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DESIGN AND EVALUATION OF A TWO WHEELER SUSPENSION SYSTEM FOR VARIABLE LOADS AND VARIABLE MATERIALS

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ABSTRACT: - A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of travelling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. When a vehicle is travelling 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. In this project a shock absorber is designed and a 3D model is created using CATIA V5. Structural analysis is done in ANSYS on the shock absorber by varying material for spring, Spring Steel En42J, Spring Steel En47 and Spring Steel IS4454 grade3. The analysis is done by considering loads, bike weight (130kgs), bike weight and person weight (205kgs) and bike weight and two person's weight (280kgs). Comparing these three materials to find the best material for spring in Shock absorber.

KEYWORDS:-CATIA, ANSYS WORK BENCH.

1. Introduction:

A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. 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 fluid) or air. This fluid-filled piston/cylinder combination is a dashpot. 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.

2. LITERATURE REVIEW AND OBJECTIVE:

An exhaustive literature review is carried out to understand the present practices and theories in shock absorber design. It will also help to obtain a better understanding of how individual internal components and internal flows had been designed and modelled in the past. In 1977, Lang published his Ph.D. dissertation studying the behavior of automotive dampers at high stroking frequencies. The work included creation of one of the first parametric models of a twin tube automotive damper with good agreement to experimental data. This paper is the milestone paper in understanding performance behavior of modern dampers. The concepts behind Lang's model involved "The development of a mathematical model of shock absorber performance based upon dynamic pressure flow characteristics of the shock absorber fluid and the dynamic action of the valves". Lang was one of the first to examine the internal physics of the fluid and the valves in an attempt to model their behavior. The model included the effective compressibility', which also accounts for the compliance of the cylinder wall.

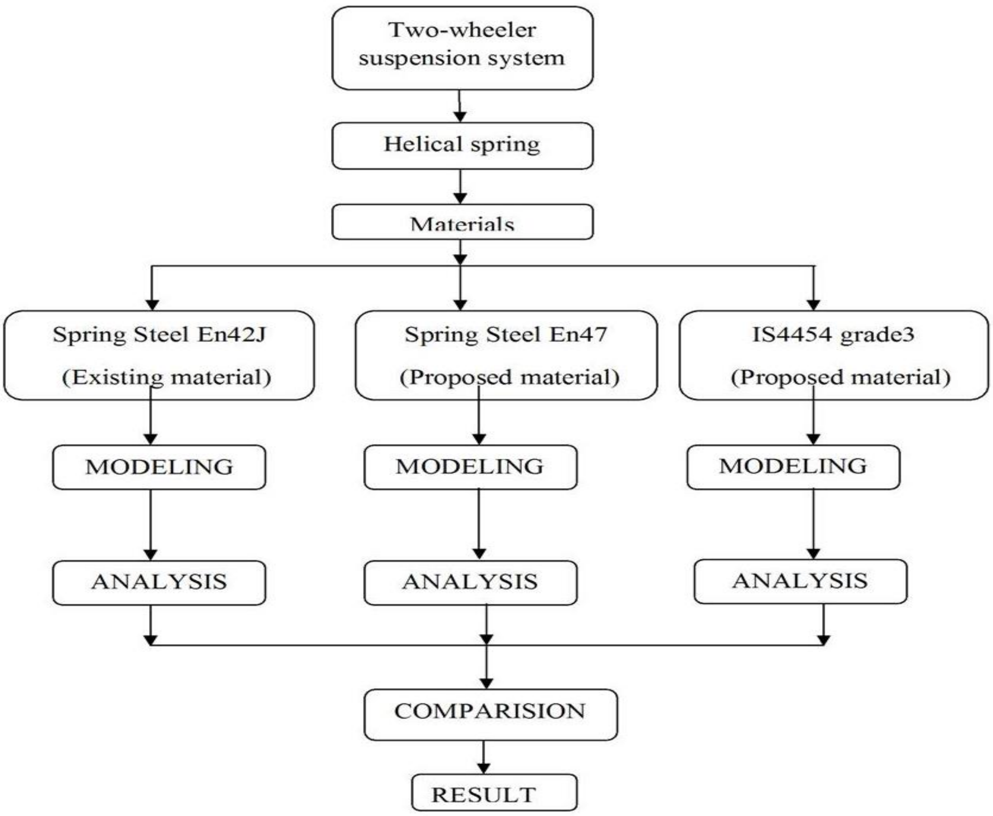
This aided in correctly modelling one influence on hysteresis. Chamber pressures were also examined. The model used equations for standard steady orifice flow based on the pressure drop across the flow orifice. The dynamic discharge coefficients and the valve opening forces were found experimentally. A limitation to Lang's model was computing power; his work was completed on an analogue computer. For this reason, dynamic discharge coefficients were assumed constant. Good agreement to experimental data was found using this assumption. Reybrouck presented one of the first concise parametric models of a mono tube damper. Flow restriction forces were found using empirical relationships that included leak restriction, port restriction and spring stiffness correction factors. Once individual internal forces were found, another empirical relationship was used to calculate the total damping force. Pressure drops across the specific flow restrictions could also be found. These correction factors had some physical meaning, but their values were found through experimentation. Reybrouck later extended his model to a twin tube damper and included a more physical representation of hysteresis.

It was shown that hysteresis was caused not only by oil compressibility, but the compressibility of gas bubbles transferred from the reserve chamber. It was also shown that reserve chamber pressure greatly affects the solubility of nitrogen. As the pressure increases the entrapped bubbles are absorbed. This effect should not be neglected for accurate results. Kim also performed an analysis of a twin tube damper with focus on implementation into a vehicle suspension system. Kim's model included chamber compliance and fluid compressibility which yielded a differential equation for the chamber pressures that was solved using the RungaKutta Method. Discharge coefficients were experimentally found and applied to the model. Incorporating damping data into a quarter car model, the frequency response of the sprung mass and tire deflection were calculated numerically. Good agreement with experimental data was found for single strokes of the damper, but no full cycle FV plots were included. Mullica and Youcef-Tuomi presented a mono tube damper model created using the bond graph method, based on Mollica's M.S. thesis work. This reference concluded five major sources for hysteresis in FV plots.

Talbott and Starkey also published these findings in SAE paper. Total flow is comprised of valve orifice flow, bleed orifice flow, and piston leakage flow. Flow resistance models were created for each separate flow based on the pressure drop across the orifice, path per Lang's work. Pressure in the gas chamber, Pg, was related to the pressure in the compression chamber, Pc using force balance on the gas piston. This relation of Pg and Pc was one of the important findings of this modelling method. Talbott assumed the oil and gas in the damper was incompressible. Adrian Simms et al. Modelled damper for the output characteristics of interest were simulated for sinusoidal excitations of 1, 3 and 12 Hz. In order to select the optimum damper modelling strategy for a 'virtual damper tuning environment', the suitability of the differing approaches were determined with respect to the different criterion likeability to capture damper non-linearity and dynamic behaviour, flexibility to model different shock absorber types, ease of model generation (Experiment/Parameter identification), suitability for use in vehicle simulations and usefulness as predictive tool. All of the sine wave amplitudes were 0.05m with exception of the 12 Hz signal which was0.005m.

3. METHODOLOGY

3.1 Flowchart



3.2 PROBLEM DEFINITION AND WORKING OBJECTIVES

3.2.1 Problem Definition

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.

3.2.2 Objectives of This Work

The design of spring in suspension system is very important. In this project a shock absorber is designed and a 3D model is created using CATIA V5

Structural analysis is done in ANSYS on the shock absorber by varying material for spring, Spring Steel En42J, Steel En47 and Spring Steel IS4454 grade3. The analysis is done by considering loads, bike weight (130kgs), bike weight and person weight (205kgs) and bike weight and two person's weight (280kgs)

Comparison is done for three materials to verify best material for spring in Shock absorber.

3.3 SPRING MATERIAL

Commonly Used Spring Materials

One of the important considerations in spring design is the choice of the spring material. Some of the common spring materials are given below.

3.3.1 Hard-drawn wire:

This is cold drawn, cheapest spring steel. Normally used for low stress and static load. The material is not suitable at subzero temperatures or at temperatures above 1200C.

3.3.2 Oil-tempered wire:

It is a cold drawn, quenched, tempered, and general-purpose spring steel. It is not suitable for fatigue or sudden loads, at subzero temperatures and at temperatures above 1800C.

3.3.3 Chrome Vanadium:

This alloy spring steel is used for high stress conditions and at high temperature up to 2200C. It is good for fatigue resistance and long endurance for shock and impact loads.

3.3.4 Chrome Silicon:

This material can be used for highly stressed springs. It offers excellent service for long life, shock loading and for temperature up to 2500C.

3.3.5 Music wire:

This spring material is most widely used for small springs. It is the toughest and has highest tensile strength and can withstand repeated loading at high stresses. It cannot be used at subzero temperatures or at temperatures above 1200C.

3.3.6 Stainless steel:

Widely used alloy spring materials.

Phosphor Bronze / Spring Brass:

It has good corrosion resistance and electrical conductivity. It is commonly used for contacts in electrical switches. Spring brass can be used at subzero temperatures.

3.4 MATERIALS

3.4.1 Spring Steel

3.4.1.1Mechanical Properties

Table3.1 Mechanical properties of Spring Steel

Quantity	**Value**	**Units**
Young's Modulus	210000	Mpa
Tensile Strength	615.4	Mpa
Elongation	24.7	%
Density	8080	Kg/m^3
Position’s Ratio	0.3	-

3.4.2 Beryllium Copper

3.4.2.1Mechanical Properties

Table 3.2 Mechanical properties of BerylliumCopper

Quantity	**Value**	**Units**
Young's Modulus	130000	Mpa
Tensile Strength	689	Mpa
Elongation	13	%
Fatigue	315	Mpa
Yield Strength	517	Mpa
Density	8710	Kg/m^3
Position’s Ratio	0.3	-

3.4.3Aluminum 6063

3.4.3.1Mechanical Properties

Table 3.3Mechanical propertiesof Aluminum 6063

Quantity	Value	Units
Young's Modulus	68300	MPa
Tensile Strength	186	MPa
Yield Strength	145	MPa
Density	2700	Kg/m^3
Position's Ratio	0.3	-

4. DESIGN OF EXPERIMENT

4.1 Introduction to CATIA

CATIA is one among the world's leading high-end CAD/CAM/CAE software packages. CATIA (computer assisted 3-dimensional interactive application) could be a multi-platform PLM/CAD/CAM/CAE business code suite developed by Desalt systems and marketed worldwide by IBM. CATIA is written within the C++ artificial language. CATIA provides open development, design through the employment of interfaces, which might be accustomed customize or develop applications. The applications in programming interfaces supported visual basic and C++ programming languages.

Commonly said as 3D product Lifecycle management (PLM) software system suite, CATIA supports multiple stages of development. The stages vary from conceptualization, through design (CAD) and producing (CAM), till analysis (CAE). Every work bench of catiaV5 refers and every stage of development for various merchandise. CATIA V5 options a constant solid/surface-based package that uses NURBS because the core surface illustration and has many work benches however offer KBE (knowledge primarily based engineering) support

4.2 Parts of Shock Absorber

Shock absorber helical spring specifications are mentioned in below table

Table.4.1: Helical Spring Design Parameters

Sr.No	Specifications	Value	Units
1	Spring Wire Diameter	6.92	Mm
2	Outer Diameter	49.22	Mm
3	Mean Coil Diameter	42.3	Mm
4	Number of Turns	17	-
5	Actual No. of Turns	19	-
6	Pitch	14.10	Mm
7	Free Length of Spring	232	Mm

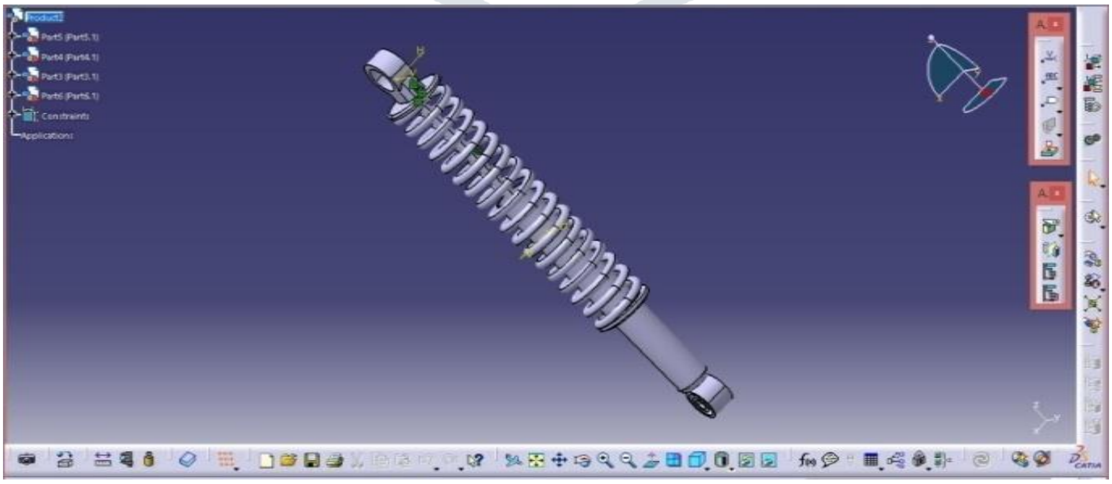


Fig: 4.1: Total assembly or suspension system or shock observer

5. INPUT CALCULTIONS

5.1 Load Calculations

Load calculations will be considered for Hero Honda Company splendor pro modal Motor cycle (Bike or Two-wheeler). Weight of that bike is 130 kgs. One Person average weight will be considered as 75kgs and two-person average weight will be considered as 150kgs.Rear suspension of the bike will be considered as 65% of suspension.Weight of bike and one-person weight will be considered as 205kgs and Weight of bike and two persons weight will be considered as 280kgs.

Weight of bike	W= 130kg
Let weight of one-person	p_1= 75Kg
Weight of two persons	p_2= 75×2=150Kg
Weight of bike and one person	W_{1-1} = 205Kg
Weight of bike and two persons	W_{2-1} = 280Kg
Rear Suspension	R_s = 65%

5.2 Weight of bike and one person W_{1-1} = 205Kg

65% Rear Suspension of 205×0.65 = 133.25Kg

$$W_{g1}=133.25\times 9.81$$

$$W_{g1}=1307.18\ N$$

W_1=1307.18N load acting on two shock absorbers

For single shock absorber acting load = 1307.18 /2

$$W_{1-2} = 653.59N$$

5.3 Weight of bike two persons W_{2-1} = 280Kg

65% Rear Suspension of 208×0.65 = 182Kg

$$W_{g2} =182\times 9.81$$

$$W_{g2} =1785.42N$$

W_2=1785.42N load acting on two shock absorbers

For single shock absorber acting load =1785.42/2

$$W_{2-2} =892.71N$$

6. ANALYSIS OF SHOCK ABSORBER

6.1 Introduction to ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

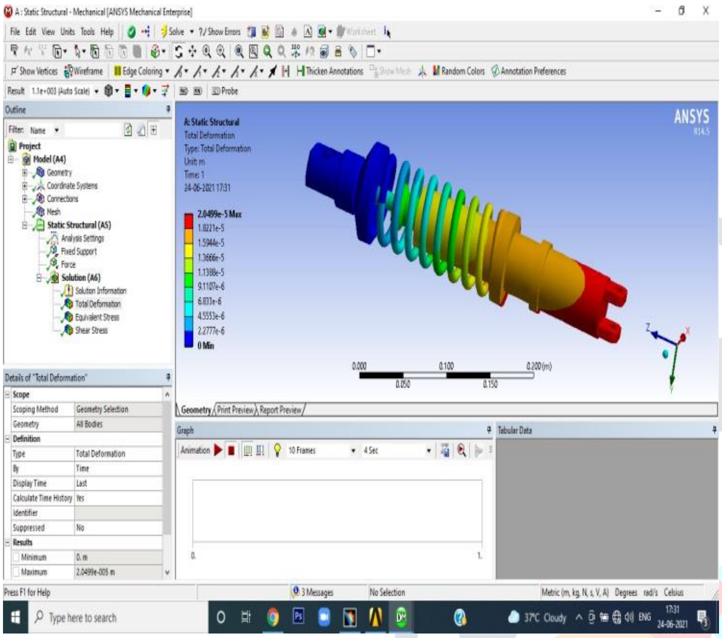
ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

Generic Steps to Solving any Problem in ANSYS

Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describe the processes in terminology slightly more attune to the software.



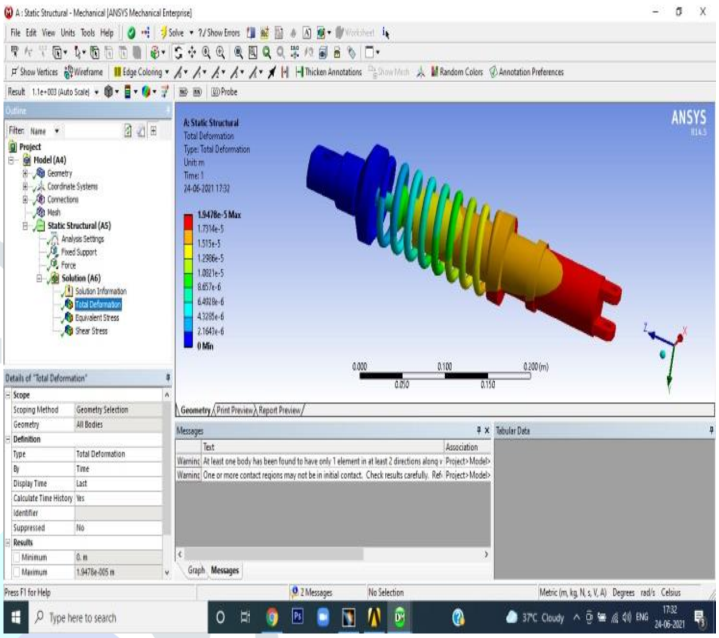


Fig.6.1: Deflection of Stainless-Steel material at 3000N

Fig.6.2: Deflection of Copper Alloy Material at 3000N

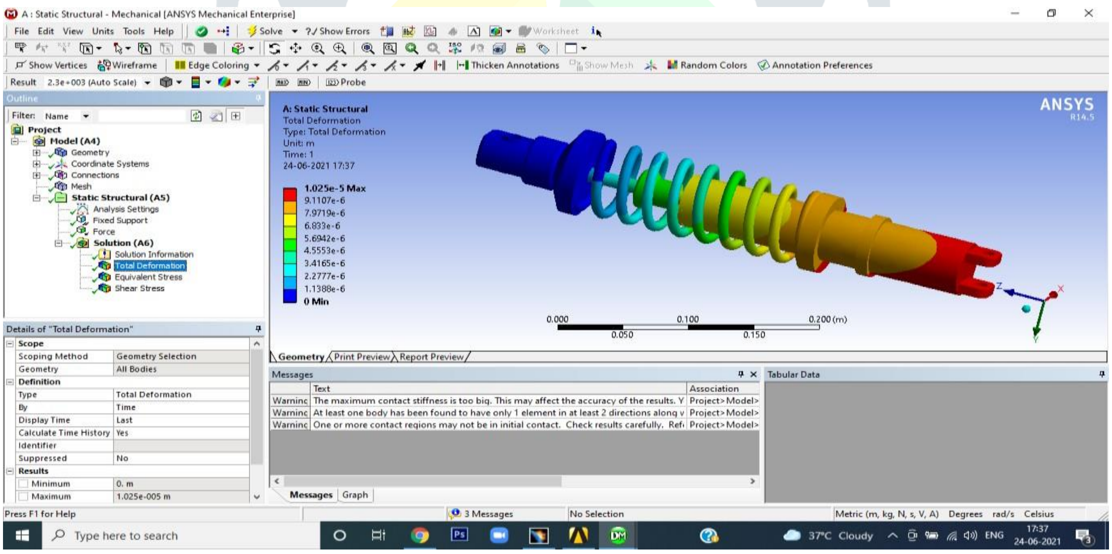
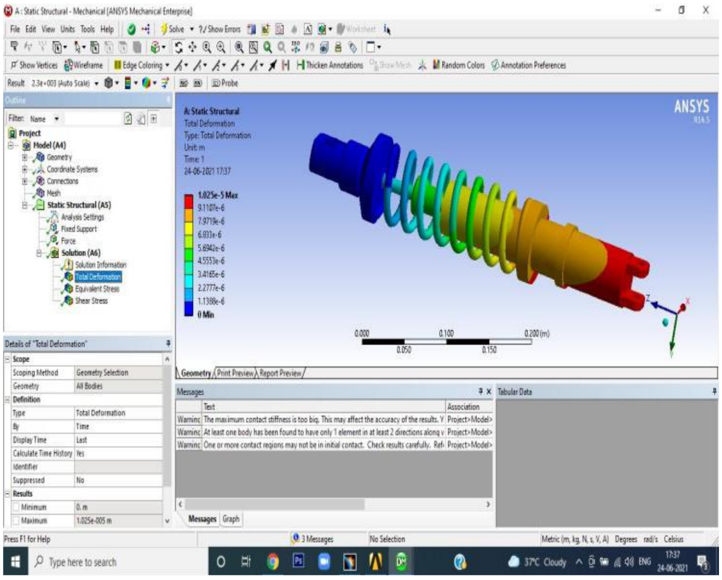


Fig.6.3: Deflection of Aluminum Alloy Material at 3000N



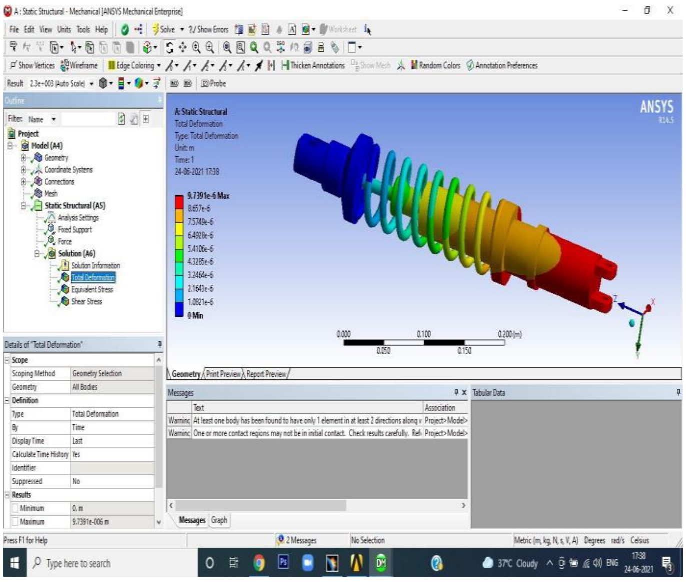


Fig.6.4: Deflection of Stainless-Steel material at 6000N

Fig.6.5: Deflection of Copper Alloy Material at 6000N

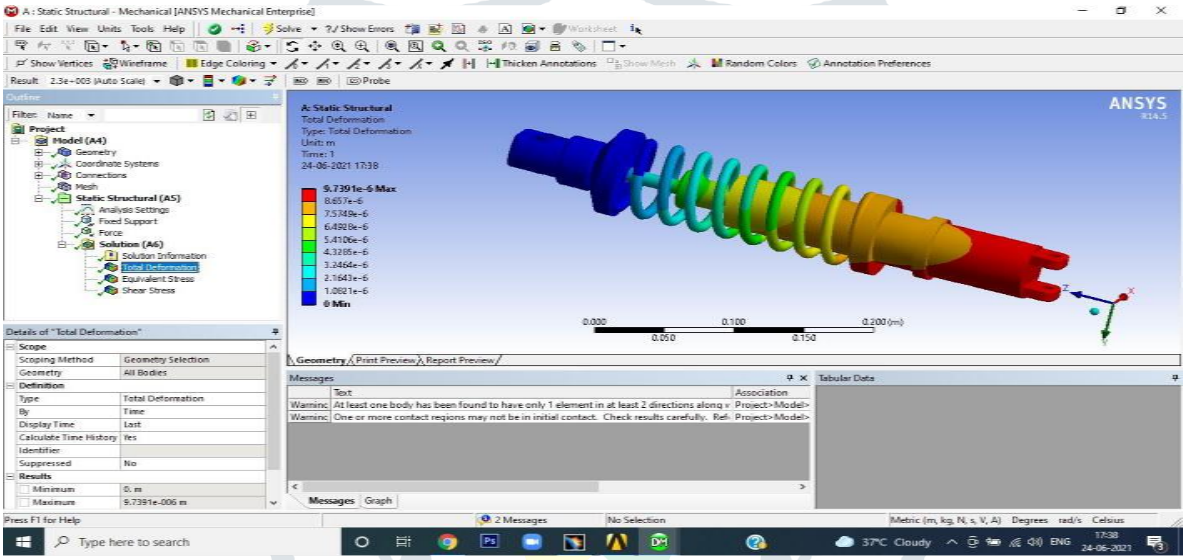


Fig.6.6: Deflection of Aluminum Alloy Material at 6000N

7. RESULTS

The design of SHOCK ABSORBER using CATIA V5 is developed successfully.

This study attempted to analyze stress & strain on the Shock absorber design using **ANSYS.** This is important because the simulation data are useful for further design improvement and subsequently leads to cost effectiveness.

The below table is obtained by applying varying loads on different materials.

Table:7.1 Results

	Stainless Steel		**Copper**		**Aluminum 6063**	
Loads	Load-1 3000N	Load-2 6000N	Load-1 3000N	Load-2 6000N	Load-1 3000N	Load-2 6000N
Minimum Deflection	0	0	0	0	0	0
Maximum Deflection	$2.049e^{-5}$ m	$9.75e^{-6}$ m	$1.94e^{-5}$ m	$9.14e^{-5}$ m	$1.86e^{-5}$ m	$9.02e^{-5}$ m

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