

INVESTIGATION ON HYDRAULIC DOOR OPENING DEVICE

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Abstract : Hydraulic systems are basically used to reduce effort for applying force. This concept can be used for the opening the door. In door opening system hydraulic system implemented from very early days. But, here we are using different method for applying force to operate mechanism for opening door. The purpose of the investigation is to apply force by the weight of object. Weight can be applied in many ways, like self-weight or some external weight. There is one footstep for locating force to operate mechanism. Hydraulic cylinders are used for the opening door and applied force used for operating cylinders. That mechanism used for opening door. So, this concept is used in certain industry to operate door due to weight of container in dispatch section or material storage section.

Keywords: Hydraulic system, prototype, hydraulic cylinder.

1. INTRODUCTION

Basically we can see hydraulic system is used for the closing of the door. It is used for the closing door. But in this investigation hydraulic force is used for opening door. That force for operating cylinder is given by certain weight. Hydraulic systems are used for reducing effort in working stroke. Other systems also can be used but hydraulic system is optimum.

Here, spring force also used for closing the door. In this set up, force is applied by weight and due to that weight door can be opened. After removing the weight that door is closed due to spring action. So, hydraulic system is required for opening door and reaction force due to spring cause closing the door. There are many systems and mechanism for this purpose. But, hydraulic system has certain advantages.

1.1 ALTERNATIVE METHODS AND MECHANISM

There are mainly two systems used for operating mechanism viz.:

- 1) Pneumatic
- 2) Hydraulic.

There are some advantages of the system and on other hand some drawbacks are also there. Here is the comparison between hydraulic and pneumatic system in reference to current investigation work:

Hydraulic system: In particular door opening system, if we use hydraulic system closing of door is not possible only by hydraulic cylinder. Additional spring force is required for closing. Liquid is not very compressible, so there is no delay in movement.

Pneumatic system: Suction and compression is used for operating system, so there is no other mechanism required for closing door. Because gas is compressible, there is delay in movement. But we cannot use this system because of its quick response. Pneumatics system does not have the potential force that hydraulics system has to offer. The lifting or moving of heavy loads is not best suited to pneumatics. Hydraulics can smoothly lift and move loads because the hydraulic oil is not compressible compared to air. Pneumatics offer rapid movement of cylinders. So, response will be greater and fast. It can cause damage to prototype.

In terms of energy costs pneumatics is more costly than hydraulics systems; this is mainly due to the amount of energy lost through heat production while compressing air. Mechanisms used for transmission of force and impart motion:-

1. **Quick return mechanism:** - A quick return mechanism is an apparatus that converts circular motion (rotating motion following a circular path) into reciprocating motion. These mechanisms used where return stroke is required faster than the forward stroke.
2. **Slider crank mechanism:** - The Slider-crank mechanism is used to transform rotational motion into translational motion by means of a rotating driving beam, a connecting rod and a sliding body.

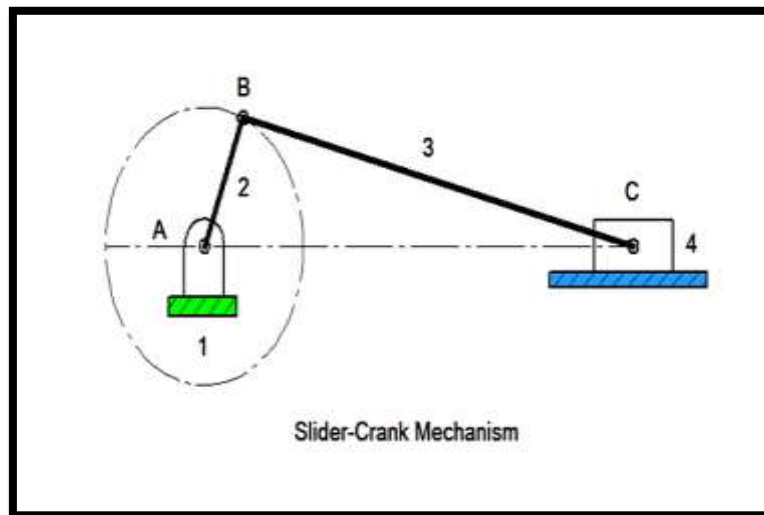


Figure 1 Slider Crank Mechanism

1.2 WORKING OF DOOR OPENING SYSTEM

Working of this type of door closer is as discussed above. One push type of force is applied by self-weight or by some type of external weight. That weight is used for the opening of the door. There are two cylinders for opening two doors separately. The external force is applied on the one foot step. Because of that spring get compressed and cylinders are operated due to linkage through foot step. After removing the weight spring expanded and reaction force of spring cause hydraulic piston to move opposite side and door gets closed. So, spring compression and hydraulic force is used to open the door and spring expansion is used to close the door. Hydraulic cylinders are operated through the compression of oil in respective pipes. Two separate cylinders are used for the both doors.

1.3 HYDRAULIC DOOR - ADVANTAGES AND APPLICATION

Because of not fast response, motion of the door is safe. It is also feasible and robust method than sensor based door. Application of the particular prototype is in industries for opening the door of store or other by self-weight of the raw material or product itself. So, this concept is very useful to dispatch and material handling department. In some garage there is also used this type of concept. In this particular application slider type door is used.

2 METHODOLOGIES

Equations for hydraulic cylinder are as below:-

- ❖ Cylinder Blind End Area: - $A = \pi R^2$.
Here, R = cylinder radius.
- ❖ Cylinder Rod End Area: -
Blind end area – rod end area.
Rod end area = $a = \pi r^2$.
Here, r = rod radius.
- ❖ Cylinder Output Force :-
Cylinder push force = pressure \times cylinder blind area.
Cylinder pull force = pressure \times cylinder rod area.
- ❖ Fluid Pressure Required to Lift Load :-
- ❖ Pressure = Force needed \div cylinder area.
Here for push type take cylinder blind Area and for pull type take cylinder rod area. These are the calculations useful for selecting cylinder for particular operation. By calculating weight or load to be lifted cylinder can be easily selected for the various range of load.

For the calculation taking dimension of the prototype:-

1. Height of the Door = 600mm
2. Width of the Door = 600mm
3. Thickness of the door = 20mm.
4. Mass of the door = 1.3kg.

Here, we are going to use two doors. So, total weight is equal to sum of both weights.

1. Total Mass = 2.6 kg.
2. Accordingly total weight =
 $2.6 \times 9.81 = 25.506\text{N}$.

We choose cylinder of maximum 60 bar capacity for this purpose. Cylinder specifications are defined by the load range that may be used in our prototype. And this particular model 3 to 5 kg load range is set for the applying load. Accordingly cylinder is

selected of 20 to 60 bar capacity. Various cylinder calculation can be made by cylinder specification and load applied by equation given in previous page.

3 PROTOTYPE BUILDING

3.1 COMPONENT SPECIFICATION

❖ Frame for the door:-

Height of the door = 600 mm.

Width of the door = 600 mm.

Thickness of the door = 20 mm.

Material for the metal framing is stainless steel.

Young modulus of material is 200 GPa

And poisson ratio is 0.270.

Mass of the door = 1.3kg.

Number of the door: - 2.

Foot step dimension: - 600×150×600 mm.

Material and Material properties are same as frame of door.

❖ Helical spring: -

Length = 40 mm.

Wire diameter = 4mm.

Coil diameter = 25mm.

Number of turns= 8.

Number of spring = 2.

Material for the spring is stainless steel. Material properties are same as framing material.

❖ Hydraulic cylinder:

Structure: Plunger type Cylinder

Power: Hydraulic

Body Material: Stainless Steel

Maximum Stroke: 15,500mm

Shaft Diameter: 12mm to 500mm

Working Pressure: 20 Bar

Number of cylinder: 2

We use cylinder of rod diameter of 12 mm and capacity up to 60bar.

DESIGN OF THE FRAME

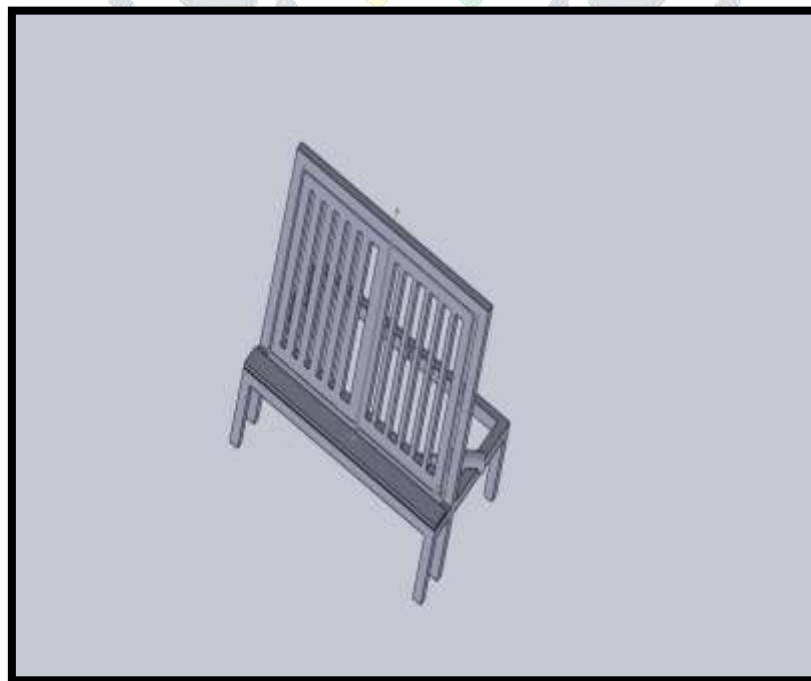


Figure 2 Assembly of Frame

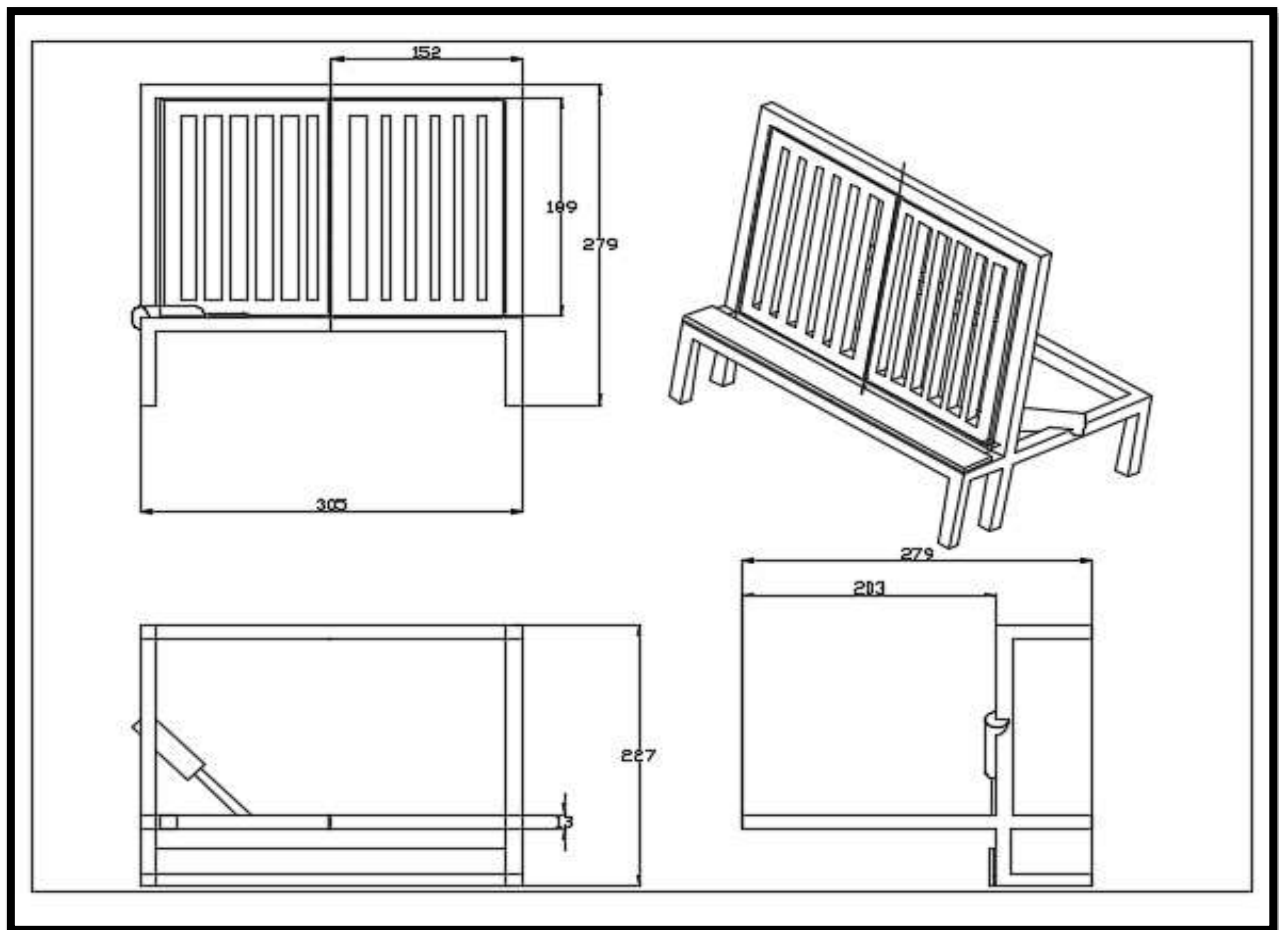


Figure 3 Details of Frame

DESIGN OF SPRING

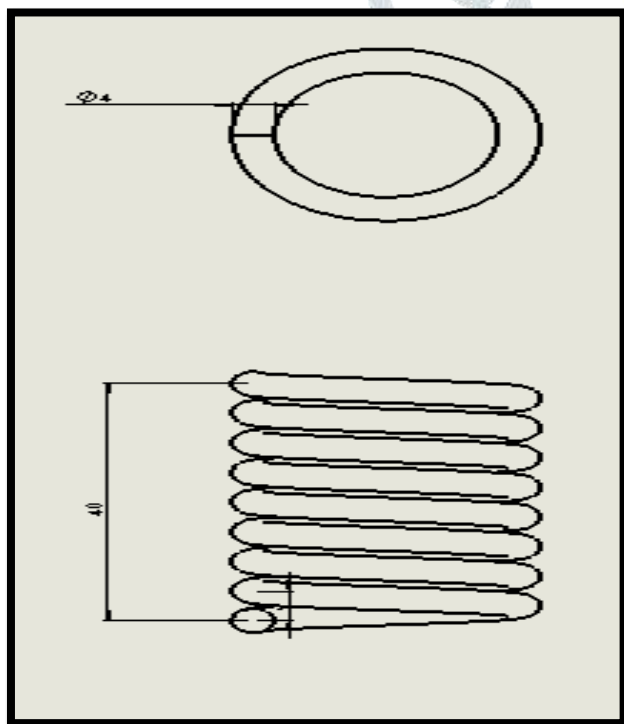


Figure 4 Details of spring

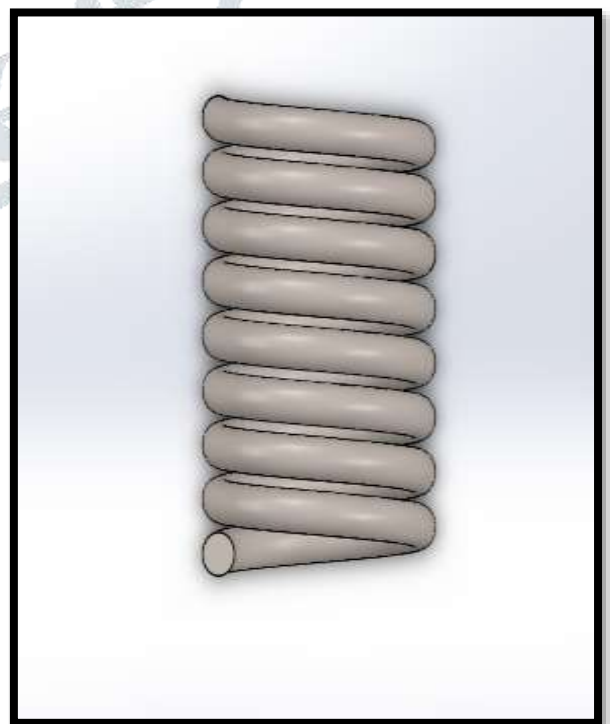


Figure 5 Solid Model of spring

Here, two springs of same dimensions are used for each door.

Wire diameter: 4mm.

Coil diameter: 25mm

Length: 40mm.

Number of turns 8

First of all frame of door with its outer framing is welded. After that foot step and cylinders along with spring in the foot step is welded and assembled.



Figure 6 Doors in Close Position

3.2 READING ON PROTOTYPE

Here, some readings are taken on prototype. Readings of time taken to open door for specific weight on foot step is taken.

Pressure(bar)	Maas(gram)	Time(sec)
10	500	No effect on door
15	1000	No effect on door
25	2000	No effect on door
35	3000	Door gradually open in 3 sec

Table 1 Observed Effect

So, after observation of load and timing we can say that door will be open for minimum mass of 3 kg. In particular our investigation prototype is made for range above 3 kg and up to 5 kg. It can work on above 5 kg but it can damage frame for this prototype.

5. COST ESTIMATION

Component	Cost (Rs.)
Hydraulic cylinder [2]	1250/-
Pressure valve [1]	385/-
Pipe	230/-
Helical spring	700/-
Frame	1750/-
Foot step	500/-
Labour cost	800/-
Transport cost	800/-
Paint	500/-
Overall cost	6917/-

Table 2 Cost associated with prototype

6. CONCLUSION

From the investigation, it is concluded that we can use hydraulic system in opening door. Normally we see that hydraulic cylinder is used for the closing door. But here it used for opening. Here self-weight is used though foot step to apply force. So, it can be useful in many industries for operating door by application of weight itself. We observed that door cannot open until sufficient amount of weight is not applied. As per reading taken on prototype, we can say that minimum weight required for opening door is around 3kg. Less weight than 3kg, it has no effect on door opening system. Maximum weight that can operate mechanism without damage is 5 to 6 kg. So, by this we can conclude that door can open by hydraulic cylinder which is operated by any type of weight. It can be used in industries for material handling section as per configuration. In this investigation some amount of shock is observed during opening the door.

Generally in hydraulic system there is no shock, but here due to spring action shock is observed. Using different stiffness of spring and under damped system of spring shock can be reduced.

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