Introduction to Hydraulics, Exercise Answers

Chapter 1 Basic Principles

1. How is pressure created in a hydraulic system?

Answer: Resistance to flow creates Pressure, usually expressed in MPa or bar.

2. Name several advantages to using hydraulics.

Answer: High power to weight ratio; overload protection; can be stalled; reversible; small packages.

3. On an area of 1m square, what force is available at 8 MPa?

Answer: 8 meganewton

4. Describe the difference between laminar flow and turbulent flow.

Answer: Laminar flow is where the oil particles move in parallel and there is the least amount of friction between the fluid and the conduit. Turbulent flow is where the fluid particles travel at high velocity; this causes more friction, higher-pressure drop and wasted energy.

5. Explain Bernoulli's principle.

Answer: Bernoulli demonstrated that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure.

6. In what direction does oil flow through an orifice.

Answer: Oil will flow in the direction of the pressure drop across the orifice.

7. True or false: 'pressure determines the speed of an actuator'?

Answer: False.

8. What is the purpose of a relief valve?

Answer: Overload protection, the relief valve limits the system pressure.

9. Explain the purpose of a flow control in a hydraulic system.

Answer: It provides infinitely variable speed.

10. Does a pump provide pressure?

Answer: No a pump provides flow; resistance to flow creates pressure.

11. What determines the speed of an actuator?

Answer: The speed of an actuator is determined by the rate of oil flow.

12. What is the force obtainable on a 100 mm diameter cylinder at 12 MPa.

Answer: 94.24 kN

13. What is the velocity of a 50 mm diameter cylinder with a pump flow of 15 l/min?

Answer: 0.127 m/sec.

14. Assuming an efficiency of 80% what size of electric motor is required for a pump flow of 35 l/min at 18 MPa pressure.

Answer: 13.12 kW (15 kW motor).

Chapter 2 Pressure Controls

1. Name four applications of pressure control valves.

Answer: Pressure relief valve, Counterbalance valve, Pressure Reducing valve, Sequence valve, Unloading valve, Brake valve/Overcentre valve.

2. Describe how pressure override effects a direct acting relief valve.

Answer: When the direct acting relief valve initially opens at its setting, this is called cracking pressure and moves further off its seat as the flow increases. This is known as pressure override, causes the pressure to rise, and is undesirable in most applications.

3. Explain how the pilot operated relief valve reduces override.

Answer: By use of a direct acting relief valve, plus a balanced poppet with a light spring and an orifice. When the simple relief valve opens, the pressure rises to overcome the light spring, diverting the balance of the pump flow at the direct relief valve setting plus the light spring setting. As the flow increases, there is no appreciable pressure override.

4. Explain venting a relief valve.

Answer: the vent port is connected to a chamber above the balanced poppet. Connecting this port to the reservoir opens the balanced poppet to the tank and unloads the pump at minimal pressure, determined by the setting of the light spring.

5. What is the purpose of a pressure-reducing valve?

Answer: to reduce pressure in certain portions of a circuit.

6. Is a pressure reducing valve normally open or normally closed?

Answer: Normally open.

7. What is the purpose of a pressure-reducing valve?

Answer: to reduce pressure in certain portions of a circuit.

8. Explain the function of a sequence valve.

Answer: To cause actions to take place in a definite order.

9. Can a counterbalance valve control a vertical load?

Answer: Yes.

10. Explain the function of the remote pilot on a brake/overcentre valve?

Answer: The remote pilot is connected to the external port of the brake/overcentre valve and holds the valve open while the actuator is being driven. Any tendency for the load to pull or runaway creates a void, closing off the valve and its direct pilot brakes and controls the actuator.

11. Describe the use of an unloading valve operation on a Hi-Lo circuit.

Answer: The unloading valve is applied in a dual pump circuit and enables a fast approach to the work piece under minimal load, then as the load pressure rises, unloads a large volume pump and continues with a small volume pump at high pressure. This circuit minimises the power required.

12. Describe the operation of the unloading relief valve used on accumulator circuits.

Answer: This valve unloads the pump when the accumulator charged. When the accumulator discharges, the accumulator automatically recharges the accumulator.

Chapter 3 Directional Control Valves

1. Describe the purpose of Directional control valves.

Answer: They direct the flow in hydraulic systems.

2. Explain the purpose of a check valve.

Answer: They provide free flow in one direction and check flow in the opposite direction.

3. Describe the connection of a three-position four-way valve.

Answer: It connects the ports P, T, A, B; it has three positions and connects P-A, B-T and P-B and A-T when energised.

4. Describe four methods of energising a directional control valve

Answer: Manually, hydraulically, electrically and pneumatically.

5. True or false, 'a tandem centre valve is all ports open in neutral'?

Answer: False.

6. True or false, 'On a solenoid, pilot operated D.C. Valve. The pilot valve and the main spool always have the same configuration.

Answer: False.

7. True or false, 'in pilot operated check valves, oil can flow in both directions'.

Answer: They provide free flow in one direction and check flow in the opposite direction.

8. How many positions does a spring-offset valve have?

Answer: Two.

9. Describe a three-position four-way float centre directional control valve.

Answer: Energised P-A, B-T and P-B, A-T. In neutral P closed, A and B open to tank.

Chapter 4 Flow Control Valves

1. Describe the applications for Meter in, meter out and bleed off flow controls.

Answer: Meter in when the load always resists movement, Meter out when the load tends to pull or run away, Bleed off when the load resists.

2. Explain pressure compensation in a flow control.

Answer: Pressure compensation in a flow control, is achieved by creating a constant pressure drop across an orifice.

3. When should a pressure compensated flow control be used?

Answer: On varying load applications where a constant speed is required.

4. Can a meter out flow control regulate a negative load?

Answer: Yes.

Chapter 5 Flow Dividers/Combiners

1. What accuracy can be obtained using pressure compensated flow dividers?

Answer: At best +- 5%.

2. Can a pressure compensated flow divider combine flow?

Answer: No, a combiner is a separate unit.

3. What accuracy can be achieved, using pressure compensated flow dividers?

Answer: At best +- 5%.

4. Can a gear type flow divider also combine flow?

Answer: Yes.

5. Name three applications where Flow Divider/Combiners can be used.

Answer: 1. Synchronise and combine the extension and retraction of two cylinders.

2. Balance the speed forward and reverse of two hydraulic motors.

3. Split and combine

Chapter 6 Accumulators

1. Name four different types of construction of accumulators.

Answer: Bladder, cylinder, weighted and spring loaded.

2. As a percentage what is the recommended gas charge pressure for storage applications.

Answer: Bladder, cylinder, weighted and spring loaded.

3. In gas charged accumulators, what gas is the recommended?

Answer: Nitrogen.

4. What is the main difference between gas filled and weighted accumulators.

Answer: Weighted accumulators provide a constant pressure as they are discharged. With gas charged accumulators, pressure decreases as it discharges.

5. Does a weighted accumulator provide a constant pressure?

Answer: Yes.

6. What safety procedures must be implemented, before disconnecting an accumulator from the system?

Answer: Isolate the accumulator from the main system. Discharge the oil in the accumulator until the pressure is zero; discharge the gas charge pressure in accordance with the manufactures instructions if necessary.

Chapter 7 Hydraulic Pumps

1. What is meant by a positive displacement pump?

Answer: For every revolution, there is a positive displacement from the pump. Gear, vane and piston units are positive displacement pumps.

2. Which pump compensates for wear?

Answer: A vane pump. Centrifugal force and pressure behind the vane allows the vane to follow the contour of the cam ring, this compensates for light wear on the vanes.

3. What determines the output from a pump?

Answer: The pumps displacement per revolution (cc/rev) x (rpm).

4. Name the construction of four types of hydraulic pumps?

Answer: Centrifugal, Gear, Vane, and Variable vane.

5. Name three types of construction of piston pumps?

Answer: Axial, Bent Axis and Radial piston.

6. Does a pump create pressure?

Answer: No. A pump creates flow; resistance to flow creates pressure.

7. What would be the volume from a 10 cc/rev pump running at 1500 rpm?

Answer: 15000 cc/min (15 l/min).

8. A pump with a theoretical output of 20 l/min, delivers 15 l/min. What is its volumetric efficiency?

Answer: $15\ l/min \div 20\ l/min = 0.75 \times 100 = 75\%$

9. Describe the functions of a variable volume pressure compensated piston pumps.

Answer: From full flow, the pump, by means of flow control valve can supply variable flow, and minimal flow (maintain internal leakage) at the compensator setting. A curing press would be an example

Chapter 8 Actuator – Hydraulic Motors

1. Describe the purpose of a hydraulic motor.

Answer: Hydraulic motors provide rotation (rpm) and rotational force (torque Nm).

2. What determines the rpm of a hydraulic motor?

Answer: $rpm = l/min \times 1000 \div cc/rev$

3. What determines the torque output of a hydraulic motor?

Answer: $torque\ Nm = cc/rev \div bar \div 20\pi$

4. Name three types of construction of a hydraulic motor?

Answer: Gear, Vane and Piston.

5. When using a closed centre directional control valve with a motor, what circuit protection is required?

Answer: Crossover relief valves connected A-B and B-A.

6. When comparing piston and gear motors, which one would be the most efficient?

Answer: Piston.

7. What determines the force of a hydraulic cylinder?

Answer: $pressure \times area$

8. What is the push force obtained with a 100 mm diameter bore cylinder operating at 15 MPa pressure.

Answer: $force\ N = area(mm^2) \times pressure\ (MPa) = 117.809.70(N)\ 117.8\ kN$

9. What would be the flow required (l/min) to extend a 100 mm bore cylinder at a velocity of 0.06 m/sec.

Answer: $l/min = area(m^2 \times velocity\ m/sec \times 60 \times 10^3 = 28.8\ l/min$

10. What hydraulic valves are used to lock a cylinder hydraulically?

Answer: Depending on the application. A pilot operated check valve or a poppet type counterbalance/over-centre valve.

Chapter 9 Filtration

1. Name four circuit positions for placing a filter in a hydraulic system?

Answer: Suction, pressure line, return line and offline.

2. What is the efficiency of a filter with a beta rating B10=100?

Answer: 99%.

3. Explain the function of a bypass check valve, in a filter?

Answer: In event of the filter clogging, pressure rises to the spring setting of the bypass check valve. Allowing unfiltered oil to bypass the filter.

4. What considerations are required when sizing a return line filter?

Answer: The pump flow, the area ratio of the filter and the bypass setting with a clean element.

5. Name five sources of contamination in a hydraulic system?

Answer: Inbuilt contamination, cavitation, erosion, aeration, abrasion, heat, oxidation, water and cylinder rod seals.

6. What maintenance concept is recommended in hydraulic systems?

Answer: Proactive.

7. If a system has a pump capacity of 50 L/min and a double acting cylinder ratio of 2:1. What would be the minimum return line filter capacity recommended.

Answer: 100 l/min

8. Explain the ISO Code 4406 1999 18/15/12.

Answer: It is the recommended particle count at (18) 4, (15) 6, (12) 14 micron per millilitre of fluid.

Chapter 10 Reservoirs

1. Name four functions of a reservoir?

Answer: Storehouse for the fluid, dissipate heat, maintain atmospheric pressure, provide oil circulation, and dissipate entrained air and a fluid conditioner.

2. What would be the recommended reservoir capacity for a system with a 50 l/min pump?

Answer: 200-250 litres.

4. What does a breather achieve in a reservoir?

Answer: maintains atmospheric temperature.

5. Explain the purpose of the reservoir baffle plate.

Answer: Provides circulation, reduces oil velocity and minimises turbulence and aeration.

6. What is the advantage of using a flooded suction on a reservoir?

Answer: Provides a positive pressure at the pump inlet.

7. Name two ways of checking fluid level in a reservoir?

Answer: Level gauge or a level switch.

8. Why are return lines terminated below the oil level and cut at a 45-degree angle?

Answer: To prevent aeration and reduce oil velocity.

Chapter 11 Hydraulic Circuits

1. In an accumulator charge circuit, when is the pump unloaded.

Answer: When the pre-set charge pressure is reached.

2. In Fig. 11.6 how is curing pressure maintained whilst the pump is unloaded.

Answer: By means of the accumulator.

3. What are the advantages of unloading the pump during the cycle of a machine operation?

Answer: Saves on energy.

4. What is the purpose of the sequence valve in the operation of circuit Fig. 11.8?

Answer: It achieves a minimum pressure on clamp before the drive motor can operate.

5. Explain the purpose of a Prefill Valve in a press operation.

Answer: On the approach to the work-piece, it creates a void, which fills the cylinder from the reservoir by means of atmospheric pressure.

6. When would venting the relief valve be used in a hydraulic system.

Answer: When the system is in neutral and the pump is required to be off-loaded.

7. On circuit Fig. 11.12, what is the function off the sequence valve in the operation of the press?

Answer: It extends the side cylinders and enables prefilling of the main cylinder.

Chapter 12 Spot the mistakes

1. Suggest a position change of the filter, which will improve the filtration capacity of the system (fig.12.1).

Answer: Place a filter with 60 l/min capacity at the inlet to the 60 l/min pump.

2. What circuit changes are required on circuit (Fig.12.2) for the system to operate correctly?

Answer: Use an open centre D.C. Valve and rotate the flow controls 180 degrees (meter out).

3. What circuit changes are required on circuit (Fig.12.3) to improve the efficiency and function of the system?

Answer: Suction filter bypass check is incorrect, rotate 180 degrees. The D.C. valve requires an open centre valve, the check valve on the brake valves are the wrong orientation.

3. List the item numbers of the symbols or settings on circuit (Fig.12.4) that are incorrect.

Answer: Items, 2,7,12,16,17,18,20,21,23,24,26,27,28,29,34,35,37,39,40.

Chapter 13 Designing hydraulic systems.

1. Where does the design of a hydraulic system begin?

Answer: With the job to be done.

2. What consideration should be given to safety in the design of a hydraulic system?

Answer: safety is priority in the design of a hydraulic system.

3. What ISO cleanliness level code should be used when designing a hydraulic system and what determines the recommended cleanliness level?

Answer: ISO Contaminant Code 4406 1999. The components requiring the highest level as recommended by the manufacturer.

4. What would be the benefit of using highly efficient components?

Answer: less leakage, more efficiency, lower running costs, reduces fluid degradation and increases life expectancy of components.

5. When calculating the power required to drive a hydraulic system. What is the overall efficiency normally assumed?

Answer: 80%

Chapter 14 Slip in Cartridge Valves – Logic Elements

1. Describe the benefits of applying slip in cartridge valves (Logic elements).

Answer: Versatility can be used as directional, pressure control, flow control, check valves and have high flow capacities.

2. Name three cartridge valve poppet ratios available?

Answer: 1:2, 1:1.1, 1:1.

3. To what cavity specification do cartridge valves comply?

Answer: DIN 24342

4. To what applications are the cartridge valve ratios of 1:2, 1.1:1, and 1.1 best applied?

Answer: 1:2, directional and check valves, 1:1, 1, directional, check and pressure control. 1:1, pressure control.

5. What determines the opening and closing of a cartridge valve?

Answer: Imbalance of forces.

6. Explain the purpose of cartridge valve cover and names five types of covers that are available.

Answer: It seals the cartridge in the manifold, connects the pilot, drain ports, and is available in directional, relief, flow control, shuttle, P.O. check, basic and vented relief covers.

7. When using a 1:2 ratio cartridge as a check valve. To what cartridge ports should the cartridge pilot line be connected on the circuit and why.

Answer: Port (B) to (Ax) to be leak free.

8. Explain the use of ports X, Y, Z1 and Z2 in a cartridge valve circuit.

Answer: X, Z1 and Z2 are pilot ports and Y, is a drain port.

9. What is the minimum number of cartridges required to obtain a three-position regenerative cylinder circuit?

Answer: Three cartridges.

10. In a four-cartridge directional control application, what would be the benefit of using a two-position four-way pilot valve on each cartridge?

Answer: Energising the different pilot valve combinations provides sixteen positions, five of them being the same.