DESIGN AND ANALYSIS OF TRESTLE JACK FOR FOUR WHEEL DRIVE SUVs WITH A GROUND CLEARANCE 200 mm

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

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IN

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CERTIFICATE

This is to certify that the Project Report Work entitled "**DESIGN AND ANALYSIS OF A TRESTLE JACK FOR FOUR WHEEL DRIVE SUVs WITH A GROUND CLEARANCE OF 200 mm**" has been carried out by CH. DURGA PRASAD (315126520246), V. BHARGAV SHIVA SAI (315126520226), V.DIVYAKANTH (315126520235), V. HYNDAVI(315126520224), B. CHANIKYA VARMA (315126520267) of MECHANICAL ENGINEERING, **ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES,** Visakhapatnam during the year 2018-2019 in partial fulfilment of the requirements for the award of the Degree of Bachelor of Mechanical Engineering by ANDHRA UNIVERSITY, VISAKHAPATNAM.

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ABSTRACT

A TrestleJack is a device which is used to lift vehicles with minimal manual effort reducing the chances for human injuries .In this project we designed a basic model of TrestleJack and performed static structural analysis was using Solidworks software. From the results produced it can be proved that the TrestleJack designed is safe to use.

Further advancements can be done to the TrestleJack design where adjustments to the cylinder block can be provided such that it can be used for different vehicles having varying ground clearance providing an wide range of usage in automobile industry.

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SOLIDWORKS

1.1 INTRODUCTION TO SOLID WORKS

Solid Works is a solid modelling computer-aided design (CAD) and computer aided engineering (CAE) computer program that runs on Microsoft Windows. Solid Works is published by Dassault Systems.

Solid works Corporation was founded in December 1993 by Massachusetts Institute of Technology graduate Jon Hirschtick. Solid Works released its first product Solid works 95 in November 1995. In 1991 Dassault, best known for its CATIA CAD software, acquired Solid Works for $310 million in stock.

Solid Works currently markets several versions of the Solid Works CAD software in addition to eDrawings, a collaboration tool, and Draft Sight, a 2D CAD product.

The SOLIDWORKS CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings. A SOLIDWORKS model consists of 3D geometry that defines its edges, faces, and surfaces. The SOLIDWORKS software lets to design models quickly and precisely. SOLIDWORKS models are

- Defined by 3D design
- Based on components

1.1.1 3D DESIGN

SOLIDWORKS uses a 3D design approach. As to design a part, from the initial sketch to the final result, to create a 3D model. From this model, to create 2D drawings or mate components consisting of parts or subassemblies to create 3D assemblies. We can also create 2D drawings of 3D assemblies.

When designing a model using SOLIDWORKS, to visualize it in three dimensions, the way the model exists once it is manufactured. This document discusses concepts and terminology used throughout the SOLIDWORKS application. It familiarizes with the commonly used functions of SOLIDWORKS. Parts are the basic building blocks in the SOLIDWORKS software. Assemblies contain parts or other assemblies, called subassemblies.

1.1.2 TERMINOLOGY

These terms appear throughout the SOLIDWORKS software and documentation.

Origin

Appears as two blue arrows and represents the (0,0,0) coordinate of the model. When a sketch is active, a sketch origin appears in red and represents the (0,0,0) coordinate of the sketch. To can add dimensions and relations to a model origin, but not to a sketch origin.

Plane

Flat construction geometry. To use planes for adding a 2D sketch, section view of a model, or a neutral plane in a draft feature, for example.

Axis

Straight line used to create model geometry, features or patterns. To create an axis in different ways, including intersecting two planes. The SOLIDWORKS application creates temporary axes implicit for every conical or cylindrical face in a model.

Face

Boundaries that help define the shape of a model or a surface. A face is a selectable area of a model or surface. For example, a rectangular solid has six faces.

Edge

Location where two or more faces intersect and are joined together. To select edges for sketching and dimensioning, for example.

Vertex

Point at which two or more lines or edges intersect. To select vertices for sketching and dimensioning, for example.

User interface

The Solidworks application includes user interface tools and capabilities to help you create and edit models efficiently.

Windows Function

The Solidworks application includes familiar windows functions, such as dragging and resizing windows. Many of the same icons, such as print, open, save, cut, and paste are also part of the Solidworks application.

Solidworks Documents Window

Solidworks document windows have two panels. The left panel, or Manager Panel.

Feature Manager Design tree

Displays the structure of the part, assembly, or drawing.

Property Manager

Provides settings for many functions such as sketches, fillet features, and assembly mates.

Configuration Manager

Create, select, view, multiple configurations of parts, and assemblies in a document.

1.2 DESIGN PROCESS

The design process usually involves the following steps

- Identify the model requirements
- Conceptualize the model based on the identified needs
- Develop the model based on the concepts
- Analyse the model
- Prototype the model
- Construct the model
- Edit the model, if needed

1.3 DESIGN INTENT

Design intent determines how you want your model to react as a result of the changes you need to make to the model. For example, if you make a boss with a hole in it, the hole should move when the boss moves.

Design intent is primarily about planning. How to create the model determines how changes affect it. The closer the design implementation is to design intent, the greater the integrity of the model. Various factors contribute to the design process, including

Current needs

Understand the purpose of the model to design it efficiently.

Future considerations

Anticipate potential requirements to minimize redesign efforts.

1.4 DESIGN METHOD

Before actually designing the model, it is helpful to plan out a method of how to create the model. After identifying needs and isolating the appropriate concepts, model can be developed.

Sketches

Create the sketches and decide how to dimension and where to apply relations.

Features

Select the appropriate features, such as extrudes and fillets, determine the best features to apply, and decide in what order to apply those features.

Assemblies

Select the components to mate and types of mate to apply .

LITERATURE REVIEW

A. Saravanan, P. Suresh, V. Arthanari, S. Nethaji and S. Muthukumar, " Design and Analysis of Trestle Hydraulic Jack Using Finite Elementt Method".

In this work designed a new type of hydraulic jack with trestle feature. The new model was designed based on numerical calculation with loading and no loading condition also FEA model of trestle hydraulic jack has been created using solid works software according to design values. The Analytical value of stress and strain and deflection values of Trestle Hydraulic Jack is less than the design value. From that it can be concluded that the designed Trestle Hydraulic Jack is under the safety region when it's in under loading condition. Numerical result and analytical result both are similar. So the design parameters are verified numerical and analytically from that it concluded that design is safe.

Timoshenko, S.P. and Goodier, J.N., "*Theory of Elasticity*, 3rd ed"., McGraw-Hill, New York, 1987.

In this study, stress, bending moment and factor of safety for curved beams, disks and curved beams of narrow rectangular cross sectional had been discussed and evaluated accordingly. Analysis had been discussed when one end of the beam is fixed and load is subjected at the free end and stresses induced in the beam are calculated as mentioned in the above review.

Manoj R Patil1* and S D Kachave1.,"DESIGN AND ANALYSIS OF SCISSOR JACK"

The paper will include a scissor jack of automobile L.M.V. vehicle and other same type of variants. This proposed design of scissor jack after its stress analysis concludes that: This is a common jack for the variant (satisfying the product requirements). The proposed jack has the reduced weight (by changing the manufacturability). Designing this new jack reduces the no. of parts for simplifying the assembly process. Only rivet joints are induced (Removal of welding to avoid distortion).

P. S. Rana1, P. H. Belge1, N. A. Nagrare1, C. A. Padwad1, P. R. Daga1, K. B. Deshbhratar N. K. Mandavgade2*.,"Integrated Automated Scissor Jack For LMVs".

The present invention is a vehicle scissor jack positioned on a each side between the front and rear wheels with an electric motor drive arrangement for the operation of lifting and descending of the vehicle to its position for operation. The jack has gear configured for a high speed and a low speed of operation. Switches and are used to control the direction of movement of the jack. Releasing the switches during operation stops the jack in the present position.

This invention relates to a jacking arrangement for automobiles whereby a lifting jack is secured on the lower part of the chassis of a vehicle. The jack has a scissors configuration with a motor positioned between scissor arm elements. The extension of the jack is limited by a switch handle which is configured for cutting off the current flow as the switch is closed by the action of a jack arm approximately reaching a maximum extension position.

K. Balveera Reddy, K. Mahadevan.,Design Data Handbook: For Mechanical Engineers (in SI and Metric Units), (Fourth Edition)"

Machine design is one of the important subjects in mechanical engineering and a thorough knowledge of the design aspects of machine elements is essential for all design engineers. Working out the design of a machine as a whole, or its components, usually involves use ofseveral formulae, graphs, standard tables and other relevant data. Availability of all such information in one handbook not only eliminates the unnecessary task ot remembering the required formulae and equations, but also helps the design engineers to solve the problems in machine design quickly. Design Data Handbook has been prepared keeping these basics in mind.

Dassault Systèmes SolidWorks Corp.,"SolidWorks simulation"

In this study, it is said how physics based motion simulation can be used to improve the quality and performance of design. SolidWorks Motion simulates the mechanical operations of motorized assemblies and the physical forces they generate, by determining factors such interference between moving parts. SolidWorks Motion helps you ascertain if your designs will fail, when parts will break, and whether or not they will cause safety hazards

INTRODUCTION

3.1 TRESTLEJACK

In general, to lift and lower any vehicle for maintenance purpose conventional Jacks such as screw Jacks, A Trestle Jacks uses driving motion from the tractor to lift and lower trailer axles. It is a portable vehicle jack that allows you to lift a car, van or truck in seconds. You simply reverse the jack and it holds the axle securely in place for maintenance. Because nobody is required underneath for the lifting and lowering once the Trestle Jacks is upright, it transforms into an axle support stand with safe working load. Once the TrestleJack is upright, it transforms into an axle support stand for the vehicle.

Fig 3.1 TrestleJack

Fig 3.2 Before loading

Fig 3.3After loading (upright position)

3.2 PARTS OF A TRESTLEJACK

A TrestleJack consists of the following parts naming:

1. Flat plate
2. Curved plate
3. Solid cylinder
4. Axle holder
5. Stiffeners
6. Rubber Lining

Each of the parts' shape, its placement and its significance is explained in the following paragraphs.

1. Flat Base plate

It is the bottom most part of the TrestleJack holding the structural member. The load from the solid cylinder is transferred on to the base plate. As it is flat, the total load on the flat plate is then transferred to the ground uniformly when it is at the final loading position.

2. Curved plate

It is the part, adjacent to the base plate. It acts as an base plate when the TrestleJack is subjected to the dynamic loading, say at initial , second and third loading positions .The shape of the curved plate like a polygon such that, the individual small rectangular plates are arranged in an curved shape at an inclination of 22^0 with respect to each other.

3. Solid Cylinder

It is a structural member supporting the entire TrestleJack. It is placed on the flat base plate. The cylinder transfers the load from the axle holder to the flat base plate. The position of the cylinder is such that it is inclined at an angle of 5^0 with respect to the normal of the base plate.

4. Axle Holder

It is the component holding the axle rod of the vehicle. The shape of the holder is made such that the axle always remains in contact with the axle holder. To attain such possibility the radius of curvature is maintained at 63.8mm.The axle holder is mounted on top of the cylinder.

5. Stiffeners

To support the axle holder, stiffeners are provided in such a way that the load acting on the axle holder is also transferred onto the stiffeners in small amounts to avoid failure of the axle holder. The load on the stiffeners is again then transferred onto the Flat base plate and Curved plate.

6. Rubber lining

To attain a rigid position, a lining has to be provided under the flat base plate and curved base plate, such that slipping of TrestleJack does not take place. Usually a rubber lining is provided to avoid slipping of the TrestleJack.

3.3 MATERIAL OF THE TRESTLEJACK

When the question arises if that the TrestleJack could damage the axle or any part of the vehicle, the answer is that the TrestleJack is made in such a way that the jack may fail but it does not cause any harm to the axle. So, the TrestleJack is made up of a material that is weaker than the material with which the axles are made up of. The TrestleJack is thus made up of Mild steel.

3.4 ADVANTAGES OF THE TRESTLEJACK

- Using a TrestleJack - which is both a jack and a trestle - to safely lift troubled axles whilst the driver is kept secure in the cab makes this the safest lifting method currently known. All other similar equipment requires a person to be underneath the trailer during the operation of lifting and lowering axles.Occupational Health and Safety standards require employees to be kept safe.
- In the industries, the conventional methods take an average time of 20 minutes to lift a trailer but this jack can do this work within 10 seconds which serves its best purpose in the industries.

Fig 3.4 Loading under 10 seconds

- When the vehicle is reversed in more than a required manner such that it is still moving even after the jack is in upright position, then the jack just simply gets unloaded without undergoing any failure or causing any failure to that vehicle's axle.

3.5 APPLICATIONS OF THE TRESTLEJACK

The TrestleJack can be applied under any conditions such as on road or off road, it can used to perform repairs, change tires etcetera.

DESIGN OF TERSTLEJACK

4.1 INTRODUCTION

The TrestleJack is designed not as an assembly of parts but as a whole body. The axle holder, solid cylinder, base plate, curved plate and fixtures are designed in a single body. As we do not have proper measurements for designing of TerstleJack, the only data available was the height, width and length of the baseplate. So, to reverse engineer the design, we have taken a front view picture of the TerstleJack and measured the dimensions of the design. Later, we have determined the scale of this printed design to the actual dimensions(taking the height of the original jack into consideration). Then the dimensions of the actual design were obtained. Using these dimensions, the design was scaled down to the required height (desired height of TrestleJack for 4 wheel drive cars of ground clearance around 200mm). Thus, the design parameters of the TerstleJack for 4 wheel drive cars are obtained. The design was developed using DSS SOLIDWORKS 2019 version.

4.2 DESIGN

The design of the TrestleJack is developed in the following steps.

4.2.1 DESIGN OF THE CYLINDER

The cylinder is designed using Solidworks, here the front view is selected. The units are changed from inches to millimetres in the settings dialogue box. A centreline is drawn in the vertical direction of a random height more than 240 mm. For the construction of the cylinder, it is mentioned that the cylinder is inclined at an angle of 5 degrees to the normal.In the upright position, the TrestleJack is a safe axle standing, supporting or blocking device. The cup's position of five degrees over the top dead centre ensures that no rolling forward can occur without applying significant force. So, another centreline is drawn inclined at an angle of 5 degrees with a length of 241.46 mm. Then a rectangle is drawn with the length along the centreline. The width of the rectangle is entered as 18.98 mm which is the radius of the solid cylinder. The sketch designed is shown in the figure.

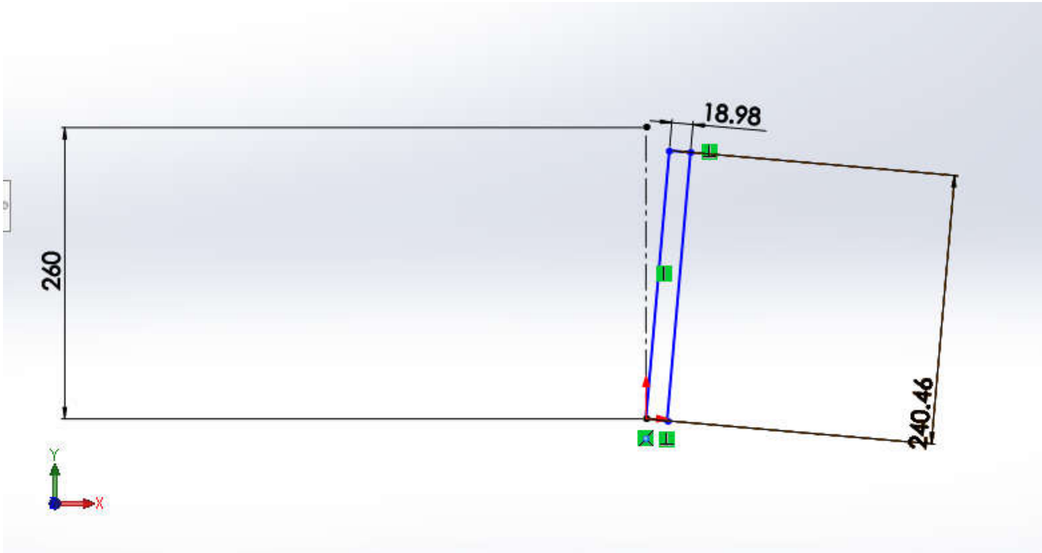

Fig 4.1 Sketch of the solid cylinder

This rectangle is selected and in the 'Features' toolbar, 'Revolved Boss/Base' is selected with the line of reference as the centreline of the cylinder through which the rectangle is constructed. By applying this command, the solid cylinder is constructed which is shown in the figure.

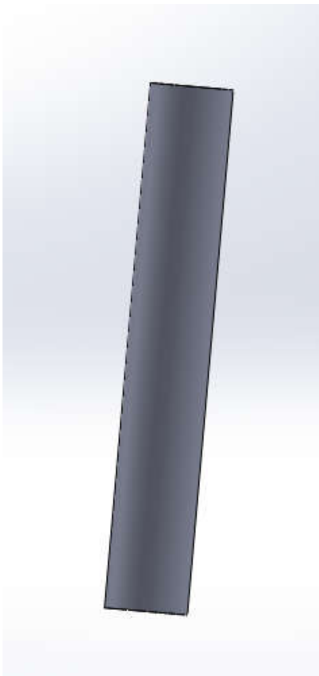

Fig 4.2 Solid cylinder (front view)

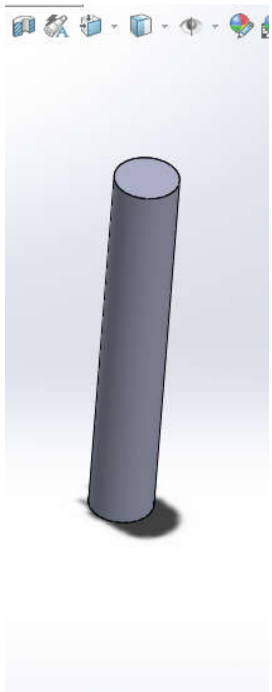

fig 4.3 Solid cylinder (isometric view)

4.2.2 DESIGN OF THE BASE PLATE

A rectangle is constructed with its length and height as 166.11mm and 6.33mm respectively which are the dimensions of the flat base plate. Later, the rectangle is extruded into a solid. The sketch of the base plate is shown in the figure.

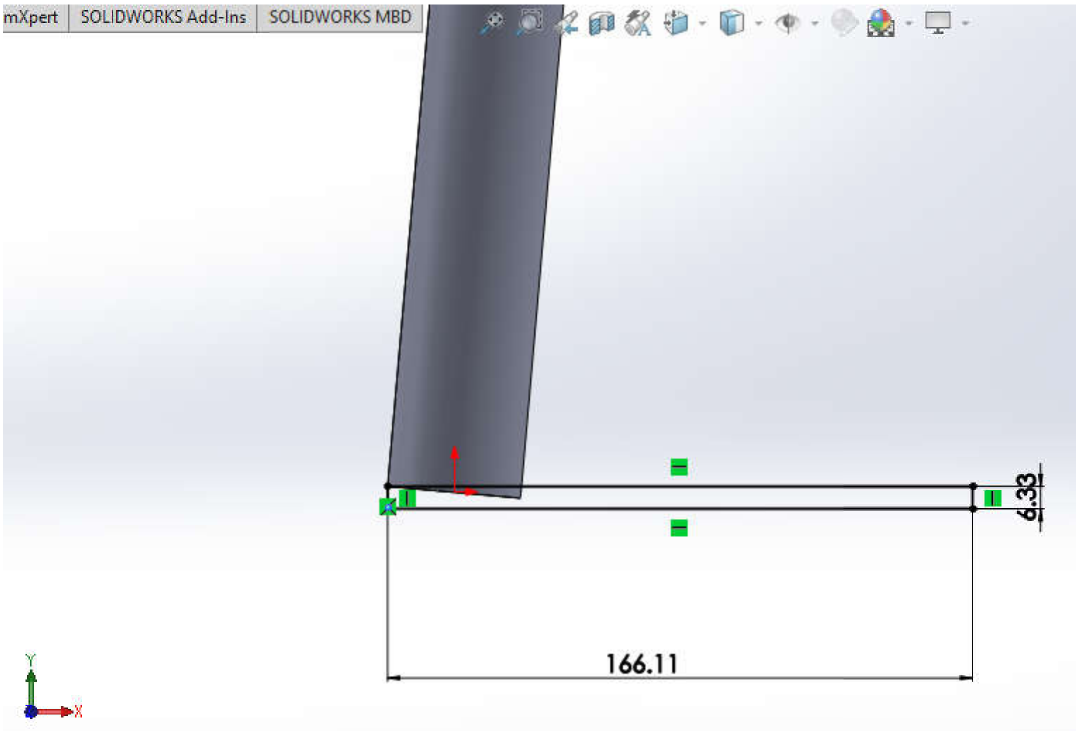

Fig 4.4 Sketch of the Flat base plate

In the 'Features' toolbar, 'Extruded Boss/Base' is selected and in that dialogue box, 'Mid-plane is selected' and the required width is applied. Then the flat base plate is formed with a width of 54.34mm.

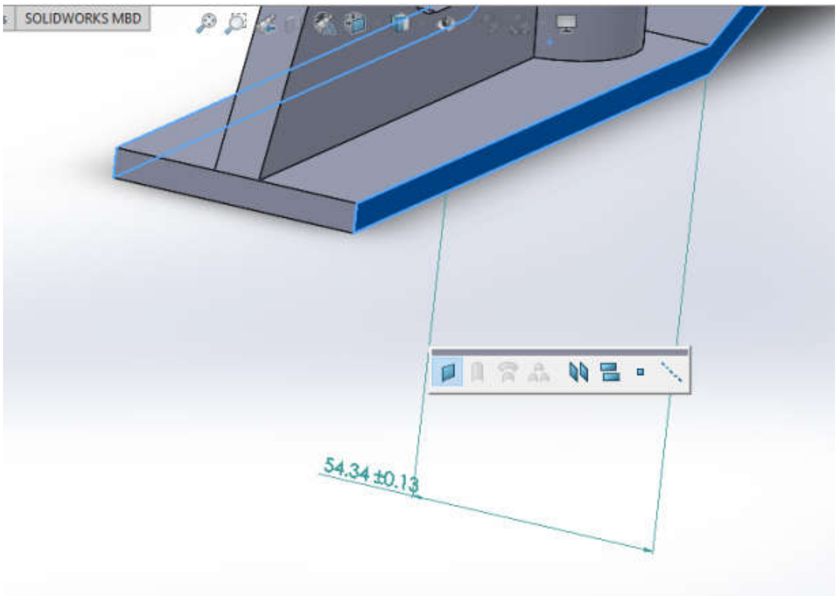

Fig 4.5 Solid model of Flat base plate with thickness

4.2.3 DESIGN OF THE CURVED PLATE

Using the 'sketch' option, the structure of the curved plate is drawn as shown in the figure. The curved plate looks like a series of plates each of length 42.71mm inclined to each other at an angle of 22 degrees whereas the last plate is inclined orthogonally to the horizontal.

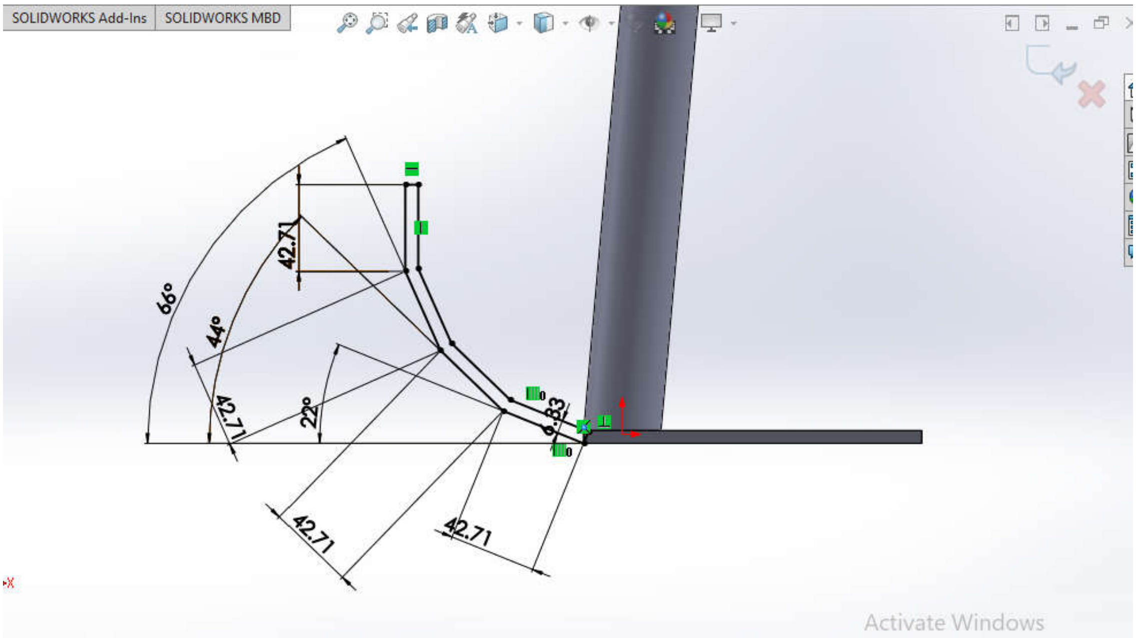

Fig 4.6 Sketch of the Curved plate

Using the 'Features' toolbar, selecting 'Extruded Boss/Base' and the by selecting 'Mid-plane' option, the desired width(54.34mm) is entered and then the solid curved plate is formed as shown in figure.

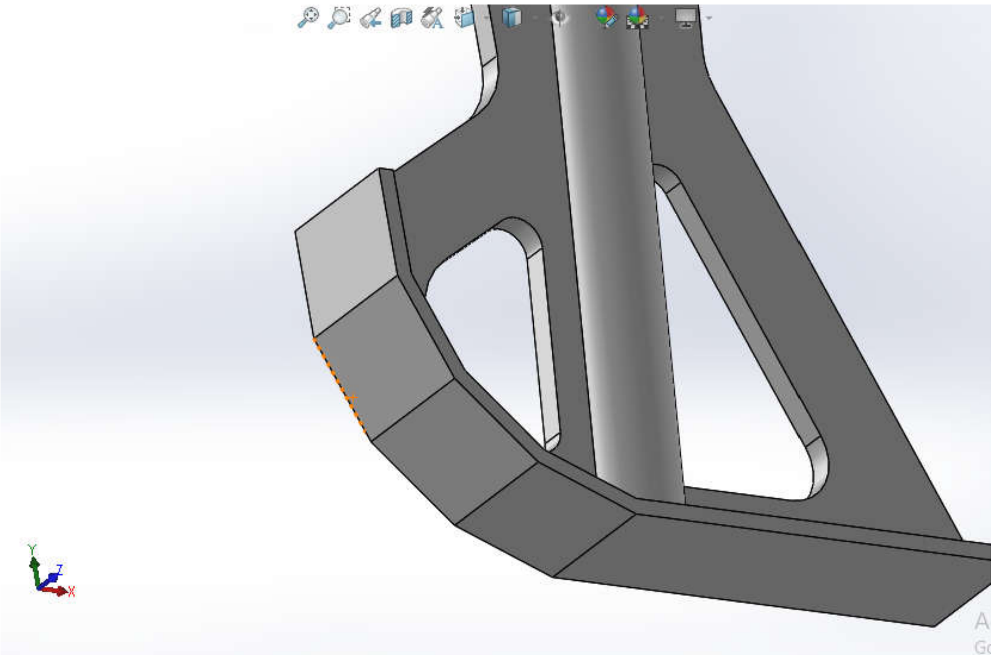

Fig 4.7 Solid model of the Curved plate

4.2.4 DESIGN OF AXLE HOLDER

The Axle holder is first drawn on the front plane using the 'Sketch' option. From the top end of the cylinder, a centreline is constructed of length 58mm. From the end point of the centreline using 'Arc' feature, an arc is drawn with a radius of curvature of 63.28mm to an angle of 50 degrees. Using the 'Mirror' command, the entities are mirrored with respect to the centreline and the structure of the axle holder is obtained of angle 100 degrees. Then using the 'Offset Entitles' command on the taskbar, an offset of 6.33mm is created on the upper side of the arc. Then ends of the arc and its offset are closed using 'Line' commands. The structure of the axle holder thus created is shown in the figure.

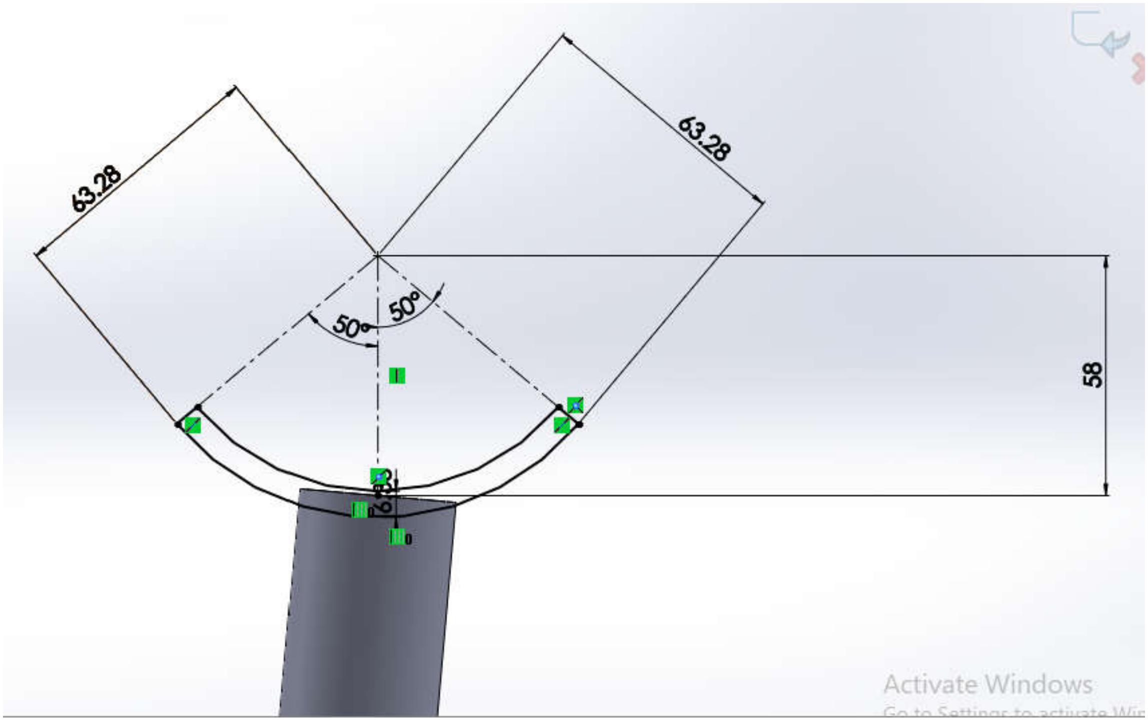

Fig 4.8 Sketch of the Axle holder

Now in the 'Features' toolbar, 'Extruded Boss/Base' feature is selected and 'Mid-plane' option is selected and the desired width is entered(54.34mm). After the required solid model is constructed, the 'Fillet' command is applied by selecting one face with respect to adjacent face. A fillet of radius 20mm is applied and this is repeated for the four sides of the Axle holder. Thus the desired Axle holder is constructed as shown in the figure.

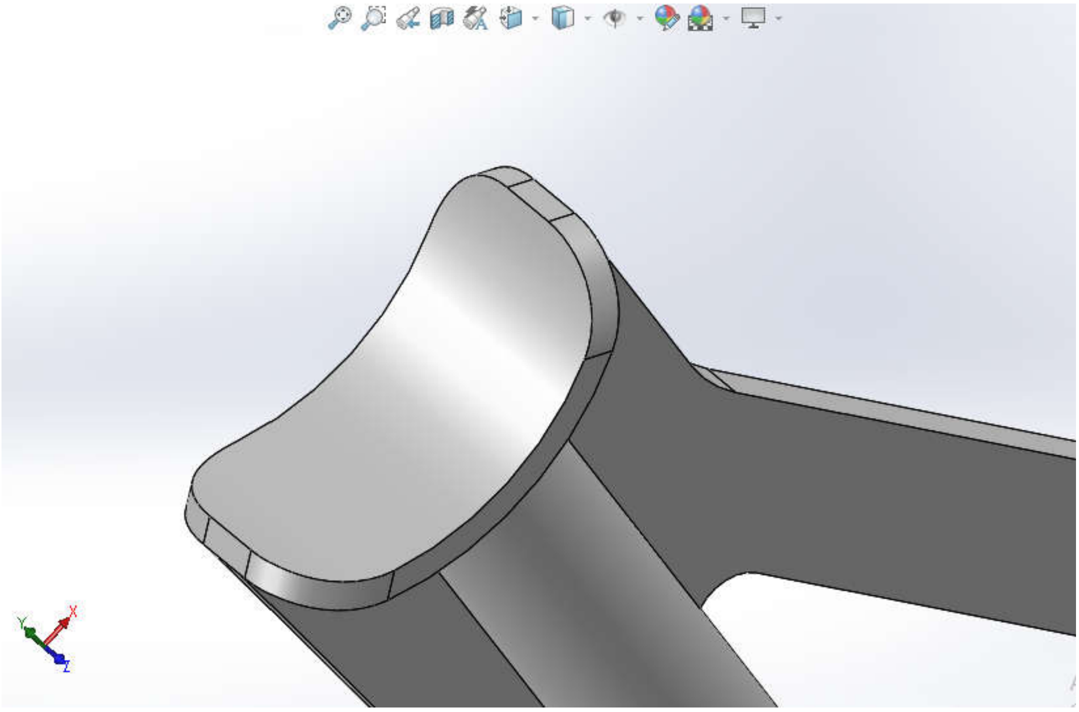

Fig 4.9 Solid model of the Axle holder

4.2.5 DESIGN OF STIFFENERS

The stiffeners are developed in order to provide supports for the axle holder, curved base plate, flat base plate and the solid cylinder. They help the jack to withstand the axle loads without undergoing any fracture or failure. In this project the stiffeners are designed in such a way that they help maintaining the factor of safety greater than 1. In this design the stiffeners are designed with a thickness of 15mm. The sketch and the final design of the stiffeners are shown in the below figures.

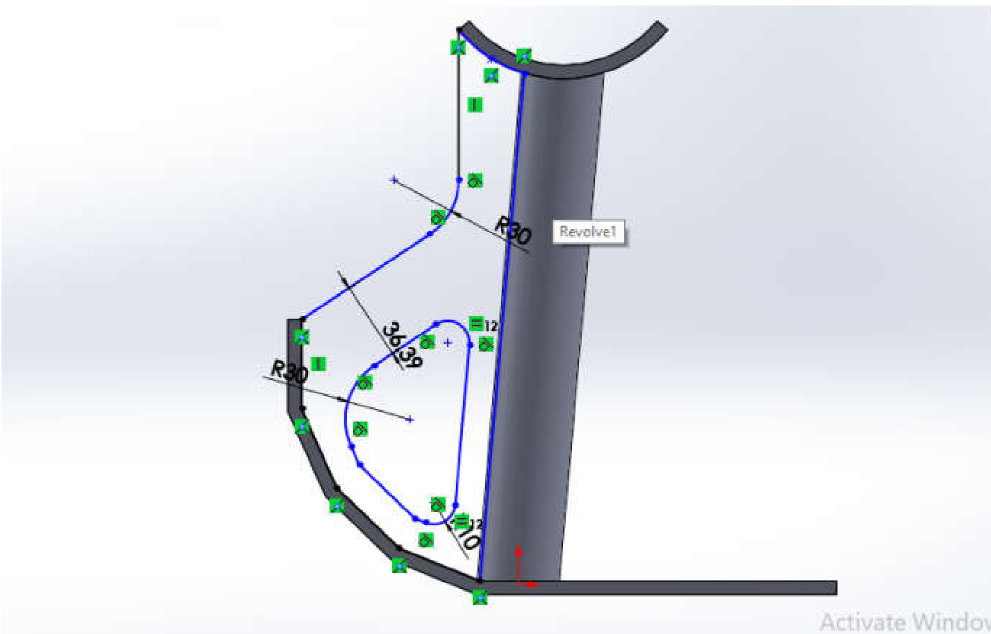

Fig 4.10 Sketch of stiffener supporting the Curved plate and the Axle holder

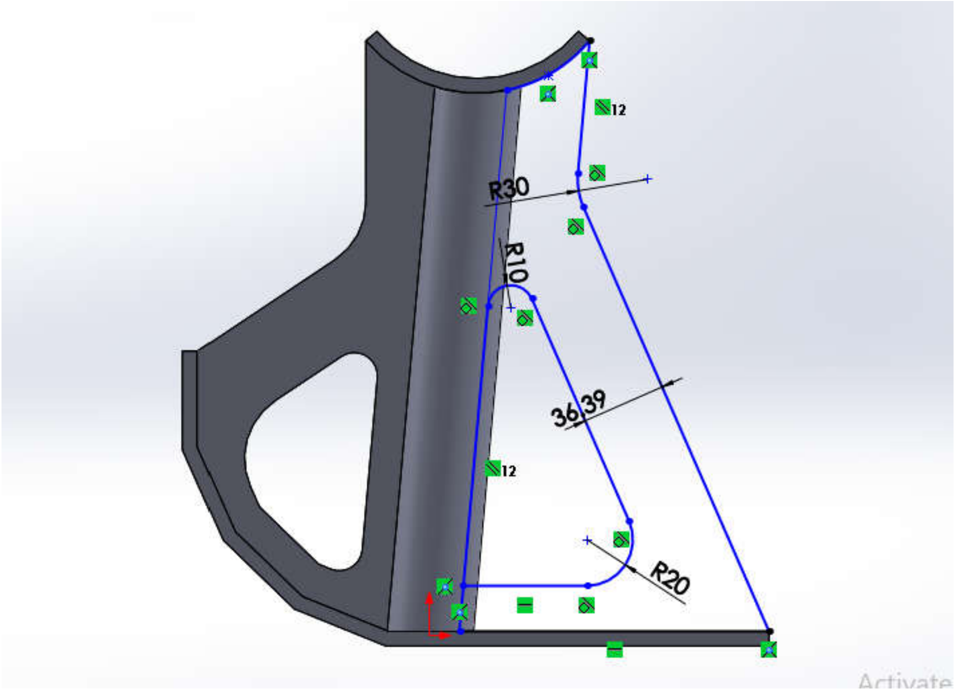

Fig 4.11 Sketch of stiffener supporting the flat base plate and the Axle holder

4.3 FINAL DESIGN OF THE TRESTLEJACK

After sketching and designing the parts of the TrestleJack in the order of previously mentioned parts, the final body obtained is shown in the below figures. Below are the figures of the constructed TrestleJack in respective front view and isometric view.

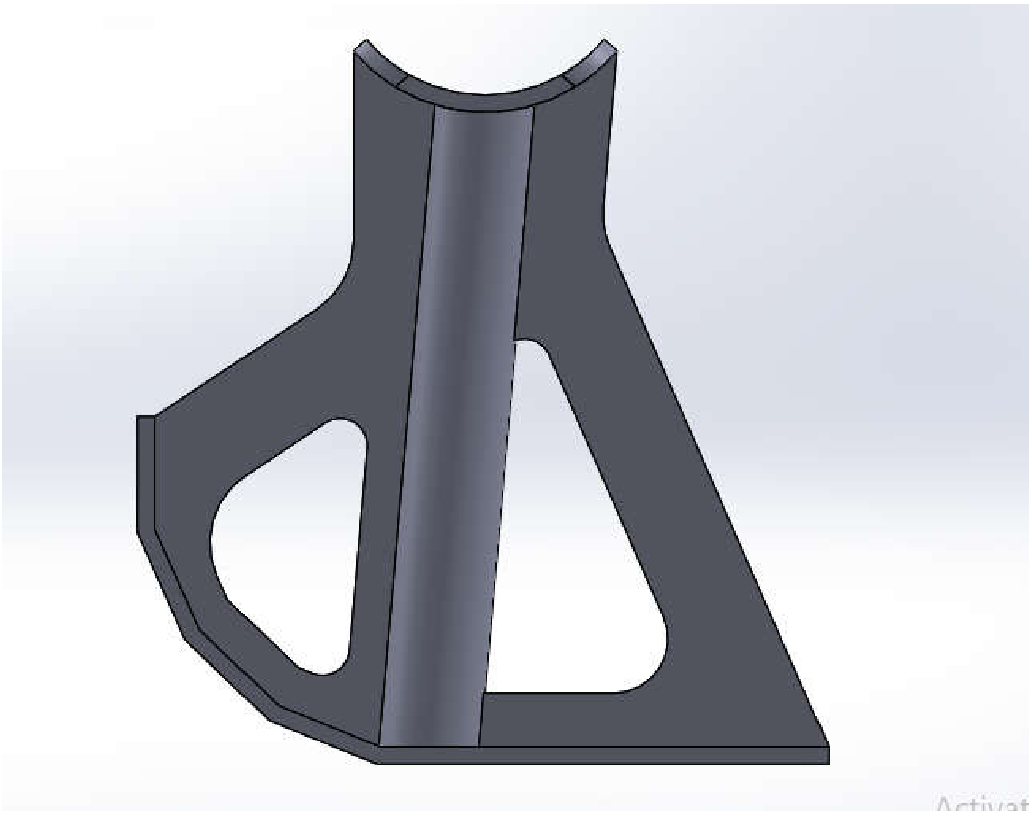

Fig 4.12 Final design of TrestleJack for 4 wheel drive SUVs (front view)

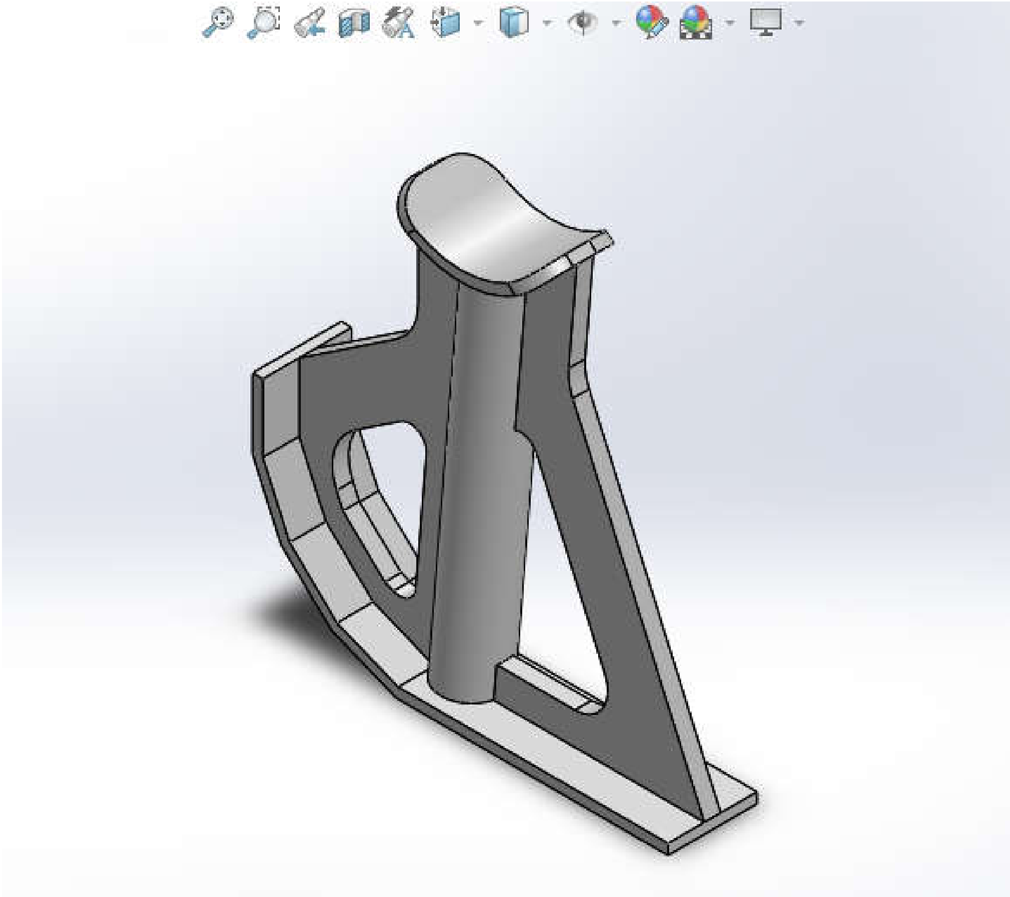

Fig 4.13 Final design of the TrestleJack for 4 wheel drive SUVs (isometric view)

THEORETICAL ANALYSIS

Since the TrestleJack is a very complex body to establish theoretical calculations, the body has been simplified which is shown in the following pages. In this simplified body, theoretical analysis was performed and the results of this analysis are compared by performing analysis on the same simplified body using Solidworks Simulation. This theoretical analysis is proved when the result from the analysis in Solidworks simulation is same as that of the theoretical analysis.

In this theoretical analysis, only the solid cylinder along with the base plate is taken into consideration i.e., the Axle holder and both the stiffeners are removed from the body. This is done so because the body is very complex for undergoing theoretical calculations. Another reason for performing calculations only on the solid cylinder is that most of the load that is applied on the TrestleJack is carried by the solid cylinder itself at the final position condition.

5.1 LOADING ON THE SIMPLIFIED BODY

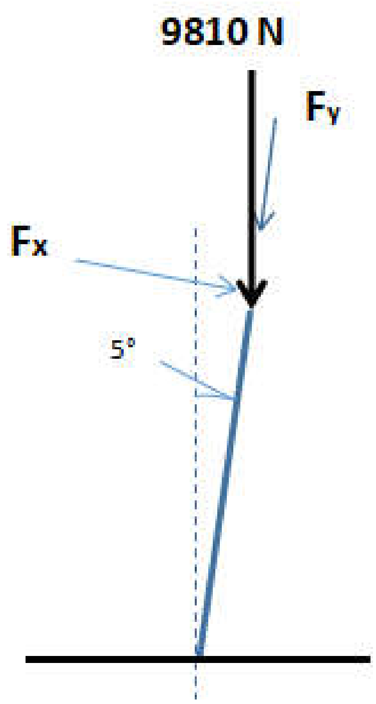

Fig 5.1 Free body diagram of solid cylinder experiencing load

A load of 1000kg (9810 N) is applied on the solid cylinder on its head. The load is applied in the negative y-axis direction i.e., downward direction.Since the cylinder is inclined at an angle of 5 degrees to the vertical, the load applied does not act in-line with the axis of the cylinder. It acts at an angle with respect to the axis if the cylinder. Thus, the load applied is divided into two components with respect to the axis of the cylinder. These components are named vertical and horizontal loading.

This division of the applied load into the horizontal and vertical components is explained using the free body diagram which is mentioned above.

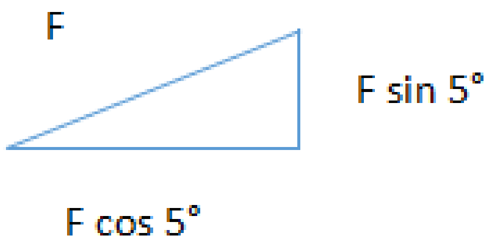

Fig 5.3 Resolving into components

5.1.1 VERTICAL LOADING

Vertical loading takes the concept of loading on a short column. The vertical load that is acting along the axis of the cylinder is determined.

$P \times \cos(5^o) = P_v$

$9810 \times (\cos 5^o) = 9772.66$

$P_v = 9772.66$ N

$\sigma_c = P_v/A$

Where,

σ_c is the compressive stress

P_v is the vertical load

A is the cross-sectional area of the solid cylinder.

$A = \pi * r^2$

$\sigma_c = (9772.66)/\{3.14*(38.4)^2*10^{-6}\}$

$\sigma_c = 8438406.826 N/m^2$

$\sigma_c = 8.43 N/mm^2$

5.1.2 HORIZONTAL LOADING

Horizontal loading takes the concept of loading on a cantilever beam. The horizontal component acts on the end of the cylinder which is fixed at the bottom.

$P * \sin(5^o) = P_h$

$9810 * \sin(85^o) = 854.12$

P_h = 854.12 N

Using Bending Equation,

$\sigma/y=M/I=E/R$

Where,

M is momentum

I is moment of inertia

E is young's modulus

R is the radius of curvature of the beam

σ is the bending stress

y is the distance from the neutral axis to outer layer of the beam

M = P_h * (length of the cylinder L)

L =240.9mm

$M = 854.12*(240.9*10^{-6})$

M =205.9 N-m

Diameter of the cross-section D =38.4mm which implies r = 19.2 mm

$I = \pi d^4/64$

$\sigma_b/ \{(38.4/2)*10^{-3}\}=205.968 /\{3.14*(38.4*10^{-3})^4/64\}$

$2*\sigma_b=(205.968*64)/\{3.14*(38.4)^3*(10^{-9})\}$

$\sigma_b=37051533.25 N/m^2$

$\sigma_b=37.015 N/mm^2$

5.2 RESULTANT STRESS ACTING ON THE CYLINDER

The resultant stress acting on the body is as shown below. The resultant of two forces is the square root to the sum of their squares. The resultant force is denoted by root of the squares of the bending and crushing stresses

$\sigma_{resultant}{}^2= [(stress^2)_{bending} + (stress)^2_{crippling}]$

$\sigma_{resultant} = \sqrt{\{(\sigma_b^2) + (\sigma_c^2)\}}$

$\sigma_{resultant}= \sqrt{\{(37.015^2) + (8.43^2)\}}$

$\sigma_{resultant} = 37.99 N/mm^2$

5.3 FACTOR OF SAFETY OF THE THEORETICAL ANALYSIS

Factor of safety is the ratio of the Ultimate stress to the working stress. The Ultimate stress of mild steel is 247 MPa whereas the Working stress of the TrestleJack is 37.99 MPa.

Factor of safety = Ultimate stress / Working stress

From the calculations, resultant stress is the working stress which is 37.99 Mpa or 37.99 N/mm^2.or 37.99 N/ m^2

Ultimate stress of Mild Steel (or) low carbon steel is 247 Mpa or 247 N/mm^2 or 247 N/ m^2

Factor of safety = Ultimate stress / Working stress

$= 247 * 10^6 / 37.99 * 10^6$

$= 6.501$

Factor of safety obtained thorugh theoretical calculations is 6.501

ANALYSIS ON THE SOLID CYLINDER USING SOLIDWORKS SIMULATION

In order to support the analytical calculations, we have also performed the analysis on the same cylinder with the same dimensions and parameters using Solidworks simulation. Taking into consideration only the cylinder subjected to the load and the remaining parts of the TrestleJack have being removed according to the constraints used in the analytical calculations.

The cylinder with its flat base plate is subjected to a load of 9810 N (1000 kg). Then by conducting static structural analysis with mild steel as the material, load is applied in downward direction. After generating the mesh the stresses and the factor of safety are determined.

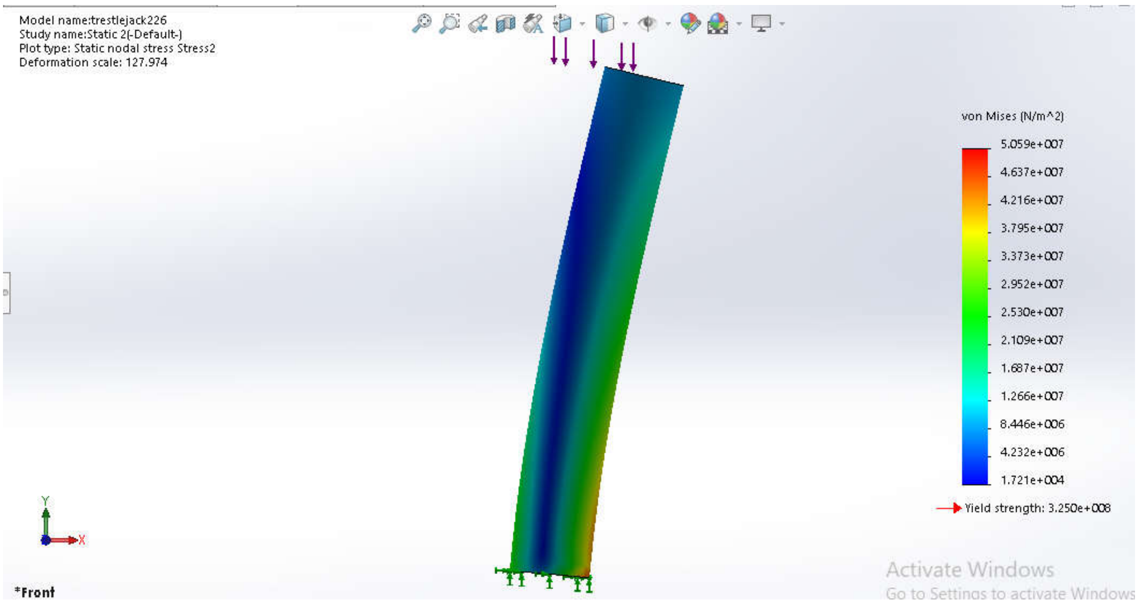

Fig6.1Stresses on the cylinder

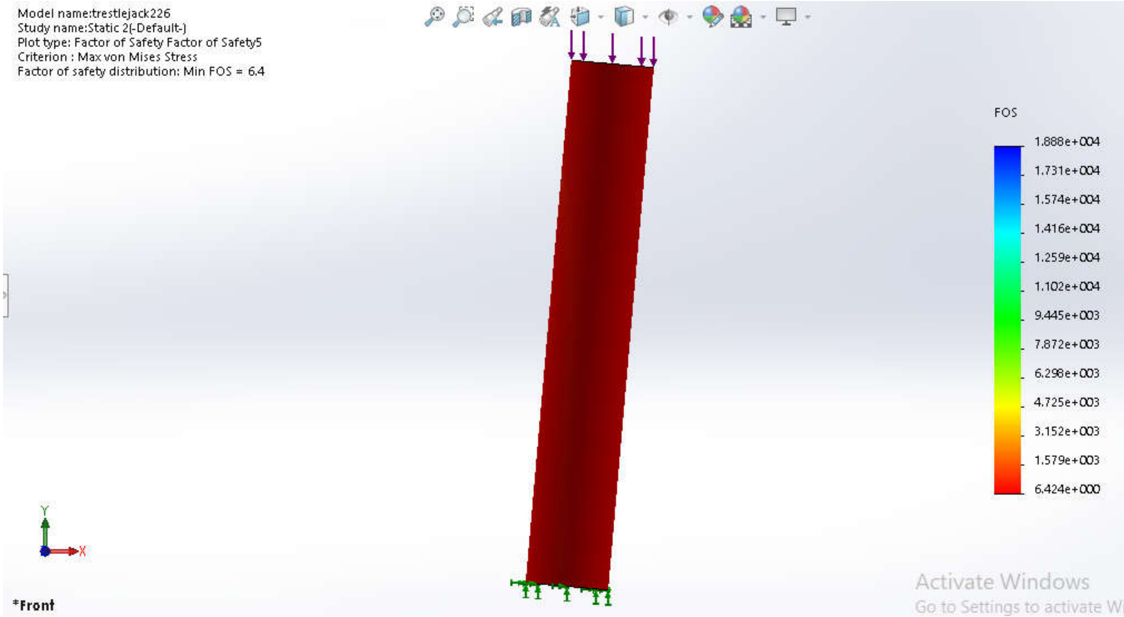

Fig6.2 Factor of safety of the cylinder

By comparing theoretical and analytical values,

The resultant stress which was calculated as 37.99 MPa is represented in the analysis at the mid green-yellow portion of the von Mises stress bar of the analysis.

The factor of safety in the theoretical calculations have been determined as 6.501 and in the analysis is has been described that the minimum factor of safety as 6.4 which serves as a proof for the theoretical calculations that they are correct.

ANALYSIS OF TRESTLEJACK

7.1 ANALYSIS OF THE JACK

The process of loading a TrestleJack is divided into various stages. Since we are performing static structural analysis on the model, the process of loading and the model's behaviour during loading is determined at various stages. During this simulation we are determining the von Mises stresses, Factor-of-safety and deformation scale.

7.1.1 ANALYSIS AT INITIAL STAGE OF LOADING

At this stage, the height difference between the plate at which the initial stage occurs and the axle holder is less than 200mm and is nearly 180mm. But the jack we have designed is desirable for a vehicle with lesser ground clearance. In the 'Solidworks Simulation' tab, 'New Study' is selected in which 'Static' type of analysis is selected. Then in the 'Apply Material' tab, selecting 'Mild Steel' which was added into the material library by us since mild steel was not initially available in the material library. Later in the 'Fixed Geometry' tab, the face on the curved plate at which the initial loading occurs is selected. Then, force is applied on the axle holder at a magnitude of 9810 N (1000 kg) in the direction perpendicular to the fixed face in reversed direction. Mesh is created with mesh size set towards 'Fine'. After the mesh is generated 'Run this Study' is selected and the von Mises stresses are obtained. In the 'new plot', by selecting factor of safety, the factor of safety throughout the design is thus obtained and also the minimum factor of safety of the design is also displayed on the screen. In the given figures are the stresses, factor of safety and deformation scales.

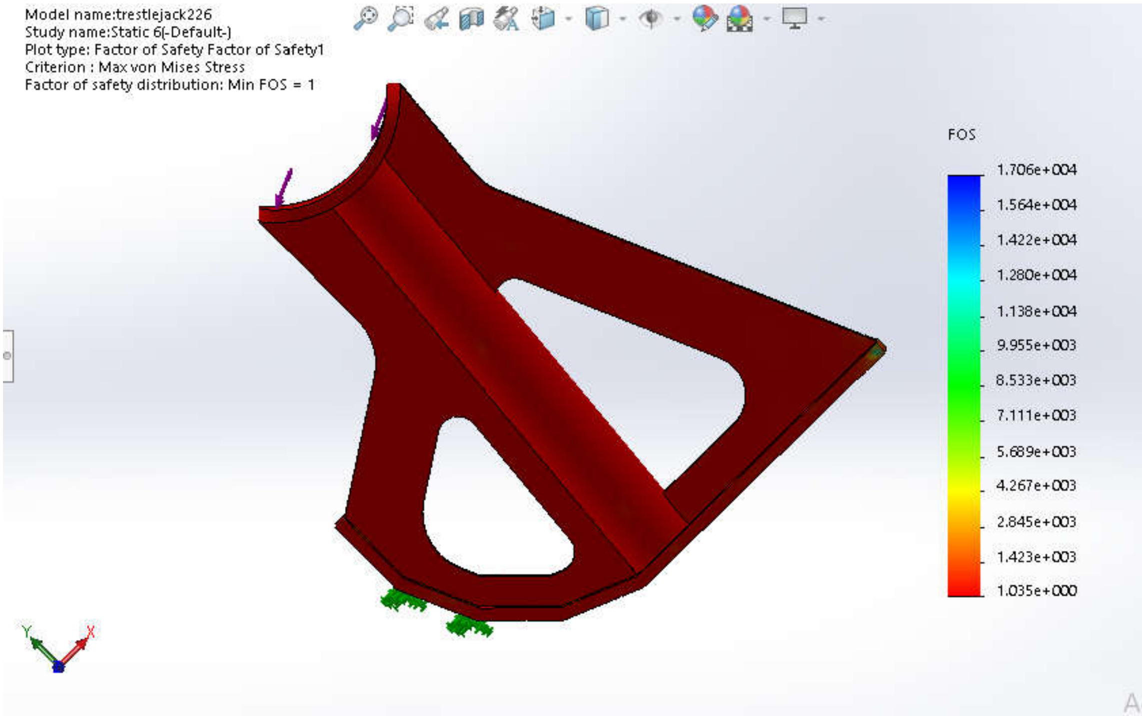

Fig 7.1 Factor of safety at initial stage (undeformed model)

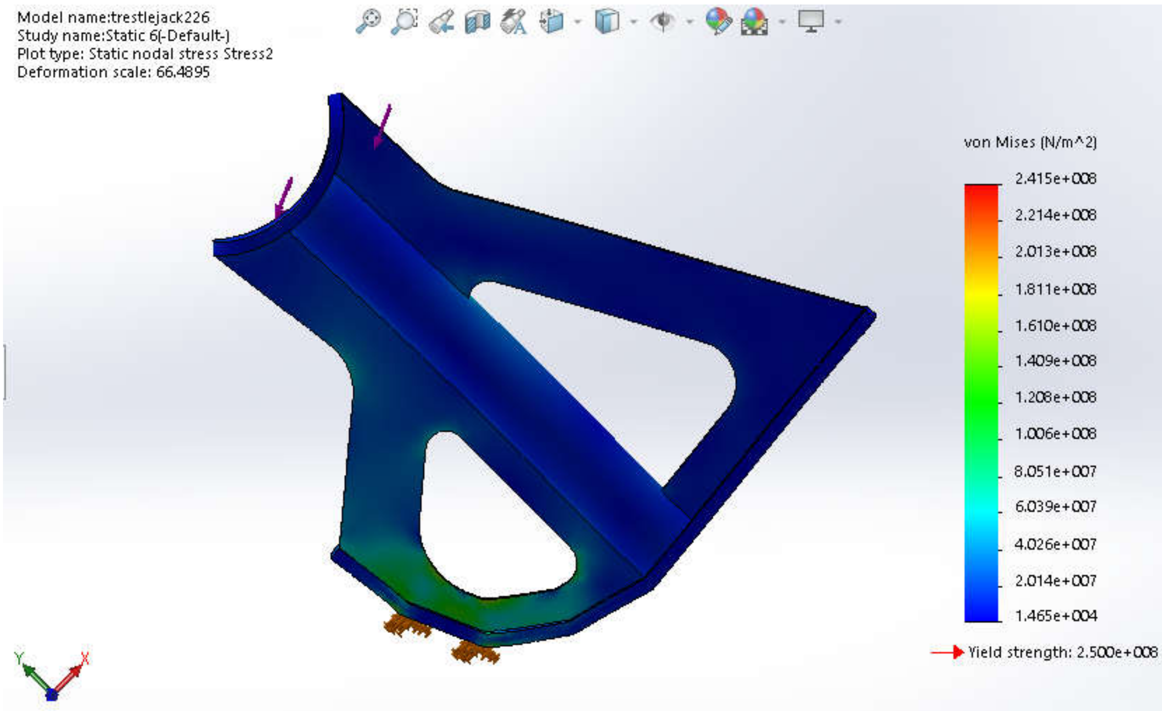

Fig 7.2 von Mises stresses at first stage (deformed model)

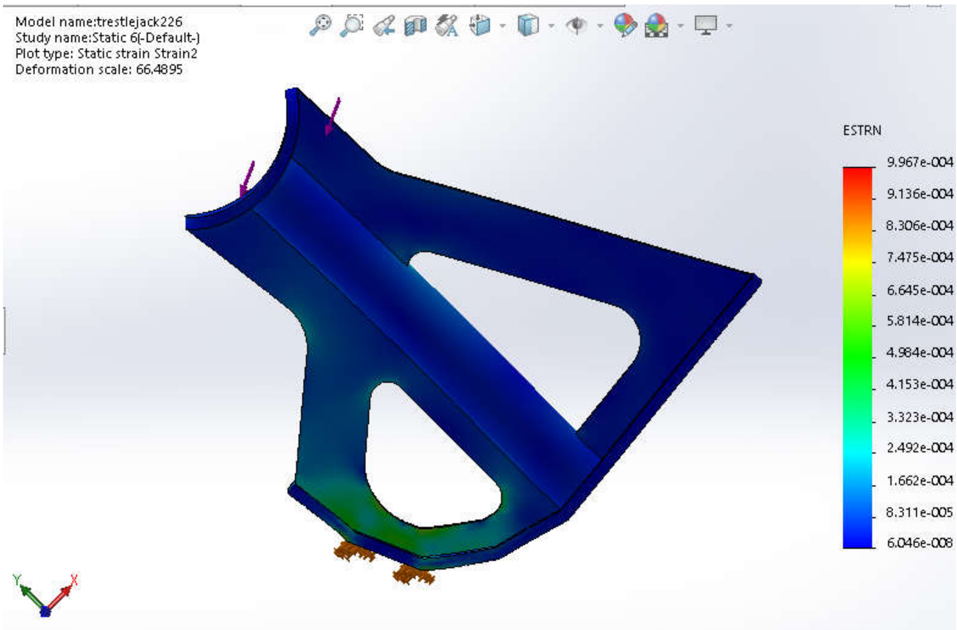

Fig 7.3 Deformation scale at first stage (deformed model)

7.1.2 ANALYSIS AT SECOND STAGE

This is the actual initial position for vehicles with ground clearance 200mm. The study is set as static structural analysis and material is applied (Mild steel). In the 'Fixed Geometry' tab, the second face adjacent to the face in the initial stage is fixed and load of 9810 N is applied on the axle holder perpendicular to the fixed face in reversed direction. Mesh is generated and the desired results are obtained such as von Mises stresses, factor of safety and deformation scale.

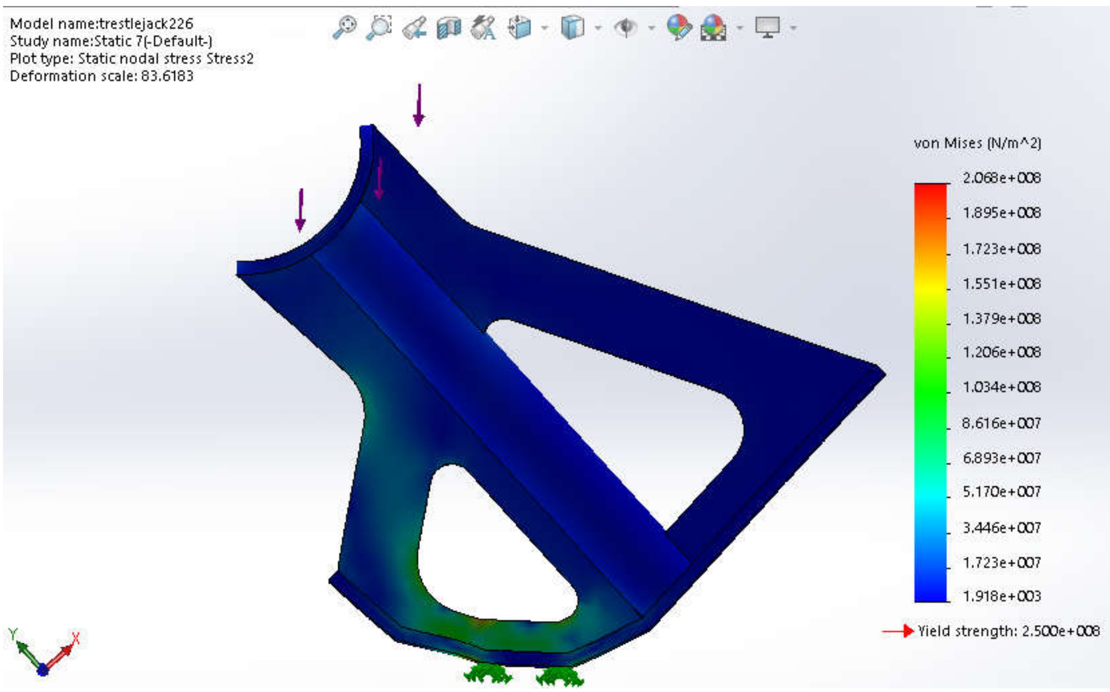

Fig 7.4 von Mises stresses at second stage (deformed model)

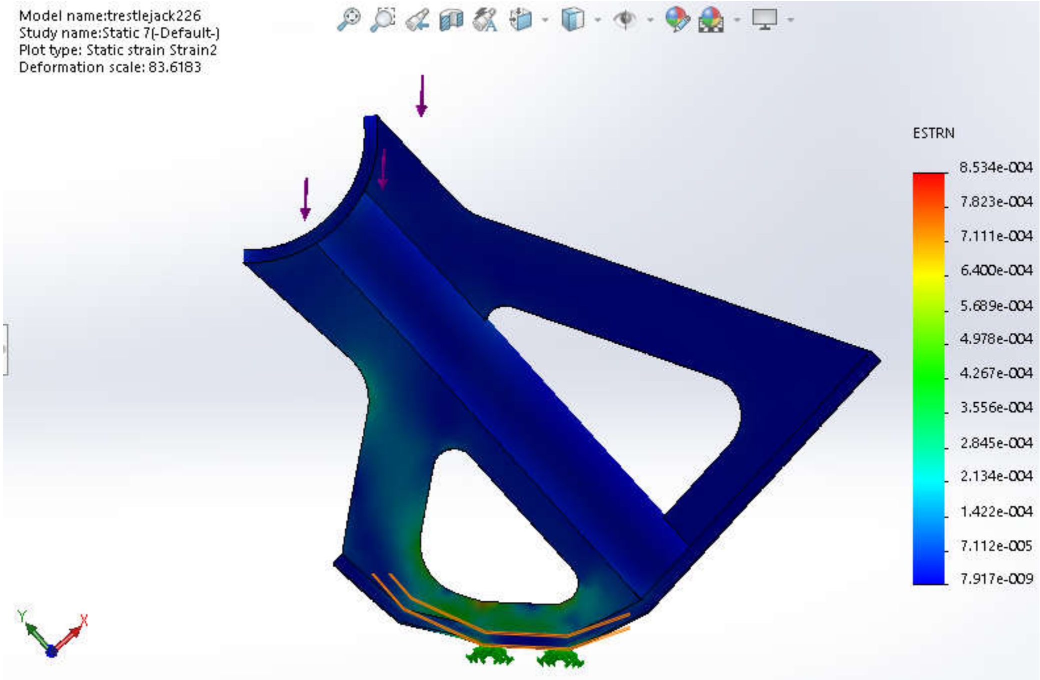

Fig 7.5 Deformation scale at second stage (deformed model)

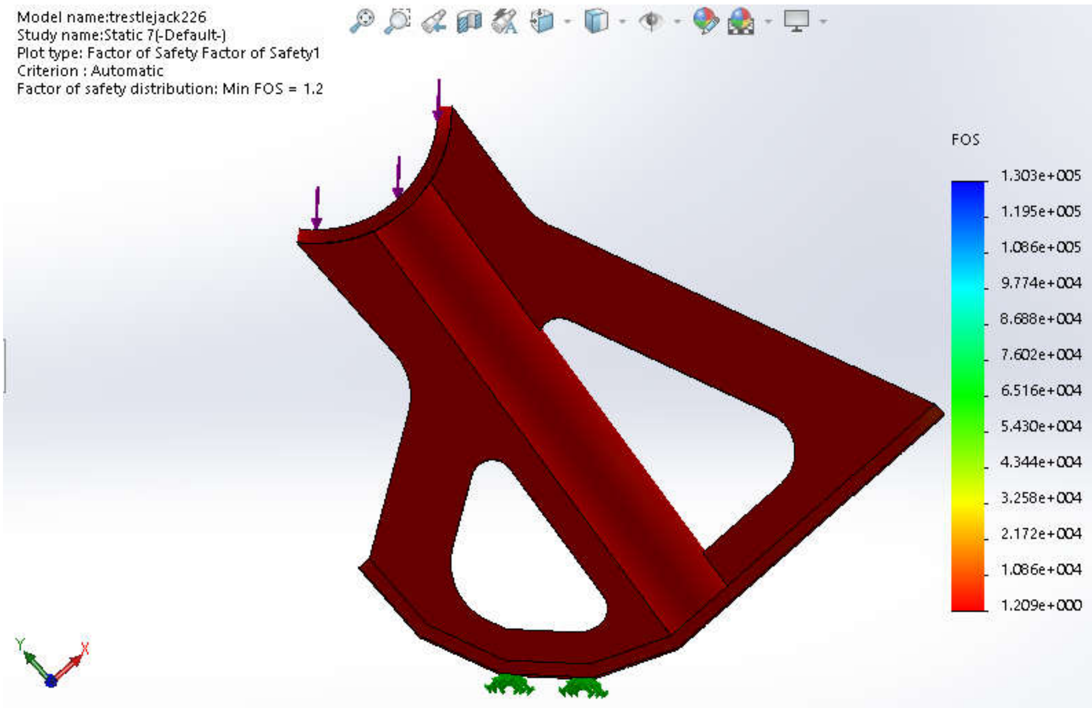

Fig 7.6 Factor of safety at second stage (undeformed model)

7.1.3 ANALYSIS AT THIRD STAGE

This is the stage before the jack attains the loaded position. In this stage, the fixed face is the face adjacent to the flat base plate. By performing static structural analysis with material as Mild Steel applying a load of 9810 N perpendicular to the fixed face, the von Mises stresses, deformation scale, strain and factor of safety are obtained. The results are shown in the below figures.

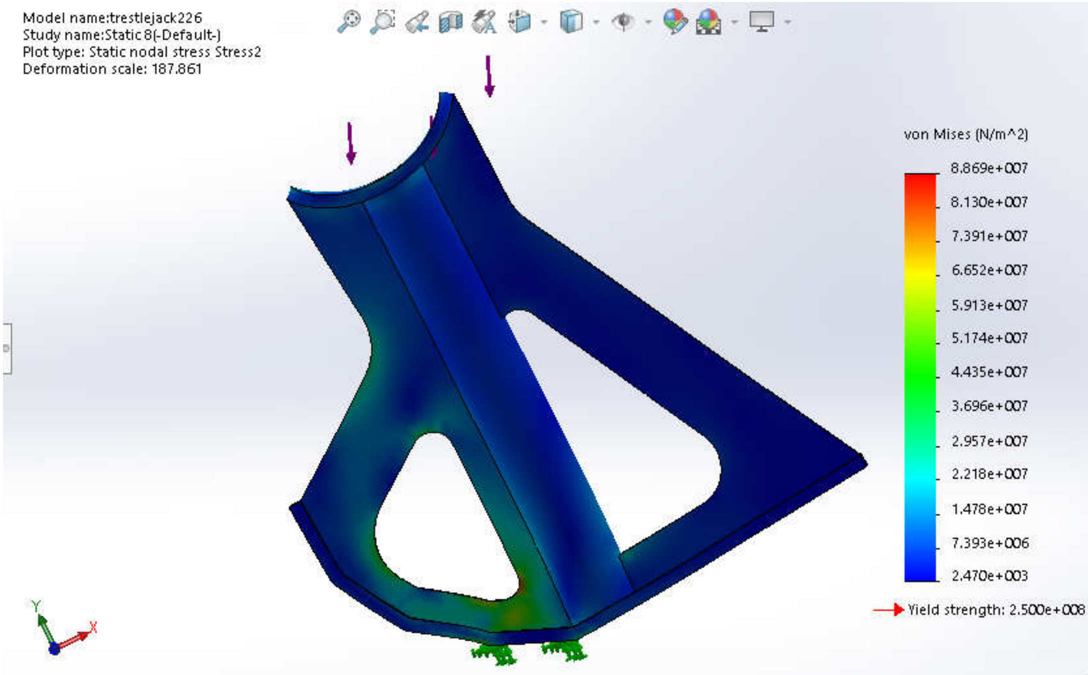

Fig 7.7 von Mises stresses at third stage (deformed model)

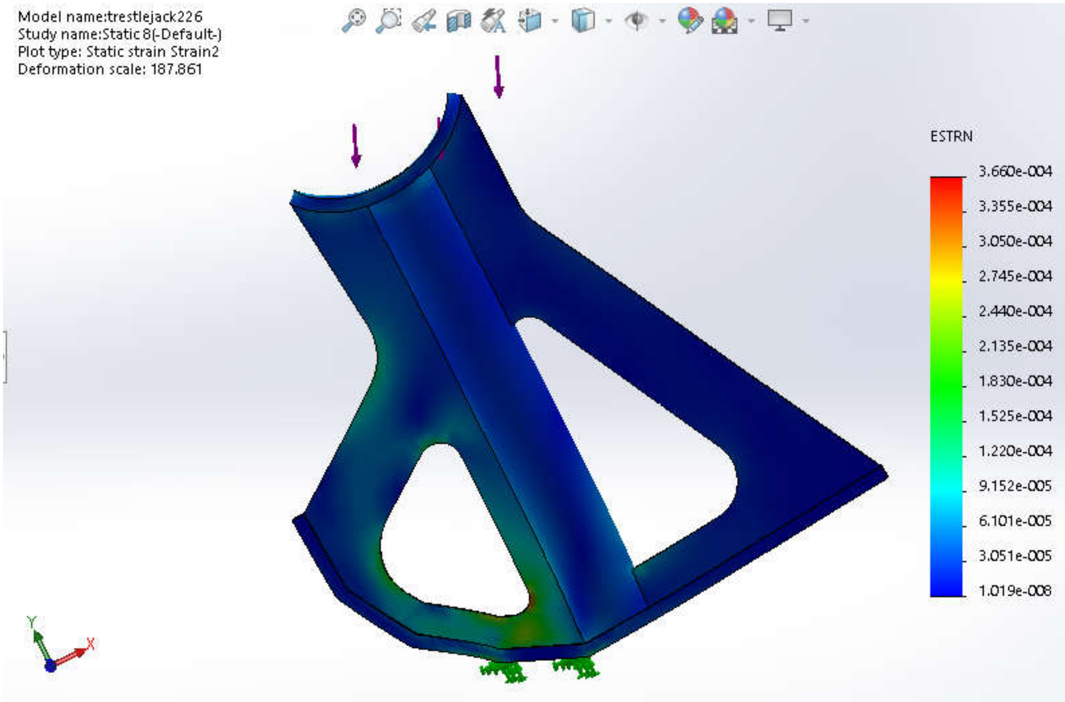

Fig 7.8 Deformation scale at third stage (deformed model)

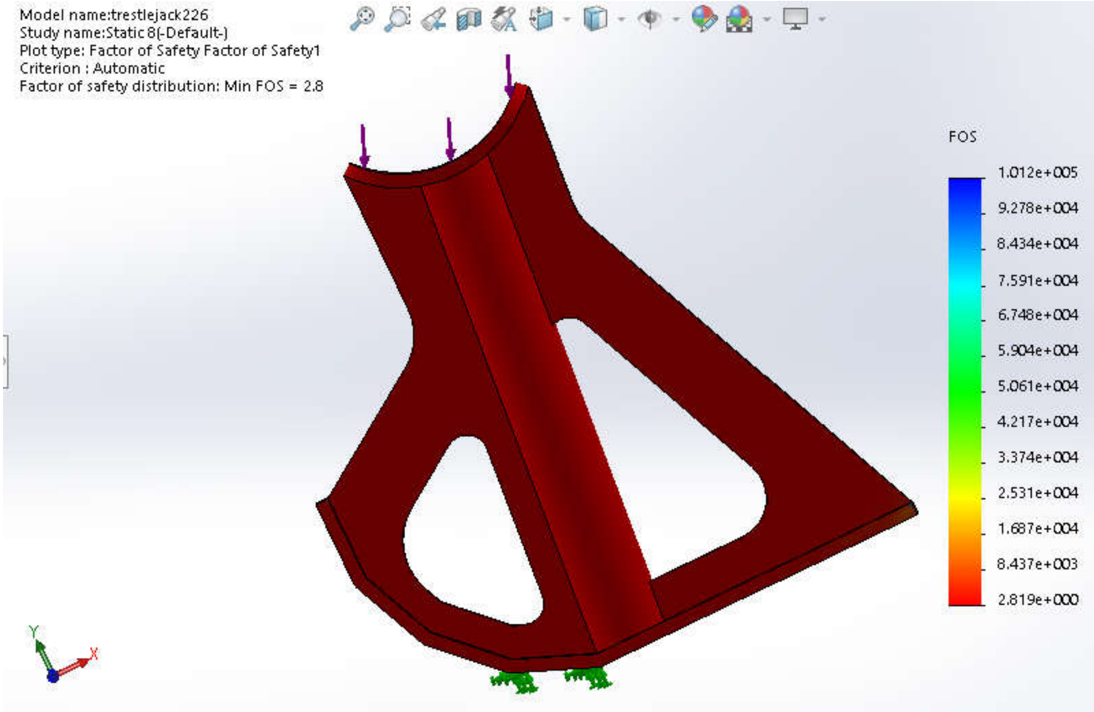

Fig 7.9 Factor of safety at third stage(undeformed model)

7.1.4 ANALYSIS AT FINAL STAGE

It is the stage where the TrestleJack attains its final position (upright position). At this stage the jack is at a resting position such that any kind of required activities such as repairs, changing tires etcetera can be performed. In the final position, the flat base plate is selected as the fixed geometry. The load is applied in the direction perpendicular to the flat base plate and in downward direction (negative y-axis). After generating the mesh and running the study, the following results are obtained.

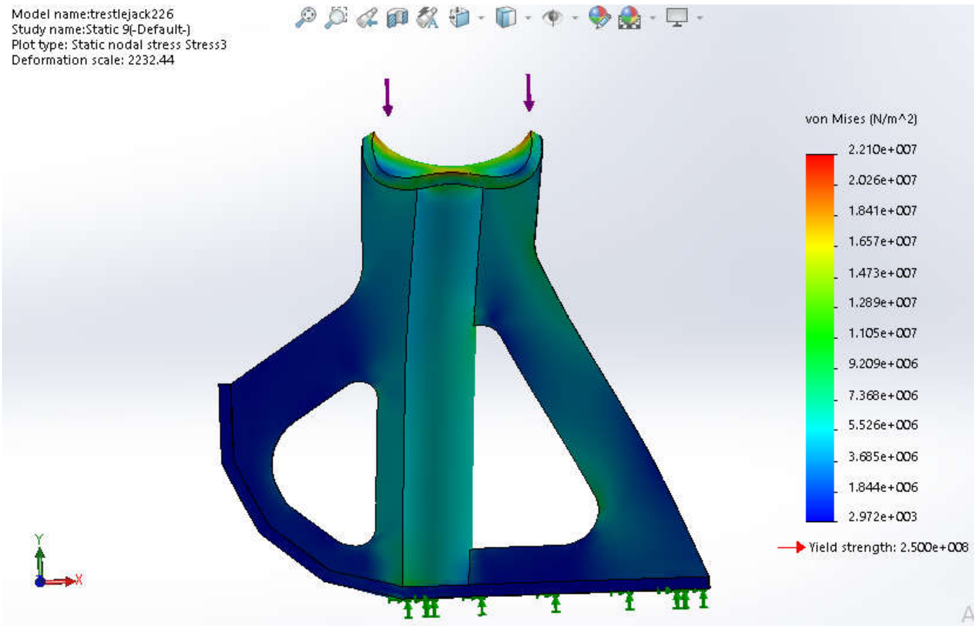

Fig 7.10 von Mises stressesat final stage (deformed model)

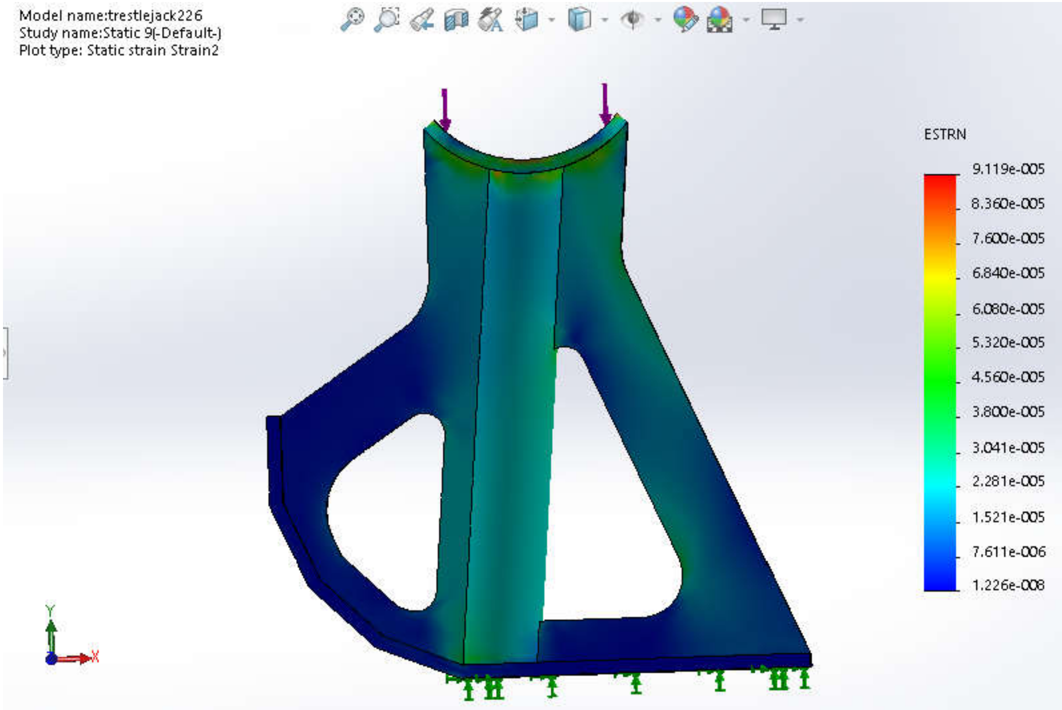

Fig 7.11 Deformation scale at final stage (deformed model)

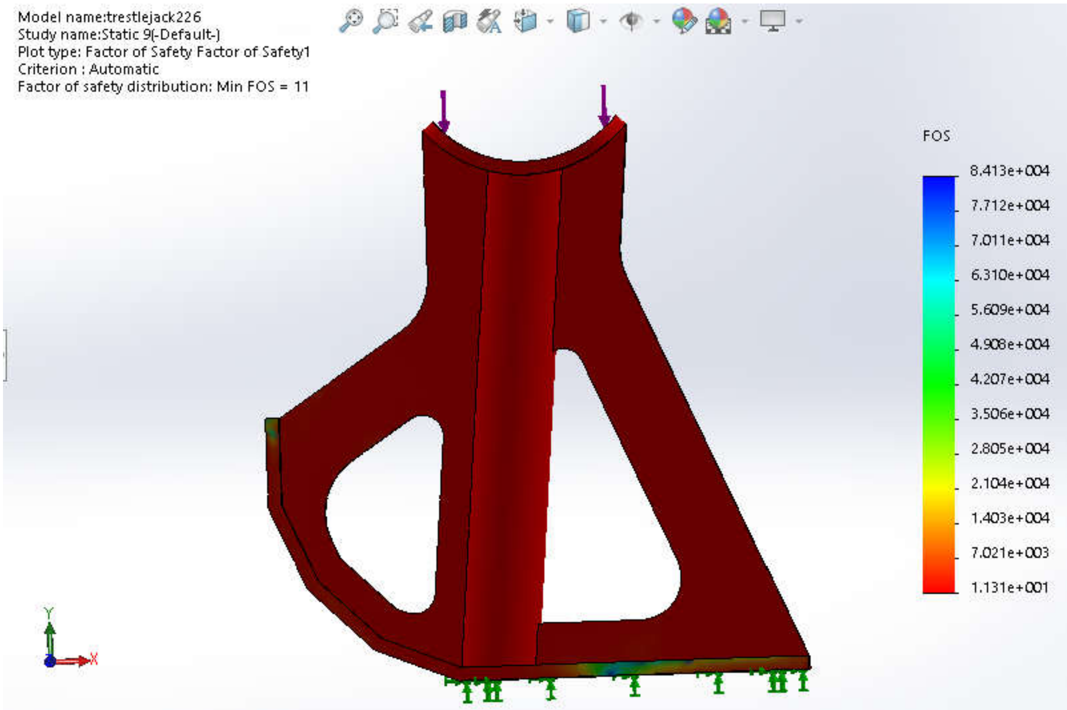

Fig 7.12 Factor of safety (undeformed model)

RESULT

After performing the theoretical calculations on the cylinder when the TrestleJack is in upright position, to support the calculations an analysis using Solidworks simulation has been performed on the solid cylinder. The respective von Misses stresses and the Factor of safety were determined and then compared.

The resultant stress obtained thorough calculations is 37.99 Mpa whereas this value rests in the beginning of the yellow region.

Comparision of the factor of safety results obtained by the theoretical calculations and the anlysis in solidworks simulation are in the following table.

Type of Analysis	Factor of safety
Theoretical	6.501
Solidworks Simulation	6.4 (minimum FOS)

Table 8.1 Factor of Safety values for a solid cylinder

Anlysis was also performed on the designed model of the TrestleJack. This is a static structural analysis on the jack at different stages and the results were obtained such as the von Mises stresses and Factor of safety. The obtained values of the factor of safety are depicted in the given table at different stages of loading.

Stage	Minimum Factor of Safety
Stage 1 (initial position)	1
Stage 2	1.2
Stage 3	2.8
Stage 4 (final position / upright position)	11

Table 8.2 Values of Factor of Safety determined using Solidworks Simulation

Thus the analysis is performed and from the results it has been proved that the jack is safe under the given loading conditions thereby satisfying the design and its purpose.

CONCLUSION

The TrestleJack suitable for 4 wheel drive SUVs have been designed using Solidworks software. Theoretical calculations have also been performed in order to achieve the results and then compared with the same analysis which was performed using Solidworks simulation. After comparison, the results were determined to be closer to each other which provide a proof. Later, analysis using Solidworks simulations has been performed on each stage of loading and determining the results such as von Misses stresses, factor of safety and deformation scale which had proved that the TrestleJack is safe under the specified loading conditions for a 4 wheel drive SUVs. Thus a safe design of TrestleJack for a four wheel drive SUV with ground clearance of 200 mm has been made which is the aim of our project.

FUTURE SCOPE

In the future, the TrestleJack can be designed with adjustable pins such that a single jack can be used to perform its operation to any car of any ground-clearance. It also has scope to be automated, which means that it can be embedded in the vehicle itself and can come out of the vehicle into action when desired.

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