Scheme of Evaluation and Solutions

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Internal Assessment Test 2 – Oct. 2019								
Sub:	Fluid Power Systems			Sub Code:	15ME72	Branch:	ME	
Date:	12/10/2019	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7th sem A & B		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1.	Three Classification of Hydraulic control valves. 3 Marks Neat sketch of Check valve and graphical symbol. 4+1 Marks Explanation. 2 Marks	[10]	CO1	L2
2.	Define hydraulic circuits. 2 Marks Explain with suitable circuit how Double acting cylinders are controlled. 6+2 Marks	[10]	CO4	L3
3.	Neat sketch of a Pressure Relief Valve and graphic symbol also. 5+1 Marks Explanation 4 Marks	[10]	CO4	L2
4.	Hydraulic circuit diagram 5 Marks Explain briefly the principle involved in regenerative circuit. 2 Marks Obtain an expression for the speed of actuator.3 Marks	[10]	CO4	L3
5.	A hydraulic motor having a displacement of 500 ml per revolution, operates at a speed of 75 rpm and is required to develop an output torque of 1200 N-m. The volumetric and mechanical efficiencies of motor are 0.9 and 0.94 respectively. Determine i) Pressure rating of the motor = 160 bar ii) Input flow 0.04166 m^3/min iii) Overall efficiency = 0.846	[10]	CO2	L3
6.	An 8cm-dia hydraulic cylinder has a 4cm dia rod. If the cylinder receives flow at 100 LPM and 12 MPa, find the a. Extension speed= 0.3315 m/s Retraction speeds=0.442 m/s b. Extension load carrying capacity=60.318 kN Retraction load carrying capacity=45.24 kN	[10]	CO2	L3
7.a)	Draw the symbolic representation of actuation system: i) Push button ii) Solenoid iii) Lever iv) Pressure line (pilot).4 *1 = 4 Marks	[10]	CO2	L1
b)	Draw the various types of center flow path configuration for three position four way valves.2*3=6 Marks		CO2	L2

Solutions

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Answer any FIVE FULL Questions

1. Classify Hydraulic control valves. Explain with a neat sketch, the working of Check valve and draw its graphical symbol.

The control of hydraulic power in hydraulic power systems is carried out by means of control valves. The control requirements are imposed by the function of the system. The parameters of the mechanical power delivered to the load are managed hydraulically by controlling the direction, pressure, and flow rate.

The selection of these control components not only involves the type, but also the size, the actuating method and remote control capability. There are 3 basic types of valves.

1. Directional control valves (DCV)

1. Pressure control valves (PCV)

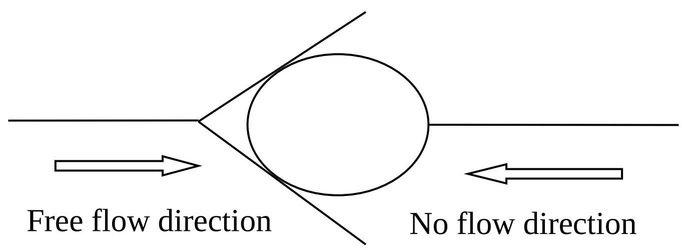
2. Flow control valves. (FCV)

The spool valve consists of a spool which is a cylindrical member that has large- diameter lands machined to slide in a very close- fitting bore of the valve body. The spool valves are sealed along the clearance between the moving spool and the housing. The degree of sealing depends on the size of the gap, the viscosity of the fluid and especially on the level of pressure. Especially at high pressures (up to 350 bar) leakage occurs to such a extent that it must be taken into account when determining the system efficiency.

Check Valve : 2/2 DCV (Poppet design)

a. Valve Closed b. Valve Opened

Fig 3.1 2/2 DCV (Poppet Design)



2. Define hydraulic circuits. Explain with suitable circuit how Double acting cylinders are controlled.

A hydraulic circuit is a group of components such as pumps, actuators, control valves, conductors and fittings arranged to perform useful work. It gives us an idea about how these components are interconnected. There are three important considerations in designing a hydraulic circuit:

1. Safety of machine and personnel in the event of power failures.
2. Performance of given operation with minimum losses.
3. Cost of the component used in the circuit.

Control of a Double-Acting Hydraulic Cylinder

The circuit diagram to control double-acting cylinder is shown in Fig. 4.2. The control of a double-acting hydraulic cylinder is described as follows:

1. When the 4/3 valve is in its neutral position (tandem design), the cylinder is hydraulically locked and the pump is unloaded back to the tank.
2. When the 4/3 valve is actuated into the flow path, the cylinder is extended against its load as oil flows from port P through port A. Oil in the rod end of the cylinder is free to flow back to the tank through the four-way valve from port B through port T.
3. When the 4/3 valve is actuated into the right-envelope configuration, the cylinder retracts as oil flows from port P through port B. Oil in the blank end is returned to the tank via the flow path from port A to port T.

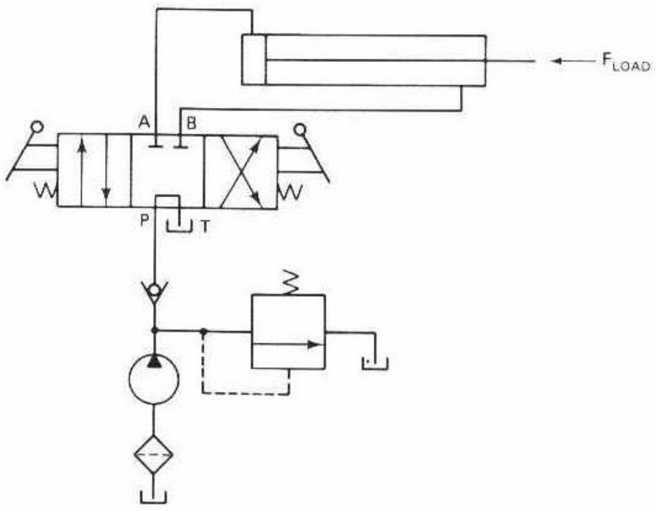


Figure 4.2 Control of a double-acting cylinder.

At the ends of the stroke, there is no system demand for oil. Thus, the pump flow goes through the relief valve at its pressure level setting unless the four-way valve is deactivated.

3. Explain with a neat sketch, the principle of working of a Pressure Relief Valve. Draw graphic symbol also.

Pressure-Relief Valves

The pressure relief valves are used to protect the hydraulic components from excessive pressure. This is one of the most important components of a hydraulic system and is essentially required for safe operation of the system. Its primary function is to limit the system pressure within a specified range. It is similar to a fuse in an electrical system. Pressure relief valve is normally a closed type and it opens when the pressure exceeds a specified maximum value by diverting pump flow back to the tank. The simplest type valve contains a poppet held in a seat against the spring force as shown in Figure 3.13. The fluid enters from the opposite side of the poppet. When the system pressure exceeds the preset value, the poppet lifts and the fluid is escaped through the orifice to the storage tank directly. It reduces the system pressure and as the pressure reduces to the set limit again the valve closes.

Schematic of direct pressure relief valve is shown in figure 3.13. This type of valves has two ports; one of which is connected to the pump and another is connected to the tank. It consists of a spring chamber where poppet is placed with a spring force. Generally, the spring is adjustable to set the maximum pressure limit of the system. The poppet is held in position by combined effect of spring force and dead weight of spool. As the pressure exceeds this combined force, the poppet raises and excess fluid bypassed to the reservoir (tank). The poppet again reseats as the pressure drops below the pre-set value.

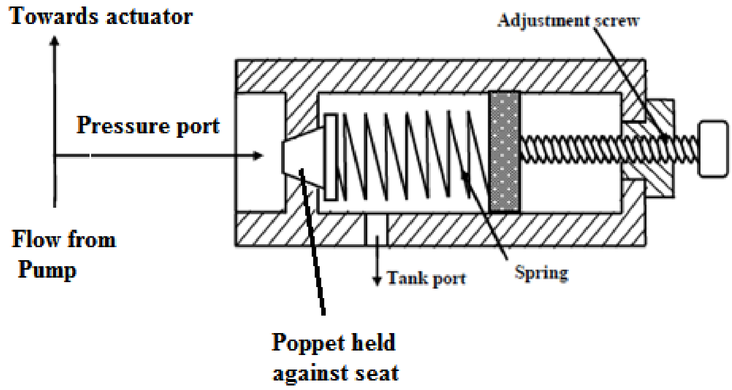


Figure 3.13 Simple pressure relief valve

4. Explain briefly the principle involved in regenerative circuit and obtain an expression for the speed of actuator.

Regenerative Cylinder Circuit

Figure 4.3 shows a regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening. During retraction stroke, the 4/3 valve is configured to the right envelope. During this stroke, the pump flow bypasses the DCV and enters the rod end of the cylinder. Oil from the blank end then drains back to the tank through the DCV.

When the DCV is shifted in to its left-envelope configuration, the cylinder extends as shown in Fig. 1.3.The speed of extension is greater than that for a regular double-acting cylinder because the flow from the rod end regenerates with the pump flow Q_P to provide a total flow rate Q_T.

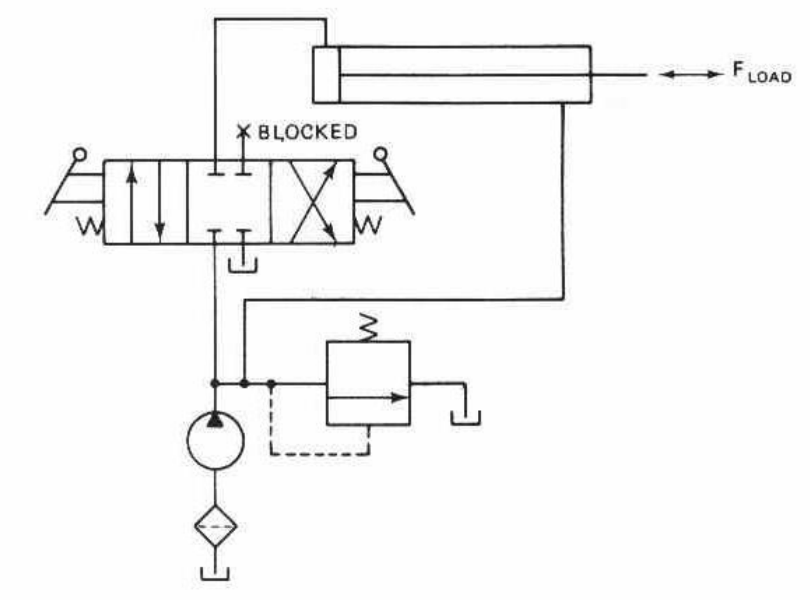


Figure 4.3Regenerative circuit.

Expression for the Cylinder Extending Speed

The total flow rate Q_T entering the blank end of the cylinder is given by

$Q_T = Q_P + Q_r$

Where Q_P is the pump flow rate and is Q_r the regenerative flow or flow from the rod end.

Hence, Pump flow rate,

$= Q_P = Q_T - Q_r$

But the total flow rate acting on the blank rod end is given by

$Q_P = A_P V_{ext}$

Similarly, the flow rate from the rod end is given by

$Qr = (A_P - A_r) V_{ext}$

So pump flow rate is

$Q_P = A_P V_{ext} — (A_P — A_r) V_{ext}$

$Q_P = A_r V_{ext}$

The extending speed of the piston is given as

$V_{ext} = Q_P / A_r$

Thus, a small area provides a large extending speed. The extending speed can be greater than the retracting speed if the rod area is made smaller. The retraction speed is given by

$V_{ret} = Q_P / A_P — A_r$

The ratio of extending and retracting speed is given as

$V_{ext} / V_{ret} = Q_P / A_r / Q_P / A_P — A_r$

$= A_P — A_r / A_r$

$= (A_P / A_r) — 1$

When the piston area equals two times the rod area, the extension and retraction speeds are equal. In general, the greater the ratio of the piston area to rod area, the greater is the ratio of the extending speed to retraction speed.

Load-Carrying Capacity during Extension

The load-carrying capacity of a regenerative cylinder during extension is less than that obtained from a regular double-acting cylinder. The load-carrying capacity *F*load-extension for a regenerative cylinder during extension equals pressure times the piston rod area. This is because system pressure acts on both sides of the piston during extension. Then

$F_{load\text{-}extension} = p\, Ar$

Thus, we do not obtain more power from the regenerative cylinder during extension because the extension speed is increased at the expense of reduced load-carrying capacity.

5. A hydraulic motor having a displacement of 500 ml per revolution, operates at a speed of 75 rpm and is required to develop an output torque of 1200 N-m. The volumetric and mechanical efficiencies of motor are 0.9 and 0.94 respectively. Determine i) Pressure rating of the motor ii) Input flow, iii) overall efficiency.

Given data:

$V_D =$ 500 ml/rev = 0.0005 m^3

N = 75 rpm

T_A = 1200 N-m

η_V=0.9

η_m= 0.94

Theoretical discharge is given by $Q_T = V_D \times N$.

$$Q_T = 0.0375 \text{ m}^3/\text{min}$$

Input flow,

$$Volumetric\ efficiency\ (\eta_V) = \frac{Q_A}{Q_T}$$

$$Q_A = \mathbf{0.04166} \text{ m}^3/\text{min}$$

$$Mechanical\ efficiency\ (\eta_m) = \frac{T_T}{T_A}$$

$$T_T = \mathbf{1276.59\ Nm}$$

Pressure is determined as follows:

$$T_T = \frac{V_D \times p}{2\pi}$$

p = **1276.59 N-m**

$Overall\ efficiency\ (\eta_o) = \eta_v \times \eta_m$

$\boldsymbol{\eta_o}$**= 84.6%**

6. An 8cm-dia hydraulic cylinder has a 4cm dia rod. If the cylinder receives flow at 100 LPM and 12 MPa, find the

a. Extension and retraction speeds. b. Extension and retraction load carrying capacities.

Solution:

Let us first convert the flow in LPM to m^3/s before we calculate forward velocity Q_{in}=100 LPM = 100/(1000 × 60) =1/600 m^3/s

Now

D_C = Diameter of cylinder = 8 cm = 8×10^{-2} m

d_r = Diameter of piston rod = 4 cm = 4×10^{-2} m

p = 12 MPa = 12×10^6 N/m^2 or Pa

(a) Forward velocity is given by

$$v_{ext} = \frac{Q_{in}}{A_p} = \frac{1/600}{\pi d^2/4} = 0.3315 \text{ m/s}$$

Return velocity is given by

$$v_{ret} = \frac{Q_{in}}{(A_p - A_r)} = \frac{\frac{1}{600}}{\frac{\pi(d_C^2 - d_r^2)}{4}} = 0.442 \text{ m/s}$$

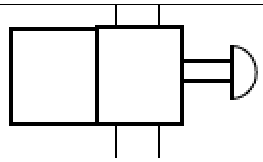
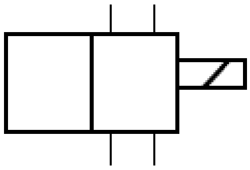
(b) Force during extension is given by

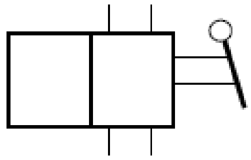
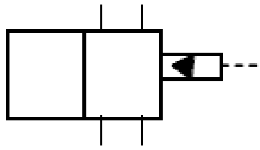
$$F_{ext} = p \times a_p = 12\times10^6 \frac{\pi(8\times10^{-2})^2}{} = 60318.57 \text{ N}$$

Force during retraction is given by

$$F_{ret} = p \times (A_p - A_r)$$
$$= 12 \times \frac{10^6 \times \pi[(8\times10^{-2})^2 - (4\times10^{-2})^2]}{4}$$
$$= 42238.9 \text{ N} = 45.24 \text{ kN}$$

7.a) Draw the symbolic representation of actuation system:

Push button	
Solenoid	

Lever	
Pressure line (pilot).	

b) Draw the various types of center flow path configuration for three position four way valves.

Three- position, four- way DCV have different variety of center configurations. The common varieties are the open center, closed center, tandem center, floating center, & regenerative center with open, closed and tandem are the three basic types A variety of center configurations provides greater flexibility for circuit design.