

Course	Hydraulic and Pneumatic Transmission			Date	/	/	18 questions
Name		School		Class		ID	

I Fill in the blanks. (20 points, 1 point for each blank)

1. Hydraulic transmission systems consist of five main components, among which power input segment (energy portion) and power output segment (actuator) serve as energy conversion devices. Please write out other three hydraulic components: control element, assistant (auxiliary) element, working oil (hydraulic oil).
2. The three basic motion equations to describe the dynamics laws in flowing fluid are equation of continuity (conservation of mass), Bernoulli equation (conservation of energy), equation of momentum (conservation of momentum).
3. The volume of a liquid changes with pressure. At a constant temperature, the relative change in liquid volume per unit increase of pressure is called the liquid's compressibility. Viscosity is the property that is easily affected by temperature.
4. In a swash-plate axial piston pump, the displacement can be varied by changing the swash plate's angle, while in a radial piston pump, the displacement can be varied by changing the eccentricity between the stator and the rotor.
5. The common pressure operated valves include relief valves, pressure-reducing valves, sequence valves and pressure relay.
6. There are three basic types for speed control circuits. They are throttle speed-regulating circuit, volume speed-regulating circuit, volume-throttle speed-regulating circuit. (Hints: Speed regulating can be done by two methods, i.e., changing input flow rate or displacement)
7. The neutral function types of a four-way spool valve are diverse. When in the neutral position, if all ports are closed, hydraulic oil does not flow, the actuator is locked, and the pump is not unloaded; this neutral function is of type O. When all ports are open, the actuator is in a floating state, and the pump is unloaded; this neutral function is of type H.

II Short answer question items. (20 points, 5 points for each)

1. The British physicist Osborne Reynolds, through numerous experiments, discovered that the energy loss of liquid flow in a pipe is related to the flow state of the liquid. Please briefly describe the two flow states of liquid in a pipe and give their definitions. Also explain how to determine the flow state of the liquid.

Solution: two flow states: laminar flow and turbulent flow. (1 point)

If the fluid particles move in layers without transverse pulsations, flowing in an orderly manner without mixing, this motion is called laminar flow. (1 point)

When the flow velocity exceeds a certain value, the fluid not only moves in a crisscrossed and disordered manner along a general direction but also has pulsating transverse velocities. This

Whether the fluid exhibits laminar or turbulent flow depends on velocity, pipe diameter, and viscosity. Reynolds introduced a dimensionless parameter, the Reynolds number (Re), to determine the flow state. (1 point)

By comparing the Reynolds number (Re) with the critical Reynolds number (Re_c), the flow state can be judged: when $Re < Re_c$, the flow is laminar; when $Re > Re_c$, the flow is turbulent. (1 point)

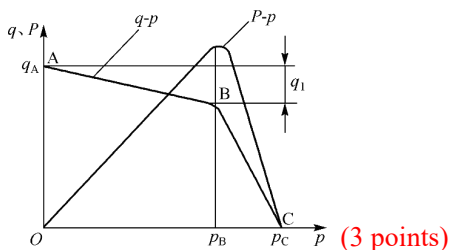
2. Why are thin wall orifices used in throttle valves and speed-control valve?

Solution: According to the throttle characteristic equation, the flow rate through a thin wall orifice is proportional to the square root of the pressure difference across it, (1 point) while the flow rate through a slot is proportional to the first power of the pressure difference. (1 point) Under the same conditions, when the pressure difference changes, the flow variation of a slot is greater than that of a sharp-edged orifice. (1 point)

The flow coefficient of a thin wall orifice is independent of viscosity, (1 point) whereas that of a slot depends on viscosity. Thus, under the same conditions, when the temperature varies significantly, the flow rate through a slot changes largely, while the flow rate through a thin wall orifice remains unaffected by temperature changes. (1 point)

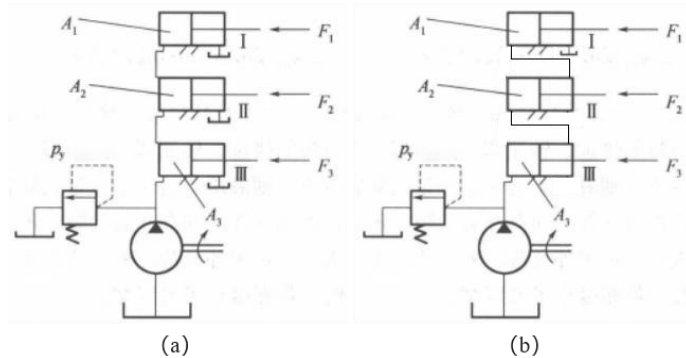
3. Plot the characteristic curve of the pressure-limited variable pump. With reference to the curve, please explain suitable applications.

Solution:



A pressure-limited variable pump is suitable for low-pressure rapid traverse and high-pressure slow feed applications. When the actuator moves rapidly, a large flow at low working pressure is required—this corresponds to segment AB of the characteristic curve. (1 point) When the actuator moves slowly under higher load, the required flow decreases as the pressure rises — this corresponds to segment BC of the curve; therefore, proper adjustment of the knee (set) pressure p_B is essential. (1 point)

2. In the hydraulic system shown, the piston areas of the hydraulic cylinders are $A_1 = A_2 = A_3 = 20 \times 10^{-4} \text{ m}^2$, and the rod areas of the three cylinders are $A_r = 10 \times 10^{-4} \text{ m}^2$. The loads are $F_1 = 4000 \text{ N}$, $F_2 = 6000 \text{ N}$, $F_3 = 8000 \text{ N}$, and the hydraulic pump flow rate is $Q = 50 \text{ L/min}$. When the relief valve functions as a safety valve and is in a closed state, analyze and calculate the movement states and speeds of the hydraulic cylinders in diagrams (a) and (b).



Solution:

Figure (a) Hydraulic cylinders I, II, and III work in sequence (1 points)

$$u_1 = u_2 = u_3 = \frac{Q}{A} = \frac{50 \times 10^{-3} / 60}{20 \times 10^{-4}} = 0.417 \text{ (m / s)} \quad (2 \text{ points})$$

Figure (b) Each hydraulic cylinder moves simultaneously but at different speeds (1 points)

The flow rate into hydraulic cylinder III is equal to the flow rate of the hydraulic pump $Q=50 \text{ L/min}$;

$$u_3 = \frac{Q}{A} = 0.417 \text{ (m / s)} \quad (2 \text{ points})$$

Flow rate into hydraulic cylinder II Q_2

$$Q_2 = Q \frac{A}{A_3} = 50 \times \frac{20 \times 10^{-4}}{10 \times 10^{-4}} = 25 \text{ (L / min)}$$

$$u_2 = \frac{Q_2}{A_2} = \frac{25 \times 10^{-3} / 60}{20 \times 10^{-4}} = 0.208 \text{ (m / s)} \quad (2 \text{ points})$$

Flow rate into hydraulic cylinder I Q_1

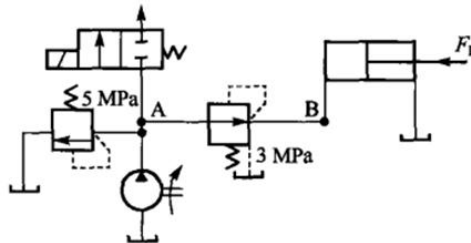
$$Q_1 = Q_2 \frac{A}{A_2} = 12.5 \text{ (L / min)}$$

$$u_1 = \frac{Q_1}{A_1} = \frac{12.5 \times 10^{-3} / 60}{20 \times 10^{-4}} = 0.104 \text{ (m / s)} \quad (2 \text{ points})$$

3. In the circuit shown in the diagram, the area of the cylinder chamber without the rod is 50 cm^2 , and the load F_L is 10,000 N. The set pressures for each valve are indicated in the diagram. Calculate and determine: (5 points)

(1) The pressures at points A and B when the piston is in motion; (3 points)

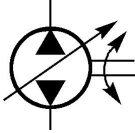
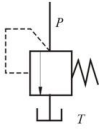
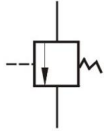
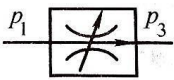
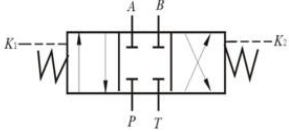
(2) The pressures at points A and B when the piston stops at the end of its stroke. (2 points)



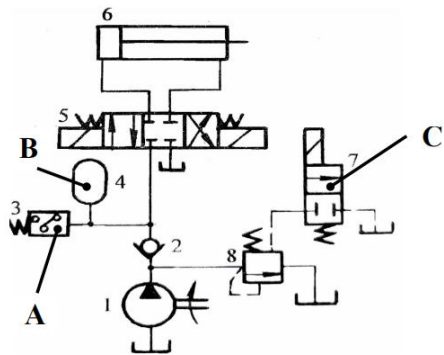
IV Diagramming question. (15 points)

Please write the name of basic hydraulic circuits (4 points) and hydraulic components (11 points)

(1)

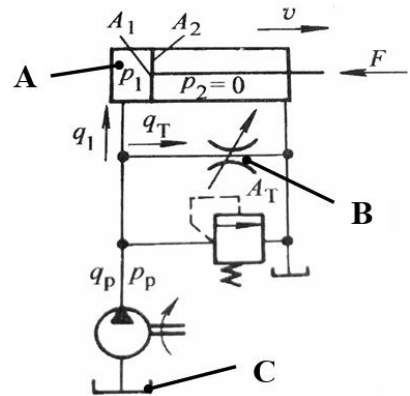
Reversible variable delivery hydraulic pumps	Direct-acting relief valve	External control internal discharged sequence valve
		
Speed-regulating valve	Three-position four-way hydraulic-operated directional control valve	
		

(2)



Hydraulic basic circuit	Fast speed circuit
Component A	Pressure relay
Component B	Accumulator
Component C	Two-position, two-way directional control valve

(3)

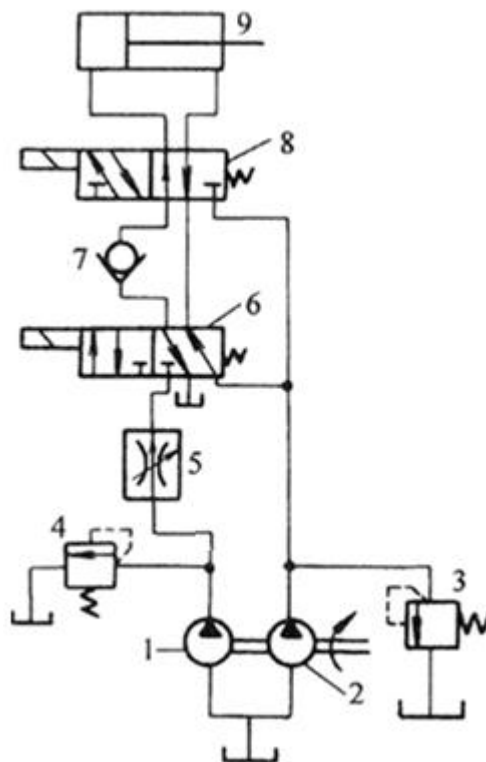


Hydraulic basic circuit	Bypass throttle speed-regulating circuit
Component A	Hydraulic cylinder
Component B	Throttle valve
Component C	Reservoir

V Analysis. (15 Points)

In the hydraulic system shown in the diagram, Pump 1 is a pump with a small flow rate and Pump 2 is a large-flow-rate pump. Actuator 9 finishes autocratically in a cycle motion of “fast extends → slow extends → quick retract” respectively. Analyze the diagram and answer the following questions:

- (1) How does the system achieve the “fast extends” motion, what is the path of oil flow during this motion, and what is the name of the basic circuits used? (5 points)
- (2) How does the system achieve the “slow extends” motion, what is the path of oil flow during this motion, and what is the name of the basic circuit used? (5 points)
- (3) How does the system achieve the “quick retract” motion, and what is the path of oil flow during this motion? (5 points)



Solution

(1) When the left electromagnet of the two-position five-ways solenoid operated valve 8 is activated, the hydraulic cylinder is only supplied by the large-flow-rate pump 2, performing a fast extend via a differential connection.

The oil inlet path is: Hydraulic Pump 2 → two-position five-ways solenoid operated valve 6 (right envelop) → two-position five-ways solenoid operated valve 8 (left envelop) → left chamber of Hydraulic Cylinder 9. (2 points)

The return path is: right chamber of Hydraulic Cylinder 9 → two-position five-ways solenoid operated valve 8 (left envelop) → two-position five-ways solenoid operated valve 6 (right envelop) → left chamber of Hydraulic Cylinder 9. (2 points)

The basic circuit employed is a differential connection and fast-speed movement circuit by double pumps oil supply. (1 points)

(2) When the left electromagnet of the two-position five-ways solenoid operated valve 6 is inactivated, and the left electromagnet of the two-position five-ways solenoid operated valve 8 is activated, the large-flow-rate pump 2 disconnects the left chamber of the cylinder 9. The small-flow-rate pump 1 and the flow control valve 5 are integrated into the circuit, initiating the 'slow extend' motion.

The oil inlet path is: The small-flow-rate pump 1 → flow control valve 5 → the two-position five-ways solenoid operated valve 6 (left envelop) → check valve 7 → two-position five-ways solenoid operated valve 8 (right envelop) → right chamber of cylinder 9. (2 points)

The return path is: right chamber of cylinder 9 → two-position five-ways solenoid operated valve 8 (right envelop) → two-position five-ways solenoid operated valve 6 (left envelop) → reservoir (2 points)

The basic circuit employed is inlet throttle orifice speed-regulating circuit. (1 points)

(3) When the left electromagnet of the two-position five-ways solenoid operated valve 6 and 8 are activated, the hydraulic cylinder is only supplied by the large-flow-rate pump 2, performing a 'quick retract' motion. (1 points)

The oil inlet path is: pump 2 → two-position five-ways solenoid operated valve 8 (left envelop) → right chamber of cylinder (2 points)

The return path is: left chamber of cylinder → two-position five-ways solenoid operated valve 8 (left envelop) → two-position five-ways solenoid operated valve 6 (left envelop) → reservoir (2 points)