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# STRUCTURAL ANALYSIS OF MECHANICAL JACK SYSTEM USED IN VEHICLES

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*Abstract:* In this research paper, we perform generative structural analysis for various components. Generative Structural Analysis (GAE) enables designers to understand how their designs behave and accurately calculate the displacements and stresses in a component or assembly under various loading conditions. The primary role of structural study and analysis is to determine the internal loading and support responses of a structure subjected to mechanical loading, forced deformations, and settlement of supports. The parameters considered are stress concentration, equivalent stress and total strain and so on. Using various software like Solid works, Catia etc. This project covers the basics of Generative Structural Analysis (GSA). It gives you the knowledge to effectively use finite element structural analysis software to reduce design time. This gives individuals the opportunity to apply their knowledge through real-world scenarios and examples.

**Keywords: Car Jack, Screw Rod, Analysis, Modeling.**

## I. INTRODUCTION

A jack is a mechanical lifting device used to apply large forces or lift heavy loads. A mechanical jack uses a screw thread to lift heavy equipment. A hydraulic jack uses hydraulic power. The most common form is a car jack, floor jack, or garage jack that lifts vehicles to perform maintenance. Jacks are usually rated for maximum load capacity (for example 1.5 tons or 3 tons). Industrial jacks can be rated for many tons of loads.

Car jacks are lifting devices that raise your vehicle either by purely mechanical means, electrical power or hydraulic power. Jacks come in three main forms: scissor, bottle, and floor, and each has its advantages and disadvantages, with specific weight limits for each piece. They are available in various price ranges. Like spare tires, some vehicles come with a jack and some don't. A jack is a mechanical device that is used to raise the car by its hydraulic power so that you can change a tire and perform any maintenance. In today's world, we can get auto parts and tools easily at any store. As DIY methods grow, it is equally important to discuss an effective way of getting the job done. After all, a car is part of a complex machine and needs to be handled just as effectively.

A car jack is also an essential tool that is mostly needed in repair situations. One of the most common reasons people use jacks is to change tires. But really, if you want to lower any part of the car, you'll need a jack. They are designed to lift the weight of the vehicle so you can get a real view of what is going on under the body. Working under the vehicle also means you'll need heavy-duty, high-quality jack parts and axle stands to ensure safety.

Having a jack in the garage is always handy. However, there is a lot of confusion about how a car jack works, why it is needed and when it is employed. Before you know how to use a car jack, you should first know what different types of jacks are available.

## II. History of Car Jack: -

A car jack is a device used to lift a vehicle for repair or cleaning purposes. The first car jack was invented in the early 20th century by George Jack, a Scottish engineer.

Trolley jacks, bottle jacks, and scissor jacks are the three most common automotive jacks. Some types are more stable than others and they all do the same thing but in slightly different ways. It should be placed under the lifting point and then turned clockwise until the vehicle is off the ground. A bottle jack, like a trolley jack, uses hydraulic power to lift the car. To lower it back down, remove the handle and turn the safety valve clockwise to open it. Axle stands are only allowed to be used on firm, level ground in the same way that any type of jack can be used.

William Joseph Curtis, a British inventor, is credited with inventing the automobile jack in 1840. In order for the user to change a tire, the jack must be able to lift part of the car under a wide range of conditions. The support base rests on the ground to support the jack, the arms that pivot at points to form a 4-bar connection, the top that connects to the car, the threaded rod that pulls the arms together, the thrust bearing and the threaded rod to thread the rod could rotate The design analysis for the environment (DFE) shows no impact on the environment while the device is in operation and it can be recycled at the end of its use. A jack is most likely to fail due to user error rather than mechanical failure. We can study how users and the lifter react during normal use by studying how they react to typical use. A jack is commonly used to lift a car when changing a tire. The jack was designed with a few simple components that can be made quickly and easily. Sheet steel is used to press and bend most parts, making them easier to manufacture.

A car jack is not only a necessity, but also the pride of every car enthusiast. Having the right jack is important to keep your vehicle running smoothly, whether you're a weekend mechanic or a full-time professional. The most common are light stands made of aluminum or light steel, and the most common are heavy stands made of cast iron or steel. These jacks are available in various shapes and sizes for lifting small and large vehicles, heavy and heavy trucks and larger vehicles. To lift your vehicle safely, make sure you have a car jack with the appropriate load capacity. When purchasing a jack, you must consider the weight of your vehicle. If you use a stand that is too heavy to support the vehicle, you and the vehicle may be damaged. It is important that you use the jack correctly and safely, as it depends on the weight and size of your vehicle.

## III. Working:-

Car jacks basically work on three mechanisms which are mechanical and hydraulic mechanism. A mechanical car may have a lifting screw or ratchet system to slowly raise the vehicle.

To clarify, when the screw jack unit is operated, the rotation of the worm shaft also causes the rotation of the worm wheel. The lead screw is attached to the worm gear to rotate the screw jack and they rotate at the same speed. As the worm wheel rotates, the frictional forces on the screw thread also act to rotate the nut.

Automotive jacks also known as scissor jacks. As this is a common and simple type, as a result they are generally used on smaller cars. It is small and portable, fits in a small space. Since they work on the principle of mechanical jacks, they use a screw mechanism to lift the car.

Depending on the model you have, their lift height is relatively small, ranging from 15 inches to 30 inches. The advantage of a scissor lift is its safety, especially compared to high-lift lifts and farm lifts, which require more care and expertise. In addition, they are also lighter and cheaper than floor jacks.

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## IV. Problem Statement

Using modeling software, we need to prepare a three-dimensional model of an effective Car Jack with the right design, material, dimensions and strength. To also perform a complete structural analysis of the model using the software. From the results of the analysis, we will judge whether the model is safe for the above parameters or not.

The material properties and dimensions of the model are listed below:

**Material Properties:**

- Yield strength : 4.6e+08 N/m^2
- Tensile strength : 5.6e+08 N/m^2
- Elastic modulus : 2.05e+11 N/m^2
- Poisson's ratio : 0.285
- Mass density : 7,850 kg/m^3
- Shear modulus : 8e+10 N/m^2

**Dimensions:**

- Base:
  Length: 144mm
  Height: 50mm
  Width: 12 mm
- Arms/Pins:
  Width: 6.5 mm
  Diameter Width: 12 mm
- Screw Rod:
  Total Length: 550mm
  End diameter: 25mm
  Rod Diameter: 24mm
- **Thickened Joint :**
  Length: 75 mm
  Width: 38 mm
  Height: 38 mm
  Circle Diameter: 12 mm
- Top Resting Cup:
  Outer Diameter: 29.84 mm
  Inner Diameter : 27.68 mm
  Rod Diameter: 12 mm

## V. Softwares Used:

**Modeling software**: SOLIDWORKS 2022

Solid Works is a computer-aided design (CAD) and computer-aided engineering (CAE) application for solid modeling published by Dassault Systems. Solid Works is a solid modeler and uses the parametric function approach originally developed by PTC (Creo/Pro-Engineer) to create models and assemblies. The software uses the Parasolidmodelling core. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Design intent is how the component creator wants to respond to changes and updates. Elements refer to the building blocks of a component. Creating a model in Solid Works usually starts with a 2D sketch. A sketch consists of geometry such as points, lines, arcs, conics (except hyperbolas), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity.

The assembly contains analog relationships and a bond sketch. Just as sketch relationships define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly relationships define equivalent relationships with respect to individual parts or components, allowing easy construction of assemblies.

**Analysis Software:** Solid works 2022 R2

SOLIDWORKS is a general-purpose, finite-element modeling package for numerically solving a wide variety of mechanical problems. These problems include static/dynamic, structural analysis, heat transfer, and fluid problems, as well as acoustic and electromagnetic problems. The range of problem it can solve is immense. Most of its simulation is performed using SOLIDWORKS Workbench system. It also develops software for data management and backup.

**Modeling: -**

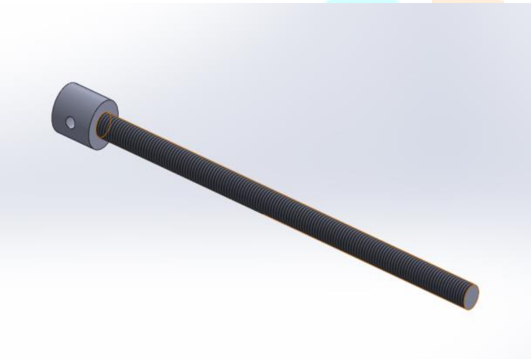
• Run SOLIDWORKS 2022 R2 and select <Part> in the splash window
• Now select <Front Plane> and go to <sketch>
• Use the <Line> tool and then the <3 point arc> to draw the outline of the car jack
• Now click on <Exit sketch> and go to < Features>
• Select <Excruded boss/base> and select the axis of the Car Jack base
• Now click <Ok> and the jack base is ready.
• Now select <Top plane> and go to <sketch>
• Use the <Straight Line> tool to draw the outline of the shoulder/Pivot.
• Now click on <Exit sketch> and go to < Features>
• Select < Circle > and click on the end center point of the Arm/Pin groove that was extruded.
• Now click on <Exit sketch> and go to < Features>
• Select < Extrude Boss/ Base> and the Pin/Arm is ready.
• Now select <Top plane> and go to <sketch>
• Use the <Circle> tool to draw the outline of the top of the bolt.
• Now click on <Exit sketch> and go to < Features>
• Select < Extrude Boss/ Base> and select the screw rod circle.
• Now click <Ok> and select the back side of the extended cylinder and click <sketch> to draw a circle.
• Select the circle and click <Excruded boss/base> to the desired length.
• Click on <Annotation> and select <Cosmetic thread> and select both edges of the rod.
• Now click <Ok> and the jack bolt is ready
• Now select <Top plane> and go to <sketch>.
• Use the <Line Groove> tool to draw the contour of the reinforced joint.
• Now click on <Exit sketch> and go to < Features>
• Select <Circle> and click on the end center of the slot whose slot has been removed.
• Now select <Cut Excruded> and click on the circles.
• Now click <OK> and the reinforced link is ready.

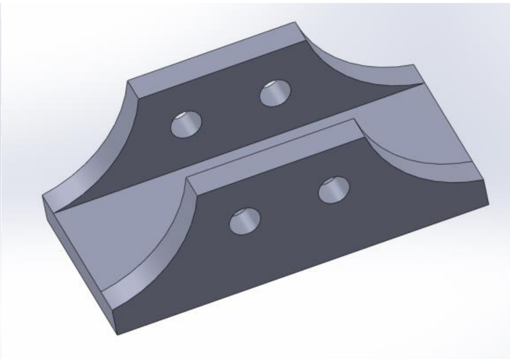
**Assembly: -**

• Run SOLIDWORKS 2022 and select <Assembly> in the opening window.
• Select the previously designed screw base and insert it into the assembly.
• Now match the circular holes of the screw rod with the circular hole of the 4 pin/arm.
• Now connect the circular pin/arm holes to the reinforced joint holes.
• The additional holes of the reinforced joints connect to the other 4 arms/pins.
• The top pin/arm holes match the top support cup.
• Now connect the circular end face of the upper support cup to the upper reinforced joint.
• And connect the holes of the upper reinforced joint with the arms/pins. The final outcome of the assembly procedure is shown in the following pictures

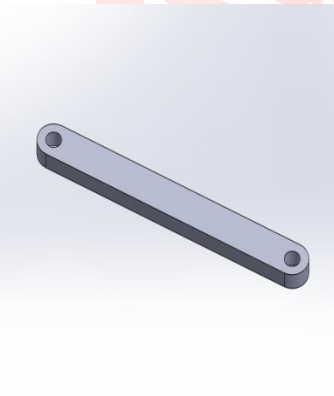
## VI. Car Jack Model Photos:

**Screw Rod:** **Base-Car Jack**

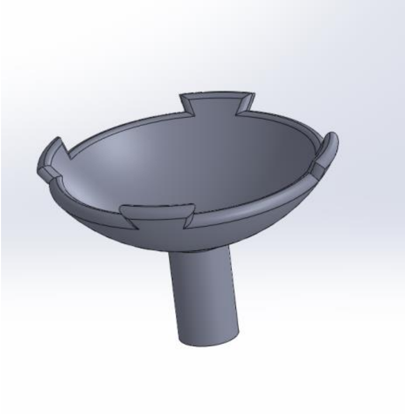




**Pin/Arm-Car Jack:** **Thickened Top:**




**Thickened Joint** **Top Resting Cup**

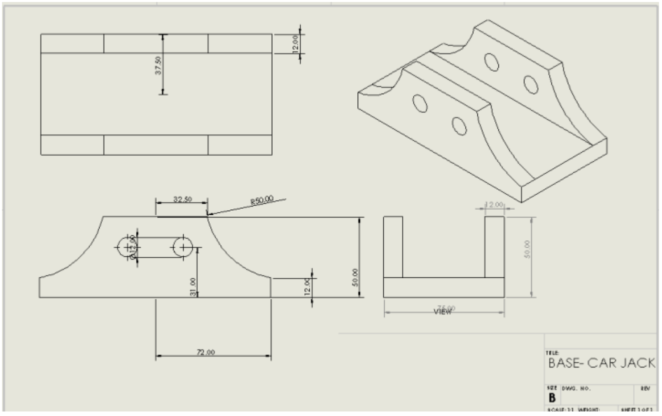


## VII. Analysis Steps

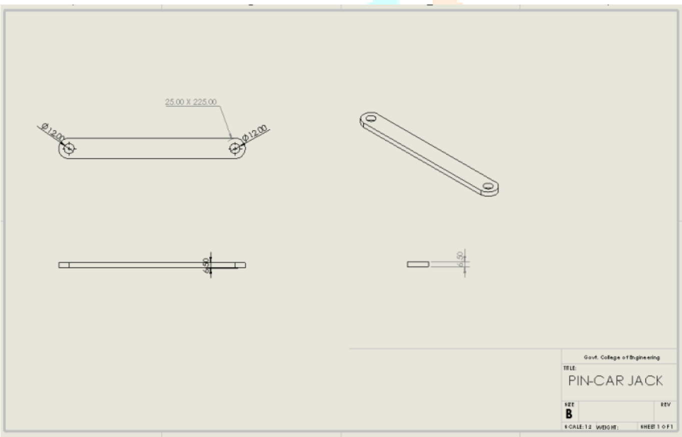
• Open Solidworks and the saved Car Jack.
• Now click on SOLIDWORKS Add-Ins and then select Solidworks simulation.
• Now select the simulation and click New Study.
• In the study dialog box, select the Static Study option.
• Now apply the material by clicking the Apply Material function.
• Now use Fixtures to fix the jack base and then select the external load for which you want to apply the load
2000 N on the rod of the upper part of the jack.
• Now select the mesh option to apply the mesh to the component.
• Now click Run this study and click Repot to generate a study report.

# VIII. DRAFTING

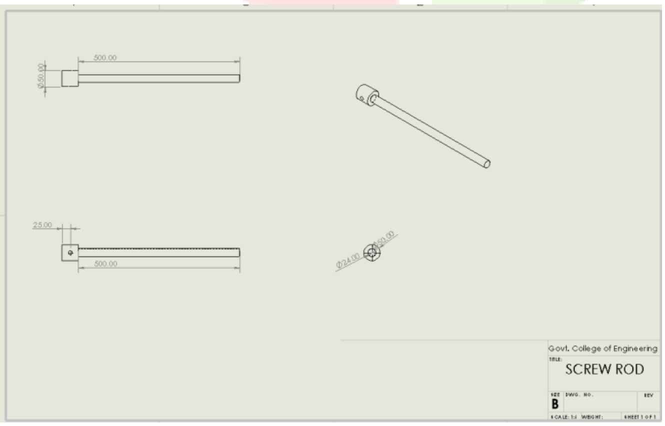
## 1.1) BASE- CAR JACK



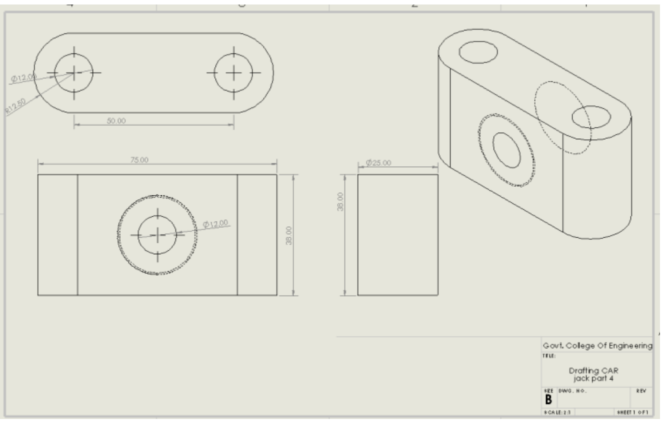

## 1.2) ARMS/ PIN



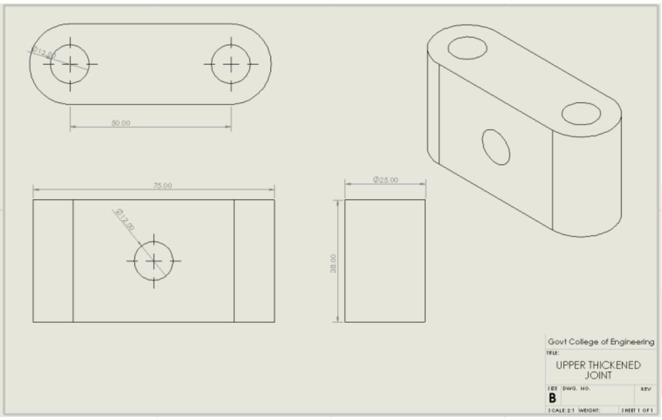

## 1.3) SCREW ROD



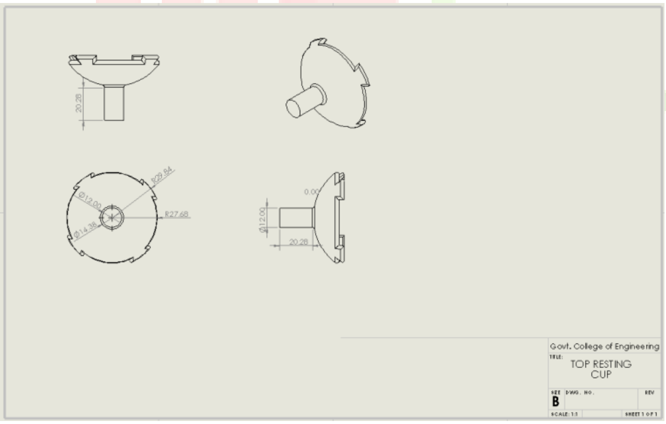
## 1.4) THICKENED JOINT




## 1.5) UPPER THICKENED JOINT




## 1.6) TOP RESTING CUP



## IX. Result and Evaluation

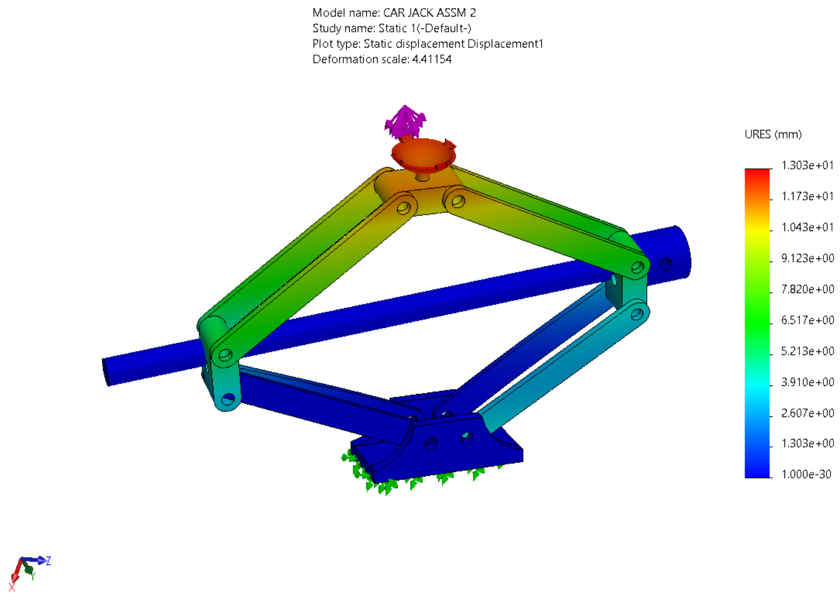
- **CAR JACK Assembly: -**

**Study Properties**

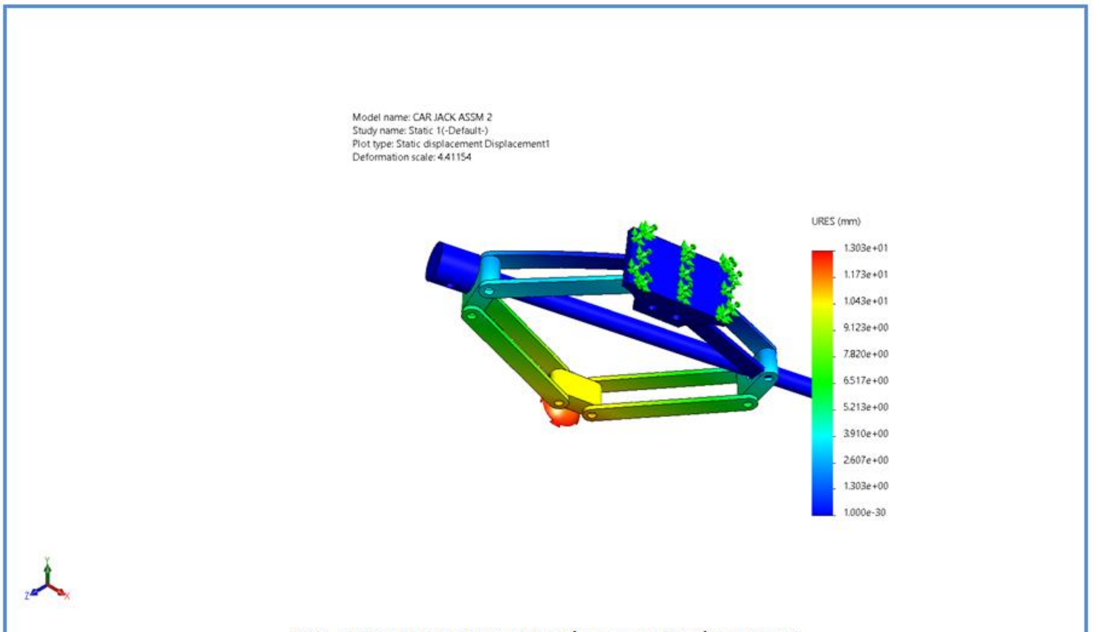
| | |
|---|---|
| **Study name** | Static 1 |
| **Analysis type** | Static |
| **Mesh type** | Solid Mesh |
| **Thermal Effect:** | On |
| **Thermal option** | Include temperature loads |
| **Zero strain temperature** | 298 Kelvin |
| **Include fluid pressure effects from SOLIDWORKS Flow Simulation** | Off |
| **Solver type** | Automatic |
| **Inplane Effect:** | Off |
| **Soft Spring:** | Off |
| **Inertial Relief:** | Off |
| **Incompatible bonding options** | Automatic |
| **Large displacement** | Off |
| **Compute free body forces** | On |
| **Friction** | Off |
| **Use Adaptive Method:** | Off |
| **Result folder** | SOLIDWORKS document (D:\my data\CAME) |

- **Study Results**

| **Name** | **Type** | **Min** | **Max** |
|---|---|---|---|
| Stress1 | VON: von Mises Stress | 0.000e+00N/m^2 Node: 1 | 5.700e+08N/m^2 Node: 35217 |



| Name | Type | Min | Max |
|---|---|---|---|
| Strain1 | ESTRN: Equivalent Strain | 0.000e+00<br>Element: 1 | 1.571e-03<br>Element: 34028 |




CAR JACK ASSM 2-Static 1-Displacement-Displacement1

## X. Conclusion

The three-dimensional Car Jack model of the above dimensions was modeled in SOLIDWORKS 2022 software and its structural analysis was carried out in Solidworks R2 2022. The structural analysis was mainly carried out for Von Mises stress, Von Mises strain and total strain. The numerical data that was obtained from the analysis report was mentioned in the previous section.

The results that were obtained from the analysis concluded that the Car Jack design modeled by us is safe and does not show any deformation for the stress and strain values used. Also, there is no significant change in the geometry of the Car Jack due to the applied forces.

We also conclude from the analysis that the construction, dimensions, material used in the modeling, assembly and analysis of the Car Jack model are safe and do not violate the purpose of the Car Jack. Thus, the observations made in the entire procedure from component modeling, component assembly to static analysis of the model proved to be successful and their numerical data is included in this report.

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