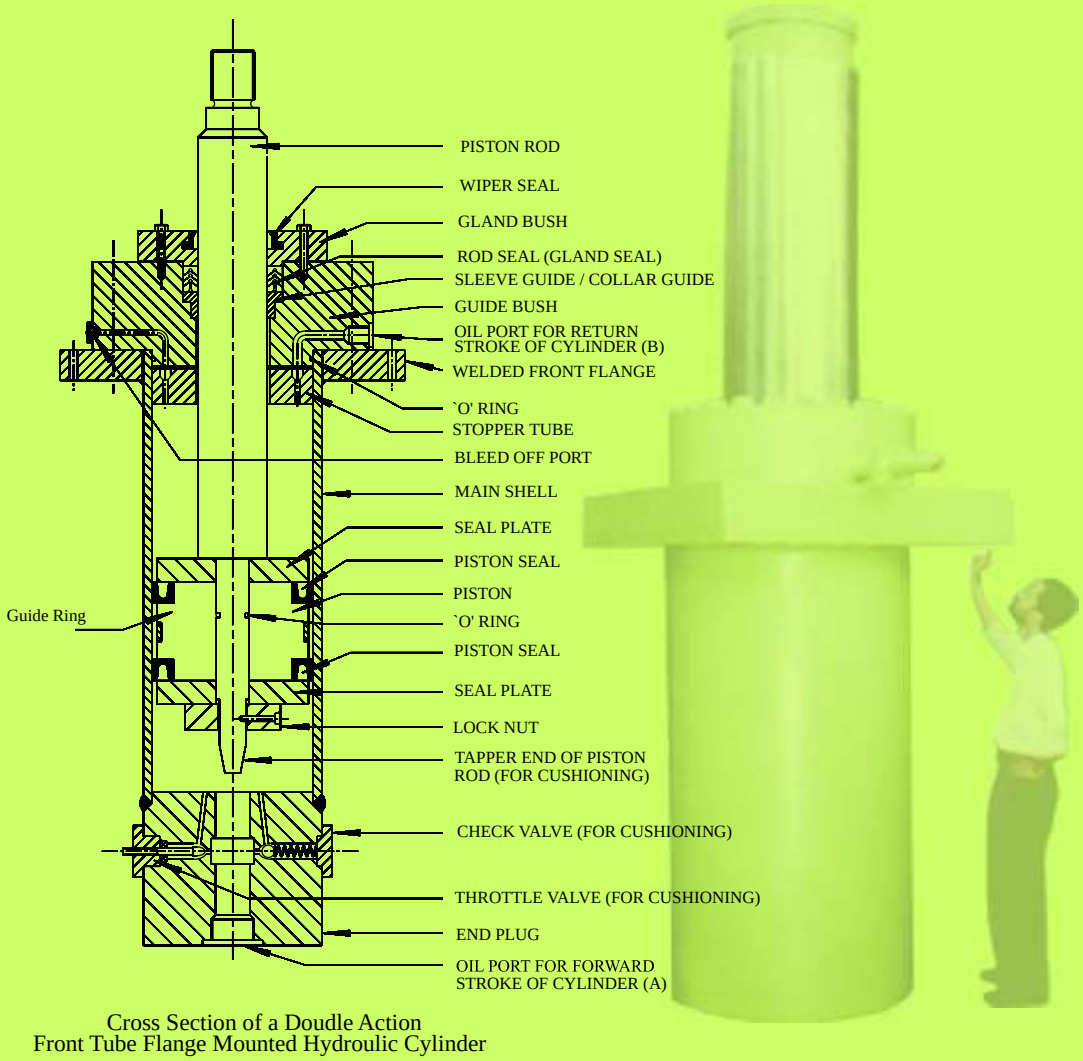
DESIGN OF HYDRAULIC CYLINDER

Q.S. Khan



Cross Section of a Doudle Action
Front Tube Flange Mounted Hydroulic Cylinder

TANVEER PUBLICATIONS
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Chapter - 1

Introduction to Hydraulic Cylinder

Hydraulic cylinder is most important part of a hydraulic press. It develops the necessary force require to carry out a pressing operation. As cylinder is one of the most important parts of a press, hence we will discuss it in detail in this chapter.

1.1 Definition: -

The hydraulic cylinder is a positive displacement reciprocating hydraulic motor, which convert the energy of a fluid into the kinetic energy of the moving piston.

In other word we can say a hydraulic cylinder is a device which converts the energy of fluid which is in a pressure form in to linear mechanical force and motion.

1.2 Type of Hydraulic Cylinders:

Hydraulic cylinders could be classified into two broad categories.

i. Single action cylinders.

ii. Double action cylinders.

Single action cylinder can be defined as "Cylinder in which displacement in one direction is by working fluid pressure and in the other direction by external force.

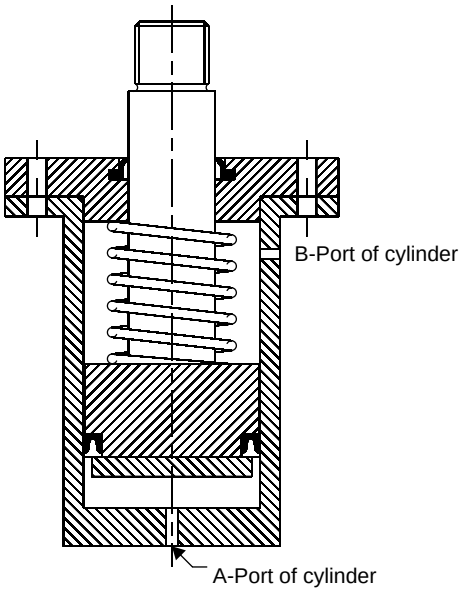
Single action cylinder can take power-stroke only in single direction. That is either it can develop necessary force in forward stroke of cylinder or return stroke of cylinder, depending on its construction. The non-productive direction of cylinder stroke is achieved by various means

such as self-weight (gravity), spring, auxiliary cylinder etc.

Double action cylinders are those in which forward as well as reverse strokes are actuated by fluid pressure.

Double action cylinder can develop power-stroke in both forward and reverse direction.

In figure 1.1 when oil supplied in port A, cylinder will develop force in forward direction. Return stroke is achieved by gravity and spring. While in figure 1.2, when oil is supplied in port A, cylinder will take forward power stroke and when oil is supplied in B-port, then cylinder will take power stroke in reverse direction.



Spring Return Single Action Cylinder

Figure No. 1.1

1.3 Components of Hydraulic Cylinder

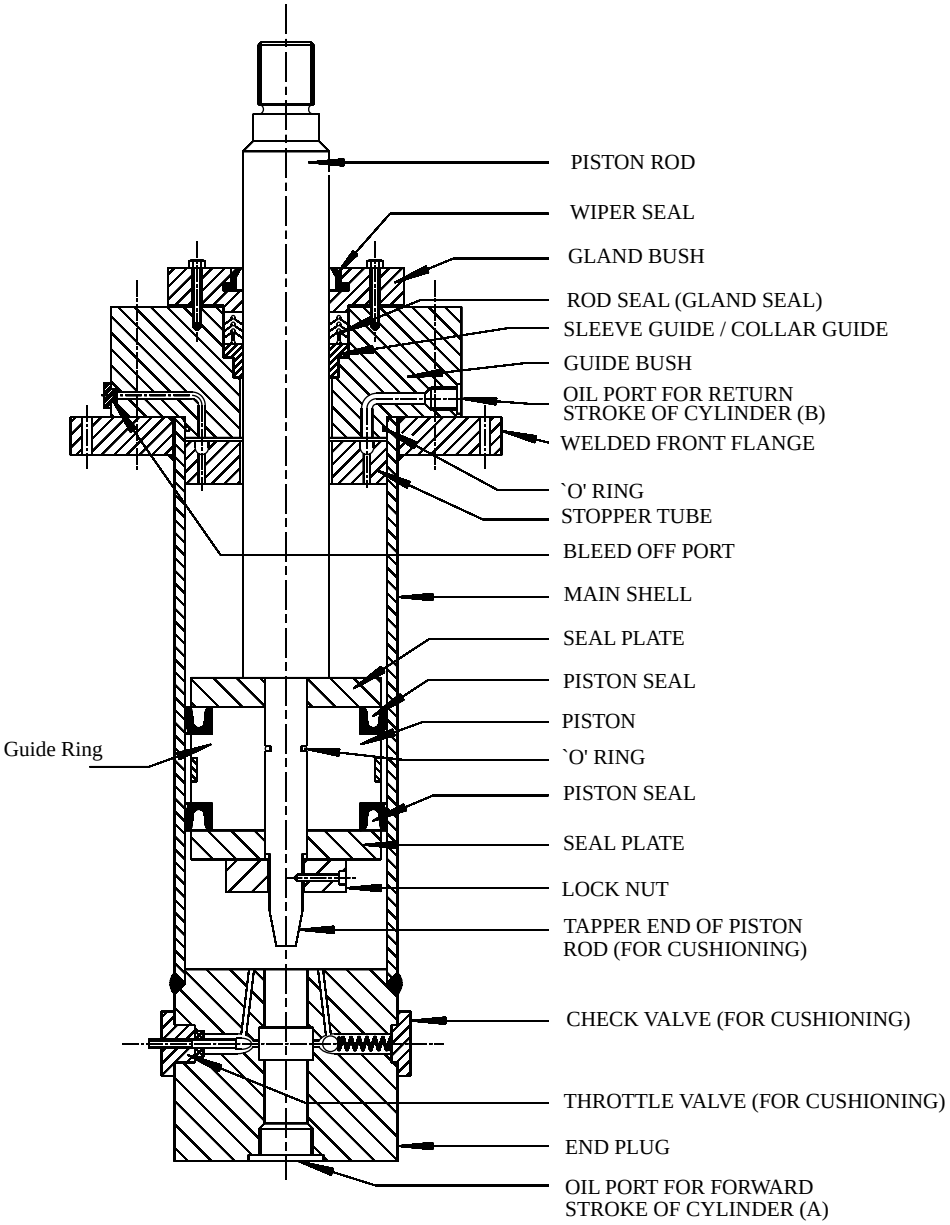


Figure No.4.2 Cross Section of a Double Action
Front Tube Flange Mounted Hydraulic Cylinder

1.3.1 Piston Rod: -

When diameter of piston rod is almost equal to piston diameter then generally it is called as RAM. But in general all large size of piston rods are called "RAM". Piston rod is a mechanical member, which transmit kinetic energy, which got developed at piston, to the work-piece. It is circular in cross-section in case of double action cylinder, as hydraulic sealing is required between piston rod and guide bush. In ram type of single action cylinder, piston rod is also circular in cross action, while in piston type single action cylinder in which sealing is not required between piston rod and guide bush, piston rod may be of any type of cross section. For example in case of lock nut type of single action jack, piston rod has thread on its entire length. Piston-rod is also called as plunger. It could extend from both the end of cylinder, and it could be hollow also. Piston-rod could be attached to other component by means of threading, eye bolt type arrangement, or groove and split coupling arrangement etc.

1.3.2. Wiper Seal: -

These are used to avoid entry of dust particle in cylinder. When these seal softly wipe the rod then it is called wiper seal and when they are stiffly and forcefully rub the piston rod to avoid entry of dust particle in cylinder then they are called "scraper".

1.3.3. Gland-Bush: -

Gland-bush is used to retain gland seal, accommodate wiper seal, and provide guide to piston rod. It is an optional component; it could be merged with Guide-bush. That means guide-bush can also accommodate rod seal, wiper seal and can provide guide to piston rod. We provided separate gland-bush for convenience in manufacturing, controlling dimension accurately, and stronger design.

Making grove in Guide-bush and maintaining tolerance and surface finish is too difficult, so by using gland bush we make an open step for accommodating seal and solve this problem.

Guide-bush is made from mild steel, while guiding piston rod requires bearing material. So instead of making complete guide bush of bearing material we make gland-bush of bearing material, Which is smaller in size as compare to guide-bush, and hence we save money.

Strips and bush could be used to provide guide to piston-rod in Guide bush, instead of making separate gland bush. But long guides provide by gland-bush which are made from bearing material are much stronger and give long life as compare to thin and short bushes and strips Filled in guide-bush.

1.3.4. Rod Seals: -

These are also called as Gland seals. It is a device which used to avoid the leakage of working fluid or air from the periphery of piston-rod, Generally it is used to stop leakage between piston rod and guide-bush of cylinder.

1.3.5. Removable Guide Bush (Sleeve Guide): -

This is inserted in guide-bush before seals. This gives additional guide to Piston - Rod. It is also called sleeve guide or collar guide.

1.3.6. Guide-Bush: -

It is also called as "Head End", "Rod-end", "front-end:, or "front-Face" (of cylinder). This is a cylinder end enclosure, which covers the annular area or the differential area between the cylinder bore area and piston rod area.

In addition to functioning as end-closer, it also could be used for mounting cylinder, providing oil-port, accommodating bleeding and cushion arrangement, and providing guide to piston rod.

1.3.7. Oil Port: - A port is an internal or external terminus of air or fluid passage in hydraulic or pneumatic component.

In hydraulic cylinder, oil ports are provided to feed pressurised oil. It may be threaded or bolted type, and its size depends on the flow of oil thought these oil ports and inside diameter of cylinder

1.3.8. Cylinder-Tube-Flanges: -

These are circular or rectangular rings, threaded and welded to the outside diameter of cylinder tube. When this is fixed at front-end of cylinder then it is called Front-Tube-Flange. It may be used for bolting of guide-bush and cylinder mounting, in case of Front-Tube-Flange mounted type of cylinder.

When it is fixed to the rear-end of cylinder (end-plug side), then it is called "Rear-Tube-Flange" of cylinder. It may be used for bolting of End-Plug and cylinder mounting in case of Rear-Tube-Flange mounted cylinder.

1.3.9. 'O' Ring:-

it is a ring with round cross-section, and used to stop leakage between mating components.

1.3.10. Stopper Tube: -

When cylinder has long stroke, and in fully extended condition of Piston-rod, if there is a chance of buckling of piston-rod or any damage to cylinder, then piston-rod is always kept sufficiently inside cylinder, so that the gland-bush and piston, which provide guide to piston-rod are sufficiently apart from each other, and provide good cantilever support against bending and buckling.

A piece of pipe, which floats freely between piston and guide-bush, and stop ram from taking its full stroke, is called stopper-tube.

1.3.11. Air-Bleed-Off-Port:-

Air may get trapped in cylinder. This air may be due to cavitations and de-aeration in oil, or air present while assembling and commissioning of cylinder. Trapped air gives spongy operation, jerks, and loss of control on cylinder movement. To remove trapped air small tapped holes are provided in end-plug and guide-bush, which always remains plugged. To release air these plugs are loosened allowing air to escape to atmospheres. When air is completely removed then oil started leaking-out from these plugs, then plugs are tighten again.

This process of removing air till oil starts coming out is called bleeding and the port provided for this purpose is called "air-bleed-off-port".

1.3.12. Main Shell: -

It is also called "cylinder-tube", or "cylinder-pipe", or "cylinder-body". It has circular inside cross-sectional area. It receives, confines, and direct the fluid under pressure to piston or ram so that the pressure energy in fluid get converted into kinetic energy of the moving piston or ram. The cross-section area of cylinder-tube withstands radial as well as longitudinal stress developed due to the fluid-under-pressure. It also provides guide to ram or piston.

1.3.13. Seal Plates: -

These are round rings or plates, used to retain piston-seal on piston.

1.3.14. Piston Seal: -

These are hydraulic seals used to avoid leakage between piston and inside diameter of cylinder tube.

1.3.15. Piston: -

Piston is circular in cross-section. It slides in main shell, and provides guide to piston rod at one-end (piston-end). Piston has provision and means to avoid leakage between cylinder and piston, and because of this feature, when fluid-under-pressure when enters in main shell in one direction, piston get pushing force in other direction. Hence it assists in conversion of pressure energy in fluid to kinetic energy

1.3.16. Lock Nut:-

To avoid losing of piston from piston-rod these lock nut are provided.

1.3.17. Guide-Ring: -

These are flat rings of plastomeric material. And used in piston, guide-bush, and gland-bush to avoid metal to metal contact, and act as guide. All mechanical property of guide-rings are similar to bearing material.

1.3.18. Cushioning:-

As per the requirement of hydraulic system piston-rod may travel at extremely high speed in its stroke range. On completing its stroke if piston hit guide-bush or end-plug with same high speed then it will damage the whole cylinder. Hence special arrangements are made in piston and end-covers to reduce the speed of piston-rod as it completes its stroke. This process of deceleration of piston or piston-rod is called cushioning.

Cushioning is achieved by throttling the rate of exhaust or return of oil, from cylinder. Cushioning may be fixed type or variable type; Detail about arrangement of cushioning will be discussed in design of

cylinder.

1.3.19. End-Plug: -

It is also called as “Cap-End” “Cover - End” or “Rear - End” (of cylinder) this is a cylinder-end enclosure which completely cover the cylinder-bore-area. In addition to providing end enclosure, end plug also could be used for mounting of cylinder, providing oil port, making arrangement for bleeding, and cushion etc.

For more knowledge about terms used for hydraulic cylinder, and other items kindly refer IS:10416:1982 which describes about 855 terms related to oil hydraulic.`

Chapter-2
Classification of Hydraulic Cylinders

Basically there are only two types of hydraulic cylinder, namely single action

cylinder and double action cylinder. These two principal types of hydraulic cylinders have been modified in so many ways as per requirement of industry, convenience in manufacturing, economy and duty cycle. Some of them are described as follow.

2.1 Classification Based On Body Construction Of Hydraulic Cylinder: -

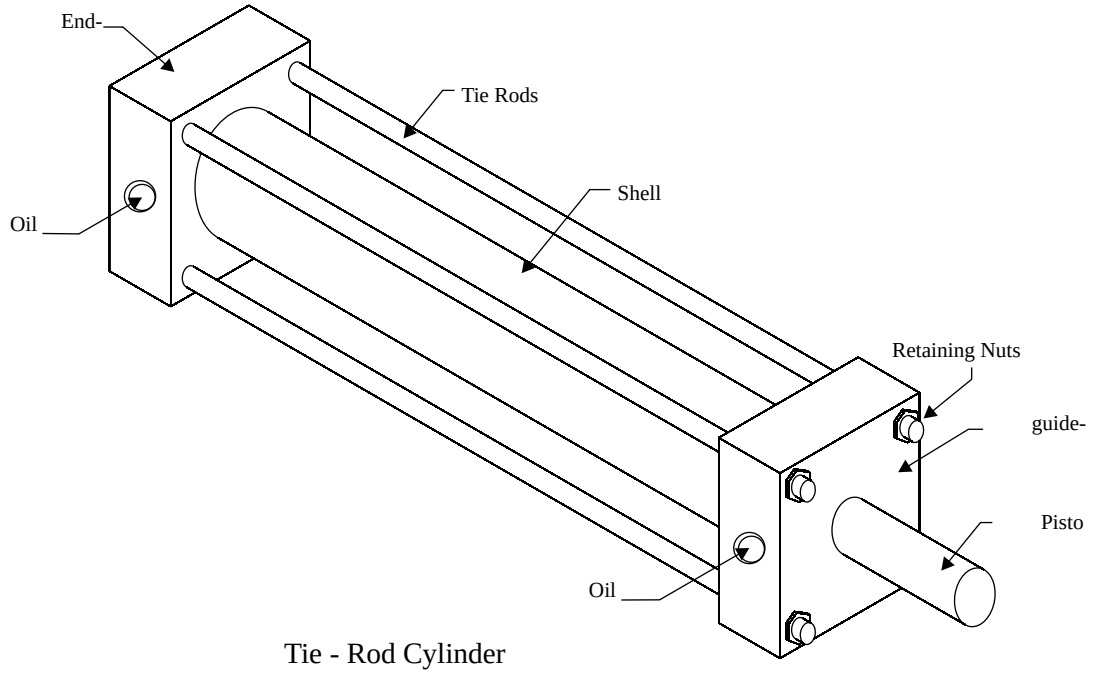
On construction basis hydraulic cylinders could be divided in to five categories.

1. Tie - Rod Construction.
2. Threaded Construction.
3. Bolted Construction.
4. One Piece welded construction.
5. Costume Build Cylinder with combination of above mentioned constructions.

2.1.1 Tie - Rod Construction: -

This type of construction is most widely used in industry. ISI standard also generally refers to one of this type of construction. As all the components are only machined and assembled together and not welded. Hence planning manufacturing, quality control, assembly, and maintenance are more convenient then other types of construction. As long tie rods are used to hold all the component together hence special care required to tighten them, and safe guard against loosening in operation.

Like standard valves and pumps, these types of cylinders are also manufactured as standard hydraulic component, and used for low to medium pressure and low to medium duty operation for general purpose, and machine tool industry.

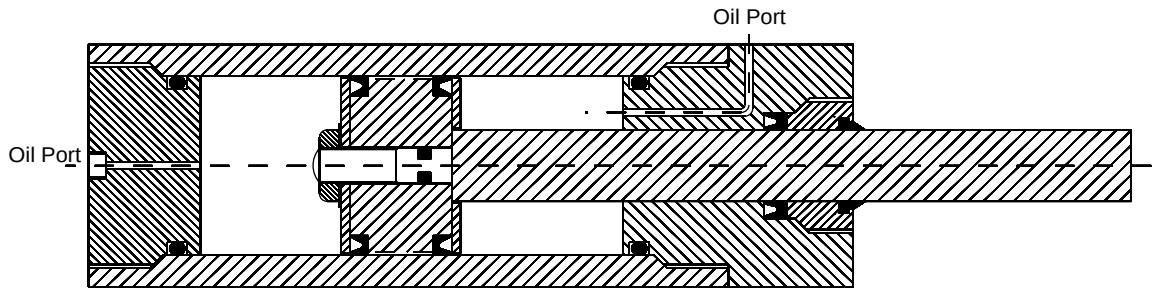


Tie - Rod Cylinder
Figure No. 2.1

2.1.2 Threaded Construction: -

This construction is similar to tie - rod construction, but more compact, stronger, and require more accuracy and care in manufacturing and quality control. In this design both ends are assembled with cylinder tube by threading, as shown in following design.

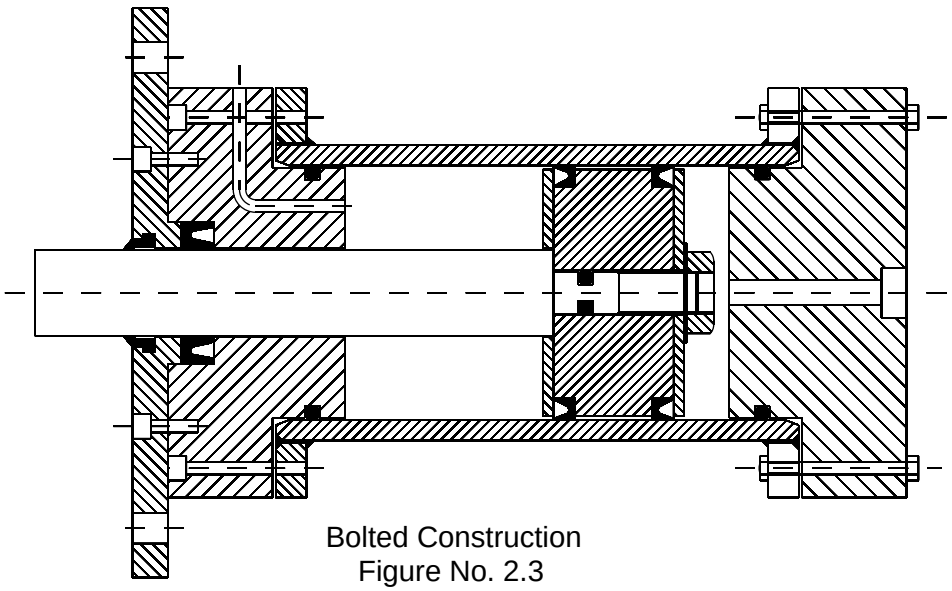
These are used for medium to heavy-duty operation, and widely used in earth moving



Threaded - Head Cylinder
Figure No. 2.2

2.1.3 Bolted Construction: -

This type of construction involves welding of flanges to cylinder tube, and bolting of end cover to the welded flange. Similar to tie rod construction these are also designed and manufactured as standard hydraulic component and widely used in industry.

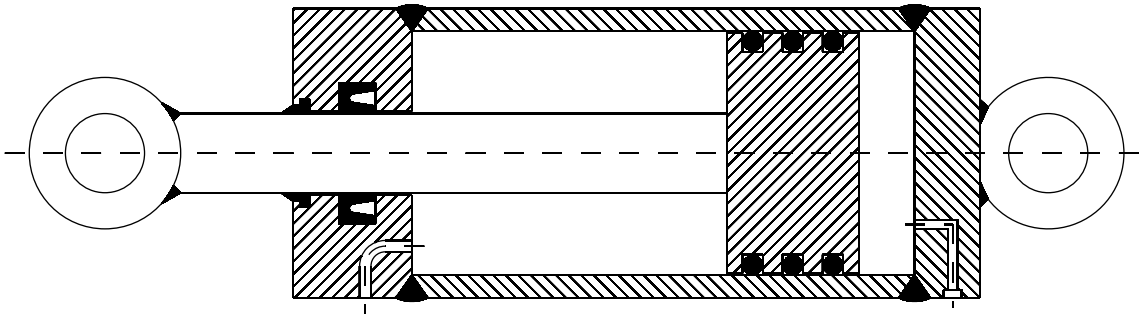


Bolted Construction
Figure No. 2.3

2.1.4 One Piece - Welded Cylinder: -

Similar to shock - absorber, in this design the end covers and cylinder tube are welded together. These are economical but can not be repaired. There are used for

low pressure; agriculture machinery application.

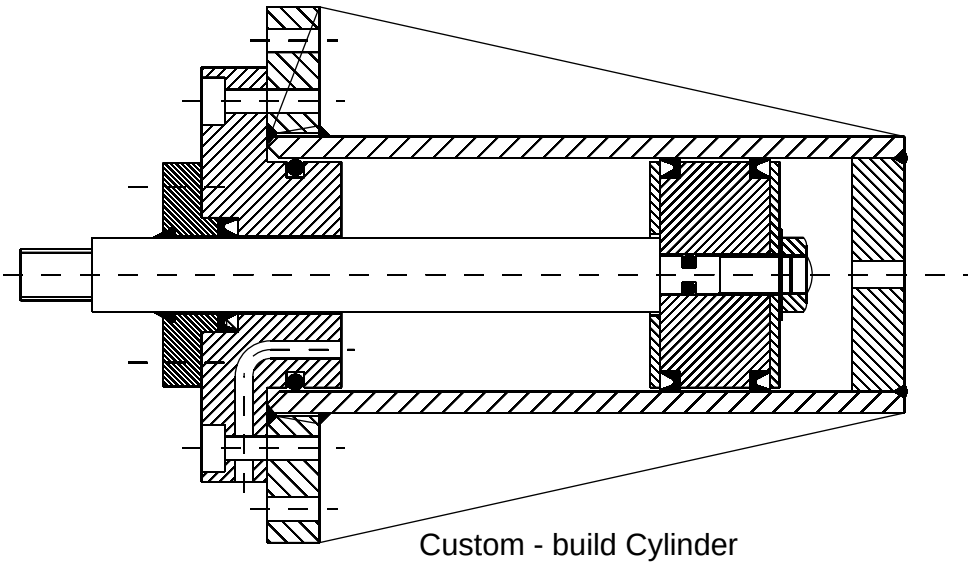


One Piece - Welded Cylinder
Figure No. 2.4

5.1.5 Custom - Build Cylinder: -

In this type of cylinder, various type of construction are mix together to suit the requirement. One of the most widely used combination is welded cap-end cover, bolted head-end cover. With front tube flange mounting.

In case of high capacity cylinder when it is steel cast or machined from solid steel forging, then end cover and front flange may be integral part of cylinder tube. Cylinder with this type of construction widely used in hydraulic press.

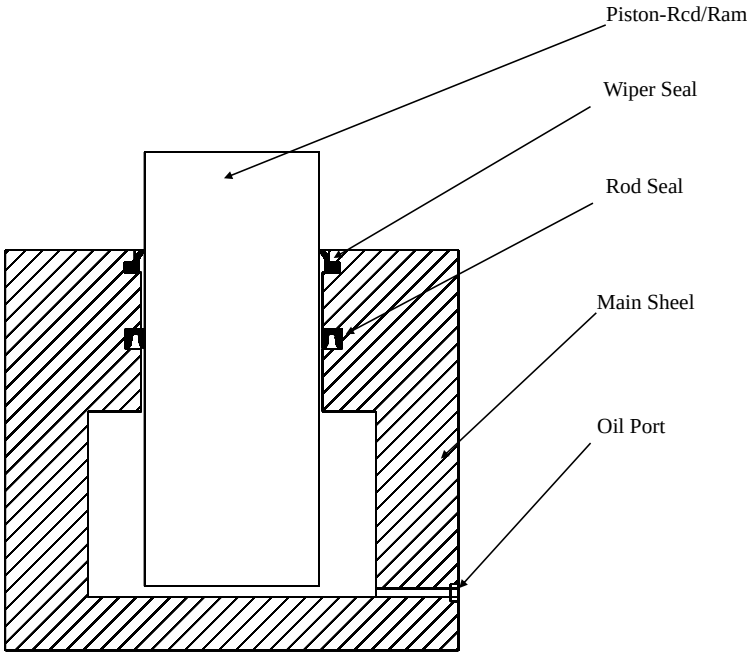


Custom - build Cylinder
Figure No.2.5

2.2 Classification based on operating features of Hydraulic cylinder

2.2.1 Single Action Cylinder: -

This is the simplest type of cylinder and used since introduction of water hydraulic. In this type of cylinder, ram or piston-rod have such construction that their displacement in one direction is by fluid force and in other direction by external force.



Gravity return single action cylinder

Figure No. 2.6

2.2.2 Double Action Cylinder: -

This type is most widely used cylinder in industry. In this type of design the stroke of piston rod in forward as well as in reversed direction is due to fluid pressure, as shown in figure 2.2

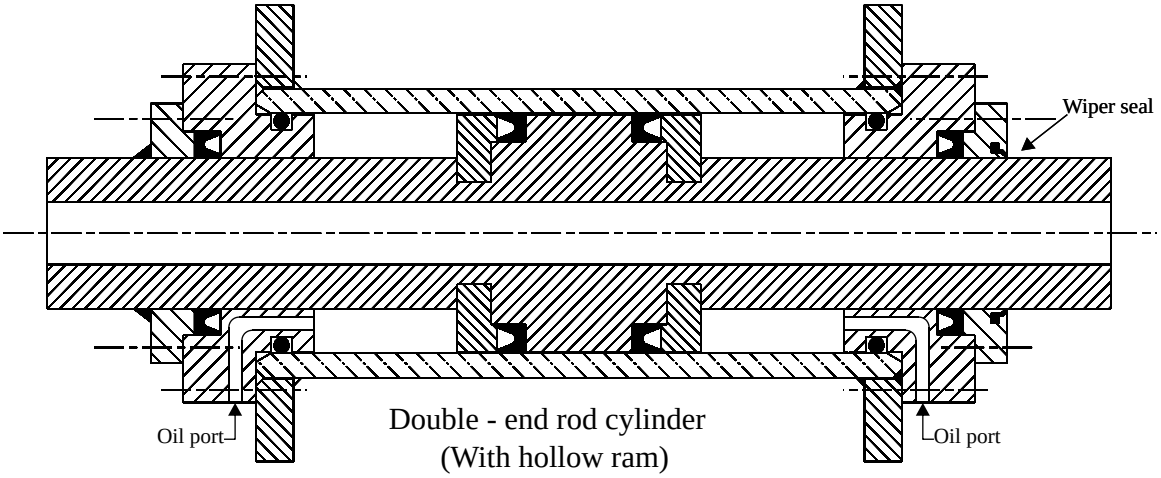
2.2.3 Differential Cylinder: -

When cross - section area of Piston-rod (Ram) is half the cross - sectional area of cylinder bore of double action cylinder, then such cylinders are called Differential Cylinder.

When differential cylinders are connected to regenerative hydraulic circuit then it gives same (equal) forward and return speed.

2.2.4 Double - End Rod Cylinder: -

In this type of cylinder piston rod extends from both the ends of cylinder. As annular area on both ends are same, hence it moves with same speed in its forward and return stroke. Sometime piston is made hollow to pass the work-piece or another



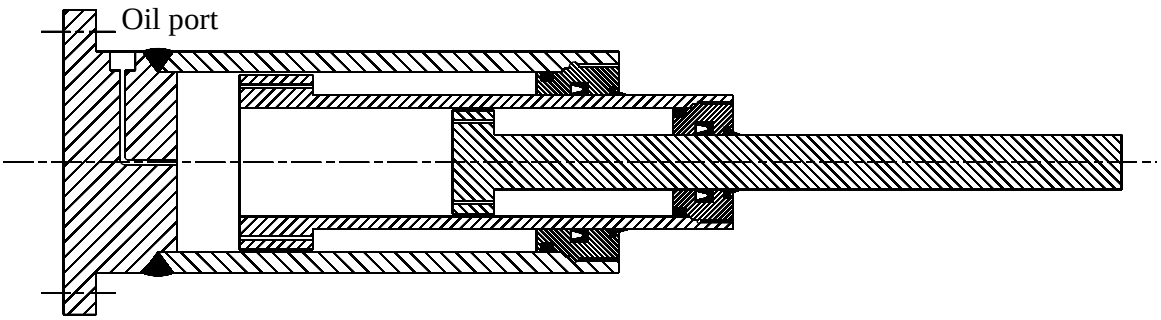
Double - end rod cylinder
(With hollow ram)

Figure No. 2.7

2.2.5 Telescopic Cylinder: -

This type of cylinder provides long stroke from short body. Total stroke length may be as much as four to six times longer than collapsed length of the cylinder. Telescopic cylinders are single as well as double action. The force out-put varies with stroke. We get maximum force on first stage when full piston area is used, while minimum force at the end of stroke.

These types of cylinders are used in dumper-truck, hydraulic mobile crane, and lift etc.

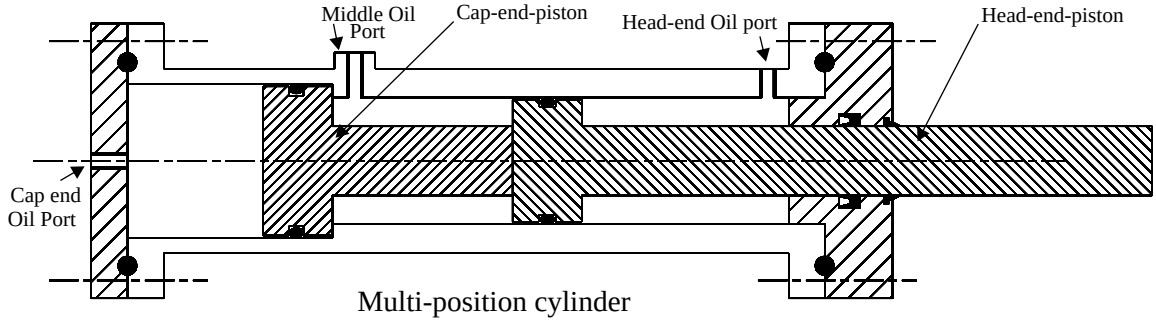


Telescopic Cylinder (Single action)

Figure No. 2.8

2.2.6 Multi position Cylinder: -

These type of cylinders provide special motion by moving two or more pistons inside the cylinders. For example, in three-position cylinder as shown in following diagram, on pressurizing the cap-end-oil port the cap-end piston-rod forces against the head- end-piston, and moves it to some portion of its stroke (generally about half of its total travel).

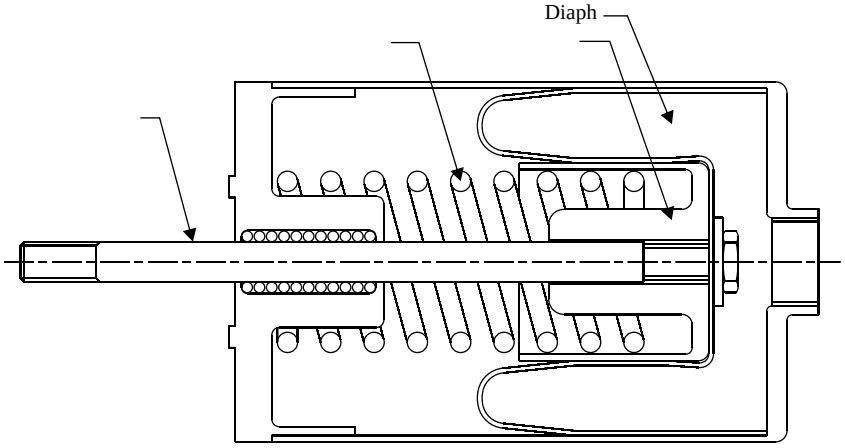


Multi-position cylinder
Figure No.2.9

By Pressurizing the middle oil port, oil pressure separates the head-end-piston from the cap-end rod, and force the head-end-piston to full extension. Three-position cylinders are often used to actuate multi position valves or to shift gears in machine tools.

2.2.7 Diaphragm Cylinder: -

Diaphragm cylinders are used in either hydraulic or pneumatic service for applications that require low friction, no leakage across the piston, or extremely sensitive response to small pressure variations. They are frequently used as pneumatic actuators in food and drug industries because they require no lubrication and do not exhaust a contaminating oil dust. Spring- return models shown in figure should not be pressurized in the reverse direction because reversals can pleat the diaphragm and shorten its life. Double-acting actuators with twin diaphragm are available for application requires pressure in both directions.



Diaphragm Cylinder
Figure No.2.10

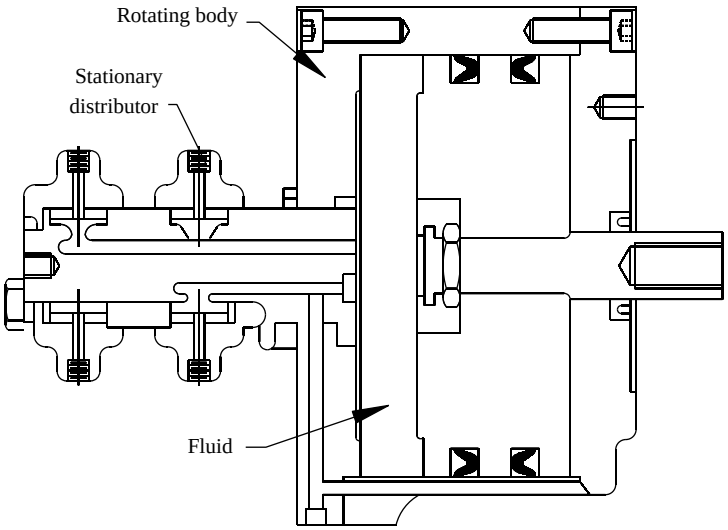
2.2.8 Rotating cylinder: -

Rotating cylinders impart linear motion to a rotating device. They are often used to actuate rotating chucks on turret lathe.

In this type of cylinder, complete cylinder assembly may rotate along with mating components. Special journals, thrust bearing etc. are used to guide piston - rod and to reduce friction while rotating. Fluid is supplied through special stationary distributor.

(like rotary joints)Generally relative rotary motion between cylinder and piston are avoided as high pressure seal would then be subjected to both rotary and linear wear force. But with low RPM they can have relative rotary motion.

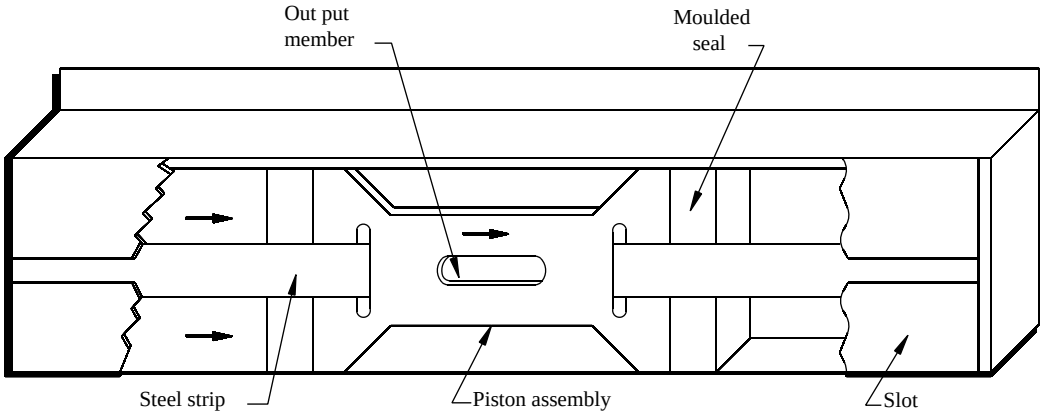
Hydraulic rotating cylinder and hydraulic torque motor are two different units. Hydraulic rotating cylinder only imparts liner motion to a rotating device. While torque motor impart rotary motion to a device to be rotated.



Rotating Cylinder
Figure No.2.11

SLOTTED CYLINDER (Rod less):-

In slotted cylinder, piston extends through a slot in the side of the cylinder. The slot is sealed with a spring-steel strip that is threaded through the piston assembly. So far sloteded cylinders are available for pneumatic system but not hydraulic system.



Slotted Cylinder
Figure No. 2.12

2.2.10 Compound Cylinder: -

Compound cylinder consists of a secondary cylinder inside the main primary cylinder to improve the performance of main primary cylinder.

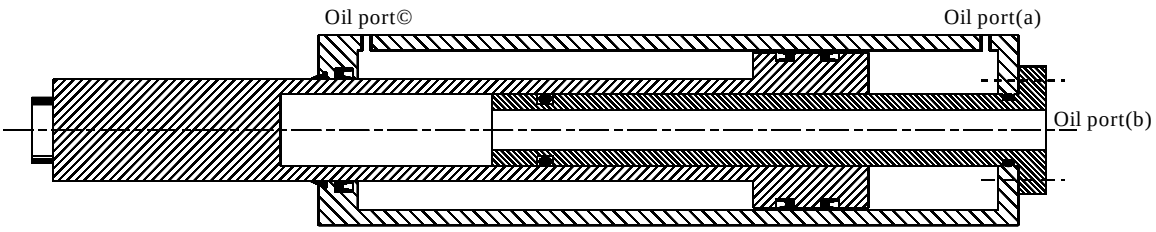
Cross - section a simple of compound cylinder is shown in following figure. In this cylinder we can have three forward speeds and pressing force.

1) We get Maximum speed and minimum force when pump is connected to only B port, and A & C is connected to tank.

2) Medium speed and force is achieved when A is connected to pump and B & C is connected to tank.

3) Minimum speed and maximum force is achieved by connecting A & B to pump and C to tank.

4) Single speed return speed is achieved by connecting C to pump & A & B to tank.



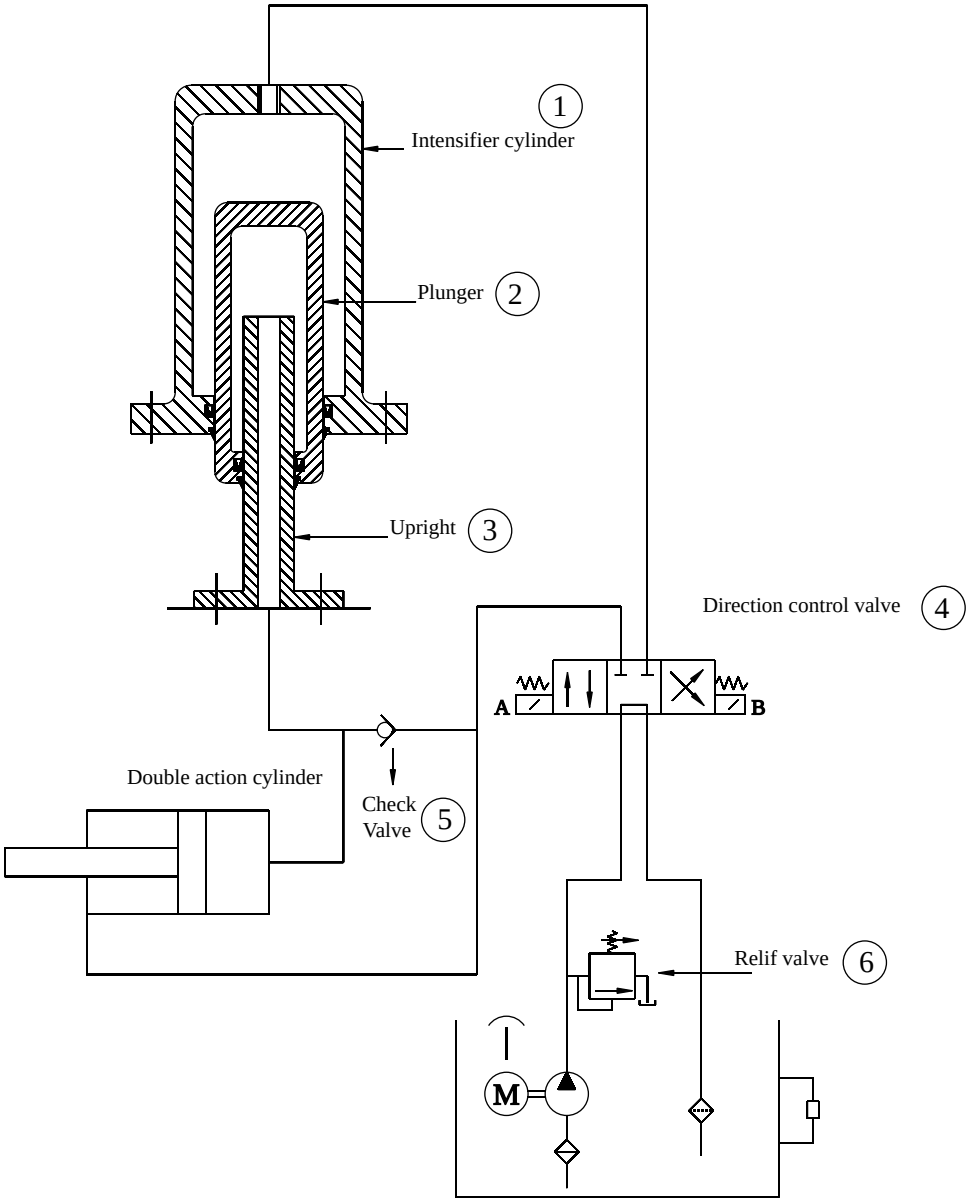
COMPOUND CYLINDER
Figure No. 2.14

2.2.11 Intensifier: -

This is a type of compound cylinder. Which is used to boost the pressure of working fluids. Intensifier may be a part of hydraulic circuit, in which pump initially supplies hydraulic fluid at low to medium pressure to carry out all the operation and function of a hydraulic system and when high pressure required then with the help of medium pressure hydraulic fluid and intensifier, high pressure is developed. (fig.___)

Now-a-days readily available and economical. Piston pump can develop up to 630 Bar. Some sophisticated pump can also develop up to 1000 Bar. But when oil at 1500 Bar or 2000 bar pressure is continuously required then such type of intensifier is used.

In following example using low pressure pump very high pressure oil can be supplied to cylinder



Intensifier
Figure No. 2.15

E] Operation Principle: -

I) When direction control valve Actuated to (A) piston, oil from pump passes to return side of cylinder. Spring of check valve No.(5) is so strong that it does not allow oil to enter forward port of cylinder and upright (3) unless. Cylinder gets fully retracted.

II) After full retraction of cylinder , oil passes from check valve (5) and enter in upright (3), which cause plunger (2) to retract.

III) In fully retracted condition of cylinder and plunger (2) system is ready for forward stroke cylinder.

IV) When solenoid is activated to B-position. Oil from pump is directed to forward port of intensifier cylinder. This cause plunger (2) to more down and transfer oil in upright (3) to port for forward stroke of

V) If area of intensifier cylinder (1) in A1 and pump pressure is P1, Area of upright (3) is A2 , them pressure P2 got developed in up-right will be

$$P_2 = \frac{P_1 A_1}{A_2}$$

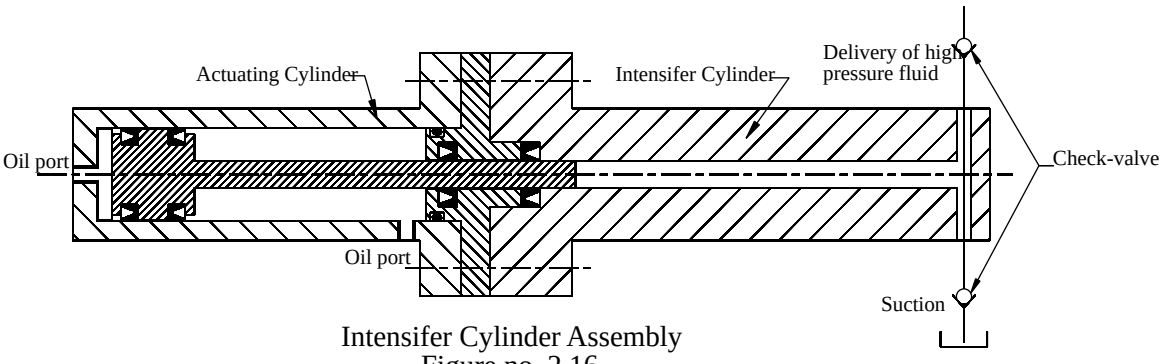
By this simple method method very high pressure could be developed by using simple low pressure

2.2.12 Hydro-Pneumatic Reciprocating Pump: -

This is also a type of compound cylinder, it consist of a double acting pneumatic cylinder and a single action hydraulic cylinder with common piston rod. Pneumatic cylinder is completely made from non-magnetic material such as aluminum, brass or non-magnetic stainless steel. Piston ring of pneumatic cylinder consists of an additional magnetic ring. Out side cylinder tube two "Proximity switches" are provided at both ends of cylinder tube. When piston with magnetic ring passes near the proximity switch, it actuate. Proximity switch closes the electrical circuit and supply of current to the coil of pneumatic direction control valve to actuate it. Pneumatic direction control valve is detention type, that is once it get energized it changes its position, and even after its coil gets de-energised, it remain in same position, and do not changes its position, unless other side of coil is energised to changes it's direction.

In operation, pressurized air is supplied to four-way-two-position pneumatic direction control, which operates cylinder, as cylinder takes its stroke, and piston with magnetic ring moves across the "Proximity switch" it temporarily energies coils of direction control valve for the reverse direction of cylinder. As reverse stroke progress, even though direction control valve get de-energized but do remain in same position due to its detention characteristic. When reverse stroke reaches its end, piston passes through the other "Proximity switch", it get operated for a very short period of time. But in that short period it energies coil of direction control valve for forward stroke and again change the direction of cylinder. That is how it changes direction of stroke and cylinder keep on reciprocating. This reciprocating pneumatic cylinder connected to a single action type of hydraulic cylinder, with two-check valve, which on its retraction stroke suck oil, and on its forward stroke deliver oil under pressure.

The simple system we have described is by using magnetic ring, Proximity switch and detention type Direction control valve. Reciprocating pumps are also available which are with out Proximity switch, and use only special pneumatic direction control valve. In one such system, pneumatic cylinder has cushion like arrangement at its both end. When piston reaches the end of its stroke the pressure of air trapped between piston and end-cover increases slightly more than supplied air pressure. This extra pressure is used to change the direction of detention type direction control valve. In operation spool of direction control valve get equal air pressure at its both end and remain in balance, but at the end of stroke increase in pressure of the air-trapped in



Intensifer Cylinder Assembly
Figure no. 2.16

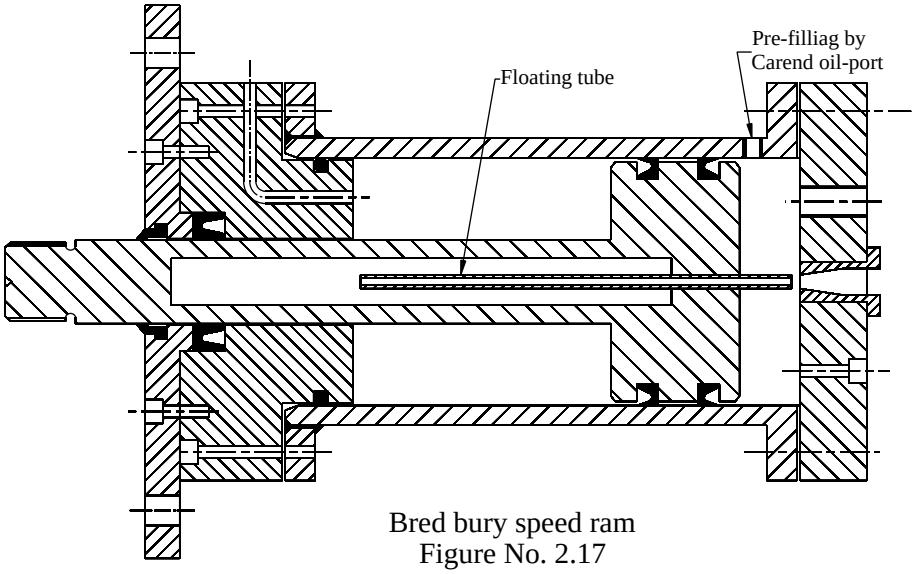
2.2.13 Bred Bury Speed Ram: -

This is also a type of compound cylinder, in which ram of secondary cylinder is a free-floating tube. Refer figure.

Primary cylinder is similar to convention at double action cylinder, but with hollow ram. A tube freely float in this hollow ram, and held freely at some distance from inlet oil port. Oil is injected through a nozzle at high velocity in the tube. When oil come out from other end of tube inside hollow ram at high velocity, as velocity decreases, pressure increases. This pressure forces tubes out of hollow ram, and presses it firmly on the opening of nozzle. This allows all the oil injected by nozzle to pass on to hollow ram and force it out at high speed. As ram take its stroke at high speed the volume of cap end cylinder is filled by oil through a large size of pre-fill valve, to avoid cavitations.

As main ram (hollow ram) reaches its full stroke, some arrangement is made to leak the pressurized oil getting injected in hollow ram to main cap-end area of cylinder, to develop full pressure and force. This may be achieved by providing a side hole in tube or making it taper at the end and increase the clearance.

This cylinder gives very high speed with very small capacity pump and motor. Speed ram is developed by Mr. Farel bred bury, and m/s. Broughton Redman Engineering Ltd. Birmingham is Licensees to manufacture these cylinder commercially.



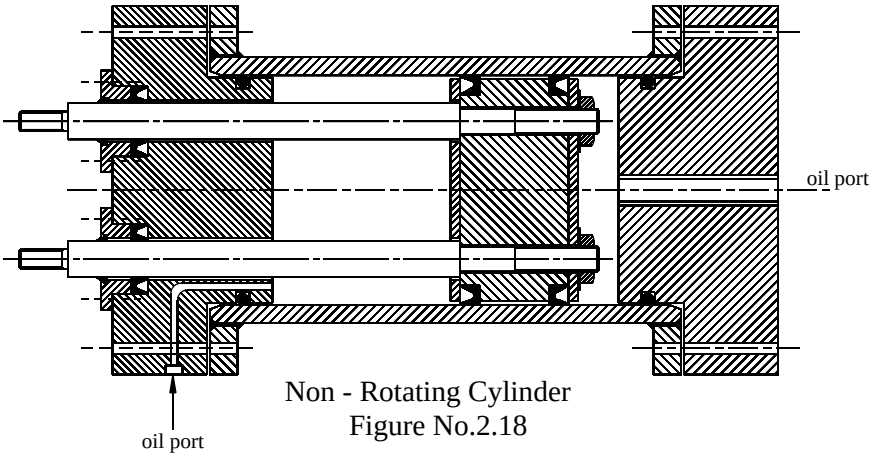
Bred bury speed ram
Figure No. 2.17

2.2.14 Non - Rotating Cylinder: -

Cylinder, piston, piston - rod, guide-bush, gland-bush all these components have circular guide. When piston and piston rod take their stroke more, they are free to rotate. Hence alongwith a desired linear motion, there is also an undesired rotary motion of piston rod along its central axis.

When a cylinder is assembled in hydraulic press and piston - rod is coupled to moving platen, this rotary motion gets arrested. But when cylinder is not assembled in hydraulic press, and is required to perform independently in various operations such as marking, punching, indexing etc. and rotary motion of piston-rod not desired then piston-rod is guided externally. But this additional and external guide takes lots of space and is a costly affair.

Hence non-rotating type of cylinders has been developed. It is similar to conventional double action cylinder with three piston rods. All the three piston rod are coupled to same piston, and passes through guide-bush, gland-bush etc. While manufacturing such cylinders, too much precaution has to be taken regarding quality



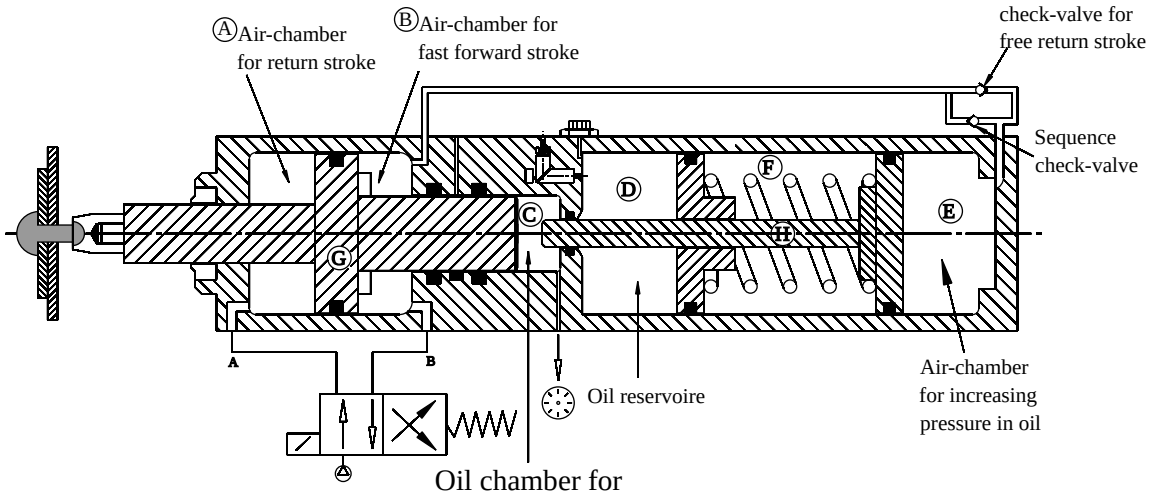
Non - Rotating Cylinder
Figure No.2.18

2.5.15 Hydro - Pneumatic Cylinder: -

These are very important type of cylinders used extensive in industry for such operations which require high production, very short production cycle, They require small stroke of cylinder under load, such as punching reverting, marking etc.

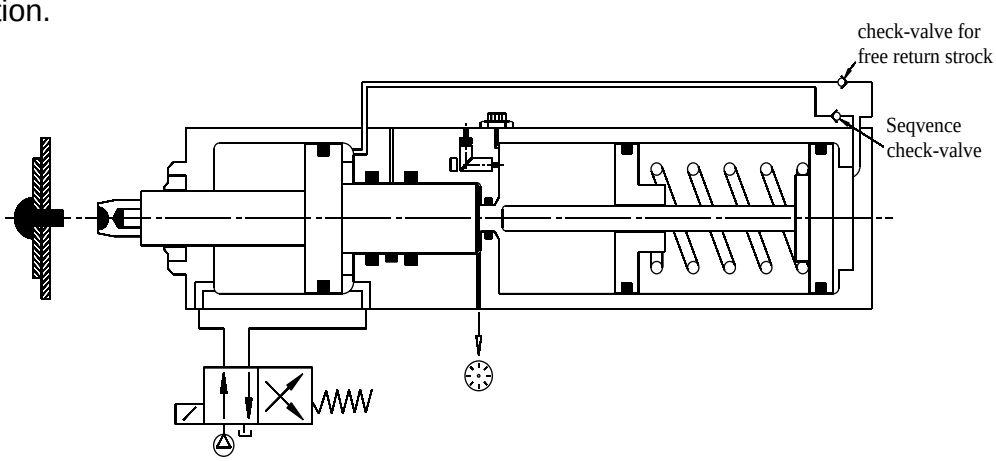
Hydro-pneumatic cylinder is a compound cylinder in which a pneumatic cylinder and hydraulic cylinder are assembled together in a special way.

Following figure and description will explain it various component and

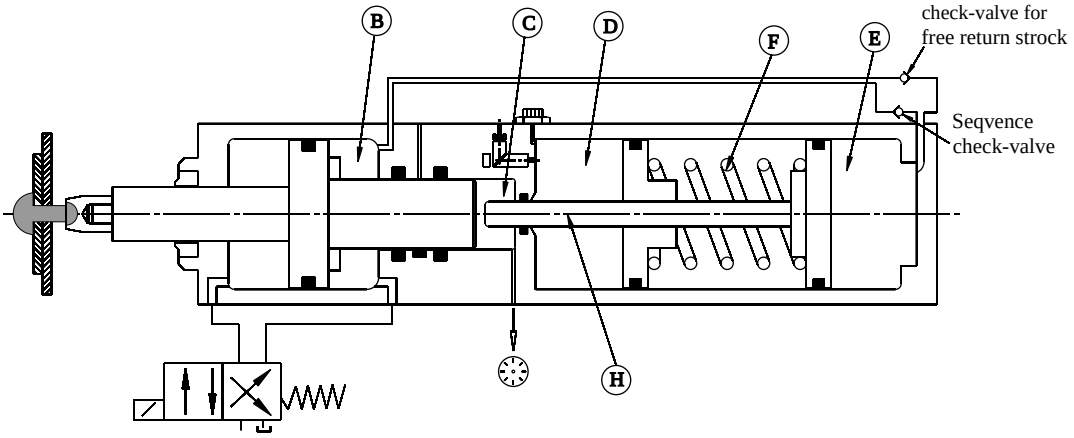


Oil chamber for pressure intensification
Figure No. 2.19

1] System start with revetting plunger at retracted position, and valve in switch-off condition.



2] To start system solenoil valve is energies, which cause supply of air in chamber.(B) which is air chamber for a forward stroke. In this energized condition of solenoil chamber (E) which is air chamber for increasing pressure in oil is also get connected to air - pressure line. But due to sequence check-valve, air does not enter in this chamber up to a set pressure (may be 5 bar). Because of this oil get sucked in chamber (C) from (D) which is oil reservoir chamber. Spring (F) expand when oil is sucked from chamber (D) to chamber (C). This also creates low pressure in chamber (E)



3] When reveting punch senses some resistance, air pressure increases and over come resistance offered by sequence check valve, and pressurised air enter in chamber (E). This causes plunger

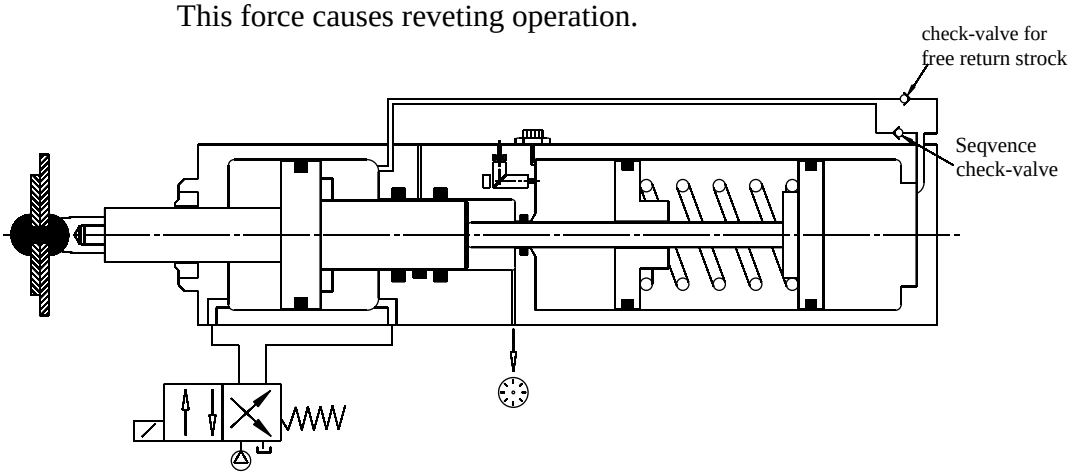
(H) to enter in chamber (C). As soon plunger (H) enter the opening of chamber (C), oil get trapped in chamber (C) due to oil seal and fine clearance. When air pressure further increases in chamber (E) it exert more force on plunger (H). This causes

If Air pressure is = P_1
Area of chamber (E) is =A_1
Area of chamber (C) is =A_2
Then pressure (P_2) in oil will be

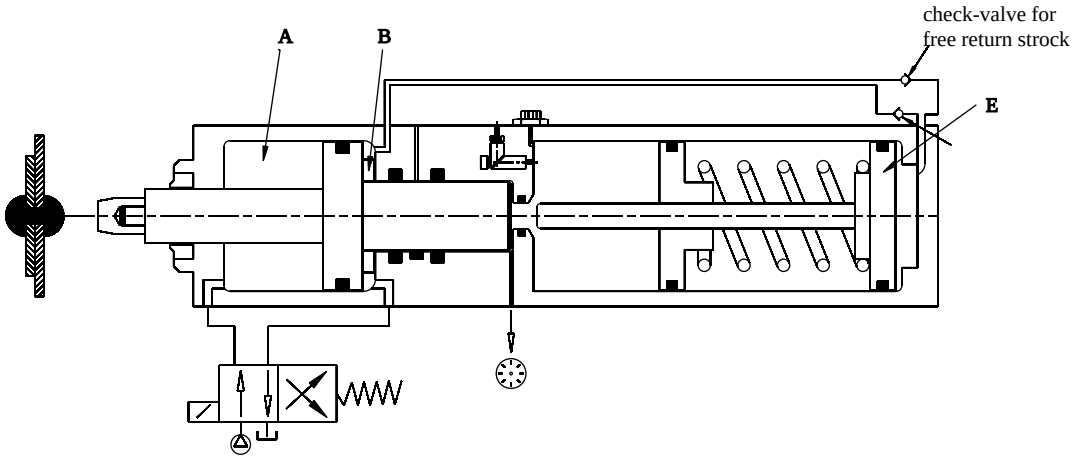
$$P_1 A_1 = P_2 A_2$$

$$\text{hence } P_2 = \frac{P_1 A_1}{A_2}$$

Force developed at plunger will be
$F=P_2A_2$
This force causes reveting operation.



4] As soon as reveting get completed, solenoil valve get de-energized, which connect chamber (B) and (E) to atmosphere, and chamber (A) to compress pressure. This causes plunger (G) and (H) to retract under pressure of air and oil and transfer of oil from chamber (C) to (D).



5] This couplets one production cycle, and system get ready for next operation.

2.5.16 Duplex Cylinder: -

These are two standard double action cylinder with independent direction control valve. These cylinder are mechanically connected to each other with a common central axis. By this arrangement we get number of piston-rod position depending on application.

.2.5.17 Tendum Cylinder: -

In case of tendum cylinders we have two or more cylinders with inter connected piston assemblies.

2.5.18 Adjustable Stroke Cylinder: -

In this type of cylinder we have external mechanical arrangement, such as thread

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