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ANALYTICAL AND EXPERIMENTAL ANALYSIS OF HELICAL SPRING- A Technological Review

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ABSTRACT-

of different parts such as spring, damper, shock absorber etc. In suspension system of tractor spring plays a vital role. As the suspension system in any vehicles performs function of

1) Isolating vehicle and person from road The seats of tractors are provided with springs, either tension or compression, to reduce vibration generated, take the load of driver , isolate driver from road shocks and provide cushioning effect as well. the tension springs are provided on back side of driver seat where as compression springs are placed below driver seat. Both perform same function as stated above. But it has seen that helical tension springs are widely used rather than helical compression springs. The companies such as Mahindra, Force, Sonalika, John Deer use helical tension springs whereas companies such as Mitsubishi and some new models of Mahindra makes use of helical tension springs. This review focuses on finding out which one out of both the springs is better in wider aspect. Regarding to this Analytical and Practical analysis has been carried out. The aspects such as fatigue strength, load carrying capacity, stress life deformation of spring in compression and tension force applied, vibration generated have been focused

Keywords- Fatigue Strength, Helical Springs, Life Cycle, Stresses.

I.INTRODUCTION

Tractor is an automobile vehicle having no chassis or fixed rigid frame, i.e. it is a frameless vehicle. Therefore it becomes very essential to design all element of tractor with proper calculation and analysis, as the strength of tractor is reduced due to frameless construction and thus its elements or parts could be subjected to permanent deformation or damage. In addition to which tractor is used along various with various fittings and mountings like plough, etc. which increases the load acting on it. Tractor, obviously, is driven and used over an uneven and rough terrain. All these above mention things should be taken into consideration while designing elements of tractor.

suspension system consist shocks

2) Providing comfortable ride to driver.

3) Minimizing the stress induced in vehicle frame during road shocks.

For the above mentioned purposes springs of different types can be used which will satisfy these needs. As the tractor seat is attached to frame of tractor along with Helical Tension or Helical Compression Spring, This seats and springs generally design for person sitting on it having weight of 100kg i.e. 980.665 N is applied upon it. The spring should be so design that it could take such high load and force or even more than this one considering the factor of safety. So in this paper we aimed and focused on determining which types springs, whether Helical Tension or Helical Compression, is better as well as what material used for them is ideal and serves better.

Researchers were used various methods for analysis and optimization of coil spring. M. P. Nagarkar, Dr. G. J. Vikhe Patil, R. N. Zaware Patil [1] investigated a non linear quarter car suspension-seat-driver model for optimum design. A non linear quarter car model comprising of quadratic tyre stiffness and cubic stiffness in suspension spring and seat cushioning with 4 degrees of freedom (DoF) driver model was presented for optimization and analysis. Tausif M. Mulla, Sunil J. Kadam, Vaibhav S. Kengar [2] studied the stress analysis of a helical compression spring which was employed in three wheeler's auto-rickshaw belonging to the medium segment of the Indian Automotive Market. The material used for study was ASTM A227. To ensured structural reliability of spring the static stress analysis using finite element method has been done in order to find out detailed stress distribution of spring. The stress distribution clearly shows that the shear stress having maximum value at the inner side of the every coil.

2.DESIGN OF SUSPENSION SPRING

2.1 Calculation For Helical Tension Spring

Let, D = Mean diameter of the spring coil (mm), D_o = Outside diameter of the spring coil (mm), D_i = Inside diameter of the spring coil (mm), d = Diameter of the spring wire (mm), N = Number of active coils, Nt = Total number of coils, G = Modulus of rigidity for the spring material, P = Axial load on the spring (N or Kg), τ = Max. Shear stress induced in the wire (N/mm^2), C = Spring index = D/d, p = Pitch (mm), δ = Deflection of the spring, as a result of an axial load P, L = Free Length (mm), K = Wahl factor, k = Stiffness of the spring (N/mm).

The spring having specification as follows:

W = 902N, d = 4.25mm, D_o = 34.04mm, D_i = 26.4mm, D_m = ((D_o + D_i) /2) = 30.22, C = D_m/d =7.1105, n = 24,

n' =24, G=7.9 x 10^4 N/mm^2

We have design parameters are :

1. Shear stress concentration factor= K_s = 1+ (1/2C) = 1.0709

2. Wahl's correction factor = K_w = (((4C-1) / (4C-4)) + (0.615/C)) = 1.2092

3. Direct shear stress = τ_d = (w / ((π/4) x d^2)) = 63.58 N/mm^2

4. Torsional shear stress = τ_T = (8WD_m /πd^3) = 841.7080 N/mm^2

5. Resultant shear stress = τ_R = (8W$D_{m/}$ πd^3) x (1+ 1/2C)= 905.2907 N/mm^2

6. Deflection = δ= (8WD^3n/ Gd^4) = 185.4351 mm

7. Spring rate or stiffness = K = W/δ= 4.8642 N/mm

2.2 Calculation For Helical Compression Spring

Let, D = Mean diameter of the spring coil (mm), D_o = Outside diameter of the spring coil (mm), D_i = Inside diameter of the spring coil (mm), d = Diameter of the spring wire (mm), N = Number of active coils, Nt = Total number of coils, G = Modulus of rigidity for the spring material, P = Axial load on the spring (N or Kg), τ = Max. Shear stress induced in the wire (N/mm^2), C = Spring index = D/d, p = Pitch (mm), δ = Deflection of the spring, as a result of an axial load P, L = Free Length (mm), K = Wahl factor, k = Stiffness of the spring (N/mm).

The spring having specification as follows:

W = 1090N, d = 5.63mm, D_o = 51.36mm, D_i = 40.4mm, D_m = ((D_o + D_i) /2) = 45.88, G=7.9 x 10^4 N/mm^2

We have design parameters are :

1. Shear stress concentration factor= K_s = 1+ (1/2C) = 1.0613

2. Wahl's correction factor = K_w = (((4C-1) / (4C-4)) + (0.615/C)) = 1.803

3. Direct shear stress = τ_d = (w / ((π/4) x d^2)) = 43.77 N/mm^2

4. Torsional shear stress = τ_T = (8WD_m /πd^3) = 670.8932 N/mm^2

5. Resultant shear stress = τ_R = (8W$D_{m/}$ πd^3) x (1+ 1/2C)= 714.677 N/mm^2

6. Deflection = $\delta = (8WD^3n/ Gd^4)$ = 53.0512 mm

7. Spring rate or stiffness = K = W/δ= 20.54N/mm

3. EXPERIMENTAL WORK

The experimental study was carried out for design validation. Physical testing on the spring in compression and tension is done. The testing was done by 10 tonne universal testing machine along with load cell having load carrying capacity 1000 kg as in figure 1.

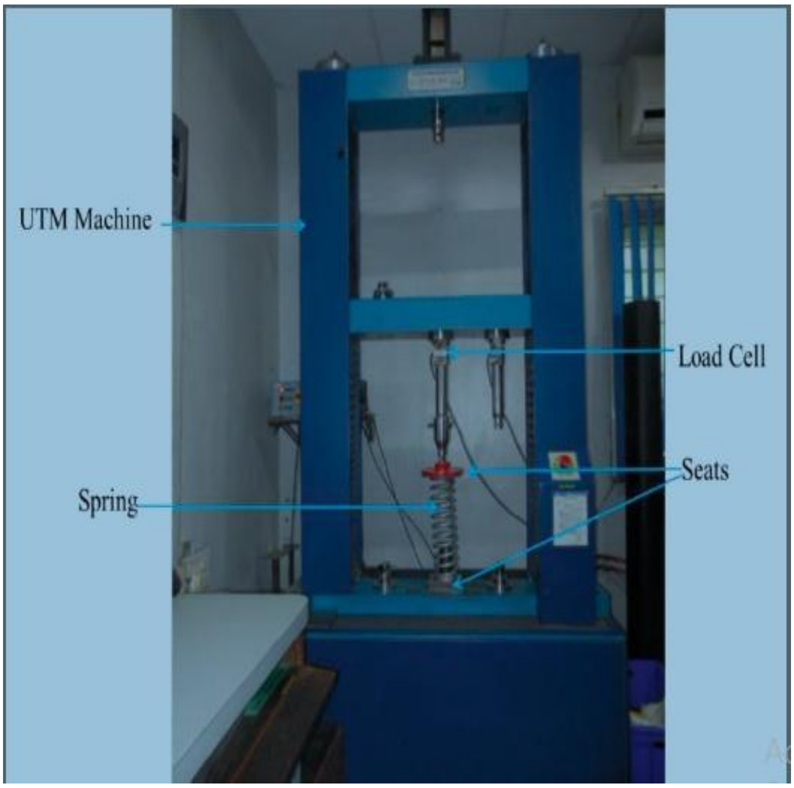

Fig 1. Experimental Setup

3.1 Comparison of data required for results calculation

Table 1. Data For Comparison

Test Specimen	Load (N)	Displacement (mm) Approx.	Displacement (%)	Ultimate Strength (N/mm^2)	Stiffness (N/mm)
Helical Compression	1090	220	51.93	43.77	21.08

Spring					
Helical Tension Spring	902	40	217.64	63.56	4.47

The graphical representation of the data obtained from UTM Tests has been shown in the figure 2 below:

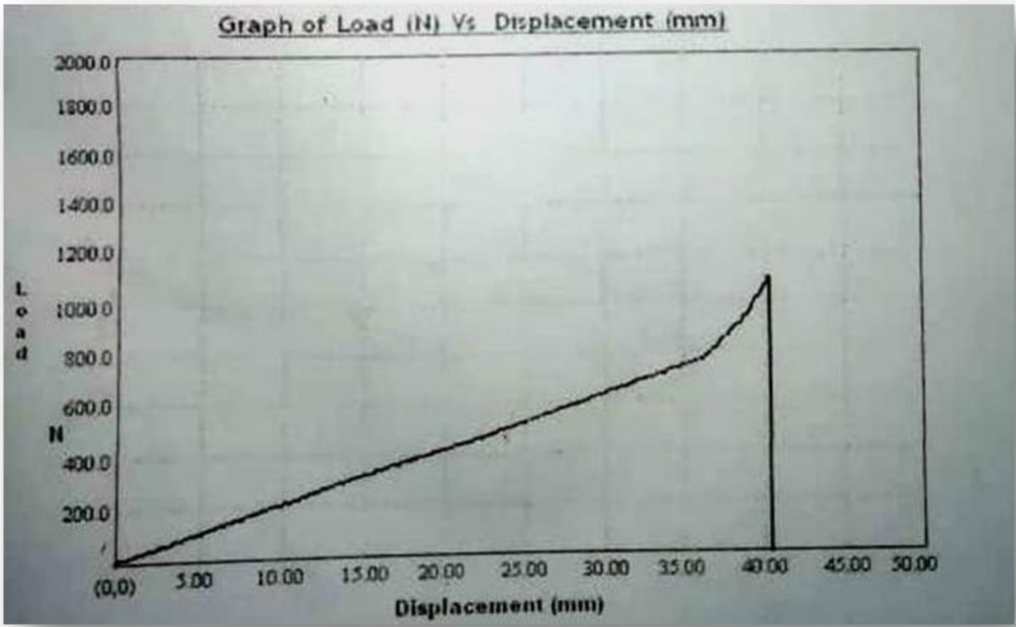

Fig. 2 Load vrs Displacement Graph For Helical Tension Spring

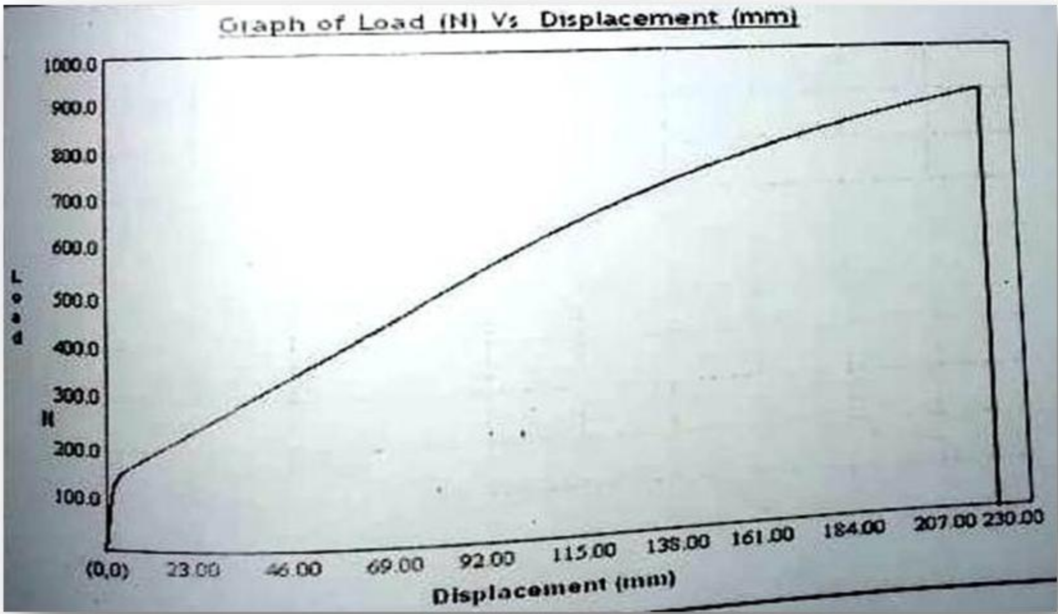

Fig. 2 Load vrs Displacement Graph For Helical Compression Spring

4. RESULT TABLE

The following table compares spring rate and deflection for helical tension and compression spring with respect to 2 types of analysis viz. Analytical and Experimental Analysis.

Table 2. Result Table

	Helical Tension Spring		Helical Compression Spring	
Parameters	Spring Rate (N/mm)	Deflection (mm)	Spring Rate (N/mm)	Deflection (mm)
Analytical Analysis	4.8642	185.4351	20.54	53.0512
Experimental Analysis	4.47	220	21.08	40

5. CONCLUSION

It is concluded that load applied on helical tension spring was less than that on helical compression spring, despite of which the stress developed in helical tension (τ_R) is more than that developed in compression spring.

The deflection (δ) in helical tension spring is more than that in helical compression spring.

The spring rate (k) of helical compression is more than that of helical tension spring.

We concluded that stresses developed in helical tension spring is more than in helical compression spring therefore life of helical compression spring is more.

The spring rate of helical compression spring is more than that of helical tension spring therefore helical compression deflects less despite of taking more load.

Thus helical compression spring is better than helical tension spring.

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