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Inbuilt Hydraulic Jack System for Light Motor Vehicles and Heavy Motor Vehicles

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Abstract: When a vehicle's tyre fails, it is extremely difficult for humans to lift the vehicle from the ground. This requires a significant amount of human effort and is a time-consuming process. This built- in hydraulic jack system, rather than a traditional mechanical jack, aids in the automatic lifting of the car from the ground level, saving time and labour . It is attached to the car's chassis. This built-in hydraulic approach can be quickly activated using the vehicle's board panel's automatic function buttons. This technique's setup is as follows: the hydraulic jack will be installed close by the suspension system of the car. All older folks, physically challenged individuals, and notably females who realized it difficult to set off the jack manually in any tyre crash situation would benefit greatly from this jack.
Keywords: Hydraulic Jack, tyre crash, easy to operate, pneumatic system, incompressible Hydraulic Oil, Pascal Law

I. INTRODUCTION

Ramachandra C.G, et al. [1] (2013) found that when a car's tyre fails, lifting the vehicle from the ground level is a difficult process that requires a lot of personal effort even when a jack is utilized. Borkar,P.S., et al. [2] (2015) investigated to produce motion mechanically using pressurized air. The pneumatic jack is a manufactured type that, when stationed in four-wheelers, eliminates the complications connected with standard operated jacks.P.S. Rana, et al. [3] they discuss integrated automated jacks for four-wheelers in their case study and said that a car hydraulic jack may be simply activated by the use of a single dash board push button. he jack will be attached to the chassis on both sides in accordance with the weight distribution of the vehicle. Additionally, it will be placed on the automobile's opposite side. There are three main parts that make up the hydraulic driving system: a hydraulic pump powered by an electric motor, and a hydraulic cylinder that lifts the automobile. Depending on the breakdown status, the hydraulic jacks operate independently on either side of the vehicle. The automobile is raised; the advantage of using a hydraulic system over a pneumatic system is that it gives considerable power and is simpler to build, and the load is distributed across three points: the hydraulic cylinder's plunger or ram, and the two tyres on the opposite side of the elevated side.This jack will be extremely useful to all elderly people, especially ladies (women), whoever find it challenging to manually operate the jack, in the event of a breakdown.On the front and back of the chassis, built-in elevating and walefare measures a hydraulic bottle jack system is installed for a four wheeler, according to Rajmohan G, et al. [4] in Inbuilt Lifting Arrangements for Heavy Vehicles. Drop the hydraulic bottle jack with a single button during a puncture or repair that does not need lifting outside.

For heavier vehicles such as trucks and lorries, it will be simple to install a system that will elevate the vehicle from all four sides with a single switch. The hydraulic jack is controlled by a cam that operates on a single slider crank chain system. The lever is attached to a return spring rod, one sliding pair and three turning pairs.Balkeshwar Singh, Anil Kumar Mishra. [5] (2015) This study looks at how a current motor screw jack may be improved by integrating an electric motor inside the screw to make load elevate simpler and control valve regulate air flow. Professor Mali P.K. [6] of the mechanical department at SGREF's G H Raisoni College of Engineering, Ahmednagar stated that pneumatically based fabrication, which is the science and practice of using pressurized air to create motion mechanically.

The pneumatic jack is a constructed type that, when fitted in a four-wheeler, alleviates the issues that arise with the traditionally operated jack. This constructed model includes a compact reciprocating air compressor powered by the four-battery, wheelers in a compressed air tank, pneumatically, and a double acting cylinder used as a jack for raising are all included. As a consequence, the car is elevated using a jack, and tyre-related concerns such as damaged tyres, tyre substitution, and wheel balance may be handled with little labour and hour.Musa Nicholas, et al. [7] (2016) investigated how to reduce the challenges associated with using a single jack and other lifting gear for totally raising automobiles off the ground for repairs.

In their case studies, Parth M Patel and Sunil M Shah [8] have stated that using an improved hydraulic jack design may significantly improve comfort and security.

II. METHODOLOGY

Here, an automated process is employed instead of a manually controlled screw jack. For the fabrication we use Mild Steel frame (1inch × 1inch) by using arc welding joining process on which all the components are installed. We casted two pulleys for power transmission from AC motor to the vane pump, the pulley in the ratio of 1:9. Attached the four nylon wheels to the frame by using two axels and axels supported by the four ball bearings. AC motor mounted one side on the frame by using fasteners and vane pump placed another side of the frame with the help of fasteners. Here we use two 2/2 solenoid valves for oil flow control these also mounted on the frame. Two MS plate box structures used for placing the oil reservoir and battery at front and back side of the frame. We constructed a sliding route for the cylinder's movement on the frame, and the rotational motion of the DC motor is translated to linear motion of the slider by means of a rack and pinion arrangement set on the frame. Here we use two push button for controlling the two solenoid valves separately. Hoses are used to connect the vane pump, oil reservoir, solenoid valves, and cylinder for the oil flow.

III. MATHEMATICAL CALCULATIONS

A. Design Considerations

1) Inner diameter of cylinder = 150 mm
2) Outer diameter of cylinder = 154 mm
3) Thickness of the cylinder = 2 mm
4) Pressure inside the cylinder = $2 N/mm^2$
5) Maximum tensile strength = $407 N/mm^2$
6) Yield strength = 250 MPa

B. Design Calculation

Assuming internal diameter = 45mm

Area = πr^2

$= \pi*(75)^2$

$= 17671.46\ mm^2$

Pressure P = F/A

Assuming pressure force (F) = 20000 N

P = 20000/17671.46

$=1.31\ N/mm^2$

Using Lame's principle

$Px = b/x^2 - a$……………Radial Pressure

$\sigma x = b/x^2 + a$……………Hoop stress

where a and b are fixed values.

$Px = b/x^2 - a$

$1.31 = b/(75)^2 - a$………………(1)

$\sigma x = b/x^2 + a$

$250 = b/(75)^2 + a$………………(2)

By figuring out this equation

b = 706809.375

a = 124.345

For outer cylinder radius Px = 0

$Px = b/x^2 - a$

$0 = 706809.375/x^2 - 124.345$

$x^2 = 5684.032$

x = 75.39

As a result, the cylinder's thickness =

75.39 – 75

= 0.39 mm

As a result, we assume that the thickness of the cylinder is 2 mm.

C. Volumetric *Displacement* Of Vane Pump

VD = $\frac{\pi}{2}$[dc + dr] e × l

VD = $\frac{\pi}{2}$ [50 + 30] 10 × 20

VD = 2.5132 × 102 mm3

VD = 2.513 × 10-5 m3

D. *Discharge Of Vane Pump*

E. *QT = VD* × N

QT = 2.513 × 10-5 × 320

QT = 8.042 × 10-3 m3/min

F. *Pump Torque*

Here we are assuming the mechanical efficiency of pump is 100 %

ηm = $\frac{P \times QT}{Tp \times 2\pi N}$

1 = $\frac{50 \times 10^\wedge 5 \times 8.042 \times 10^\wedge -3}{Tp \times 2\pi \times 320}$

Tp = 20 N-m

G. *Motor Torque*

The power from motor is = the power to the pump

Assuming there is no power loss

$$\frac{2\pi NTm}{60} = \frac{2\pi NTp}{60}$$

$$\frac{2\pi \times 1440 \times Tm}{60} = \frac{2\pi \times 320 \times 20}{60}$$

Tm = 4.44 N-m

H. *Power capacity of AC Motor*

P = $\frac{2\pi NTm}{60}$

P = $\frac{2\pi \times 1440 \times 4.44}{60}$

P = 670.166 watt

P = 0.670 Kw

P = 0.898 hp

So that we are using 1 hp power capacity AC Motor

I. *Power Capacity Of Dc Motor*

Calculation of force

F = $m \times a$

F = 15 9.81

F = 147.15 N

Calculation of torque

T = F r

T = 147.15 0.0435

T = 6.40 N-m

So that we are using 10N-m torque capacity DC Motor.

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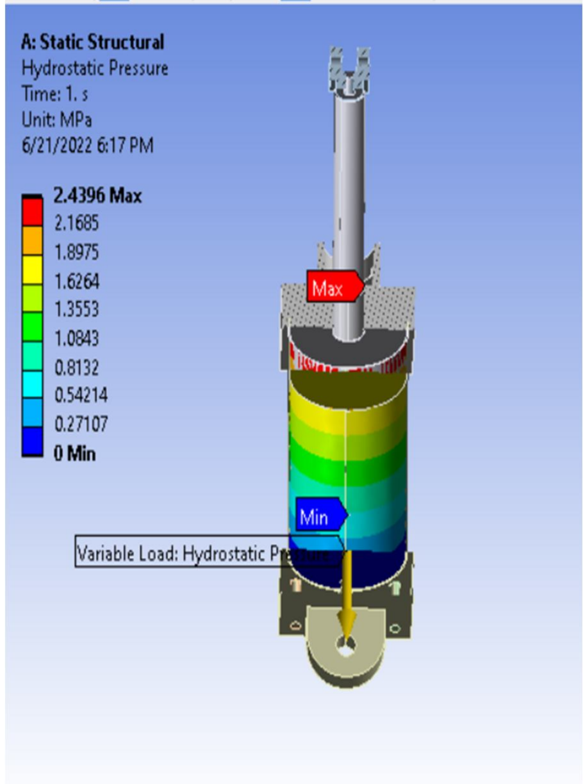
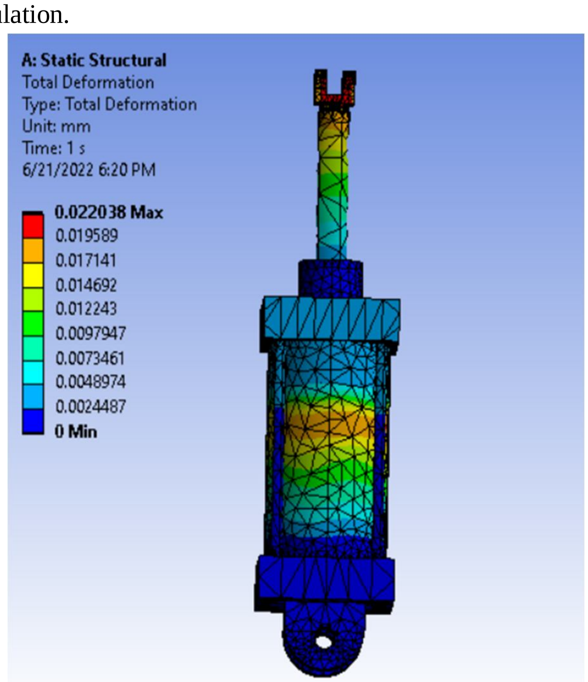
IV. STRUCTURAL ANALYSIS

We have applied 20000N force on a hydraulic jack with grade 46 hydraulic oil and got these results through simulations.

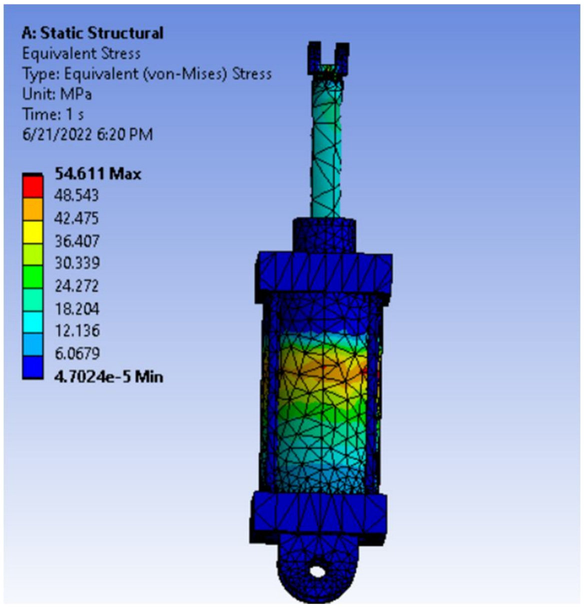


This figure shows us internal tank pressure due to hydraulic oil i.e. 1.6264 MPa (yellow part) and theoretically we got 1.31 MPa. This verifies that our hydraulic jack is feasible and we can use it for our purpose.

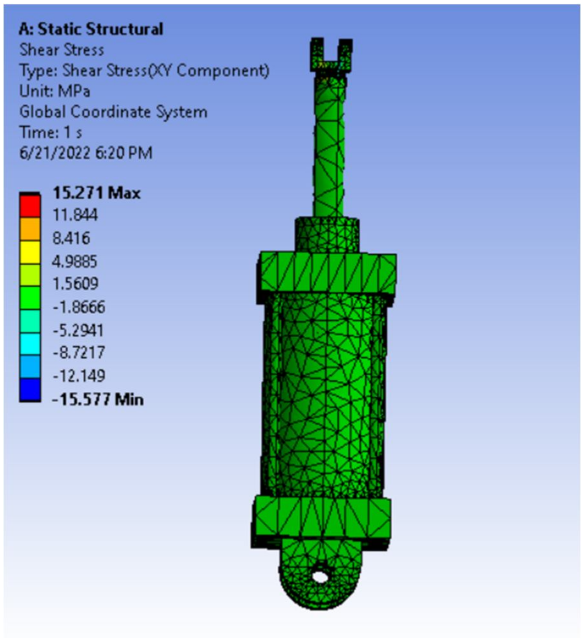
Following are some results of the simulation.



Above figure shows total deformation in the hydraulic jack.



Above figure shows stress in the hydraulic jack.



Above figure shows shear stress in the hydraulic jack.

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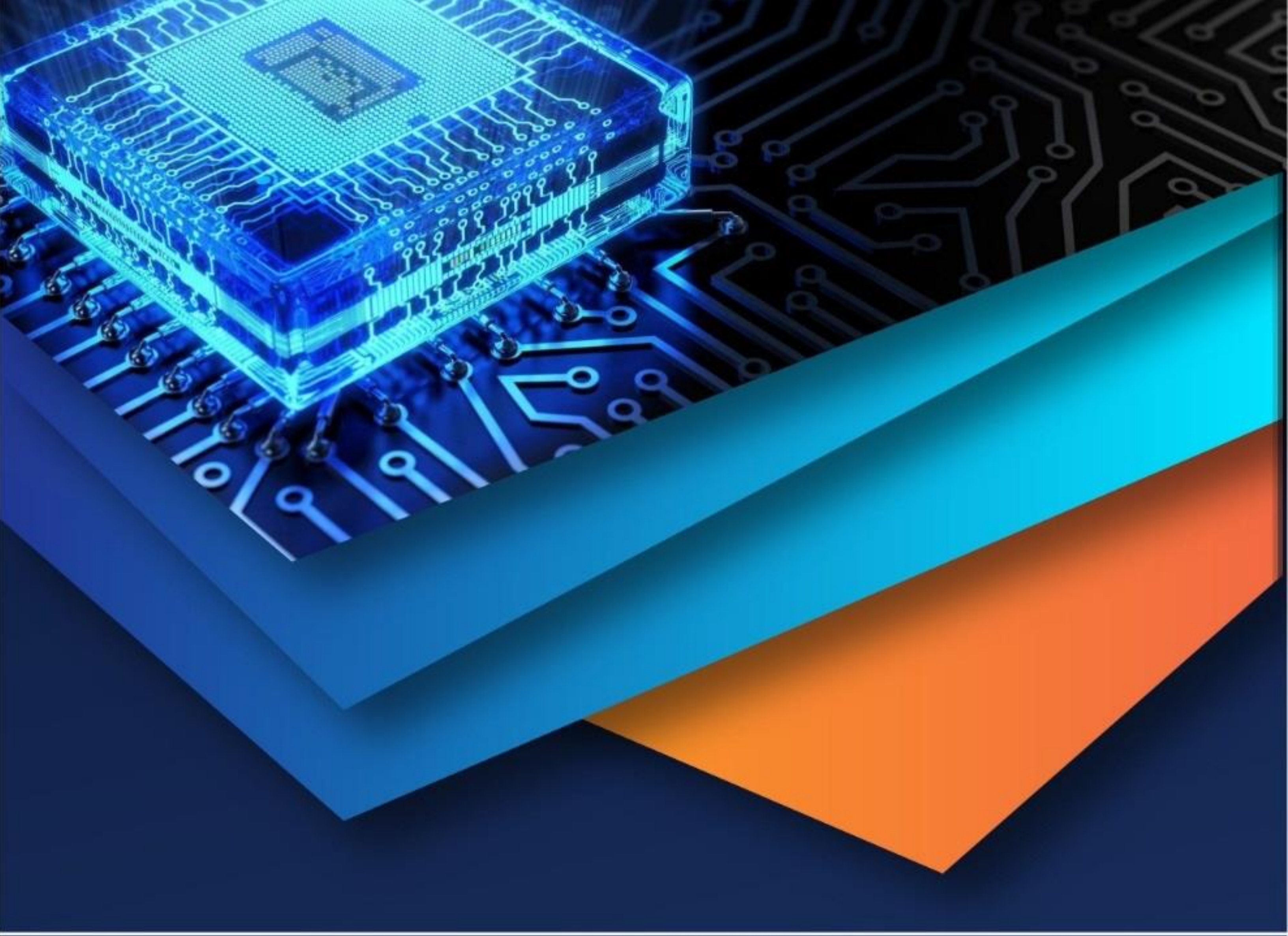

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