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RESEARCH ARTICLE

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STRCTURAL ANALYSIS OF SHOCK ABSORBER BY USING ANSYS

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ABSTRACT

In a vehicle, shock absorbers reduce the effect of traveling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. In this project a shock absorber is designed and a 3D model is created using CATIA. Structural analysis and modal analysis are done on the shock absorber by varying material for Spring Steel and Molybdenum. The analysis is done by considering loads, bike weight, single person and double persons. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. Comparison is done for two materials to verify best material for spring in Shock absorber. Modeling is done in CATIA and analysis is done in ANSYS. CATIA is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

Key Words: Shock Absorber, Spring Steel and Molybdenum, ANSYS 12.0, CATIA.

1. INRODUCTION

A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. When a vehicle is traveling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length and, in so doing, will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. This, in turn, causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up-and-down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult. The design of spring in suspension system is very important.

1.1 Description

Pneumatic and hydraulic shock absorbers commonly take the form of a cylinder with a sliding piston inside. The cylinder is filled with a fluid (such as hydraulic flu id) or air. Th is fluid-filled piston/cylinder combination is a dashpot.

1.2 Explanation

The shock absorbers duty is to absorb or dissipate energy. One design consideration, when designing or choosing a shock absorber, is where that energy will go. In most dashpots, energy is converted to heat inside the viscous fluid. In hydraulic cylinders, the hydraulic fluid will heat up, while in air cylinders, the hot air is usually exhausted to the atmosphere. In other types of dashpots, such as electromagnetic ones, the dissipated energy can be stored and used later. In general terms, shock absorbers help cushion cars on uneven roads.

1.3 Applications

Shock absorbers are an important part of auto mobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swaying excessively from side to side and are important in passenger railroads, commuter rail and rapid transit systems because they prevent railcars from damaging station platforms. The success of passive damping technologies in suppressing vibration amplitudes could be ascertained with the fact that it has a market size of around $ 4.5 billion.

Fig(1) Rear shock absorber and spring of a BMW R75/ 5 motorcycle

1.4 Vehicle suspension

In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement. Control of excessive suspension movement without shock absorption requires stiffer (higher rate) springs, which would in turn give a harsh ride. Shock absorbers allow the use of soft (lower rate) springs while controlling the rate of suspension movement in response to bumps. They also, along with hysteresis in the tire itself, damp the motion of the unspring weight up and down on the springiness of the tire. Since the tire is not as soft as the springs, effective wheel bounce damping may require stiffer shocks than would be ideal fo r the vehicle motion alone. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in tensional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy. Vehicles typically emp loy springs and torsion bars as well as hydraulic shock absorbers. In this combination, "shock absorber" is reserved specifically for the hydraulic p iston that absorbs and dissipates vibration.

1.5 Structures

Applied to a structure such as a building or bridge it may be part of a seismic retrofit or as part of new, earthquake resistant construction. In this application it allows yet restrains motion and absorbs resonant energy, which can cause excessive motion and eventual structural failure.

1.6 Types of shock absorbers

There are several commonly-used approaches to shock absorption: Hysteresis of structural material, for example the compression of rubber disks, stretching of rubber bands and cords, bending of steel springs, or twisting of torsion bars. Hysteresis is the tendency for otherwise elastic materials to rebound with less force than was required to deform them. le vehicles with no separate shock absorbers are damped, to some extent, by the hysteresis of their springs and frames.

Dry friction as used in wheel brakes, by using disks (classically made of leather) at the pivot of a lever, with friction forced by springs. Used in early automobiles such as the Ford Model T, up through some British cars of the 1940s. Although now considered obsolete, an advantage of this system is its mechanical simplicity; the degree of damping can be easily adjusted by tightening or loosening the screw clamping the disks, and it can be easily rebuilt with simple hand tools. A disadvantage is that the damping force tends not to increase with the speed of the vertical motion.

Solid state, tapered chain shock absorbers, using one or more tapered, axial align meant(s) of granular spheres, typically made of metals such as national, in a casing. [1],[2]

Fluid friction, for example the flow of fluid through a narrow orifice (hydraulics), constitutes the vast majority of automotive shock absorbers. An advantage of this type is that using special internal valving the absorber may be made relatively soft to compression (allowing a soft response to a bump) and relatively stiff to extension, controlling "jounce", which is the vehicle response to energy stored in the springs; similarly, a series of valves controlled by springs can change the degree of stiffness according to the velocity of the impact or rebound. Specialized shock absorbers for racing purposes may allow the front end of a dragster to rise with minimal resistance under acceleration, then strongly resist letting it settle, thereby maintaining a desirable rearward weight distribution for enhanced traction. Some shock absorbers allow tuning of the ride via control of the valve by a manual adjustment provided at the shock absorber. In more expensive vehicles the valves may be remotely adjustable, offering the driver control of the ride at will while the vehicle is operated. The ultimate control is provided by dynamic valve control via computer in response to sensors, giving both a smooth ride and a firm suspension when needed. Many shock absorbers contain compressed nitrogen, to reduce the tendency for the oil to foam under heavy use. Foaming temporarily reduces the damping ability of the unit. In very heavy duty units used for racing and/or off-road use, there may even be a secondary cylinder connected to the shock absorber to act as a reservoir for the oil and pressurized gas. Another variation is the Magneto rheological damper which changes its flu id characteristics through an electromagnet.

Compression of a gas, for example pneumatic shock absorbers, which can act like springs as the air pressure is building to resist the force on it. Once the air pressure reaches the necessary maximum, air dashpots will act like hydraulic dashpots. In aircraft landing gear air dashpots may be combined with hydraulic damping to reduce bounce. Such struts are called oleo struts (combining oil and air) [3]. Magnetic effects. Eddy current dampers are dashpots that are constructed out of a large magnet inside of non-magnetic, electrically conductive tube.

Inertial resistance to acceleration, for example prior to 1966 [4] the Citroën 2CV had shock absorbers that damp wheel bounce with no external moving parts. These consisted of a spring-mounted 3.5 kg (7.75 lb) iron weight inside a vertical cylinder [5] and are similar to, yet much smaller than versions of the tuned mass dampers used on tall buildings

Composite hydro-pneumatic devices which combine in a single device spring action, shock absorption, and often also ride-height control, as in some models of the Citroën automobile.

Conventional shock absorbers combined with composite pneumatic springs with which allow ride height adjustment or even ride height control, seen in some large trucks and luxury sedans such as certain Lincoln and most Land Rover automobiles. Ride height control is especially desirable in highway vehicles intended for occasional rough road use, as a means of improving handling and reducing aerodynamic drag by lowering the vehicle when operating on imp roved high speed roads.

The effect of a shock absorber at high (sound) frequencies is usually limited by using a compressible gas as the working fluid and/or mounting it with rubber bushings.

The detailed analysis of shock absorber/isolation systems is very complicated and involves assessment of the dynamic response of the equipment to different types of activating energy inputs. The notes below relate only to illustrating the benefits of using shock absorbers to reduce the forces experienced by equipment to impacts. The more complicated scenarios involving systems continuously operating and withstanding sudden changes of loading and acceleration e.g., car suspension systems and aircraft landing gear, are outside of the scope of this work. Moving objects have kinetic energy related to their velocity and their mass. If the velocity of an object is significantly changed in a short time span e.g. it impacts on a stationary body, then high forces result. These forces can be useful e.g., a forging press using the kinetic energy to form metal. However real life impact forces (shock loads) are generally very destructive and are avoided. Kinetic energy increases in a direct ratio to the mass and to the velocity squared.

The heavier the object or the faster it travels, the more energy it has. Methods of energy absorption include rubber buffers, metal springs, air springs, and hydraulic shock absorbers. When the systems have to continuously operate under the influence of shock loads the shock isolation system generally includes spring-dashpot isolation systems. For simple shock absorber applications required to mitigate the effect of a single events then viscous dampers which dissipate the energy, as heat rise of a flu id, are often preferred. In normal everyday life simple examples of shock absorber systems include crash helmets, steel toe caps in industrial boots, collapsible bumpers on cars, motor way barriers. The notes below are general in nature provided to show the benefits of using shock absorbers. For more detailed information links are provided to shock absorber suppliers.

1.7 Shock Absorber types

There are a number of different methods of converting an impact /collision into relatively smooth cushioned contact.

- Metal Spring
- Rubber Buffer
- Hydraulic Dashpot
- Collapsing safety Shock Absorbers
- Pneumatic Cylinders
- Self compensating Hydraulic

1.7.1 Metal springs

Simply locating metal springs to absorb the impact loads are a low cost method of reducing the collision speed and reducing the shock loading. They are able to operate in very arduous conditions under a wide range of temperatures. These devices have high stopping forces at end of stroke. Metal springs store energy rather than dissipating it. If metal sprint type shock absorbers are used then measures should be provided to limit Oscillations . Metal springs are often used with viscous dampers.

There are a number of different types of metal springs including helical springs, bevel washers (cone-springs), leaf springs, ring springs, mesh springs etc. Each spring type has its own operating characteristics.

1.7.2 Elastomeric shock observers

These are low cost options for reducing the collision speed and reducing the shock loading and providing system damping. They are conveniently molded to suitable shapes. These devices have high stopping forces at end of stroke with significant internal damping. Elastomeric dampers are very widely used because of the associated advantages of low cost and mouldability together with performance benefits. The inherent damping of elastomers is useful in preventing excessive vibration amplitude at resonance – much reduced compared to metal springs. However elastomeric based shock absorbers are limited in being affected by high and low temperatures. And are subject to chemical attack. Silicone rubber is able to provide reasonable mechanical properties between temperatures of -50O to +180O deg. C- most other elastomer has inferior temperature tolerance.

1.7.3 Hydraulic Dashpot

This type of shock absorber is based on a simple hydraulic cylinder. As the piston rod is moved hydraulic flu id is forced through an orifice which restricts flow and consequently provides a controlled resistance to movement of the piston rod. With only one metering orifice the moving load is abruptly slowed down at the start of the stroke. The braking force rises to a very high peak at the start of the stroke and then falls away rapidly. On completion of the stroke the system is stable - the energy being dissipated in the hydraulic flu id as heat. This type of shock absorbers are provided with Springs sufficient to return the actuator to its initial position after the impacting load is removed.

1.7.4 Collapsing Safety Shock Absorbers

These are single use units which are generally specially designed for specific duties. They are designed such that at impact they collapse and the impact energy is absorbed as the materials distort in their inelastic/yield range. They therefore are more compact compared to devices based on deflections within their elastic range.

1.7.5 Air (Pneumatic) spring

These devices use air as the resilient medium. Air has a high energy storage capacity compared to metal or elastomer materials. For duties with high loads and deflections the air spring is generally far more compact that the equivalent metal or elastomer device. Due to the compressibility of air these have a sharply rising force characteristic towards the end of the stroke. The majority of the energy is absorbed near the end of the stroke. The force on an air cylinder buffer is determined by the relation PVn =constant. Air springs require more maintenance than meal or elastomer based springs and the temperature range is restricted compared to metal springs.

1.8 Molybdenum material:

Molybdenum is a Group 6 chemical element with the symbol Mo and atomic number 42. The name is from Neo-Latin Molybdaenum, from Ancient Greek Μόλυβδος molybdos, meaning lead, since its ores were confused with lead ores.[4] Molybdenum minerals have been known into prehistory, but the element was discovered (in the sense of differentiating it as a new entity from the mineral salts of other metals) in 1778 by Carl Wilhelm Scheele. The metal was first isolated in 1781 by Peter Jacob Hjelm. Molybdenum does not occur naturally as a free metal on Earth, but rather in various oxidation states in minerals. The free element, which is a silvery metal with a gray cast, has the sixth-highest melting point of any element. It readily forms hard, stable carbides in alloys, and for this reason most of world production of the element (about 80%) is in making many types of steel alloys, including high strength alloys and superalloys.

Most molybdenum compounds have low solubility in water, but the molybdate ion MoO2−
4 is soluble and forms when molybdenum-containing minerals are in contact with oxygen and water. Industrially, molybdenum compounds (about 14% of world production of the element) are used in high-pressure and high-temperature applications, as pigments, and as catalysts. Molybdenum-containing enzymes are by far the most common catalysts used by some bacteria to break the chemical bond in atmospheric molecular nitrogen, allowing biological nitrogen fixation. At least 50 molybdenum-containing enzymes are now known in bacteria and animals, although only bacterial and cyano-bacterial enzymes are involved in nitrogen fixation, and these nitrogenases contain molybdenum in a different form from the rest. Owing to the diverse functions of the various other types of molybdenum enzymes, molybdenum is a required element for life in all higher organisms (eukaryotes), though not in all bacteria.

Molybdenum material properties:

Name	**Molybdenum**
Symbol	Mo
Atomic Number	42
Atomic Mass	95.94 amu
Melting Point	2617.0 °C (2890.15 K, 4742.6 °F)
Boiling Point	4612.0 °C (4885.15 K, 8333.6 °F)
Number of Protons/Electrons	42
Number of Neutrons	54
Classification	Transition Metal
Crystal Structure	Cubic
Density @ 293 K	10.22 g/cm3
Color	silverishTable -1
Electrical resistivity	(20 °C) 53.4 nΩ•m
Thermal conductivity	138 W•m−1•K−1
Thermal diffusivity	(300 K) 54.3[3] mm^2/s
Thermal expansion	(25 °C) 4.8 µm•m−1•K−1
Speed of sound (thin rod)	(r.t.) 5400 $m{\cdot}s^{-1}$
Young's modulus	329 GPa

Shear modulus	126 GPa
Bulk modulus	230 GPa
Poisson ratio	0.31

2. LITRATURE REVIEW

Shock absorber is designed and a 3D model is created using CATIA. The model is also changed by changing the thickness of the spring. Structural analysis and modal analysis are done on the shock absorber by varying material for spring, Spring Steel and Beryllium Copper. The analysis is done by considering loads, bike weight, single person and 2 persons.

Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. Comparison is done for two materials to verify best material for spring in Shock absorber. Modeling is done in CATIA and analysis is done in ANSYS. CATIA is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

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Molybdenum does not occur naturally as a free metal on Earth, but rather in various oxidation states in minerals. The free element, which is a silvery metal with a gray cast, has the sixth-highest melting point of any element. It readily forms hard, stable carbides in alloys, and for this reason most of world production of the element (about 80%) is in making many types of steel alloys, including high strength alloys and superalloys.

In this project design a shock absorber by using CATIA and analysis is done by using ANSYS workbench at various loads by taking this molybdenum material property.

3. CATIA MODEL DESIGN

3.1 Introduction to CATIA

CATIA is one of the world's leading high-end CAD/CAM/CAE software packages. CATIA (computer aided three dimensional interactive application) is a multi-platform PLM/CAD/CAM/CAE commercial software suite developed by Dassault systems and marketed worldwide by IBM. CATIA is written in the C++ programming language. CATIA provides open development, architecture through the use of interfaces, which can be used to customize or develop applications. The applications in programming interfaces supported visual basic and C++ programming languages.

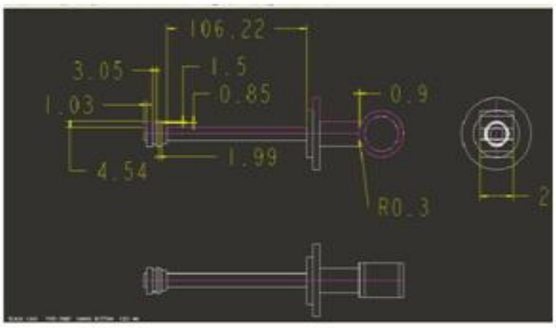
Commonly referred to as 3D product Lifecycle management (PLM) software suite, CATIA supports multiple stages of product development. The stages range from conceptualization, through design (CAD) and manufacturing (CAM), until analysis (CAE). Each work bench of catiaV5 refers and each stage of product development for different products. CATIA V5 features a parametric solid/surface-based package which uses NURBS as the core surface representation and has several work benches but provide KBE (knowledge based engineering) support.

3.2 Fundamentals of CATIA:

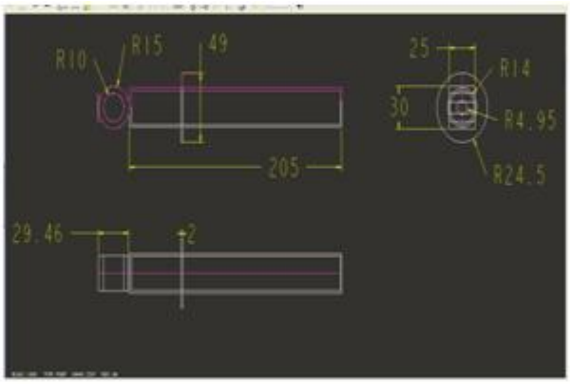
Part Design

The Part Design Workbench is used to create Solid geometry using a Feature based approach. In general the features are produced from sketches created in the Sketcher workbench. The specification tree contains all the features created along with the sketch used to define them. All the Solid features are contained within a node called a Part Body. They also contain wireframe sketches that are used to create the features. As you create features they are added to the tree in order of creation. There may be multiple Part bodies within a CAT Part which can be Boo learned together in order to form complex solid models. Part bodies can be added to the Specification Tree by selecting Body from the Insert drop down menu when in the Part

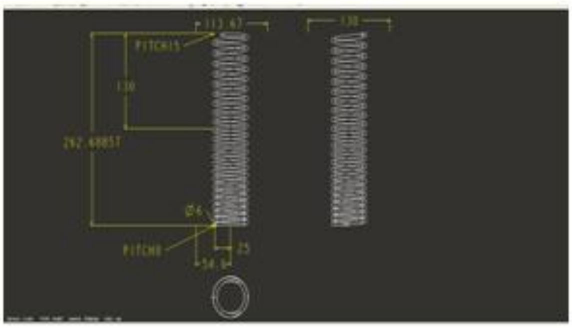
Design Workbench. The Part body can then be renamed by editing its properties.



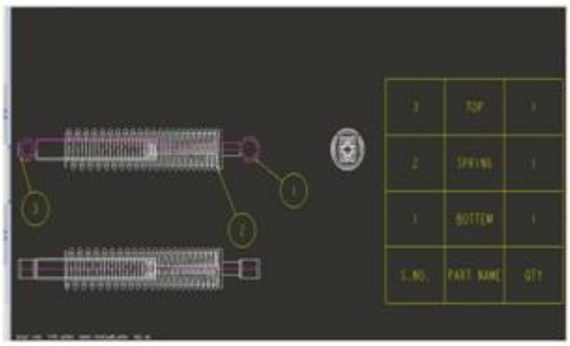
Fig(3.1):Bottom part



Fig(3.2):Top part



Fig(3.3):Helical Spring part



Fig(3.4):Assembly

3.3 EXPERIMENTAL PROCEDURE:

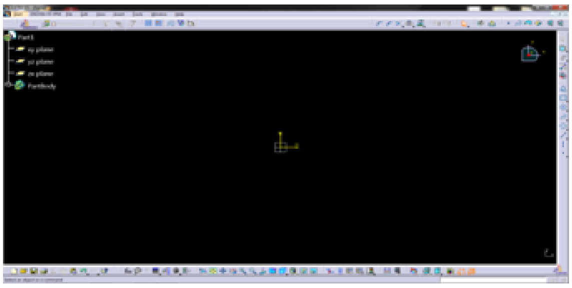
Aim: To design a 3D model of a shock absorber by using CATIA V5 R20.

Equipment: Intel Core 2 duo computer installed with CATIA V5 R19.

Software: CATIA V5 R19.

Step 1: Click Start in Menu bar > Mechanical Design > Sketcher.

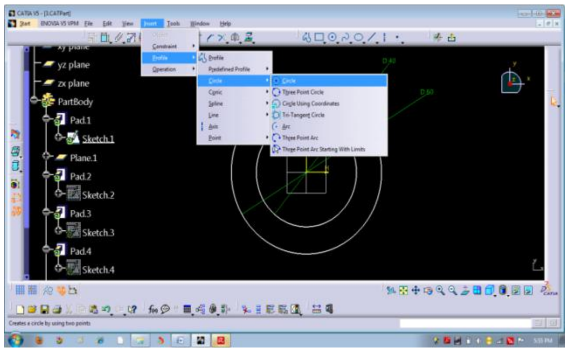
Step 2: Select XY Sketch plane.



Fig(3.5):CATIA software display

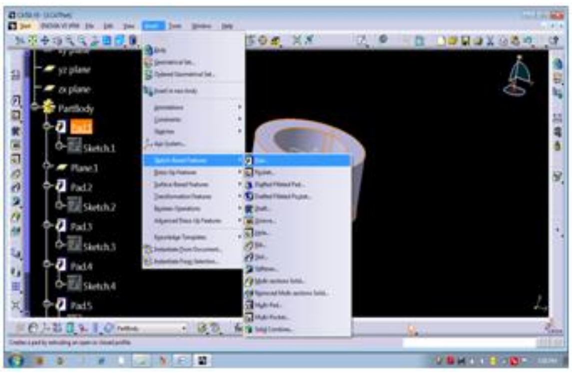
Step 3: Take the geometric coordinates to construct rectangle.

Shock observer 1



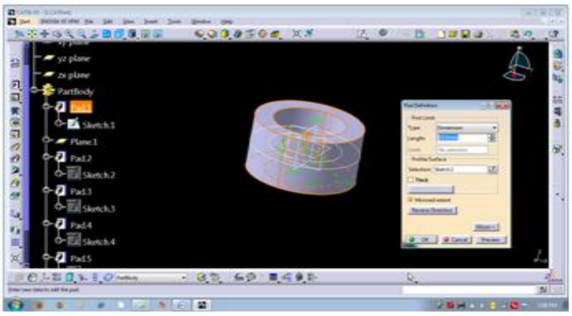
Fig(3.6):CATIA bottom design step-1

By the definition insert, Profile, Circle, Center point 0,0 and the diameter 60.00mmm and 40.00mm exist workbench.



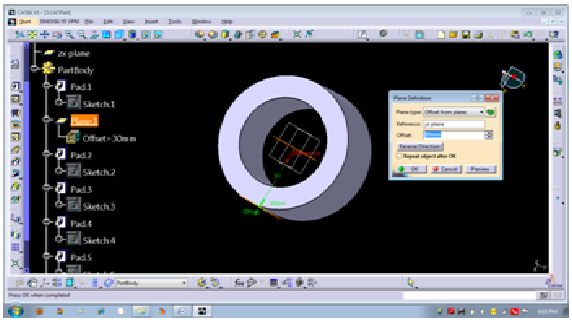
Fig(3.7)CATIA bottom design step-2

Insert, sketch based features, pad definition



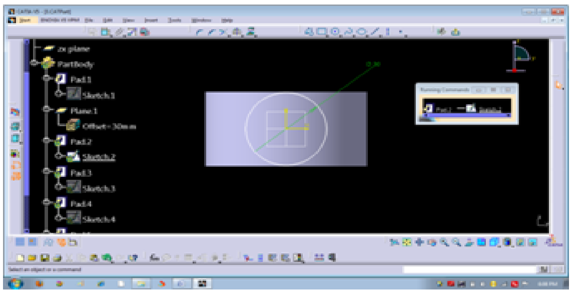
Fig(3.8):CATIA bottom design step-3

Pad definition select the sketch 1 and type select dimension and give the length 15.5 mm



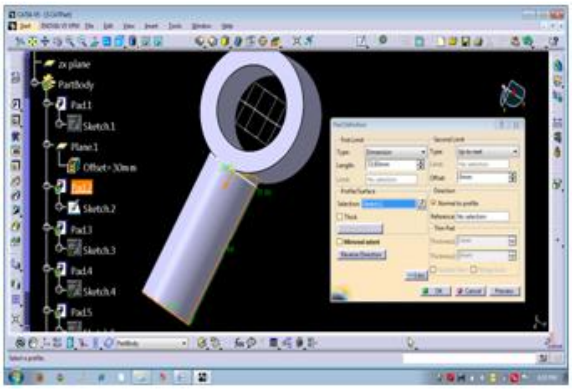
Fig(3.9):CATIA bottom design step-4

As for the plane definition offset from plan and select yz plane offset distance 30mm



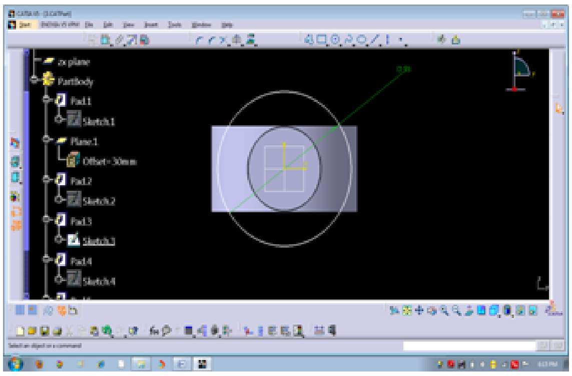
Fig(3.10):CATIA bottom design step-5

Select the plane and draw the sketch circle 30mm diameter and exit workbench



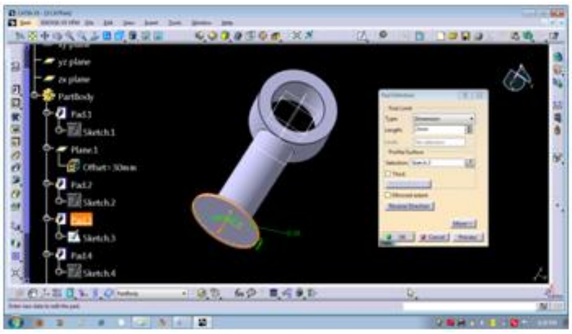
Fig(3.11):CATIA bottom design step-6

Go to pad definition select the sketch 2 first limit type dimension and length 72.93mm and second limit up to next, And go to insert sketch select the end part of the previous operation.



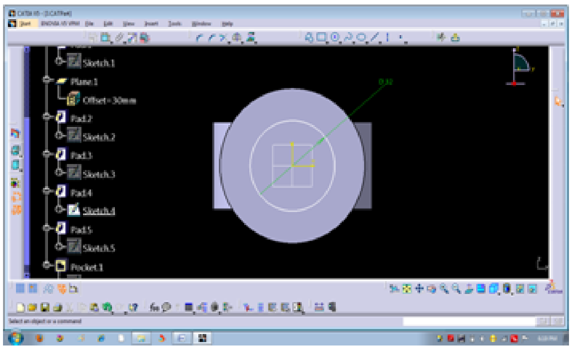
Fig(3.12):CATIA bottom design step-7

Insert, Profile, Circle ,center point and diameter of 55mm and exit workbench



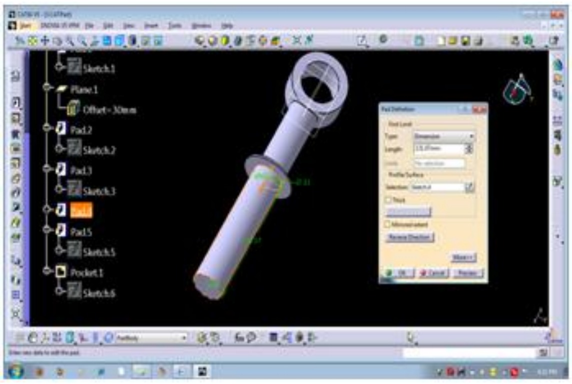
Fig(3.13):CATIA bottom design step-8

And pad definition give the distance of 2mm



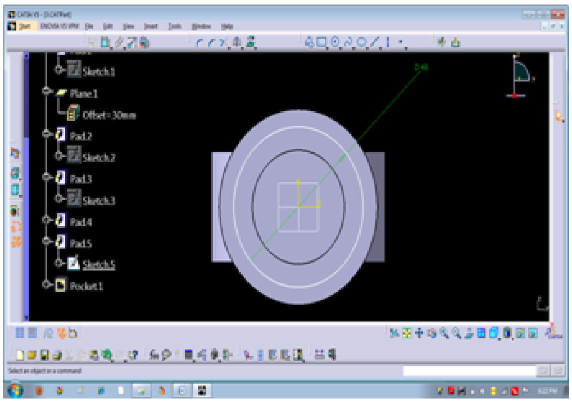
Fig(3.14):CATIA bottom design step-9

Select the base of the bottom and again give the circle definition give the diameter of 32 mm



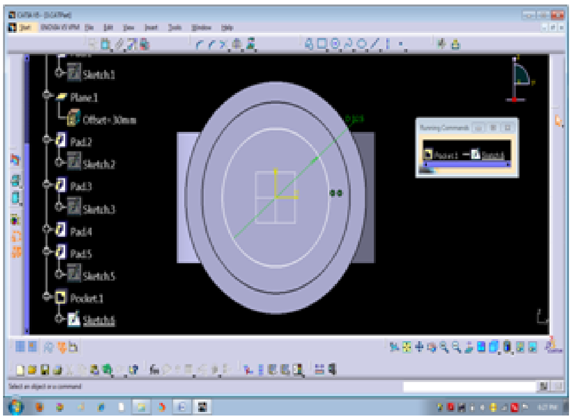
Fig(3.15):CATIA bottom design step-10

Exit workbenches go to pad definition and give the length of 131.07mm



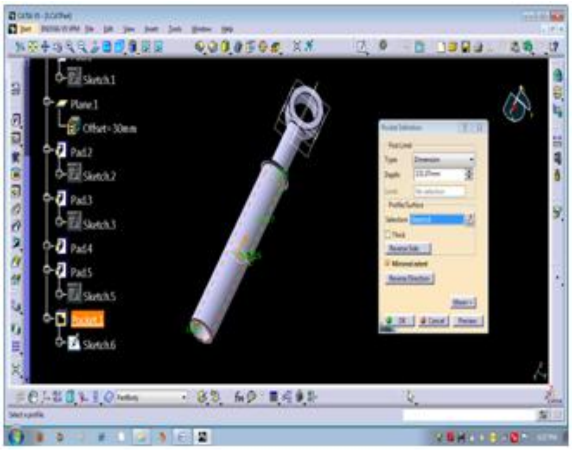
Fig(3.16):CATIA bottom design step-11

Same above Operation can be done with dia of 45mm with 130.072mm



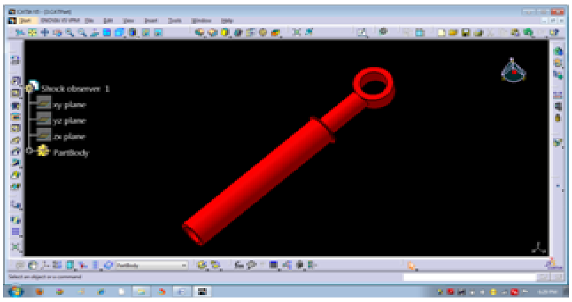
Fig(3.17):CATIA bottom design step-12

Select the bottom face and give the dia of 32.5 mm and go to pocket definition



Fig(3.18):CATIA bottom design step-13

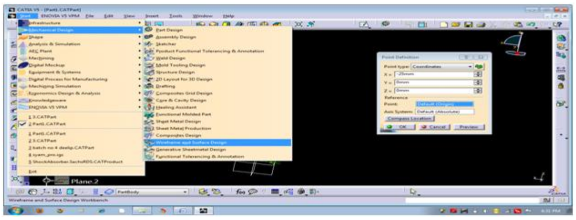
Pocket definition select the sketch give the length of 131.07mm



Fig(3.19): Final Bottom part

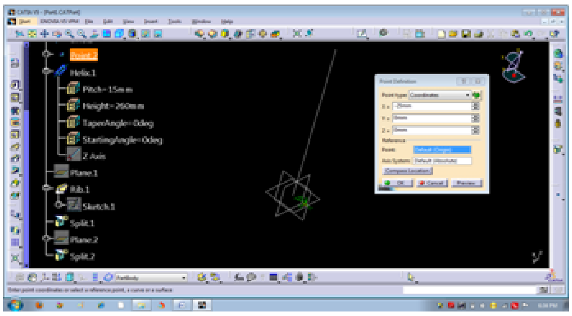
Helical spring modeling

Go to start ,mechanical design ,Wireframe and surface design

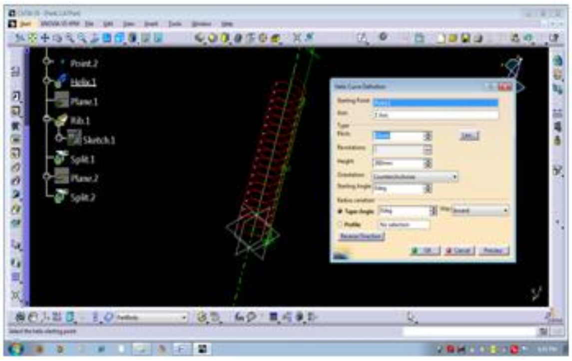


Fig(3.20): Helical spring design step-1

Insrt defination refrence point of Point defination x=-25.00mm y=0.0mm z=0.0 mm

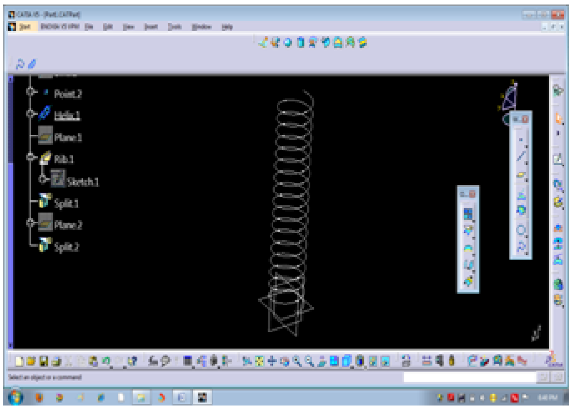


Fig(3.21): Helical spring design step-2



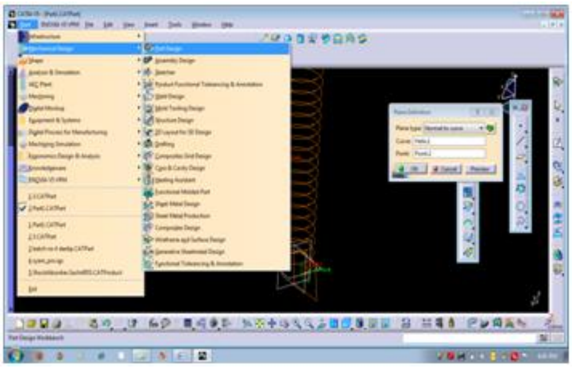
Fig(3.22): Helical spring design step-3

Insert ….wire frame and select the helical definition. As for the helical spring definition select the point 2 and axis in z-dir pitch 15.0mmand height 260.00mm



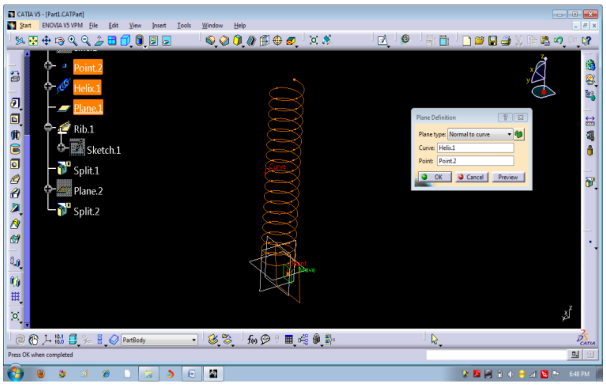
Fig(3.23): Helical spring design step-4

And go to start …mechanical …. Part design



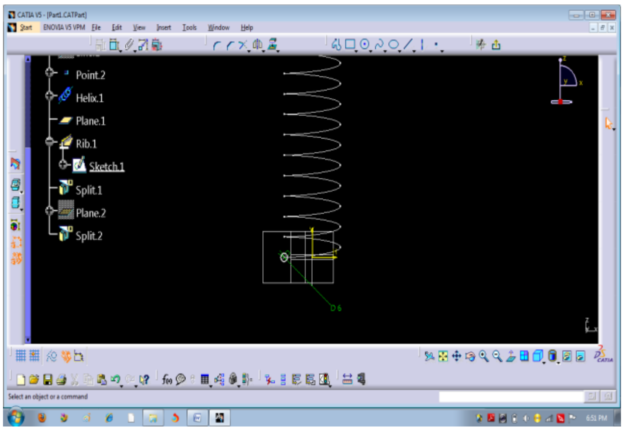
Fig(3.24): Helical spring design step-5

Go to plane definition and select the normal to profile definition select the curve and select end point of helical spring



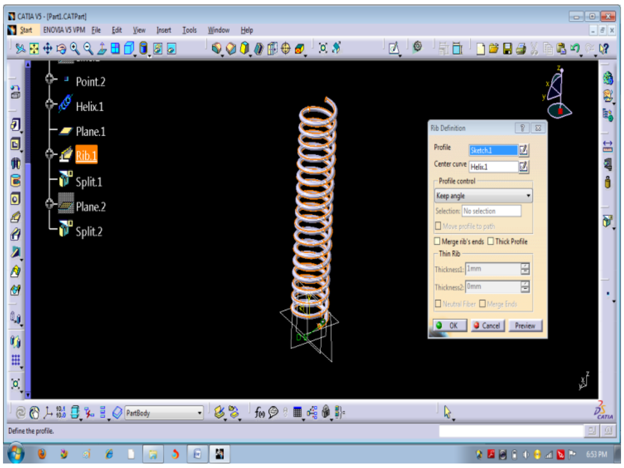
Fig(3.25): Helical spring design step-6

Insert , sketcher , Sketch and selecting the plane and draw the circle 6.00mm

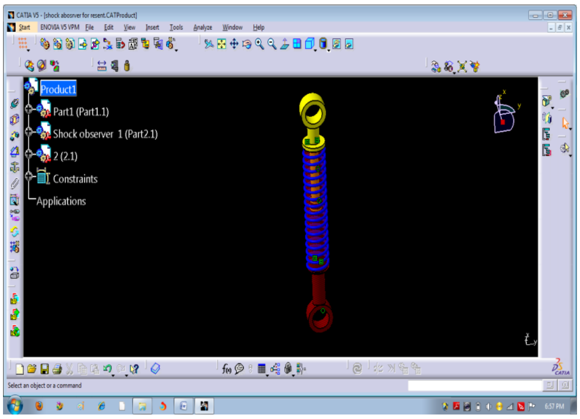


Fig(3.26): Helical spring design step-7

And exit workbench goes to insert the rib definition



Fig(3.27): Helical spring design step-8



Fig(3.28): Assembly of shock absorber

Final assembly shock observer

4. FINITE ELEMENT ANALYSIS

4.1. INTRODUCTION

Finite Element Analysis (FEA) is a computer-based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It can be used to analyze either small or large-scale deflection under loading or applied displacement. It can analyze elastic deformation, or "permanently bent out of shape" plastic deformation. The computer is required because of the astronomical number of calculations needed to analyze a large structure.

The power and low cost of modern computers has made Finite Element Analysis available to many disciplines and companies. In the finite element method, a structure is broken down into many small simple blocks or elements. The behavior of an individual element can be described with a relatively simple set of equations. Just as the set of elements would be joined together to build the whole structure, the equations describing the behaviors of the individual elements are joined into an extremely large set of equations that describe the behavior of the whole structure. The computer can solve this large set of simultaneous equations. From the solution, the computer extracts the behavior of the individual elements. From this, it can get the stress and deflection of all the parts of the structure. The stresses will be compared to allowed values of stress for the materials to be used, to see if the structure is strong enough.

The term "finite element" distinguishes the technique from the use of infinitesimal "differential elements" used in calculus, differential equations, and partial differential equations. The method is also distinguished from finite differential equations, for which although the steps into which space is divided are finite in size, there is little freedom in the shapes that the discreet steps can take. Finite element analysis is a way to deal with structures that are more complex than can be dealt with analytically using partial differential equations. FEA deals with complex boundaries better than finite difference equations will, and gives answers to "real world" structural problems. It has been substantially extended in scope during the roughly 40 years of its use.

4.2 General description of the FEA

In the finite element analysis, the actual continuum or body of matter like solid, Liquid or gas is represented as an assemblage of subdivisions called finite elements. These elements are considered to be interconnected at specified joints called nodes or Nodal points. The nodes usually lie on the element boundaries where adjacent elements are considered to be connected since actual variation of the field variable inside a finite variable inside a finite element can be approximated by a simple function. These approximate functions are defined in terms of the value of the field's variables at the nodes. By solving the field equations, which are generally in the form of matrix equations, the nodal values of the field variable will be known.

.4.3 STEPS IN FINITE ELEMENT ANALYSIS:

The steps in the finite element method when it is applied to structural mechanics are as follows.

1. Divide the continuum into a finite number of sub regions (or elements) of simple geometry such as line segments, triangles, quadrilaterals (Square and rectangular elements are subset of quadrilateral), tetrahedrons and hexahedrons (cubes) etc.

2. Select key point on the elements to serve as nodes where conditions of equilibrium and compatibility are to be enforced.
3. Assume displacement functions within each element so that the displacements at each generic point are depending upon nodal values.
4. Satisfy strain displacement and stress – strain relationship within a typical element. Determine stiffness and equivalent nodal loads for a typical element using work or energy principles.
5. Develop equilibrium equations for the nodes of the discredited.
6. Continuum in terms of the element contributions.
7. Solve the equilibrium for the nodal displacements.

The basic premise of the FEM is that a solution region can be analytically modeled or approximated by replacing with an assemblage of discrete elements. Since these elements can be put together in a variety of ways, they can be used to represent exceedingly complex shapes. The important feature of the FEM, which sets it apart from the other approximate numerical methods, is the ability to format solutions for the individual element before putting them together to represent the entire problem. Another advantage of FEM is the variety of ways in which one can formulate the properties of individual elements.

FEM can be broadly classified in to:

1. Pre-processing
2. Processing (solution)
3. Post-processing

1) Pre-processing:

It consists of solid model generation and discretization that in to finite elements. Definition of properties of modal such as element type, material properties, various constants such as young's modulus, Poisson ratio etc., dimension of each element i.e., thickness, moment of inertia, area etc.

Generation of element: two different methods are used in generating the elements.

1. Direct generation
2. From solid model

In direct generation method, the node is defined first and the elements are interconnected to obtain the final model.

In solid generation method solid model is generated and then, model is divided into finite elements. This conversion of solid model to finite elements is done through mesh generation. This method is more useful for complex models. In the present work solid generation method is used for making FEM models. Elements from solid model method can be subdivided into two categories.

- Free meshing.
- Mapped meshing.

Free meshing: Free meshing allows more flexibility in defining mesh areas. Free mesh boundaries can be much more complicated than mapped mesh without subdividing in to multiple regions. The mesh will automatically be created by an algorithm that tries to minimize element distortion (deviation from a perfect square). Free mesh surfaces can easily have internal holes, where mapped mesh surfaces can't. Free meshing is controlled by two parameters assigned to each mesh surface or volume that affect the size of the elements generated. The first is the element length, which is the normal size of elements the program will attempt to generate. The second parameter controls mesh refinement at curves in the model by controlling how much deviation is allowed between straight element sides and curved boundaries. This parameter is expresses either as a percentage deviation or an absolute number.

Mapped meshing: Mapped meshing requires the same number of elements on opposite sides of the mesh area, and requires that mesh area be bounded by three or four "edges". If you define a mapped mesh area with more than four curves, you must define which vertices are topological corners of the mesh. Mapped mesh boundaries with three corners will generate triangular elements in on "degenerate" corner. The number of elements per edge and biasing of elements of elements of element size towards the end or the center of edges control the mesh density. Another advantage of mapped meshing is we can produce dense mesh where we are interested and can produce coarse mesh where we are not interested even though it is of curved structure.

2) Processing Solution: The FE solver can be logically divided into three main parts, the pre-solver, the mathematical-engine & the post-solver. The pre-solver reads in the model created by the pre-processor and formulates the mathematical representation of the model. All parameters defined in the pre-processing stage are used to do this, so if one left something out, chances are the pre-solver will complain and cancel the call to the mathematical-engine. If the model is correct the solver proceeds to form the element-stiffness matrix for the problem & calls the mathematical-engine, which calculates the result (displacement, temperatures, pressures, etc.). The results are returned to the solver & the post-solver is used to calculate strains, stresses, heat fluxes, velocities, etc. for each node within the component or continuum.

3) Post-Processor: Here the results of the analysis are read & interpreted. They can be presented in the form of a table, a contour plot, deformed shape of the component or the mode shapes and natural frequencies if frequency analysis is involved. Other results are available for fluids, thermal and electrical analysis types. Most post-processors provide an animation service, which produces an animation & brings your model to life. Contour plots are usually the most effective way of viewing results for structural type problems. Slices can be made through 3D models to facility the viewing of internal stress patterns.

All post-processors now include the calculation of stress & strains in any of the x, y or z directions, or indeed in a direction at an angle to the coordinate axes. The principal stresses and strains may also be plotted, or if required the yield stresses and strains according to the main theories of failure (Von-Misses, St. Venant, Tresca etc.). Other information such as the strain energy, plastic strain and creep strain may be obtained for certain types of analyses.

Many user- oriented general-purpose finite element packages such as MSC-NASTRAN, NISA, ANSYS etc., are available in the market today. In the present context, the finite element analysis for the base frame was carried out by using the package, MSC NASTRAN (NASA TRANSLATION).

4.4 Advantages and Disadvantages of FEA

Advantages:

1. This method can be efficiently applied to cater irregular geometry. It can take care of any type of boundary.

2. Material anisotropy and non-homogeneity can be catered without much difficulty.

3. Any type of loading can be handled. Although we have many approximate methods such as wide residual methods, Rayleigh-Ritz method, Gale kin's method, FEM is superior to all of them.

Disadvantages: 1. There are many types of problems where some other methods of analysis may prove efficient than the finite element method.

2. The cost involved in the solution of the problem for vibration and stability problem in many cases, the cost of analysis by the finite element method may be prohibitive.

3. In FEM, the admissible functions are valid over the simple domain and have to do with the boundary, however simple or complex it may be.

4.5 Limitations of FEA

1. Due to the requirement of large computer memory and time, computer programs based on the FEM can be run only in high-speed computers.

2. There are also certain categories of problems where other methods are more effective. E.g.: fluid problems having boundaries at infinity are better treated by the boundary element method.

3. In the FEM the size of the problem is relatively large. Many problems lead to round-off errors. Since the computer works with a limited number of digits, a desired degree of accuracy may not be expected or in some cases it gives totally erroneous results. This results in errors in the analysis results

5. ANALYSIS USING ANSYS

5.1 INTRODUCTION TO ANSYS

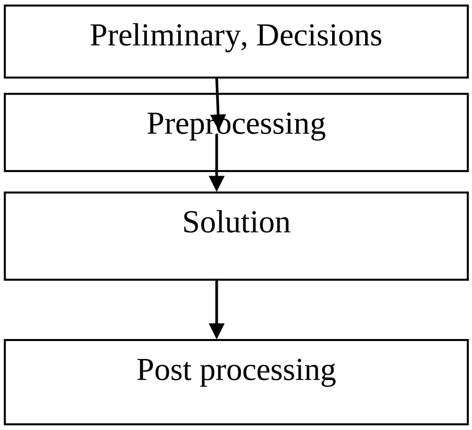
ANSYS is an engineering simulation software provider founded by software engineer John Swanson. It develops general-purpose finite element analysis and computational fluid dynamics software. While ANSYS has developed a range of computer-aided engineering (CAE) products, it is perhaps best known for its ANSYS Mechanical and ANSYS Multi-physics products.

ANSYS Mechanical and ANSYS Multi--physics software are non exportable analysis tools incorporating pre-processing (geometry creation, meshing), solver and post-processing modules in a graphical user interface. These are general-purpose finite element modelling packages for numerically solving mechanical problems, including static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems.

ANSYS Mechanical technology incorporates both structural and material non-linearity's. ANSYS Multi-physics software includes solvers for thermal, structural, CFD, electro-magnetic, and acoustics and can sometimes couple these separate physics together in order to address multidisciplinary applications. ANSYS software can also be used in civil engineering, electrical engineering, physics and chemistry.

Every analysis involves four main steps:

A. Preliminary Decisions
   1. What type of analysis: Static, modal, etc.?
   2. What to model: Part or Assembly?
   3. Which elements: Surface or Solid Bodies?
B. Preprocessing
1. Attach the model geometry
2. Define and assign material properties to parts
3. Mesh the geometry
4. Apply loads and supports
5. Request results
C. Solve the Model
D. Post processing
1. Review results
2. Check the validity of the solution



5.2 ANSYS WORK BENCH ANALYSIS

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex metaphysics analyses with drag-and-drop simplicity. With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development.

The Workbench environment allows you to solve much more complex analyses, including:

1. Multi-part assemblies
2. 3-D solid elements, shell elements, and shell-solid assemblies
3. Nonlinear contact with or without friction
4. Small-displacement and large-displacement static analyses
5. Modal, harmonic, and Eigen value buckling analyses
6. Steady-state thermal analysis, including temperature-dependent material properties and thermal contact.

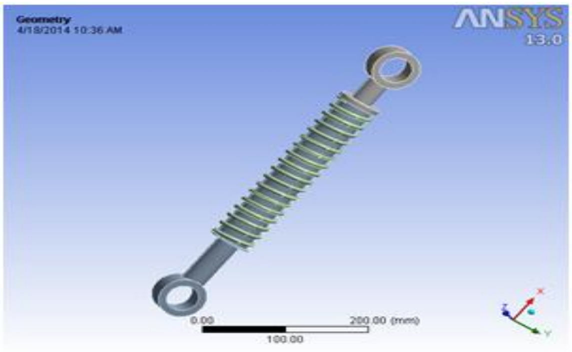
5.3 ANALYSIS SYSTEMS

One way to start an analysis in ANSYS Workbench is to select an analysis system from the Toolbox. When you select one of these analysis types, the corresponding system will appear in the Project Schematic, with all the necessary components of that type of analysis. Some analysis types offer different solvers, noted in parentheses. The features available can differ from one solver to another.

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. You will configure your static structural analysis in the Mechanical application, which uses the ANSYS or SAMCEF solver, depending on which system you selected, to compute the solution.

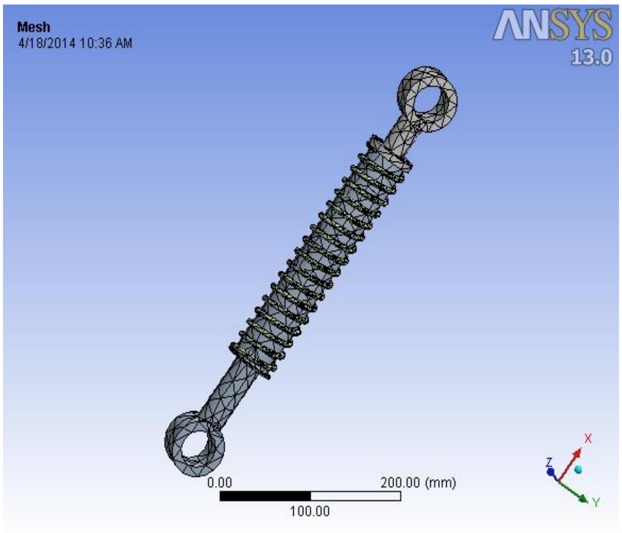
1. Add a static structural analysis template by dragging the template from the Toolbox into the Project Schematic or by double-clicking the template in the Toolbox.
2. Load the geometry by right-clicking on the Geometry cell and choosing Import Geometry.
3. View the geometry by right-clicking on the Model cell and choosing Edit or double-clicking the Model cell. Alternatively, you can right click the Setup cell and select Edit. This step will launch the Mechanical application.
4. In the Mechanical application window, complete your static structural analysis using the Mechanical application's tools and features. See Static Structural Analysis in the Mechanical application help for more information on conducting a structural analysis in the Mechanical application.

Imported model form CATIA



Fig(5.1):Imported model

Shock absorber after meshing



Fig(5.2):Meshed model

Model (A4) > Geometry > Parts

Object Name	***2***	***Shock observer 1***	***Part1***
State	**Meshed**		
Graphics Properties			
Visible	**Yes**		
Transparency	**1**		
Definition			
Suppressed	**No**		
Stiffness Behavior	**Flexible**		
Coordinate System	**Default Coordinate System**		
Reference	**By Environment**		

Temperature			
Material			
Assignment	**Structural Steel**		
Nonlinear Effects	**Yes**		
Thermal Strain Effects	**Yes**		
Bounding Box			
Length X	**239.62 mm**	**397.07 mm**	**260. mm**
Length Y	**60. mm**		**56. mm**
Length Z	**55. mm**		**56. mm**
Properties			
Volume	**1.4236e+005 mm³**	**3.0513e+005 mm³**	**76958 mm³**
Mass	**1.1175e-003 t**	**2.3953e-003 t**	**6.0412e-004 t**
Centroid X	**690.05 mm**	**488.91 mm**	**556.86 mm**
Centroid Y	**-3.751e-011 mm**	**1.6037e-009 mm**	**-0.2671 mm**
Centroid Z	**-4.6046 mm**	**-4.6053 mm**	**-4.4485 mm**
Moment of Inertia Ip1	**0.25254 t·mm²**	**0.80082 t·mm²**	**3.5294 t·mm²**
Moment of Inertia Ip2	**5.2794 t·mm²**	**31.771 t·mm²**	**3.5268 t·mm²**
Moment of Inertia Ip3	**5.3711 t·mm²**	**31.863 t·mm²**	**0.37568 t·mm²**
Statistics			
Nodes	**3440**	**2711**	**8552**
Elements	**1844**	**1349**	**3420**
Mesh Metric	**None**		

1.Structural Analysis for bike weight (125kgs) using Spring Steel as spring material

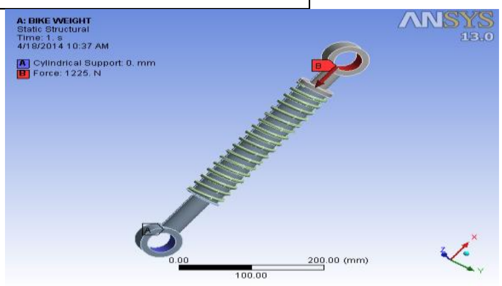
Case 1: Load 125kgs

Element Type Solid 20 node 95 Material: Spring Steel

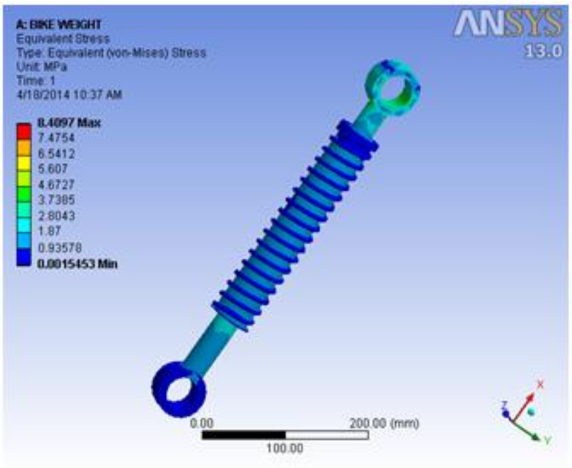
Material Properties: Young's Modulus (EX): 210000N/ mm2 Poisson's Ratio (PRXY): 0.29

Density: 0.000007850kg/mm3

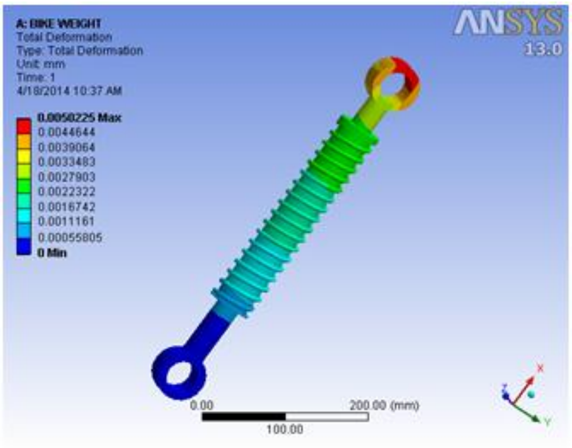
Static Structural:



Fig(5.3):Appling loads



Fig(5.4):Vonmisses stresses



Fig(5.5):Displacement vector sum

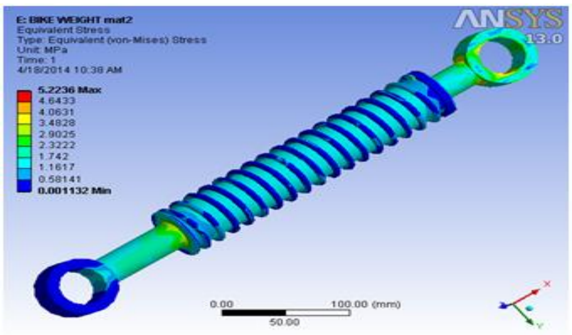
2.Structural Analysis for bike weight (125kgs) using molybdenum as spring material

Case 2: Load 125kg

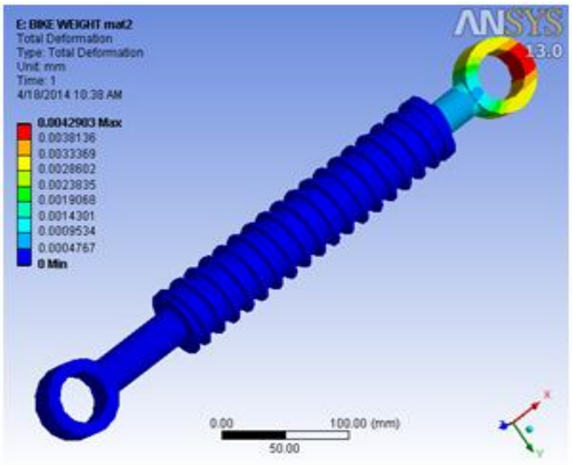
Element Type: Solid 20 nodes 95 Material: molybdenum

Material Properties: Young's Modulus (EX) : 329000N/ mm2 Poisson's Ratio (PRXY): 0.31

Density: 0.000001023kg/ mm3



Fig(5.6):Vonmisses stresses



Fig(5.7):Displacement vector sum

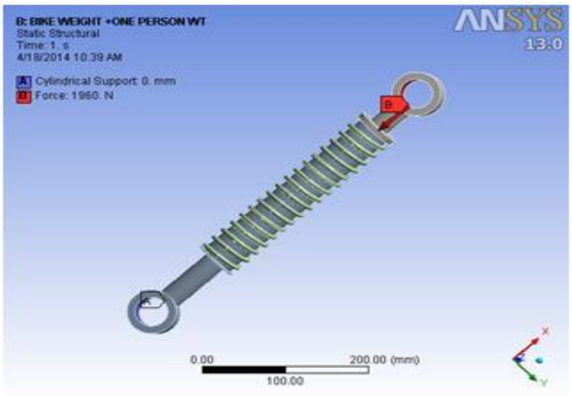
3.Structural Analysis for bike weight (200kgs) using Spring Steel as spring material

Case 1: Load 200kgs

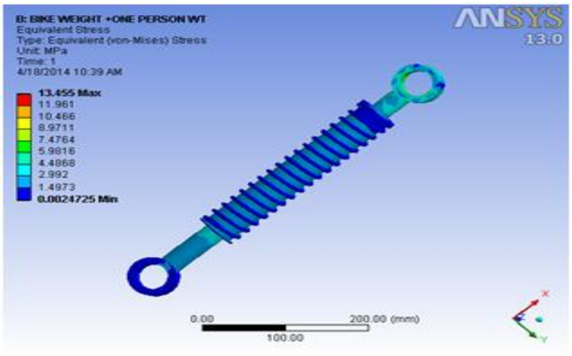
Element Type Solid 20 node 95 Material: Spring Steel

Material Properties: Young's Modulus (EX): 210000N/ mm2 Poisson's Ratio (PRXY): 0.29

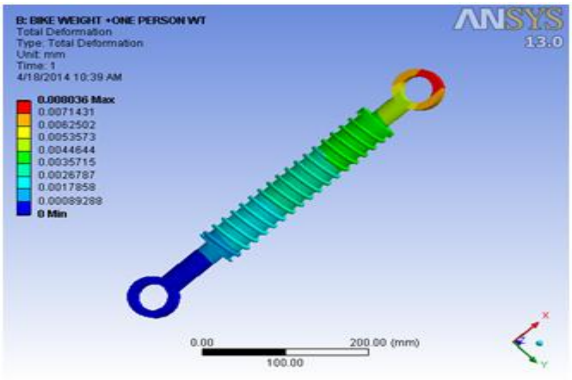
Density: 0.000007850kg/mm3



Fig(5.8):Appling loads



Fig(5.9):Vonmisses stresses



Fig(5.10):Displacement vector sum

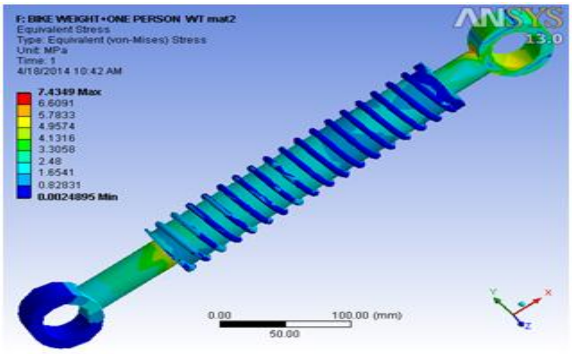
4.Structural Analysis for bike weight (200kgs) using molybdenum as spring material

Case 2: Load 125kg

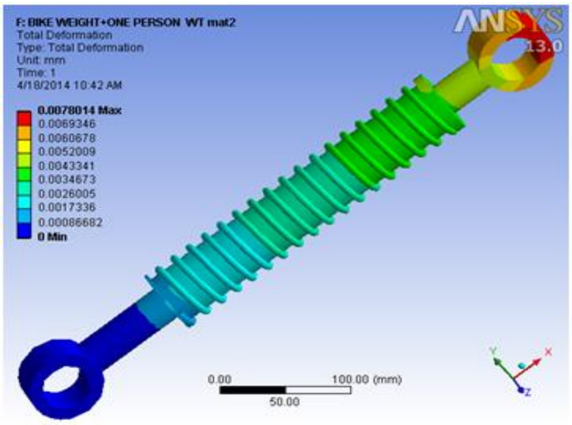
Element Type: solid 20 node 95 Material: molybdenum

Material Properties: Young's Modulus (EX) : 329000N/ mm2 Poisson's Ratio (PRXY): 0.31

Density: 0.000001023kg/ mm3



Fig(5.11):Vonmisses stresses



Fig(5.12):Displacement vector sum

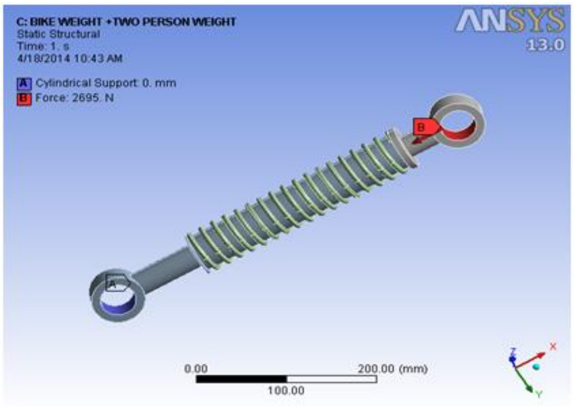
5.Structural Analysis for bike weight (275kgs) using Spring Steel as spring material

Case 1: Load 275kgs

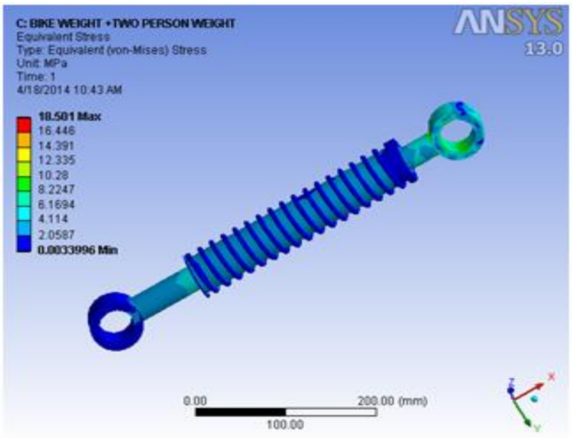
Element Type Solid 20 node 95 Material: Spring Steel

Material Properties: Young's Modulus (EX): 210000N/ mm2 Poisson's Ratio (PRXY): 0.29

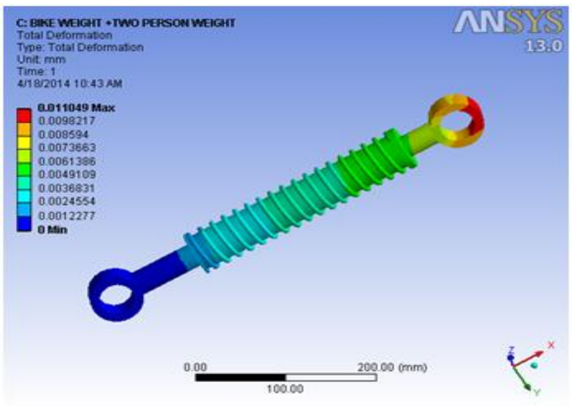
Density: 0.000007850kg/mm3



Fig(5.13):Appling loads



Fig(5.14):Vonmisses stresses



Fig(5.15):Displacement vector sum

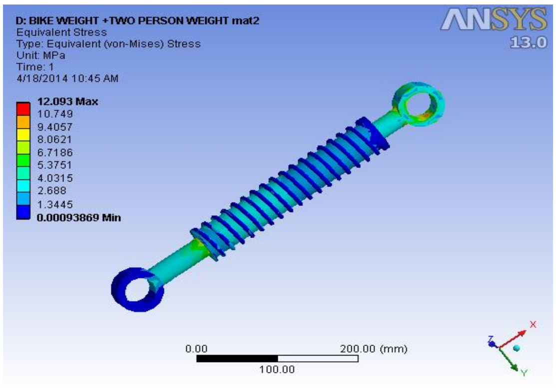
5.Structural Analysis for bike weight (275kgs) using molybdenum as spring material

Case 2: Load 275kg

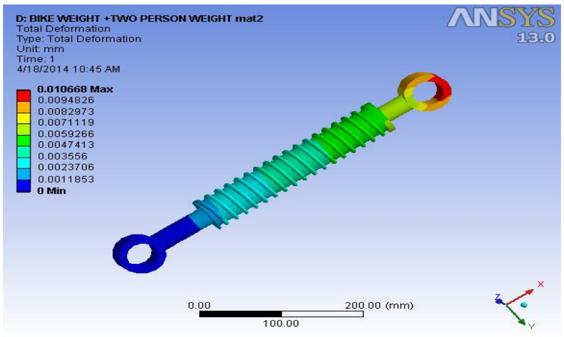
Element Type: Solid 20 nodes 95 Material: molybdenum

Material Properties: Young's Modulus (EX) : 329000N/ mm2 Poisson's Ratio (PRXY): 0.31

Density: 0.000001023kg/ mm3



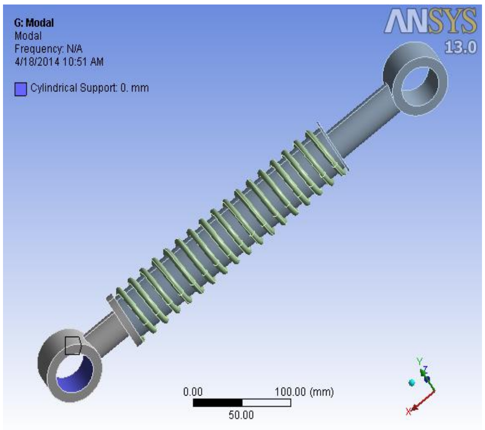
Fig(5.16):Vonmisses stresses



Fig(5.17):Displacement vector sum

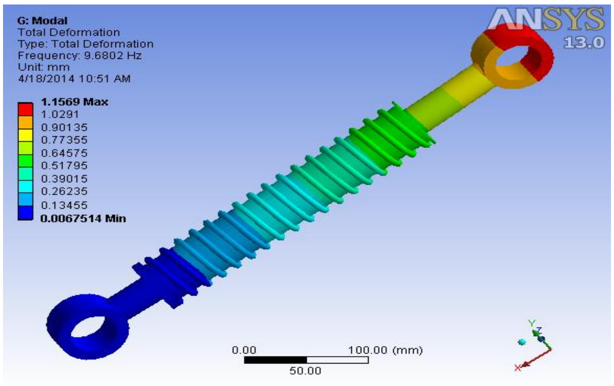
FREQUENCYS:

Shock absorber model

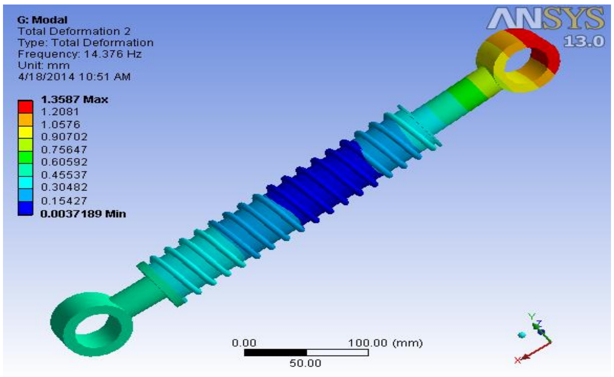


Fig(5.18): Total Deformation of the shock absorber at mode-1

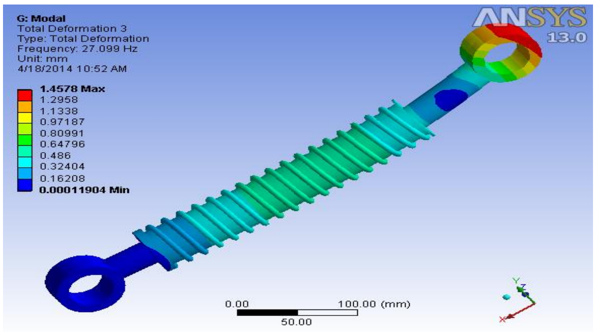
Frequencies for steel:



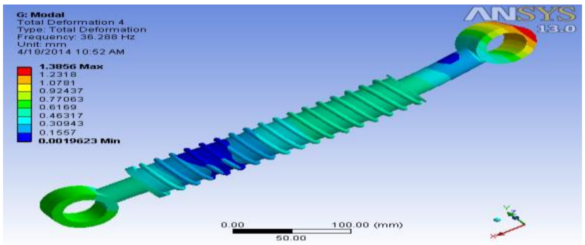
Fig(5.19): Total Deformation of the shock absorber mode-2



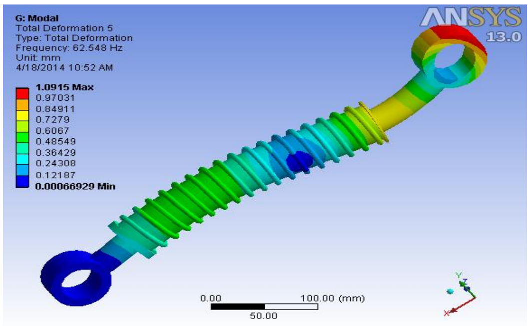
Fig(5.20): Total Deformation of the shock absorber at mode -3



Fig(5.21): Total Deformation of the shock absorber at mode -4

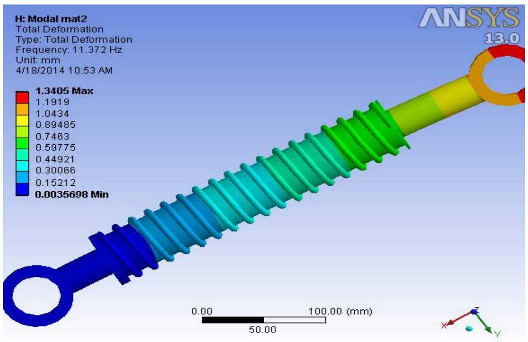


Fig(5.22):Total Deformation of the shock absorber at mode -5

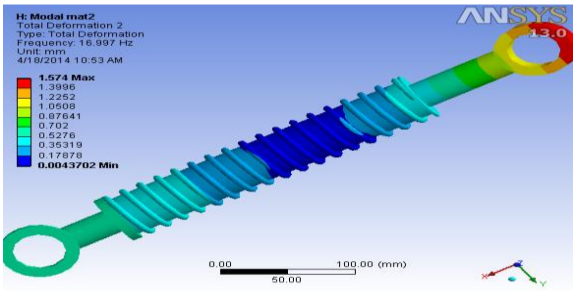


Frequencies for molybdenum:

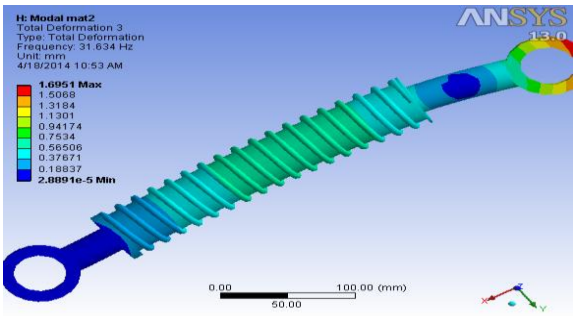
Fig(5.23): Total Deformation of the shock absorber at mode -1



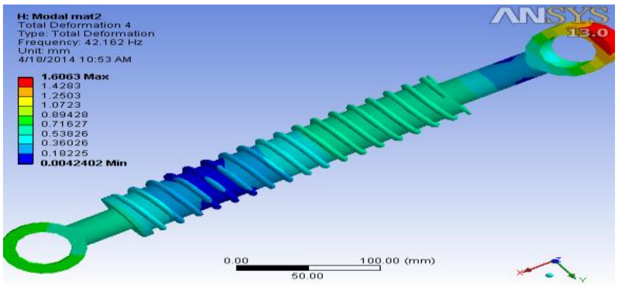
Fig(5.24):Total Deformation of the shock absorber at mode -2



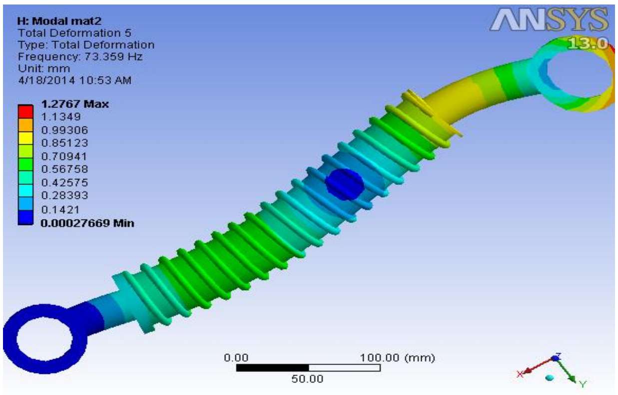
Fig(5.25): Total Deformation of the shock absorber at mode -3



Fig(5.26): Total Deformation of the shock absorber at mode -4



Fig(5.27)Total Deformation of the shock absorber at mode -5

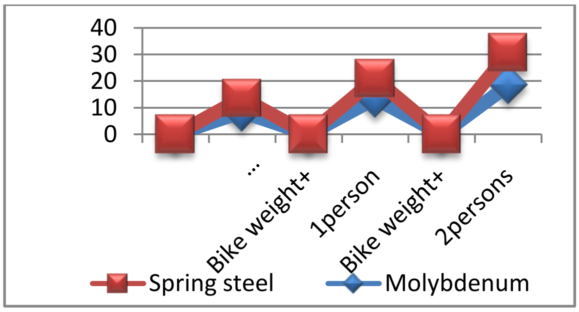


Fig(5.28): Total Deformation of the shock absorber at mode -5

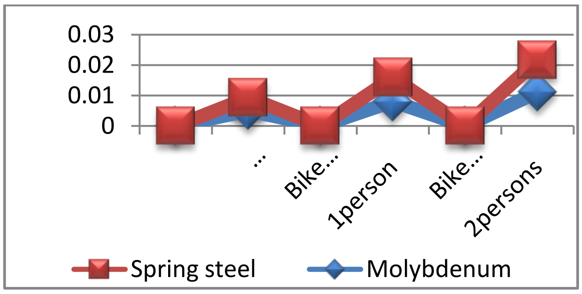
Stresses for both material

TABLE(5.1): stresses for both material at max,min

Applying load	Spring steel			Molybdenum		
	Stresses		Deformation	Stresses		Deformation
	Max	Min		Max	Min	
Bike weight	8.4097	0.0015453	0.0050225	5.2236	0.001132	0.0042903
Bike weight + 1person	13.455	0.00247	0.008036	7.4349	0.0024895	0.0078014
Bike weight + 2persons	18.501	0.0033996	0.011049	12.093	0.00093869	0.010668



Grphs(1): Maximum Stresses in both matrial.



Grphs(2): Maximum Stress in both matrial.

6.CONCLUSION

I. In this project a shock absorber is designed and a 3D model is created using CATIA.

II. Structural analysis and modal analysis are done on the shock absorber by varying material for Spring Steel and Molybdenum at different loads.

III. Von-misses Stresses, deflection and frequencies are calculated.

IV. The induced stresses for molybdenum are very low as compared to steel.

V. Conclude that as per our analysis using material molybdenum for spring is best and also design is safe.

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