Design And Evaluation of Suspension System Using Helical Spring on 3D Catia Model And Ansys Structural Analysis

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Abstract- *In vehicle, Shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy towards achieving improved ride quality and vehicle handling. In addition, it reduces the effect of travelling over rough ground on increasing the comfort by the substantially reduced amplitude of disturbances. In this paper, we design and analyse a suspension system using 3D model in the CATIA. The model is also analysed on changing the thickness of the spring applied in the suspension system. Structural analysis and modal analysis are done on the shock absorber in parallel on varying different spring materials. Spring materials employed in this analysis are Spring Steel, Phosphor bronze, Beryllium Copper and Titanium alloy.*

Further to validate the strength and displacement on varying the load on particular helical spring of the model, the structural analysis has been carried out. The analysis is done by considering energy absorbing capacity in terms of loads and bike weight on varied frequency. Modal analysis is has been carried on stiffness of the spring and stability of the string on displacements for different frequencies for number of modes. Finally performance comparison has been carried out using different materials to verify best material for spring in Shock absorber of the vehicle. Modelling is done in CATIA and analysis is done in ANSYS to determine the stability and stiffness on varying load. In addition strength ability, damping factor, shock absorbing capacity have been check with the help of Ansys software for static and dynamic analysis. On this particular analysis, it suggests the best material to provide the ability of shock absorber.

Keywords- Vehicle Shock Absorber, CATIA, ANSYS, Static analysis, Dynamic Analysis, spring, Dampers

I. INTRODUCTION

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it smooth out and reduces the effect of travelling over rough ground, leading to improved quality, and increase in comfort due to substantially reduced amplitude of disturbances [1]. When a vehicle is travelling on a level road and the wheels strike a bump, the spring is compressed quickly and pushes the spring down below its loaded height.

The compressed spring will attempt to return to its normal loaded height by causing the body to be lifted in so doing to rebound past its normal height [2]. In addition , weight of the vehicle's weight bearing drum will be push down during suspension and rebounds to its normal loaded height. The extra braking force provides the wedging action. This bouncing process is repeated more than one time until the up-and-down movement finally stops its movement. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult [3]. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in tensional shocks side to side.

The modelling of spring design is a important aspect in suspension system. In this paper, a vehicle shock absorber is designed and a 3D model is created using Catia V5. The rest of the paper is sectioned as follows, section 2 represents design calculation of helical spring for shock absorbers, section 3 describes the design procedures and Section 4 provides the introduction of the ANSYS for static and dynamic structural analysis.

II. DESIGN CALCULATION

The Design calculation for vehicle shock absorber for helical compression Spring is given as follows

Material: ASTM A228 (steel)
$G = 40000 N/mm^2$
Diameter of the wire d =10mm
Mean Diameter of the coil D =75mm
No of Active Turns n=14

Total no of coil n^1=7
Weight of the vehicle w=150kgs
Weight of the Person =100
Total Weight =250kgs
Rear Suspension = 70%
Rear Suspension in Kgs = 150kgs
For single shock absorber weight =140kg
Compression of Helical Spring (δ)
Spring index© = 7.75 = 8
Solid length (Ls) = n1×d =18×8 = 144 mm
(Lf) = solid length + maximum compression + clearance between adjustable coils
(Lf) = 144 + 282.698 + 0.15 × 282.698
(Lf) = 469.102
Spring rate (K) = 5.719 Pitch of coil
Stresses in helical springs (P) = 28

Maximum shear stress induced in the wire of the coil is given by (τ) = 499.519 N/mm2

Values of buckling factor (KB) = 0.07 (for hinged and spring)
The buckling factor for the built-in end springs and hinged end is as follows
(Wcr) = 5.719×0.07×469.102=154.139N

III. DESIGN PROCEDURE

The design of vehicle Suspension system consists of five major engineering materials to produce the desired result on employing the procedure which are described in terms of 3D model with parameter in CATIA.

3.1 Design Parameters of upper mount of the Spring in suspension

A circle with 80mm diameter and 40mm diameter, thickness 10mm, rectangle length 50 mm and width 25mm has been defined to model the suspension system

3.2 Design parameter of lower mount of the Spring in suspension

A circle with 190mm diameter and 180mm diameter, thickness 25mm, rectangle length 100 mm has defined as parameter for modelling suspension system.

3.3 Design parameter of oil pad

A oil pad of the suspension system is consisting of circle with 90 mm diameter, length of 200 mm, the helix of pitch 20 mm, a circle of 25 mm diameter, depth 180mm has been defined.

3.4 Design of Rod parameter

Rod parameter consists of the circle with 25 mm diameter, 400 mm length, a pitch with 60 mm and height of 430 mm has been defined for effective design.

3.5 Assembly Section Design parameter

Assembly section consist of module which inserts all the existing component of the suspension system such as upper mount, lower mount, strip rod, spring and oil Pad using coincide, offset, and contact constrain, Manipulation and Smart Move methods.

IV. DYNAMIC STRUCTURAL ANALYSIS OF SUSPENSION SYSTEM USING ANSYS

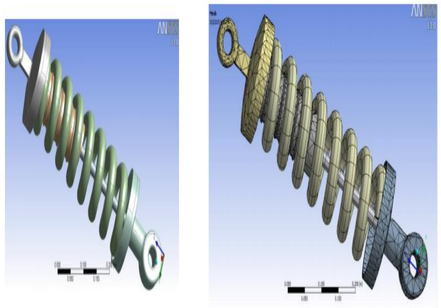
Analysi is carried out in terms of finite element analysis through various steps of weight application. It is considered a computational technique on varying load. It is used to obtain approximate solutions of boundary value problem of the suspension rebounding. A boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation of the variable under analysis. In some cases, rod and oil pad consist of domain of independent variables and satisfy specific conditions on the boundary of the domain [4]. The field is the domain of interest and most often represents a physical structure of the suspension system on varying load.

In static analysis, The field variables are the dependent variables of interest governed by the differential equation towards modelling suspension system. The boundary conditions are the specified values of the field variables (or related variables such as derivatives) on the boundaries of the field on derivatives of the system [5]. The analysis can be structural, electromagnetic, fluid flow or manufacturing simulation

- Geometry
- Material properties
- Mesh
- Boundary conditions

Procedure for Finite Element Analysis

STEP 1: First the domain is represented as finite elements of the spring elements. This is called discretization of domain consisting variables of different derivatives. Mesh generation programs called processors used operate and help to partition the structure. The geometry of the model is described in the figure 1 and mesh of the model is described in the figure 2



(a) (b)

Figure 1: (a) Geometry of the model and (b) Mesh of the Model

STEP 2: Formulate the properties of each element of the spring to varying load in stress analysis. It means determining the nodal loads associated with all element deformation stress that is allowed to maximum limit.

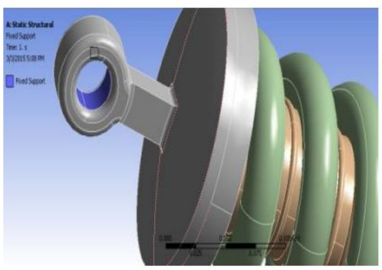


Figure 2: Directional Deformation of the model

STEP 3: Assemble elements to obtain the finite element model of the structure to bear the load and suspension rebounding to specified limit. The figure 3 presents the total deformation of static structure analysis.

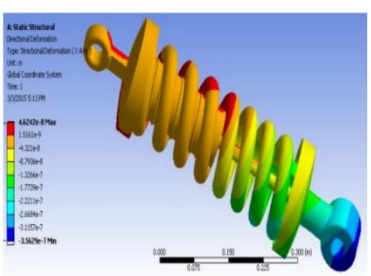


Figure 3: Total Deformation of static structure Analysis

STEP 4: Apply the known loads, nodal forces in stress analysis to determine the capacity of the spring. In stress analysis the support of the structure has to be specified on various derivatives of finite system of model designed on the parameters.

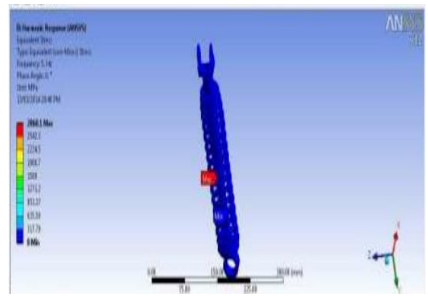


Figure 3: Total Deformation of Dynamic Structural analysis

STEP 5: Solve simultaneous line algebraic equations to determine nodal displacements in the stress analysis of particular spring materials on varied energy.

STEP 6: Postprocessors of the calculation help the user to sort the output and display in the graphical output form. A typical finite element model is comprised of nodes, degrees of freedom of the spring elements and its material properties to the externally applied loads and analysis type has given effective solution on using helical spring in the vehicle. The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide range of engineering problems especially in modelling suspension and brake system.

V. CONCLUSION

In this paper, suspension system developed using the helical spring has been analysed using ANSYS and it evaluated on various load. In order to employ it as a shock absorber by varying different spring materials like steel, titanium alloy, copper alloy and Phosphor bronze Modal analysis is done to determine the displacements for different frequencies for Number of modes of the material.

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