Chapter 1 Problems

Introduction to Hydraulics

1-1. List five fields of application where fluid power can be used more effectively than other power sources.

1-2. Why is hydraulic power especially useful when performing heavy work?

1-3. Compare the use of fluid power to a mechanical system by listing the advantages and disadvantages of each.

1-4. What is the basic law that is important in applying fluid power, and what is its significance?

1-5. Comment on the difference between using pneumatic fluid power and hydraulic fluid power.

1-6. Define fluid power.

1-7. What hydraulic device creates a force that can push or pull a load?

1-8. What hydraulic device creates a force that can rotate a shaft?

1-9. What two factors are responsible for the high responsiveness of hydraulic devices?

1-10. Why can't air be used for all fluid power applications?

1-11. What is the prime mover?

1-12. Name the six basic components required in a hydraulic circuit.

1-13. Name the six basic components required in a pneumatic circuit.

1-14. Obtain from the Fluid Power Society or Fluid Power Foundation the requirements to become a certified fluid power technician.

1-15. From publications such as *Hydraulics and Pneumatics* (The Magazine of Fluid Power and Control Systems), trace the economic growth of the fluid power industry since World War II.

1-16. From publications such as the *Hydraulics and Pneumatics*, trace the economic growth of pneumatics in the fluid power industry since World War II.

1-17. From publications such as *Hydraulics and Pneumatics*, trace the history of moving-part logic (MPL) applications in the fluid power industry.

1-18. Take a plant tour of a company that manufactures fluid power components such as pumps, cylinders, valves, or motors. Write a report stating how at least one component is manufactured. List the specifications and include potential customer applications.

1-19. Why are some fluid power circuits controlled by electricity?

1-20. List five applications of fluid power in the automotive industry.

1-21. What is the difference between a closed-loop and an open-loop fluid power system?

1-22. What three types of personnel work in the fluid power field in industry?

1-23. What is the significance of the phrase "fluid power preserves the heartbeat of life"? Cite two examples that support the subject phrase.

1-24. Discuss the phrase "the expanding size and scope of fluid power." Cite two facts that show the size and two additional facts that show the growth of the fluid power industry.

1-25. What are moving-part logic devices?

1-26. Name three ways moving-part logic devices can be actuated.

1-27. What are fluidic devices?

1-28. What must be done to ensure that fluidic devices will operate reliably?

1-29. Give one reason why automotive hydraulic brakes might exhibit a spongy feeling when a driver pushes on the brake pedal.

1-30. Relative to the automobile, is cruise control an open-loop or closed-loop system? Explain your answer.

1-31. What is the difference between the terms *fluid power* and *hydraulics and pneumatics*?

1-32. Differentiate between *fluid transport* and *fluid power* systems.

1-33. Name one source of error that is compensated for in a closed-loop system.

1-34. Name five hydraulic applications and five pneumatic applications.

1-35. Name the components on one hydraulic application and give their functions.

1-36. Name the components on one pneumatic application and give their functions.

1-37. Contact the National Fluid Power Association to determine the requirements for becoming a fluid power engineer.

1-38. From publications such as *Hydraulics and Pneumatics*, trace the history of programmable logic control (PLC) applications in the fluid power industry.

1-39. What is a programmable logic controller?

1-40. How does a PLC differ from a general-purpose computer?

1-41. What is the difference between a PLC and an electromechanical relay control?

1-42. Name three advantages that PLCs provide over electromechanical relay control systems.

1-43. Describe the environmental issues dealing with developing biodegradable fluids, reducing oil leakage, and reducing noise levels.

Chapter 2

Hydraulic Fluid properties

2-1. What are the four primary functions of a hydraulic fluid?
2-2. Name 10 properties that a hydraulic fluid should possess.
2-3. Generally speaking, when should a hydraulic fluid be changed?
2-4. What are the differences between a liquid and a gas?
2-5. Name two advantages and two disadvantages that air has when used in a fluid power system.

Chapter 3

Energy and Power in Hydraulic Systems

3-1. Explain the meaning of Bernoulli's equation and how it affects the flow of a liquid in a hydraulic circuit.
3-2. What is the continuity equation, and what are its implications relative to fluid flow?
3-3. State Torricelli's theorem in your own words.
3-4. Explain how a siphon operates.
3-5. State the law of conservation of energy.
3-6. Explain how a venturi is used to produce the Bernoulli effect in an automobile carburetor.
3-7. What is meant by the terms *elevation head*, *pressure head*, and *velocity head*?
3-8. State Newton's three laws of motion.

Chapter 4

The Distribution System

4-1. What is the primary purpose of the fluid distribution system?
4-2. What flow velocity is generally recommended for the discharge side of a pump?
4-3. What is the recommended flow velocity for the inlet side of the pump?
4-4. Why should conductors or fittings not be made of copper?
4-5. What metals cannot be used with water-glycol fluids?
4-6. What effect does hydraulic shock have on system pressure?
4-7. What variables determine the wall thickness and safety factor of a conductor for a particular operating pressure?
4-8. Why should conductors have greater strength than the system working pressure requires?

4-9. Name the major disadvantages of steel pipes.

4-10. Name the four primary types of conductors.

4-11. What is meant by the term *average fluid velocity?*

4-12. Why is malleable iron sometimes used for steel pipe fittings?

4-13. Why is steel tubing more widely used than steel pipe?

4-14. What principal advantage does plastic tubing have over steel tubing?

4-15. Explain the purpose of a quick disconnect fitting.

4-16. What is the disadvantage of threaded fittings?

4-17. What is the difference between a flared fitting and a compression fitting?

4-18. Under what conditions would flexible hoses be used in hydraulic systems?

4-19. Name three factors that should be considered when installing flexible hoses.

4-20. What is the basic construction of a flexible hose?

4-21. Relative to steel pipes, for a given nominal size, does the wall thickness increase or decrease as the schedule number is increased?

4-22. How is a pipe size classified?

4-23. What is meant by the schedule number of standard pipe?

Hydraulic Pumps

6-1. Name the three popular construction types of positive displacement pumps.

6-2. What is a positive displacement pump, and in what ways does it differ from a centrifugal pump?

6-3. How is the pumping action in positive displacement pumps accomplished?

6-4. How is the volumetric efficiency of a positive displacement pump determined?

6-5. How is the mechanical efficiency of a positive displacement pump determined?

6-6. How is the overall efficiency of a positive displacement pump determined?

6-7. Explain how atmospheric pressure pushes hydraulic oil up into the inlet port of a pump.

6-8. What is the difference between a fixed displacement pump and a variable displacement pump?

6-9. Name three designs of external gear pumps.

6-10. Name two designs of internal gear pumps.

6-26. Comment on the relative comparison in performance among gear, vane, and piston pumps.

6-27. What pressure is typically available to push liquid into the inlet port of a pump? Why?

6-28. How is pressure created in a hydraulic system?

6-29. What are the basic characteristics of positive displacement pumps?

6-30. What are two ways of expressing pump size?

6-31. What types of pumps are available in variable displacement designs?

6-32. Explain the principle of a balanced vane design pump.

6-33. How can displacement be varied in an axial piston pump?

6-34. What limits the pressure capability of a gear pump?

6-35. What are two ways of altering displacement volumes in gear pumps?

6-36. Explain how the size of the pumping chamber of a variable displacement vane pump is changed.

6-11. Why is the operation of a screw pump quiet?

6-12. Name the important considerations when selecting a pump for a particular application.

6-13. What is a pressure-compensated vane pump, and how does it work?

6-14. What is pump cavitation, and what is its cause?

6-15. How is pressure developed in a hydraulic system?

6-16. Why should the suction head of a pump not exceed 5 psi?

6-17. Why must positive displacement pumps be protected by relief valves?

6-18. Why are centrifugal pumps so little used in fluid power systems?

6-19. What are the reasons for the popularity of external gear pumps?

6-20. What is meant by a balanced-design hydraulic pump?

6-21. What is a pressure intensifier? List one application.

6-22. Name the two basic types of piston pumps.

6-23. What parameters affect the noise level of a positive displacement pump?

6-24. What is meant by the pressure rating of a positive displacement pump?

6-25. Name four rules that will control or eliminate cavitation of a pump.

Pump flowrates

6-44E. What is the theoretical flow rate from a fixed displacement, axial piston pump with a nine-bore cylinder operating at 2000 rpm? Each bore has a 0.5-in. diameter, and the stroke is 0.75 in.

6-45E. A vane pump is to have a volumetric displacement of 7 $in.^3$. It has a rotor diameter of $2\frac{1}{2}$ in., a cam ring diameter of $3\frac{1}{2}$ in., and a vane width of 2 in. What must be the eccentricity?

6-46E. Find the offset angle for an axial piston pump that delivers 30 gpm at 3000 rpm. The pump has nine $\frac{3}{8}$-in.-diameter pistons arranged on a 5-in. piston circle diameter.

6-47M. What is the theoretical flow rate from a fixed displacement, axial piston pump with a nine-bore cylinder operating at 2000 rpm? Each bore has a 15-mm diameter and the stroke is 20 mm.

6-48M. A vane pump is to have a volumetric displacement of 115 cm^3. It has a rotor diameter of 63.5 mm, a cam ring diameter of 88.9 mm, and a vane width of 50.8 mm. What must be the eccentricity?

6-49M. Find the offset angle for an axial piston pump that delivers 0.0019 m^3/s at 3000 rpm.

Pump Efficiencies

6-52. A positive displacement pump has an overall efficiency of 88% and a volumetric efficiency of 92%. What is the mechanical efficiency?

6-53E. A gear pump has a $3\frac{1}{4}$-in. outside diameter, a $2\frac{1}{4}$-in. inside diameter, and a 1-in. width. If the actual pump flow rate at 1800 rpm and rated pressure is 29 gpm, what is the volumetric efficiency?

6-54M. A gear pump has a 82.6-mm outside diameter, a 57.2-mm inside diameter, and a 25.4-mm width. If the actual pump flow at 1800 rpm and rated pressure is 0.00183 m^3/s, what is the volumetric efficiency?

6-55E. A pump has an overall efficiency of 88% and a volumetric efficiency of 92% while consuming 8 hp. Determine the mechanical efficiency and the frictional horsepower.

6-56M. Determine the overall efficiency of a pump driven by a 10-hp prime mover if the pump delivers fluid at 40 L/min at a pressure of 10 MPa.

6-57. The intensity (in units of W/m^2) of the noise of a pump increases by a factor of 10 due to cavitation. What is the corresponding increase in noise level in decibels?

Pump Power

6-58E. How much hydraulic horsepower would a pump produce when operating at 2000 psi and delivering 10 gpm? What hp electric motor would be selected to drive this pump if its overall efficiency is 85%?

6-59E. A pump has a displacement volume of 6 $in.^3$. It delivers 24 gpm at 1000 rpm and 1000 psi. If the prime mover input torque is 1100 in.·lb,

a. What is the overall efficiency of the pump?

b. What is the theoretical torque required to operate the pump?

6-60M. How much hydraulic power would a pump produce when operating at 140 bars and delivering 0.001 m^3/s of oil? What power-rated electric motor would be selected to drive this pump if its overall efficiency is 85%?

6-61M. A pump has a displacement volume of 98.4 cm^3. It delivers 0.0152 m^3/s of oil at 1000 rpm and 70 bars. If the prime mover input torque is 124.3 N·m,

a. What is the overall efficiency of the pump?

b. What is the theoretical torque required to operate the pump?

System Problems

6-67E. For the fluid power system of Fig. 6-42, the following data are given:

cylinder piston diameter = 8 in.

cylinder rod diameter = 4 in.

extending speed of cylinder = 3 in./s

external load on cylinder = 40,000 lb

pump volumetric efficiency = 92%

pump mechanical efficiency = 90%

pump speed = 1800 rpm

pump inlet pressure = −4.0 psi

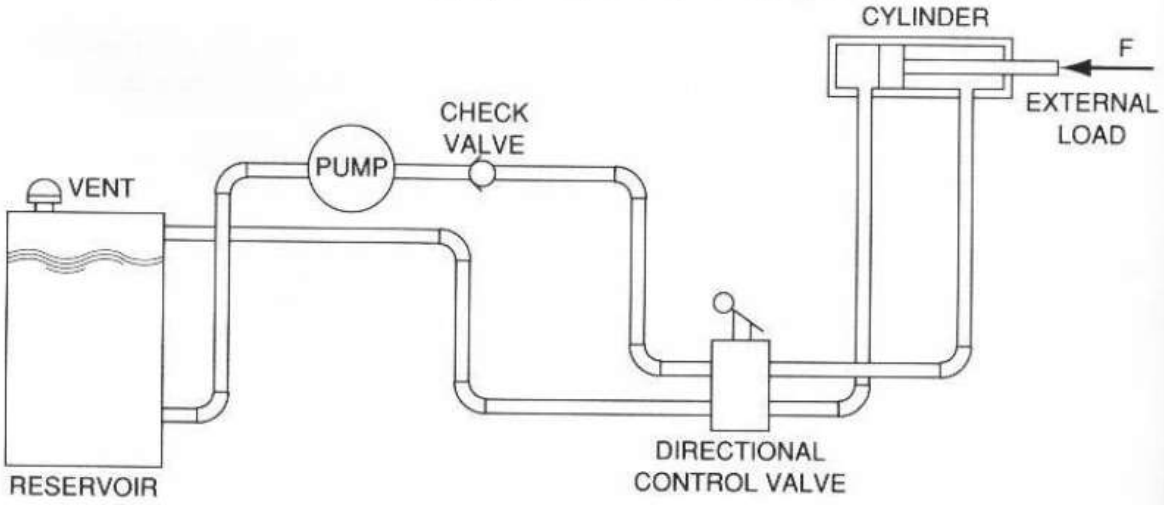

Figure 6-42. System for Exercise 6-67.

The total pressure drop in the line from the pump discharge port to the blank end of the cylinder is 75 psi. The total pressure drop in the return line from the rod end of the cylinder is 50 psi. Determine the

a. Volumetric displacement of the pump

b. Input hp required to drive the pump

c. Input torque required to drive the pump

d. Percentage of pump input power delivered to the load

6-68M. For the system of Exercise 6-67, change the data to metric units and solve parts a, b, c, and d.