Testing of helical spring under compression test

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Abstract: Vehicle springs are made of (ultra) high-tensile and heat-treated steel, subjected to high static and cyclical loads and sensitive to superficial defects that can be caused by mechanical and corrosive action during production or operation. To reduce the risk of fracture, manufacturers use different types of surface coatings that provide protection against both corrosion and mechanical damage by grit or other abrasives. This document examines the complex stress conditions for vehicle springs and describes the most frequent types of damage. It presents the findings of an extensive test project that was conducted primarily to examine the influence of corrosion combined with mechanically generated surface defects on the durability of vehicle springs. Comprehensive durability tests on generic springs manufactured with different technologies are verified and quantification of the dominant influence of advance mechanical damage by grit impact and abrasion on the fatigue strength under loading conditions can be done. An effective countermeasure is to improve surface protection.

Keywords: *Helical spring, spring testing machine, stiffness, vernier caliper, vehicle spring*

Introduction This document examines the complex stress conditions for vehicle springs and describes the most frequent types of damage. It presents the findings of an extensive test project that was conducted primarily to examine the influence of corrosion combined with mechanically generated surface defects on the durability of vehicle springs. In the course of this project, different spring production technologies and surface coating systems were compared for a generic spring type in order to determine the best manufacturing and corrosion protection practices that would ensure a long fatigue life as well as to derive the necessary measurements and parameters for reliable testing.

Types of springs

Though there are many types of sprigs, these are the main springs which we can see often.

1. Helical springs.
2. Conical and volute springs.
3. Torsion springs.
4. Laminated or leaf springs.
5. Disc or Belleville springs.

Helical springs: The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile loads.

2. LITERATURE REVIEW:

C.A. Calder et al have conducted the experiments on the helical springs by mounting the strain gauges on the inner radius of the spring. The experiment provides the opportunity to mount gauges on a curved surface with limited access. It is an application for rosette gauges, switch and balance unit, a digital read out and use of an Instron or similar test machine. Stresses acting on the springs can be determined with the mounted gages.

K.V. Sudhakar has worked on the failure analysis of an automobile valve spring which failed in service. The fractured surfaces as well as the surface of the spring material close to the fractured surface were examined in a scanning electron microscope at suitable magnifications. Optical microscopy was performed to evaluate the basic microstructure of the as- received material. Detailed electron microscope studies have indicated that the failure was due to the presence of nonmetallic inclusions near the surface of the spring material. Dammak Fakhreddine [10] has used the finite element method for the stress analysis of isotropic cylindrical helical spring. The efficient two node finite element model, with six degrees of freedom per node, was developed and was capable to model the total behavior of a helical spring.

Michel Langa et al of Allevard resin an Auto suspensions company, a subsidiary of the Italian society group, has developed a suspension coil spring and rubber insulator system design methodology. The particular aim is to identify more robust optimization criteria seeking compromise between ride control handling & NVH. The results obtained underline the importance of integrating the rubber insulators for optimal spring performance with regard to road-holding qualities and low frequency vibration comfort, while filtering the spring modes such as friction and drift in particular, in the case of McPherson suspension. Josef Salwinski et al

R.K. Luo et al [13] have worked on the fatigue failure analysis of anti-vibration rubber spring. Rubber springs are widely used in industry as anti-vibration components giving many years of service. The metacone type of rubber spring is well established to control vertical and lateral movements.

C. Berger et al [14] have conducted very high cycle fatigue tests on helical compression springs which respond to external compressive forces with torsional stresses. The results of this investigation can add an important contribution to the experience of fatigue behaviour in the very high cycle regime. Most investigations performed on that field deal with specimens under tensile or rotating bending load. The springs tested were manufactured of Si-Cr-alloyed valve spring wire with a Wire diameter between 2 and 5 mm, shot-peened and preset. Compared to the fatigue limits evaluated in fatigue tests on these springs up to 10^ cycles substantial decrease in fatigue strength are to be observed if the fatigue tests are continued up to 10^ cycles or even more. It is obvious that nucleations of fractures tend to occur *be\o\N* the surface, if fractures happen after more than 10^ cycles. Investigations of broken springs by scanning electron microscope show a typical appearance of fracture initiation sites without non-metallic inclusions at the nucleation of fracture. Results of fatigue tests on a variety of helical springs up to a number of 10^ cycles were studied by Bruno Kaiser [15]. These results were obtained in research project which extensively investigated the fatigue properties of helical springs with five different wire diameters (1, 2, 3, 5, and 8mm) up to 10^ cycles. The test springs for this project were made out of six different spring materials, two patented cold drawn unalloyed spring steel wires, two oil hardened and tempered spring steel wires and two stainless steel spring wires. The results of these fatigue tests with different mean stresses were statistically evaluated, presented as fatigue strength diagrams.

3. DESIGN OF HELICAL COIL SPRING FOR LIGHT VEHICLE

Springs are the elastic machine element /structure components in that they undergo significant deformation when loaded; their compliance enables them to store recoverable mechanical energy. In a vehicle suspension, when the wheel meets an obstacle, the springing allows movement of the wheel over the obstacle and thereafter returns the wheel to its normal position.

Compression springs may be cylindrical, conical, tapered, concave or convex in shape and are wound in a helix usually out of round wire. The largest working length of the spring should be appreciably less than the free length to avoid all possibility of contact being lost between spring and structure member, with resulting shock when contact is restore. As the spring approaches solidity, small pitch differences between coils will lead to progressive coil- to- coil contact rather than to sudden contact between all coils simultaneously. Any contact leads to impact and surface deterioration, and to an increase in stiffness

To avoid this, the working length of the spring should exceed the solid length by a clash allowance. The performance of a spring is characterized by the relationship between the loads (P) applied to it and the deflections (δ) which result, deflections of a compression spring being considered from the unloaded free length. The P-δ characteristic is approximately linear provided the spring is close coiled and the material elastic. The slope of the characteristic is known as the stiffness of the spring

$k = P/\delta$

The designing of spring in a suspension system is very crucial. The analysis is done by considering mass, loads acting on the spring. Comparison is done by varying the wire diameter of the coil spring to verify the best dimension for the spring.

Spring Terminology:

Do – Outer diameter (OD) (in mm)

Di - Inner diameter (ID) (in mm)

d – Wire diameter (in mm)

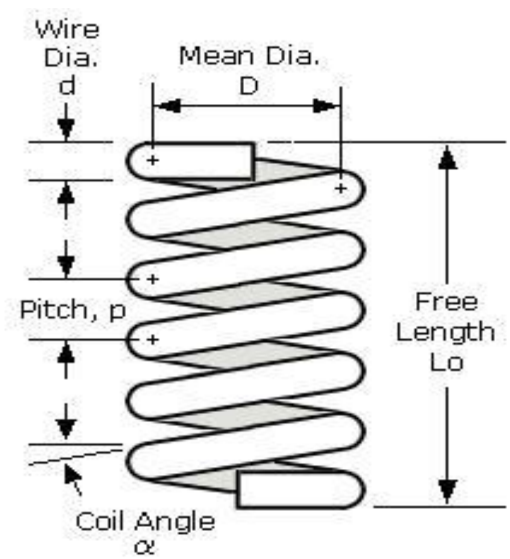
L – Free length- (in mm)

Ls – Solid height (in mm)

δ – Deflection (in mm) P –
Load (in N)

K – Stiffness (in N/mm)

Fig.3.2 Diagram of a Helical Spring



Dimension of helical spring

Upper outer diameter: 45mm

Lower outer diameter: 60mm

Height of the spring: 240mm

Diameter of spring wire: 6mm

Pitch at end: 16mm

Pitch at the quarter middle: 13mm

Table: 1 nominal chemical property. Nominal Mechanical Properties

Young`s Modulus: 206000 MPa.
Modulus of Rigidity: 85000 MPa.
Density: 7800 kg/m3
Poisson Ratio: 0.33

Sample calculation for the helical spring:

Spring index,
= 52.5/6 = 8.75
=4×8.75−14×8.75−4+0.6158.75

= 1.167 Maximum shear stress,

= ×8 3

= 1.167×8×50×9.81×52.5 ×63
= 354.287 MPa.
=
=8 3 = 8×50×9.81×8.753×1687500×6

= 80.115 mm.

4. RESULTS AND DISCUSSIONS:

COMPRESSION TEST

Spring Testing

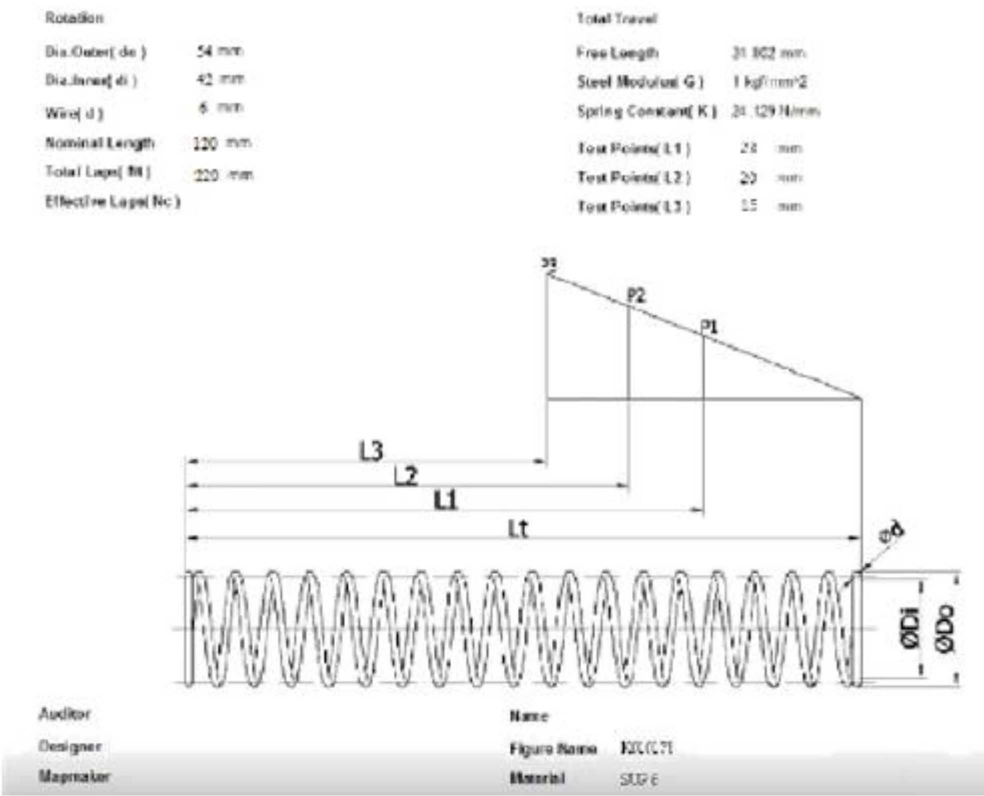
To determine the stiffness of the spring and modulus of rigidity of the spring wire. It consists of i) Spring testing machine. ii)A spring iii) Vernier caliper, Scale. Micrometer. Springs are elastic member which distort under load and regain their original shape when load is removed. They are used in suspension (passion pro) etc. According to their uses the springs perform the following Functions: To absorb shock or impact loading as in carriage springs.To store energy as in clock springs. To apply forces to and to control motions as in brakes and clutches.To measure forces as in spring balances.
To change the variations characteristic of a member as in flexible mounting of motors. The spring is usually made of either high carbon steel (0.7 to 1.0%) or medium carbon alloy steels. Phosphor bronze, brass, 18/8 stainless steel and Monel and other metal alloys are used for corrosion resistance spring. Several types of spring are available for different application. Springs may classify as helical springs, leaf springs and flat spring depending upon their shape. They are fabricated of high shear strength materials such as high carbon alloy steels spring form elements of not only mechanical system but also structural system. In several cases it is essential to idealize complex structural systems by suitable spring.

PROCEDURE:

Measure the diameter of the wire of the spring by using the micrometer. Measure the diameter of spring coils by using the vernier caliper**.** Count the number of turns. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression. Increase the load and take the corresponding axial deflection readings. Plot a curve between load and deflection. The gives the stiffness of the spring.

OBESERVATION:

Least count of micrometer = 0.001mm
Diameter of the spring wire, d = 6mm
(Mean of three readings)
Least count of vernier caliper = 0.1mm
Diameter of the spring coil, D = 54mm
(Mean of three readings)
Mean coil diameter, Dm = D – d=42m
Number of turns, n =16
Total Length L = 220



5. CONCLUSION:

For the purpose of systematically strength of suspension springs under realistic environmental conditions, reproducible parameters for premature damage and durability tests were determined with uncoated spring results. Comprehensive durability tests on generic springs manufactured with different technologies are verified and quantification of the dominant influence of advance mechanical damage by grit impact and abrasion on the fatigue strength under loading conditions can be done. An effective countermeasure is to improve surface protection.

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