Design and analysis on Suspension Systems in bikes

A project report submitted in partial fulfilment of the requirement for the award of the degree of

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IN

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BY

SANAPATI VENKATESH	**(317126520220)**
BANKURU SUNEEL	**(317126520184)**
NAMBALLA ROOPESH	**(317126520209)**
SARAGADAM ROHITH KUMAR	**(317126520L45)**
RATTI MANOHAR	**(317126520218)**

Under the esteemed guidance of

Mrs. K.S.L SOUJANYA, M.TECH (PHD)

Asst. Professor

DEPARTMENT OF MECHANICAL ENGINEERING
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
(Affiliated to Andhra University, Accredited By NBA and NAAC with 'A' Grade)
SANGIVALASA, VISAKHAPATNAM (District) – 531162

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
(Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with A grade)
SANGIVALASA, VISAKHAPATNAM (District) – 531162

PRAGNANAM BRAHMA
ANITS

CERTIFICATE

This is to certify that the Project Report entitled **"DESIGN AND ANALYSIS OF SUSPENSION SYSTEM ON BIKE"** being submitted by SANAPATI VENKATESH (317126520220), BANKURU SUNEEL (317126520184), NAMBALLA ROOPESH (317126520209), SARAGADAM ROHITH KUMAR (318126520L45), RATTI MANOHAR (317126520218) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING**. It is the work of bona-fide, carried out under the guidance and supervision of **MRS. K.S.L.SOUJANYA**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

PROJECT GUIDE	Approved By HEAD OF THE DEPARTMENT
(MRS. K.S.L.SOUJANYA) Assistant Professor Mechanical Engineering Department ANITS, Visakhapatnam.	(Dr. B. Naga Raju) Head of the Department Mechanical Engineering Department ANITS, Visakhapatnam.

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Sangivalasa-531 162 VISAKHAPATNAM Dist. A.P.

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SANAPATI VENKATESH (317126520220)
BANKURU SUNEEL (317126520184)
NAMBALLA ROOPESH (317126520209)
SARAGADAM ROHITH KUMAR (317126520L45)
RATTI MANOHAR (317126520218)

ABSTRACT

Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. The need for dampers arises because of the roll and pitches associated with vehicle maneuvering, and from the roughness of road. This led to make the ride quality for the people very uncomfortable which led to invention and innovation of shock absorbers. Shock absorbers are devices that smooth out an impulse experienced by a vehicle, and appropriately dissipate or absorb the kinetic energy. shock absorbers have become such an essential component of an automobile.

Suspension system is the main part of the vehicle which is used for comfort and for better ride through rough roads. It absorbs shocks and vibration by providing smooth functioning to the vehicle. Currently there are different types of suspension in the market.

In this study, we considered mono suspension and dual suspension. We compare the ride quality of mono suspension and dual suspension of two-wheeler vehicles to know how they differ from each other by performing static structural analysis under different loading conditions by designing 3D model of suspension system using software like CATIA V5 and ANSYS for performing analysis.

We have also performed for the same and have depicted the convergence of the simulation with the design clearly.

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INTRODUCTION

1.INTRODUCTION

1.1 SUSPENSION SYSTEM:

A motorcycle's suspension serves a dual purpose- contributing to the vehicle's handling and braking and providing safety and comfort by keeping the vehicle's passengers comfortably isolated from road noise, bumps and vibrations.

Shock absorber is a mechanical device designed to smooth out or damp shock impulse and dissipate kinetic energy. In this work, suspension system is designed and a 3D model is created using CATIA V5R21. Structural analysis is done on the shock absorber by varying different types of materials and loading conditions. Suspension types considered in this analysis are mono suspension and twin suspension systems. To validate the strength of the model, the structural analysis on the design of suspension systems is performed. The analysis is done by considering different loading conditions like bike weight, bike weight with single, and double rider. Finally, comparison is done for different suspension systems by varying different materials such as stainless steel, aluminium alloy, magnesium alloy.

1.2 WORKING:

The primary goal of motorcycle suspension is to keep vehicle tires in contact with the ground. Without proper suspension, tires would lose traction when encountering bumps, dips or other ground imperfections. We can’t forget about braking, acceleration or cornering forces either.

Motorcycle suspensions use a spring and damper combination to isolate the chassis and rider from road imperfections. On-road motorcycle suspension systems work to minimize the effect of potholes, bumps, cornering and acceleration/deceleration forces. Off-road motorcycle suspension systems handle roots, rocks, jumps, ledges and more.

Without suspension, any impact between a vehicle tire and a ground imperfection is at best uncomfortable, and at worst, the cause of a dangerous crash.

Basic motorcycle suspension lacks adjustability. It works fairly well in a wide variety of circumstances, whereas more premium suspension is tunable to rider weight and intended riding type. Cruisers or dual sport motorcycles have vastly different needs than a dedicated sport bike.

Adjustability can include ride height (under load), fine tuning how quickly springs compress or rebound as well as preloading spring tension to accommodate differing weight for different riding styles, such as riding with a passenger and/or luggage.

The most common suspension systems found on motorcycles use a coil spring and hydraulic damper setup. Air springs and other types of suspension exist.

1.2.1 Spring:

Springs allow a motorcycle wheel to move independently from the chassis, and dampers control and manage movement of the spring. A motorcycle riding only on springs would bounce continuously and dangerously after every road impact.

Springs are coiled steel wire that compress or stretch when acted upon by an external force. Spring rate is the measurement of force required to compress it a certain distance, which is typically measured in pounds per inch. Spring rate varies with material thickness and number of coils. Heavier duty springs will have relatively thicker coils spaced further apart from one another.

1.2.2 Damper (Shock Absorber):

In its most basic sense, a damper slows and controls spring action. Dampers control spring action using hydraulic fluid, which travels through a series of passages and restrictions.

A piston with a precisely measured passage (orifice) travels within the shock body in a bath of hydraulic fluid. The weight of the fluid and the size of the passage determines the piston’s travel speed. When a motorcycle encounters a bump, dampers slow spring compression and rebound as the fluid slowly travels through the passages within the shock body.

Kinetic energy from spring movement turns into heat energy within the damper, and the hydraulic fluid dissipates the heat. Rear motorcycle shocks generate much more heat than front forks, due to the additional loads they support.

1.2.3 Compression and Rebound Damping:

Compression damping is the intentional slowing of spring compression (hitting a bump) travel. Rebound damping is the intentional slowing of the spring expansion as it resumes to its natural state.

Some motorcycles will have both high and low-speed adjustments to compression and rebound damping. Sport bikes and off-road motorcycles typically offer greater adjustability than entry level, or cruiser style motorcycles.

High and low-speed damping refers to the speed of the suspension travel, rather than the speed of the motorcycle. High-speed damping affects suspension behavior when hitting a sudden pothole on the street, or an individual rock on a trail. Low-speed damping affects behavior such as braking related dive or cornering changes.

1.2.4 Sag:

Motorcycle springs are always under tension, even when stationary. Vehicle weight causes compression at all times. Add a rider or two and luggage, and the suspension compresses even further.

Sag is the percentage of suspension travel utilized while stationary. If the suspension sags too much when at rest, the bike may bottom out when encountering bumps once underway. Too little sag can cause a stiff, harsh ride.

1.2.5 Preload:

Some motorcycles offer suspension preload adjustability. Preload is the amount of tension on the springs when the bike is at rest. Increasing preload will decrease sag, and vice versa. Since a single motorcycle is often used for solo riding, riding with a passenger or riding with luggage, preload adjustment allows a degree of adaptability for multiple use cases.

Although not recommended, adjusting preload can increase ground clearance for off road travel or decrease seat height for shorter riders. Some novice riders use preload as a 'band-aid' for overcoming incorrect spring stiffness relative to their height and weight. While not ideal, this is a common practice, as changing springs is expensive and labor intensive.

The image below shows a typical rear suspension preload adjuster. By turning the bottom adjuster collar, more or less preload force is applied to the spring, while not changing the overall length of the spring. Increasing preload will result in less suspension sag once under rider load.

1.3 HISTORY:

The first suspension to be introduced is from horse-drawn carriages in the 19th century. It uses a multiple layer of steels, or in some cases, use wood as a spring. It is known as a leaf spring. As modern cars were design to move at a faster speed, new type of suspension are needed. Later other types of suspension systems are evolved, and their history is given below.

- MacPherson strut Invented by a guy the name of Earl S. MacPherson in the 1940's. Ford started to use this kind of technology in the 1950 because of its low cost and space saving and thus, MacPherson is one of the dominating suspension system.
- The double wishbone suspension was introduced in the 1930s. French car maker Citroen began using it in their 1934 Rosalie and Traction Avant models. Packard Motor car Company of Detroit, Michigan, used it on the Packard One-Twenty from 1935 and advertised it as a safety feature.
- Twin suspension system was first recognized by Ford in the 1950's. This kind of suspension has an axle that's able to break into two suspension members. This suspension is being used to minimize the camber and track change. When one of the wheels camber changes, the other follows but in an opposite direction.
- In 1972, Yamaha introduced the *Mono-Shock* single shock absorber rear suspension system on their motorcycles competing in the Motocross World Championships. The suspension, which was designed by Lucien Tilkens, became so successful that other motorcycle manufacturers developed their own single shock absorber designs. Honda's version is called *Pro-link*, Kawasaki's is *Uni-Trak*, and Suzuki's is *Full-Floater*. Honda's *Unit Pro-Link*, used first on the Honda RC211V MotoGP racer, and then on the 2003 Honda CBR600RR sport bike, is intended to isolate the frame and the steering head from undesirable forces transmitted by the rear suspension by having the dampers upper mount contained within the rear swingarm subframe, rather than connecting it to the frame itself.

1.4 TYPES OF SUSPENSION SYSTEMS:

Suspension systems in two wheelers are classified as front and rear suspension systems.

1.4.1 Front suspension system: The most common form of front suspension for a modern motorcycle is the telescopic fork. Other fork designs are girder forks, suspended on sprung parallel links (not common since the 1940s) and bottom leading link designs, not common since the 1960s. Few other front suspensions used are

- Telescopic forks.
- Hossack/Fior (Duolever) fork.
- Single sided.
- Hub-center steering.

1.4.2 Rear suspension system: This type of suspension systems in motorcycles are adapted to improve the ride quality and is located at the rear wheel of the motorcycle. Rear suspension is only found on full-suspension mountain bikes, and is commonly referred to as the rear shock, or "shock" for short. The shock allows the rear wheel to soak up impacts, helping to keep the tire in contact with the ground, increasing rider control and decreasing rider fatigue. Few of them are

- Early rear suspensions.
- Plunger suspension.
- Swing arm suspension.
- Twin suspension.
- Mono suspension.

Types of suspension systems used in this project are Mono suspension and Twin suspension systems.

1.4.3 Mono Suspension system:

Originally, Yamaha developed the monoshock suspension to improve the performance of its bikes in motocross competition. Some manufacturers also use the term "flying suspension" for monoshock suspension. It provides a great deal of stability in the jumps and landings of the bike.

This suspension design uses a single (mono) shock absorber, bigger in size. In addition, it has a stronger spring fitted on the outside. The monoshock is usually positioned near the center of the bike's chassis.

Fig.1.1 Mono shock suspension

fig.1.2 Mono suspension

Furthermore, one of its ends attaches to the chassis. However, the other end to the rear swing-arm of the bike which attaches to the rear wheel. As the wheel moves up or down, the monoshock absorber either collapses or extends further.

Consequently, this enables longer stroke for the shock absorber. Thus, it results in longer travel for the rear wheel. Besides, this suspension is located closer to the bike's center. Thus, it helps to improve agility & handling of the bike.

1.4.4 Twin suspension system:

Twin shock refers to motorcycles that have two shock absorbers. Generally, this term is used to denote a particular era of motorcycles and is most frequently used when describing off-road motorcycles.

It is the most widely used suspension in two-wheeler vehicle. It transfers loads equally to the chassis of the vehicle. There is not any type of harm to this suspension if we increase load on the vehicle. It is widely preferred in the vehicle which is used in rough terrain vehicle. As in rough roads there is continuously changing loads on the vehicle, so its suspension transfers the load properly to get better ride comfort. The adjustment of this suspension is difficult. We can drive the vehicle if any one of suspension gets oil leaked, damaged, and failed while driving. The lifespan of this suspension is more that is why it is used in a greater number of two-wheeler vehicles. It is cost effective suspension. The two pistons also separate the shock fluid and the gas components. Whenever we encounter the bump on a motorcycle with two shocks, both the shocks compress but there is a rare situation when both of them compress for equal length. This leads to downgraded dynamics when it comes to stability.

Fig.1.3 Twin suspension

Fig.1.4 Twin suspension

1.5 APPLICATIONS OF SUSPENSION SYSTEMS:

Suspension systems are an important part of automobile 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.

1.6 MATERIALS USED:

Steel alloys are the most used spring materials. The most popular alloys include high-carbon (such as the music wire used for guitar strings), oil-tempered low-carbon, chrome **silicon,** chrome vanadium, and stainless steel other metal alloys are also used such as aluminium alloy, chromium, magnesium alloy etc.

Other metals that are sometimes used to make springs are beryllium copper alloy, phosphor bronze, and titanium. Rubber or urethane may be used for cylindrical, non-coil springs. Ceramic material has been developed for coiled springs in very high-temperature environments. One-directional glass fiber composite materials are being tested for possible use in springs. The materials used in this project are stainless steel, aluminium alloy and magnesium alloy.

CHAPTER – 2

LITERATURE REVIEW

2.LITERATURE REVIEW

1. Study and Design of Advance Suspension System for Two Wheeler

Shubham Kadu, Kailas Gaware, Tushar Kale, Harshal. D. Patil, International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 08 | Aug 2018. Now a day's various types of suspension are available in market but for optimizing the better and efficient cushioning effect. It is a need of today to improve and advancement in suspension system. In This research literature they thoroughly studied design parameters required to design magnetic suspension system and gives information about various types of rear suspension of two-wheeler. Research literature describes techniques for the design, construction of magnetic suspension system.

2. Experimental investigation of mono suspension spring. Vidya S.Visave, J.R.Mahajan (IRJET) checked the convenient method of replacing metal coil spring with the composite coil spring using composite materials like carbon fiber , glass fiber and combination of Carbon fiber and glass fiber. Using composite material it will reduce the weight of the coil spring, according to experimental result the spring rate of the carbon fiber is 34% more than the glass fiber and 45% more than the glass fiber/carbon fiber spring. The cost of glass fiber springs are 25% more than steel springs and cost of the carbon fiber spring is 200% more than steel springs. The stiffness of composite spring is less than steel springs and hence its application is limited to light vehicles.

3. Comparison between Dual Suspension and Mono Suspension of Two Wheelers

Pratik G. Chute, Nayan M. Chauhan, Aditya N. Palkar, *Mechanical Engineering, D.Y. Patil College of Engineering, Pune, India.* International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 09 | Sep 2018. Suspension system is the main part of the vehicle which is used for comfort and for better ride through rough roads. It absorbs shocks and vibration by providing smooth functioning to the vehicle. So, currently there are different types of suspension in the market. So, let us consider mono suspension and dual suspension. Now a days, we see that mostly all the two-wheeler have mono suspension. So, there should be difference between mono suspension and dual suspension. So, we compare mono suspension and dual suspension of two-wheeler vehicle to know how they differ from each other. Also, we discuss any type of change in the stability of vehicle. The Changes which will be feel by passenger, difference between them and the working of suspension system are included in this paper.

4. Design and Analysis of Two-Wheeler Shock Absorber Coil Spring

Prof. Prince Jerome Christopher J, Pavendhan R of J.J College of Engineering &Technology, Trichy ***IJMER***. The objective of this project is to design and analyze the performance of Shock absorber by varying the wire diameter of the coil spring. They collected theoretical information and working of the shock absorbers and then performed the design calculations of helical spring of shock absorber. They designed the shock absorber using PRO/ENGINEER software with calculated dimensions. They then performed analysis on the design using ANSYS software for finding displacement, loading and Von mosses stresses on the spring.

5. Design and Analysis of Shock Absorber

Mr. Sudarshan Martande, Mr. Y.N. Jangale, Mr. N.S. Motgi of Design Walchand Institute of Technology, Solapur *IJAIEM* **Volume 2, Issue 3, March 2013** Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. The need for dampers arises because of the roll and pitches associated with vehicle maneuvering, and from the roughness of roads. In the mid nineteenth century, road quality was generally very poor. The rapidly increasing power available from the internal combustion engine made higher speeds routine; this, plus the technical aptitude of the vehicle and component designers, coupled with a general commercial mood favoring development and change, provided an environment that led to invention and innovation of shock absorbers. They first performed analytical design of shock absorber and validated forces on the shock absorber. They next designed the shock absorber using engineering design software and performed stresses on it using ANSYS.

6. Suspension Systems: A Review

Dishant, Er. Parminder Singh, Er.Mohit Sharma. Dept. Of Mechanical Engineering, DIET, Kharar, India. International Research Journal of Engineering and Technology (IRJET). Volume: 04 Issue: 04 | Apr -2017. Suspension systems don't tend to get much publicity, but they're probably the most crucial factor in the day-to-day enjoyment of your car. Automakers are always tweaking and refining their designs in search of that elusive ideal: a perfect ride coupled with race-worthy handling. We haven't quite gotten there yet, but the latest systems are better than ever at reconciling the competing goals of comfort and performance. Like most other components on a vehicle, manufacturers have taken many different approaches when it comes to suspension design. Luxury cars are engineered for a comfortable ride, while sports cars need to corner at high speed. Trucks, on the other hand, need to carry heavy loads and may travel off the pavement.

7. Modelling and analysis of two-wheeler Suspension Spring

T.R Sydanna, Chittetu Maheshwara Reddy INTERNATIONAL JOURNAL OF PROFESSIONAL ENGINEERING STUDIES Volume VIII /Issue 4 / APR 2017. The objective of this paper is to analyze the performance of shock absorber spring by varying stiffness, which is obtained by doing optimization using genetic algorithm as optimization tool to obtain maximum ride comfort. The Shock absorber which is one of the Suspension systems is designed mechanically to handle shock impulse and dissipate kinetic energy. It reduces the amplitude of disturbances leading to increase in comfort and improved ride quality. The spring is compressed quickly when the wheel strikes the bump. The compressed spring rebound to its normal height when the weight of the vehicle pushes the spring down spring resist deformation. The present work is carried out on modelling, analysis and testing of suspension spring is to replace by different material for two-wheeler vehicle the stress and deflections of helical spring is going to be reduced by using the new material. Thus, in this project we designed the suspension spring for three bike models splendor, tvs and Yamaha and by applying two materials alloy steel and chromium vanadium steel analysis is carried out in ansys.

8. Design and Analysis of helical springs in two-wheeler Suspension System

K. Vinay kumar, R.Rudhra abhi Ramu & CH. Siva Rama Krishna. IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET) Vol. 4, Issue 7, Jul 2016, Impact Journals. The present work is carried out on modeling, and analysis of suspension spring is to replace the existed steel helical spring used in popular two wheeler vehicle. The stress and deflections of the helical spring is going to be reduced by using the new materials. The comparative study is carried out between existed spring and new material spring. Static analysis determines the stress and deflections of the helical compression spring in finite element analysis. The analytical modal is used to test the spring under different loading conditions. Finite element analysis methods (FEA) are the methods of finding approximate solutions to a physical problem defined in a finite region or domain. FEA is a mathematical tool for solving engineering problems. In this, the finite element analysis values are compared to the analytical values and are successfully validated. A typical two-wheeler suspension spring is chosen for study. The modeling of spring is developed on pro/E 5.0 analysis is carried out on Ansys 14.

9. An Experimental Study on Dynamic Characteristics of Twin Accumulator Suspension System

M. M. M. Salem, Ali M. Abd-El-Tawwab, M. H. Abd-El-Aziz, K. A. Abd El-gwwad. International Journal of Advanced Science and Technology Vol. 29, No.0 3, (2020). Hydro-pneumatic suspension system can meet the engineering vehicle demand because of its excellent nonlinear stiffness characteristic and good vibration reduction characteristic, the use of hydro-pneumatic suspension system is becoming more and more widespread in the engineering vehicles. In this paper the behavior of the twin-accumulator suspension is studying over the conventional passive system focusing on ride quality behavior. The optimum solution was obtained numerically by utilizing a multi objective evolutionary strategy algorithm and employing a cost function that seeks to improve the ride comfort indicated parameters such as the root mean square, the suspension displacement and the dynamic tire load. The simulation results of passive and optimized twin accumulator suspension consisted of body displacement, wheel deflection; vehicle body acceleration, suspension travel and dynamic tire load were compared and analyzed. Results show that the twin-accumulator suspension system gives improvements in ride behavior in compression with the conventional passive suspension system.

10. Comparison between Dual and mono Suspension of two wheelers

Mr. Kommalapati Rameshbabu and Mr. Tippa Bhimasankara Rao did analysis on shock absorber by varying the spring material, Spring Steel and Berillium Copper and observed that stress and displacement value for Spring Steel is less than Berillium Copper and concluded that Spring Steel for spring is best.

11. An Experimental Study on Dynamic Characteristics of Mono Suspension System

Prof. Sagar S Khatavkar, Mr. Shrikant Dabekar, Ms. Namrata Bhokare, Ms. Nikita Dhandhukia and Ms. Shilpa Bafna states that Mono shocks gives a superior vehicle handling and provides safety while braking than telescopic fork. The spring in Mono shocks have been designed by consideration of many practical conditions like dynamic resistance, road tracks and aerodynamic properties. In Mono shock suspension design the uneven vibration in the telescopic forks have been balanced using the mass centralization concept. This design of suspension using mass centralization concept may antiquate the present telescopic forks and alloy steel is most suitable for suspension system.

CHAPTER - 3

CATIA

3. CATIA

3.1 INTRODUCTION:

CATIA is an acronym for **C**omputer **A**ided **T**hree-dimensional Interactive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

CATIA is a multi platform 3D software suite developed by Dassault Systèmes, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and addresses every design-to-manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi-directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

3.2 HISTORY OF CATIA:

CATIA started as an in-house development in 1977 by French aircraft manufacturer AVIONS MARCEL DASSAULT, at that time customer of the CADCAM software to develop Dassault's Mirage fighter jet. It was later adopted by the aerospace, automotive, shipbuilding, and other industries.

In 1984, the Boeing Company chose CATIA V2 as its main 3D CAD tool, becoming its largest customer.

In 1988, CATIA V3 was ported from Mainframe computers to Unix.

In 1990, General Dynamics Electric Boat Corp chose CATIA as its main 3D CAD tool to design the U.S. Navy's Virginia class submarine. Also, Lockheed was selling its CADAM system worldwide through the channel of IBM since 1978.

In 1992, CADAM was purchased from IBM, and the next year CATIA CADAM V4 was published.

In 1996, it was ported from one to four Unix operating systems, including IBM AIX, Silicon Graphics IRIX, Sun Microsystems SunOS, and Hewlett-Packard HP-UX.

In 1998, V5 was released and was an entirely rewritten version of CATIA with support for UNIX, Windows NT and Windows XP (since 2001).

In the years prior to 2000, problems caused by incompatibility between versions of CATIA (Version 4 and Version 5) led to $6.1B in additional costs due to years of project delays in production of the Airbus A380.

In 2008, Dassault Systems released CATIA V6. While the server can run on Microsoft Windows or Linux client support for any operating system other than Microsoft Windows was dropped.

In November 2010, Dassault Systems launched CATIA V6R2011x, the latest release of its PLM2.0 platform, while continuing to support and improve its CATIA V5 software.

In June 2011, Dassault Systems launched V6 R2012.

In 2012, Dassault Systems launched V6 2013x.

In 2014, Dassault Systems launched 3DEXPERIENCE Platform R2014x and CATIA on the Cloud, a cloud version of its software.

In 2018, Dassault Systems launched 3D Experience Marketplaces to connect CATIA Users, with manufacturers, standard parts creators and engineers. In 2019, 3D Experience Marketplaces launched an Add-in in Catia, to connect directly manufacturers with designers.

3.3 WHAT DOES CATIA DO?

CATIA provides the capability to visualize designs in 3D. When it was introduced, this concept was innovative. Since Dassault Systems did not have an expertise in marketing, they had revenue sharing tie-up with IBM which proved extremely fruitful to both the companies to market CATIA. In the early stages, CATIA was extensively used in the design of the Mirage aircrafts; however, the potential of the software soon made it a popular choice in the automotive sector as well. As CATIA was accepted by more and more manufacturing companies, Dassault changed the product classification from CAD / CAM software to Project Lifecycle Management. The company also expanded the scope of the software.

CATIA can be used at different stages of the design - ideate, draw, test and iterate. The software comes with different workbenches (“modules”) that allow CATIA to be used across varied industries – from parts design, surface design and assembly to sheet metal design. CATIA can also be used for CNC.

- CATIA offers many workbenches that can be loosely termed as modules. A few of the important workbenches and their brief functionality description is given below:

3.3.1 Part design: The most essential workbench needed for solid modelling. This CATIA module makes it possible to design precise 3D mechanical parts with an intuitive and flexible user interface, from sketching in an assembly context to iterative detailed design.

3.3.2 Generative Shape Design: allows you to quickly model both simple and complex shapes using wireframe and surface features. It provides a large set of tools for creating and editing shape designs. Though not essential, knowledge of Part Design will be very handy in better utilization of this module.

3.3.3 Assembly: The basics of product structure, constraints, and moving assemblies and parts can be learned quickly. This is the workbench that allows connecting all the parts to form a machine or a component.

3.3.4 Kinematic Simulation: Kinematics involves an assembly of parts that are connected by a series of joints, referred to as a mechanism. These joints define how an assembly can perform motion. It addresses the design review environment of digital mock-ups. This workbench shows how a machine will move in the real world.

These are only four of the many workbenches that CATIA offers. A few of the other modules include Machining, Equipment & System, Infrastructure and Ergonomics Design & Analysis. And of course, there are many other CATIA workbenches, each important in its own way.

3.4 MODULES IN CATIA:

3.4.1 Mechanical design: Involve the part design, sheet metal, and surfacing, molds,

structure design for the production and manufacturing.

3.4.2 Shape design: Generative **Shape Design** (GSD) helps to design advanced shapes based on a combination of wireframe and extensive multiple surface features, with full specification capture.

3.4.3 Analysis & Simulation: The structure analysis of a product with this module can be done with the help of advanced meshing tools.

3.4.4 AEC (Architecture, Engineering and Construction) PLANT – CATIA V5 modules list: Layout design for a manufacturing plant or other type of plant. The focus of the product is to allow the preliminary or conceptual design of a plant to be accomplished quickly. It provides an efficient, cost-effective way to lay out an initial plant design for review and validation.

3.4.5 Machining: All the machining process can be defined for CNC in this module. see the below picture for the list of machining operations possible in CATIA.

3.4.6 DMU (Digital Mockup): DMU allows engineers to design and configure complex products and validate their designs without ever needing to build a physical model. See the following image for the list DMU features.

3.4.7 Equipment & Systems: Design and integration of electrical, fluid and mechanical systems within a 3D digital mock-up while optimizing space allocation. Creation of circuit boards and design of structural products, cable harness.

3.4.8 Machining Simulation: The simulation of NC machine tools can be done with this module. we can build NC machine tool with this module.

3.4.9 Ergonomics Design & Analysis: The meaning of Ergonomics is the study of people's efficiency in their working environment. Which is a branch of science that aims to learn about human abilities and limitations, and then apply this learning to improve people's interaction with products, systems and environments.

3.5 CATIA INTERFACE(GUI):

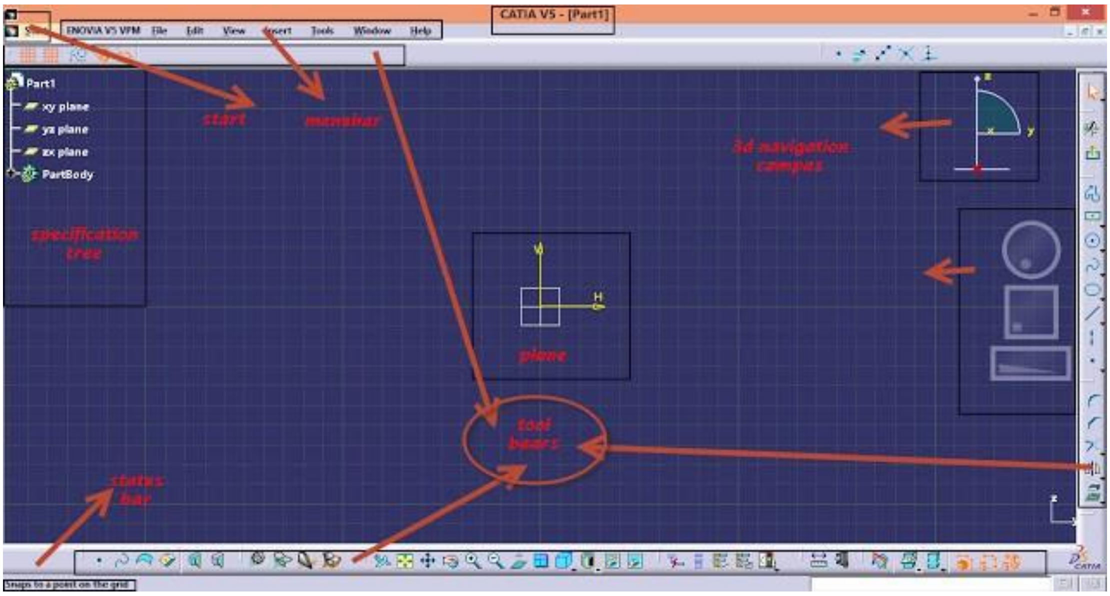


Fig.3.1 CATIA interface

3.6 SKETCHER MODULE:

The Sketcher workbench is a set of tools that helps you create and constrain 2D geometries. Features (pads, pockets, shafts, etc...) may then be created solids or modifications to solids using these 2D profiles. You can access the Sketcher workbench in many ways. Two simple ways are by using the top pull down menu (Start – Mechanical Design – Sketcher), or by selecting the Sketcher icon. When you enter the sketcher, CATIA requires that you choose a plane to sketch on. You can choose this plane either before or after you select the Sketcher icon. To exit the sketcher, select the Exit Workbench icon.

The Sketcher workbench contains the following standard workbench specific toolbars.

3.6.1 Profile toolbar: The commands located in this toolbar allow you to create simple geometries (rectangle, circle, line, etc...) and more complex geometries (profile, spline, etc..).

3.6.2 Operation toolbar: Once a profile has been created, it can be modified using commands such as trim, mirror, chamfer, and other commands located in the 'Operation' toolbar.

3.6.3 Constraint toolbar: Profiles may be constrained with dimensional (distances, angles, etc..) or geometrical (tangent, parallel, etc...) constraints using the commands located in the Constraint toolbar.

3.6.4 Sketch tools toolbar: The commands in this toolbar allow you to work in different modes which make sketching easier.

3.7 PART DESIGN MODULE:

Part design environment is used to create 3D models from the basic 2D sketches created in sketcher environment.

3.7.1 PAD command:

In most CAD software, the equivalent of this is called EXTRUDE, but in CATIA we call it PAD. This command adds material in the third direction, a direction other than the sketch.

3.7.2 POCKET command:

The POCKET commands somehow the opposite of PAD command. It simply helps remove geometry belonging to an already create part. On the figure below the POCKET command is helping to create the cylinder hole in the middle of the cube.

3.7.3 SHAFT command:

It is Like revolve command in other CAD software, the SHAFT command is mostly used to make shaft like parts. It requires an axis, around which the sketch will be revolved.

3.7.4 RIB command:

This command which is usually known as SWEEP is called RIB IN CATIA. It adds material along a guide curve. RIB is used to make components like springs, pipes etc.

3.7.5 SLOT command:

SLOT removes the material along a guide curve. Here is an example of slot. While using SLOT, I have used the same guide curve that was used for RIB. This ensures that the cross section will be uniform throughout.

3.8 ASSEMBLY MODULE:

Assembly environment is used to provide mating to two or more part-models to from complete assembly.

- Product Structure Tools

  - ❑ Insert New Component
  - ❑ Insert New Product
  - ❑ Insert New Part
  - ❑ Insert Existing Component
  - ❑ Replace Component
  - ❑ Reorder Tree
  - ❑ Generate Numbers
  - ❑ Load Components
  - ❑ Unload Components
  - ❑ Manage Representations
  - ❑ Multi-Instantiation

- Move Toolbar

  - ❑ Manipulate
  - ❑ Snap
  - ❑ Explode and Assembly

- Constraints Toolbar

  - ❑ Coincidence
  - ❑ Contact
  - ❑ Offset
  - ❑ Angular
  - ❑ Anchor
  - ❑ Fix Together

Fig.3.2 CATIA toolbars

We have two approaches in assembly.

Top -down approach, Bottom -up approach.

entire design structure will be created in product environment in Top - down approach whereas in bottom - up parts will be created separately and will be mated using mating or constraint tools.

CHAPTER – 4

DESIGN OF SUSPENSION SYSTEMS

4. DESIGN OF SUSPENSION SYSTEMS

4.1 MONO SUSPENSION:

4.1.1 Introduction:

There are different types of suspension available for a motorcycle. In those mono suspension is included. On a motorcycle with a mono-shock rear suspension, a single shock absorber connects the rear Swingarm to the motorcycle's frame. Typically, this lone shock absorber is in front of the rear wheel and uses a linkage to connect with the swing arm such linkages are frequently designed to give a rising rate of damping for the rear. Mono-shocks are said to eliminate torque to the Swingarm and provide more consistent handling and braking. Consequently, this enables longer stroke for the shock absorber. Thus, it results in longer travel for the rear wheel. Besides, this suspension is located closer to the bike’s center. Thus, it helps to improve agility & handling of the bike. That is why these suspensions are very useful at the roads.

Originally, Yamaha developed the monoshock suspension to improve the performance of its bikes in motocross competition. Some manufacturers also use the term “flying suspension” for mono shock suspension. It provides a great deal of stability in the jumps and landings of the bike.

4.1.2 Working:

Shock absorbers work on the principle of fluid displacement on both the compression and expansion cycle. The compression cycle controls the motion of a vehicle's unsprung weight, while extension controls the heavier sprung weight. There are two cycles in which Shock Absorber works:

a. Compression In the compression cycles the piston moves downward and compresses the hydraulic fluid in the chamber which is situated below the piston. In this cycle or downward movement, the fluid flows to upper chamber from down chamber through piston. Some of the fluid also flows into reserve tube through the compression valve. Flow is controlled by valves in the piston and in the compression valve.

b. Extension: In the extension cycle the piston moves upwards toward the top of the pressure tube. The upward movement results in the compressing of the fluid in the chamber lying above the piston. The extension cycle generally provides more resistance than compression cycle.

Fig.4.1 Mono suspension

4.2 TWIN SUSPENSION:

4.2.1 Introduction:

The first motorcycle rear suspension was called dual shock suspension. It was created in around 1913. It consisted of two springs and dampers. All the loads acting at the rear of the motorcycle are divided on the spring damper mechanism. Twin shock refers to motorcycles that have two shock absorbers. Generally, this term is used to denote a particular era of motorcycles and is most frequently used when describing off-road motorcycles. It is the most widely used suspension in two-wheeler vehicle. It transfers loads equally to the chassis of the vehicle. There is not any type of harm to this suspension if we increase load on the vehicle. It is widely preferred in the vehicle which is used in rough terrain vehicle.

4.2.2 Working:

In twin suspension system the load gets distributed on the either side of the vehicle. As in rough roads there is continuously changing loads on the vehicle, so its suspension transfers the load properly to get better ride comfort. The adjustment of this suspension is difficult. We can drive the vehicle if any one of suspension gets oil leaked, damaged and failed while driving. The lifespan of this suspension is more that is why it’s used in a greater number of two-wheeler vehicles. It is cost effective suspension. The two pistons also separate the shock fluid and the gas components. Whenever we encounter the bump on a motorcycle with two shocks, both the shocks compress but there is a rare situation when both compress for equal length. This leads to downgraded dynamics when it comes to stability.

Fig.4.2 Twin suspension

4.3 PROJECT DESCRIPTION:

In this project three-dimensional mechanical design of both suspension systems (i.e) the design of both mono suspension system and twin suspension system is designed using CATIA V5 software.

Firstly, all the parts of the suspension systems are designed separately by using part design module present in CATIA. After completion of the sketching of each part in sketcher module they converted into three-dimensional object using various commands like pad, slot, rib, etc., After the completion of designing of all the required parts assembling of the parts are done to get the final assembly of both suspension systems.

The final assemblies of both the suspensions are now ready to perform analysis in ANSYS software. The main motto of this project is to perform the analysis on both the suspension systems in ANSYS software to validate their strength and force absorbing capability by varying the loading conditions and different materials of the suspension systems.

In this project the simulation and analysis of the suspension systems are performed in ANSYS software so the designs of the suspension systems done in CATIA are converted to '.igs' format and imported to ANSYS workbench to perform the analysis. The designs are imported into the workbench and the material is added to the design and proceeded to further steps. Required type of analysis is selected and then meshing of the designs are performed and then loading is given accordingly and the information required for obtaining the solution is selected and solving of the analysis is done using FEA formulation in ANSYS. After solving the obtained solutions are tabulated. This process is done for both the suspension systems.

The above obtained solutions are for both the suspension systems are compared and the system which has the better performance is identified by basing on the strength and load absorbing capacity for different materials for the suspension systems.

The above obtained results are verified by performing theoretical calculations and comparing them with the obtained simulation values as well as the theoretical values and error percentage is tabulated.

CHAPTER– 5

MODELLING

5. MODELLING

Modelling can be done in various methods such as wireframe modelling, surface modelling, solid modelling, etc. the easiest way is chosen for modelling. Here we have chosen solid modelling method of creating a solid. There are many packages for modelling, out of which CATIA V5 has been selected for its ease of availability and as it is user friendly.

5.1 CATIA:

CATIA is among the very few software which has its application in about every industrial sector. It is mostly used by the designer team. The designer team of any organization needs to create a digital copy of any object which has to be manufactured. This digital copy can be created with much ease by using CATIA. It is mostly found in companies who are associated with design and manufacturing of products.

5.2 PART MODELLING:

5.2.1 Mono suspension: In this suspension system there are four main parts Spring, base , top screw and a nut. These four parts are designed using sketcher and part design modules.

***(i.)* Spring:**

step 1: select part design in CATIA and then open sketcher module and select yz- plane. Plot a point at a distance of 50mm and 20mm from Y and Z axes.

Step 2: exit the sketcher module and click on helix option in tool bar and select the axis and

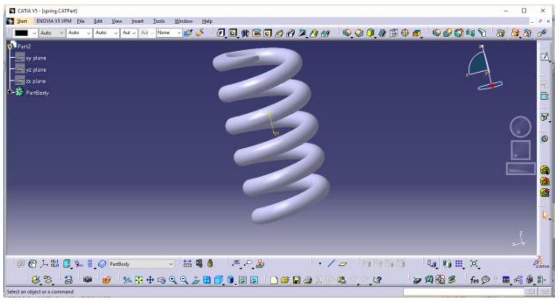


Fig.5.1 Spring

provide helix details like pitch, height , orientationand then click on OK you will get a sketch of sring with given dimensions.

Step 3 : Draw a circle at the starting point of the helix and constrain both the point and the centre of the circle with coincidence. Use Rib command and select both the helix curve and the circle and click on OK, you will get the solid spring.

Step 4 : Draw a plane off-set from the axis at required distance and exit sketcher. Use pocket command to ground the spring. Similarly do the same for the bottom of the helix.

(*ii.*) Base part :

Step 1: select part design in CATIA and then open sketcher module and select xy- plane. draw a circle and exit the sketcher. Click on Pad and enter the thickness and click on OK.

Step 2: Select the plane on the solid cylinder after padding and draw a circle of required diameter and exit sketcher and define the height for padding and click OK.

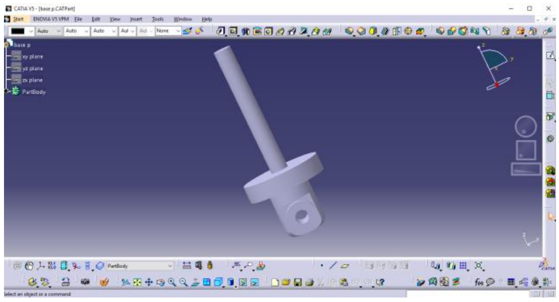


Fig.5.2 Base part

Step 3: click on the other side of the cylinder and create a cylindrical body and define the edge fillet of the end of the cylinder.

Step 4: Remove the unwanted part of the bottom cylinder using pocket feature. Create a hole of required diameter on the leftover part of the bottom cylinder using sketcher and pocket commands.

(*iii.*) Top screw:

Step 1: select part design in CATIA and then open sketcher module and select xy- plane. Draw a circle and exit sketcher to define padding dimension of the circle and click on OK.

Step 2: Select the bottom face of the cylindrical body and draw another circle and give the required dimensions for padding and click OK.

Step 3: select the top face and click on edge fillet and give required radius of the fillet. Remove the unwanted faces on the top part of the cylinder using pocket command.

Step 4: create a hole and a cylindrical section on the top part of the cylinder using pocket and pad commands.

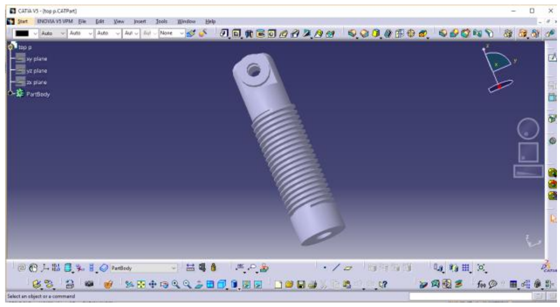


Fig.5.3 Top screw

Step 5: Create a circular hollow section in the bottom of the cylinder at required depth using pocket command. Plot a point on the surface of second cylinder and create a helix curve through that point with required pitch and height. Create threading for the helix on the cylinder slot command of required angle.

(*iv.*) Nut:

Step 1: select part design in CATIA and then open sketcher module and select xy- plane. Draw two concentric circles of required dimensions and exit the sketcher and use pad command to extrude it into required dimension.

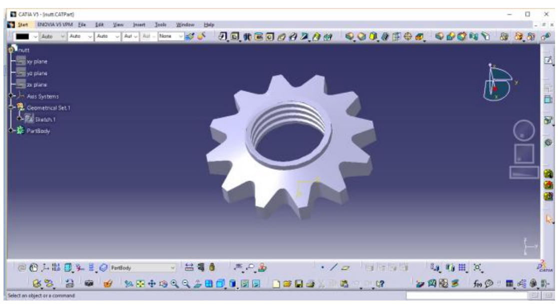


Fig.5.4 Nut

Step 2: select the top face and draw a circle on the surface at specified distance from centre and connect the circle with lines to the circle drawn with dimension of outer diameter. Select symmetry between the lines and remove unwanted part and then use pocket command to create the external teeth of the nut and use circular pattern command for the entire object with required number of instances.

Step 3: Draw a triangular section front view of the nut with required angle and distance from the centre and exit the sketcher.

Step 4: use groove command to and select the z-axis and click on OK to create required shape of the nut.

Step 5: draw two concentric circles on the face of

the nut at required dimensions and use pad option to get extruded surface as shown in the figure.

Step 6: Insert the top screw designed earlier into the nut body and remove the top screw from the nut using remove command to create internal threading for the nut with respect to the top screw.

5.2.2 Twin Suspension: This suspension system is an assembly of multiple parts and the main parts present in this assembly design are Spring, piston rod, top part , strut , and washers. These parts are designed using sketcher and part design modules.

(*i*) Top part:

Step 1: select part design in CATIA and then open sketcher module and select yz- plane. Use sketcher to draw the front view if the profile of required dimensions.

Step 2: exit the sketcher and use shaft command to get the required design. Use pocket command on the top half of the object to remove the unwanted elements of the object.

Step 3: select the front view and draw the circles of required dimensions and a triangle and exit the sketcher. Use pocket command to create the above hollow profiles.

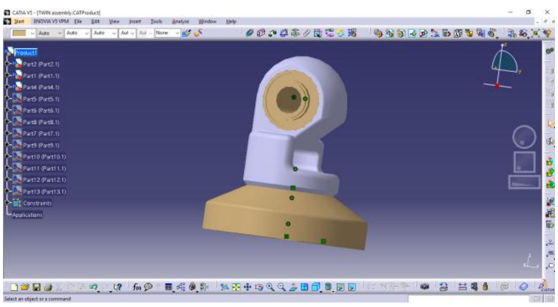


Fig.5.5 Top part

Step 4: Also remove the bottom part using pocket command. Use chamfer, edge fillet commands to create curved edges for the design.

(*ii*) Spring:

step 1: select part design in CATIA and then open sketcher module and select yz- plane. Plot a point at a required distance from both Y and Z axes.

Step 2: Exit the sketcher module and click on helix option in tool bar and select the axis and provide helix details like pitch, height , orientationand then click on OK you will get a sketch of sring with given dimensions.

Step 3: Draw a circle at the starting point of the helix and constrain both the point and the centre of the circle with coincidence. Use Rib command and select both the helix curve and the circle and click on OK, you will get the solid spring.

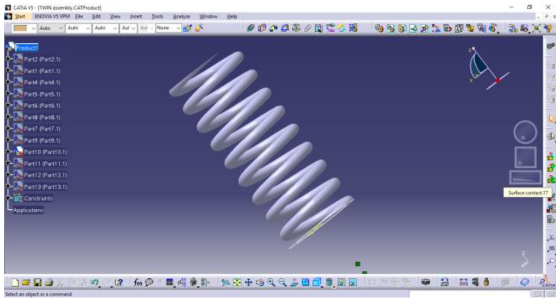


Fig.5.6 Spring

Step 4 : Draw a plane off-set from the axis at required distance and exit sketcher. Use pocket command to ground the spring. Similarly do the same for the bottom of the helix.

(*iii.*) Piston Rod :

step 1: Select part design in CATIA and then open sketcher module and select yz- plane. Click on profile command and draw the two-dimensional profile of the piston rod with respect to the vertical axis as shown in the figure.

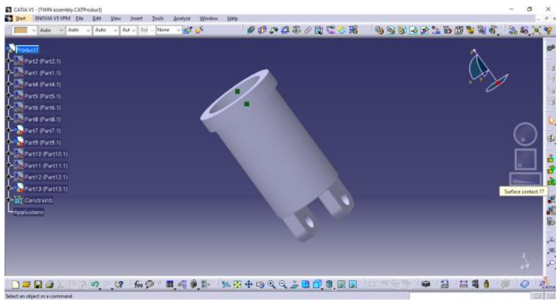


Fig.5.7 piston rod

Step 2: exit the sketcher module and use shaft command to create a three-dimensional cylindrical object with respect to the vertical axis as shown in the figure.

Step 3: select the top face of the piston rod and draw a circle of required dimensions to create a hollow circular region across the length of the piston rod.

step 4: exit the sketcher and the select the circle drawn on the top face and use pocket command to create hollow region for the entire length of the piston rod.

(*iv*) Strut:

Step 1: Select part design in CATIA and then open sketcher module and select yz- plane. Draw a rectangle of required dimensions from the origin and exit the sketcher.

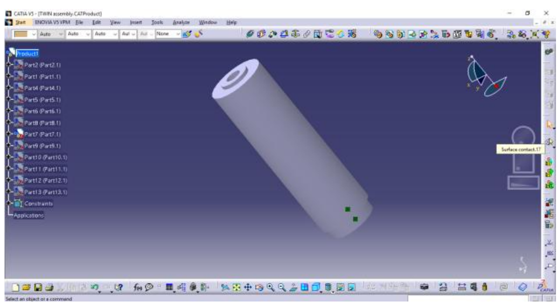


Fig.5.8 Strut

Step 2: use shaft command to create cylindrical profile and the click on the front face and draw a rectangle at the top of cylinder at required distance from axis and use shaft command to get the required profile as shown in figure.

Step 3: select the front face of the cylinder and draw a square and a circle inside it with required dimensions and exit sketcher. Use pad option to create solid object at bottom of cylinder.

Step 4: Use edge fillet command to get curved edges with required radius. Draw a rectangle on the side face of the bottom object and use pocket command for the entire object to get the hollow space as shown in the figure.

(*v*) Washers:

A washer is a thin plate (disk shaped) used to distribute the pressure or force between two joining surfaces. In this design multiple washers are used between the objects.

Step1: Select part design in CATIA and then open sketcher module and select yz-plane.

Step 2: draw a rectangle of required height and thickness according to required dimension of the washer.

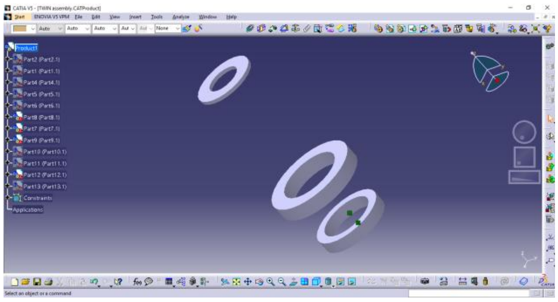


Fig.5.9 washers

Step 3: Constrain the rectangle with required distance vertical axis according to the diameter of hole required for the washer.

Step 4: exit the sketcher and use shaft option with respect to the vertical axis to get the washer of required dimensions.

5.3 ASSEMBLY MODELLING:

5.3.1 Mono suspension Assembly:

Step 1: Click on Assembly design module in mechanical design. Right click on product and select component and add the existing components into the assembly design.

Step 2: After adding all the components required for mono suspension system into the assembly module, click on the manipulation command and separate each part to place it in the correct position.

Step 3: Now use constraints tool bar for performing required constraint operations like coincidence, off-set, contact constraint, angle constraint etc.

Step 4: after performing all the constraint operations to get the required assembly, then finally click on the update all command to complete the assembly design.

Now this assembly design can be imported to simulation software for performing analysis.

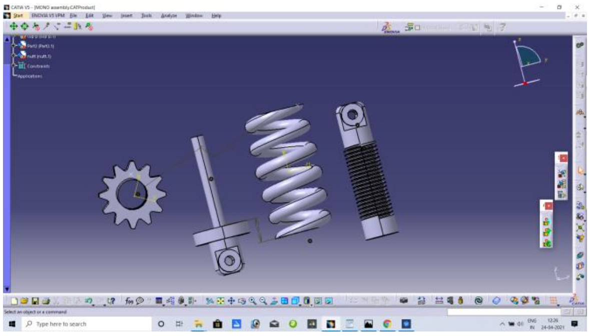


Fig.5.10 Mono pre-assembly

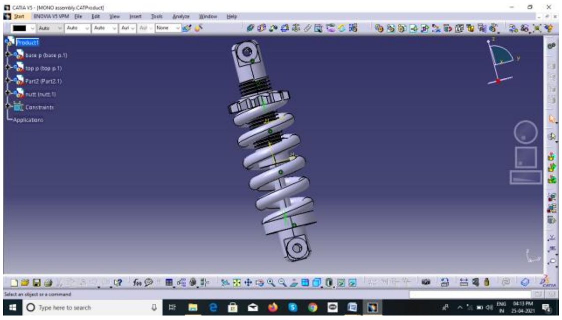


Fig.5.11 Mono assembly

5.3.2 Twin suspension Assembly:

Step 1: click on Assembly design module in mechanical design. Right click on product and select component and add the existing components into the assembly design.

Step 2: After adding all the components required for twin suspension system into the assembly module, click on the manipulation command and separate each part to place it in the correct position.

Step 3: Now use constraints tool bar for performing required constraint operations like coincidence, off-set, contact constraint, angle constraint etc.

Step 4: after performing all the constraint operations to get the required assembly, then finally click on the update all command to complete the assembly design.

Now this assembly design can be imported to simulation software for performing analysis.

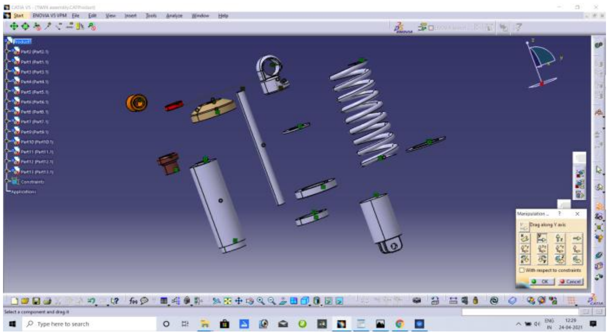


Fig.5.12 Twin pre assembly

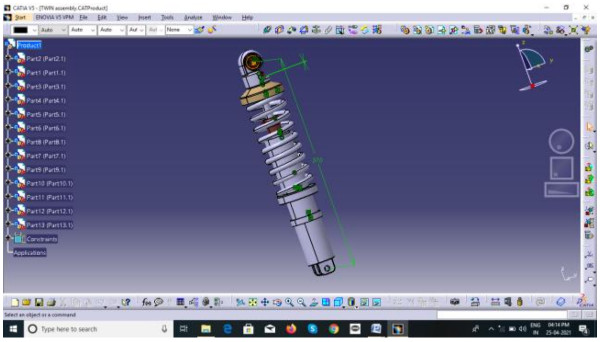


Fig.5.13 Twin assembly

CHAPTER -6

ANALYSIS

6. ANALYSIS

6.1 INTRODUCTION:

The Ansys finite element solvers enable a breadth and depth of capabilities unmatched by anyone in the world of computer-aided simulation. Thermal, Structural, Acoustic, Piezoelectric, Electrostatic and Circuit Coupled Electromagnetics are just an example of what can be simulated. Regardless of the type of simulation, each model is represented by a powerful scripting language.

Most Ansys simulations are performed using the Ansys Workbench system, which is one of the company's main products. Typically, Ansys users break down larger structures into small components that are each modeled and tested individually. A user may start by defining the dimensions of an object, and then adding weight, pressure, temperature and other physical properties. Finally, the Ansys software simulates and analyzes movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time.

In this project analysis on the designs of mono and twin suspension systems are performed with different loading conditions. Materials selected to perform this analysis are aluminium alloy and stainless steel.

6.2 SIMULATION IN ANSYS:

6.2.1 Mono suspension:

Step 1: Pre processor: A typical analysis in ANSYS begins with pre processing where data such as the geometry, material types are specified

Step 2: Select the type of analysis to be performed let say static analysis and provide the required data.

Step 3: click on geometry to add the mono suspension system into ansys workbench. Import the IGS file and then the geometrical editor opens for any changes to be performed in design.

Step 4: click on the setup and perform meshing operation to the required object. After meshing the object is ready to carry out the required analysis.

Step 5: After meshing add a fixed support to the object and select a face or plane to apply force.

Step 6: Apply the force after fixing the nodes on the required direction and then add stresses strains and other required components to obtain the solutions.

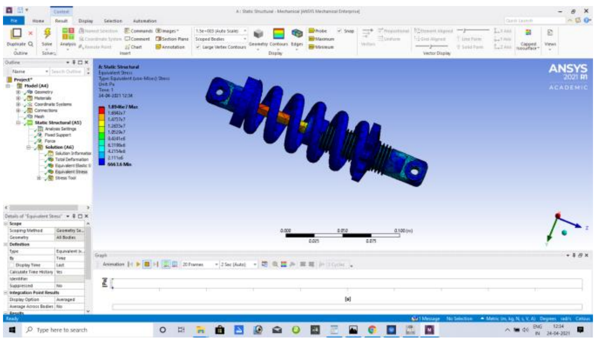


Fig.6.1 Mono meshing

Step 7: click on solve to obtain the results and thus the analysis to be performed is completed and note down the solutions.

In this analysis two materials aluminium alloy and stainless steel is used and three loading conditions i.e bike weight , weight of bike and one person , weight of bike and two persons.

6.2.2 Twin suspension system:

6.2.1 Mono suspension:

Step 1: Pre processor: A typical analysis in ANSYS begins with pre processing where data such as the geometry, material types are specified

Step 2: Select the type of analysis to be performed let say static analysis and provide the required data.

Step 3: Click on geometry to add the Twin suspension system into ansys workbench. Import the IGS file and then the geometrical editor opens for any changes to be performed in design.

Step 4: Click on the setup and perform meshing operation to the required object. After meshing the object is ready to carry out the required analysis.

Step 5: After meshing add a fixed support to the object and select a face or plane to apply force.

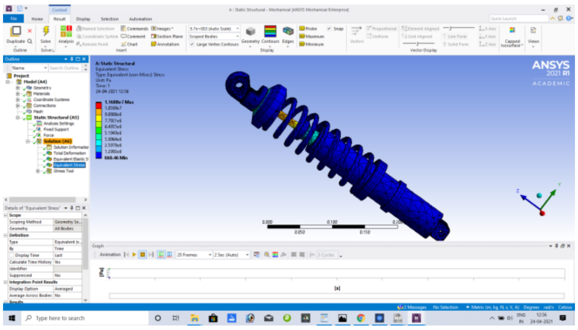


Fig.6.2 Twin meshing

Step 6: Apply the force after fixing the nodes on the required direction and then add stresses strains and other required components to obtain the solutions.

Step 7: Click on solve to obtain the results and thus the analysis to be performed is completed and note down the solutions.

In this analysis two materials aluminium alloy and stainless steel is used and three loading conditions i.e bike weight , weight of bike and one person , weight of bike and two persons.

6.3 CONSIDERATIONS :

The properties of the above considered materials aluminium alloy and stainless steel are

Aluminium alloy:

Modulus of rigidity (G) = 27×10^3 Mpa

Modulus of elasticity (E) = 70×10^3 Mpa

Tensile yield strength = 310 Mpa

Compressive yield strength = 310 Mpa

Density = 2.7 g/cm^3

Stainless steel:

Modulus of rigidity (G) = 77.2$\times 10^3$ Mpa

Modulus of elasticity (E) = 210$\times 10^3$ Mpa

Tensile yield strength = 505 Mpa

Compressive yiels strength = 505 Mpa

Density = 7.83 g/cm^3

In this project three loading conditions are considered and they are

1. Weight of the bike
2. Weight of the bike with one person
3. Weight of the bike with two people

As we are working on the rear suspension systems of the bike so only 65% of the weight is considered and while considering dynamic load multiplication factor 2 is used.

Average weight of bike = 110 kg

Average weight of a person = 65 kg

Mono suspension :

1. Weight of the bike

65% of the weight of the bike = 110$\times \frac{65}{100}$ = 71.5 kg

W_1 = (71.5$\times$ 9.81) $\times$ 2 = 1402 N

2. Weight of the bike with one person

65% of the total weight = (110+65)$\times \frac{65}{100}$ = 114.1 kg

W_2 = (114.1$\times$ 9.81)$\times$ 2 = 2238.6 N

3. Weight of the bike with one person

65% of the total weight = (110+65+65)$\times \frac{65}{100}$ = 156.7 kg

W_3 = (156.7$\times$ 9.81)$\times$ 2 = 3074.4 N

Twin suspension : In this suspension system the load is distributed across two shock absorbers so the actual load will be 50% of the obtained load.

1. Weight of the bike

65% of the weight of the bike = 110$\times \frac{65}{100}$ = 71.5 kg

W_1 = (71.5× 9.81) × 2 × $\frac{50}{100}$ = 701 N

2. Weight of the bike with one person

65% of the total weight = (110+65)$\times \frac{65}{100}$ = 114.1 kg

W_2 = (114.1× 9.81)× 2 × $\frac{50}{100}$ = 1119.3 N

3. Weight of the bike with one person

65% of the total weight = (110+65+65)$\times \frac{65}{100}$ = 156.7 kg

W_3 = (156.7× 9.81)× 2 × $\frac{50}{100}$ = 1537.2 N

6.4 SOLUTIONS :

6.4.1 Mono Suspension :

W_1 = 1402 N

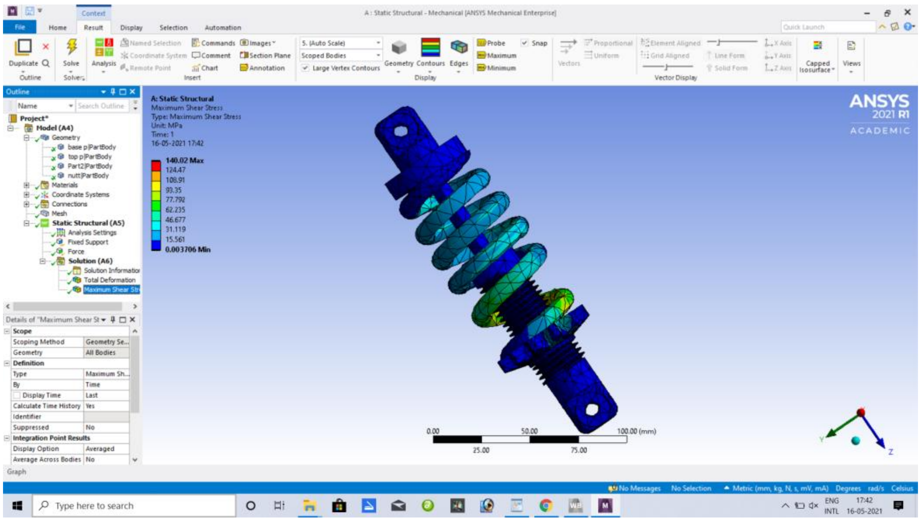


Fig.6.3 Maximum shear stress at W_1 = 1402 N

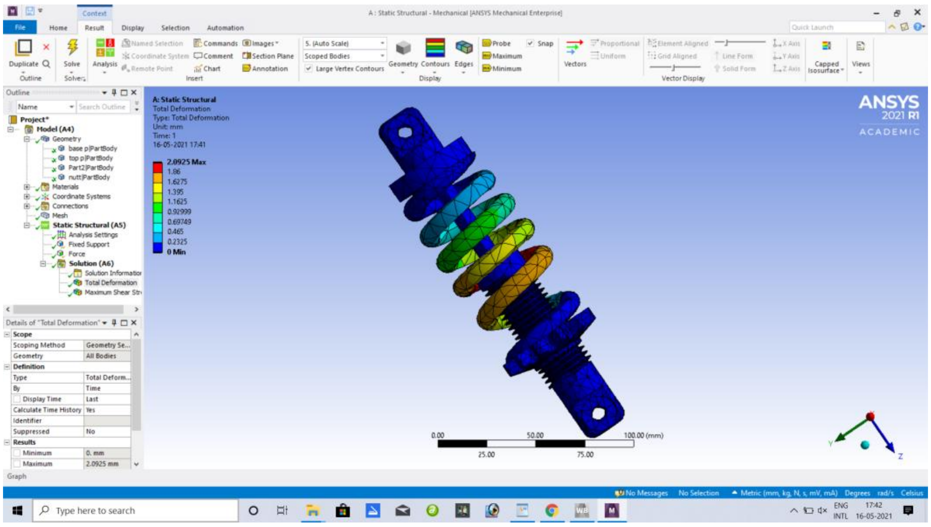


Fig.6.4 Total deformation at W_1 = 1402 N

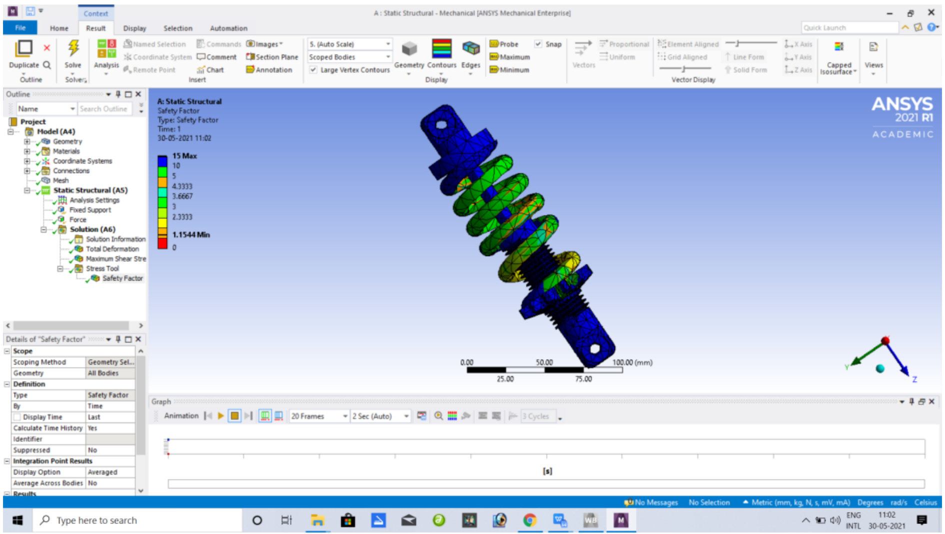


Fig.6.5 Factor of safety at W_1 = 1402 N

W_2 = 2238.6 N

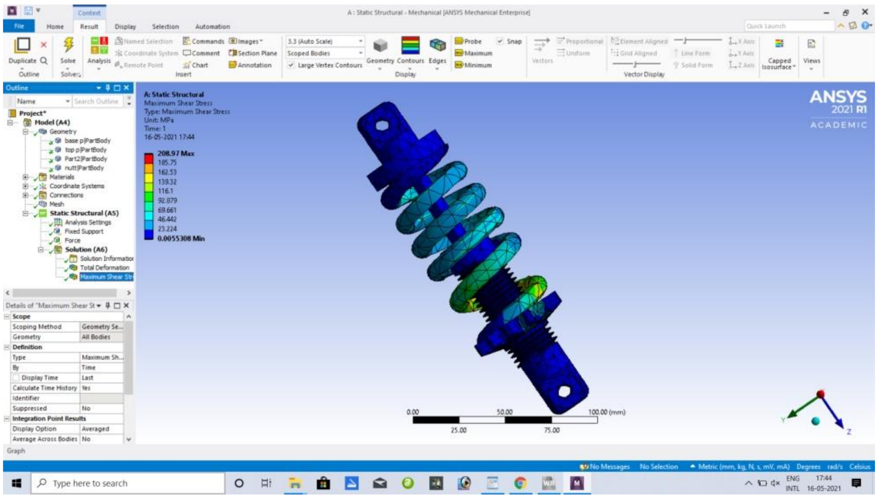


Fig.6.6 Maximum shear stress at W_2 = 2238.6 N

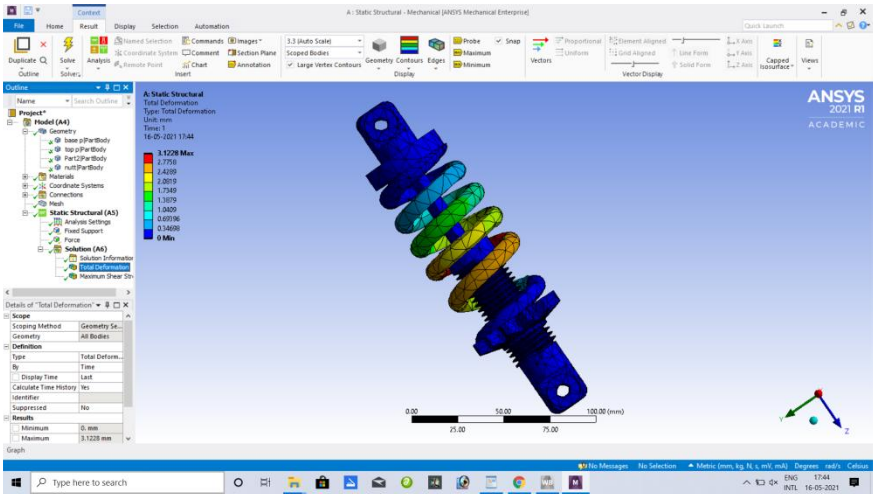


Fig.6.7 Total Deformation at W_2 = 2238.6 N

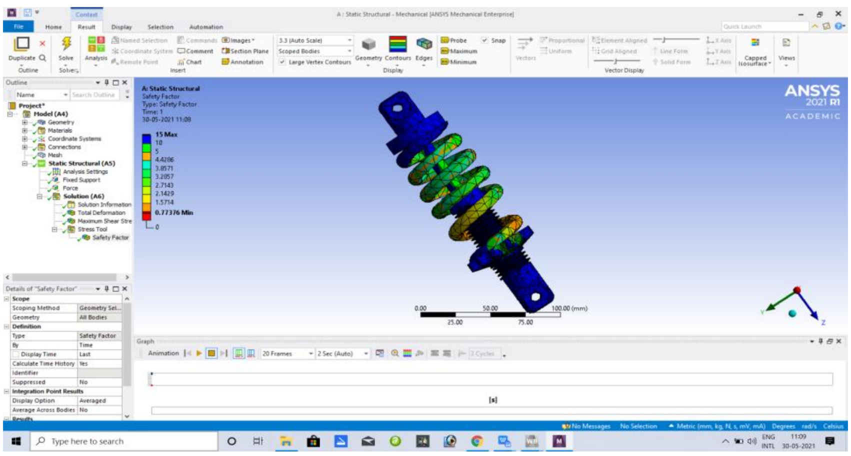


Fig.6.8 Factor of safety at W_2 = 2238.6 N

$W_3 = 3074.$ N

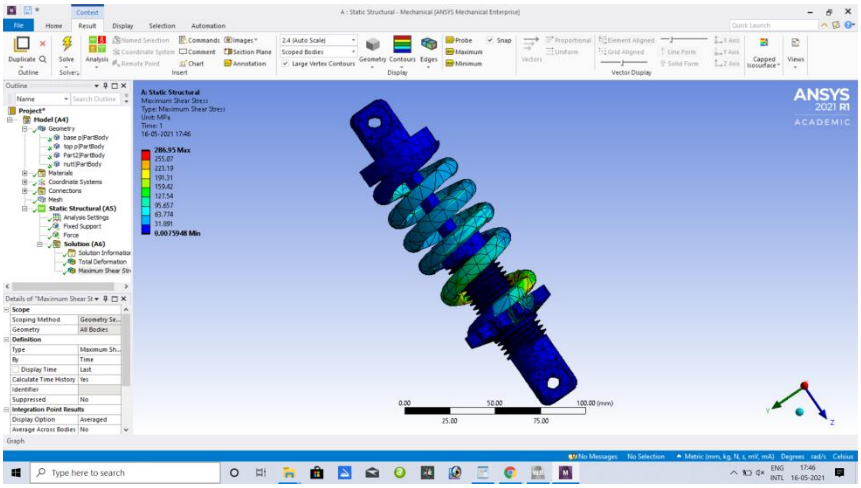


Fig.6.9 Maximum shear stress at $W_3 = 3074.$ N

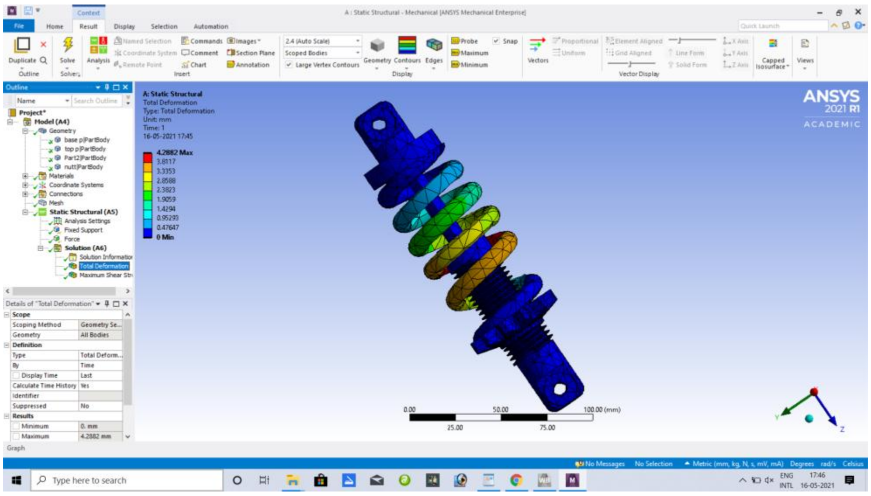


Fig. 6.10 Total Deformation at $W_3 = 3074.$ N

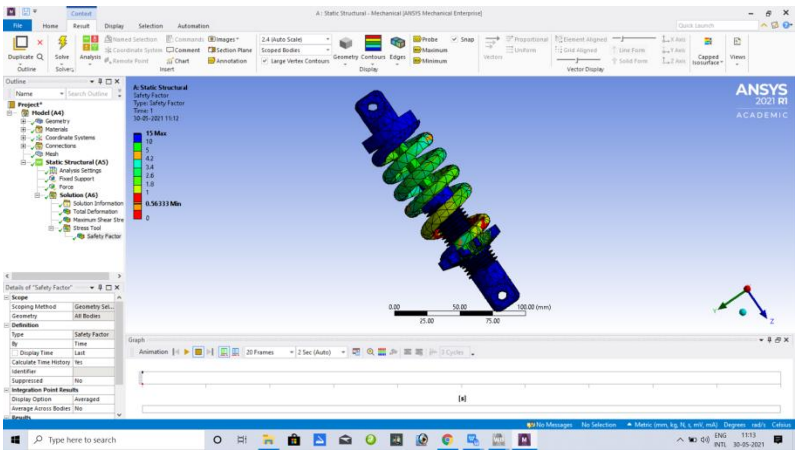


Fig.6.11 Factor of safety at $W_3 = 3074.$ N

6.4.2 Twin Suspension:

W_1 = 701 N

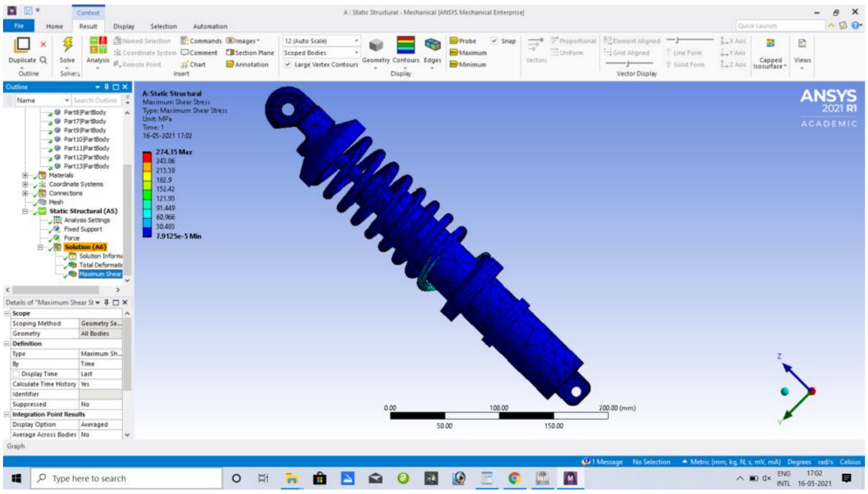


Fig.6.12 Maximum shear stress at W_1 = 701 N

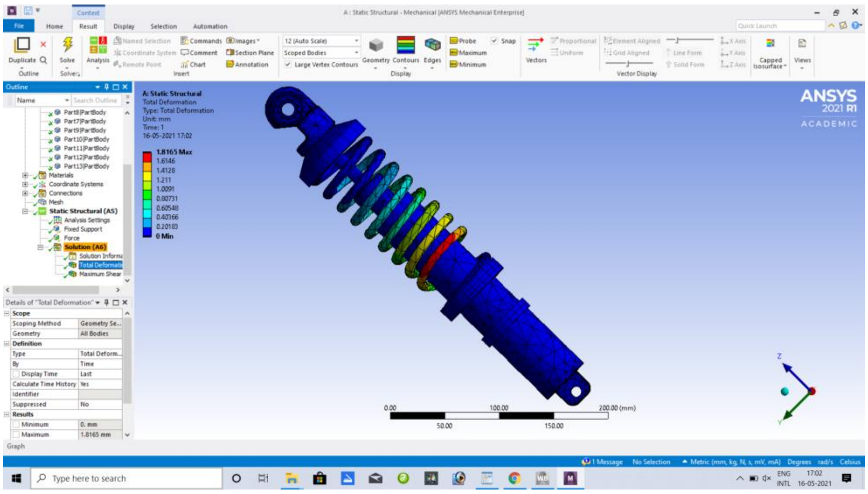


Fig.6.13 Total deformation at W_1 = 701 N

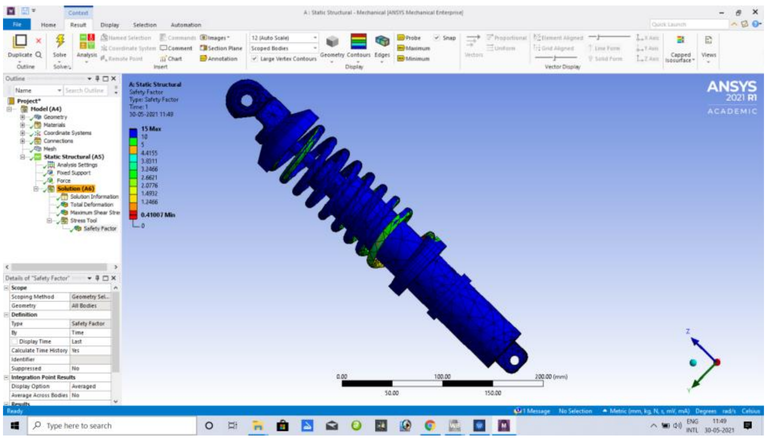


Fig.6.14 Factor of safety at W_1=701N

W_2 = 1119.3 N

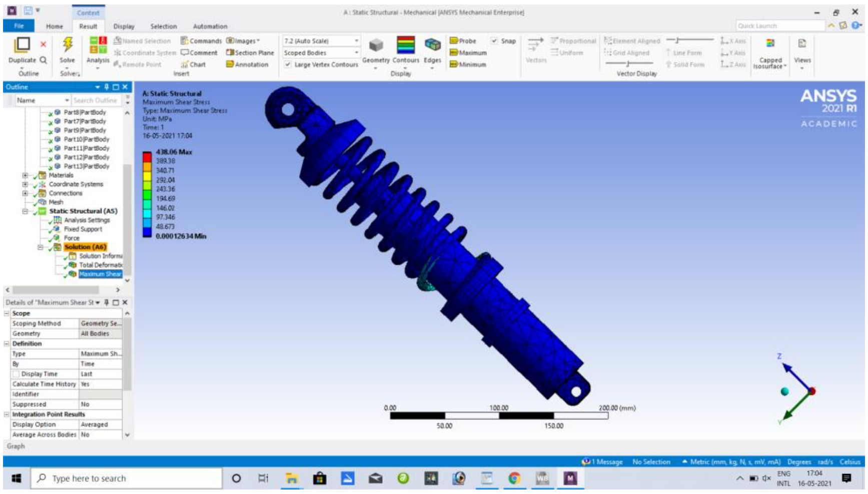


Fig.6.15 Maximum shear stress at W_2 = 1119.3 N

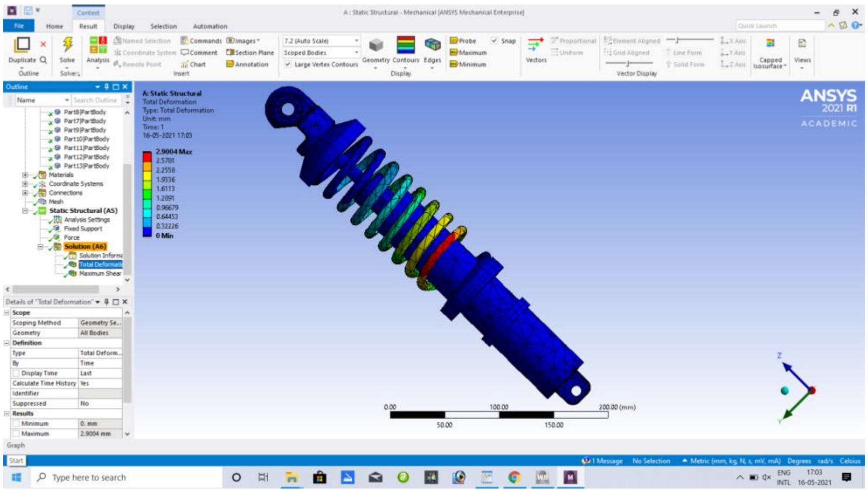


Fig.6.16 Total deformation at W_2 = 1119.3 N

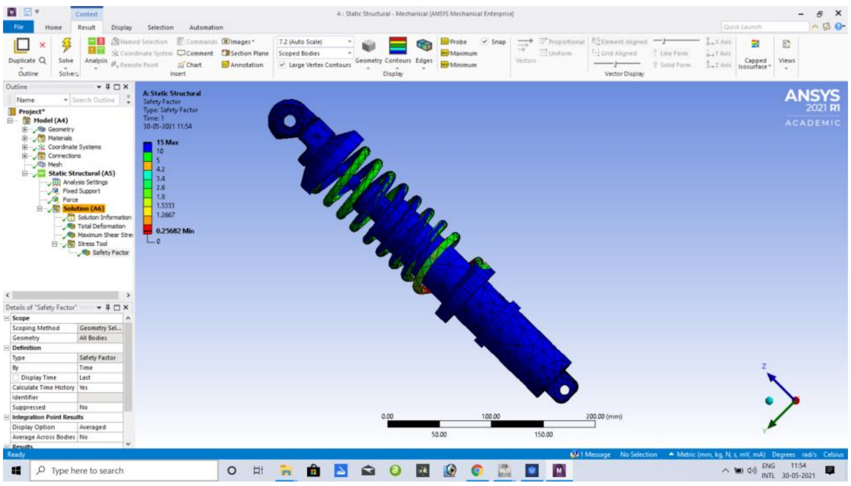


Fig.6.17 Factor of safety at W_2 = 1119.3 N

$W_3 = 1537.2$ N

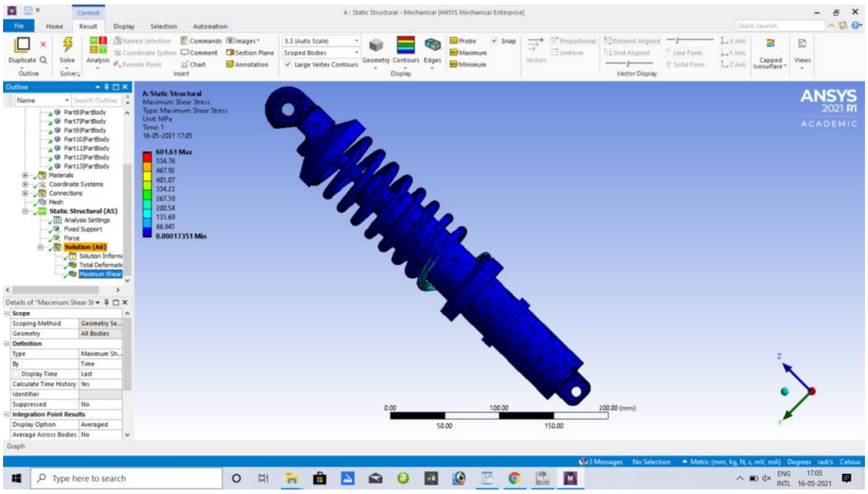


Fig.6.18 Maximum shear stress at $W_3 = 1537.2$ N

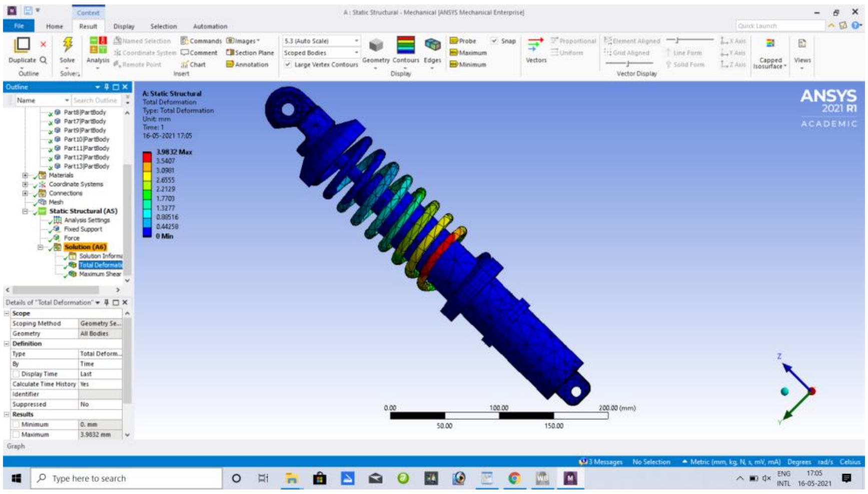


Fig.6.19 Total Deformation at $W_3 = 1537.2$ N

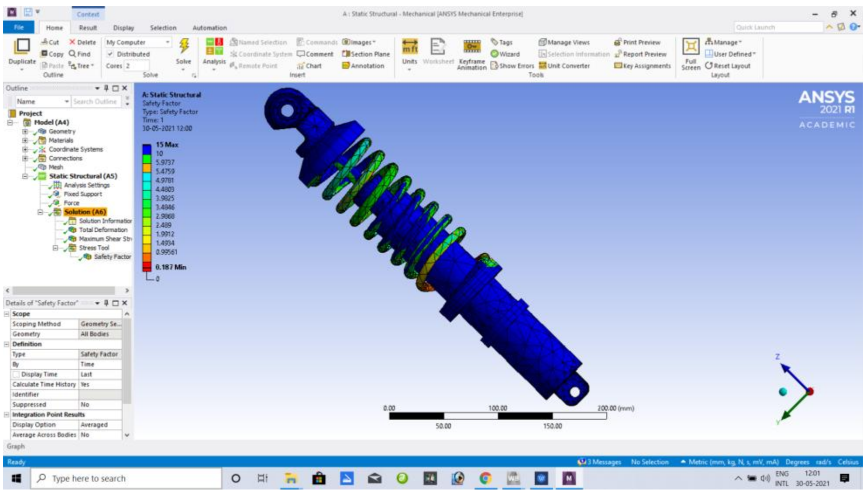


Fig.6.20 Factor of safety at $W_3 = 1537.2$ N

CHAPTER -7
CALCULATIONS

7.CALCULATIONS

7.1 DIMENSIONAL DETAILS:

7.1.1 Mono Suspension:

Spring:

Wire diameter (d) =11 mm,

Coil outer diameter (Do) =46 mm,

Coil inner diameter (Di) =26;mm,

Coil free height (h) =100 mm,

No. of active coils (n)=5,

Pitch (P) =18 mm

Base:

Radius=22.5mm

Shaft Radius=5mm

Shaft length=75mm

Top part:

Length=110mm

Diameter=13.5mm

Inner diameter=5mm

Nut:

Outer Diameter=54mm

Inner Diameter=24mm

7.1.2 Twin Suspension:

Spring:

Wire diameter (d) =7.8 mm,

Coil outer diameter (Do) =68 mm,

Coil inner diameter (Di)=52mm,

Coil free height (h) =165 mm,

No. of active coils (n)=8,

Pitch (P) =19 mm

Bottom part:

Radius=24mm

Height =94.5mm

Top Bearing:

Base Diameter=20mm

Bearing Diameter=14mm

Height =58mm

Shaft

Diameter=6.5mm

Length=200mm

Nut:

Outer Diameter=54mm

Inner Diameter=40mm

Thickness=10mm

7.2 FORMULAS USED:

mean coil diameter(D) = $\frac{Di+Do}{2}$

Spring index (C) = $\frac{D}{d}$

Wahl's Stress Factor(K) = $\frac{4C-1}{4C-4} + \frac{0.615}{C}$

Spring Constant(K) = $\frac{d^4 G}{8nD^3}$

Shear Modulus (G) = $\frac{K8nD^3}{d^4}$

Maximum shear stress (τ) = $\frac{K8PD}{\pi d^3}$

Factor of safety = $\frac{ultimate\ stress}{working\ stress}$

7.3 THEORETICAL CALCULATIONS:

7.3.1 Mono Suspension:

mean coil diameter(D) = $\frac{Di+Do}{2}$ = 36 mm

Spring index (C) = $\frac{D}{d}$ =3.27

Wahl's Stress Factor(K) = $\frac{4C-1}{4C-4} + \frac{0.615}{C}$ = 1.51

Maximum shear stress (τ) = $\frac{K8PD}{\pi d^3}$ =(1.51*8*36*1402/π*11^3) =143.06 MPa

Error = [(143.06-140.02)/ (143.06)] *100 =0.0211

=2.1%

Factor of safety = $\frac{310}{140.02}$ = 2.21

7.3.2 Twin Suspension:

mean coil diameter(D) = $\frac{Di+Do}{2}$ = 60mm

Spring index (C) = $\frac{D}{d}$ =7.69

Wahl's Stress Factor(K) = $\frac{4C-1}{4C-4} + \frac{0.615}{C}$ = 1.19

Maximum shear stress (τ) = $\frac{K8PD}{\pi d^3}$ =(1.19*8*701*60/π*7.8^3) =268.57 MPa

Error = [(268.57-265.22)/(268.57)]*100= 0.0124

= 1.24%

Factor of safety = $\frac{310}{265.22}$ = 1.16

CHAPTER- 8

RESULTS

8. RESULTS

After performing the theoretical calculations on both suspension systems when the suspensions are in compressed position, to support the calculations an analysis using Ansys simulation has been performed on both suspension system. The respective Maximum shear stress and factor of safety were determined and then compared.

The resultant stress obtained through calculations of suspension systems of different materials at different loading conditions are tabulated in the following table.

8.1 SHEAR STRESS:

8.1.1 Mono suspension:

Type of material	Load applied in N	Maximum shear stress (theoretical) MPa	Maximum shear stress (Ansys Simulation) MPa	Percentage convergence
Aluminium alloy				
	W1=1402N	143.06	140.02	97.9 %
	W2=2238.6N	214.57	208.97	97.4 %
	W3=3074.4N	290.74	286.95	98.7 %
Stainless steel				
	W1=1402N	143.06	140.36	98.1 %
	W2=2238.6N	214.57	209.4	97.5 %
	W3=3074.4N	290.74	287.68	98.95%

Table 8.1 Max. Shear stress(mono)

8.1.2 Twin suspension:

Type of material	Load applied in N	Maximum shear stress (Theoretical) MPa	Maximum shear stress (Ansys Simulation) in MPa	Percentage convergence
Aluminium alloy				
	W1=701N	268.57	265.22	98.76%
	W2=1119.3N	428.84	423.48	98.8 %
	W3=1537.2N	588.59	581.59	98.89%
Stainless steel				
	W1=701N	268.57	274.35	97.9 %
	W2=1119.3N	428.84	438.06	97.9 %
	W3=1537.2N	590.50	601.61	98.2 %

Table 8.2 Max. Shear stress(twin)

8.2 FACTOR OF SAFETY:

8.2.1 Mono suspension:

Type of material	Load applied in N	Factor of safety (Theoretical)	Factor of safety (simulation)
Aluminium alloy			
	W1=1402N	2.213	2.33
	W2=2238.6N	1.48	1.76
	W3=3074.4N	1.08	1.35
Stainless steel			
	W1=1402N	3.59	3.66
	W2=2238.6N	2.41	2.6
	W3=3074.4N	1.75	1.88

Table 8.3 Factor of safety(mono)

8.2.2 Twin suspension:

Type of material	Load applied in N	Factor of safety (Theoretical)	Factor of safety (Simulation)
Aluminium alloy			
	W1=701N	1.16	1.3
	W2=1119.3N	0.73	1.12
	W3=1537.2N	0.53	0.98
Stainless steel			
	W1=701N	1.84	2.07
	W2=1119.3N	1.15	1.53
	W3=1537.2N	0.83	1.12

Table 8.4 Factor of safety(twin)

8.3 TOTAL DEFORMATION:

8.3.1 Mono Suspension:

Type of material	Total Deformation in mm		
	W1 = 1402 N	**W2=2238.6 N**	**W3 = 3074.4 N**
Aluminium alloy	2.09 mm	3.12 mm	4.288 mm
Stainless steel	0.761 mm	1.135 mm	1.559 mm

table 8.5 total deformation(mono)

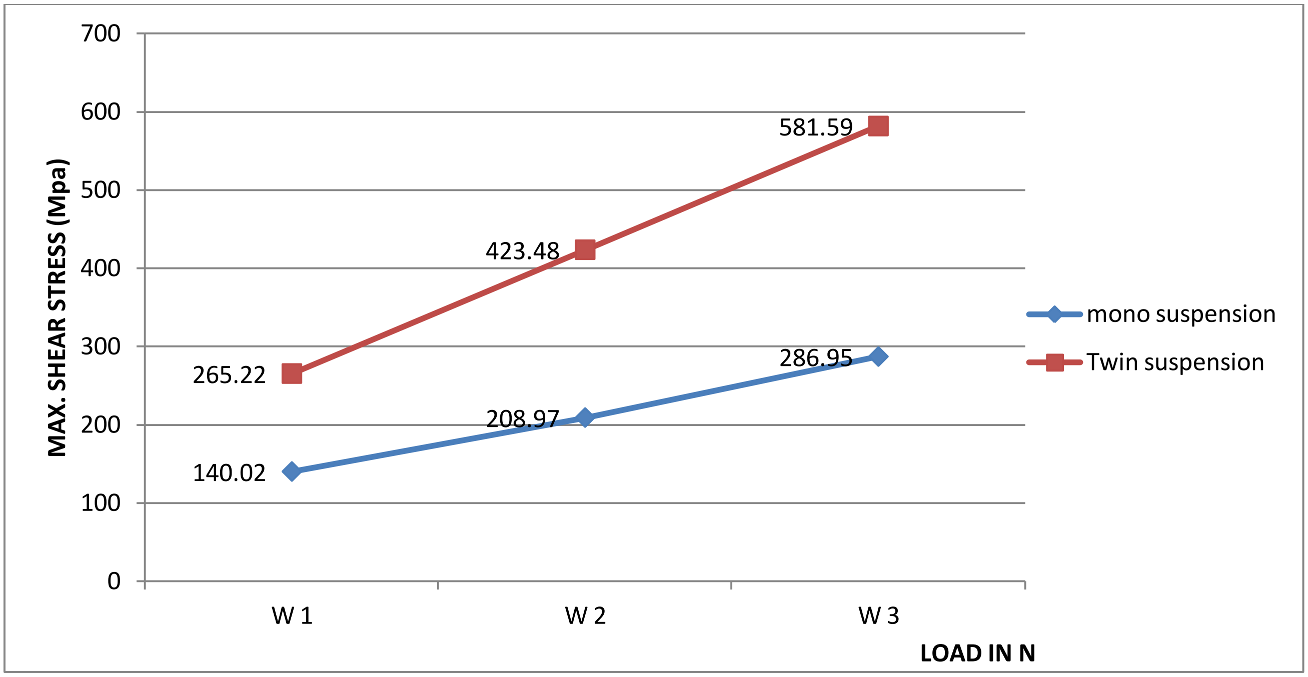
8.3.2 Twin Suspension:

Type of material	Total Deformation in mm		
	W1 = 701 N	**W2=1119.3 N**	**W3 = 1537.2 N**
Aluminium alloy	4.99 mm	7.97 mm	10.94 mm
Stainless steel	1.81 mm	2.90 mm	3.98 mm

Table 8.6 total deformation(twin)

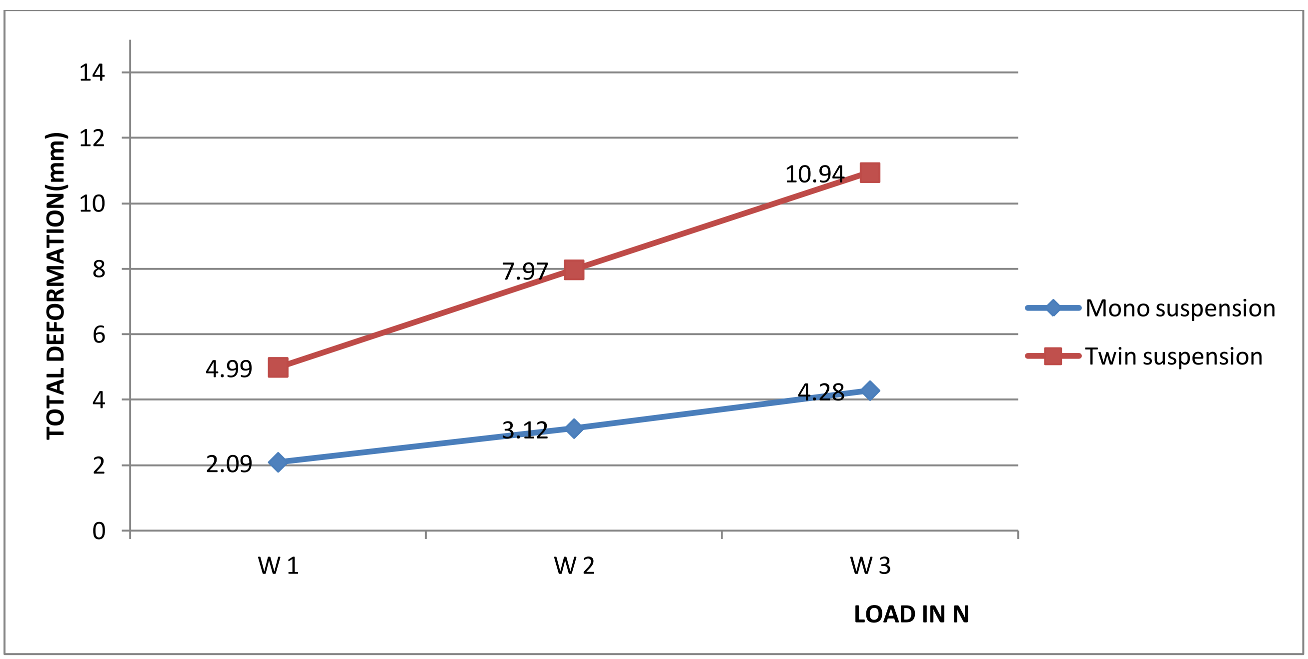
8.4 GRAPHS:

8.4.1 Maximum shear stress:

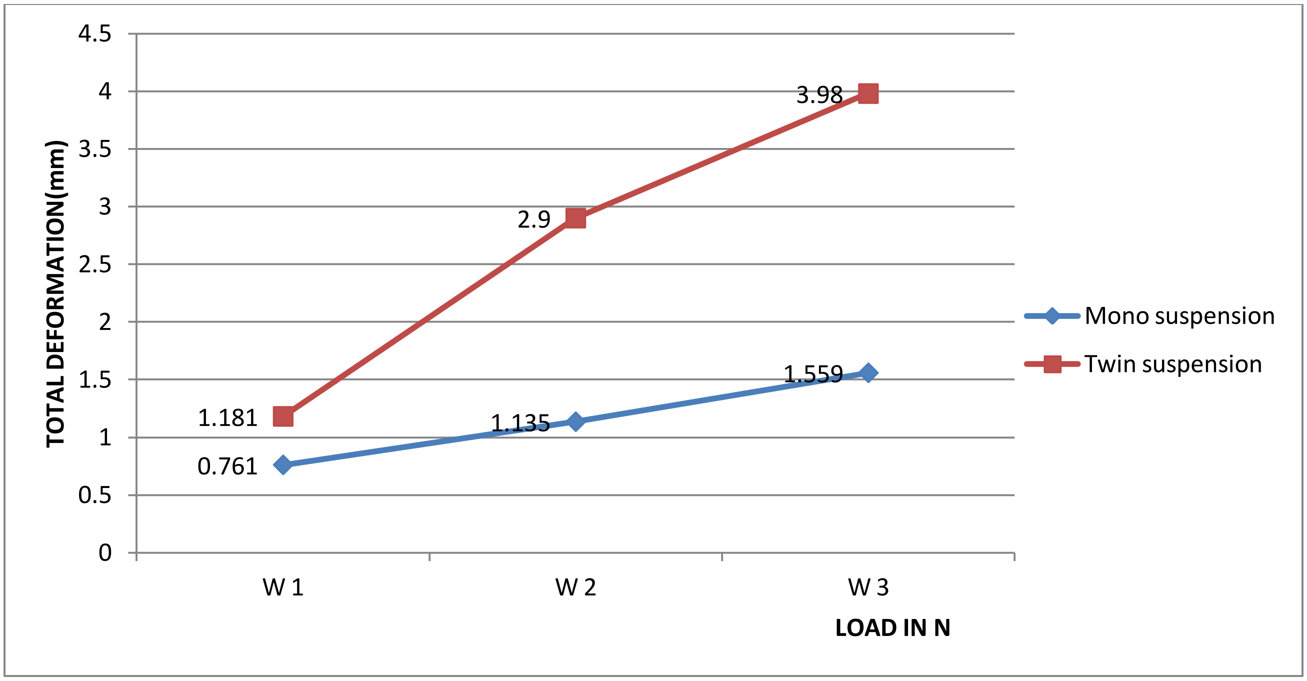


Graph 8.7 Load v/s Max. shear stress

8.4.2 Total Deformation:



Graph 8.8 Load v/s Total deformation for aluminium alloy



Graph 8.9 Load v/s Total deformation for stainless steel

From the above graphs and results obtained we can see that the total deformation of the mono suspension system is less when compared to the twin suspension system for the same loading conditions this shows that mono suspension system has higher strength with less deformation.

CHAPTER-9

CONCLUSION

9. CONCLUSION

The suspension systems used in bikes have been designed using CATIAV5 software. The designs were then imported into ANSYS workbench to perform analysis. Theoretical calculations have also been performed to validate the simulation which was performed in ANSYS workbench. After comparison, the results were determined to be closer to the real time design conditions by which the simulation can be taken into consideration at different loading conditions. Later, analysis using ANSYS workbench has been performed on both the suspension systems by adding different materials at different loading conditions and required results such as static stress, total deformation and factor of safety are determined for different loading conditions. After validating the results, the conclusion of the project is made by considering the values of factor of safety, total deformation and type of material used for above specified loading conditions.

From this project we conclude “MONO SUSPENSION SYSTEM” with stainless steel material is best suited and has good factor of safety. Mono suspension system has low total deformation and convincing factor of safety which shows that the system can absorb more load and has higher strength for above specified loading conditions.

10. FUTURE SCOPE

In future this project can be further modified by performing other type of analysis like explicit dynamics under different loading conditions, thermal analysis can also be performed on the suspension systems as they are in continuous working when the vehicle is in motion which might affect the suspension systems due to change in temperature. Further the three-dimensional assembly design of the suspension systems can also be fabricated using a 3-D printer for any other practical purposes.

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