LECTURE 28 to 29– ACCUMULATORS

FREQUENTLY ASKED QUESTIONS

1. Define an accumulator and explain its function

A hydraulic accumulator is a device that stores the potential energy of an incompressible fluid held under pressure by an external source against some dynamic force. This dynamic force can come from different sources. The stored potential energy in the accumulator is a quick secondary source of fluid power capable of doing useful work.

It is a simple hydraulic device which stores energy in the form of fluid pressure. This stored pressure may be suddenly or intermittently released as per the requirement. In the case of a hydraulic lift or hydraulic crane, a large amount of energy is required when the lift or crane is moving upward. This energy is supplied from the hydraulic accumulator. But when the lift is moving in the downward direction, it does not require a huge amount of energy. During this particular time, the oil or hydraulic fluid pumped from the pump is stored in the accumulator for future use.

2. What are the different types of accumulators?

There are three basic types of accumulators

1. Weight loaded or gravity accumulators
2. Spring loaded accumulators
3. Gas loaded accumulators

3. Why are accumulators used?

To supplement pump flow: The most common use for accumulators is to supplement pump flow. Some circuits require high-volume flow for a short time and then use little or no fluid for an extended period. Generally speaking, when half or more of the machine cycle is not using pump flow, the application is a likely candidate for an accumulator circuit.

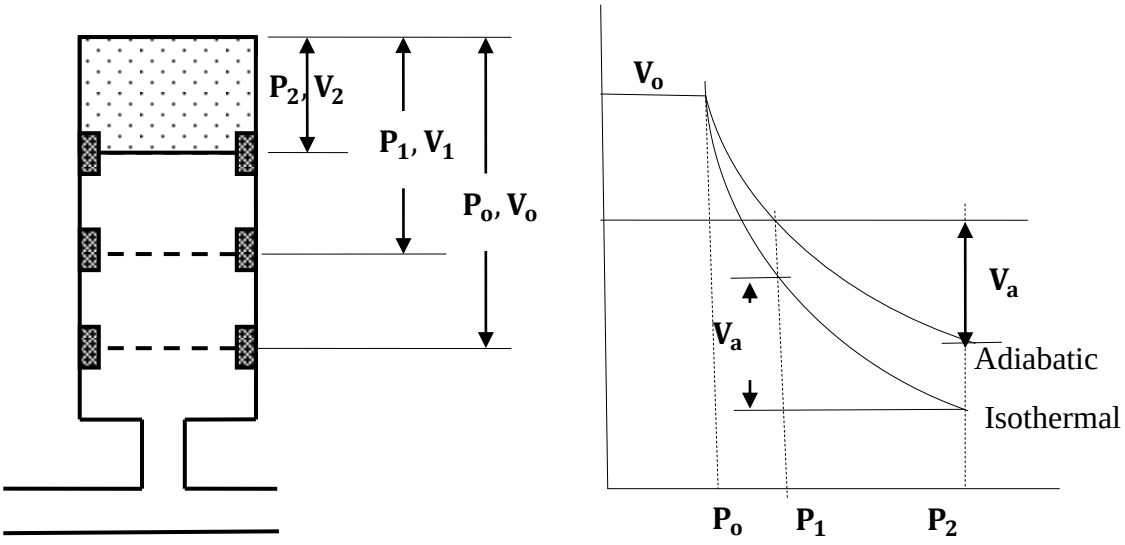
4. Explain the principle of operation and possible application of the hydraulic accumulators

Like an electrical storage battery, a hydraulic accumulator stores potential power, in this case liquid under pressure, for future conversion into useful work. This work can include operating cylinders and fluid motors, maintaining the required system pressure in case of pump or power failure, and compensating for pressure loss due to leakage. Accumulators can be employed as fluid dispensers and fluid barriers and can provide a shock-absorbing (cushioning) action.

Accumulators are used mainly on the lift equipment to provide positive clamping action on the heavy loads when a pump's flow is diverted to lifting or other operations. An accumulator acts as a safety device to prevent a load from being dropped in case of an engine or pump failure or fluid leak. On lifts and other equipment, accumulators absorb shock, which results from a load starting, stopping, or reversal.

5. Define and derive an expression for the volumetric capacity of bladder type accumulators

The volumetric capacity of the accumulator is defined as volume of the oil delievered to /from the accumulator at pressure P in operating range $P_1 = P = P_2$



$$V_a = V_1 - V_2 = V_0 \left\{\left(\frac{P_0}{P_1}\right)^{\frac{1}{n}} - \left(\frac{P_0}{P_2}\right)^{\frac{1}{n}}\right\} - for\ polytropic\ process$$

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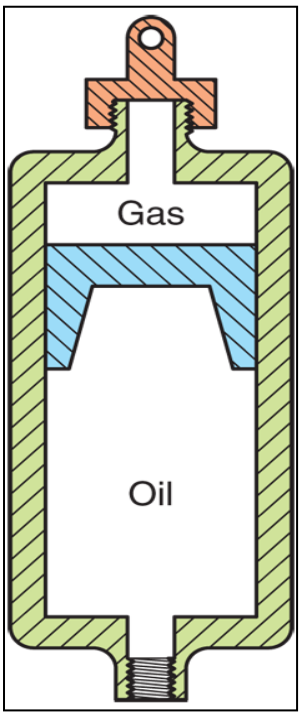
6. Explain the construction and operation of the piston type accumulator

Piston type accumulator: - It consists of a cylinder with a freely floating piston with proper seals. Its operation begins by charging the gas chamber with a gas (nitrogen) under a predetermined pressure. This causes the free sliding piston to move down. Once the accumulator is precharged, hydraulic fluid can be pumped into the hydraulic fluid port. As the fluid enters the accumulator, it causes the piston to slide up, thereby compressing the gas which increases its pressure and this pressure is then applied to hydraulic fluid through the piston. Since the piston is free sliding, the pressure on the gas and the hydraulic fluid is always equal.



Piston type accumulator

7. Explain the construction and operation of the bladder type accumulator

Bladder accumulator: - These accumulators function in the same way as the other two accumulators. Here the gas and the hydraulic fluid are separated by a synthetic rubber bladder. The bladder is filled with nitrogen until the designed pre-charge pressure is achieved. Hydraulic fluid is then pumped into the accumulator, thereby compressing the gas and increasing the pressure in the accumulator. The port cover is a small piece of metal that protects the bladder from damage as it expands and contacts the fluid port.

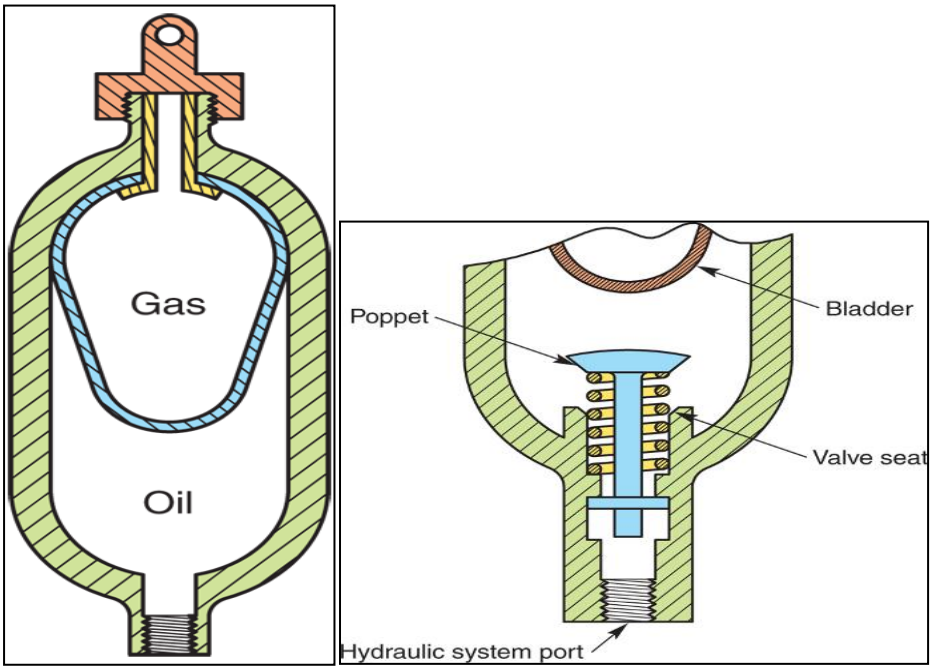


Figure 6 Bladder type accumulator

In an accumulator, at any point of time, we are either compressing a pre-charged gas or allowing it to expand. This compression or expansion brings about a status change in the gas, which is governed by the perfect gas equation,

$$PV = mRT$$

Where P is the absolute pressure in Bar, V is the gas volume in m^3, m is the mass in kg, R is the universal gas constant. (most common gas used in industry is Nitrogen) For the particular gas and the accumulator, the value of WR is constant written as, PV/T = constant or

$$P_0V_0/T_0 = P_1V_1/T_1$$

When the change takes place over a long period of time the temperature of the gas remains constant and such a change is called isothermal, resulting in the equation

$$P_0V_0 = P_1V_1 = P_2V_2$$

When the change occurs instantaneously, there is no time for heat transfer from the work to the environment and such a change is called isentropic or reversible adiabatic and is given by,

$$P_0V_0^n = P_1V_1^n = P_2V_2^n$$

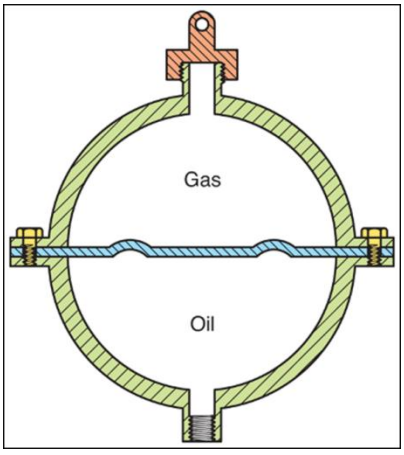
All changes between isothermal and isentropic are called polytropic.

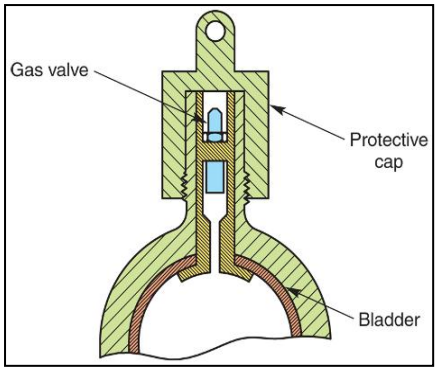
Pressure volume diagram shown in the figure 7will help us to understand how the volume variation as a function of pressure is depending on the value of polytropic exponent n which for nitrogen is contained within the limits $1 \leq n \leq 1.4$. The value of n is taken to be equal to 1 if the compression and expansion process takes place under isothermal process. For adiabatic conditions, the value of n is taken equal to 1.4.

Isothermal conditions can be considered to exist if the accumulator is used as a volume compensator, leakage compensator and pressure compensator or as a lubrication compensator. In all other cases such as, energy accumulation, pulsation damping, emergency power source, dynamic pressure compensator, shock absorber, hydraulic spring, etc., expansion and compression process may be considered to take place under 'adiabatic' conditions. Generally, adiabatic condition is considered to exist if the compression or expansion period is less than 3 minutes.

8. Explain the construction and operation of diaphragm type accumulator

In this type, the hydraulic fluid and nitrogen gas are separated by a synthetic rubber diaphragm. The gas is filled through the gas port under predetermining pressure. The advantage of diaphragm accumulator over piston accumulator is that they have no sliding surface that requires lubrication and can therefore be used with fluids with poor lubricating qualities. They are less sensitive to contamination due to the lack of any close fitting components





9. Discuss in detail the application of hydraulic accumulators as energy storage elements. Draw a hydraulic circuit for this application.

1. **Accumulator as an auxiliary power source**

The purpose of accumulator in this application is to store the oil delivered by the pump during a portion of the work cycle. The accumulator then releases the stored oil on demand to complete the cycle, there by serving as a secondary power source.

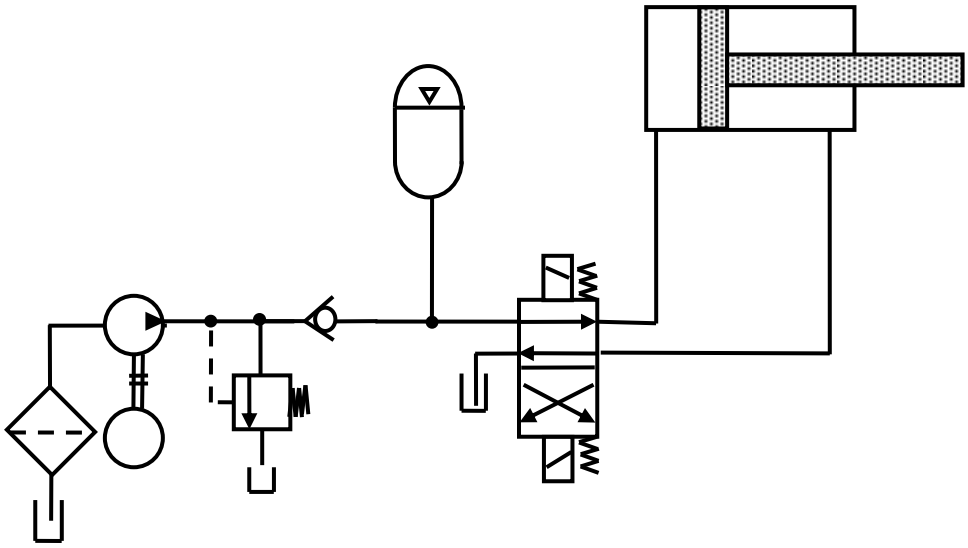
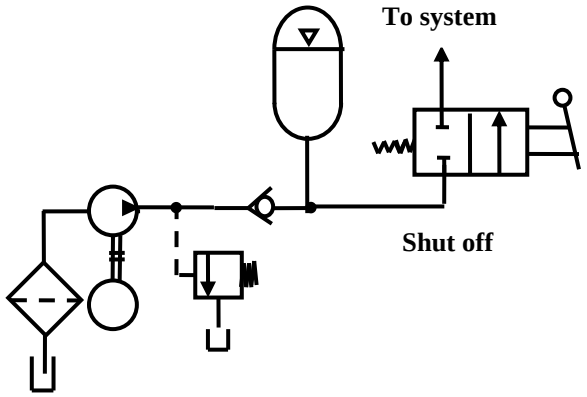


Figure 8 Accumulator as an auxiliary power source

When the four way valve is manually activated oil flows from the accumulator to blank end of cylinder. This extends the piston until it reaches the end of the stroke. When the cylinder is in its fully extended position, the accumulator is being charged. The four way valve is then deactivated for retraction of the cylinder oil flows from both pump and accumulator to retract the cylinder rapidly.

10. Discuss in detail the application of hydraulic accumulator for protection against shocks

Accumulator as a hydraulic shock absorber



Accumulator as a hydraulic shock absorber

One of the important applications of accumulator is the elimination of hydraulic shock. Hydraulic shock is caused by the sudden stoppage or declaration of a hydraulic fluid flowing at relatively high velocity in a pipe line. By rapidly closing a valve creates a compression wave. This compression wave travels at the speed of sound upstream to the end of the pipe and back again to the closed valve, which causes an increase in pressure.

The resulting rapid pressure pulsations or high pressure surges may cause damage to the hydraulic system components. If an accumulation is installed near the rapidly closing valve, the pressure pulsations or high pressure surges are suppressed.

11. Discuss in detail the application of hydraulic accumulator in protecting against thermal expansion.

When closed loop hydraulic systems are subjected to heat conditions, both the pipe lines and the hydraulic fluid expand volumetrically. Since the coefficient of cubical expansion of most fluid is higher than that for pipe materials, this expanded liquid volume increases the entire system pressure. This condition may cause pressures to exceed the limits of safety, and may damage the system components. Under these conditions, an accumulator of proper capacity precharged to the normal system working pressure is installed. It takes up any increase in the system fluid volume, thus reducing the system pressure to its safe limits. The accumulator also feeds the required volume into the system as thermal contraction takes place.

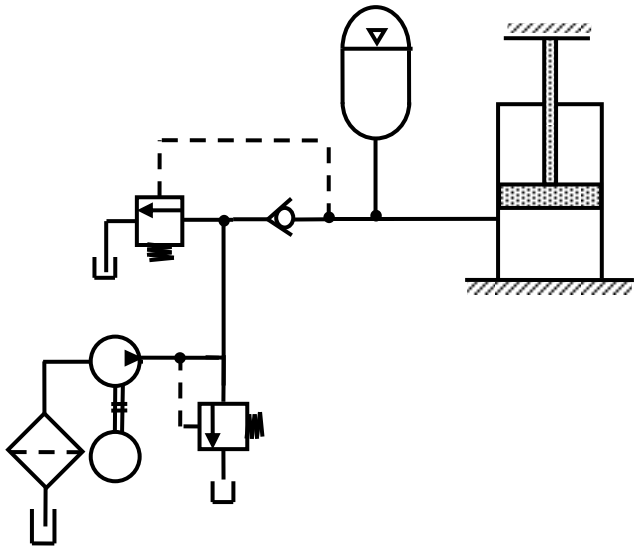


Figure 12 Accumulator as a Thermal Expansion compensator

12. Discuss in detail the application of hydraulic accumulator for internal leakage compensation and the application of constant pressure

Accumulator as a leakage compensator

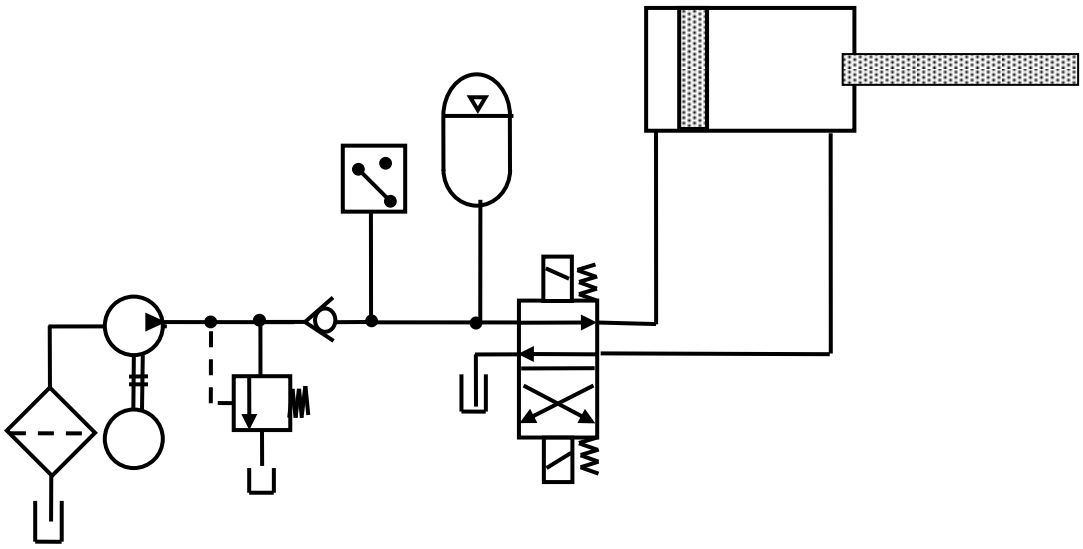


Figure 9 Accumulator as a leakage compensator

Accumulator can be used as a compensator for internal and external leakage during an extended period during which the system is pressurized but not in operation. The pump charges the accumulator and the system until the maximum pressure setting on the pressure switch.

The contacts on the pressure switch then open to automatically stop the electric motor that derives the pump. The accumulator then supplies leakage oil to the system during a long period.

Finally, when system pressure drops to the minimum pressure setting of the pressure switch, it closes the electrical circuit of the motor until the system has been recharged. The check valve is placed between the pump and accumulator so that the pump will not reverse when the motor is stopped and will not permit all the accumulator charge to drain back into the power unit. With this circuit the only time the power unit operates is when the pressure drops to a unsafe operating level. This saves electric power and reduces the heat in the system.

13.What are the precautions you have to take in using Accumulator

- Always arrange some method to drain the accumulator at shut down.
- Never work on a circuit with an accumulator until it is depressurized.
- Make sure accumulator flow is restricted to a reasonable rate during operation and shut down to avoid damage to the machine or piping. Accumulators will discharge fluid at any rate the exit flow path will allow. Such high flow does not last long, but the damage it causes is done quickly.
- Always isolate the pump from the accumulator with a check valve so fluid cannot back flow into the pump. Without a check valve, accumulator back flow can drive the pump backward -- and overspeed it to destruction in some instances.
- Check the accumulator's pre-charge pressure at installation and at least once a day for the first week of operation. If there is no noticeable loss of pressure during this time, do the next check a week later. If all is well then, do a routine check every three to six months thereafter. Whenever the accumulator pre-charge drops below nominal pressure, the volume of available fluid is reduced and finally the cycle slows.

14. List the three method by which we can store enery using accumulator

Energy is stored in an accumulator by: Lifting a weight, compressing a spring, Compressing a gas