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Analysis of Helical Spring in Monosuspension System Used in Motorcycle

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Abstract- Shock absorbers are important part of vehicle's suspension, which is manufactured to reduce shock impulse. Shock absorbers work on the principle of fluid displacement on both the compression and expansion cycle. The modern motorcycle uses suspension to accomplish several things; it provides a smooth comfortable ride absorbing bumps and imperfections in the road. It also allows the rider to fine tune the machine to give better control over the machine when riding.

The project deals with analysis of mono suspension by using FE approach and validated with analytical with varying speed. Helical spring is the most common element that has been used in suspension system. In this research, helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. Maximum stress and deflection have been compared at various speeds for carbon steel material.

Index Terms- Monosuspension spring, FE Analysis, Deflection and shear stresses.

1. INTRODUCTION

A helical spring may be defined as an elastic member whose primary function is to deflect or distort under the action of applied load. It recovers its original shape when load is released. They are made of wire coiled into a helical form, the load being applied along the axis of the helix. The main property of helical spring is to act in tension or in compression when the load is applied at both ends. Helical coils are mostly uses in springs, cables etc. These are used in brakes and clutches for applying the forces and controlling the motion of vehicles and machines. Similarly these are also useful for storing the energy in watches and toys. Most important application of helical spring is for reducing the effect of shock and vibrations invehicles and machine foundation. These are also useful for measurement of the forces.

In this research, monosuspensionspring of Unicorn bikeis considered. The dimensions of the mono suspension spring are considered as follows.

Length a (l_f) = 270 mm

Mean dia. (D) = 58 mm

Wire dia. (d) = 12 mm

Pitch (p) = 30 mm

Spring index (c) = D/d = 4.83

Total weight =300 Kg =2943N,

Here, analysis of mono suspension spring is carried out by varying the different speed of bike at a bump of 50mm., The analysis is carried out using finite element method with FE software ANSYS. Shear stress and deflection are calculated analytically and compared with FE results.

2. DETERMINATION OF STRESSES AND DEFLECTION OF MONO SUSPENSION SPRING USING ANALYTICAL METHOD

Here, the dimensions of the mono suspension spring are considered as follows. Length a (l_f) = 270 mm. Mean dia. (D) = 58mm .Wire dia.(d) =12 mm. Pitch (p) = 30 mm. Spring index (c) =D/d = 4.83Total weight =300 Kg =2943N,In this, deflection and shear stresses are calculated by using analytical equations.The material of mono suspension spring is Carbonsteel. Following are thematerial properties of carbon steels shown in table 1.

Table 1:- Material properties of carbon steel

Sr.no	Symbols	Parameter	Values
1	E	Young's modulus	170×10^3
2	G	Modulus of elasticity	80×10^3
3	M	Poisson's ratio	0.295

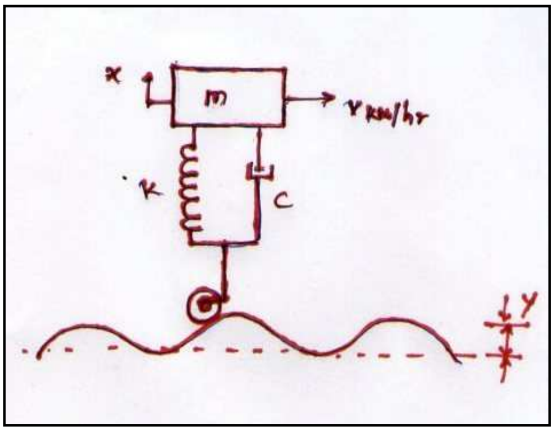

Fig 1:- Model of monosuspension spring

Figure 1 shows model of monosuspension motor vehicle that can vibrate in vertical direction while travelling over a rough road .The vehicle has mass of 300kg .The suspension system has a spring constant(spring rate) of 61312.5 N/m and here we consider a damping ratio of ξ =0.5 The road surface varies with an amplitude of Y = 50mm.Calculation made for 1km/hr to 40 km/hr& deflection & stresses value determine atvarious speed.The frequency ω of the base excitation can be found by dividing the vehicle speed v km/hr by the length of one cycle of road roughness.

For 3Km/hr

$\omega = 2\pi f = 2\pi\ (V \times 1000)/3600 \times (1/1) = 1.74\ v$ rad/s

$\omega = 1.74 \times 3 = 5.22$ rad/s

The natural frequency of the vehicle is given by

$\omega_n = \sqrt{k/m} = \sqrt{122625/300} = 20.21$rad/s

Frequency ratio:-r = $\omega / \omega n = 5.22 / 20.21 = 0.26$

Amplitude ratio:-(Displacement transmissibility)

$X/Y = \{ 1 + (2\xi r)^2 / (1 + r^2)^2 + (2\xi r)^2 \}^{1/2}$

$X/Y = \{1+(2\times0.5\times0.26)^2/(1+0.26^2)^2+(2\times0.5\times0.26)^2\}^{1/2}$

X/+Y = 1.07

Thus the displacement of vehicle at 3 km/hr is given by

X= 1.07 × Y = 1.07 × 0.05 = 0.0534 m = 53.4 mm

This indicates that a 50mm bump in the road is transmitted as a 53.4mm deflection to the chassis.

Forces (F) $= \frac{\delta G d^4}{8 D^3 n}$

$= (53.4\times42\times10^3 \times 12^4) / (8\times58^3 \times9)$

F= 6305.7 N

Stresses(τ)= $K \frac{8FD}{\pi d^3}$

$\tau = (1.32 \times 8 \times 6305.7\times58) / (\pi \times12^3)$

τ = 711.43 N

Table 2 shows the Deflection and stress results at various speeds by analytical method.

Sr.No	Speed	ω	ω_n	r	ξ =0.5	Force (F)	Shear stress (τ)
1	3	5.2	20.2	0.26	53.4	6305.7	711.4
2	10	17.4	20.2	0.86	71.1	8395.9	947.25
3	25	43.5	20.2	2.15	28	3306.1	372.9
4	40	69.6	20.2	3.44	15.7	1853.9	209

3. DETERMINATION OF STRESSES AND DEFLECTION OF MONO SUSPENSION SPRING USING FE APPROACH

Finite Element Analysis (FEA) is one of the most popular mechanical engineering applications. This is attributed to the fact that the finite element method is perhaps the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape or geometry, any material properties, any boundary conditions and any loading conditions. The generality of the finite element methods fits the analysis requirement of today's complex engineering systems and designs were closed from solutions of governing equilibrium equations arc usually not available. In addition, it is efficient design tool by which designers can perform parametric design studies by considering various design cases (different shapes, material, loads, etc) analysis them and choosing the optimum design. The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. The method originated in the aerospace industry as a tool to study stress in a complex airframe structures. It grew out of what was called the matrix analysis method used in aircraft design. The method has gained increased popularity among both researchers and practitioners.For FE analysis, firstly CAD model of mono suspension spring is created in Pro-E software. After that this model is imported in FEA software ANSYS 11.Here spring is meshed with element of brick 8 node solid 45. For stress analysis, constraints are applied at the one side of spring and the force is applied on the center of other side of spring. By giving these conditions, deflection and shear stresses are calculated. at various speeds as shown below.

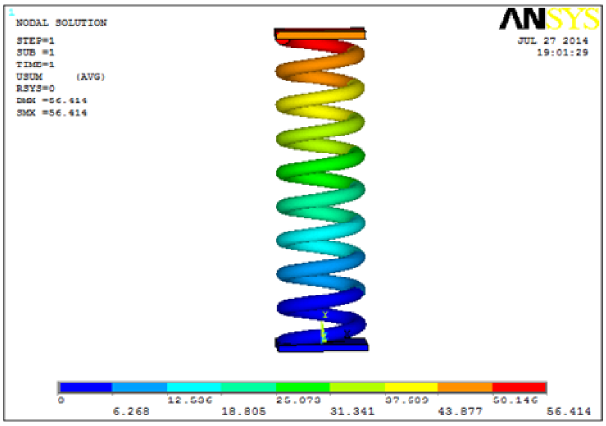

Fig.2:-Deflection result for mono suspension at 3 km/hr

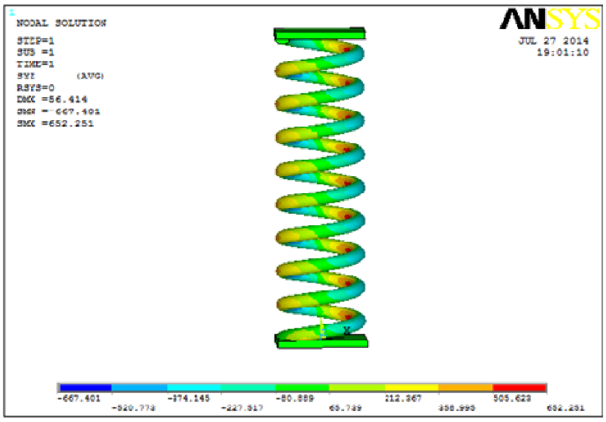

Fig.3:-Stress result for mono suspension at 3 km/hr

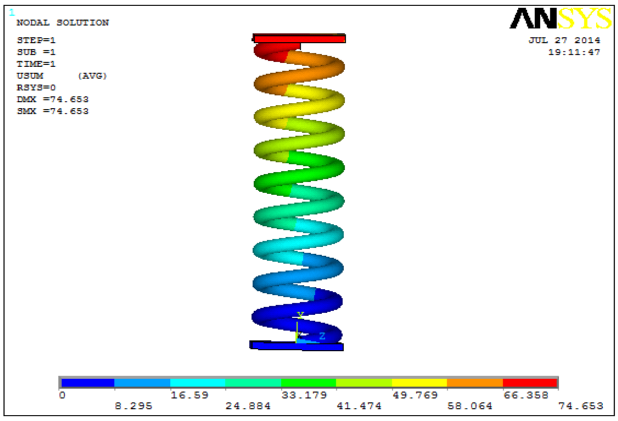

Fig.4:- Deflection result for mono suspension at 10km/hr

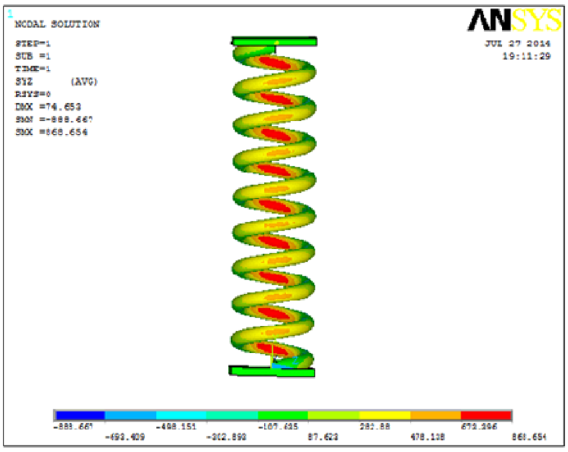

Fig.5:-Stress result for mono suspension at 10 km/hr

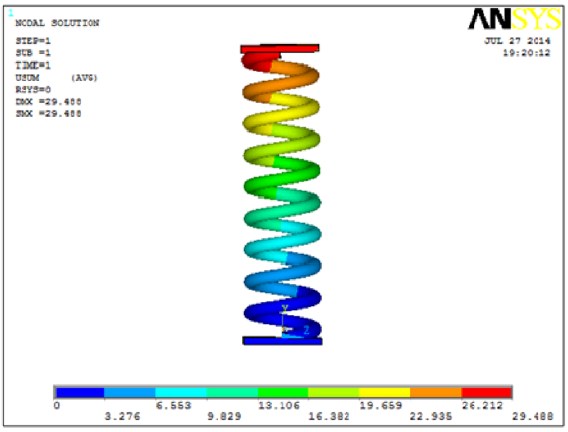

Fig.6:-Deflection result for mono suspension at 25 km/hr

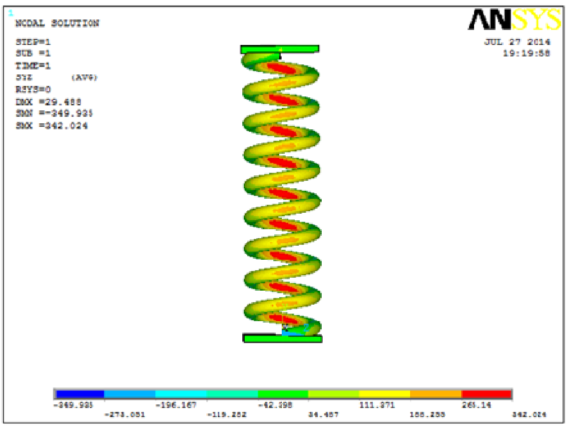

Fig.7:-Stress result for mono suspension at 25 km/hr

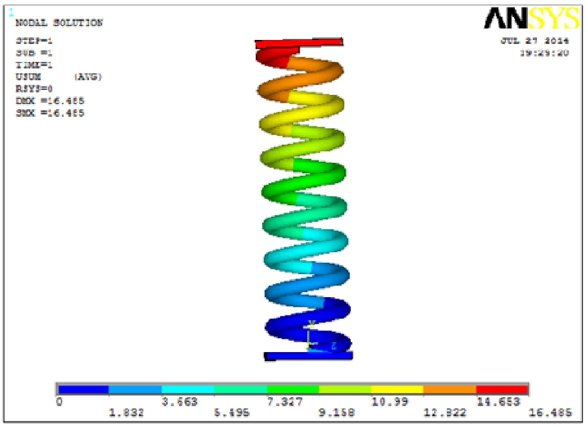

Fig.8:- Deflection result for mono suspension at 40 km/hr

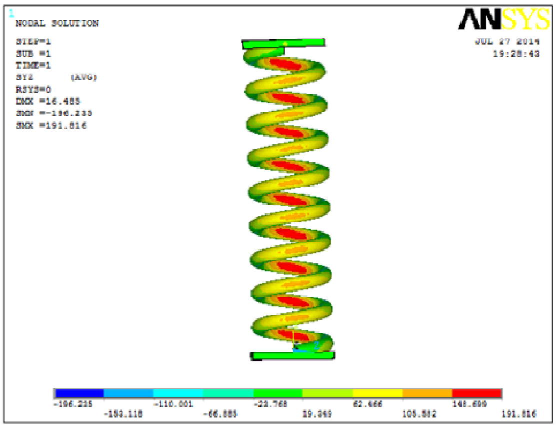

Fig.9:-Stress result for mono suspension at 40 km/hr

4. RESULT AND DISCUSSION

The analytical and FE results of mono suspension springs are determined with varying its speed are given in Table 3

Table 3.Results of mono suspension spring with varying its speed.

Sr. no	V (km /hr)	ANALYTICAL		FEA	
		Deflection (mm)	Stress (N/m m^2)	Deflection (mm)	Stress (N/m m^2)
1	3	53.4	711.43	56.41	652.25
2	10	71.1	947.25	74.65	868.65
3	25	28	372.9	29.4	342.02
4	40	15.7	209	16.48	191.81

This study presents the stress analysis of mono suspension spring. Here, stresses and deflections are calculated with changing speed and validated with FEA. From the finite element analyses, the following findings are reported.

Though, the results are elaborated in earlier chapter, the brief discussion and conclusion is presented as follows. For Mono suspension spring, it is observed that deflection get increases with increasing speed upto 10 km/hr on other hand shear stresses are also increases. But after 10km/hr, both deflection and shear stresses are going to decreases with increasing in speed. It means at higher speed, it gives low deflection and low shear stresses.

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