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A Review of Modeling and Structural Analysis of Helical Spring with Different Applied Load

Siddharth Shankar Dubey[1], Prof. A.K. Jain[2]

[1]ME IVth sem student, Department of Mechanical Engineering ,Jabalpur Engineering College Jabalpur (M P), India
Prof. A.K. Jain
[2]Associate professor , Department of Mechanical Engineering ,Jabalpur Engineering College Jabalpur (M P), India

ABSTRACT

One of the most important systems in a vehicle is the suspension system. The main objective of any suspension system is to maximize friction between the ground surface and the tires to provide driving stability. The coil spring performs significant work in various applications, for example machines and vehicles. At the point where a coil spring is under a static load. The normal static model for helical spring is the Wahl factor equation, which considers all design parameters, eg wire diameter, helix radius, spring radius and pitch angle are constant.

Keywords- Helical springs, Coil springs, Ansys software.

1 Introduction

Springs are used in a wide variety of industries for their mass damping and mechanical energy storage properties. As there is a wide variety of applications for springs, the design and parameters of springs are very broad based on their applications. These properties can include geometry, stiffness (K), offset to closing height, and resonance frequency. Metal springs can easily achieve desired stiffness parameters, but due to the density of these metals, springs can be heavier than desirable for many applications.

Figure 1 Stainless Steel Coil Spring

Figure 2 Suspension Coil Spring

2 Literature Review

Composite coil spring investigation in the early 1960s failed to produce the production unit due to inconsistent fatigue performance and absence of a strong need for mass reduction. Research in the field of automotive components is currently receiving considerable attention. Particularly car manufacturers and parts manufacturers have been trying to reduce the weight of vehicles in recent years. The emphasis on vehicle weight reduction in 1978 warranted a new look at compound springs.

S. Kamiya, et.al presented the FEA model on the load spring to determine the effects of parameters such as number of free turns and slenderness ratio on spring characteristics. They also explained spring adjustment preparation methods and spring seat tilt angle procedure to reduce lateral force. They developed a finite element model for the sideload spring and also studied the effects of parameters such as spring end coil angles and seat angles on the sideload spring reaction force line. They feature the new design with the combination of Finite Element Analysis and mechanical dynamics. However, the design procedure was not entirely significant, and some developments still need to be deliberated for the design procedure. P Singh et al. they developed the 3D finite element model of the coil spring using Ansys software. They applied different types of material to develop the coil spring. **P.Ghate et al.** analyzed the failure of a helical spring of a freight locomotive, redesigning to improve durability and displacement index, the composite suspension system can sustain loads under normal operating conditions and maintain displacement index, but the failure occurs during curves of hunting and speeds to avoid this the study of the dynamic behavior of a compound spring.

K Pavan Kumar et al. deliberate on the static analysis of the primary suspension system, based on the coil spring modeling in Pro/E and ANSYS analysis of the primary suspension spring with two materials Chrome Vanadium is an existing material and 60Si2MnA steel is a new material, the traditional helical steel The 60Si2MnA spring is demonstrated as the best material for helical spring due to the decrease in deflection and high pressure. The objective of the present work is to determine the safe load of the helical spring of the vehicle suspension with different types of materials and to arrive at the ideal project. In this project work, Catia and Ansys software were used to create and analyze the design of the helical spring. **N. Lavanya et. al.** They investigated the optimal design and analysis of a suspension spring for a motor vehicle subjected to static analysis of coil springs. the work shows that the voltage and voltage reaction of the spring conduit will be seen under recommended or expected loads and the pressure and strain estimates initiated for low carbon base steel are less contrasted with the chrome vanadium material, furthermore, it improves exhaustion cyclic of the helical spring.

Takao T. Takeaki and **G. Mitsuo** showed a design formulation for the ideal coil spring weight for a controlled permissible shear stress, number of active coils, and usual coil radius as a nonlinear integer software design problem. and solve it directly keeping the nonlinear constraint using improved genetic algorithm. As a result, the number of decision (design) variables did not increase, generating the best cooperative solution. The objective of the present work is to determine the safe load of the helical spring of the vehicle suspension with stainless steel materials and arrive at the ideal design. In this project work, Catia and Ansys software were used to create and analyze the design of the helical spring.

3 Material for coil springs

The spring material should have the following properties as mentioned below High ductility High resilience Creep resistant Mainly coil spring material selection largely depends on the application such as Heavy duty, medium duty and light duty. Coil springs are also called tightly wound when the spring wire is wound so closely that the plane containing each turn is nearly perpendicular to the axis of the helix and the wire is subjected to twist. In open coil springs, the spring wire is wound in such a way that there is a gap between the two consecutive turns.

4 Material Selection

Materials make up around 60%-70% of the vehicle's cost and contribute to the vehicle's quality and performance. Even a small reduction in vehicle weight, anywhere, can have a significant economic impact. Composite materials have proven to be suitable substitutes for steel in terms of vehicle weight reduction. Thus, composite materials were selected for the design of helical springs.

5 Coil Springs come in four basic categories

They are versatile as they are used in many different types of applications. You can find coil springs used by the medical, automotive and construction industry. Industrial equipment often requires the use of precision and strength in the design and materials of its parts. Before you start designing the necessary components, you will have to determine which of the categories is most appropriate:

The vehicle's suspension system contains three elements which are spring, wishbones and shock absorbers. The application of the above three elements is to filter and transmit the forces exerted between the vehicle body and the road. The spring is one of the most important systems as it transports the vehicle's body mass on an uneven, zigzag surface. This contributes to providing a comfortable ride. The spring is an elastic component whose function is to distort when loaded and return to its original shape when the load is removed. To control energy, absorb or provide damping due to shock or vibration, as in car springs, rail dampers, aircraft landing gear and dampers. It also serves to apply forces as in clutches, brakes and spring valves. Spring also uses it to store energy like clocks. Based on the shape and application of the spring, there are different types of spring. Among all the above types of springs, leaf springs and coil springs are most commonly used in car suspension system. The structure of helical springs is composed of a wire wound in the shape of a helix. The cross section of the wire from which the spring is made can be circular, square or rectangular. The two forms of helical springs are helical compression spring and helical tension spring. Only compression springs will be of interest in this study.

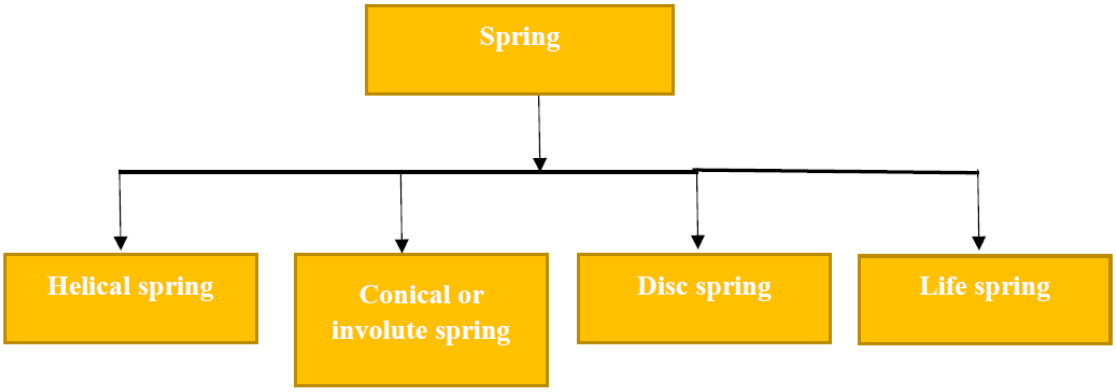

Figure 3 Classification of different type of spring

5.1 Compression Springs

These springs have an open coil system that is designed to oppose compression along the wind axis. In other words, loosely wound coils resist compressive force, the amount of force resisted can be affected by wind tension adjustment. This is the most common type of configuration and is commonly used in combination with a shank or fitted into a cylindrical hole.

5.2 Extension Springs

This type of coil is designed to absorb energy or store energy. In general, they will be used to create resistance to pulling forces. The degree of tension is determined by how tightly wound the coils are. These coils can be used in industrial robots such as door locks or baby strollers.

5.3 Torsion Springs

These coils are characterized by their torsional strength. The object's flexible wind stores mechanical energy. As the coil is twisted more tightly, the force, or torque, becomes stronger in the opposite direction. Helical torsion springs are used to operate clothespins, garage doors and suspension systems in automobiles. Of course, these systems are available in many different sizes, from very small to very large and powerful.

5.4 Spring guides

These guides are known by many different names such as coil tubes, medical springs and cable sheaths. They are long and thin and are used to provide flexible support within a project. They can be found in bicycle brakes, control cables in animatronics, or can be used as reinforcement inside plastic tubes.

6 Applications

The most common purpose of composite materials replacing metal parts is to reduce weight and/or increase performance. A composite spring must be able to offer weight savings due to decreasing the density of composite materials and increasing the resonant frequency of the spring. The stiffness and geometry must be acceptable and capable of allowing replacement of a metal spring with a composite spring without any additional components or designs.

Ideally, by simply swapping a metal spring for a composite spring, performance increases and weight decreases to offset the increased cost associated with composites. Potential markets for this spring include the competitive aerospace and automotive industries, but due to barriers to entry such as FAA approval with rigorous testing, this first product design will be aimed at a mountain bike suspension spring. Titanium springs are already used as mountain bike forks, with riders opting to save around half a pound by replacing an original steel spring with a lighter titanium spring. A successful composite spring can be half the weight of a titanium spring, offering an added advantage.

The composite spring described here will include similar geometry, stiffness and displacement to current titanium and steel springs used in mountain bikes. The broader objective of this analysis is not only to create a design for a composite spring to be used on mountain bikes as a proof of concept, but also to outline a design formulation that will allow the design of a composite spring to replace any metal spring. used today. . Factors like spring height, inner diameter, and spring constant are likely values that the compound spring would have to match to allow the user to say, swap your steel mountain bike spring for a composite spring. For this reason, these three values are kept constant for this analysis.

7 Spring Design

Conventional spring design holds that a spring behaves like a torsion bar with maximum direction of principal tension occurring at 45 degrees along the wire cross section. Below is the equation that allows calculation of spring stiffness factor (K) from spring geometry and material properties. This is true for all isotropic materials, but not for composites, as the composite material behaves orthotopically.

$$\text{Spring Constant } K = \frac{(G * r^4)}{(4 * R^3 * N_a)}$$

Na is the number of applicable coils in the spring, G the shear modulus of the material, R the radius of the coil, and r the radius of the spring's wire. This equation is derived from the equality of the linear spring constant K with angular terms of the torsion constant κ and substituting the material properties. , although not accurate for orthotropic composite materials.

8 Conclusion

To reduce the weight of the suspension spring and thus improve the vehicle's overall performance, the weight of the suspension system must be reduced by changing the coil spring material. By reducing the weight of the suspension spring, the total weight of the vehicle will also be reduced. Composite materials are selected which are composed of low carbon steel mixed with Vanadium and Chromium and other composite material of stainless steel with Vanadium and Chromium. The voltage distribution clearly shows that the shear stress is having maximum value on the inner side of each coil. Voltage distribution is similar across all coils. Therefore, the probability of spring failure on all coils is the same, except for the final turns. In this case, the residual voltage in each coil can be an important factor influencing the failure.

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