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The Quicklift: Redefining Car Jack Dynamics & Design

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Abstract

A Jack is a tool that aids in raising the vehicles without considerable physical efforts and thereby reducing strain injuries. This paper is about designed model of Jack and performing the static analysis (viz:structural) with the help of Solid works software. The outcomes obtained demonstrates that jack can be used safely. Additional improvements to be made in the jack is by modifying the vertical cylindrical bar so that it can accommodate various vehicles with different ground clearances, thus offering broad range of applicability in automotive sector. In future upgrades, we will integrate this jack into the chassis of the vehicle, making it fully automatic, so that vehicle lifting does not need to be done manually, which saves a lot of time. In addition to the structural analysis, detailed stress–strain evaluation was conducted to identify critical regions subjected to maximum load concentration. The simulation results from SolidWorks indicated that the designed jack maintains stresses within permissible limits of the selected material, ensuring structural integrity under standard vehicle loading conditions. The factor of safety calculated from the analysis confirms that the design can withstand static loads typically encountered during maintenance operations such as tire replacement and underbody inspection. Material selection was carried out considering strength, weight, corrosion resistance, and cost-effectiveness. High-strength steel alloy was preferred due to its durability and load-bearing capability, while maintaining economic feasibility for mass production. The threaded mechanism and base plate were optimized to ensure even load distribution and enhanced stability on uneven surfaces. Ergonomic considerations were also incorporated into the design to minimize user effort and enhance operational safety. The base geometry was widened to improve balance, and anti-slip surface features were proposed to prevent displacement during lifting. Additionally, the modified vertical cylindrical bar design enables height adjustability, increasing compatibility with sedans, SUVs, and light commercial vehicles.

Keywords: Quicklift, SolidWorks, CAD model, von Mises stresses, software analysis

INTRODUCTION

Automotive maintenance and repair often need tools that are efficient, stable, and safe to use. One such tool is a car jack, which provides support for lifting vehicles, this allows us to perform underbody operations and tire change. Though the traditional car jack such as scissor jack and hydraulic type jack are widely used, they have certain limitations in terms of user efforts and ease of operation. Addressing these limitations, the Quicklift car jack introduces a unorthodox design; a hexagonal shaped mechanism engineered to enhance load distribution and minimize human efforts[1].

The design of Quicklift provide better stability during lifting also even distribution of forces across its frame and resistance to lateral forces. In this paper, we will explore the engineering principles behind this innovative design, and assess its performance

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through load testing and safety analysis. We will also examine how the Quicklift enhances the user experience, making car maintenance more accessible and efficient for both professional mechanics and everyday users.

METHOD OF DEVELOPMENT

Objective

A Quicklift car jack is a device that lifts heavy cars, enabling you to work on portions of vehicles that require maintenance or simply tiring a wheel, in a very simple way. The first and most noticeable benefit of Quicklift car jack is the mechanical advantage it gifts the user with by converting rotational force into linear, lift heavy constructed up the user would find it impossible to do without this tool. There are jack structures which are based on having a screw-threaded part which is responsible for height changes and others through hydraulic or pneumatic but at a higher cost. However, Quicklift car jack is design as semi- automatic jack which require negligible effort to jack up the car [2-5].

Methodology

- Identification of topic.
- Literature survey.
- Preparing synopsis.
- Study of equilibrium stress analysis.
- Weight calculation and operation time.
- Design of beam of the jack as per capacity.
- Calculation of stresses.
- Study of various material suitable for Jacks.
- Validation by using software's
- Manufacturing of Jack

THEORETICAL ANALYSIS

Since the jack is a highly intricate structure for theoretical calculations, it has been simplified as depicted in Figure 1. For the theoretical analysis we have considered the solid cylinder and the base plate . This simplification is made because the structure is too complex for theoretical evaluations. Additionally, calculations focus solely on the solid cylinder since it supports the majority of the load applied to the jack in its final position [6].

A weight of 3000kg (29430N) is exerted on the top of the solid cylinder. This force is directed downwards along the negative y-axis. Given that vertical cylindrical bar is tilted with an angle of 50° relative to the upstanding, the impact force do not align with the cylinder's axis. Instead, it applies at an angle concerning the cylinder's axis. Therefore, the force can be decomposed into two components: vertical and horizontal loading [7].

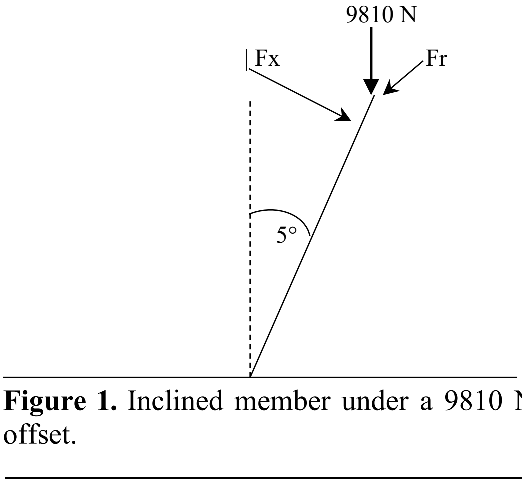

Figure 1. Inclined member under a 9810 N load showing force components F_x and F_r with a 5-inch offset.

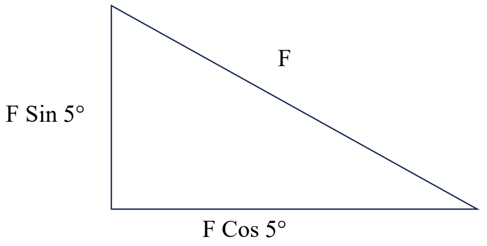

Figure 2. Force vector resolution diagram.

The breakdown of the force applied onto these vertical components and horizontal component is illustrated in the FDD referenced in Figure 2.

VERTICAL LOAD CONDITION

Applying Vertical load condition the idea of loading to a short column.

The axial load exerted on the cylinder is calculated

P X cos (5^{o}) = Pv

29430 X (cos 5^{o}) = 29318.5 Pv = 29318.5 N

6c= Pv/A Where,

6c denotes stress in compressive and the vertical load is denoted by Pv.

‘A’ denotes c/s area of the vertical cylindrical bar

A = 3.14 ∗ r^2

6c = (29318.5)/{3.14*(19.2*10^-3)^2}

6c = 25328510 N/m2

6c = 25.33 N/mm2

Horizontal Load condition

Applying Horizontal load condition the idea of load applied on a cantilever beam The perpendicular force is applied to cylinders bottom that is secured at the base [8]

P X sin (5^{o}) = Ph

29430 X cos(85^{o}) = 2564.99 Ph = 2565 N

Now, Bending Equation is , 6/y=E/R =M/I

Where,

M denotes momentum

I denote moment ofinertia and E denote modulus of elasticity.

R denotes the beam curvature radius .

6 denotes the bending stress.

Y denotes the length measured between the line of a beam not suffering extension and the beam outermost layer.

M = Ph X(length of the cylindrical bar L)

L = 240.9 mm

M = 2565X(240.9X10$^{\wedge-3}$) = 617.91 N - m

Dia of c/s D =38.4 mm

It suggest ,r = 19.2 mm I = 3.14Xd^4 /64

6b/ {(38.4/2)X10^{-3}}= 617.91/{3.14X(38.4X10$^{\wedge-3}$)^4/64}

6b=111212058.9 N/m2

6b=111.212 N/mm

Resultant Stress acting on cylinder

The stress which is affecting the body can be represented as illustrated here. The resultant of the two force is calculated by taking the Sq root of the addition of their squares and is represented by the square root of the bending stresses square and compressive stresses squares.

(6 resultant)^2 = [(6 c)$^{\wedge2}$+ (6b)$^{\wedge2}$]

Therefore,

6 resultant = 114.060 N/mm

CAD MODEL

Before developing the model, it is useful to think out how to produce it. A model can be created after the needs have been determined and the relevant concepts have been isolated. Create sketches in the Sketches area, then provide dimension them and apply relations. Then Select the features to utilize, like extrudes and fillets. Choose the characteristics that are most relevant to use. Select the sequence in which to use those features. Choose the components for mating with the types of mates [9].

Procedure

The whole structure has been designed with the help of solid works software. Figure 3. Cad model of the assembled project is designed on Solid works software (Figure 4).

Factor of Safety

As we are known what is the FOS. For mild steel the Ultimate stress 247 MPa as per standard and the calculated Working stress of the Jack is 114.06 Mpa .

So by definition the FOS = (Ultimate stress i:e 247MPa) / (Working stress)

= 247 X 10$^{\wedge6}$ / 114.06 X10$^{\wedge6}$

= 2.1655

FOS calculated theoretically by calculation above is 2.165

Figure 3. CAD Model of assembled project

Figure 4. Isometric view of the model.

SOFTWARE ANALYSIS

We have also used Solid-works simulation to conduct the study on the same cylinder with the same dimensions and characteristics in order to support the analytical calculations. Only the cylinder that was under stress is taken into account, and the rest of the jack has been disassembled in accordance with the limitations applied in the analytical computations.

A 3000 kg weight is put in on the cylindrical link considering on its flat base (29430N). The load is then applied downward by performing static analysis(viz:structural) using MS as the material. All of the stresses and the FOS are ascertained when the mesh is generated.

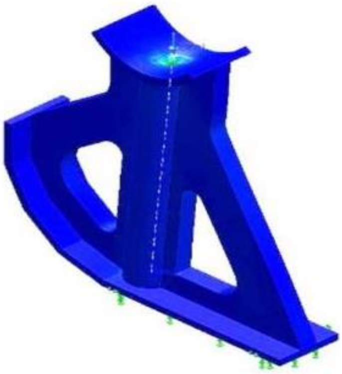

Figure 5. Part1-Static 2-Stress-Stress1

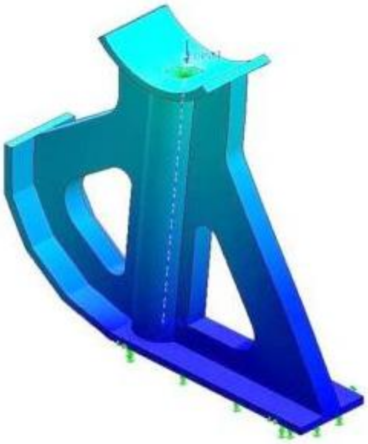

Figure 6. Part1-Static 2-Displacement-Displacement1

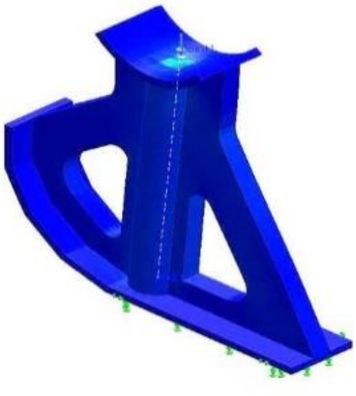

Figure 7. Part1-Static 2-Strain-Strain1

RESULTS

After conducting theoretical calculations on the cylinder with the Lifting Jack positioned upright, a Solidworks simulation was utilized to validate these calculations of the solid cylindrical link. A corresponding von Mises stresses and the FOS were established and later compared (Figure 5–7).

The calculated resultant stress is 114.06 MPa, which is at the lower end of the yellow region. The theoretical calculations yielded a Factor of Safety of 2.1655, while the analysis indicated a minimum Factor of Safety of 2, which supports the accuracy of the theoretical calculations.

CONCLUSION

The jack is designed to accommodate all vehicle types with a ground clearance of up to 240mm and a weight capacity of 3 tons. Theoretical calculations were conducted to obtain results, which were then compared with findings from a Solidworks simulation.

Upon comparing , the results were found to be closely aligned, providing validation. Subsequently, Solidworks simulations were executed at each loading stage to ascertain results such as von Mises stress, safe factor, and changing scales, which confirmed that it is safer to use for the defined load state of all vehicle types. In addition to validating the structural integrity, a detailed load distribution study was performed to evaluate the behavior of the jack under incremental loading conditions. The analytical approach involved calculating compressive stresses, buckling resistance of the vertical cylindrical bar, and shear stresses in the threaded components. These theoretical values were carefully cross-verified with finite element analysis results obtained from SolidWorks, ensuring consistency between mathematical modeling and simulation outputs.

The von Mises stress contours indicated that the maximum stress concentrations occurred near the threaded region and base contact surface; however, these stresses remained well below the yield strength of the selected material. The computed factor of safety at maximum load conditions was within acceptable engineering standards, demonstrating adequate margin against failure. Deformation analysis also showed minimal displacement under full load, confirming stability and rigidity during operation.

FUTURE SCOPE

The jack could be modified with adjustable height, enabling a jack to operate with multiple vehicles of varying ground clearance. Also can have the potential for automation, allowing it to be integrated into the vehicle itself and to activate from the vehicle when needed. It will be directly connected to the vehicle body and controlled by buttons, usable at any place, at any time, and under any conditions In addition to adjustable height functionality, the design can incorporate a telescopic lifting mechanism or multi-stage threaded system to provide precise height control and improved adaptability. This enhancement would allow the jack to efficiently serve compact cars, sedans, SUVs, and light commercial vehicles without requiring separate lifting devices. The adjustable configuration would also improve stability by ensuring optimal contact between the jack head and the vehicle's lifting points.

The automation feature could be implemented using an electric motor or compact hydraulic actuator powered directly by the vehicle's battery system. A control module integrated with the vehicle's electrical architecture would allow operation through dashboard-mounted buttons or a remote key interface. This would significantly reduce manual effort and improve convenience, especially during emergencies such as tire punctures.

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