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DESIGN AND ANALYSIS OF HYDRAULIC JACK

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ABSTRACT

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 car jacks and house jacks, lift heavy equipment and are rated based on lifting capacity (for example, the number of tons they can lift). Hydraulic jacktend to be stronger and can lift heavier loads higher, and include bottle jacks and floor jacks. HYDRAULIC JACKS depend on force generated by pressure. Essentially, if two cylinders (a large and a small one) are connected and force is applied to one cylinder, equal pressure is generated in both cylinders. However, because one cylinder has a larger area, the force the larger cylinder produces will be higher, although the pressure in the two cylinders will remain the same. Hydraulic jacks depend on this basic principle to lift heavy loads: they use pump plungers to move oil through two cylinders. The plunger is first drawn back, which opens the suction valve ball within and draws oil into the pump chamber. As the plunger is pushed forward, the oil moves through an external discharge check valve into the cylinder chamber, and the suction valve closes, which results in pressure building within the cylinder.

Keywords: Hydraulic Jack, AutoCAD, Design.

I. INTRODUCTION

A hydraulic jack is a jack that uses a liquid to push against a piston. This is based on Pascal's Principle. The principle states that pressure in a closed container is the same at all points. If there are two cylinders connected, applying force to the smaller cylinder will result in the same amount of pressure in the larger cylinder. However, since the larger cylinder has more area, the resulting force will be greater. In other words, an increase in area leads to an increase in force. The greater the difference in size between the two cylinders, the greater the increase in the force will be. A hydraulic jack operates based on this two cylinder system.

Figure 1: Hydraulic Jack

Selection criteria for hydraulic Jack

There are several specifications of a hydraulic jack to consider when deciding which is best for you and your application. Here are some guidelines that you may find useful:

1. **Load capacity:** The lifting load capacity is the most crucial parameter.
2. **Clearance:** Check to see that the hydraulic jack can fit under the load. The hydraulic floor jack offers the lowest profile of the two main types. If it is a side lift, you can also consider the toe type bottle jack.

3. Lift height: The telescoping bottle jack extends the lift height of a standard bottle jack, but with a lower lifting capacity.

4. Orientation: Consider if the hydraulic jack is for vertical lift, horizontal push, or both.

5. Automatic or manual: A heavy-duty hydraulic bottle jack operates with air or electric pumps. An automatic hydraulic jack replaces the manual hand lever with a powered pump. The general principle remains as described in the article.

6. Application: The design of some hydraulic jacks is explicitly for specific industrial functions, e.g. hydraulic jacks used for splitting logs of wood. Check to ensure it can work for your purpose.

II. METHODOLOGY

Different Parts of Hydraulic Jack

1. Cylinder Barrel: The cylinder barrel is mostly a seamless thick walled forged pipe that must be machined internally. The cylinder barrel is ground and/or honed internally.

2. Cylinder Base or Cap: in most hydraulic cylinders, the barrel and the bottom portion are welded together. This can damage the inside of the barrel if done poorly. Therefore, some cylinder designs have a screwed or flanged connection from the cylinder end cap to the barrel. In this type the barrel can be disassembled and repaired.

3. Piston Rod: The piston rod is typically a hard chrome-plated piece of cold-rolled steel which attaches to the piston and extends from the cylinder through the rod-end head. In double rod-end cylinders, the actuator has a rod extending from both sides of the piston and out both ends of the barrel.

4. Gland (End Cap: The cylinder head is fitted with seals to prevent the pressurized oil from leaking past the interface between the rod and the head. This area is called the rod gland. It often has another seal called a rod wiper which prevents contaminants from entering the cylinder when the extended rod retracts back into the cylinder.

5. Reservoir: The main function of a reservoir is to hold system hydraulic fluid in a convenient location for the pump inlet. In addition to system requirements, the reservoir also holds excess fluid needed when the hydraulic system is in operation.

6. Base Plate: Base Plate, which again increases stability four to five times, and gives you up to eight times the support area. The larger the support area, the more stable and secure your jack will become.

Experimental Procedure:

1. When the handle is operated, the plunger reciprocates then the oil from the reservoir is sucked into the plunger cylinder during upward stroke of the plunger through the suction valve. The oil in the plunger cylinder is delivered into the ram cylinder during the downward stroke of the plunger through the delivery valve.
2. This pressurized oil lifts the load up, which is placed on top plate of the ram. After the work is completed the pressure in the ram cylinder is released by unscrewing the lowering screw thus the pressure releases and the ram is lowered, then the oil is rushed into the reservoir.
3. It consists of plunger cylinder on one side and ram cylinder on the other side. These two cylinders are mounted on base which is made of mild steel.
4. Plunger cylinder consists of plunger which is used to build up the pressure by operating the handle. Plunger cylinder consists of two non-return valves i.e. one for suction and other for delivery. Ram cylinder consists of ram which lifts the load.
5. The ram cylinder connected to delivery valve of plunger cylinder. It is also consists of lowering screw this is nothing but a hand operated valve used for releasing the pressure in the ram cylinder for get down the load.

Figure 2: Experimental Setup of hydraulic Jack

III. DESIGN OF HYDRAULIC JACK

Table 1: Diamension of hydraulic Jack

Sr No.	Parts	Length (mm)	Inner Dia.(mm)	Outer Dia.(mm)
1	Ram Cylinder	220	70	90
2	Ram	200	70	-----
3	Reservoir	218	120	128
4	Plunger	138	10	-----
5	Plunger Cylinder	132	10	20

Design Consideration

- Load (W) = 06 ton(60kN)
- OPERATING PRESSURE (p) = 25 M Pa
- Lift range (L) = 20 cm
- Man effort put on the handle (e) = 20 Kg
- Permissible tensile stress of mild steel (σt) = 120 N/mm2
- No. of strokes for lifting load (n) = 150
- Factor of safety = 5
- Permissible shear stress of mild steel (τ) = 20 N/mm2
- Permissible compressive stress of mild steel(σc)= 20 N/mm2
- Permissible compressive stress of cast iron (σCI)= 120 N/mm2
- Permissible shear stress of cast iron (τCI) = 35 N/mm2

1] DESIGN OF RAM CYLINDER

It is a cylinder in which produces a slide way to the ram. The ram cylinder is made up of mild steel with density of 8.868 gm/cc. It is mounted on the base plate

Let,

d = inner diameter of ram cylinder

D = outer diameter of ram cylinder

P = pressure acting on cylinder =25 Mpa

W = load =60kN T = thickness of ram cylinder

2] DESIGN OF PLUNGER CYLINDER:

The plunger cylinder is made up of mild steel and is mounted on the base plate. It provides slide way to the plunger in order to build up the pressure.

Let,

dp = inside dia of plunger cylinder = 10 mm

Dp = outside dia of plunger cylinder

tp = thickness of plunger cylinder Assume the thickness of plunger cylinder (tp) = 5 mm

Tensile strength of mild steel (σt) = 120 N/mm2

By LAME'S equation t = 5+ 5.0625(25 - 1) 126.5625 – 5.0625 +5.0625 = 101.5625 = 16.752 N/mm2

Hence the induced tensile strength of M.S. is less than permissible value. So, the design is safe. By using thickness and inside diameter, we can calculate the outer diameter of plunger cylinder Dp =dp + 2t

= 10+2(5) = 20 mm

Outer diameter of plunger cylinder (DP) = 20 mm

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3] DESIGN OF PLUNGER

Let the plunger is made up of mild steel which reciprocates in plunger cylinder to increase the pressure of the oil.

Let,

W = load acting on plunger

dp = diameter of plunger

P = pressure developed in plunger cylinder from standard table inside diameter of plunger cylinder is fixed i.e. 10 mm

Load acting on plunger = pressure × area = 25×106 = 1256.63 N = 128.09 kg

We taken Load acting on the plunger =130 kg

4] PLUNGER DISPLACEMENT

We know that,

Velocity ratio (V.R.) = Assume V.R. = 150

150 = 114.49 mm = 11.449 cm; Therefore plunger displacement = 11.5 cm

5] DESIGN OF LEVER

A lever is made up of mild steel and is used to apply load on the plunger. It is attached to the plunger with the help of pivot.

Assumptions,

1. Effort put on lever by man = 20 kg
2. Load acting on plunger = 120kg

Velocity ratio of lever = 5.5

Required distance from fulcrum to load = 11.5 cm

Total length of lever = 5.5× 11.5 = 64 cm.

We taken length of lever = 64 cm

Lever is made up of mild steel. Permissible tensile strength of mild steel (σt) = 120 N/mm2

Where, M = maximum bending moment

I = moment of inertia = permissible tensile strength

Y = distance between outer most layer to neutral layer

Z = section modulus

6] DESIGN OF RESERVOIR

The volume of oil circulated in the system is 835c.c

But, we take the volume of oil is 33% greater than the volume of circulated in the system. Volume of oil in the reservoir = 835+ × 8 = 1110c.c [× L] = 1110 c.c

Where,

D = outer dia of ram cylinder

L = height = 218 mm

We adopt inner dia of reservoir = 120mm

Assuming thickness of reservoir = 6mm

Therefore outer dia of reservoir (Dr) = 120+ (2×4) = 128mm

7] DESIGN OF BASE

Fix the dimensions of base plate as

l× b × tb = 200×150×25

Where,

l = length of base

b =width of base

tb =thickness of base is made up of mild steel.

Permissible compressive stress of M.S (σc) = 20 N/mm2

Compressive area of base =200×15 = 30000

Permissible shear stress of mild steel (τ) = 20 N/mm2

Shearing area = π × d × tb = π × 71.5 × 25 =5615.59

Where,

d = inner dia of ram cylinder

tb =thickness of base plate

Load acting on base = 100.17 KN

Checking for compressive strength σc = 3.339 N/mm2

Checking for shear strength τ =17.83 N/mm2

The induced shear and compressive stresses are less than permissible valve. Hence the design is safe

IV. RESULTS AND DISCUSSION

We have designed AUTO CAD model of hydraulic jack according to the proper defined dimensions based upon our requirements for the lifting of different load.

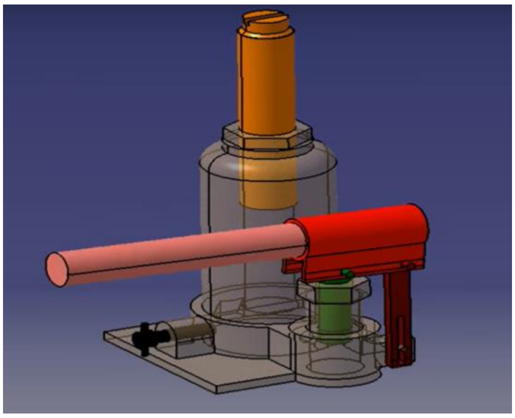

Figure 3: Isometric View

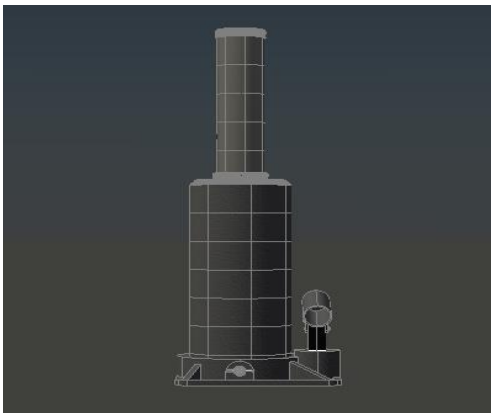

Figure 4: Front View

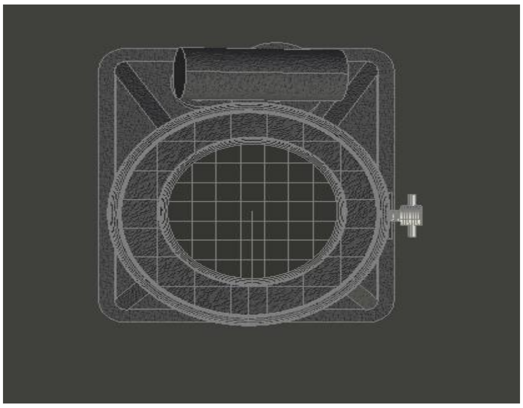

Figure 5: Top View

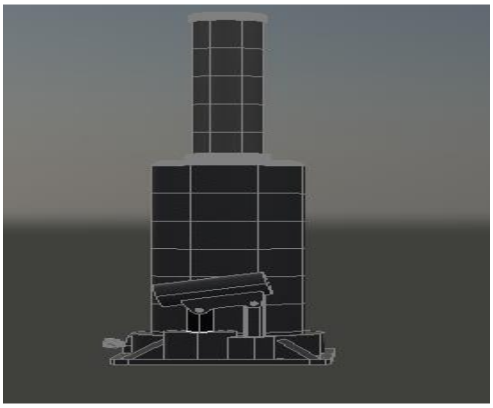

Figure 6: Side View

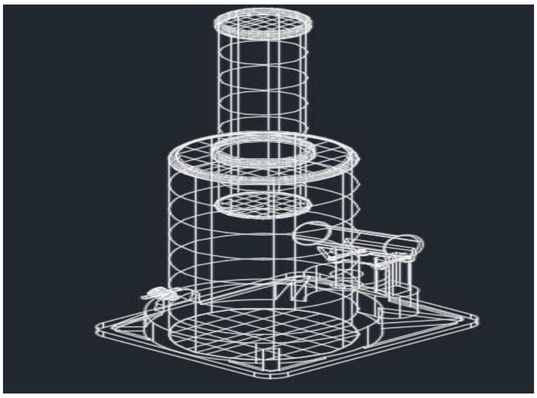

Figure 7: 2D Wire Frame

Here we have the folowing result based upon our design of hydraulic Jack. The procedure we adopted is given as below in an exapmle as;

The weight to be lifted is 100kg or 1000N.

Let us find out the effort required by the Human

Formula

$$F=P*A$$

Putting Values;

$1000=P*\pi/4(70*10^{-3})^2$

$P=1000*4/\pi*(70*10^{-3})^2$

Force required at the working piston:

$$F=P*A$$

$$= 509.29*10^3*\pi/4*(9*10^{-3})^2$$

$$F =165.305N=16.5305kg$$

Therfore, the force to be applied at the working piston is 90N, which is 10 times than the weight to be lifted.

Moreoever, based upon our calculations we have the following results which were performed on MAT LAB then listed down in the table below;

Table 2: Obtained Result

Lifted Load	Applied Effort
100	1.6530
500	8.2849
1000	16.5505
1500	24.8070
2000	33.0616
3000	49.5928
5000	82.6535

And then, based upon our calculations,a graph was plotted between applied load to be lifted.

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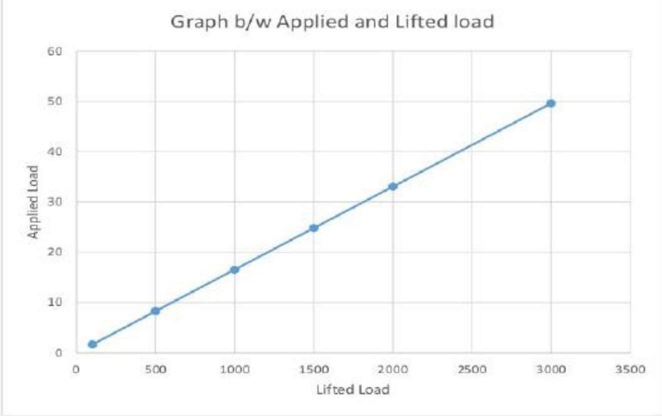

Figure 8: b/w Applied & Lifted Load

V. CONCLUSION

1. The design and construction of the 5 ton hydraulic jack would be very useful in automobile maintenance, marine vessels diesel engines maintenance because of its ease of operation and speed in lifting load. This could be further constructed using steel and other materials with the aim of adding value and maximizing local content.
2. Ergonomics, material handling and providing comfort to the operator was our main motive behind developing this lifter this was considered as a radical improvement in the productivity by the company.
3. The hydraulic jack can be design for high load also if a suitable high capacity hydraulic cylinder is used. The hydraulic jack is simple in use and does not required routine maintenance.
4. It can also lift heavier loads. The main advantages of this device are its low initial cost, & low operating cost. The shearing tool should be heat treated to have high strength. Savings resulting from the use of this device will make it pay for itself with in short period of time and it can be a great companion in any engineering industry dealing with rusted and unused metals.

VI. REFERENCES

[1] R. Sharavanan et.al, Design of built-in hydraulic jack for light motor vehicles. International Journal of Pure and Applied Mathematics Volume 116 No. 17 2017, 457-461.
[2] Chetan S.Dhamak et.al, Design and optimization of scissor Jack. INTERNATIONAL JOURNAL OF ADVANCES IN PRODUCTION AND MECHANICAL ENGINEERING (IJAPME).
[3] Rohan Hatti et.al, Design, Manufacturing & Analysis of Hydraulic Scissor Lift. International Journal of Engineering Research and General Science Volume 3, Issue 2, Part 2, March-April, 2015 ISSN 2091-2730
[4] Abhishekh a Singh et.al, Design and Fabrication of Adjustable Hydraulic Jack with Wheel System. IJSRD - International Journal for Scientific Research & Development| Vol. 6, Issue 01, 2018 | ISSN (online): 2321-0613.
[5] "Analysis & Optimization of Hydraulic Scissor Lift", Sabde Abhijit Manoharrao, Prof. Jamgekar R.S. 2016 IJEDR Volume 4, Issue 4 | ISSN: 2321-9939.
[6] "Design, Manufacturing & Analysis of Hydraulic Scissor Lift" Gaffar G Momin, et al, International Journal Of Engineering Research And General Science Volume 3, Issue 2, Part 2, March-April, 2015
[7] "Design, Analysis and Development of Multiutility home equipment using Scissor Lift Mechanism", Divyesh Prafulla Ubale, et al. Volume-3, Issue - 3, Pages- 2405-2408, 2015
[8] "Design and Analysis of Hydraulic Pallet System in Chain Conveyor" Setu Dabhi, et al, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 ISSN: 2321-7308
[9] "Design and analysis of an aerial scissor Lift" M. Abhinay, P.Sampath Rao SSRG International Journal of Mechanical Engineering (SSRG-IJME) – volume1 issue 5 September 2014.
[10] "Design and Analysis of an Aerial Scissor Lift", Soma Raghavendra, C. Raghunath Reddy International Journal of Engineering Science and Computing, July 2017.