A REVIEW ON VIBRATION ANALYSIS OF MONO SUSPENSION USED IN A TWO WHEELER BY NUMERICAL RELATION AND MATLAB SOFTWARE

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ABSTRACT

The present work deals with the behaviour of mono suspension helical spring of a two wheeler suspension system under different road conditions and to find the different governing parameters using the numerical relations which are traditionally accepted and to compare the parameters such as speed, transmissibility, stress, and force (i.e. the jerk obtained at different speeds of a running vehicle due to uneven road conditions) to perform a forecasting of that analysis using MATLAB ANN tool using different inputs which are responsible for certain outputs. Finally we will perform a comparative study on numerically obtained results and the results obtained from MATLAB ANN tool to validate our research. The present work also involves the study of behaviour of different spring materials which can be used for manufacturing of a mono suspension spring.

Keywords: *Mono suspension Spring, MATLAB, Speed, Force, Stress, Transmissibility, Artificial Neural Network (ANN)*

INTRODUCTION

The springs are the separate machine elements of various configurations, having the primary function to act as a cushioning element. This means undergoing significant deflection under load, thereby absorbing energy in the form of strain energy.

Helical springs are often used in mechanical systems. They can be designed in such a way that they show nonlinear behavior. This means that the spring stiffness is not constant but depends on the compression. This nonlinear behavior occurs when the number of active coils decreases or increases with varying compression. The nonlinear behavior of a spring can be achieved by

- varying the coil diameter
- - varying the pitch
- - varying the mean spring diameter in axial direction

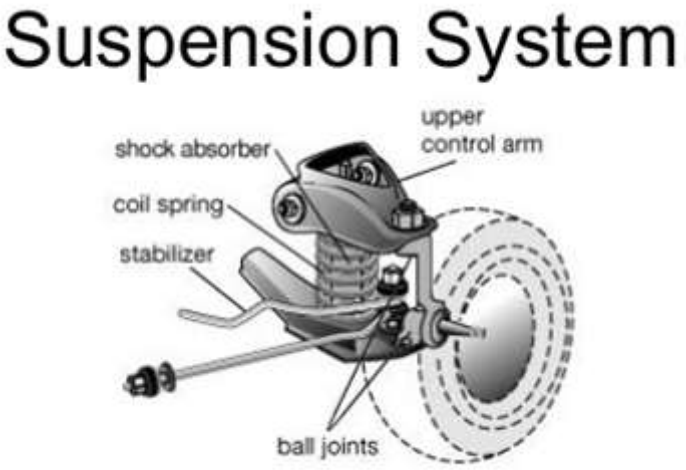


Figure 1 Suspension System

Types of suspension system: It is broadly classified in three categories

A. **Independent Suspension System:** It means it act as a independent suspension in all the wheels on a particular vehicle and provides better stability, better ride quality and handling ability. It is of many types, some of them are specified as under
   i. Double wishbone suspension
   ii. Multi-link suspension
   iii. MacPherson strut
   iv. Transverse leaf-spring

B. **Dependent Suspension System:** It is that type of suspension system which have a single suspension system which connects the wheels by linkages in both axial and transverse directions. For Example Solid Axle suspension system

C. **Semi-Independent System:** It is the combination of both independent and dependant types of suspension systems which have partial effect of deviation of one wheel over another wheel. For example twist beam suspension system.

Mono suspension spring: A mono suspension spring is that type of spring which is generally used in the front wheel of a two wheeler automobile as it connects the frame and swing arm which is finally pivoted to the axle to act as a cushion. Sometimes it is also placed in the rear suspension to act the same function of absorbing shock. The mono suspension spring are used now days as they are compatible with the present Indian roads which are much better then the severe road conditions if we talk around 20 years back. Although the dual shock absorbers are strong enough to withstand the load coming from a extremely bad road surface but due to weight and cost associated, it is now can be replaced by mono suspension spring which is comparatively very light and can handle the variable loads with grater handling and stability.

LITERATURE REVIEW

Lade AV, Paropate RV, Choube AM and Wakulkar RE [1] analyzes spring, shock absorbers and linkages which connects vehicle to its wheel and allows relative motion between them are termed as suspension. Springs are helical metal coil which can be pressed or pulled but they have tendency to return to its original shape and size when released generally springs are used to absorb the shock or movement by its elastic action. Helical springs are being used in many vehicles as shock absorbers to have smooth ride, better control over vehicle, maintain correct ground clearance, and keep tires in contact with road.

Kumhar Vikky, [2] analyzed the effectiveness of the shock absorber in spring frequency under load condition. The shock absorber is commonly used at all vehicles today. The purpose of this research paper is to investigate and identified the problem in shock absorber spring during ride a motor cycle on bump. After identified problem we can decreases stress, deformation and increases its frequency capability by changing its coil diameter of spring. There are some problem happen at the vehicle when ride at the bumping road condition. One of the problems is that the vehicle bounce continuously more than one times and it is called as bouncing problems. The scope of study for this paper includes, experimental of suspension systems and bouncing problem in vehicle, apply structural analysis and model analysis on the shock absorber spring and application of Finite Element Analysis (FEA). To study the stress pattern of shock absorber spring in its loaded condition, a solid model of Shock absorber is prepared with the help of Creo Parametric 2.0 software. Pattern of stress distribution in 3D model of shock absorber spring is obtained using ANSYS 15.0 software. In this present work, the obtained stresses by using finite element analysis with different coil spring as same material and validate to other research work reduce stress & Deformation by changing material property.

Choube AM, [3] deals with analysis of mono suspension by using FE approach and validated with analytical with varying speed. Helical spring is the most common element that has been used in suspension system. In this research, 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. Maximum stress and deflection have been compared at various speeds for carbon steel material.
This study presents the stress analysis of mono suspension spring. Here, stresses and deflections are calculated with changing speed and validated with FEA. From the finite element analyses, the following findings are reported. Though, the results are elaborated in earlier chapter, the brief discussion and conclusion is presented as follows. For Mono suspension spring, it is observed that deflection get increases with increasing speed upto 10 km/hr on other hand shear stresses are also increases. But after 10km/hr, both deflection and shear stresses are going to decreases with increasing in speed. It means at higher speed, it gives low deflection and low shear stresses which are beneficial for life of spring.

Lavanya N and Rao P Sampath and Reddy Pramod M, [4] in 2014 Observe the vibrations from shock loads due to irregularities of the road surface. It is perform its function without impairing the stability, steering (or) general handling of the vehicle. Generally for light vehicles, coil springs are used as suspension system. A spring is an elastic object used to store mechanical energy and it can be twist, pulled (or) stretched by some force and can return to their original shape when the force is released. The present work attempts to analyze the safe load of the light vehicle suspension spring with different materials. This investigation includes comparison of modeling and analyses of primary suspension spring made of low carbon-structural steel and chrome vanadium steel and suggested the suitability for optimum design. The results show the reduction in overall stress and deflection of spring for chosen materials.

Manjunatha, TS and Budan, D Abdul, [5] in 2012 deals with the applicability of fiber reinforced plastic in springs. Three different types of springs were manufactured using glass fiber, carbon fiber and glass/carbon fiber in +45 degree orientation. Tests were conducted on the springs to study the mechanical behavior. The spring rate of the carbon fiber spring is found to be 24% more than the glass fiber spring and 10% more than the glass/carbon fiber spring. Stresses acting on the composite springs were less compared to steel spring. The weight of the composite spring is almost 70% less than that of the steel spring. The specimen preparation and experiments were carried out according to ASTM standards.

Singh Niranjan,[6] in 2013 Studied the main functions of automobile suspension systems are to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems basically consist of all the elements that provide the connection between the tires and the vehicle body. A spring is an elastic object used to store mechanical energy. It is an elastic body that can be twisted, pulled, or stretched by some force. It can return to their original shape when the force is released. It is a flexible element used to exert a force or a torque and, at the same time, to store energy. The force can be a linear push or pull, or it can be radial, acting similarly to a rubber band around a roll of drawings. The torque can be used to cause a rotation. The literature review discussed above depicts that the design of mechanical springs used in automobiles is quite necessary to do it's deign analysis which involves stress distribution analysis, maximum displacement and different mode of failure. The springs undergo the fluctuating loading over the whole span of service life. In addition, various Design

softwares like ANSYS, SolidWorks, Pro-E, CATIA, Autodesk Inventor, etc., have been used for performing the stress analysis of mechanical springs. Comparison of the theoretical results obtained by the shear stress equation and Finite Element Analysis (FEM) of springs provides the better solution of the problems arises in the existing design of the mechanical spring. In future, it will help the designers for predicting the safe design of mechanical springs used in the automobiles to get better and comfortable ride.

Setty Thriveni, G and Gowd, G Harinath, [7] in 2014 Choosen the mono suspension system for various two wheelers in their study. The present work focuses mainly on obtaining the optimal spring dimensions without affecting the riding comfort for mono suspension system. To meet the above objective, first the existing springs of Honda CB Unicorn & Yamaha FZ springs will be tested for its strength by conducting the compression test. Later its 3D model drawn using SOLIDWORKS will be imported to HYPERMESH for meshing the spring & to apply the required loads on it. Finally by importing it into the ANSYS software to evaluate the stresses, strains and its load carrying capacity by doing static analysis. Mainly, this paper deals with the coil spring which is used in the Mono Suspension system. Then further analysis using the above softwares will be done by changing the spring dimensions and by using alternate materials. Thereby the optimal dimensions will be identified.

Vijayeshwar BV, Preetham B M, Bhaskar U,[8] in 2017 Performes a comparative study and analysis of suspension helical coil spring with two different materials (chrome silicon and hard drawn carbon steel) static analysis using finite element analysis to determine the optimum material to reduce the stress and deflection. Suspension model is created in Pro E CREO 2.0 and the model is structurally analysed using ANSYS 15.0. The results and comparative study shows the optimum material that can be selected as spring material for efficient function and long life.
It is proved theoretically and through ANSYS that the spring in which maximum shear stress is induced. Deflection induced in chrome silicon spring is very much less than deflection induced in hard drawn carbon spring, the weight and density of chrome silicon spring is lesser than hard drawn carbon spring. So Chrome silicon spring steel is the optimum suitable material with low weight and high stiffness for helical spring application like mono shock suspensions in bikes and many more.

H. Douville, P. Masson, A. Berry,[9] in 2006 Presents a methodology for the analysis of the structure-borne noise transmission paths for an automotive suspension assembly. First, a fully-instrumented test bench consisting of a wheel/suspension/lower suspension A-arm assembly was designed in order to identify the vibro-acoustic transmission paths (up to 250 Hz) for white noise excitation of the wheel. Second, frequency response function measurements between the excitation signal and each suspension/chassis linkages are used to characterize the different transmission paths that transmit energy through the chassis of the car. Results obtained from the on-resonance transmissibility methodology of a Ford Contour 1998 suspension assembly cannot be transposed directly to any other suspension assembly. On-resonance transmissibility factors (ORTF) and on-resonance participation factors (ORPF) of any other suspension assembly can be computed by the use of the presented on-resonance transmissibility

NUMERICAL METHOD

$$Spring Index = \frac{D}{d} \quad \text{.....(3.1)}$$

$$\boldsymbol{Spring\ Index} = \frac{\boldsymbol{D}}{\boldsymbol{d}} \qquad (1)$$

Where,
D = Mean Diameter
D = Wire Diameter

$$\omega = \frac{2\times\pi\times f}{60\times60} \qquad (2)$$

Where,
f = Vehicle Speed in meters/sec.

$$G = \frac{E}{2\times(1+\nu)} \quad (3)$$

Where,
G = Modulus of Rigidity, N/mm^2
E = Modulus of Elasticity, N/mm^2
ν = Poisson's Ratio

$$K = \frac{G\times d^4}{8\times n\times D^3} \quad (4)$$

Where,
K = Stiffness in N/m
n = No. of active turns

$$\omega_n = \sqrt{\frac{K}{m}} \quad (5)$$

Where,
ω_n = Natural Frequency in rad/sec.
m = Mass of vehicle

$$\text{Amplitude Ratio} = \frac{X}{Y} \quad (6)$$

Where,
X = Deflection on Road Surface
Y = Deflection transmitted to Vehicle

$$F = K \times X$$

Where,
F = Force in N
K = Stiffness in N/m
X = Deflection in m

$$K_s = \frac{2C+1}{2C}$$

Where,
K_s = Shear stress correction factor.
C = Spring Index
Shear stress can be obtained by the formula

$$\tau = K_s \frac{8 \times F \times C}{\pi d^2}$$

Where,
τ = Shear Stress in N/m^2

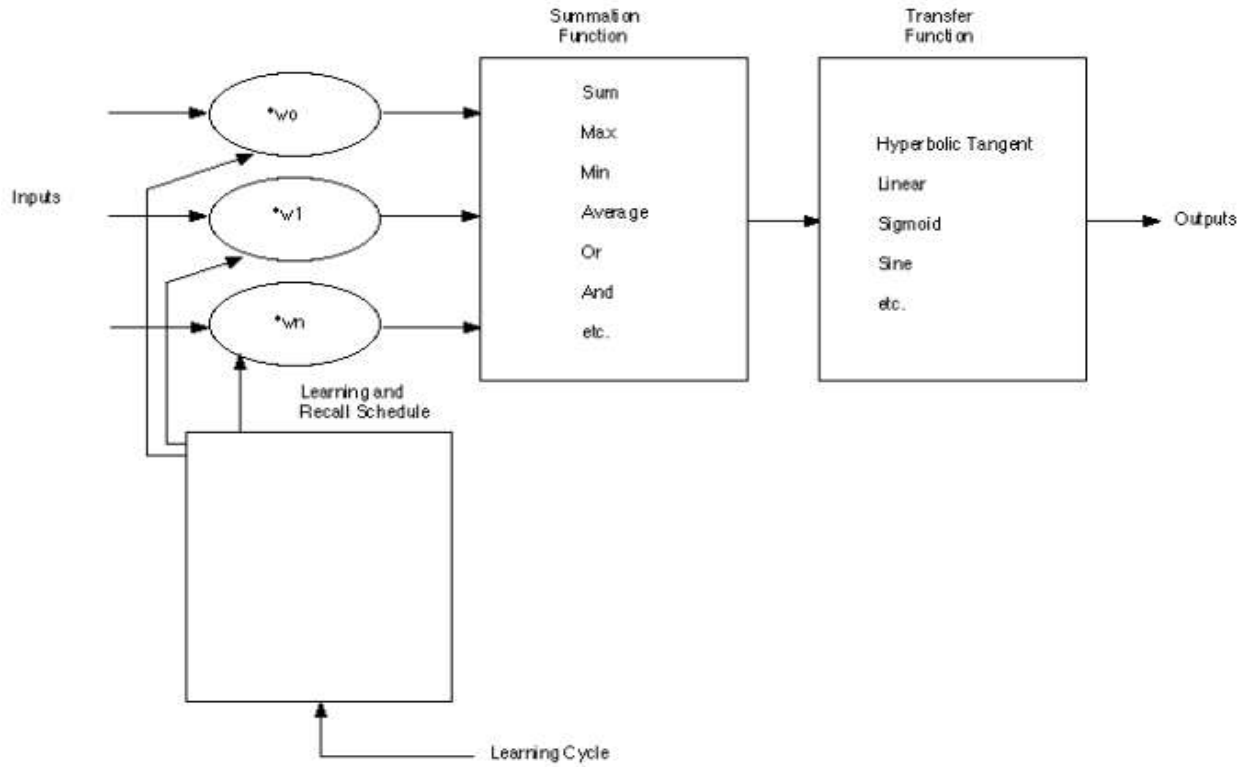
Artificial Neural Network

An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense - based on that input and output. In other words it can be defined as A computing system that is designed to simulate the way the human brain analyzes and process information. Artificial Neural Networks (ANN) is the foundation of Artificial Intelligence (AI) and solves problems that would prove impossible or difficult by human or statistical standards. ANN has self-learning capabilities that enable it produce better results as more data becomes available.

Advantages of ANN: ANNs have three layers that are interconnected. The first layer consists of input neurons. Those neurons send data on to the second layer, which in turn sends the output neurons to the third layer. An ANN has several advantages but one of the most recognized of these is the fact that it can actually learn from observing data sets. In this way, ANN is used as a random function approximation tool. These tools help to

estimate the most cost-effective and ideal methods for arriving at solutions while defining computing functions or distributions. ANN takes data samples rather than entire data sets to arrive at solutions, which saves both time and money.

Applications of ANN: Artificial Neural Networks (ANN) are paving the way for life-changing applications to be developed for use in all sectors of the economy. Artificial Intelligence (AI) platforms which are built on ANN are disrupting the traditional way of doing things. From translating webpages to other languages to having a virtual assistant order groceries online to conversing with chatbots to solve problems, AI platforms are simplifying transactions and making services accessible to all at negligible costs.



Conclusion:

ANN forecasting methods gives almost the same results as obtained by the complex numerical calculations and can be used for more accurate design of a vehicles suspension system moreover it also saves time and money by reducing experimental setup cost by minimizing the testing on material of suspension system. It easily forecast the best available result in terms of material and calibration of vehicle suspension system. From the present work it is observed that out of LM, SCG and BR forecasting method the _____ method gives the best forecasting results.

Future Scope:

All present neural network technologies will most likely be vastly improved upon in the future. Everything from handwriting and speech recognition to stock market prediction will become more sophisticated as researchers develop better training methods and network architectures.

NNs might, in the future, allow:

- robots that can see, feel, and predict the world around them
- improved stock prediction and verification

- common usage of self-driving cars
- composition of music
- handwritten documents to be automatically transformed into formatted word processing documents
- trends found in the human genome to aid in the understanding of the data compiled by the Human Genome Project
- self-diagnosis of medical problems using neural networks and much more!

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