

# Design and fabrication of Hydraulic Jack system for four wheelers

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**Abstract** – This paper is regarding the inbuilt hydraulic car jack which is integrated with the existing braking system of the car and can help in overcoming the disadvantages of the existing mechanical jack provided in the vehicle.

With the inbuilt hydraulic jack, we can now use the pressure of the braking fluid which was earlier used only for the braking purpose, to lift the punctured side (tyre) of the vehicle by using piston cylinder arrangement which are welded to the chasis of the vehicle. On pressing the brake pedal, the pressurized brake oil passed through the non-returning valves and extends the piston in the piston cylinder arrangement which results in lifting the punctured side of the vehicle.

This not only reduces the mechanical effort to lift the vehicle but also helps in saving a lot of time to replace the punctured tyre as compared to earlier methods.

**Key Words:** Single Acting Hydraulic Jack, Master Cylinder, Five Way Directional Control Valve, Non-Return Valve, Ball Valve, Hydraulic Fitting and Pipes, Chasis.

## 1. INTRODUCTION

A hydraulic jack involves a fluid usually oil to push against a piston in a cylinder to lift load. The working of hydraulic jack is based on Pascal's principle. The jack uses compressible fluid, that is forced into a cylinder by a plunger. Oil is mostly used for the liquid because it is self-lubricating and has stability compared with others.

### 1.1 Pascal's law-

<sup>[1]</sup>Blasé Pascal formulated the basic law of hydraulics in the mid 17th century. He discovered that pressure exerted on a fluid acts equally in all directions. His law states that pressure in a confined fluid is transmitted undiminished in every direction and acts with equal force on equal areas and at right angle to a container's walls.

### 1.2 Hydraulic Jack-

A hydraulic jack involves a fluid usually oil to push against a piston in a cylinder to lift load. The compressible fluid is forced into a cylinder by a plunger. Oil is mostly used for the

liquid because it is self-lubricating and has stability compared with others. As the plunger comes up, it pulls the liquid through a check valve suction pump. Again when the plunger is lowered, it sends liquid through another valve into a cylinder. A ball used for suction within the cylinder shuts the cylinder and pressure builds up within the cylinder. The suction valve present in the jack opens at each draw of the plunger. The discharge valve, that is outside the jack, opens when oil is pushed into the cylinder. The pressure of the liquid enables the device to raise heavier loads.

The industries have seen a significant increase in the dependence on the use of hydraulic from the past years. The use of oil hydraulic systems as a means of power transmission in modern machines evolved a few decades earlier in the western world whereas its applications in Indian industries are of comparatively recent choice and hence, there is great deal of urgency and importance to master the art of its applications and maintenance. There exists a big difference gap between the availability and requirement of skilled man power in this key field of the modern engineering in India.

## 2. LITERATURE REVIEW

### 2.1 P.S. Rana et al. (2012)

<sup>[2]</sup>In this research paper they have come up with the idea of Integrated Automated Jacks for 4-wheelers in which the jack is provided on both the sides of the vehicle and can be easily operated with the help of a button placed at the dashboard of the vehicle. This jack is specially designed to overcome the difficulties faced by the senior citizens and ladies who find it difficult to manually operate the jack.

### 2.2 Mohammed Abuzaid et al. (2013)

<sup>[3]</sup>In this research paper they have focused on an inbuilt hydraulic jack system which is attached to automobile vehicle on front and rear part of the chassis. There is a front suspension hydraulic jack that is mounted centrally to the front suspension of an automobile between its front wheels. There is also a rear suspension hydraulic jack that is mounted centrally to the rear suspension of the automobile

between its rear wheels. The system operates from a compressed fluid reservoir tank that has connections for the front and rear car jack outlets.

## 2.4 Mayank Agrawal et al. (2018)

[4]This paper represents a study over in- built hydraulic jack system and shows its benefits over traditional mechanical jack system. The design of inbuilt hydraulic jack is also studied and modified to require extent which can be seen by analyzing design of prototype. An Inbuilt hydraulic jack system can be easily operated by buttons provided on the dash board of the vehicle. The jack will be installed on chassis of the vehicle. The motive behind using this system instead of a conventional mechanical system is the more power produced by the system and simple in design as compared to a conventional design. As the hydraulic oil is incompressible so the lifting capacity is more in comparison with the pneumatic system which operates on air which is compressible.

## 2.3 Parth M. Patel et al. (2013)

[5]This paper describes Implementation of Automatic hydraulic jack Mechanism in a four wheeler itself. The jack will be powered by the battery. So at a time of puncture to replace the wheel one has to just press the button and the jack which is fitted in the car itself will lift the car.

## 3. PROBLEM STATEMENT

Driving a car is quite common and easy nowadays, but the problems arises when it comes to it's maintenance and replacement. The world of technology has seen a great change in the automobile industry but people still today face a lot of difficulties in replacing the tyre when it gets punctured in a deserted location and it becomes hard to find a mechanic nearby. In this situation the driver is left with only one solution i.e.- step down from the car, get the tools and manually replace the tyre which becomes quite hectic and tiring and even time consuming. The concept of tubeless tyres have overcome this problem to some extent but not completely. If punctured, the tubeless tyre also need to be replaced after running the vehicle for few kilometers. But with the idea of inbuilt hydraulic car jack one can change the punctured tyre of the vehicle not only with less effort but also within less time being consumed. The inbuilt hydraulic car jack involves an initial one time cost which is going to give benefits in the long run to the driver of the car by simplifying his job during the time of puncture.

## 4. FIELD SURVEY

Till now there is no such machine or device which can help overcoming the problem faced by a driver when the tyre gets punctured, like the one which is described through this paper that not only saves human effort but also reduces the replacement time.

To find out what people are needed practically in the field, we have interacted with the people who drive regularly and cover a long distance to different places to identify the actual requirement of this idea.

Following are some important suggestions and experience given by the people who drive regularly :-

Interaction with an OLA cab driver who drives regularly within Delhi NCR.

According to him, due to the uneven and improper roads in some areas of Delhi, even driving at a slow speed the tyre still gets punctured sometimes. Though his car has tubeless tyres still it becomes a very difficult job for him to replace the punctured tyre alone in the scorching sun while the passengers are sitting inside and are in a hurry to reach their place. As suggested by him one should develop a machine which should lower the human efforts.

Interaction with another woman employee at Arjun Marg, DLF Phase -2, Gurugram.

According to her, when a person is going back home after a daylong hectic work and is in a hurry to reach home quickly and suddenly the tyre of your car gets punctured on the highway and there is no mechanic nearby, so one has to herself get down and replace the tyre. For a woman it becomes extremely difficult to change the tyre requiring a lot of human effort and that too when she is already tired. She said she really forward in the world of technology where the problem of punctured tyre could be fixed easily and quickly without involving too much human effort.



**Figure 1:-** <https://carfromjapan.com/article/driving-tips/drive-short-distance-with-flat-tire/>

## 5. OVERLOOK AT CURRENT TECHNIQUES

Some current techniques are:-

1. Floor Jack
2. Scissor Jack

3. Hydraulic Bottle Jack
4. Hi-Lift Jack

These manually operated jacks involves more human effort and are time consuming. The operator also needs to identify the current position where the jack needs to be placed in order to safely lift the car which sometimes become a quite difficult job. Therefore, there is a need for an alternative method in the modern world where the disadvantages of the earlier discussed jacks can be overcome.

### 6. DESIGN METHODOLOGY

Design and fabrication of the machine involved the steps mentioned below :-

1. The market review was identified.
2. Made the design of the prototype model.
3. The design was evaluated.
4. Specifications of the components were noted down.
5. Observations and calculations were made.
6. The major components of the machine were assembled.
7. Fabrication of the inbuilt hydraulic car jack was carried out.
8. Later on, testing and trial runs were carried out.

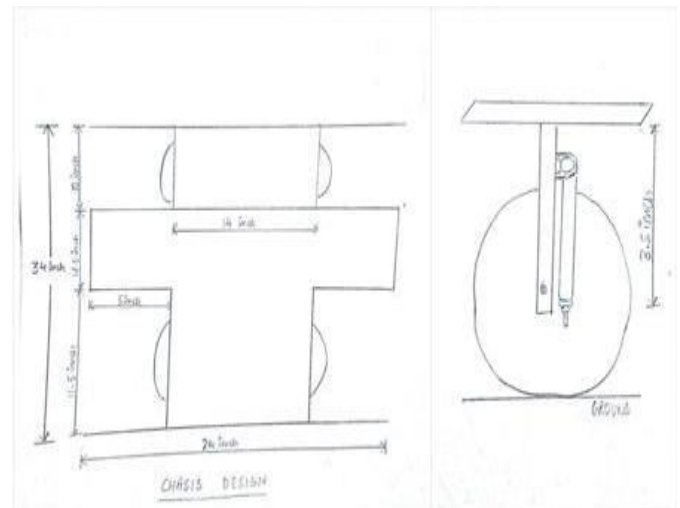


Figure 3:- Design of the chasis and wheel base made on paper.



Figure 4:- Completely welded chasis.

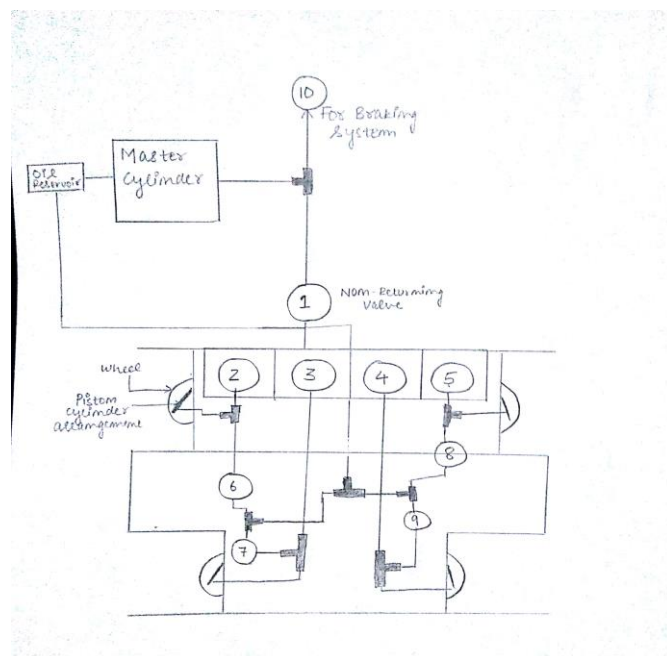


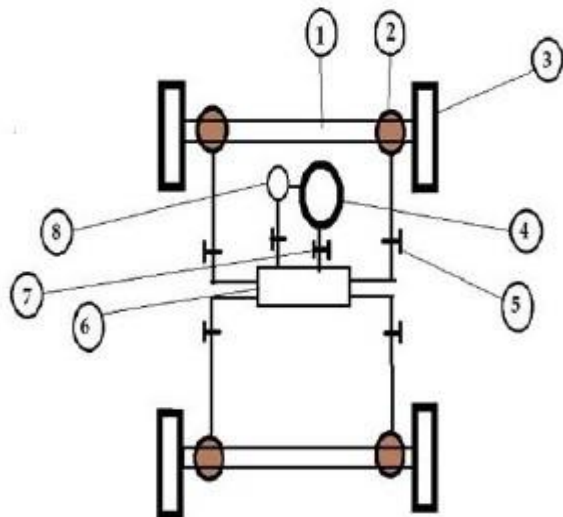
Figure 2:- Diagrammatic representation of the model made on paper.

### 7. MAIN COMPONENTS USED IN THE PROTOTYPE

1. Single acting hydraulic cylinder or jack
2. Manifold
3. Master cylinder
4. Non return valve
5. Ball valves
6. Hydraulic fitting and pipes
7. Five way directional control valve
8. Disk brakes.



Figure 5:- Main components used in the prototype.



- 1-Axle
- 2-Hydraulic jack
- 3-Tyre
- 4-Master cylinder
- 5-Valve
- 6-Manifold
- 7-Non-return valve
- 8-Oil reservoir

Figure 6:- Components used in the prototype [Mayank Aggarwal 2018]

## 8. WORKING AND PRINCIPLES

### 8.1 Hydraulic Brake System Working-

The hydraulic brake is an arrangement of braking mechanism which employs a brake fluid, usually ethylene

glycol (contained in the reservoir), so that the pressure is transferred from the controlling unit (from the master cylinder on pressing the foot pedal) to the actual brake mechanism, which is usually at or near the wheel of the vehicle in order to stop or reduce the speed of a moving body.

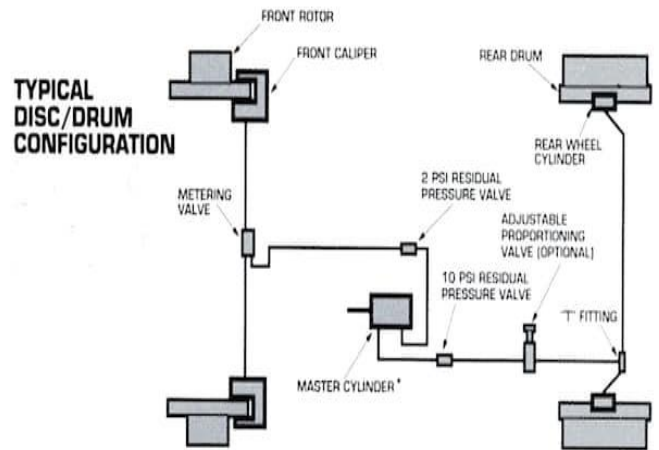


Figure 7:- Hydraulic Braking System (<http://st.hotrod.com/uploads/sites/21/2015/03/eci-typical-dic-drum-configuration-diagram.jpg?interpolation=lanczos-none&fit=around%7C596%3A372>)

### 8.2 Working of Inbuilt Hydraulic Jack-



Figure 8:- Completely project photo

The braking system of the vehicle is now used to integrate the jack into to chassis of the vehicle with a set of unions, ball valves, master cylinder, five-way directional control valve, separated by a piping arrangements. If in a certain condition,

any tyre of the vehicle undergo a tyre failure than first we will turn the five-way valve handle toward the failed tyre jack. Which in turn will operate the left front jack, when the brake pedal is operated as the handle is in the directions of the left front jack marking of the cover plate. It will. Now when we push the brake pedal than the fluid from the master cylinder will pass through the five-way valve and move in the direction of the handle of valve, this will make the piston in the hydraulic cylinder(jack) to move down and as the piston of hydraulic cylinder touches the ground than after further pushes that tyre start raising.

## 9. OBSERVATION & CALCULATIONS

### 9.1 Design of Hydraulic Jack System-

Unaided weight of the car = 12.3 kg

Weight on each wheel= 3kg

Dimensions of pipe:

Outer dia. Of pipe = 8mm

Inner dia. Of pipe = 5mm

### 9.2 Specification of master cylinder-

Diameter of the master cylinder = 1.2 cm = 12 mm

Area of master cylinder = 114 mm<sup>2</sup>

### 9.3 Specifications of hydraulic cylinder-

Outer diameter of cylinder = 30 mm

Inner diameter of cylinder = 20 mm

Diameter of the piston = 20 mm

Stroke = 50mm

Pressure range = 1.5-8kgf/cm

Overall Length = 191mm

Piston Material = Magnetic

Body Material = Stainless Steel

Piston Rod Material = Stainless Steel

Rod Dia. = 8mm

Rod Thread Size = M8 x 1.25"

Rod Thread Length = 18mm

### 9.4 Distance the larger piston moves-

$$D_2 = F_1 \cdot D_1 / F_2$$

Where,  $F_1$  = force of the small piston, in pounds

$D_1$  = distance the small piston moves, in inches

$D_2$  = distance the larger piston moves, in inches

$F_2$  = force of the larger piston, in pounds

### 9.5 Design of Piston-

We know that cylinder's inner diameter is equal to piston's outer diameter so piston outer diameter is 20mm. Generally piston's are maded from MILD STEEL & SUITABLE MATERIAL.

Design of Piston Rod-

Material strength EN9 = 1750 kg/cm<sup>2</sup>

$$P = \frac{\pi}{4} D_o^2 \times \text{STRENGTH}$$

Force Required to Lift the Wheel-

The weight to be lifted is 12 kg or 120N.

So now the effort required by the human.

Formula:  $F = P \cdot A$

$$120 = P \cdot 314 \text{mm}^2$$

$$P = 3.8617 \text{N/MM}^2$$

Force required at the working piston:

$$F = P \times A = 0.3861 \cdot 114 \text{mm}^2$$

Therefore,  $F = 45\text{N}$ .

## CONCLUSIONS

This concept will not only save the effort of a person but will also save one's precious time under critical circumstances and will eliminate the need of carrying a conventional mechanical jack while travelling. It is a very feasible concept and if worked over cautiously, will become popular very soon. The advantages of the inbuilt hydraulic jack are that this type of system is very useful for ladies and old people since during the problem of puncher of tyres, they can easily change the wheel, the maintenance of vehicle will be very easy and cheap and A single person can go on a long drive without worrying about getting stuck in the way. The disadvantages of this system are that cost will increase slightly and the weight of vehicle will increase slightly.

After successful implementation of the above idea in small passenger cars, future developments can be made in design to apply the same in heavy duty automobiles also.

## ACKNOWLEDGEMENT

We express our sincere thanks to the director of the institute Dr. RK Raghuvanshi for providing us every possible facility to do the project work. We are grateful to Dr Devendra Jha HOD and Dean of Mechanical Engineering for encouraging us for this project. Special thanks to our guide Mr. Ashutosh Singh, Assistant professor, Department of Mechanical Engineering who is also the supervisor of this project work.

We are extremely grateful and indebted to him for his expert, sincere and valuable guidance and encouragement extended to us.

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