C^3 \, x \, N}{G \, d}$

$\delta = \frac{8 \, x \, 1569.6 \, x \, (6)^3 \, x \, 7}{(44000) \, x \, 10}$

<u>δ = 43.145 mm.</u>

5 Pitch-

$P = \frac{FREE\ LENGTH}{N}$

$P = \frac{172}{6}$

<u>P = 28.666 mm.</u>

6 Spring rate (K)-

$$K = \frac{Gd^4}{8D^3N}$$

$K = \frac{(44000) \, x \, (10)^4}{8 \, x \, (60)^3 \, x \, 7}$

<u>K = 36.375</u>

<u>Final Dimensions Are</u> -

1.d (diameter of coil) = 10mm

2. D (diameter of spring) = 60mm

3. Kc (Wahls Factor) = 1.35

4. τ (stress) = 323.753 N/mm2

1. δ (Deformation) = 43.145 mm

2. P (Pitch) = 28.666 mm

3. K (Spring Const.) = 36.375

IV. CAD DESIGN-

<u>Autodesk Inventor 2022</u> was used for CAD Model design.

Assembly Of Components-

All 3 components are assembled and constrains are added for Analysis part. It is made sure that Guide can slide into lower mount and constrains are added accordingly.

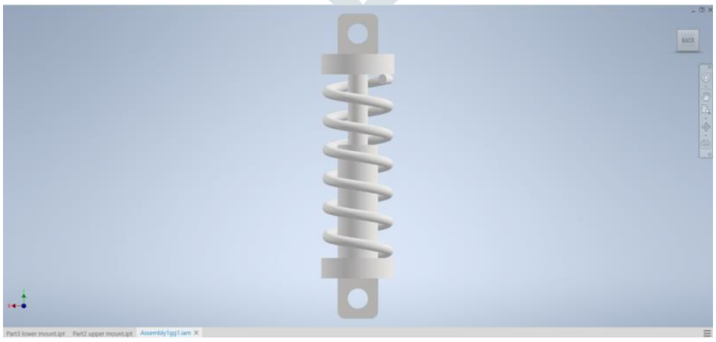

Fig. Assembly of the suspension.

V. ANALYSIS OF ASSEMBLY-

I. *Engineering Data* - Material properties were added according to Table.

And for mounts, aluminium alloy material is selected from Ansys library.

II. *Geometry and Model* - The Autodesk Inventor Assembly model was imported into Ansys Workbench.

III. *Meshing* - Fine mesh was generated on the model.

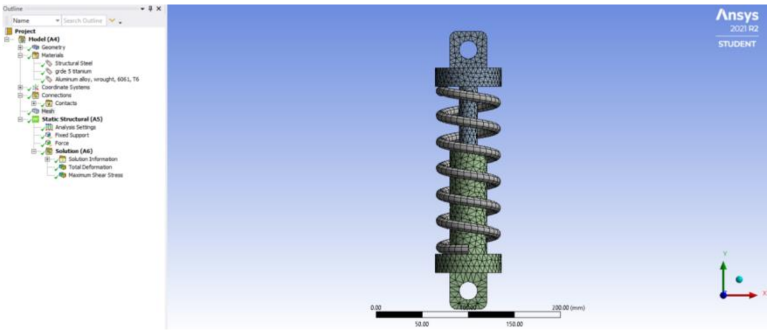

Fig. Meshed Model of Assembly.

IV. *Setup* - Fixed support added to one end (A) and Calculated Force of 1569.6N was applied on other end (B) in the direction shown below-

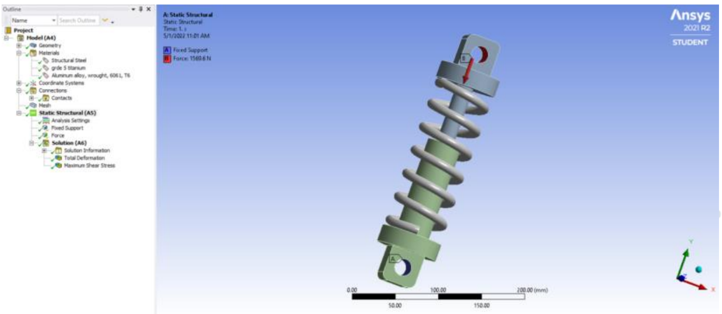

Fig. Constrains And Force applied for static structural analysis

V. Static Structural Analysis -

Analysis was carried on models of all 3 materials.

i. *Grade 5 Titanium Alloy* - Total Deformation and max. Shear stress -

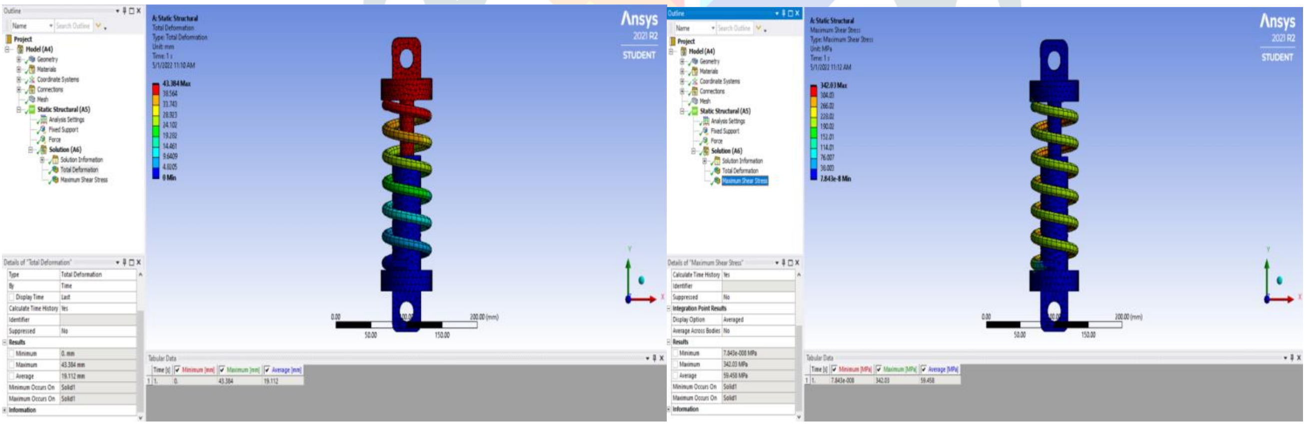

Fig. Total Deformation and Maximum Shear Stress for titanium alloy

ii. *Cold Drawn Carbon Steel* - Total Deformation and max. Shear stress -

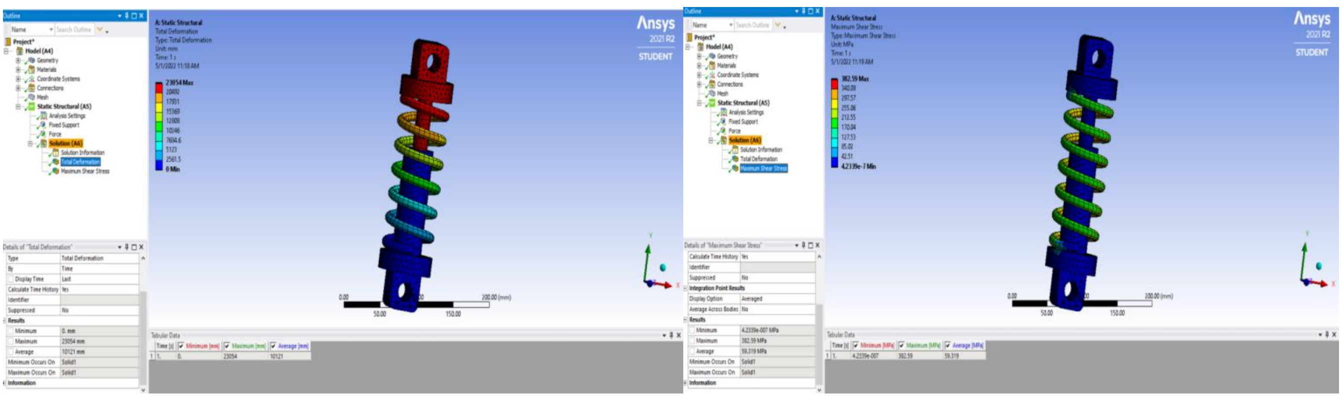

Fig. Total Deformation and Maximum Shear Stress for Cold Drawn Carbon Steel

iii. *Chrome Silicone Steel* - Total Deformation and max. Shear stress -

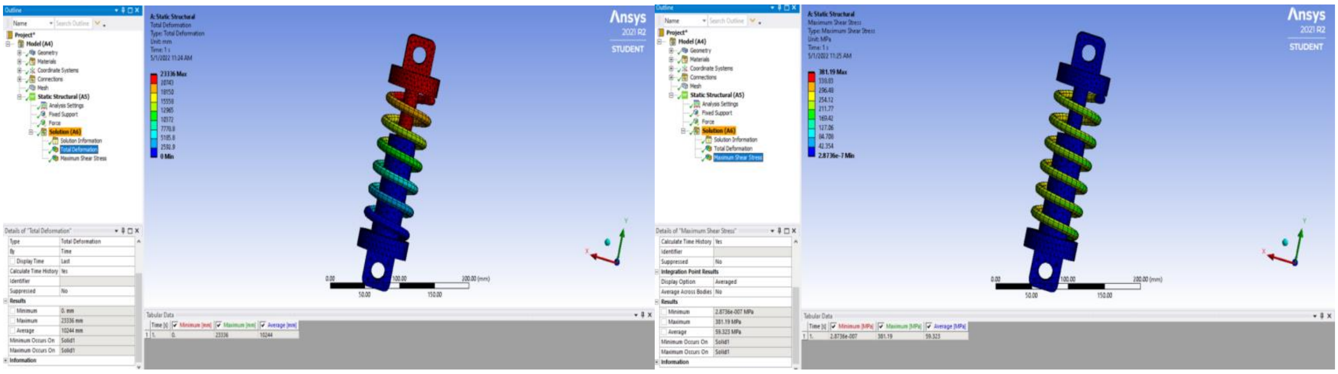

Fig. Total Deformation and Maximum Shear Stress for Chrome Silicone Steel

VI. RESULTS

Materials	Total Deformation	Max Shear Stress
Titanium Alloy	43.441mm	344.67MPa
Carbon Spring Steel	23.054mm	382.59MPa
Chrome Silicone Steel	23.336mm	381.19MPa

Table3. Results of Analysis

VII. CONCLUSIONS

1. Carbon Spring Steel and Chrome Silicone Steel springs have almost identical Deformation and Max Shear Stress.
2. But Titanium Alloy has significantly higher Total Deformation for less Maximum shear stress. Hence Titanium alloy is more well suited material for suspension spring.

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