# OPTIMIZATION AND DESIGN OF STEEL HELICAL SPRING BY USING COMPOSITE MATERIAL

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*Abstract :* It is observed that, in four-wheeler vehicle suspension system the helical coil spring is used, factor consider for suspension system failure are as uneven stress distribution, materials properties and manufacturing defects. If the spring failure happened, it affects the performance of vehicle which is not preferable in automobiles. The research work is focusing to find out the failure happened due to factors like dynamic and stability response, deflection of spring and so on. The research study also encourages to use of composite material like Glass fiber to improve strength, it can improve the performance to high extract. In this research work we are focusing on the conventional spring failure and on that ground optimization of existing design of spring replace by composite material. We are analyzing it by experimentation testing on UTM machine and validate by experimental on ANSYS environment putting experimental data.

***IndexTerms* - Decarburization1, Inclusion2, Delayed quench crack3, Coil spring4, Stress distribution.**

## I. INTRODUCTION

The automobile chassis is mounted on axles, not direct but through some form of spring this done to isolate the vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and cause additional stress in automobile frame and body. All the parts which perform the function of isolating the automobile from the road shocks are collectively called the suspension system. The energy of road shocks causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper, which is more commonly called a shock absorber. Suspension system prevents the road shocks from being transmitted to the vehicle components and to safeguard the occupants. It also prevents the stability of vehicle in pitching or rolling, while in motion.

### 1.1General defects in helical coil spring

As we know placement of springs are in between the road wheels and the vehicle body. Bumps always rises and deflects the spring when the wheel comes across a bump on the road and stores energy therein. On decompression due to the elasticity of the spring material it bounces back thereby expending the stored energy. It results into spring starts vibrating, change in amplitude gradually decreases on account of internal friction of spring material and friction of the suspension joints up until up to the vibrations die down. As per observation it is found that the helical spring broke down under uneven loading or high impact jerk conditions. Spring broke down due to uneven distributed stresses developed result in to spring broke down in to two parts. Sometime spring may get failed due to manufacturing defect, over flexible suspension system is cause of dislocation of spring position result in to broke down of spring due surging.

fig.1.1 broken helical coil spring

### 1.2PResone Behind Helical Coil Spring Failure

#### 1.2.1 Longitudinal Forces

As the wheel of vehicle comes across a bump or pit on the road, it is subjected to vertical loads. It is absorbed by the elastic compression, shear, bending or twisting properties of the spring. Material type of the spring is deciding factor here for the mode of spring resistance developed.

#### 1.2.2 Spinning of Spring

While taking the turns, the centrifugal force of vehicle acts outwards on the C.G. of vehicle, while the road resistance acts inward, at the wheels, as center of gravity of the vehicles is fixed above the ground. This generate a couple while turning of vehicle about a longitudinal axis known as spinning or rolling. Vehicle is sprung determines the axis among which vehicle will have roll tedancy. The tendency of roll is checked by means of a stabilizer

#### 1.2.3 Stop Drench of Spring

On applying brakes, the nose of the vehicle has tendency to bow down or to drench. The center of gravity to the ground, the wheelbase, and other suspension characteristics are deciding factor here. Torque loads during acceleration tend the front of the vehicle to be lifted. These restrictions occurred due to braking, driving acted directly by deflecting the spring, by wishbone arms or by radius rods.

#### 1.2.4 Uncoiled weight of Spring

Uncoiled weight is the ratio of weight of vehicle components between the suspension and the road surface. It will involve rear axle assembly, steering knuckle, and front axle. If in case of rear drive vehicle, rear drive rigid axle suspension, wheels, tires and brakes are involved. The uncoiled weight, i.e., the weight supported by the vehicle suspension system, includes the body and body frames, engine transmission system.

## I. CONCEPT OF SPRING

Manish Dakhore [1] has studied value of stress found to be more at the critical section of the spring as indicated by red colour. Hence possibility of failure is more at that section compared to other section of spring. This paper is a discussed about locomotive suspension coil springs, their fundamental stress distribution and materials characteristic. The analysis of loco spring is carried out by considering cases, when the loco moving at the straight path, curved path and on uphill. This paper also discusses the Experimental analysis of a helical suspension spring by using strain gauge. The stress analysis for the forces obtained and for modal and harmonic response has been carried out by FEA using ANSYS. Md. Mustak

[2] studied the used of E-poxy glass materials for the design of helical suspension spring. The metal coils of helix spring are replaced by e-poxy carbon. In this works finite element analysis of helical spring is analyzed by using ANSYS, and in out the values of all parameters. Aamir A. Waghade

[3] have carried out the works on harmonic analysis of helical suspension spring. In this paper they have introduced the method for rectangular cross section helical spring. This paper discusses the Experimental analysis of ahelical suspension spring by using strain gauge. The stress analysis for the forces obtained and for modal and harmonic response has been carried out by FEA analysis. Achyut P. Banginwar

## II. CONCEPT OF SPRING

While designing new spring following factor should consider

- Spring must fit in to allocated space in suspension system
- Parameter for force acting and deflection
- Allowable compress decompress range as per calculated range
- Precision and dependability
- Sustainability in salty atmosphere, high temperature an economical in cost

For spring design deciding factors are selection of proper material and fix calculated values for the wire size, the coil diameter, the number of turns and the free length, type of the spring & spring rate needed to achieve working force to control deflection state. The initial design constraint is to decide commercially available wire size, and next stage is to confirm the stress at the solid length be no longer greater than the torsional yield strength to achieve stable spring functioning.

### 2.1Stability of Spring (in Buckling)

We observed earlier that a slender member or column subjected to compressive loading will buckle, if the load will exceds a critical value. Compression coil springs will buckle if the free length of the spring is larger and the end conditions are not proper then output result will be unevenly distribute the load all along the circumference of the coil. Buckling can be controlled by limiting the deflection of the spring or the free length of the spring. We should consider two dimensionless parameters, critical length and critical deflection. Critical deflection is the ratio of deflection (y) to the free length (L X f) of the spring. The critical length is defined as free length (L X f) to mean coil diameter (D). The critical deflection is a function of critical length and has to be below a certain limit. To reduce the buckling effect following condition must be satisfied.

(L x f) <4D ….1.1

The crippling load can be given by $W_{cr} = K \times K_B \times (L \times f)$ ….1.2

Where, K = spring rate KB= buckling factor.

### 2.2Spring Surge and Critical Frequency

Consider compression spring is held against a flat surface and the other end is disturbed, then compression wave will develop which will travels back and forth from one end to the other. Sometime a resonance may occur causes in abrupt and irregular motion, which makes the spring dislocate or bump out of contact with the end plates, sometime resulting in damaging stresses. This phenomenon is called spring surge or merely surging. The designer must assure that the physical dimensions of the spring are not such as to create a natural vibratory frequency close to the frequency equal to acting force.

### 2.3Fatigue Loading

The springs must withstand for repetitive millions of cycles without failure, so has infinite life designed. For both compression and extension springs helical springs are not preferred to use. In such condition they are assembled with a preload to put additional working load condition. Thus, they have fluctuating nature stress-time diagram.

To design helical spring we consider factors AS,

$F_a = (F_{max} - F_{min})/2$ $F_a = (F_{max} + F_{min})/2$

For typical applications like the valve spring of an automotive engine, as valve springs should sustain millions working of cycles at high temperature. Unlike other elements like shafts, helical springs are never used as both compression and extension springs. Springs are usually assembled with a preload so that the working load is additional. Thus, their stress-time diagram is of fluctuating nature.

Twisting moment $\mathbf{F_{s1}} = \mathbf{K_c}(\mathbf{8PD}/\mathbf{\Pi d^3})$

Direct shear stress $\mathbf{F_{s2}} = \mathbf{W}/[(\mathbf{\Pi}/\mathbf{4})\mathbf{d^2}]$

Max shear stress $F_s = \mathbf{8KWD}/(\mathbf{\Pi d^3})$

## III. Major Flaws in Coil Production

First and most important step is raw material selection, to achieve the excellent quality coil springs. The selection of the raw material usually includes the compulsion of cleanliness, microstructure, and decarburization inspection.

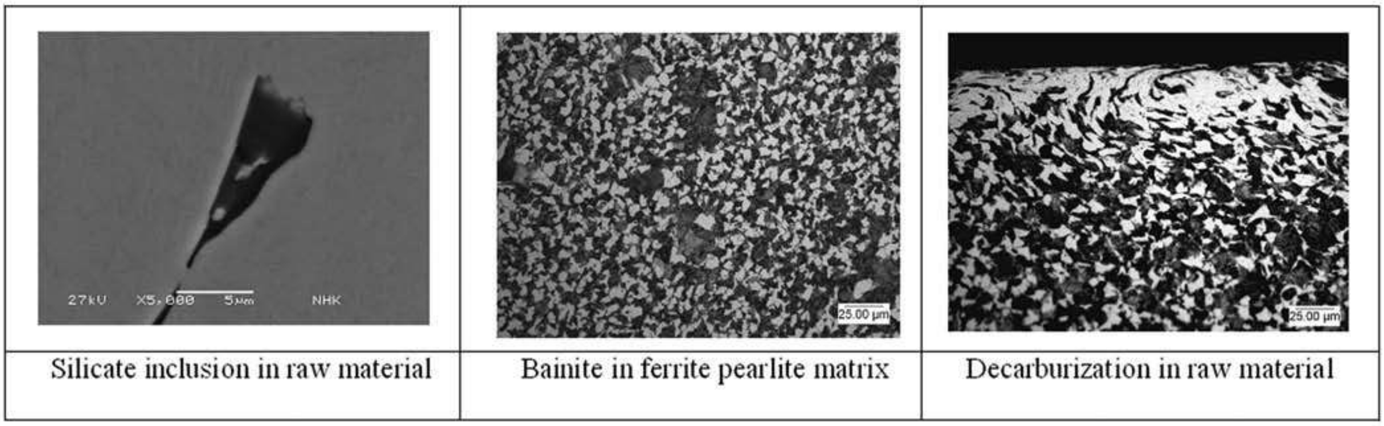
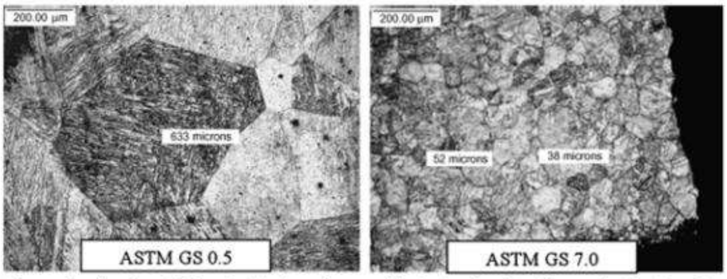



Figure 4.1 Typical defects in raw materials: inclusion (a),inappropriate microstructure (b), decarburization (c).

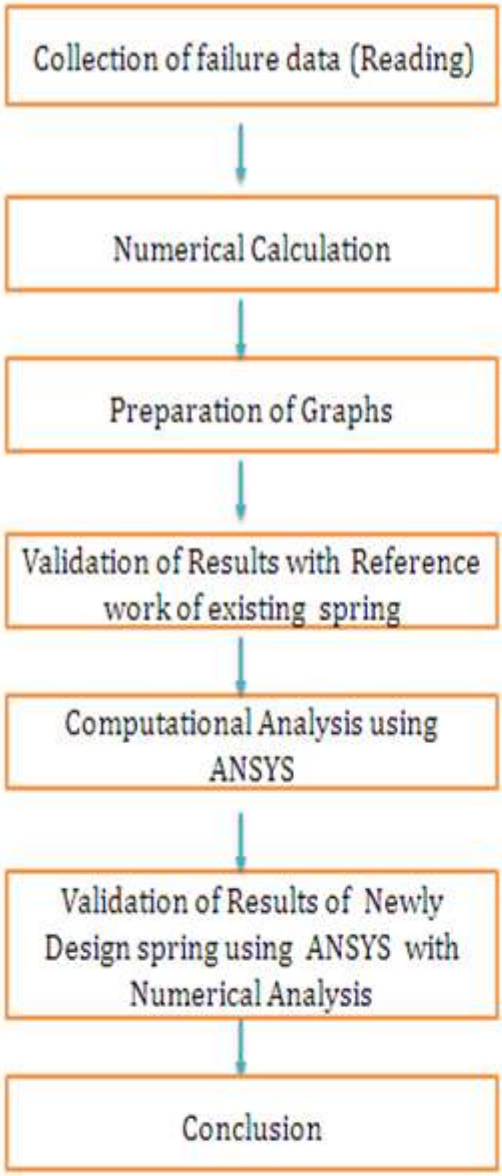
Other sources of defects are improper heating prior to coiling. To control the prior-austenite grain size is an important step in coil manufacturing. Figure 4.2 shows the difference between a large grain size and a small grain size. This example was taken from identical materials processed with different parameters, indeed not reflected by other mechanical properties larger prior-austenite grain size has proved to be less advantageous for fatigue life than as compare to small size. Fig.4.1 Typical defects in raw materials: inclusion (a), Inappropriate microstructure (b), decarburization (c). Concern may be raised that this is due to the fewer number of the grain boundaries passed during crack propagation. But raw material is heated properly, then only coil formed. Which may cause the coil may fail early due to physical defects generate during coiling process. Following coil formation, a heat treatment process of quenching and tempering is way performed. Heat treatment is another major cause of a coil failing early. These defects include, but are not limited to, quench cracking, insufficient tempering and over-tempering. After tempering, the coil spring is shortened. The shot penning process is beneficial for two reasons: it cleans the surface of defects and scale caused by quenching and introduces compressive residual stresses at the spring surface. A typical residual stress distribution formed by shot penning. Last step of coil making is Coating. The first process of coating is pre-treatment where followed by second step coating application. Zinc works as a sacrificial anode to protect the steel, as zinc is main ingredient in a pre-treatment. After pre-treatment, either a powder coat with spray.




Longer heating time (higher heating temp.) Shorter heating time (Lower heating temp.)

Fig.4.2 Identical raw materials heated with different heating conditions.

## IV. FEA Approach for Analysis of Spring



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