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Design of Lifting Device Using Hydraulic Telescopic Jack

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Abstract:- *The main purpose of the project is To Design a System Using Telescopic Hydraulic Jack For Tata Nangia Motors Pvt. Ltd. Hingna MIDC Nagpur, Maharashtra To overcome their problem of lifting automobile component like engine, gear box form inside the ram (chamber made inside the ground where the washing and repairing of chassis being carried out). This system overcomes their difficulty to lift the component from inside the ram which they do manually. This system reduces their danger of life and also increases their safety. Present paper includes the detail study of the system made by using hydraulic telescopic jack along with their analysis portion.*

The analysis portion is being carried out with the help of ANSYS SOFTWARE. The different component that we are using and going to analyzed are plate, cylinder, wheel, tank. This paper also includes the study of hydraulic because the main function of lifting is done by hydraulic oil by itself. At last the theoretical calculation is being carried out and the theoretical calculation along with the standard values and software obtain result are being compared for validation purpose.

Keywords: - *Design of cylinders, Design assumption, Design of tank, Selection of Hydraulic oil, Selection of Wheel*

Problem statement

The main purpose of this project is to make a system which is use to lift automobile component like engine, gear box from inside the ram to particular height for repairing purpose using telescopic hydraulic jack. In this project we mainly design jack to lift the maximum load of 1000kg up to the height of 1016mm (40 inches) to the ground level from inside the ram. Bearing area is also to be checked as well as the jack has to be analyzed under maximum loading condition with minimum resisting area condition.

Introduction

The telescopic hydraulic jack is work as a liquid column which is very useful in achieving desire height within the limited cross section area. The working of the telescopic jack is based on Pascal's law which states that "The pressure in a closed container is same at all points". If there are four cylinder connected applying force on the smaller cylinder will result in the same amount of pressure in the larger cylinder which has greater area, the resulting force will be greater i.e., an increase in area leads to increase in the force stepwise. Greater the difference in size between the areas of the cylinder result in greater increase in the force. The work in this project is being carried out with the help of four cylinders to achieve our purpose

Design Consideration and Methodology

Assumption:-

- Bore diameter for bottom stage or ideal stage is 50 mm.
- 2nd stage is considered as piston for first stage/bottom stage/ideal stage.
- Loading rating factor is considered as 0.8.
- For sliding purpose consider slotting.
- Take diameter ratio between stages as 0.8 times.

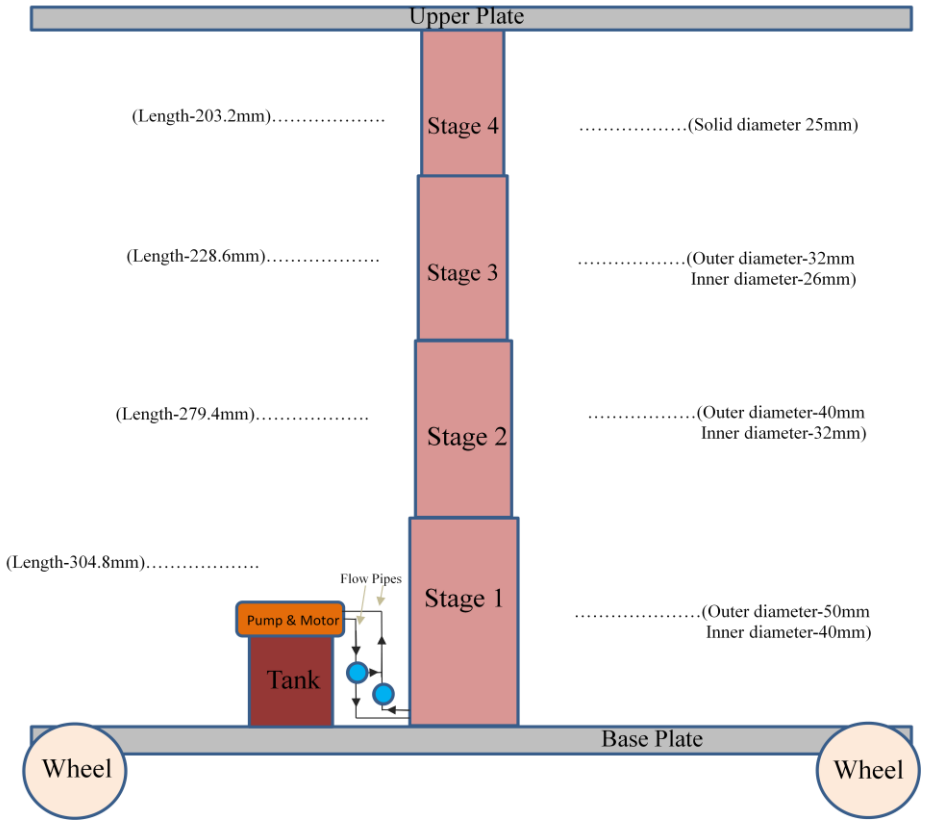


Fig. 2D sketch Arrangement

Practical consideration:-

1. Load to be lift =1000kg.
2. Height to be achieve =1016mm.
3. Material selected for jack is EN24.
4. Factor of safety =5.
5. Ultimate shear stress (Sut) =689 N/mm2.
6. Yield strength in tension (Syt) =470 N/mm2.
7. Modulus of elasticity (E) =206 N/mm2.
8. Percentage of elongation =21.
9. Brinell hardness 'BHN' =207.
10. Modulus of elasticity in shear =83Gpa.

Design of Cylinder

The ram cylinder is fixed on the base plate. The ram slides inside the ram cylinder the material chosen for the ram cylinder to be EN24 having density 7840 kg/m3.

Let

D =outer diameter of ram cylinder
d =inner diameter of ram cylinder
p =pressure acting on the cylinder
W =load (Component that to be lift) =1000kg.
t =thickness of ram cylinder

Procedure

- **For First Stage**

1. Calculation for pressure (Assume bore 50mm and take relation between diameters to be 0.8)

Area (A_1) =$\pi/4\times (D^2- d^2)$

=$\pi/4 \times (50^2- 40^2)$ (Diameter is assume in the basis of the load buckling chart)

Area (A_1) = 706.95 mm^2

(d=0.8 D, =0.8×50 = 40)

This area we get is the area of base cylinder

Now,

Pressure = (Force / Area) × Load rating

= (1000×9.81 / 706.95) ×0.8

Pressure = 17.345Mpa

Thickness is consider to be 5mm on each side

Note: The Pressure is valid, the jack is in the solid length

Volume of the first stage = Area (A_1) × Length (L_1)

= 215478.36 mm^3

- **For Second Stage -**

Note: In this case the inner diameter of the first stage becomes outer diameter of the of second stage

d = 0.8 D

= 0.8 × 40

= 32 mm

Therefore,

Area (A_2) = π/4× (D^2 - d^2)

A_2 = 452.448 mm^2

Thickness is considered to be 4mm on each side.

Therefore,

Volume of second stage = Area (A_2) × Length (L_2)

= 126418.94 mm^3

- **For stage 3**

Note - The inner diameter of the second stage becomes outer diameter for the third stage

d = 0.8 × D

= 0.8 × 32

= 25.6 mm = 26 mm

Area for third stage (A_3) = π/4× (D^2 - d^2)

= 273.354 mm^2

Thickness is considered to be 3mm on each side.

Volume of third stage (V_3) = A_3 × L_3

= 62488.724 mm^3

- **For fourth stage -**

In this stage we are using solid cylinder completely for extra safety with reference to buckling

Note: - The inner diameter of third stage becomes the outer diameter of fourth stage and the fourth stage consists of solid to prevent buckling.

Area of fourth stage = A_4

= π/4 × d^2

= 530.998 mm^2

Total volume of oil requirement for operating jack is calculated by adding three stage volume

Total volume required = volume of stage 1 + volume of stage 2 + volume of stage 3

= 404381.054 mm^3

= 0.404 liter

Selection of Hydraulic Pump for Jack

Hydraulic pump is used in hydraulic system and this pump can be hydrodynamic or hydrostatic. The function of hydraulic pump is to convert mechanical source of power into hydraulic power. This hydrostatic pump operates on the Pascal law. This Pascal law states that "The increase of pressure at one point of enclosed liquid in rest is transmitted equally to all other point". Hydrostatic pump are also called as positive displacement pump while hydrodynamic pump are fixed displacement pump which means that its displacement cannot be adjusted. Different types of pump are present they are as follows

1. Gear pump
2. Rotary vane pump
3. Screw pump
4. Bent axis pump
5. Redial piston pump

But in this system we are using Gear pump because of the following advantages
1. This pump has high precision gear.
2. High strength aluminum alloy shell.
3. It has simple structure and light weight.
4. High efficiency and low noise operation.
this pump CBN- f314 hydraulic oil gear pump are widely used in automobiles, engineering machinery, lifting machinery, light industry machinery and other hydraulic related machinery
Displacement capacity of (ml/rev) - 14
Pressure (mpa) - 20
Rotational speed of (rev/min) - 2000
Referred from (hydraulic-oil-gear-pump-cbn-f314)
Hydraulic fluid:-
The fluid are used to transfer the power from one place to another with compression fluid. This can be used for lifting purposed. So commonly hydraulic fluid are used as mineral oil or water.

Properties:-

- Non compressible
- Low foaming tendency
- Low temperature fluidity
- Anti- wear characteristics
- Corrosion control
- Fire resistance

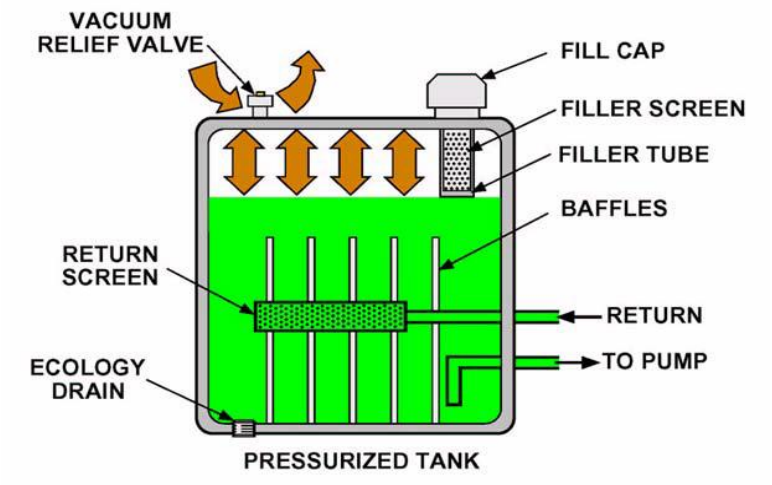
We selected the Hydraulic fluid is namely as Petroleum Based fluid in the form of Anti-wear Hydraulic Oil Grade 32 for the lifting. The min. working temperature is -5^0C and max. Working temperature is 80^0C.The specific gravity of fluid is 0.8767. The kinematic viscosity is 30 to 35 mm^2/sec and viscosity is 2.18×10^{-1} Ns/m^2.

Advantages:-

a. Rust protection superior or equivalent to the best premium quality conventional hydraulic oil.
b. Good water separation.
c. Excellent oxidation resistance.

Hydraulic tank

The hydraulic tank is used to store the fluid and to supply the system. The tank is closed to cover any loses from minor leakage and evaporation of fluid. The tank is design to provide space for fluid expansion and provide the valve for air enter and escape from the tank. With the help of air to cooling the fluid. The main function of hydraulic tank is to store and it's used to supply according to requirement of the system. The hydraulic tank have good strength, bearing capacity and the dirt remove it. The tank is not fully sealed. It provide some valve for filling oil and air exchange.



The components of tank are provided in design

Filler cap: - it is use to pour the hydraulic oil into the tank. It keeps contaminates away from the tank.

Filler screen: - it prevents large contaminates particle from entering the tank.
Filler tube: - it is medium between oil source and oil tank, which help to fill the tank up to correct level but not over fill.
Baffles: - it is mainly use to create the obstacle into the flow of oil. Due to which oil bubble formation will be ignored. It prevents sloshing as well as foaming of oil.
Vacuum relief valve: - it is use for two purpose. It prevent the vacuum formation and limiting the maximum pressure in the tank. It is a simple valve which open and allow air to enter into the tank and increase the air pressure.
Material: ISC 20 carbon steel
Yield strength: 246MPa
Modulus of elasticity: 250GPa

Calculations

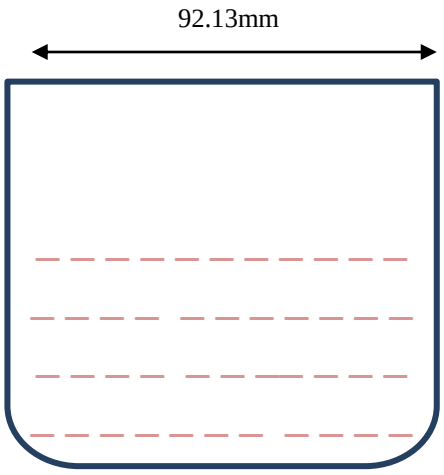


Fig. 2D Sketch of Tank

Volume = 1 Liter = 1×10^6 mm^3
V = Area × length
$V = \pi/4 \times D^2 \times L$
Where, V = Volume of tank
D = Diameter of tank
L = Length of tank = 150mm
$1\times10^6 = \pi/4 \times D^2 \times 150$
D = 92.13mm

Thickness of tank: $T_b = (P\times D)/2\times S_d$
Where,
P= Pressure of tank
D= Diameter of tank
S_{yt} = Yield strength = S_d/ 0.8
$T_b = (19.984 \times 92.13)/ 2 \times 0.8\times 246$
T_b = 5.08mm
The upper part of the tank is flat circular shape and lower portion of the tank is ellipsoidal.

Advantages:-

- Tank material is highly affordable and reliable.
- It is environmentally friendly.
- It has good weld ability and improved corrosion resistant.

Wheel

The simple machine called a wheel and axle refers to the assembly formed by two disks, or cylinders, of different diameters mounted so they rotate together around the same axis. The wheels are used for rolling motion. In this paper we needed this design of wheels for rolling the whole assembly on the ground. So that we can easily move our assembly wherever it is necessary.

Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axels. Instead of simply sliding over the ground, the wheelsdig in and rotate, turning around sturdy rods called axles.

There are many types of wheels are available in market. But we had done selection of wheels according to our requirement. So we needed soft material wheels which can easily rolls out on the hard floor surface of industry.

Fig: 5 Cast Iron Single Flanged Rail Wheels

Cast iron rail wheels are the most economic for light to medium duty, but they have a limited service life when compared to steel wheels, and are unsuitable For high rotational speeds or where substantial shock loads are to be Withstood.

Material:- Cast iron to BS1452: 1977: Grade 200

- The ‘maximum load rating’ given for each wheel is based on the full tread.
- Width being in contact with the rail.

Operating Temperature range

- Plain bored or keyway wheels – 30°C to 250°C
- Ball or taper roller bearing wheels – 30°C to 120°C

Advantage:-

- Easy maintenace
- Provide less friction

Calculation for Plate:-

Fixed the di=mention of base plate as

L ×b × t = 640 × 500 × 15

= 8640000 mm^3

Weight = 864 × 7.8

Weight = 6.739 kg

Nut and Bolt

The main function of Nut and bolt assembly is to hold the two different parts. Bolts are small which can put to hold and joint the different parts in any assembly. The bolt are provided with threads to assemble nut for stretching.

Material:-

The material of nut and bolt is I.S.C.35 Hot Rolled (SAE 1035). The ultimate strength of material is 580MPa, Yield strength of material is 367MPa.

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