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"Design, Analysis and Testing of Torsion Spring as an Independent Suspension Unit"

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Abstract: *Suspension system is provided in all vehicles so as to provide smooth and comfortable ride to passenger as well as to driver. Today coil springs are used in most cars. Most car have independent suspension on all four wheel. It has also been observed that farm vehicles employ leaf springs that are satisfying for full loading condition.*

In this work the helical torsion spring model is created by modeling software like CATIA. The dimensions of an existing light commercial vehicle are taken for getting approximate dimensions of torsion spring. The structural analysis under static loading of torsion spring is carried via finite element analysis using ANSYS-14 software. Also the experimental work is carried out on Universal Testing Machine, the output in terms of deflection results for torsion spring. The analytical results for torsion spring having wire diameter 14mm under loading of 4291N has total deflection of 38.645 mm and maximum stress of 936.89Mpa. The experimental results for 14mm has total deflection of 30.67 mm and maximum stress of 1039.08 Mpa. **Keywords-**torsion spring, Leaf spring, V-shape spring, FEA, Total deflection, Equivalent stress

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I. Introduction

1.1 Torsion spring

A torsion spring is a spring that works by torsion or twisting i.e. flexible elastic object that store mechanical energy when it is twisted. When it is twisted, it exerts a force in a opposite direction (actually torque), proportional to amount of (angle) it is twisted. a helical torsion spring, is a metal rod or wire in the shape of the helix(coil) i.e. subjected to twisting about the axis of the coil by sideways forces (bending moments) applied to its ends, twisting the coil tighter. This terminology is confusing because in a helical torsion spring the forces acting on the wire are actually bending stresses, not torsional (shear stresses).

1.2 Introduction to Structural Analysis

Structural analysis refers to the determination of the effects of loads on physical structures and their parts. Structures subject to this type of analysis include buildings, bridges, vehicles, furniture, attire, soil strata, prostheses and biological tissues. Structural analysis makes the use of applied mechanics, material science and applied mathematics to calculate deformations, stresses, support reactions, accelerations and stability. The results of the analysis are used to verify a structure's fitness for use, often precluding physical experiments. Thus structural analysis is a key part of the engineering design of structures. Finite element analysis tools offer the tremendous advantage of enabling design team to consider virtually any modeling option without incurring the expense associated with manufacturing and machine time. The ability to try new designs or concepts on the computer gives the opportunity to eliminate problems before beginning production. Additionally, designers can quickly and easily determine the sensitivity of specific modeling parameters on the quality and production of the final part. The spring model is created by modeling software like CATIA V5 and it is imported in to the analysis software and the loading, boundary conditions are given to the imported model and results are evaluated by post processer.

II. FEA (Finite Element Analysis)

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.

The finite element method (FEM), is a numerical method for solving problems of engineering and mathematical physics. The analytical solutions of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. This method gives approximate values of the unknowns. It is useful for problem with complicated geometry, loading and material properties where exact analytical solution are difficult to obtain. Most often used for structural, thermal, fluid analysis, but widely applicable for other type of analysis and simulation.

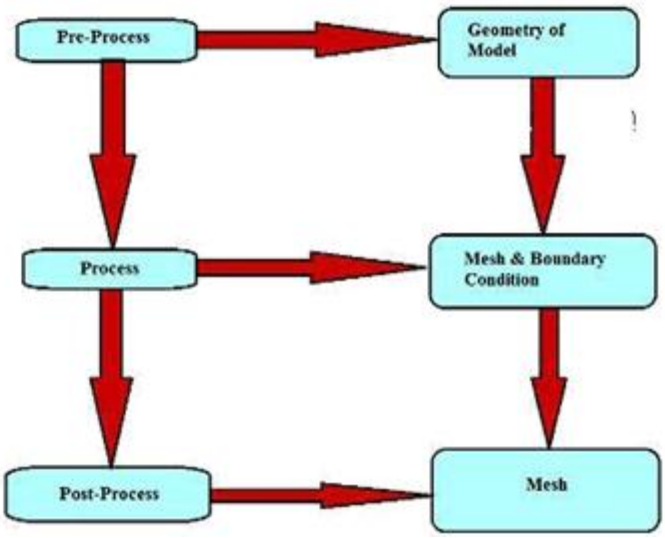

Figure no. 2.1 Typical FEA procedure for commercial software (FEA)[5]

2.1 Material for spring

Spring often made up of hardened steel, although non- ferrous metals such as bronze and titanium, Chrome silicon, Chrome vanadium, stainless steel, other metals that are sometimes used to makes spring are beryllium copper alloy, phosphor bronze and titanium this are the typical material used for helical torsion spring. The material selected for helical torsion spring is IS4454 (Patented and cold drawn steel)

Parameters	Value
Material	IS4454
Ultimate tensile stress	1473.21 N/mm^2
Yield tensile stress	1104.908 N/mm^2
Youngs modulus(E)	2e5 N/mm^2
Load(P)	4291 N
Spring index (C)	6
Wire diameter (d)	14 mm
Mean coil diameter	84mm
Number of coils	6
Leg length (L1) (L2)	170 mm 200 mm
Angle between two legs	145 degree

Table 1: Design Parameters for spring

2.2 Geometry of Torsion Spring

Figure shows the imported geometry of helical torsion spring. The geometry has been created in CATIA V5. The leg lengths of spring are 200mm and 210mm

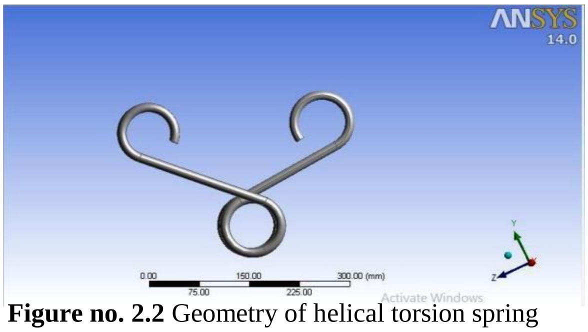

Figure no. 2.2 Geometry of helical torsion spring

2.3 Meshed model of torsion spring
Meshing is nothing but the discretization of object into the small parts called as the element. Figure no.

2.3 shows the meshed model of spring with triangular elements are used. The element size is kept 5mm.

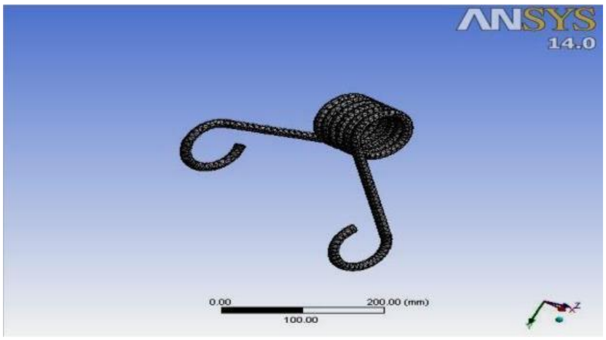

Figure no. 2.3 Meshed model of torsion spring

2.4 Loading and Boundary Condition Torsion Spring
The loading and boundary conditions are applied similar to the conditions when spring unit is installed to the vehicle chassis. The accuracy of results depends on the boundary conditions.
2.4.1 Fixed Support (A)
Fixed support has restriction to move in X and Y direction as well as rotation about that particular point. For the torsion spring one eye end of the leg is fixed to the chassis of the vehicle i.e. all the degree of freedom is restricted.
2.4.2 Compression only Support (B)
Compression support must be provided at three or more points on the coil diameter to take the reaction forces. This support is usually accomplished by means of rod inside the coil.
2.4.3 Force(C)
Force in Y component is applied at the other eye end of the leg. A force of magnitude 1226N (125kg).

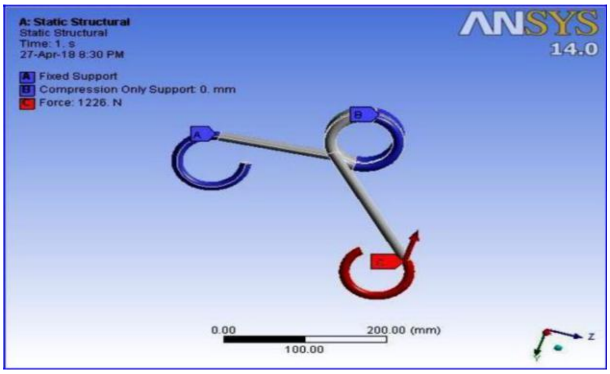

Figure no. 2.4 Loading and boundary conditions of torsion spring

2.5 Results and Discussion
2.5.1 Total deflection of torsion spring

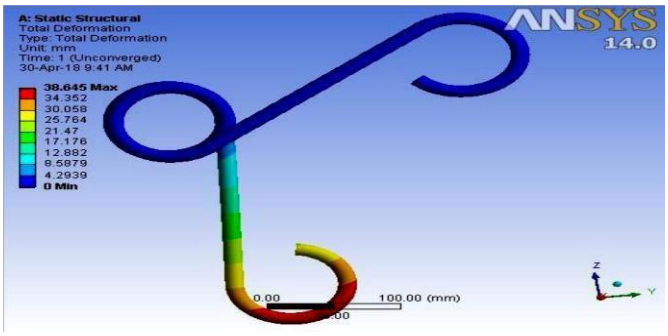

Figure no. 2.5 Total deflection of torsion spring

Figure 2.5 show the total deflection of helical torsion spring under the application of 4291N total load.The maximum deflection of spring at away from the Centre of spring. The spring having maximum deflection is

38.645mm. Red zone indicate the maximum deflection of spring and blue zone indicate the minimum deflection of spring.

2.5.2 Stress for Torsion Spring

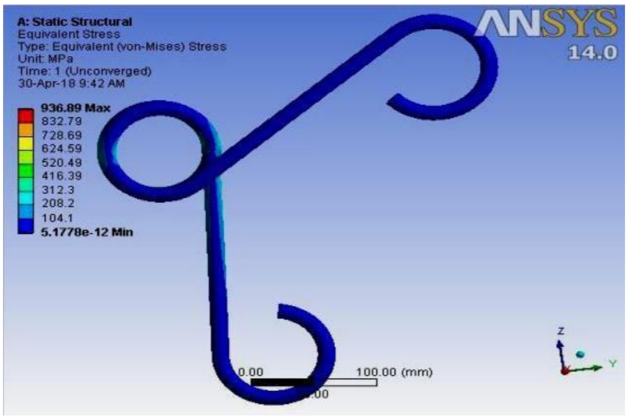

Figure no. 2.6 Stress for torsion spring

Figure 2.6 show the equivalent von-mises stress induced in the helical torsion spring under the action of 4291N load.
The maximum stress induced at the nearer to end of helical coil spring and the maximum stress value is 936.89 N/mm^2. Red zone indicates the maximum stress of spring and blue zone indicate the minimum stress of spring.

III. Result and discussion

During the course of work, the experimental work has been carried out for the helical torsion spring with 14mm wire diameter and result of that are compared with conventional leaf spring and V shape spring. In this chapter the comparison of torsion spring with v- shape spring and leaf spring concerned with deflection is shown and discussed.

Deflection for helical torsion spring, V spring and leaf spring.

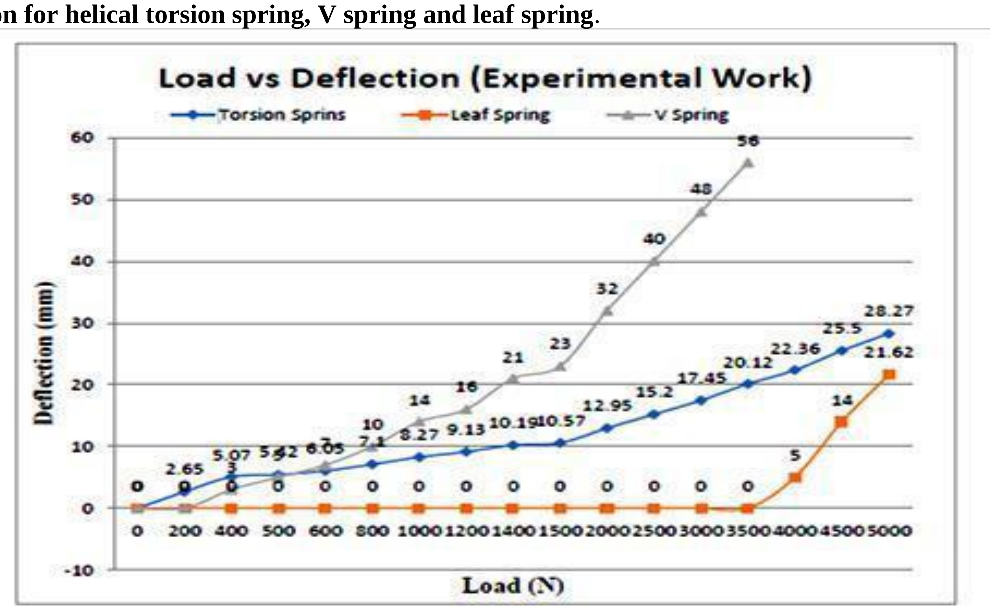

Figure no 3.1 Comparative load Vs deflection(Experimentally)

Fig 3.1 shows comparative results of load vs deflection of torsion spring vs leaf spring and V spring (variable thickness). From the graph it clearly depicts the leaf spring has deflection almost negligible at loads from 0 to 3500N and then shows considerable deflection at higher loads i.e. full loading about 3500 N,[1].

The V- spring (with variable thickness) is optimum for part loading that deflects at much lower loads and reaches a maximum to 56 mm at 3000 N. Comparatively the graph of torsion spring varies much linearly showing deflection at very low loads and continues linearly with the increasing load which can be said to suit from part to full loading functionality. The torsion spring secures a better place between V-spring and leaf spring from part loading to full loading.

IV. Conclusion

The torsion spring is designed for safe and comfort riding. The design procedure available in the books for torsion spring has specific orientation i.e. Angle between legs. For our design, as orientation of spring used is different. The present work has special orientation to satisfy assembly in vehicle body and provide suspension effect.

Hence the FEA is taken as reference as far as design of torsion spring is concerned the results of ANSYS are used as basis for comparing the experimental results after testing the spring. The material used for spring is easily available in the market which is quite cheap compared to other steel springs that are costly. From the experiments conducted and after making comparative study it is concluded that the torsion spring gives desirable output for part loading to full loading. Based on this, the torsion spring unit can be employed as suspension unit in light duty vehicle and other goods carrying trailer.

On the basis of analytical, numerical (FEA) and Experimental result it is observed that V spring is great under part loading i.e. minimum loading action, main leaf spring is superior for maximum loading condition and torsion spring is suitable for both part as well as full loading. So helical torsion spring can be a best alternative for light duty farm vehicle.

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