A REVIEW ON SUSPENSION SYSTEM USED IN AUTOMOBILES

Devesh Gautam[1], Prof. Nishant Vibhav Saxena[2]
[1]Research Scholar, Dept. of Mechanical Engineering, Millennium Institute of Technology, Bhopal
[2]Prof. & HOD, Dept. of Mechanical Engineering, Millennium Institute of Technology, Bhopal

Abstract- A mechanical spring is an elastic body which has primary function is to deflect under load and return to its original shape when load is removed. Shocks and vibrations generated from the road surface are detached from structure to the passengers by automobile suspension system. Spring undergoes different types of forces like twist, pull, stretch, etc. Force is linear tensile or compressive or it can be radial. The torque act on the spring causes rotation. The spring of the suspensionsystem plays an important role for a smooth and jerk free ride. So it is required to design the springs very precisely. The use ofconventional steel as spring increases the weight and manufacturing process energy required is more so manufacturers are willing touse composite materials light in weight and also have corrosion resistance, it can also withstand high temperature. Manufacturingcomposite material is quite costlier than the steel spring. The use of composite material is beneficial if manufacturing process isstandardized it can increase the efficiency of the vehicle adherence overcome the material cost.

Keywords: Helical Spring, Von-mises stress, Total Deformation, Ansys, static structural.

I. INTRODUCTION

If roads were perfectly flat and had no irregularities, suspensions would not be necessary. However, roads are far away from being perfectly flat, and for this reason suspension systems have been developed. A suspension system is one of the indispensable structures of land vehicles with the main functions of isolating the body from road excitations for good ride comfort and maintaining contact between road surface and tires to get better road holding and steering ability. Many types of suspension systems have been designed over the years. MacPherson strut type suspension is the most widely used suspension system type with its advantages like simplicity, low manufacturing and maintenance cost, high performance, low unsprung weight, and so forth. The MacPherson strut suspension combines simply a coil spring and a damper coaxially into a single unit that makes contribution to its simplicity and thus provides a compact and light suspension system.

The main functions of a vehicle's 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. The suspension system requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension springs. According to Gillepsie (1992), the primary functions for suspension systems are;

- Provide vertical compliance so the wheels can follow the uneven road, isolating the chassis from roughness in the road.
- Maintain the wheels in the proper steer and camber attitudes to the road surface.
- React to the control forces produced by the tires-longitudinal (acceleration and braking) forces lateral (cornering) forces, and braking and driving torques.
- Resist roll of the chassis.

Keep the tires in contact with the road with minimal load variations

1. Types of suspension

- Independent Suspensions
- Dependent Suspensions

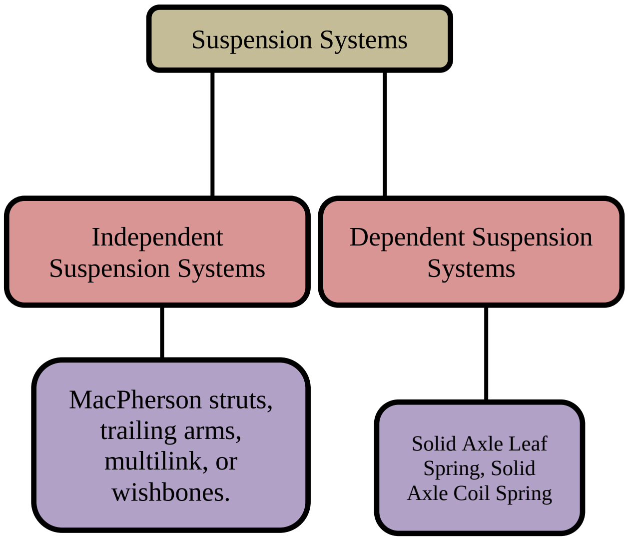

Fig. 1Different Types of Suspensions

a. Independent suspension system

Independent suspension is any automobile suspension system that allows each wheel on the same axle to move vertically (i.e. reacting to a bump on the road) independently of the others. This is contrasted with a beam axle or deDion axle system in which the wheels are linked – movement on one side does not affect the wheel on the other side. "Independent" refers to the motion or path of movement of the wheels or suspension. It is common for the left and right sides of the suspension to be connected with anti-roll bars or other such mechanisms. The anti-roll bar ties the left and right suspension spring rates together but does not tie their motion together.

b. Dependent suspension system

Dependent systems may be differentiated by the system of linkages used to locate them, both longitudinally and transversely. Often both functions are combined in a set of linkages.n a front engine, rear-drive vehicle, dependent rear suspension is either "live axle" or deDion axle, depending on whether or not the differential is carried on the axle. Live axle is simpler but the unsprung weight contributes to wheel bounce.

II. LITERATURE REVIEW

(Pawar and Desale, 2018)[1]showed thathelical compression spring used in suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse and dissipate kinetic energy. A helical compression coil spring which used in transport three wheeler is belonging to the medium segment of the Indian automotive market. It is observed that, the vehicle drifts towards one side due to high weight of suspension system. This problem can be solved by redesigning and optimizing front suspension spring. For the present study the IS 4454 material was taken for consideration. Optimization of the spring was done by reducing total number of turns and prototypes of the spring were made. As per design the springs were made of material IS 4454 and experimental test was conducted. The static analysis using finite element method has been done in order to find out the detailed load vs defection of the spring. The experimental investigation was performed to calculate the stiffness and vertical acceleration of helical compression spring. The theoretical calculations were also done. For experimental test the universal testing machine was used to find load vs defection of spring and quarter car test rig used to find the vertical acceleration of helical compression spring.

(Alsahlani, Khashan and Khaleel, 2018)[2] explained that suspension system plays a very important role in new vehicles. Its duty is to damp, smooth out the shock impulse furthermore to absorb or dissipate energy so that the suspension system provides the comfort and safety for the passengers and vehicles. In this paper, the simulation of spring is carried out by using Solid works 2018 with specific dimensions and analysis it with finite element analyzer ANSYS 14. Three materials are selected to simulate the spring steel, copper alloy, and carbon composite. The deformation, strain, stress and shear stress are obtained numerically under various values of load (1500, 2000 and 2500) N. The results showed that the deformation in carbon composite is less than steel and copper alloy so that the carbon composite is the best material for helical spring and can withstand the load and deflection.

(Gzal, Groper and Gendelman, 2017)[3]aimed at determining the stress distribution in elliptical cross-section helical springs with small helix angle (less than 10º, often termed as close-coiled springs) considering the effect of wire curvature, subjected to axial static load. Also presented both analytical and finite element analysis, validated by an experimental study conducted on an actual automotive valve spring. A novel analytical expression for the stress distribution in such springs is developed based on the theory of elasticity. In particular, this expression leads to the analytic formula for the maximum resultant shear stress and its location along the spring's cross-section as a function of the aspect ratio. Contrary to the case of the circular cross-section, this maximum shear stress location is not invariant. The proposed analytical expression agrees well with the computed FEA results and is in very good correlation with the experimentally obtained figures. As an additional outcome of this study, a method to experimentally measure the shear stress in helical springs using strain gauge was described.

(Jain *et al.*, 2017)[4]reveled thathelical spring for shock absorber used in suspension system which is designed to reduce shock impulse and liberate kinetic energy. In a vehicle, it increases comfort by decreasing amplitude of disturbances and it improves ride quality by absorbing and dissipating energy. When a vehicle is in motion on a road and strikes a bump, spring comes into action quickly. After compression, spring will attempt to come to its equilibrium state which is on level road. Helical springs can be made lighter with more strength by reducing number of coils and increasing the area. In this research work, a helical spring is modeled and analyzed to substitute the existing steel spring which is used in suspension. By using different materials, stress and deflection of helical spring can be varied.

(Sequeira, Singh and Shetti, 2016)[5]explained thatautomobile sector due to the demanding need of rapid innovation and tough competition, the old products are reengineered by new product with composite materials. Regularly new innovations are carried out in suspension area of vehicles. Fiber Reinforced Material [FRP] components are the main interest of automobile industry for replacing the steel components due to “high strength to low weight” ratio. To reduce the weight and fuel consumption to some extent, automobile industries are using the Glass Fiber Reinforced Plastic [GFRP] open coil springs in suspension system of vehicle at the place of steel open coil springs.

(Yıldırım, 2016)[6]In his study, in order to carry out such spring formulation and get closed-form solutions for the vertical tip deflection, Castigliano’s first theorem is directly employed to the linear elastic problem of cylindrical helical springs with large pitch angles. Derivation takes into account for the whole effect of the stress resultants such as axial and shearing forces, bending and torsional moments on the deformations.

(C.A. Calder et al) [7] 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.

(W.G. Jiang et al) [8] have created a general and accurate finite element model for helical springs subject to axial loads (extension or/and torsion). Due to the establishment of precise boundary conditions, only a slice of the wire cross-section needs to be modeled hence more accurate results can be achieved. As an example, an application to a circular cross-sectional spring is analyzed. FEM results agree well with the analytical models for the tension and torsion Springs as the helical angle and the ratio of wire radius to coil radius tends to zero.

(K.V. Sudhakar) [9] 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.

(DammakFakhreddine) [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) [11] 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) [12] have reviewed the stress calculation methods in helical springs with rectangular cross-section wire and have demonstrated that the methods described in literature lead to a very close accuracy. Also, the modern construction of the helical spring machined from tubular blanks is presented. It is indicated, using finite-element method, that existing classical spring with open end stress calculating methods, are not suitable for springs with capped ends because stress calculated from them are much smaller than the real ones.

(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 behavior 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 10^7 cycles substantial decrease in fatigue strength are to be observed if the fatigue tests are continued up to 10^8 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 nucleations of fracture.

III. CONCLUSION

Feasibility of composite materials is checked, composite helical springs can be easily replaced in light weight vehicles with slightsacrifice of the size. In regular vehicles, combination of springs with composite and conventional material can be used to overcomelow stiffness of composite materials and weight of spring can be optimized.

The above discussion elaborate that springs used in automobile suspension system, in which essential to do its analysis. Spring analysis includes maximum displacement, stress distribution analysis, and different mode of failure. Spring undergoes different types of loading in its life span. ANSYS, NASTRAN, CATIA, SolidWork, etc. software used for analysis of spring. Analysis of spring includes calculation of fatigue stress, shear stress and maximum displacement.

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