UNIT III

HYDRAULIC CIRCUITS AND SYSTEMS

PART-A

1. List the application of intensifier. Nov/Dec2011, Nov/Dec 2012

i) It is required in hydraulic machines such as hydraulic presses which require fluid at high pressure.

ii.) Intensifier is used commonly for clamping, holding, punching, presses, jacks, torque wrenches.

2. **List the basic arrangements in hydrostatic drives. May/June2013**

The operating principle of hydrostatic transmissions (HSTs) is simple: A pump, connected to the prime mover, generates flow to drive a hydraulic motor, which is connected to the load. If the displacement of the pump and motor are fixed, the HST simply acts as a gearbox to transmit power from the prime mover to the load. Most HSTs, however, use a variable-displacement pump, motor, or both so that speed, torque, or power can be regulate.

3. **What is the function of accumulator? May/June2014**

Leakage compensation, auxiliary power source, emergency power source, shock suppressor, thermal expansion compensator.

4. **What is the function of accumulator? NOV/DEC 2014**

Accumulator is used as an auxiliary power source. It is a device which stores the potential energy of the fluid. The stored potential energy in the accumulator acts

5. **Define the terms Lap and Null With respect to the servo valves. (April/May2008)**

Valve lap, or valve overlap, refers to the amount of spool travel from the center position required to start opening between the powered input port and the work (output) port or the tank port. A zero lapped valve is one in which any tiny, differentially small amount of spool shift, either way, starts the opening. However, there is no contact between the OD of the spool and ID of the bore. And even zero lapped valves have some slight amount of overlap. Nonetheless, the zero-lapped term persists.

Valve null is a specific point of a servo valve's pressure metering curve where the two deadhead (blocked port) work port pressures are equal. Servo valves are equipped with a mechanical adjusting device so that with no electrical power applied (connector disconnected from the valve), a spring or magnetic force can be changed to make the two work port pressures equal. That is normally where the factory adjusts a valve during final test, assuming it will be used on an equal area cylinder.

6. **What is meant by an air over oil system? (April/May2008)**

Air-over-oil tanks are another common way to create an air-over-oil system. These tanks hold more than enough oil to stroke the cylinder one way. Having an air valve piped to the air-over-oil tanks forces oil from the tanks into the cylinder

7. **State Coanda effect (April/May2008)**

Coanda effect is the phenomena in which a jet flow attaches itself to a nearby surface and remains attached even when the surface curves away from the initial jet direction. In free surroundings, a jet of fluid entrains and mixes with its surroundings as it flows away from a nozzle.

8. **What are the advantages of using intensifiers? (Nov/Dec 2009)**

- Higher performance and longer life on account of a lower operating pressure
- More compact system
- Greater safety due to lower pressure in general
- Integrated valves
- No dynamic seals
- Intensification ratio adapted to requirements

9. **What is the purpose of synchronised hydraulic circuits? (Nov/Dec 2009)**

A hydraulic circuit is connected to the cylinder assemblies, and includes synchronizer with multiple isolated chambers corresponding to the lift cylinder assemblies, a rod extending axially through the chambers, and pistons mounted on the rod and associated with the isolated chambers. An axial passageway extends continuously through the rod and is connected to first passageways for communicating hydraulic fluid to one side of the chambers.

10. **List any four applications of accumulators (April/May2010)**

Accumulators are also used for systems where thermal expansion could cause excessive pressure. Cylinders with blocked ports in a high ambient heat area can go to high pressure if there is no place for expanding fluid to go.

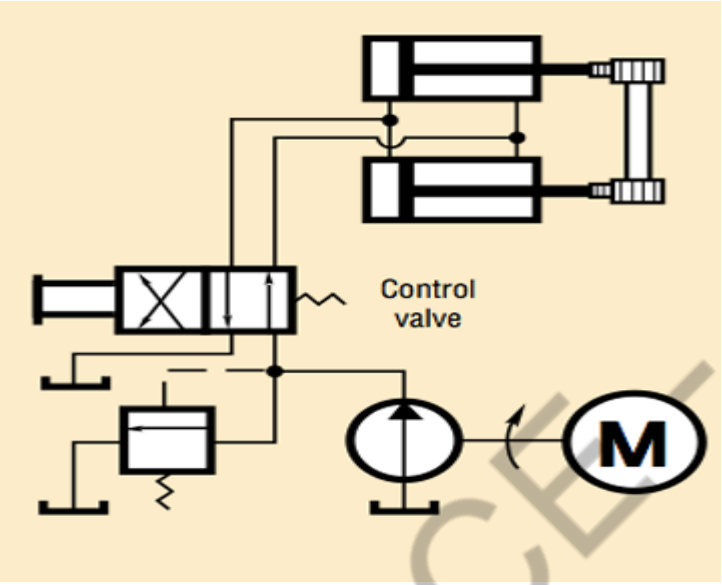
Another use for accumulators is as a barrier between two different fluids. The pump that uses hydraulic fluid keeps pressure on a circuit that uses water or another incompatible medium.

One supplier offers low-pressure accumulators as breathing devices for sealed reservoirs. This keeps airborne contaminants out of the hydraulic oil as the fluid level rises and falls.

11. What is a sequencing circuit? April/May2015

Process control pneumatics is also called as sequencing. It means performing number of actions one after another which follows each other in a simple order or with an order determined by sensors.

12. **Drawany one type of synchronizing circuit (April/May2010)**



13. What is the function of regenarative circuits (Nov/Dec2005)

The regenerative circuit is used to speed up the extending speed of a double-acting hydraulic cylinder.

14. What is servo valve? How does it work? (Nov/Dec2005)

- ✓ Servo valves are nothing but DC valves having [illegible] capability.
- ✓ A servo system is one in which the comparatively large amount of power is controlled by small impulses or command signals and any errors are corrected by feedback signals.

15. Highlight the need of usage in accumulator (Nov/Dec2006)

In hydraulic circuits, accumulators are used as:

(*i*) Leakage compensator,
(*ii*) Auxiliary power source,
(*iii*) Emergency power source,
(*iv*) Hydraulic shock absorber,
(*v*) Fluid make-up device,
(*vi*) Holding device, and
(*vii*) Lubricant dispenser.

16. What is twin pressure valve (Nov/Dec2005)

Twin pressure valve, like counter balance valve, permits free flow in one direction and restricted flow in the opposite direction.

17. What are major component of hydraulic system (Nov/Dec2007)

1. Reservoir (or tank)
2. Pump
3. Prime mover
4. Valves
5. Actuator
6. Fluid-transfer piping

18. What is an intensifier (Nov/Dec2007)

Intensifier, also known as pressure intensifier or pressure booster, is a device used to compress the liquid in a hydraulic system to a value above the pump discharge pressure. It is analogous to a step-up electrical transformer.

19. Name one application of a counterbalance valve. (Apr/May 2007)

The counterbalance valve is used to maintain back pressure on a vertical cylinder to prevent it from falling due to gravity.

20. What is the need for temperature compensation in flow control valves?

As the viscosity of oil varies with temperature, the oil becomes less viscous when temperature increases. As the less viscous fluid flow more readily through an orifice, the increase in temperature causes increase in flow for a valve setting. So temperature compensation is needed to offset the effect of such temperature variation.

UNIT III

PART-B

1. Draw and explain the hydraulic cylinder sequence circuits (April/May2005)

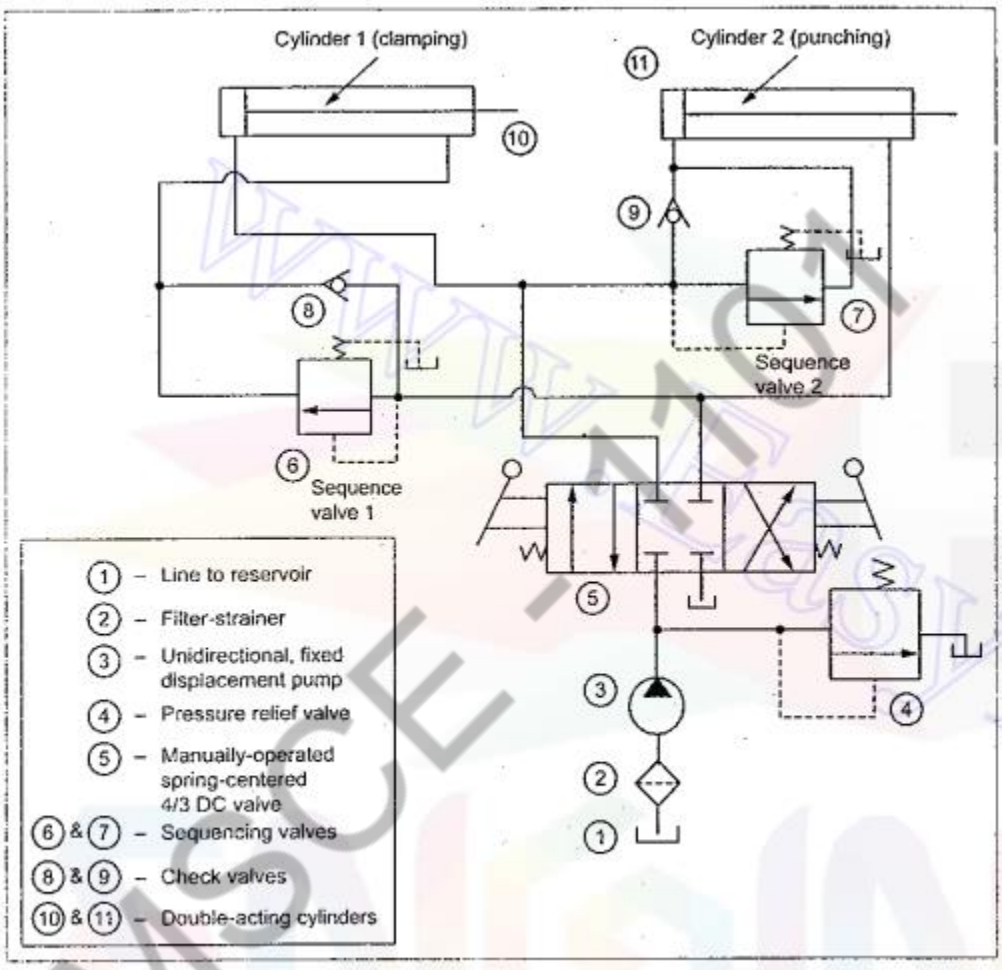


Fig. 13.5. Hydraulic cylinder sequence circuit (for clamping and punching operations)

13.8.1. Circuit

Fig.13.5 illustrates a circuit that uses two sequence valves to control the sequence of operations of two double-acting cylinders. This circuit has a manually-operated, spring-centered 4/3 DC valve, two sequencing valves, two check valves, and a pressure relief valve. Let us take that cylinder-1 is used to clamp the workpiece and cylinder-2 is to perform punching; and the sequence of operation as clamping first and then punching.

Spring-centered position : When the 4/3 DC valve is shifted to the spring-centered position, the oil drains back to the tank through the pressure relief valve. Thus during the spring-centered position, both cylinders are hydraulically locked.

13.8.2. Operation

Left mode position : When the 4/3 DC valve is shifted manually to the left envelope flow path configuration, the cylinder-1 extends completely and the workpiece is clamped. Once the cylinder-1 reaches its end of the stroke, pressure is increased and sequence valve 1 opens and the oil starts to flow into the cylinder-2. Now the cylinder-2 extends to drive a spindle to do punching operation in the workpiece.

Right mode position : When the 4/3 DC valve is shifted to the right mode, the cylinder-2 retracts. Once the cylinder-2 retracts completely, the sequence valve 2 opens and the oil starts to flow into the cylinder-1. It causes the cylinder-1 to retract and hence the unclamping of workpiece is achieved.

2. Explain the working principles of a fail -safe circuits with over load protection (April/May2005)

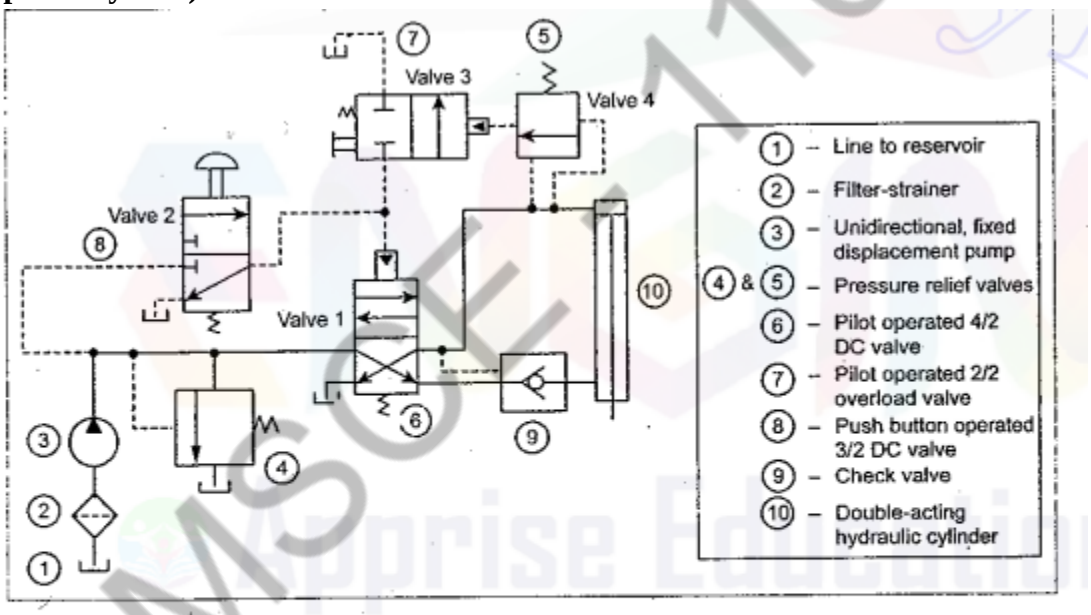


Fig. 2. Fail-safe circuit with overload protection

Operation : Push-button 3/2 valve (*i.e.*, valve 2) controls the 4/2 DC valve (*i.e.*, valve 1). When overload valve (*i.e.*, valve 3) is shifted to its left mode, it drains the pilot line of valve 1. If the cylinder experiences excessive resistance during the extension stroke, sequence valve 4 pilot-actuates overload valve 3. This drains the pilot line of valve 1, causing it to return to its spring-offset mode. If an operator operates push button valve 2, nothing will happen unless overload valve 3 is manually shifted to its blocked port configuration. Thus the system components are protected against overload during its extension stroke.

3. Describe an hydraulic circuits for synchronizing two cylinders with flow control valves (April/May2005)

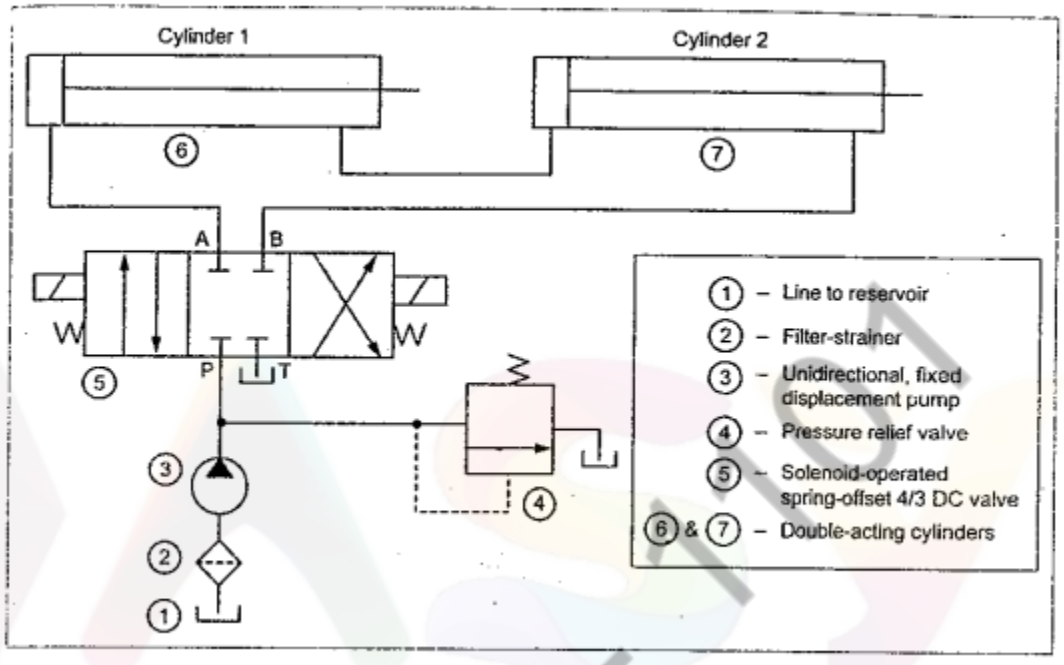


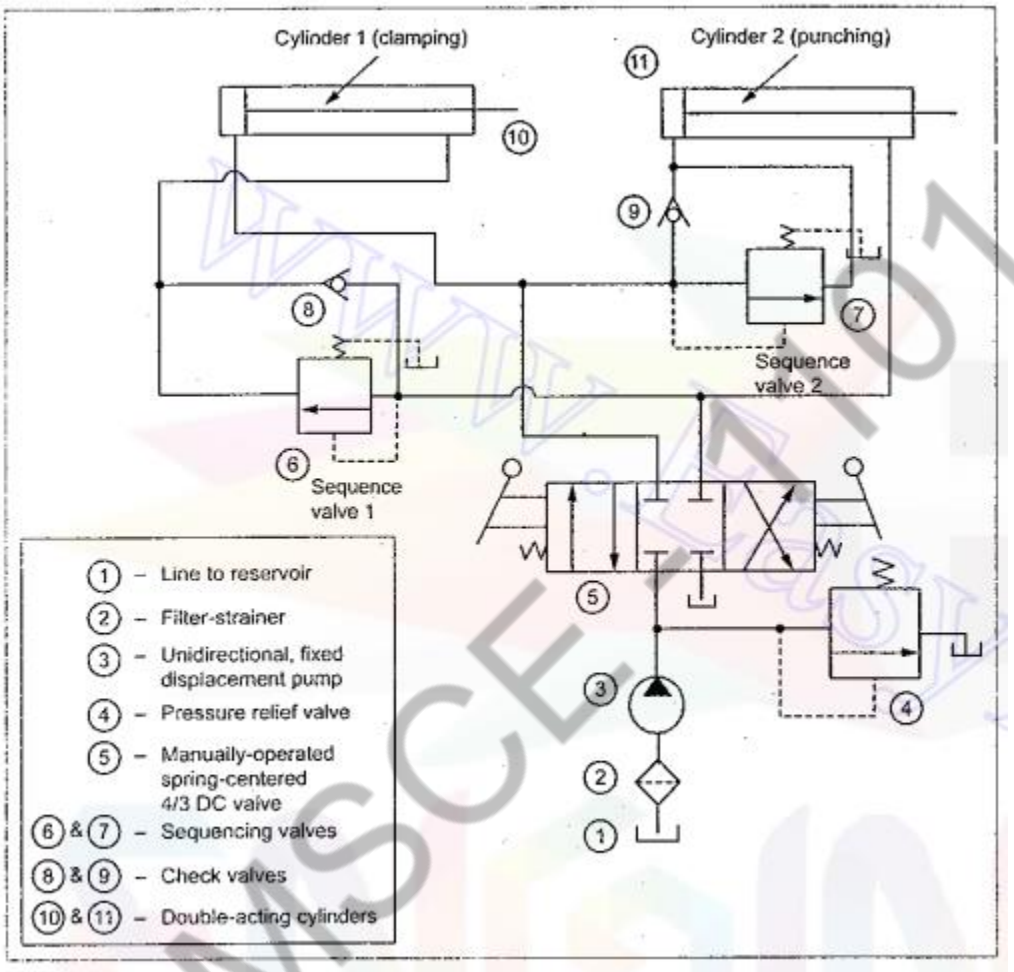
Fig. 13.7. Synchronizing hydraulic cylinders by connecting them in series

Extension of cylinders 1 and 2 : When the 4/3 DC valve is shifted to the left envelope flow path configuration, oil flows from the pump to the blind end of cylinder 1 and thus the cylinder 1 extends. At the same time, oil from the rod end of cylinder 1 is forced to the blind end of cylinder 2 and thus the cylinder 2 also extends. Now the oil returns to the tank from the rod end of cylinder 2 via the DC valve. Once full extension of cylinders 1 and 2 are over, the DC valve is shifted to the right mode.

Retraction of cylinders 1 and 2 : When the 4/3 DC valve is shifted to the right mode, oil flows from the pump to the rod end of cylinder 2 and thus the cylinder 2 retracts. At the same time, oil from the blind end of cylinder 2 is forced to the rod end of cylinder 1 and thus the cylinder 1 also retracts. Now the oil returns to the tank from the blind end of cylinder 1 via the DC valve.

Thus both extension and retraction operations of both cylinders are synchronized by connecting them in series. But for the two cylinders to be synchronized, the piston area of cylinder 2 should be equal to the difference between the areas of the piston and rod for cylinder 1.

4. Design a hydraulic sequence circuit for a milling machine with one cylinder for operating the power vice jaw and the other for controlling the cutler travel (April/May2005)



Left mode position : When the 4/3 DC valve is shifted manually to the left envelope flow path configuration, the cylinder-1 extends completely and the workpiece is clamped. Once the cylinder-1 reaches its end of the stroke, pressure is increased and sequence valve 1 opens and the oil starts to flow into the cylinder-2. Now the cylinder-2 extends to drive a spindle to do punching operation in the workpiece.

Right mode position : When the 4/3 DC valve is shifted to the right mode, the cylinder-2 retracts. Once the cylinder-2 retracts completely, the sequence valve 2 opens and the oil starts to flow into the cylinder-1. It causes the cylinder-1 to retract and hence the unclamping of workpiece is achieved.

5. Give any two application circuits employing accumulator for different purposes (May/June 2005)

8.11.3. Accumulator as Emergency Power Source

- ✓ In some hydraulic applications, it is necessary to retract the pistons of cylinders to their starting position (for safety reasons), even there may be an electrical power failure. In such applications, the accumulator can be used as an emergency power source to retract the piston of the cylinder.
- ✓ For example, consider a situation where a hydraulic system is operating a flood gate in a dam, and the electrical power fails. In such situation, the accumulator supplies the working fluid which operates the flood gate.

Fig.8.10 illustrates how gas-loaded accumulator can be used as emergency source of power. This circuit essentially has a solenoid-operated 3/2 DC valve.

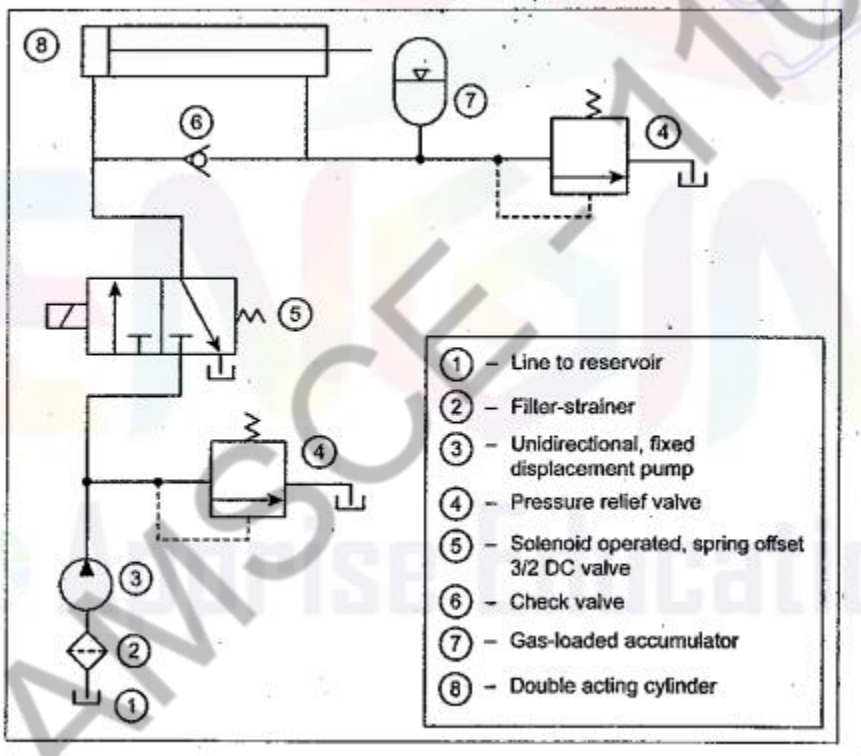


Fig. 8.10. Accumulator as an emergency power source

8.11.3.2. Operation

When operator depresses push button energizing solenoid of the 3/2 DC valve, oil flows to blind end of cylinder. At the same time, the oil also unseats check valve. So the oil under pressure flows to rod end of cylinder and into the accumulator. Now the accumulator charges the oil as the piston of cylinder extends.

When there is a power failure, the solenoid will deenergize. In the absence of solenoid-energy, the spring pressure forces the valve to shift to its spring-offset mode. Now the oil stored under pressure is forced from the bladder-type accumulator to the rod end of the cylinder. Thus the piston of the cylinder retracts to the starting position.

8.11.4. Accumulator as Hydraulic Shock Absorber

In many high-pressure hydraulic systems, the sudden stoppage or deceleration of a hydraulic fluid flowing at high velocity in pipelines can cause considerable damage to the piping. This hydraulic shock, also known as water hammer, may snap heavy pipes, loosen fittings and cause leaks. By installing an accumulator, this high-pressure pulsations or hydraulic shocks can be suppressed/absorbed.

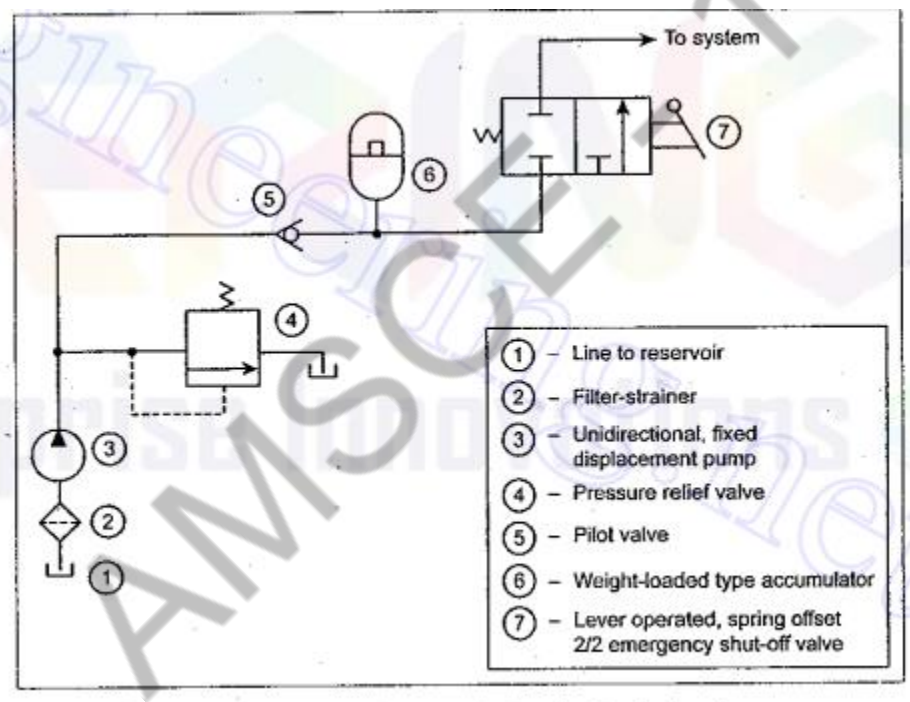


Fig. 8.11. Accumulator as a hydraulic shock absorber

6. Explain the air over oil intensifier with suitable example (Nov/Dec2006)

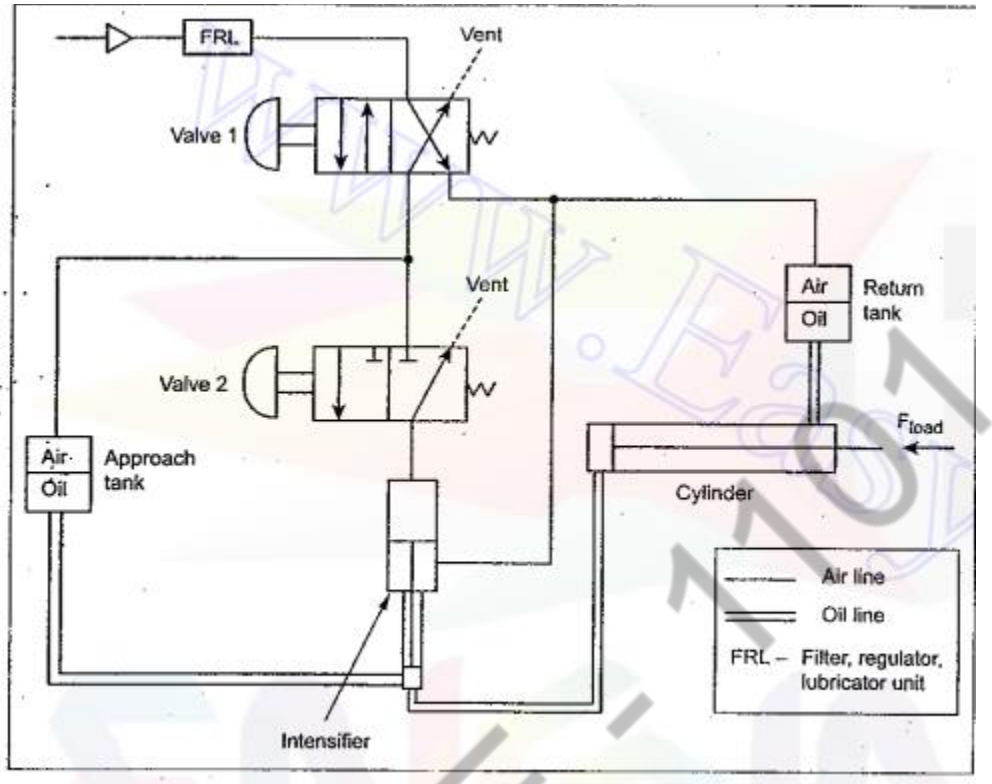


Fig. 8.18. Air-over-oil intensifier circuit

8.14.2. Air-Over-Oil Intensifier Circuit

- ✓ In some applications, the hydraulic and pneumatic circuits are coupled to best use of the advantages of both oil and air mediums.
- ✓ This combination circuit is also known as ***hydro-pneumatic*** or ***pneumo-hydraulic circuits*** or ***dual pressure systems.***

8.14.2.1. Circuit

Fig.8.18 shows a typical air-over-oil intensifier. This circuit can be used for drawing a cylinder over a large distance at a low pressure and then over a small distance at high pressure (such as in punch press applications). This circuit consists two lines—air lines and oil lines. In the circuit, the air lines are shown by single lines and oil lines by double lines.

8.14.2.2. Operation

Extension : When the first 4/2 DC valve (valve 1) is shifted to left mode, the air from the reservoir flows to the approach tank. In the approach tank, the air forces the oil to the blind end of the cylinder through the bottom of the intensifier, as shown by double lines in Fig.8.18. Now the cylinder extends.

Useful Work : When the cylinder experiences its load, the second 4/2 DC valve (valve 2) is actuated to the left mode. This valve position sends air to the top end of the intensifier.

Retraction : When the valve 2 is released (shifted to right mode), the air flow from the reservoir is blocked. The air from the top end of the intensifier is vented to the atmosphere. This completes the high pressure portion of the cycle.

When valve 1 is released (*i.e.*, shifted to right mode), the air flow is diverted to return tank and also the air in the approach tank is vented. The diverted air flow pushes the oil to the rod end of the cylinder. This causes the cylinder to retract. The oil from the piston end of the cylinder is diverted back to the approach tank through the bottom end of the intensifier. This completes the entire cycle of operation.

7. With a neat sketch explain the weight loaded accumulator (Nov/Dec2006)

8.3.1. Construction

The construction and operation of a dead-weight type accumulator is illustrated in Fig.8.1. It consists of a piston rod or plunger loaded with a dead weight and moving within a cylinder to exert pressure on the hydraulic oil. The dead-weight provides the potential energy to compress the fluid. The dead-weight may be concrete block, iron or steel block, or any other heavy material. The piston should have a precision fit with the accumulator tube so as to reduce the leakage past the piston. One side of the accumulator cylinder is connected to the fluid source (pump) and the other side to the work load (machine).

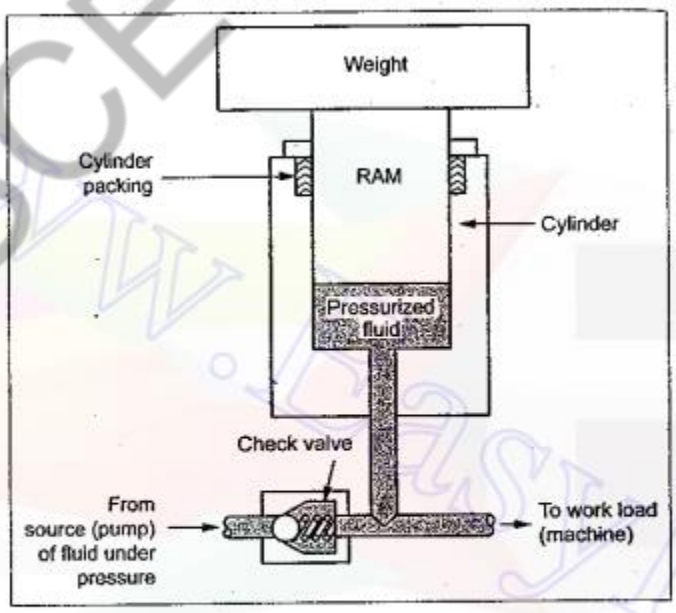


Fig. 8.1. Weight-loaded hydraulic accumulator

8.3.2. Operation

In the beginning, the ram is at the lower-most position. During idle periods of driven machine (say lift or crane) high pressure fluid (oil) supplied by the pump is admitted in the accumulator cylinder through the check valve. Fluid is allowed continuously till the ram reaches its uppermost position. At this position, the accumulator cylinder is full of fluid and the maximum amount of pressure energy is accumulated.

During the working stroke of the driven machine (*i.e.*, when it requires maximum amount of energy), the accumulated energy is discharged to the driven machine.

8.3.3. Advantages

The advantages of the weight-loaded type accumulators are :

1. The weight-loaded accumulators produce constant pressure for the full stroke *i.e.*, until all the fluid is sent out.
2. They can supply large volume of fluid under high pressure.
3. The large volume of fluid makes them possible to supply pressure to several hydraulic circuits.

8. Make a circuit showing an intensifier in a punching press application((April/May2008)

8.14.1. Intensifier Circuit in Punching Press Application

As we know, usually a heavy punching press requires two pumps (a low-pressure pump and a high-pressure pump) to obtain the high-pressure outlet flow required for the operation. But with the use of a pressure intensifier, one can eliminate the expensive high-pressure pump in the punching press application.

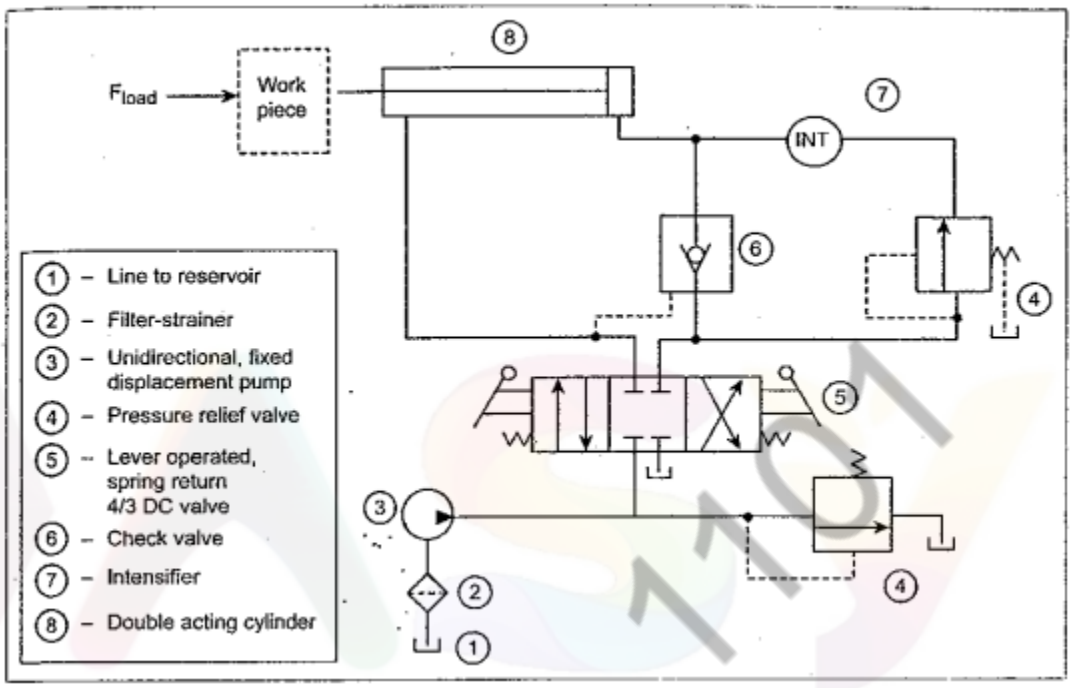
8.14.1.1. Circuit

Fig.8.17 shows a basic hydraulic circuit employing an intensifier for use in a punching operation. This circuit consists of a low-pressure pump, 4/3 DC valve, pilot check valve, sequence valve, pressure intensifier, and cylinder. As shown in Fig.8.17, the intensifier should be installed closer to the cylinder to shorten the high-pressure lines.

8.14.1.2. Operation

First operator places workpiece in fixture and shifts handle of 4/2 DC valve. When the 4/2 DC valve is shifted to the right side position, the oil flows to the blind end of the cylinder through the check valve. When the pressure in the cylinder reaches the sequence valve pressure setting, the sequence valve opens and supplies the flow to the intensifier. Now the intensifier starts to operate and gives high-pressure output. This high-pressure output of the intensifier closes the pilot check valve and pressurizes the blind end of the cylinder to perform the punching operation.

When the 4/2 DC valve is shifted to the left side position, the oil flows to the rod end of the cylinder. When it builds-up the pressure, the pilot signal opens the check valve. Thus the cylinder is retracted to the starting position.



9. Write and explain the working principle of pressure intensifier with neat diagram (Nov/Dec2008)

8.13.1. What are Pressure Intensifiers ?

- ✓ Pressure intensifiers, also known as ***pressure boosters***, are used to compress the liquid in a hydraulic system to a value above the pump discharge pressure.
- ✓ In other words, *a hydraulic intensifier is a device which converts a large-volume, low-pressure fluid supply into a proportionately small-volume, high-pressure fluid outlet.*
- ✓ The intensifier is usually located in between the pump and the machine (*e.g.*, press, crane, lift) that needs high pressure liquid for its operation.
- ✓ The action of the intensifier is similar to that of a ***step-up electrical transformer.***
- ✓ It finds its application at places where a liquid of very high pressure is to be developed from available low pressure. Typical applications include hydraulic presses, riveting machines, and spot-welders.

As shown in Fig.8.16, the unit consists of two pistons—low pressure and high pressure—having a common piston rod. The larger, piston is exposed to pressure from a low-pressure pump. The low-pressure fluid (oil) is introduced to the larger piston side and thus it forces the piston to move. Neglecting losses due to friction, the smaller end of the piston exerts the same force on the fluid in the intensifier chamber or smaller cylinder.

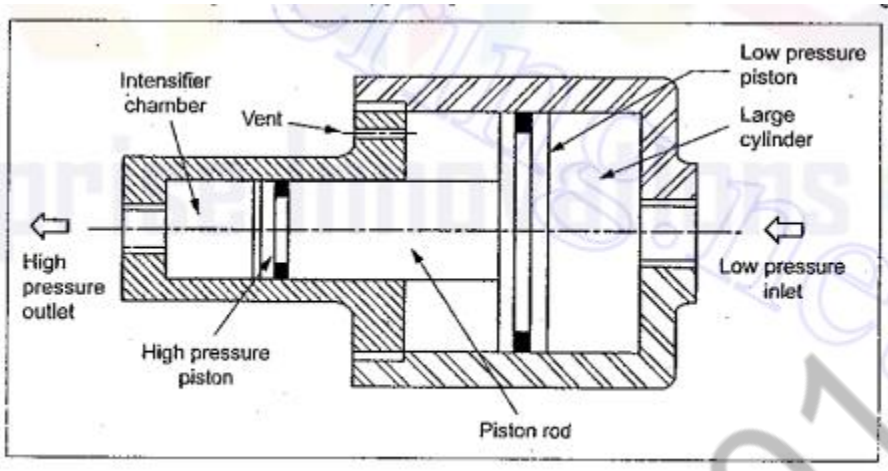


Fig. 8.16. Operation of a pressure intensifier

10 . Design and explain the working of regenerative circuits (May/June2009)

13.5. REGENERATIVE CIRCUIT

A regenerative circuit is used to speed up the extending speed of the double-actin cylinder.

13.5.1. Circuit

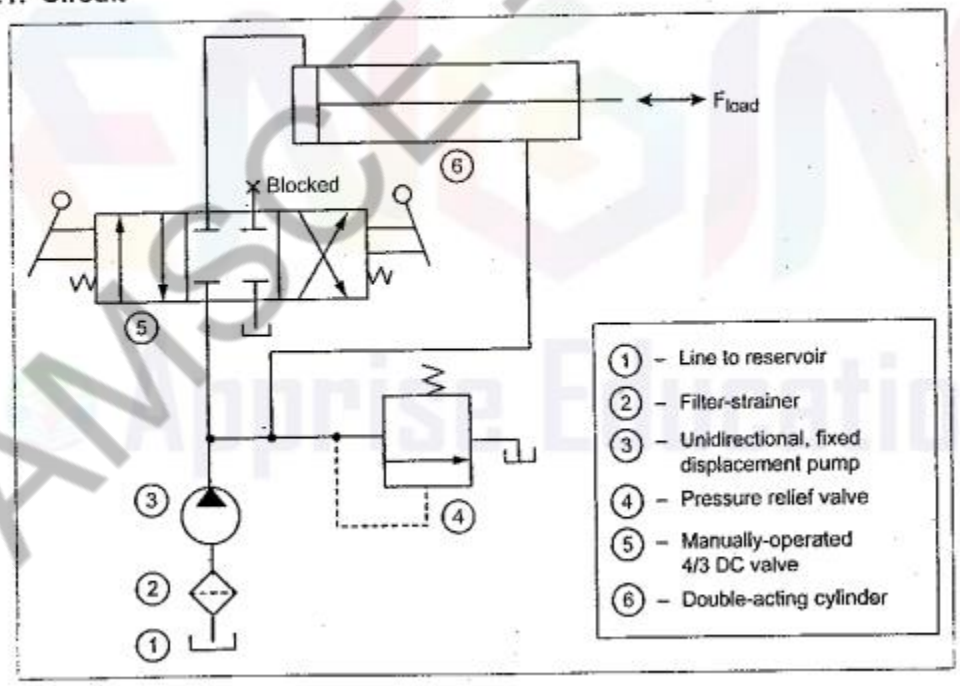


Fig. 13.3. Regenerative circuit

Fig.13.3 illustrates a regenerative circuit that can be used to speed up the extending speed of the double-acting cylinder. This circuit uses a manually-operated, three position, four way directional control valve (closed center position), and a double-acting cylinder. It should be noted in this circuit that the pipelines to the cylinder are connected in parallel and one of the ports of the DCV is blocked.

13.5.2. Operation

Extension : When the 4/3 DC valve is shifted to the left mode, the oil flows from the pump to the blind end of the cylinder. This pump flow extends the cylinder.

Retraction : When the 4/3 DC valve is shifted to the right mode, the oil from the pump bypasses the DC valve and enters into the rod end of the cylinder. Oil in the blank end drains back to the tank through the DC valve as the cylinder retracts.

11. Explain any two types of accumulator circuits with neat sketch (Apr/May 2010, May/june2012, April/May2015)

8.8. PISTON TYPE ACCUMULATOR

8.8.1. Construction

The construction and operation of a typical piston type accumulator is illustrated in Fig.8.4. It consists of a cylinder body and a moveable piston with proper seals.

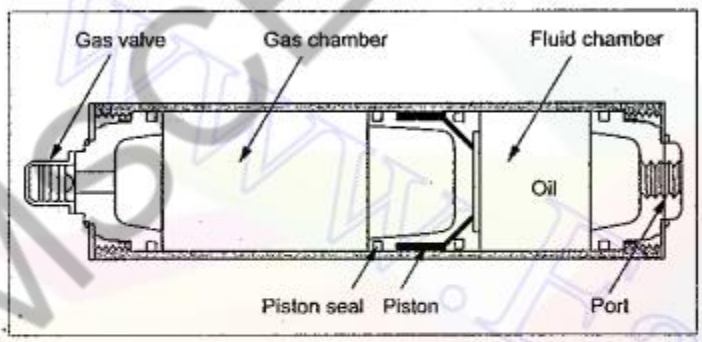


Fig. 8.4. Piston type accumulator

8.8.2. Operation

As shown in Fig.8.4, the piston serves as the barrier between the gas and oil. The gas is confined at the volume above the piston and the oil at the volume below the piston. The gas is compressed when the charged oil pushes the piston against it. This gas pressure is used as the potential energy to force the oil out when it is required in the circuit.

8.8.3. Advantage

The piston type accumulator has the ability to handle very high or low temperature system fluids.

8.4. SPRING-LOADED ACCUMULATORS

8.4.1. Construction

The spring-loaded accumulators are similar in construction to that of dead-weight type accumulators. In this type, instead of loading the ram with dead-weight, it is preloaded with compression spring, as shown in Fig.8.2. It consists of a cylinder body, a moveable piston, and a compression spring. The spring provides the compression energy required for this accumulator.

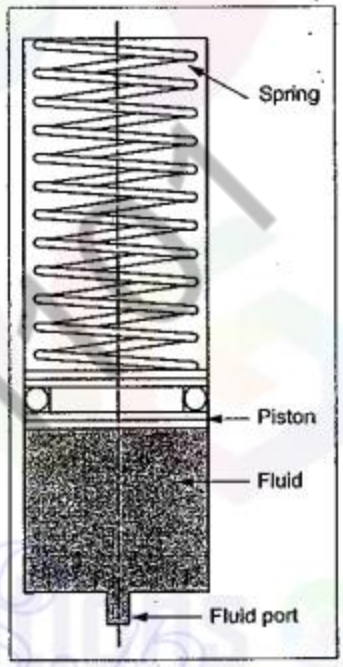


Fig. 8.2. Spring-loaded type accumulator

8.4.2. Operation

As the spring is compressed by the piston, the hydraulic fluid is forced into the accumulator cylinder. The pressure in the accumulator is dependent on the size and preloading of the spring. The accumulator pressure increases as the spring gets compressed, because incoming fluid flow increases the load required to compress the spring.

When the fluid is discharged out of the accumulator, it causes the spring to expand. As the spring approaches its free length, the accumulator pressure drops to a minimum. Thus the pressure exerted by the spring-loaded type accumulator on the fluid is not constant as in the dead-weight type.

8.4.3. Advantages

1. The spring-loaded accumulators are usually smaller and less expensive than the dead-weight type accumulators.
2. They are easy to maintain.

8.10. BLADDER TYPE ACCUMULATORS

8.10.1. Construction

The construction of a typical bladder type accumulator is depicted in Fig.8.6. It consists of a bag or bladder of synthetic material which is precharged with gas to a determined pressure. This bladder is placed within the accumulator shell and the balance of the space filled with oil. Thus the bladder serves as an elastic barrier between the gas and oil.

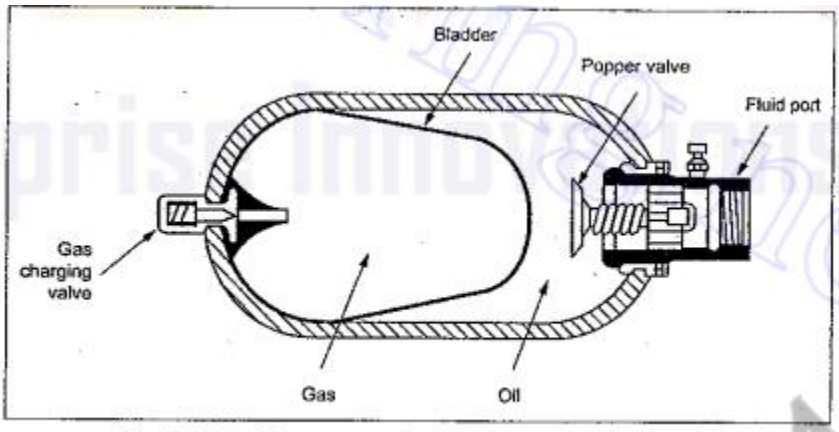


Fig. 8.6. Bladder-type gas-loaded hydraulic accumulator

12. Explain the following circuits with neat sketch. April/May2012
i)Meter-In ii) Meter Out circuits

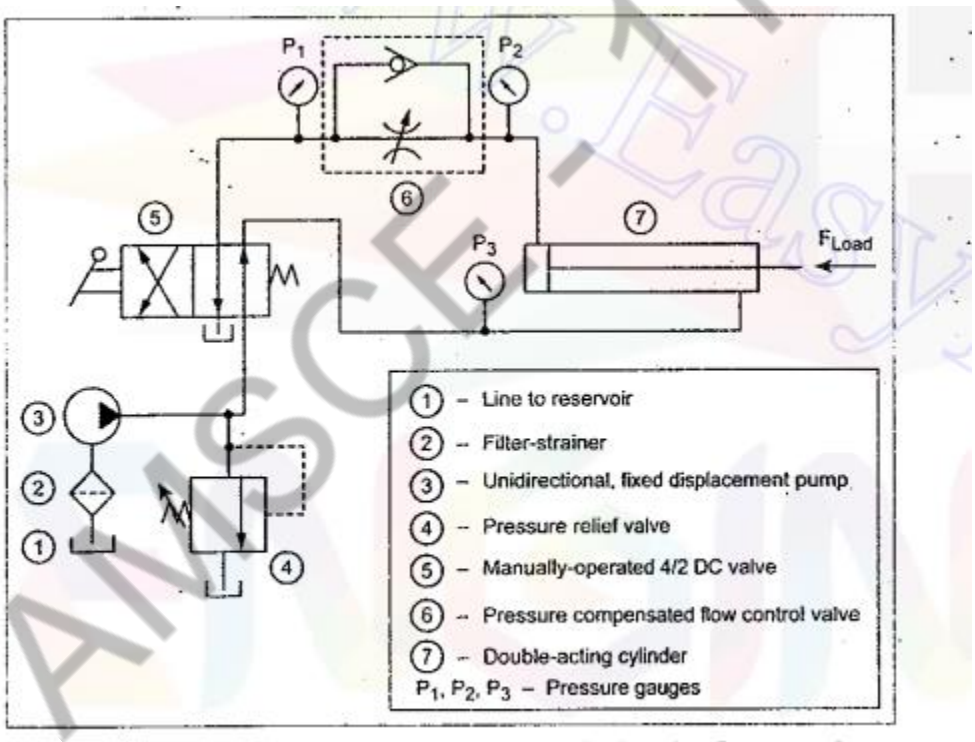


Fig. 13.8. Meter-in speed control of hydraulic cylinder using flow control

13.11.2.2. Operation

Extension : When the 4/2 DC valve is mechanically shifted to its left mode, oil flows from the pump to the blind end of the cylinder via the flow control valve. This pump flow extends the cylinder. Here it can be noted that the extending speed of the cylinder depends on the setting of the flow control valve. Thus the extending speed of the cylinder can be increased or decreased just by regulating the flow of fluid in the flow control valve.

Retraction : When the 4/2 DC valve is shifted to its right mode, oil flows from the pump to the rod end of the cylinder and hence the cylinder retracts. The oil from the blind end of the cylinder drains back to the oil tank through the check valve as well as the flow control valve.

ii) Meter out circuit

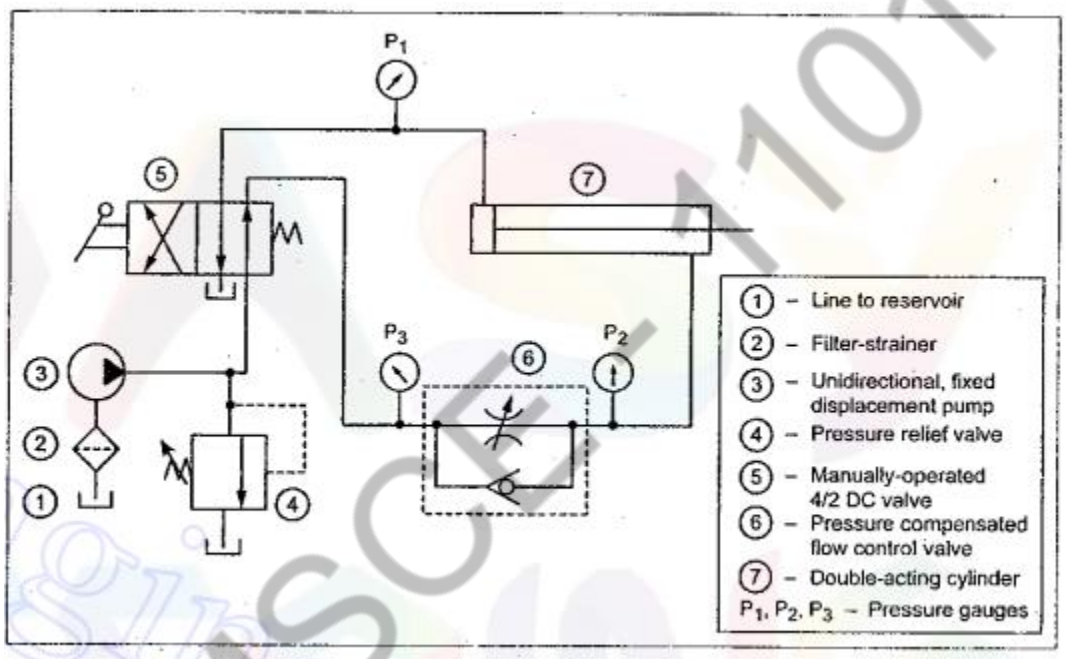


Fig. 13.9. Meter-out speed control of hydraulic cylinder using flow control

13.11.3.2. Operation

The operation meter-out circuit is very much similar to that of the meter-in circuit. The only difference is that meter-out flow control system controls the oil flow rate out of the cylinder. In other words, meter-out circuit controls the retracting speed of the cylinder.