

INBUILT JACK IN A FOUR-WHEELER BY USING HYDRAULIC ACTUATION SYSTEM

D. Prabu

Assistant Professor, Department of
Mechanical Engineering
Sri Sai Ram Engineering College
Chennai, India

A. Ajay

Department of Mechanical Engineering
Sri Sai Ram Engineering College
Chennai, India

E. Praveen Kumar

Department of Mechanical Engineering
Sri Sai Ram Engineering College
Chennai, India

K. Vijaya Kumar

Department of Mechanical Engineering
Sri Sai Ram Engineering College
Chennai, India

V.S. Vishnu

Department of Mechanical Engineering
Sri Sai Ram Engineering College
Chennai, India

Abstract—Whenever the tyre failure is occurred in the vehicle then to lifting the vehicle from ground surface is the very difficult thing for human being. And also huge human effort required and more time taking process. Though, this inbuilt hydraulic jack system helps to lift the vehicle from the ground level automatically instead of conventional mechanical jack, and saves the time and excess effort. It is fitted on the vehicle chassis. This inbuilt hydraulic technique can be quickly operated by automatic function buttons on the board panel of the vehicle. The arrangement of this technique are as follows, the hydraulic jack will be mounted near the suspension system of the vehicle. This jack will be very useful for all senior citizens, physically challenged persons and especially for females who find it extremely difficult to operate the jack manually in any breakdown condition.

Keywords—Hydraulic cylinder, incompressible Hydraulic Oil, Pascal Law, Directional Control Valve.

I. INTRODUCTION

A jack is a mechanical device used as a lifting device to lift heavy loads or apply great forces. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. The hydraulic jack is the most common form of jacks used for lifting. Various innovations have been done in the hydraulic jack with different electronic devices. With the help of technology, the priorities are given to safety, luxury and comfort. The hydraulic jack is based on the Pascal's law. The available jacks in the market are time consuming and also require much efforts which makes use of jack very difficult. As the jack is also required to set at jack point which further increases the complications in its application. So need of automatic inbuilt jack in automobiles is inescapable. It can be vastly used in light weight to medium weight cars. It can also be used as maintenance purpose. The project can be made highly feasible if considered while designing the vehicle.

A. Need for Hydraulics

In the development of the submarine from pre-war classes, many changes and improvements have occurred. One of the outstanding differences is the large variety of submarine devices which are now operated by hydraulic power. In early classes, there was no hydraulic system, and power requirements were met by means of air or electricity. Along with constantly improving submarine design has gone

a constant extension and diversification of the use of hydraulic power.

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.

B. Hydraulic Cylinder

A hydraulic cylinder 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.

C. Operations of a Hydraulic Cylinder

The hydraulic pressure in these cylinders is in the form of hydraulic fuels that are stored under pressure in these cylinders. The energy stored in these oils is converted into motion. In a complete hydraulic system, a hydraulic motor consists of one or more hydraulic cylinders. A pump regulates the oil flow in the hydraulic system. The pump is a part of the generator of a hydraulic system. The hydraulic cylinders initiate the pressure of the oil, which cannot be more than that required by the load.

A hydraulic cylinder consists of a cylindrical barrel, piston, and a piston rod. The piston that is placed within the barrel is connected to the piston rod. The cylinder bottom, and the cylinder head, closes the bottom and the head of the barrel respectively. The cylinder head is the side from where the piston rod exits the cylinder.

The piston rod starts moving outwards, as the hydraulic fluid is pumped into the bottom side of the hydraulic cylinder. In the reverse process, the hydraulic fluid is pushed back into the reservoir by the piston. The pressure in the cylinder is the ratio of unit force per unit piston area.

The pressure generated in the piston rod chamber is the ratio of the unit load per the difference in the unit piston area and unit piston rod area. This calculation is used when

the hydraulic fluid is let into the piston rod chamber as well as the fluid flows smoothly (without pressure) from the piston area to the reservoir. In this way, the expansion and retraction (push and pull) action of the hydraulic cylinder is generated.

D. Main components

Hydraulic Cylinder
 12V DC motor
 Vane pump
 4-way Directional control
 valve Oil reservoir
 12V Battery
 Frame setup
 Hydraulic Hose

II. LITERATURE REVIEW

Dr. Ramachandra C.G, Krishna Pavana, Shivraj Shet and Venugopal Reddy, Virupaxappa B (2013) have presented that whenever any vehicles undergo a tyre failure, it becomes a very cumbersome task for the person to lift the vehicle from the ground level and lot of manual effort is required even though a jack is used. Musa Nicholas, Abodunrin Tosin Oladipo Sarafadeen (2016) have studied that in order to mitigate the problems associated with the use of a single jack and other lifting devices to raise cars completely off the ground to effect repairs. P.S. Borkar, S. V. Sontakke, R. R. Dorwe, A. B. Ganorkar, S. P. Lokhande (2015) have studied application of pressurized air to produce mechanical motion. Pneumatic jack is a fabricated model which when installed in four wheelers, will ease in the problems arising in the conventional operated jack. Balkeshwar Singh, Anil Kumar Mishra. (2015) This research paper analyses the modification of the existing motor screw jack by incorporating an electric motor in the screw in order to make load lifting easier. In this modified design, the power screw is rotated by connecting motor through universal coupling, plugged to the automobile 12 V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. Mohammed Siddique Ahmed, Mohd Riyaz Uddin, Faraz Ur Rehman Azhar, MdShaffi (2014) A jack is a 'device that uses force to lift heavy loads. The primary mechanism with which force is applied varies, depending on the specific type of jack, but is typically a screw thread or a hydraulic cylinder. Jacks can be categorized based on the type of force they employ: mechanical or hydraulic. Mechanical jacks, such as carjacks and house jacks, lift heavy equipment and are rated based on lifting capacity (for example, the number of tons they can lift). Hydraulic jack tends to be stronger and can lift heavier loads higher, and include bottle jacks and floor jacks.

III. OBJECTIVES

Vehicles are lifted for various purposes like for downside inspection or repair, replacement of tyre etc. On service stations both manual hand operated and automatic hydraulic jacks are used to lift the vehicles. But on the road, for tyre replacement, driver have to put efforts with conventional hand operated jacks present in the vehicle.

The hydraulic jack project was to design, fabricate and use a motorized hydraulic jack as an inbuilt solution for lifting the vehicle with control in the hand of driver sitting inside. This can reduce all efforts of workmen with only some control switches on dashboard inside the vehicle.

It Reduces human effort at large limit and also this type of system is very useful for ladies and old people since during the problem of puncher of tyre, they can easily change the wheel. A single person can go on a long drive without worrying about getting stuck in the way. The servicing of the vehicle will be easy and cheap and it Can be operated even when the vehicle is not in starting condition. This is also suitable for uneven surfaces.

IV. METHODOLOGY

Our mechanism is mainly used for lifting the car. The mechanism is powered by the battery. The control of the mechanism will be provided at the user hand. When the operator presses the switch, the battery will run the hydraulic pump. The pump will press the oil from the reservoir to the control valve. The flow of oil to the double acting hydraulic cylinder can be controlled with the help of this control valve. When control valve directs the oil to the cylinder for a lifting stroke the pressure will be imparted to the piston and the stroke will take place. Then the piston will start lifting the car from the ground level. For the down movement of a lifted car the user can again operate the control valve which will direct the flow of oil to the other side of cylinder and the stroke will be imparted with pressurized oil. After operation the user will press the off button and that will cut-off the electrical power to the motor. This will stop the pump and the circulation of oil in the system.

This project will be very useful for lifting purpose of vehicles which are used in automobile field, especially in tire workshop. The prime movers are operated by (i) electrical system (ii) Hydraulic system (iii) Pneumatic system. In electrical system, the rotary motion is provided by simple motors. The linear motions can be obtained by converting rotary motions with the aid of screw jack (or) Rack and pinion. In Hydraulic system, enclosed water (or) oil can be used to convey energy from one location to another. In Greek, hydra means water. In Pneumatic system, normally compressed air is used to transfer energy from one location to another. All liquids are non-compressible and can be used to transmit power any load to be lifted offers resistance to flow of liquid.

Pressure is described mathematically by a Force/Area. Therefore if you have two cylinders connected together, a small one and a large one, and apply a small Force to the small cylinder, this would result in a given pressure. By Pascal's Principle, this pressure would be the same in the larger cylinder, but since the larger cylinder has more area, the force emitted by the second cylinder would be greater. This is represented by rearranging the pressure formula $P =$

F/A , to $F = PA$. The pressure stayed the same in the second cylinder, but Area was increased, resulting in a larger Force.

Nowadays, the vehicle places a vital role for transport. If May tyre gets puncture, the drivers are facing more difficulties to change the tyre or to lift the vehicle by using jack. They are using either manually operated jack or hydraulically operated jack. Hydraulic jack takes less man power to lift. Even system failure (may be slip occur) locking nut protect from slip. Our project is successfully implemented to lift the vehicles without any dangerous. It will reduce the burden of the workers as well as protect from the accident.

V. WORKING PRINCIPLE

A. Pascal's Law

Blasé Pascal formulated the basic law of hydraulics in the middle 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. "It states that the intensity of pressure at any point in a fluid at rest is the same in all direction".

B. Working Procedure

- When the DC supply is given to the motor, the motor will start to run where the motor and the vane pump is initially meshed each other with the help of gear arrangements.
- Which in terms it makes the vane pump to rotate.
- The oil from the reservoir is pumped out and passes to the control valve.
- The control valve controls the flow of oil and direct the oil into the inlet of the double acting cylinder.
- The double acting hydraulic cylinder will have one piston within a cylindrical housing.
- When hydraulic will be supplied to its cap end port, hydraulic pressure force will be applied over the piston or plunger.
- Hence, piston will be extended and this stroke of cylinder will be termed as forward stroke.
- During extension of the cylinder piston or plunger, hydraulic oil at rod end side will be pushed out and will be directed towards the control valve which actuate or retard the hydraulic cylinder in the basis of manual control.
- Hence double acting hydraulic cylinder will be operated hydraulically in both direction i.e. during extension or forward direction and also during retraction or return stroke.
- Direction of hydraulic oil will be changed with the help of directional control valve and it is also being used for changing the direction of flow of fluid.
- With the help of the rack and pinion arrangement, the piston will move forward and backward of the chassis.

VI. CALCULATION

A. Design of Hydraulic Jack System

Unaided weight of the car = 18.3

kg Weight on each wheel= 3kg

FRAME (Box section):

Material = Mild steel

Thickness = 3mm

Box Cross section =

60mmx60mm Length = 130cm

Width = 65cm

Cylindrical roller Bearing Diameter = 3cm

B. Specification of master cylinder

Diameter of the master cylinder = 1.2 cm = 12 mm

Area of master cylinder = $d^2 = (12)^2 \times A = 114 \text{ mm}^2$

C. 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 = Stainless Steel Piston

Rod Material = Stainless Steel Rod

Dia. = 8mm

Design of Piston Rod:

Material strength EN9 = 1750

kg/cm² $P = 0.785 \times 20 \times 20 \times 1750$

$P = 549500 \text{ kg/mm}$

D. Design of hydraulic unit

By Pascal's law,

= x

120 = x314 mm²

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

Force required at the working piston

$F = P \times A$

= 0.3861x114

mm² $F = 45 \text{ N}$

Therefore the force to be applied at the working piston is 45 N, which is 10 times lesser than the weight to be lifted.

VII. ADVANTAGES

Simpler design. In most cases, a few pre-engineered components will replace complicated mechanical linkages

Hydraulic components can be located with considerable flexibility

Checking and cleaning are easy
Repairing is easy

Replacement of parts is easy

The loaded light vehicles can be easily lifted
Manual power is not required

Handling is easy



VIII. LIMITATIONS AND FUTURE SCOPE

A. Limitations

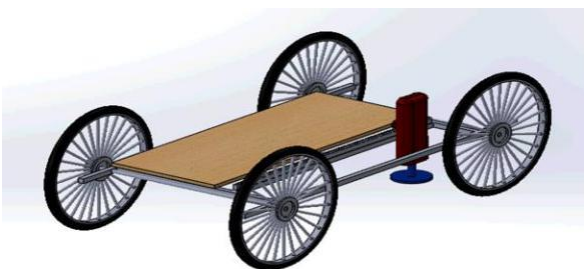
- Cost will increase slightly
- Weight of the vehicle will increase slightly
- Chances of leakage
- System required maintenance

B. Future Scope

- We are currently working on small commercial vehicles but in future it can be used for heavy duty vehicles by making small changes.
- Hydraulic pump can directly be connected to engine output instead of connecting to a motor.
- With this system can be operated through acceleration pedal.
- Similarly, use of battery can also be eliminated and power can be drawn dynamo.

IX. CONCLUSION

With some design consideration an inbuilt car lifting mechanism can easily be fitted in all light weight automobiles. The project works on hydraulic power provided by battery. Maintenance and service of the vehicle can be easily done by this project. With this project the usage of automobile can be made easy for women and old people. Some extra automation like solenoid control valve can add great value to the project. The inbuilt jack is operated by batter so it can also be used when the vehicle engine is not started.



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