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Design & Fabrication of Brake Pedal Operated Hydraulic Jack

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Abstract - *Car jack is a device used to lift up the cars while changing the tires during an emergency. Car jacks are available at the market has some disadvantages such as requiring more energy to operate, are not suitable for women and cannot be used on the uneven surface. The purpose of this project is to modify the design of the existing car jack in terms of its functionality and also human factors considerations. The scopes of research were on the designing 1.5 - 3 ton maximum lifting capacity of car jack by using optimization concept. To optimize the existing design, the hand lifter has been replaced by the use of pedal lever as it can reduce energy usage. In addition, ergonomic factors are also taken into consideration in order to reduce and simplify how to use a car jack. In the process of obtaining a suitable design, the customer needs will be translate to the engineering characteristic to obtain the concepts that need to be modified and fabricated.*

An Automobile hydraulic jack can be easily operated by a single push button provided on the dash board. The system operates on hydraulic drive which consists of three main parts: Master cylinder, 4/3 Solenoid operated direction control valve, hydraulic cylinder to lift the vehicle. The hydraulic jacks actuate separately for either side of car as per the breakdown condition. The car gets lifted and load gets distributed on three point i.e., plunger or ram of hydraulic cylinder and two tires opposite to side which is lifted. This jack will be very useful for all the senior citizens and especially for females (ladies) who find it extremely difficult to operate the jack manually in any breakdown condition.

Key Words: **Solenoid**, **Brake Fluid, Direction Control (DC) Valve**

1. INTRODUCTION

Todays in this world of speed and motion man's movement from place to place has been very rapid. Numerous ways of transport and travel have emerged owing to the needs of human being. This ideas behind many of the innovations and inventions is to make human more comfortable and enable them to cope up with the pace of rapidly changing world. When such is the emphasis laid by man on time and comfort, it is of almost importance to reduce breakdowns and unnecessary halts during travel. A person acquainted with driving problems will certainly understand the difficulties and the frustrations due to breakdown of vehicle during journey. In automobile breakdown, not only is our precious time affected but also a great amount of money is wasted due to many factors that led to breakdown. A few of them are suspension ill effects, engine problems and tyre damages. The most frequently encountered problem is that of tyres damage be it inflated tyres or punctured tyres.

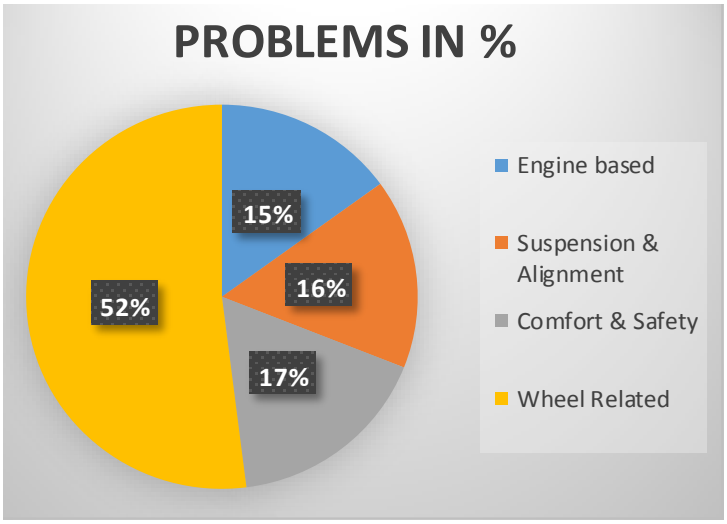


Chart -1: Problems in %

The change of tyres requires the use of jack, the most commonly adopted is the conventional screw jack. One has to place the jack under the vehicle and operate the lever i.e. physical effort is required to operate the jack and lift the car. One could overcome these hardships, if he has provided himself with a lifting device that would operate automatically with least or no physical effort being into it and is time saving.

The invention relates to hydraulic jack and more specifically to an automobile hydraulic jack system. In most of the garages the vehicles are lifted by using screw jack. This needs high man power and skilled labours. In the past both hydraulic and pneumatic jack has been utilized in combination with the structure of automobile. They have always utilized a separate jack for each of 4 wheels by having the jacks permanently installed on the vehicle. They are ready to operation at all time. Lifting device has been installed on vehicle, such as air lifting device.[2] Various types of jack or lift devices has been installed on vehicle which are turned in one fashion or another from a horizontal attitude into a vertical attitude and then extended for the purpose of lifting the vehicle. It is an object of the invention to provide a novel hydraulic jack system that only utilize a hydraulic jack that is mounted on chassis on side of car between its side

wheels. It is also an object of invention to provide novel jack system that can be operated by driver from inside the car. Now the project has mainly concentrated on this difficulty, and hence such that the vehicles can be lifted from the floor land without application of any impact force. By pressing the button in the dashboard & pressing the brake pedal, it activates the hydraulic jack automatically.

1.1. NEED OF INVENTION

It is believed that 'Necessity is the mother of invention'. Here the necessity lies in reducing the human effort applied during manual operation of the jacks and hence the need of the invention. In day to day life it is very tedious job to operate the jack manually and it is also a very time consuming work as well. So to make it easier for everyone especially for aged person and for lady drivers. To provide a safe and simple automatic hydraulic jacking system without manual effort. To provide a novel jacking system that can be operated from within the vehicle by means of a dashboard control panel. There are certain mechanisms already available for the same purpose which has a definite capacity to lift the car on 2 wheels viz. a screw jack. But the general idea of the project is to minimize the human effort while operating the jack. To provide a novel hydraulic jacking system that is directly and permanently incorporated into the vehicle frame in such a way as to prevent the additional risk of damage or weathering.

1.2. HYDRAULIC BASICS

Hydraulics is the science of transmitting force /or motion through the medium of a confined liquid. In a hydraulic device, power is transmitted by pushing on a confined liquid. The transfer of energy takes place because a quantity of liquid is subject to pressure. To operate liquid-powered systems, the operator should have knowledge of the basic nature of liquids.[1]

1.2.1 PASCALS LAW

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 trans-mitted undiminished in every direction and acts with equal force on equal areas and at right angle to a container's walls as shown in Fig.1.1

2. WORKING PRINCIPLE

The hydraulic jack is based on the law of Pascal, which is the most fundamental principle in the fluid power. It deals with hydrostatic, the transmission of force through a confined fluid under pressure.

Pascal's law states that…….

"The pressure exerted on a confined fluid is transmitted equally in all directions and acts at right angles to the containing surfaces."

The jack consist of a tank of hydraulic fluid which is connected to a plunger (piston) of small area (the lifting device) and it is in turn connected to the lifting plunger of greater area than the pumping plunger. There is two way valve between them, which allows the liquid to flow back to the pumping plunger. It connected to the tank with solenoid operated valve which is opened to get the lifting plunger down and the oil from it goes back into reservoir.

Hydraulic system based on the fact that liquids are virtually incompressible and pressure applied anywhere in the fluid is transmitted in all directions. Operated by pressure, it exerts a force which proportionally greater than that applied to the first piston but distance moved by second piston will be comparatively less. If, for instance the second piston has three times the area of the first piston, it will exert three times the force through one third of the distance travelled by first piston.

2.1. FORCE MULTIPLICATION OF MECHANICAL SYSTEMS

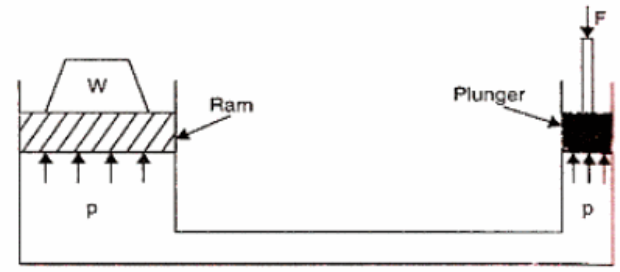


Fig -1: Working Principle

Let,

A = Area of the ram

a = Area of the plunger

P = Intensity of the pressure

F = Force applied on the plunger

W = Weight lifted by the ram

ɳ = Efficiency

Since, the intensity of pressure in the chamber is same in all direction.

Therefore,

$P = F/a$ …… (1)

$F = P \times a$

$W = P \times A$

$P = W/A$ …… (2)

From eq. (1) and (2),

$W = F \times (A/a)$……(for W)

F = W × (a/A)..... (for F)

ɳ = (W/F) × (a/A)

By applying the equation for workdone we can write,

Workdone by smaller piston = F × S1

Workdone by larger piston = W × S2

Where,

S1 = distance move by smaller piston

S2 = distance move by larger piston

By equating we get,

F × S1 = W × S2

W/F = S1/S2

Therefore, energy input to the system is equals to energy output from the system.

3. COMPONENTS

Inbuilt-Hydraulic jacking system has a simple mechanism it consist of:-

1. Master Cylinder
2. Brake line
3. Brake Drum
4. Hydraulic cylinder
5. 4/3 Direction Control Value
6. Hose Pipes.

3.1. MASTER CYLINDER

In automotive engineering, the master cylinder is a control device that converts non-hydraulic pressure (commonly from a driver's foot) into hydraulic pressure. This device controls slave cylinders located at the other end of the hydraulic system.

The master cylinder displaces hydraulic pressure to the rest of the brake system. It holds the most important fluid in your car, the brake fluid. It actually controls two Separate sub systems which are jointly activated by the brake pedal. This is done so that in case a major leak occurs in one system, the other will still function. The two system may be supplied by separate fluid reservoirs, or they may be supplied by a common reservoir. Some brake subsystems are divided front/rear and some are diagonally separated. When you press the brake pedal, a push rod connected to the pedal moves the "primary piston" forward inside the master cylinder. The primary piston activates one of the two subsystems. The hydraulic pressure created, and the force of the primary piston spring, moves the secondary piston forward. When the forward movement of the pistons causes their primary cups to cover the bypass holes, hydraulic pressure builds up and is transmitted to the wheel cylinders. When the brake pedal retracts, the pistons allow fluid from the reservoir(s) to refill the chamber if needed.

3.2. BRAKE LINE

Brake Line is used to transmit brake fluid from the master cylinder to the brake drum. These transmit the hydraulic force required for the effective application of brakes. The Pressure developed in the brake lines is 800MPa – 1200MPa. Brake Lines are of standard diameters of 6mm-10mm.

3.3. BRAKE DRUM

A drum brake is a brake that uses friction caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum. The term drum brake usually means a brake in which shoes press on the inner surface of the drum. When shoes press on the outside of the drum, it is usually called a clasp brake. Where the drum is pinched between two shoes, similar to a conventional disc brake, it is sometimes called a pinch drum brake, though such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum.

3.4. HYDRAULIC CYLINDER

A hydraulic cylinder (also called a linear hydraulic motor) is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke. It has many applications, notably in construction equipment (engineering vehicles), manufacturing machinery, and civil engineering.

Fig -2: Double acting Hydraulic Cylinder

Hydraulic cylinders get their power from pressurized hydraulic fluid, which is typically oil. The hydraulic cylinder consists of a cylinder barrel, in which a piston connected to a piston rod moves back and forth. The barrel is closed on one end by the cylinder bottom (also called the cap) and the other end by the cylinder head (also called the gland) where

the piston rod comes out of the cylinder. The piston has sliding rings and seals. The piston divides the inside of the cylinder into two chambers, the bottom chamber (cap end) and the piston rod side chamber (rod end / head end).

For double-acting single-rod cylinders, when the input and output pressures are reversed, there is a force difference between the two sides of the piston due to one side of the piston being covered by the rod attached to it. The cylinder rod reduces the surface area of the piston and reduces the force that can be applied for the retraction stroke. During the retraction stroke, if oil is pumped into the head (or gland) at the rod end and the oil from the cap end flows back to the reservoir without pressure.

3.5. 4/3 DIRECTION CONTROL VALVE

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Basic working principle of solenoid :

A **solenoid** is a simple electromagnetic device that converts electrical energy directly into linear mechanical motion, but it has a very short stroke (length of movement), which limits its applications.

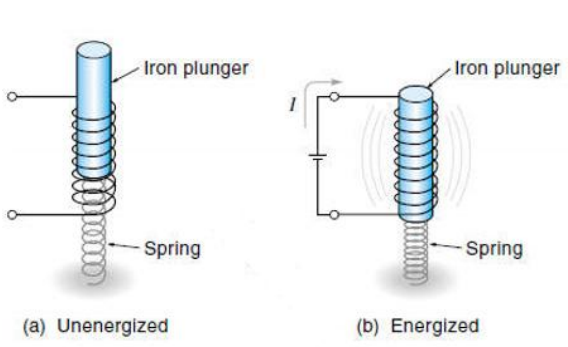


Fig -3: Working of solenoid

The solenoid consists of a coil of wire with an iron plunger that is allowed to move through the center of the coil. Above figure shows the solenoid in the unenergized state. Notice that the plunger is being held about halfway out of the coil by a spring. When the coil is energized, the resulting magnetic field pulls the plunger to the middle of the coil. The magnetic force is unidirectional — a spring is required to return the plunger to its unenergized position.

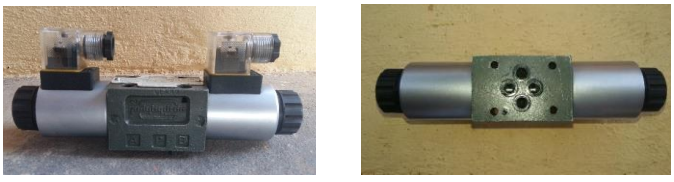


Fig -4: DC Valve

3.6. HOSE PIPE

A hose is a flexible hollow tube designed to carry fluids from one location to another. Hoses are also sometimes called pipes (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally tubing. The shape of a hose is usually cylindrical (having a circular cross section). Hoses are made from one or a combination of many different materials. Applications mostly use nylon, polyurethane, polyethylene, PVC, or synthetic or natural rubbers, based on the environment and pressure rating needed.

Fig -5: Hose pipe

3.7. WORKING FLUID (BRAKE FLUID)

The essential characteristics required of a Brake Fluid are as follows:

1. Boiling point:- Brake fluid is subjected to very high temperatures, especially in the wheel cylinders of drum brakes and disk brake callipers. It must have a high boiling point to avoid vaporizing in the lines. This vaporization is a problem because vapour is highly compressible relative to liquid, and therefore negates the hydraulic transfer of braking force - so the brakes will fail to stop the car. The Boiling point should be generally around 250.

Quality standards refer to a brake fluid's "dry" and "wet" boiling points. Wet boiling point, which is usually much lower, refers to the fluid's boiling point after absorbing a certain amount of moisture. This is several (single digit) percent, varying from formulation to formulation. Glycol-ether (DOT 3, 4, and 5.1) brake fluids are hygroscopic (water absorbing), which means they absorb moisture from the atmosphere under normal humidity levels. Non-hygroscopic fluids are hydrophobic, and can maintain an acceptable boiling point over the fluid's service life.

2. Viscosity:- For reliable, consistent brake system operation, brake fluid must maintain a constant viscosity under a wide range of temperatures, including extreme cold. This is especially important in systems with an anti-lock braking system (ABS), traction control, and stability control (ESP), as these systems may use a valve with a time-based approach,

rather than measuring pressure or volume to control the amount of fluid transferred.

3. Corrosion:- Brake fluids must not corrode the metals used inside components such as callipers, wheel cylinders, master cylinders and ABS control valves. They must also protect against corrosion as moisture enters the system. Additives (corrosion inhibitors) are added to the base fluid to accomplish this. Silicone is less corrosive to paintwork unlike glycol-ether based DOT fluids.

4. Compressibility:- Brake fluids must maintain a low level of compressibility, even with varying temperatures to accommodate different environmental conditions. This is important to ensure consistent brake pedal feel. As compressibility increases, more brake pedal travel is necessary for the same amount of brake calliper piston force.

5. Storage stability:- Lastly, the brake fluid should have sufficient stability say for at least three years so that the same is not spoiled during storage.

Composition of brake fluid:

In the beginning of brake fluids consisted of mainly ethyl alcohol and caster oil. But the same had poor low temperature properties and low boiling point. The modern brake fluids contains poly glycols as lubricants and glycol ethers as the diluents and possess all the properties of the brake fluids. Silicon based brake fluids has also been developed. This has wider operating range of temperatures, does not absorb moisture and does not attack point, however, it is more costly and causes more wear of the hydraulic system.

In case of emergencies, however, a mixture of 40-505 by weight of caster oil and 50-60% by weight of butyl alcohol could be used fairly satisfactory. Alternatively, a mixture of 60% of rectified ethyl alcohol and 35% of rectified glycerine (by weight) may also be used. Any petroleum liquid should however never be used as brake fluid.

4. WORKING

First the jack is put underneath the chassis near the tyre which is to be replaced. Then the push button on the dashboard is pressed for actuating the solenoid operated 4/3 direction control valve. This causes the valve to open and the fluid can flow through the circuit. Now when the brake pedal is pressed, it directly works the master cylinder. The pistons inside the master cylinder move in inward direction so that fluid from the reservoir flows through it. The master cylinder has two ports: one is connected to rear brake drum and the other is connected to the front. The fluid from the master cylinder flows towards 4/3 DC valve through the rear brake line. The port A of DC valve is connected to the one port of hydraulic jack by means of hose pipe. During the first actuation of DC valve, fluid flows through the circuit towards the hydraulic jack. It causes the forward stroke of the piston, thus the jack gets lifted. Therefore we can replaced the tyre.

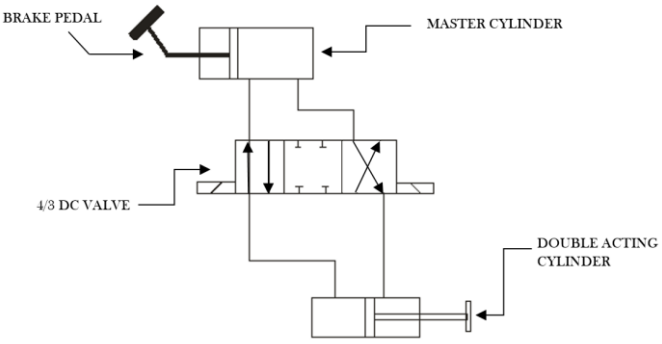


Fig -6: Hydraulic Circuit

After obtaining the required function, the push button on the dashboard is again pressed to obtain second actuation of the DC valve. When the pedal is pressed, the fluid flow through front brake line to the DC valve. The port B of DC valve is connected to the another port of hydraulic jack by means of hose pipe. During the second actuation of DC valve flows through port B towards the hydraulic jack which causes the return stroke of the piston. Thus the jack is gets lowered.

5. DESIGN OF SYSTEM

5.1. DESIGN OF CYLINDER

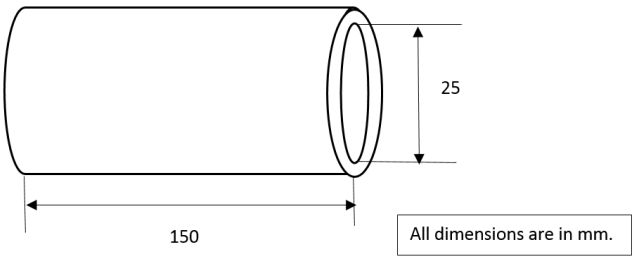


Fig -7: Design of Cylinder

ASSUMPTION:

Load to be lifted = 100kg

Pressure = 20bar = $2N/mm^2$

Therefore the force on the jack will be given by,

Force = 100 × 9.81 = 981N

According to Pascal's Law,

"The pressure exerted on a confined fluid is transmitted equally in all directions and acts at right angles to the containing surfaces."

$P = F/A$

Where,

P = pressure F = Force on jack

A = Area of piston d = diameter of piston

$$2 = \frac{981}{\frac{\pi}{4}d^2}$$

d = 25mm

Therefore, bore diameter = 25mm

Volume of cylinder :

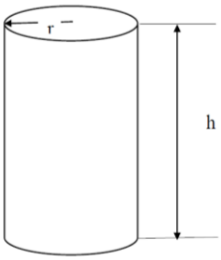
$V = \pi r^2/h$

Where,

r = inner radius of cylinder

h = height of cylinder

V = volume of cylinder



Therefore,

$V = \pi \times (12.5)^2 \times 150$

$= 73631.07\ mm^3$

V = 73.63 cc

Therefore, volume of cylinder = 73.63cc

5.2. DESIGN OF FRAME

We selected the dimensions of the frame i.e. its Length & Width as per the standard dimensions of the car chassis.

Length = 1216mm

Width = 608mm

The distance between the road surface and the Chassis of the care is considered based on which we assumed the height of the frame.

Height = 300mm

Fig-8: Frame

6. SELECTION OF MATERIALS

The proper selection of material for the different part of the machine is the main objective in the fabrication of machine. For a design engineer it is must that he be familiar with the effect, which the manufacturing process and heat treatment on the materials. The choice of material for engineering purposes depends upon the following factors:

1. Availability of materials.
2. Suitability of materials for the working condition in service.
3. The cost of materials.
4. Physical and chemical properties of materials.
5. Mechanical properties of materials.

Raw materials & Standard Materials used in Project

SR NO	PART NAME	MAT	QTY
1	Brake System	C.S	1nos
2	Hydraulic Cylinder	STD	1nos
3	4/3 Direction Control Valve	STD	1nos
4	Brake Line	STD	2nos
5	Hose Pipe	STD	2nos
6	Brake Oil	-	1 lit
7	Welding Rod	-	5nos
8	Square Channel	MS	15ft
9	Nut, Bolt &Washer	MS	16nos
10	Rear Axle	C.S	1nos

Table -1: Raw & Standard Materials

Standard Material for cylinder:

1. Rod : Hard Chrome plated Material - EN8-D
2. Tube : Honed Material - ST 52
3. Rod & wiper seal : Material - PU
4. Clevis and rod eye material : Mild Steel

MODEL

7. APPLICATION & USES

It is a sophisticated technology hence it is a part of recent trends in automobile system. Therefore it is applicable in various modern vehicles.

Its uses:-

1. When the wheel will puncture it is easy to remove the wheel.
2. It is easy for maintenance of wheel.
3. It is a time saving process.
4. This system can also be used by garage personnel for temporary lifting of vehicle for minute observation or attention that are to be made, saving a considerable time.

8. ADVANTAGES

1. It is possible to operate Manually/automatically by providing On/Off switch.
2. It can lift heavier loads while using less force.
3. Effort required is less.
4. Operation & Handling is easy.
5. Flexibility. Hydraulic components can be located with considerable flexibility. Pipes and hoses in place of mechanical elements virtually eliminate location problems.
6. Smoothness. Hydraulic systems are smooth and quiet in operation.
7. Overload protection. Automatic valves guard the system against a breakdown from overloading.

9. DISADVANTAGES

1. This system applied in the case of Tyre Replacement only.
2. Addition cost is required to install this system to four wheeler.
3. Leakage of hydraulic oil during its flow in the system causes heavy pressure drop or may not lift car.

10. CONCLUSIONS

The hydraulic jack system can be easily attached to all currently manufactured automobile chassis and frames, with small provision provided for clamping of jack beneath the chassis. The system operates on the hydraulic power. This arrangement has many advantages such as maintenance and servicing of vehicle. With the help of this system the driving of vehicles will be easy especially for ladies. Arrangement is also very useful for heavy loading vehicles and a single person can go on a long drive. Whole system is operated by 12 volt DC battery. The project worked successfully in a manner that the system thus proposed will work reliably. The manual efforts of human will be reduced, thus **fulfilling our main Objective**.

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