A REVIEW PAPER ON ANALYSIS OF HELICAL SPRING IN TWO WHEELER SUSPENSION SYSTEM

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Abstract
The suspension system is a critical component of any vehicle, including two-wheelers, as it plays a vital role in maintaining ride comfort, stability, and safety. Helical springs are commonly used in two-wheeler suspension systems due to their high strength-to-weight ratio, durability, and cost-effectiveness. However, the design and optimization of helical springs for two wheeler suspension systems remain a challenging task due to their complex behavior under various loading conditions.
The project titled " Design and Analysis of Helical Spring in Two Wheeler Suspension System" focuses on the design and analysis of helical springs used in the suspension system of two-wheelers.In this project , steel helical sprigs used in automobiles are replaced with Aluminium Alloy NL , Structural Steel and Titanium Alloy. The project involves the use of computer-aided design (CAD) software (SOLIDWORKS) to model the spring geometry and finite element analysis (FEA) (ANSYS) to simulate its behavior under different loading scenarios. The study aims to provide insights into the behavior of helical spring and improve their design for better ride comfort, handling, and stability of two-wheelers. The results obtained from the analysis will be validated through experimental testing of the designed spring. The findings of this study are expected to contribute to the development of better suspension systems for two-wheelers, leading to safer and more comfortable rides.
Keywords: ***(11 Bold)*** *Helical Spring, Suspension System, Solidworks, ANSYS.*

CHAPTER 1
INTRODUCTION
1.1 Introduction to Helical Spring
The suspension system plays a vital role in ensuring a comfortable and safe ride for vehicles, particularly in the case of two-wheelers. One crucial component of the suspension system is the helical spring, which provides support, absorbs shocks, and maintains stability while traversing uneven terrains. Designing an efficient and effective helical spring for two-wheeler suspension systems is a challenging task that requires careful consideration of various factors such as load capacity, spring rate, durability, and weight.
Helical springs are fundamental mechanical components widely used in various industries and applications due to their ability to store and release energy in the form of mechanical force. These springs are designed in a coiled shape, with a helix or spiral configuration, and are primarily used to absorb and distribute forces, provide support, and maintain equilibrium in mechanical systems.
The design and function of helical springs make them essential in numerous applications, ranging from simple everyday objects to complex industrial machinery. They are commonly found in automotive suspension systems, industrial machinery, aerospace equipment, consumer products, and even small-scale mechanisms like pens and watches.
The primary purpose of a helical spring is to resist deformation when subjected to an external force, known as the load or the applied load. When the spring is compressed, stretched, or twisted, it exerts a counteracting force in the opposite direction, known as the reactive force. This characteristic allows helical springs to store potential energy and release it when the applied force is removed, making them indispensable in applications requiring oscillation, vibration damping, shock absorption, and force distribution.
The design considerations for helical springs involve various factors, such as material selection, wire diameter, coil pitch, number of active coils, and spring index. These parameters determine the spring's mechanical properties, including stiffness or spring rate, maximum load capacity, deflection range, and fatigue life. Selecting the appropriate spring design parameters is crucial to ensure optimal performance, reliability, and safety in the intended application.

Advancements in spring manufacturing techniques, material science, and computational analysis have led to the development of highly efficient and specialized helical springs. Materials commonly used in helical spring production include high-carbon steel, stainless steel, alloy steels, and non-ferrous alloys. Additionally, the advent of computer-aided design (CAD) software and finite element analysis (FEA) tools has enabled engineers to accurately simulate and analyze the behavior of helical springs under various loading conditions, facilitating optimized designs and improved performance.
Helical springs have revolutionized numerous industries by providing solutions to complex engineering challenges. Their ability to withstand high loads, exhibit predictable and repeatable behavior, and maintain their structural integrity over extended periods makes them indispensable in ensuring the efficient functioning of mechanical systems. Whether in automotive suspension systems, industrial machinery, or everyday consumer products, helical springs continue to play a vital role in enhancing performance, reliability, and safety across a wide range of applications.
1.2 Applications of Helical Springs
Helical springs find applications in a wide range of industries and products due to their versatility and ability to provide

mechanical support and absorb and distribute forces. Here are some of the common applications of helical springs:
Automotive Industry: Helical springs are extensively used in the automotive sector, particularly in suspension systems. They help absorb shocks, maintain stability, and provide a comfortable ride. They can be found in coil springs used in independent suspension systems, torsion bars, and valve springs in engines.

Industrial Machinery: Helical springs are employed in various industrial machinery and equipment. They are used in vibratory feeders, conveyor systems, presses, clutches, brakes, and heavy machinery to provide support, absorb vibrations, and ensure smooth operation.

Aerospace and Defense: Helical springs are crucial in aerospace and defense applications. They are used in landing gear systems, control mechanisms, missile systems, aircraft seating, and parachute deployment systems, providing reliability, shock absorption, and force distribution in critical operations.

Consumer Products: Helical springs can be found in a wide range of consumer products. They are used in mattress coils, furniture springs, door locks, retractable pens, watches, and toys to provide comfort, adjustability, and reliable mechanisms.

Medical Devices: Helical springs play a vital role in various medical devices. They are used in surgical instruments, prosthetics, orthopedic implants, and hospital equipment, ensuring proper functioning and support in critical medical applications.

Electronics and Electrical Applications: Helical springs are utilized in electrical contacts, connectors, switches, relays, and battery contacts. They provide electrical conductivity, ensure proper connection, and assist in mechanical movements.

Construction and Architecture: Helical springs find applications in the construction and architecture industry. They are used in doors, windows, garage doors, and overhead doors to provide counterbalancing force, allowing smooth and controlled opening and closing.

Oil and Gas Industry: Helical springs are used in oil and gas exploration and production equipment. They can be found in valves, pressure relief devices, drilling equipment, and downhole tools, where they assist in providing reliable operation under extreme conditions.

Scientific and Laboratory Equipment: Helical springs are used in scientific instruments, laboratory equipment, and precision measurement devices. They assist in controlling forces, maintaining alignment, and ensuring accurate readings.

Railway and Transportation: Helical springs are employed in railway systems, such as bogie springs, coupler springs, and suspension systems. They provide stability, absorb vibrations, and ensure safety in rail transport.
These applications highlight the versatility and importance of helical springs in various industries, where they contribute to the efficiency, performance, and safety of mechanical systems and products.

1.3 Parts of Helical Spring

The main components of a helical spring include:
Wire: The wire is the primary material used to create the helical spring. It is typically made of various materials such as high-carbon steel, stainless steel, alloy steel, or non-ferrous alloys. The wire is coiled into a helix shape to form the spring.
Body: The body of the helical spring refers to the entire coiled structure. It consists of a series of turns or coils that form the spring's shape. The body provides flexibility, elasticity, and the ability to store and release mechanical energy.
Ends: The ends of the helical spring are the portions where the wire terminates. There are different types of ends depending on the specific application. The ends can be open, closed and ground, closed and not ground, or shaped with various hooks or loops.
Active Coils: Active coils refer to the coils of the spring that contribute to its flexibility and deflection under load. These coils are responsible for absorbing and distributing forces, providing the spring's characteristic properties, such as spring rate and load-carrying capacity.

1.4 Types of Helical Springs

There are many types of helical springs, each with its own unique properties and applications. Here are a few of the most common types:
Compression springs: Compression springs are the most common type of helical spring. They are designed to resist compression forces. Compression springs are used in a wide variety of applications, including suspension systems, valves, and clamps.

Fig 1.1 Compression Spring

Extension springs: Extension springs are the opposite of compression springs. They are designed to resist extension forces. Extension springs are used in applications where it is necessary to absorb energy, such as shock absorbers and trampolines.

Fig 1.2 Extension Spring

Torsion springs: Torsion springs are designed to resist twisting forces. Torsion springs are used in applications where it is necessary to transmit torque, such as car steering

Fig 1.3 Torsion Spring

Variable pitch springs: Variable pitch springs have a varying pitch, or distance between coils. This allows them to be more compact than conventional springs while still providing the same amount of force. Variable pitch springs are used in applications where space is limited, such as watches and cameras.

Fig 1.4 Variable Pitch Spring

Hourglass springs: Hourglass springs are a type of compression spring that has a tapered shape. This gives them a greater force output than conventional compression springs of the same size. Hourglass springs are used in applications where high force output is required, such as firearms and gas springs.

Fig 1.5 Hourglass Spring

1.5 Adavantages of Helical Springs

1. Wide Range of Load Capacities: Helical springs can be designed to handle a wide range of load capacities, making them suitable for various applications. They can be customized to meet specific requirements, from light-duty to heavy-duty applications.
2. High Energy Storage: Helical springs have excellent energy storage capabilities. They can absorb and store mechanical energy when compressed, stretched, or twisted, and release it when the force is removed. This property allows them to provide a reliable and consistent force or displacement.
3. Versatility in Design: Helical springs offer versatility in terms of design. They can be customized in terms of wire diameter, coil pitch, number of active coils, and material selection to meet specific performance requirements. This versatility allows for optimization in terms of load-bearing capacity, spring rate, and deflection range.
4. Cost-Effective: Helical springs are generally cost-effective compared to other types of springs. They can be manufactured using various materials and production methods, allowing for cost-efficient production in large quantities. This makes helical springs a practical choice for a wide range of applications.

5. Wide Range of Applications: Helical springs find applications in numerous industries, including automotive, aerospace, industrial machinery, consumer products, and more. Their versatility and ability to provide support, absorb shocks, and distribute forces make them indispensable in various mechanical systems.

1.6 Disdavantages of Helical Springs

1. Limited Deflection Range: Helical springs have a limited deflection range. While they can provide significant deflection within their design limits, their range is restricted compared to other types of springs such as gas springs or elastomeric springs. This limitation may require the use of multiple springs or additional components to achieve the desired deflection.
2. Solid Height Consideration: Helical springs require a certain amount of solid height or space to maintain their functionality. The solid height is the length of the spring when it is fully compressed without any gaps between the coils. This requirement may restrict their use in applications with limited space or tight packaging constraints.
3. Stress Concentration: Helical springs are prone to stress concentration, especially at the ends where the wire terminates. This stress concentration can lead to premature failure, particularly in high-stress applications or under cyclic loading conditions. Proper design considerations, such as end grinding or stress-relief processes, can help mitigate this issue.
4. Fatigue and Wear: Helical springs are subject to fatigue and wear over time, particularly when subjected to repetitive loading cycles. The repeated compression, extension, or twisting of the spring can lead to material fatigue, resulting in reduced performance or failure over an extended period. Proper material selection and periodic inspection and maintenance can help prolong the spring's lifespan.

CHAPTER 2
LITERATURE SURVEY

N.Lavanya et.al [1] The present work is optimum design and analysis of a suspension spring for motor vehicle subjected to static analysis of helical spring the work shows the strain and strain response of spring behaviour will be observed under prescribed or expected loads and the induced stress and strains values for low carbon structural steel is less compared to chrome vanadium material also it enhances the cyclic fatigue of helical spring.

Kommalapati. Rameshbabu, et.al [2] In this project they have designed a shock absorber used in a 150CC bike and modeled the shock absorber by using 3D parametric software Pro/Engineer. To validate the strength of design, structural analysis and modal analysis on the shock absorber was done. The analysis was done by varying spring material Spring Steel and Beryllium Copper. By observing the analysis results, the analyzed stress values are less than their respective yield stress values. The design is safe, by comparing the results for both materials, the stress value is less for Spring Steel than Beryllium Copper. Also the shock absorber design is modified by reducing the diameter of spring by 2mm and structural, modal analysis is done on the shock absorber. By reducing the diameter, the weight of the spring reduces. By comparing the results for both materials, the stress value is less for Spring Steel than Beryllium Copper. By comparing the results for present design and modified design, the stress and displacement values are less for modified design. So they concluded that as per our analysis using material spring steel for spring is best and also their modified design is safe.

C.Madan Mohan Reddy et.al [3] the comparative study has been carried out in between the theoretical values to the experimental values and the analytical values. The maximum shear stress of chrome vanadium steel spring has 13-17% less with compare to hard drawn steel spring. The deflection pattern of the chrome vanadium steel spring 10%less at specified weight with compare to the hard drawn steel spring. It is observed that 95% of the similarity in deflection pattern and 97% similarity in shear stress pattern between experimental values to the analytical values. It is observed that 60%similarity in between theoretical values of deflection to the experimental values and 85% similarity in maximum shear stress of spring.

K.Vinay Kumar et.al [4] used three different materials like alloy steel, chromium vanadium steel; stainless steel was used with a constant load of 850N. Among the above materials alloy steel material gave the better stress and deformation values. Mostly prefer alloy steel material for bike suspension spring due it its material stability and ductility by observing those analysis stress and deformation values. Alloy steel material is staying stable up to load 2550N. Later, by increasing loads the stress was crossing the yield strength of the material due to that the breaking of spring will be takes place. Therefore, from the above practical result alloy steel material is more stable and gives good efficiency compared to other two materials.

Prince Jerome Christopher.J [5] ,The objective of research is to design and analyze the performance of Shock absorber of the coil spring. The shock absorber design is improved by reducing the diameter. Author designed a Shock Absorber used in 160 cc bike .This shock absorber is modeled by using 3D parametric software called Pro/Engineer. The analysis is done by considering bike mass, loads, and number of persons seated on bike by using ANSYS.

Logavigneshwaran S [6] ,Author study the various parameters influencing the stress and deformation induced. After studying the various parameters, modeling is done by using Pro/ENGINEER. For analysis ANSYS software is used. The analysis is performed by considering the bike mass and with persons seated on the bike. Study is done by changing the wire diameter of the coil spring to check the best dimension for the spring in shock absorber.

Mallick Kamran et.al [7], The authors work is based on modeling, testing and analysis of helical suspension system used in two wheeler bike. . A typical two wheeler suspension spring for Hero Splendor 125 cc is selected for the application. The various designs of springs are modeled by reducing the diameter of the existing spring in CATIA software. The analysis is carried out by considering bike mass, loads, and no of persons seated on bike by using ANSYS. The stress and deflections of the helical spring are determined by using finite element analysis approach. The author compares the actual spring with new spring for constant material. The results from finite element analysis are compared to the experimental values.

Aakash Bhatt et.al [8], Their work demonstrates the feasibility of adopting composite material for design of helical coil suspension system. An effort is made to carry out the design & analysis of combination of steel and composite material, which has resulted into greater stiffness, with reduced weight of the spring.

Singh Pankaj [9], the authors work is based on design and 3D modeling of helical compression spring used in mono shock suspension system of unicorn bike. The statistical structure analysis is done by FEA method in ANSYS for different spring materials and varying wire diameter of spring. The materials used for analysis are 1095, 5160, Carbon steel, Cobalt chrome, Chrome vanadium, Beryllium copper and the wire diameters are 12mm,14mm. Authors calculate the forces exerted on spring for different materials. For these calculations they assume that the vehicle is in motion. The authors compared the final results and choose the better among all results.

Vijayeshwar BV. et al. [10] In this research paper they evaluated the manufacturing of helical coil suspension springs as per requirement. The objective of this work is a comparative study and analysis of suspension helical coil spring with two different materials like Chrome Silicon and Hard drawn carbon steel. They designed the shock absorber model using Pro/E Creo 2.0 and analysis of stress and deflection they used ANSYS 15.0. After the theoretical and ANSYS results shows that Chrome silicon spring steel is the optimum suitable material with low weight and high stiffness for helical spring applications like mono shock suspensions in bikes and many more.

N. Sai Kumar and Prof. R. Vijay Prakash [11] in this research paper they have design and analyze the performance of the shock absorber by varying the wire diameter of the coil spring. They explain all types of shock absorber properties and using metal spring wire. They consider various types of motorbike spring specification and modeling of suspension springs. They used alloy steel. Chrome vanadium steel of spring materials. They determine the analysis of maximum shear stress, maximum principal stress, normal stress, strain, maximum principle strain, normal strain, total deformation are noted. The results of alloy steel are showing the best results in three vehicles (Among there for Yamaha alloy steel got the least stress). The alloy steel is preferable compared to chrome vanadium steel.

Suraj R. Bhosle et al. [12] In this research paper the comparative study of suspension helical coil spring with different materials using finite element analysis. They create the shock absorber model in Creo Parametric 2.0 and structural analysis of the same is done using ANSYS 17.0. The comparative study shows the optimum material to be used for the spring by proper analysis of the deflection and stresses of the helical spring. They used four different material of spring are Chrome vanadium, Hard drawn spring wire, steel, Oil tempered carbon steel and Stainless steel. After the analysis the chrome vanadium stands out to be efficient material for spring especially at higher loads.

MacArthur, L. Stewart [13] In this paper they determine the maximum torsion stress, fatigue life, natural frequency and load loss due to stress relaxation of helical compression spring. The intent of this paper was to make a useful contribution to the published works for evaluating round wire helical compression springs. They used FEA software to construct a structural model of a helical compression spring to simulate its full range of compression. The aim of these researchers was to replace steel with a viable composite material. In this type of materials resulted in a reduction in stress and weight, but an increase in displacement. They used an innovative methodology for constructing a virtual prototype of a helical compression spring.

P.R. Jadhav et al. [14] This paper deals with analysis of dual suspension by using FE approach and validated with analytical with varying speed. In this research helical spring related to the light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solutions. They compared the analysis results to determine stress and deflection at various speeds for carbon steel material. The model of dual suspension motor vehicle that can vibrate in the vertical direction while traveling over a rough road. The results are elaborated in an earlier chapter the brief discussion and conclusion is present as follows. The deflection is Maximum in between the 3km/hrs to 10km/hrs and further reduces as speed increases stress is Maximum in between the 3km/hrs to 10km/hrs and further reduces as speed increases.

C.Rahul Tekade et al.[15] Shock absorbers are devices that smooth out an impulse experienced by a vehicle, and appropriately dissipate or absorb the kinetic energy. Almost all suspension systems consist of springs and dampers, which tend to limit the performance of a system due to their physical constraints. Suspension systems, comprising of springs and dampers, are usually designed for passengers' safety and do little to improve passenger comfort. To meet the current demands of high speed and safety we must designed and developed such a shock absorber which can sustain more and more vibrations and also improve the safety.

B. Mehdi et al.[16] In this paper author used helical spring is the most common used in car suspension system, steel helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution and steel spring has been replaced by three different composite helical springs including E-glass/Epoxy, Carbon/Epoxy and Kevlar/Epoxy. Numerical results have been compared with theoretical results and found to be in good agreement.

M. Mulla et al. [17] Presented the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of spring.

H. James M. Meagher et al. [18] The author presented the theoretical model for predicting stress from bending agreed with the stiffness and finite element model within the precision of convergence for the finite element analysis. The equation was calculated by principal stresses and von misses stress and it was useful for fatigue studies. A three-dimensional finite element model was used for two coil of different wire model, one was MP35N tube with a 25% silver core and other a solid MP35N wire material helical conductor and the result was compared with the proposed strength of material model for flexural loading.

J. Mohamed Taktak et al.[19] In their work a numerical method to model the dynamic behavior of an isotropic helical spring is coupled with optimization algorithms to construct a dynamic optimization method based not only on mechanical and geometrical objective functions and constraints; but also on dynamic ones. In the proposed dynamic optimization problem, four geometric parameters are chosen as design variables (wire diameter, middle helix diameter, active coils numbers and spring pitch). The result of simulation shows that by these algorithms the helical spring mass can be greatly reduced and the design quality is improved by moving away the helical spring first natural frequency from working zone.

K. Priyanka Ghate et al.[20] In the present investigation, it was found that the existing primary suspensions with composite spring assembly could sustain loads in normal operating conditions and maintain the required ride index, however, during cornering and hunting speeds failure of outer spring of primary suspension was observed. In the present work, an attempt was made to analyze in detail the reason for failure and a single nonlinear spring had been suggested to improve durability of the primary suspension and in the meantime the required ride index.

L. Kaiser et al.[21] In this paper, the author presents a long-term fatigue tests up to a number of 109 cycles on shot peened helical compression springs with two basic dimensions, made of three different spring materials. The test springs were manufactured of oil hardened and tempered of SiCr and SiCrV- alloyed valve spring steel wires and of a stainless-steel wire with diameters of 1.6 mm and 3.0 mm with shot peened. A lot of research paper are studied and found that there are used many type of new composite materials to reduce the many type of problems in two-wheeler suspension system. But there are some materials (Hastelloy, Elgiloy, and Inconel) are also available which are not used till now in any research papers. By using these materials (Hastelloy, Elgiloy, Inconel) the problem in suspension system can be also reduced.

Sataynarayana, K. et. al.[22] presented work is carried out on modelling and analysis of a helical spring used in two-wheeler rear suspension system and the purpose of this project is to increase the stiffness as well as reduce the stress and deflection produced in the coil and also a comparative study is carried out between existed spring with various materials. So as to the reduce vehicle problem happens while driving on bumping road condition. The modeling of spring is carried out by SOLIDWORKS 2019 and analysis it with finite element analyzer ANSYS 18.1 and further is to check the feasibility of helical spring by changing cross-sectional area from circular to square.

Chandrakant Khare et. al.[23] investigates structural steel material for helical coil suspension using the finite element method by ANSYS software and later subjected to design optimization using response surface optimization considering coil diameter and coil means radius as optimization parameters. Sensitivities of both input parameters are plotted for equivalent stress and deformation. Considerable weight reduction of helical coil suspension is achieved using the response surface method.

Agarwal and Jain [24], reported that the design and analysis of helical spring in two wheeler suspension system using finite element method (FEM) by changing the cross section of the helical spring under the static structural analysis. Three cross sections have been selected namely circular, square and square fillet. The spring models for the existing design of CBZ extreme bike helical coil spring have been created by using Pro/E Creo 2.0. The deflection and the Von-Mises stress of three spring models are obtained by finite element analysis. The maximum displacement and Von-Mises stress are achieved in circular cross section and the least by square cross section.

Rajurakar and Swami [25], aimed in caring out a feasibility check for the properties of helical spring by changing the cross section and by changing the material under varying load from 55N to 95N. The results proved that stresses are almost equal but the deflection in spring of chrome vanadium material when compared to hard carbon steel spring proved more deflection. Although the deflection is more it works efficiently with less maintance. The check also ensured that structural reliability is more in circular cross section than in rectangular.

Pawar et al. [26], proposed an optimisation technique for spring in three wheeler suspension system. The number of coils of the springs is reduced from 14 to 13 (keeping all other parameter same), in order to reduce the weight of the spring. Hence, the efficiency of vehicle improved and fuel consumption rate decreased. The weight of spring is reduced by 6% whereas the stress by 13%. The stiffness and the load carrying capacity of suspension system has also increased considerably.

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