Actuator:-

It is a device which convert electrical or liquid pressure or air pressure into mechanical energy.

Hydraulic Actuator:-

Hydraulic Actuator convert liquid pressure energy into mechanical energy.

The amount of o/p mechanical power depends on volumetric flow rate of the liquid and pressure energy.

Hydralic actuator are devided into two types

(1) Hydralic Cylinders.

(2) Hydralic Motors.

(1) **Hydralic Cylinders:-** Hydralic cylinders are use to provide the linear motion (x)

These actuator consist of piston as well as cylinderical rod inside the cylinderical chamber as shown below.

Hydralic Cylinders are devided in four types

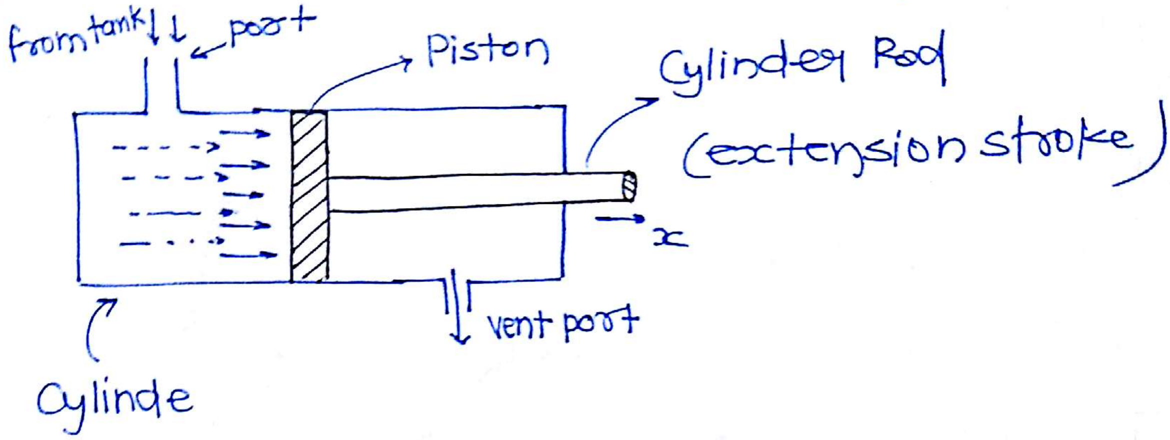
(i) single acting type

(ii) Douple acting type

(iii) telescopic type

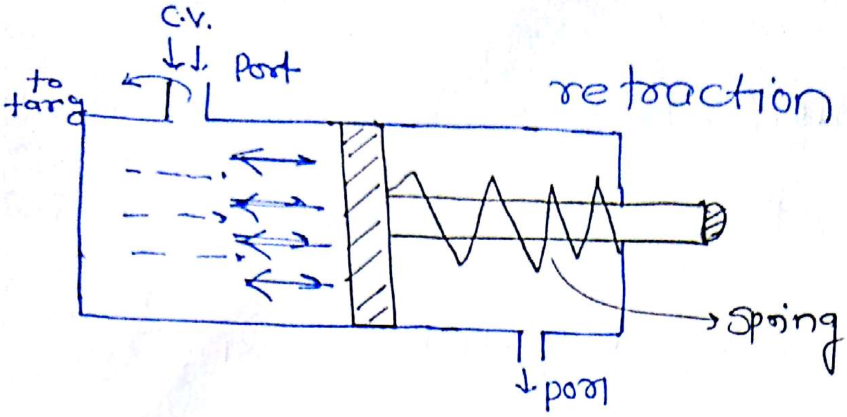
(iv) Tendem type cylinder.

(i) Single acting type:— In case of single acting type the displacement of rod is possible only in one direction hydraulically.

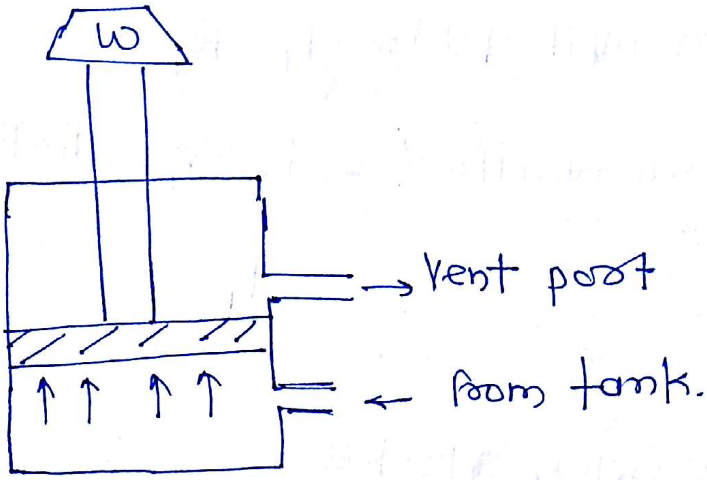


as shown in above case extension stroke is possible with the help of liquid pressure energy to get retraction (return) stroke we Generally prefer spring based Return type actuator or Gravity based return type actuator.

* Spring based return type actuator :— During extension stroke Control valve will be affected such that liquid enforce into the cylinderical chamber and during return stroke C.V. affected such that Fluid leaves from the cylinderical chamber. During retraction the energy stored in the spring can be used to bring the cylinder back to the origional position.



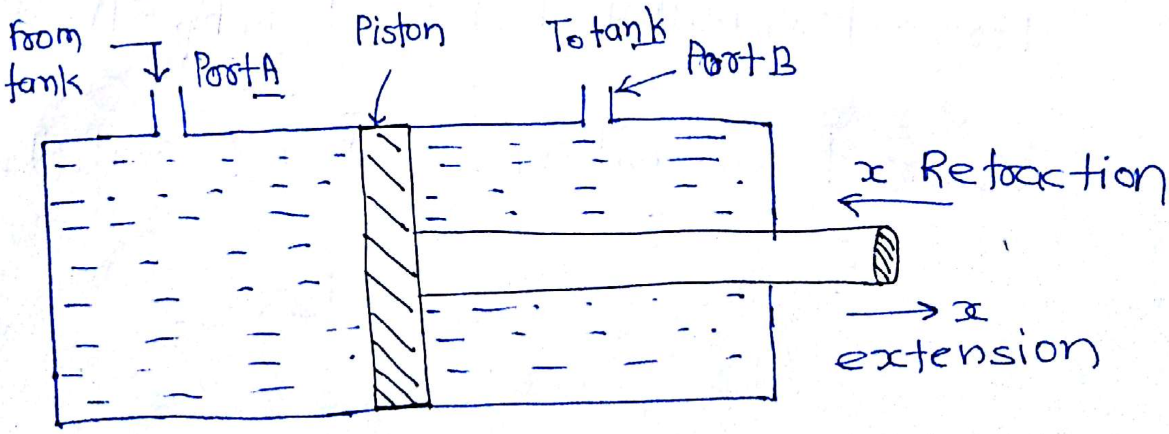
Gravity based Return :-



04/11/2016

ii) Double acting type hydraulic Cylinders:-

Here both extension as well as retraction will be done hydraulically external control Valve is used to direct the liquid into the Cylinderical Chamber.



During extension stroke

* liquid enters at Port A and leaves from port B

if Volumetric Flow rate of liquid is $Q_1 \left(\frac{mm^3}{sec.}\right)$

$$\text{Velocity } (V_1) = \frac{Q_1}{A_p}$$

$$\text{Force transmitted } (F_1) = P_1 \times A_p$$

$$\text{Power transmitted} = F_1 \times V_1 = (P_1 \times A_p) \times \frac{Q_1}{A_p}$$

$$= P_1 Q_1$$

During Retraction stroke

* liquid enters at Port B and leaves of port A

if Volumetric flow rate of liquid is $Q_2 \left(\frac{m^3}{s}\right)$

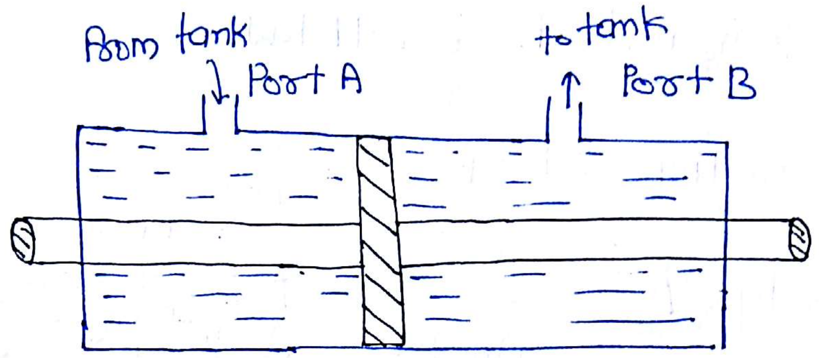
$$\text{Velocity } (V_2) = \frac{Q_2}{A_p - A_r}$$

$$\text{force transmitted } (F_2) = P_2 \times (A_p - A_r)$$

$$\text{Power transmitted} = F_2 \times V_2 = (P_2 \times (A_p - A_r)) \times \frac{Q_2}{A_p - A_r}$$

$$= P_2 Q_2$$

As shown in above case the Velocity of Rod cannot be same in both the direction for same Volumetric flow rate. To get same velocity in both the direction we Generally prefer double acting type double side rod actuator which is shown below.



Que:- A pump supplies oil at 0.002 m^3/s to a 50mm diameter double acting Cy. and a rod diameter of 20mm. If the external load is assumed to be 6000N in both extension & retraction stroke.

(i) Find the piston velocity and applied pressure as well as power transmitted in both extension & retraction stroke

$Q = 0.002\ m^3/s$, $A_p = \frac{\pi}{4}(50)^2 \times 10^{-6}$

$F = 6000\ N$ $\quad A_r = \frac{\pi}{4}(20)^2 \times 10^{-6}$

during extension stroke

Velocity $V_1 = \frac{Q_1}{A_p} = \frac{0.002}{\frac{\pi}{4}(50)^2 \times 10^{-6}} = 1.018\ m/s$

$$P_1 = \frac{F}{A_p} = \frac{6000}{\frac{\pi}{4}(50)^3 \times 10^{-6}} = 3.05$$

$$P_1 = 3.05 \text{ mpa.}$$

$$\text{Power transmitted} = F_1 \times V_1$$

$$= 6000 \times 1.018$$

$$\text{Power transmitted.} = 6.11 \text{ kW}$$

during retraction stroke

$$\text{Velocity } V_2 = \frac{Q_2}{A_p - A_r} = \frac{0.002}{\frac{\pi}{4} \times 10^{-6} \{50^2 - 20^2\}}$$

$$V_2 = 1.212 \text{ m/s.}$$

$$P_2 = \frac{F}{A_p - A_r} = \frac{6000}{\frac{\pi}{4} \times 10^{-6} \{50^2 - 20^2\}}$$

$$P_2 = 3.65 \text{ MPa}$$

$$\text{Power transmitted} = P_2 \times V_2 \quad Q$$

$$= 3.65 \times 1.212$$

$$= 7.27 \text{ kW}$$

Que:- A hydraulic cylinder has to move a table of weight 13 KN. The speed of the cylinder is to be accelerated up to 0.13 m/s in 0.5 seconds. Assume coefficient of sliding friction as 0.15 and cylinder dia. is 50 mm. Find the input pressure that should be supplied.

Ans

$F = 13000\,N$, $u = 0$

$V = 0.13\ m/s$ $\qquad V = u + at$

$D_p = 50\ mm$ $\qquad t = 0.5\ s$ $\qquad a = \frac{0.13}{0.5} = 0.26\ m/s^2$

$\mu = 0.15$

$$\text{Total force} = \left(\frac{F}{g}\right)a + \mu F$$

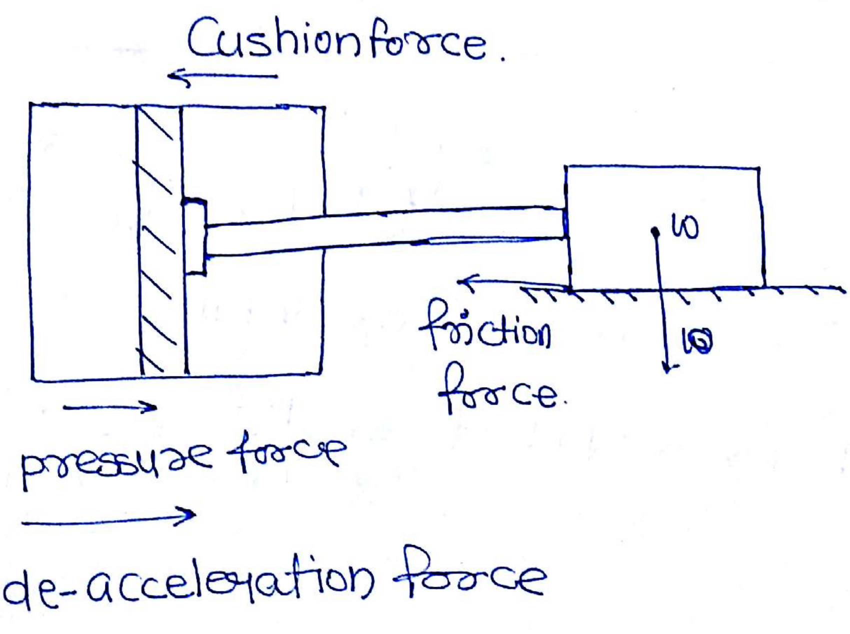
$$= \left(\frac{13000}{9.81}\right) \times 0.26 + (0.15 \times 13000)$$

Total force = 2.294 KN

$$\text{Pressure applied} = \frac{F}{A_p} = \frac{2.294 \times 10^3}{\frac{\pi}{4}(50)^2 \times 10^{-6}}$$

$$P = 1.168\ MPa$$

Ques :- A Cylinder has a diameter of 80mm and a cy. rod of 45 mm dia. It drives a load of 7000 N, travelling at a velocity of 15 m/min the load slides on flat Horizontal surface having a coefficient of friction 0.12. The load is deaccelarated to, within a cushion length of 20 mm. If the input pressure applied is 50 bar, Compute the fluid pressure developed in the Cushioning and the dirn of forced acting are indicated as shown below.



$D_p = 80\ mm$ $\quad$ $P = 50\ bar.$

$D_r = 45\ mm$

$F_w = 7000N$

$V = 15\ m/min = \frac{1}{4}\ m/s. = 0.25\ m/s$

$\mu = 0.12$

cushion length = 20mm

Sol^n

$u = 0.25$ m/s

$v = 0$ m/s

$s = 20$ mm $= 20 \times 10^{-3}$ m

$v^2 - u^2 = 2as$

$0^2 - (0.25)^2 = 2 \times a \times 20 \times 10^{-3}$

$a = -1.56$ m/sec^2 In Given dir^n $a = 1.56$ m/s^2

(Cushion Force) + (Frictional force) = (Pressure force) + (De-acceleration force)

$C.F. = (P \times A_P) + \left(\frac{F_w}{g}\right) \times a - \mu F_w$

$=$

$C.F. = 25.407$ KN.

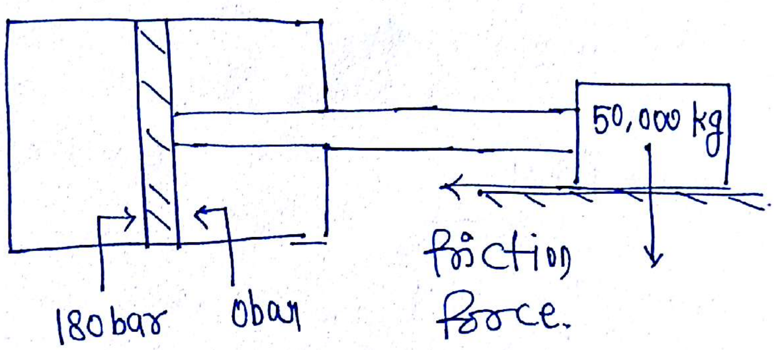
Pressure C.F. $= \frac{C.F.}{A_p - A_r} = \frac{25.407}{\frac{\pi}{4}(80^2 - 45^2) \times 10^{-6}}$

$= 7.39$ MPa

Que. A hydraulic cylinder is to accelerate a load of ~~500 50 kg~~ 50000 kg, horizontal from rest a velocity of 10 m/min to 50 mm and the coeff. of friction ~~μ =~~ between the load and sliding contact is 0.1, assume zero back pressure, find suitable size of the cylinder if the max. allowable pressure at the cy. piston is 180 bar.

Find the flow rate require to drive the piston forward at 3 m/min

S



$m = 50{,}000$ kg

$u = 0, V = 10$ m/min

$S = 50$ mm

$P = 180$ bar

$V^2 - u^2 = 2aS$

$\left(\frac{10}{60}\right)^2 - 0 = 2 \times a \times 50 \times 10^{-3}$

$a = 0.277$

Force require $(F_T) = \left(\frac{F_w}{g}\right) a + \mu F_w$

$F_T = (50{,}000)(0.277) + 0.1(50000 \times 9.81)$

$F_T = \sout{72745}\ 62900$ N

$P_{max} = F_T / A_p \Rightarrow A_p = \frac{F_T}{P_{max}}$

$\frac{\pi}{4}(D_p)^2 = \frac{\sout{72745}\ 62900}{180 \times 10^5}$

$D_p = 66.7$ mm

$Q = A_p \cdot U$

$Q = \frac{\pi}{4} D_p^2 \cdot 3$ m/min

$Q = 0.01$ m³/min

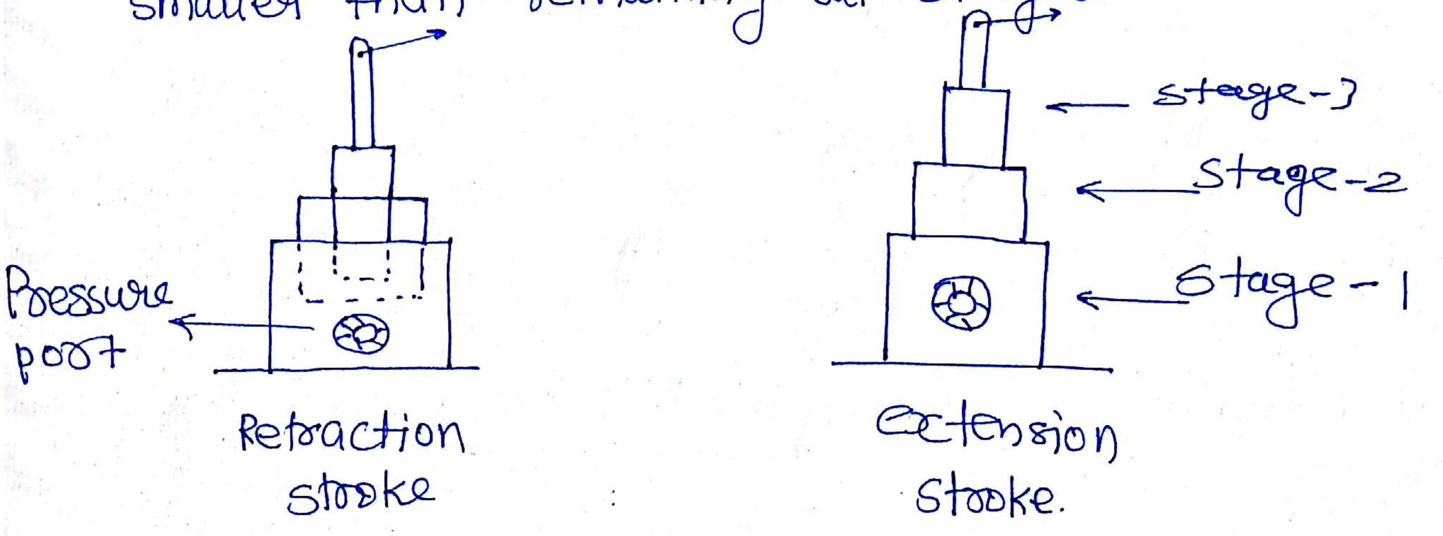
(iii) Telescope type hydraulic cylinder:-

These are used when stroke length is max in extension and min. in return stroke.

Telescoping Cylinder are available with single side rod as well as double side rod.

In telescoping actuator the cylinder motion increase stage by stages as shown below.

The velocity a rod will be maximum at the final stage and the diameter of the last stage is smaller than remaining all stages.



Que:- A 3 stage telescopic Cylinder used to tilt the body of a truck when the truck is fully loaded, the Cylinder has to exert a force equivalent to 4000 kg at all points on its stroke. The outside dia. of the Cy. forming 3-Stages are 60 mm, 80 mm & 1000 mm. If the pump powering the Cy. delivers 10 lit/min, calculate the speed of rod & Pressure required for each stage of Cylinder when tilting the fully loaded truck.

Soln

$m = 4000$ kg $Q = 10$ LPM

diameters 60 mm, 80 mm, 100 mm

Stage (1)

$$Q = 10 \text{ LPM} = \frac{10 \times 10^{-3}}{60} (m^3/sec) = 1.667 \times 10^{-4} \ m^3/sec.$$

$$V_1 = \frac{Q_1}{A_1} = \frac{1.667 \times 10^{-7}}{\frac{\pi}{4} \times (100 \times 10^{-3})^2} = 0.021 \ m/sec.$$

$$P = \frac{F}{A_1} = \frac{m \times g}{A_1} = \frac{4000 \times 9.81}{\frac{\pi}{4} \times (100 \times 10^{-3})^2} = 5 \text{ MPa}.$$

$V_1 = 0.021$ m/s , $V_2 = 0.033$ m/s , $V_3 = 0.058$ m/s

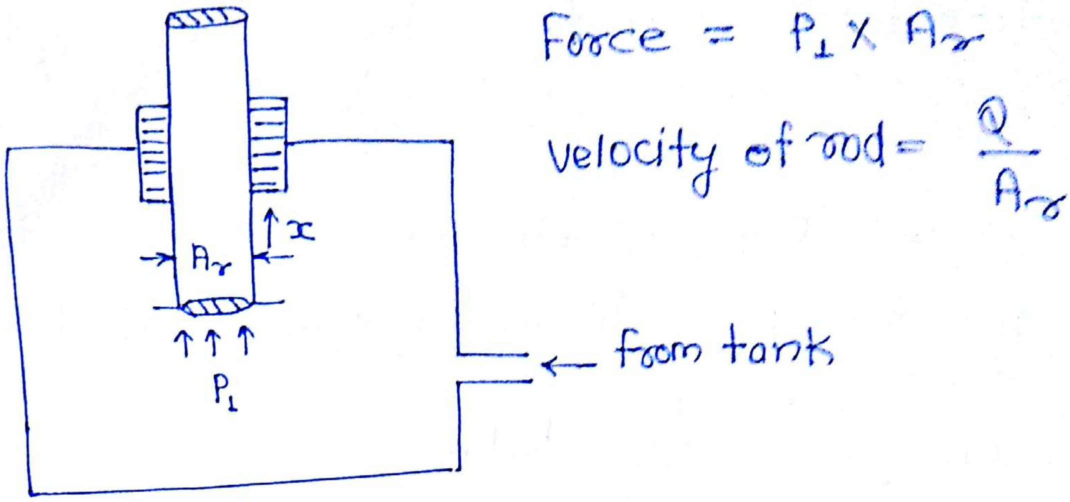
$P_1 = 5$ MPa , $P_2 = 7.8$ MPa , $P_3 = 13.8$ MPa

$$V_1 < V_2 < V_3, \quad P_1 < P_2 < P_3$$

(IV) Tendam Type hydraulic Cylinders:-

→ These actuator are used when we need to transfer the large amount of force in Vertical dirn

→ Tendam type actuator consist of a freely moving hydraulic cylinder as shown below.



$\Rightarrow$ Force = $P_1 \times A_r$ Flow rod = Q

$\Rightarrow$ Velocity of Rod = $\frac{Q}{A_r}$

Hydraulic Actuator :-

→ Hydraulic Motor are rotatory ~~acut~~ actuator.

→ They are used to transmit the torque.

→ Rotatory actuator are majorally devided into two type.

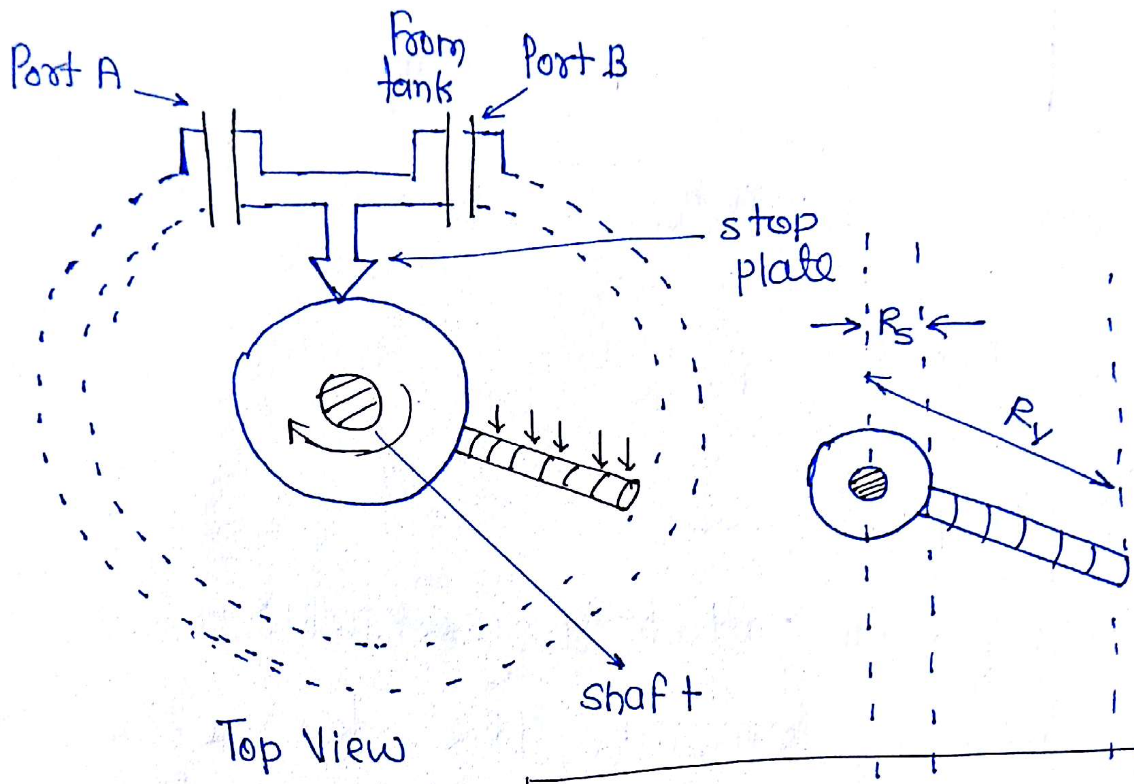
(i) Single vane rotatory actuator.

(ii) Double vane rotatory actuator.

Single vane rotatory actuator :- It Consist of cylindrical houshing, where a cylindrical shaft is placed and attached a movable vane as shown below.

→ Rotatory actuators by default double acting type

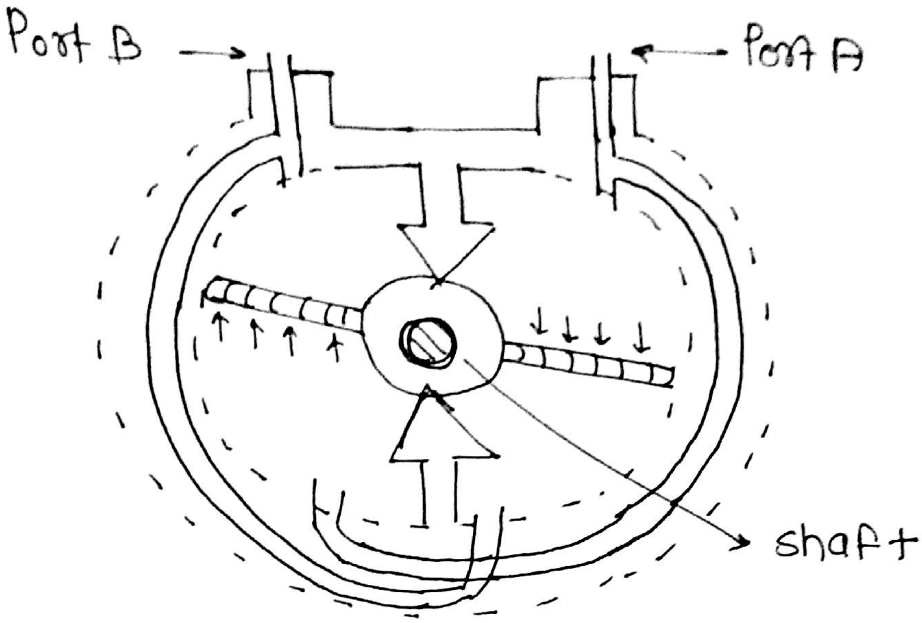
→ In Rotatory actuator we never get 360° rotation, the rotation will be always limited to < 360°



Force acting on vane $= P(R_v - R_s)L$

Double Vane rotatory actuator :-

In this case cylindrical shaft is attached to two movable vane as shown below. The angular rotation is limited to less than 180°. Rotator actuator are useful to provide angular rotation in both clockwise and anticlockwise direction



top View