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Analysis of Helical Spring in Dualsuspension 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 dual 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- Dualsuspension spring, FE Analysis, Deflection and shear stresses.

1. INTRODUCTION:

A helical spring is the thing that deflects under force and regains its original position when the load is removed.The main property of helical spring is to act in tension or in compression when the load is applied at both ends. Helical springs are mostly uses in springs, cables, in brakes, clutches watches toys etc. Most important application of helical spring is for reducing the effect of shock and vibrations invehicles and machine foundation.

In this research,dualsuspensionspring ofCBZ Extreme bikeis considered. The dimensions of the dual suspension spring are considered as follows.

Free Length (l_f) = 256 mm
Mean dia. (D) = 48 mm
Wire dia. (d) = 8 mm
No. of turns (n) = 16
Pitch (p) = 16 mm
Spring index (c) = D/d = 6
Wahl's correction factor (k_s) = 1.25

Here, analysis of dual 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 DUAL SUSPENSION SPRING USING ANALYTICAL METHOD

Here, the dimensions of the dual suspension spring are considered as follows. Length a (l_f) = 256 mm. Mean dia. (D) = 48mm .Wire dia.(d) =8 mm. Pitch (p) = 16 mm. Spring index (c) =D/d = 6Total weight =300 Kg =2943N,In this, deflection and shear stresses are calculated by using analytical equations.The material of dual suspension spring is Carbon steel. 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

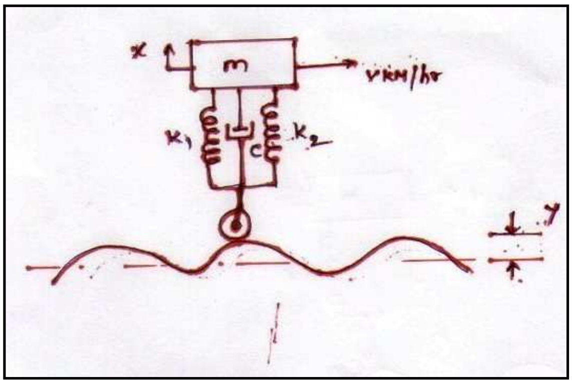


Fig 1:- Model of dualsuspension spring

Figure 1 shows model of dualsuspension 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 46714.2N/mand 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 × 1000) /3600×(1/1)=1.74 v rad/s

ω = 1.74 × 3 = 5.22 rad/s

The natural frequency of the vehicle is given by

$\omega_n = \sqrt{k/m} = \sqrt{46714.2/300} = 12.4$rad/s

Frequency ratio:-r = ω/ ωn = 5.22 /12.4 = 0.42

Amplitude ratio:-(Displacement transmissibility)

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

$X/Y=\{1+(2\times0.5\times0.42)^2/(1+0.42^2)^2+(2\times0.5\times0.42)^2 \}^{1/2}$

X/+Y = 1.17

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

X= 1.17 × Y = 1.07 × 0.05 = 0.0586 m = 58.6 mm

This indicates that a 50mm bump in the road is transmitted as a 58.6mm deflection to the chassis.

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

$= (58.6\times42\times10^3 \times 8^4) / (8\times48^3 \times6)$

F= 1356.4 N

Stresses(τ)= $K\frac{8FD}{\pi d^3}$

$\tau = (1.25 \times 8 \times 1356.4\times48) / (\pi \times8^3)$

τ = 404.8 N

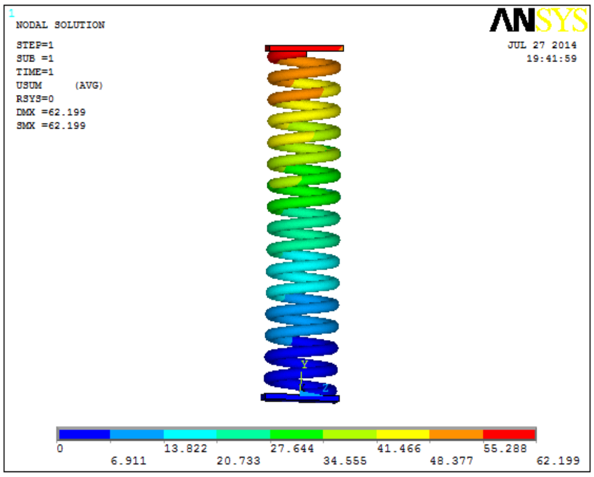
Table 2 shows the Deflection and stress results at various speeds by analytical method.

Sr .No	Speed	ω	ω_n	r	ξ =0.5	Force (F)	Shear stress (τ)
1	3	5.22	12.4	0.42	58.6	1356.4	404.79
2	10	17.4	12.4	1.4	50.6	1171.2	349.5
3	25	43.5	12.4	3.51	15.3	354.1	105.69
4	40	69.6	12.4	5.61	9.1	210.6	62.89

3 DETERMINATION OF STRESSES AND DEFLECTION OF DUAL 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.

For FE analysis, firstly CAD model of dual 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.



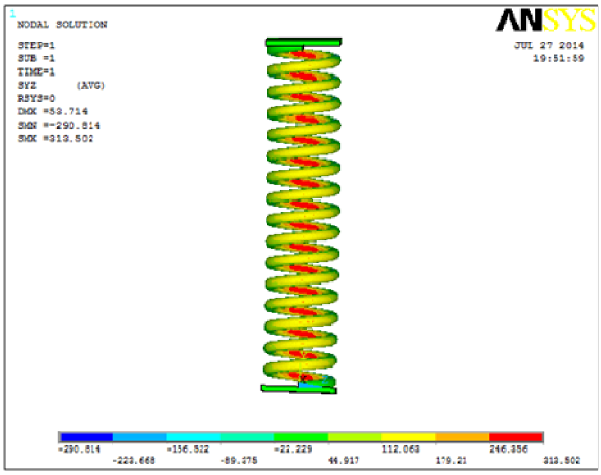
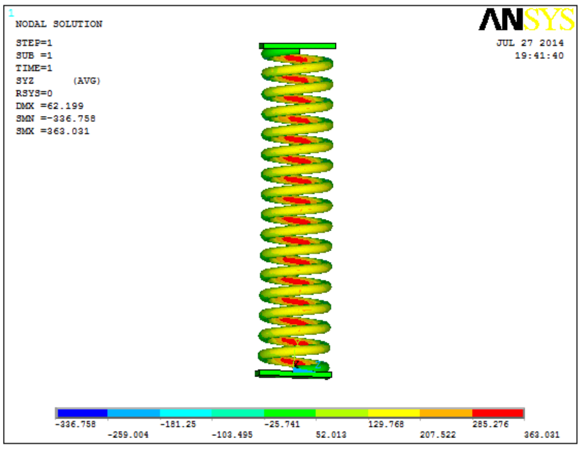


Fig 2:-Deflection result for dual suspension at3 km/hr



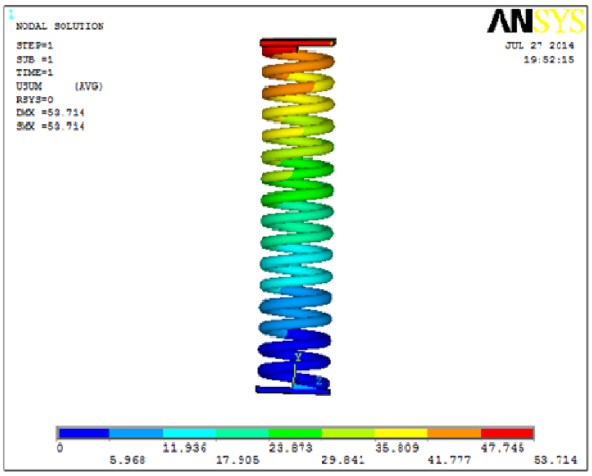


Fig3:-Stress result for dual suspension at 3 km/hr

Fig 4:-Deflection result for dual suspension at10 km/hr

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

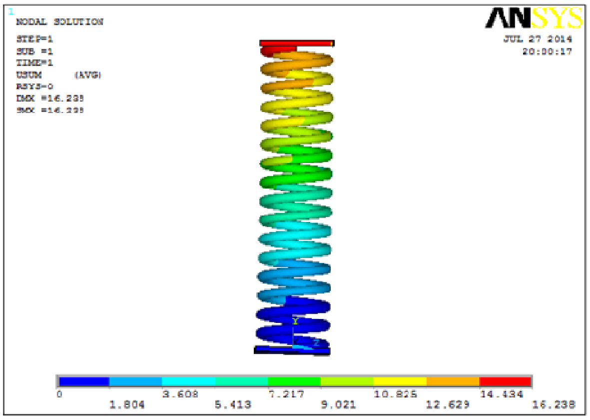


Fig 6:-Deflection result for dual suspension at25 km/hr

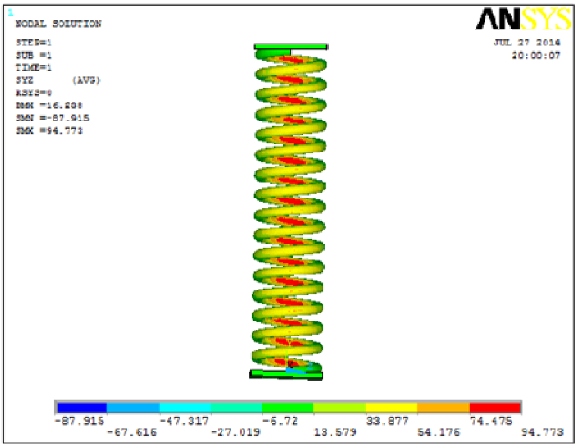


Fig 7:-Stress result for dual suspension at 25 km/hr

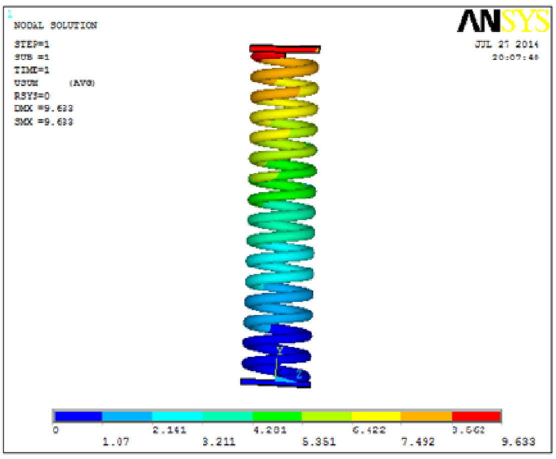


Fig 8:-Deflection result for dual suspension at 40 km/hr

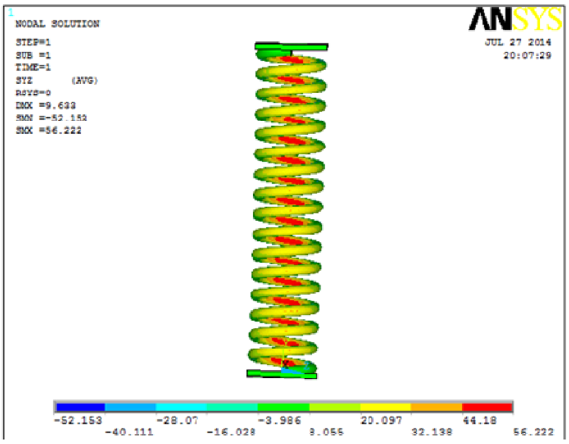


Fig 9:-Stress result for dual suspension at 40 km/hr .

4 RESULT AND DISCUSSION

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

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

Sr. no	V (km /hr)	ANALYTICAL		FEA	
		Deflection (mm)	Stress (N/mm^2)	Deflection (mm)	Stress (N/mm^2)
1	3	58.6	404.79	62.19	363.03
2	10	50.6	349.5	58.71	313.5
3	25	15.3	105.69	16.23	94.77
4	40	9.1	62.89	9.63	56.22

This study presents the stress analysis of dual 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. Deflection is maximum in between 3 km/hr to 10 km/hr& further reduces as speed increases.Stress is maximum in between 3 km/hr to 10 km/hr& further reduces as speed increases.

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