Lesson 7: Cylinders

Basic Hydraulic Systems

- Hydraulic Tank
- Hydraulic Fluids
- Hydraulic Pumps and Motors
- Pressure Control Valves
- Directional Control Valves
- Flow Control Valves
- **Cylinders**

Introduction

Cylinders are basically linear actuators. Their outputs are straight line motion or force. The most common types are single acting cylinders and double acting cylinders.

Objectives

Upon completion of this lesson the student will:

1. Identify the two basic types of hydraulic cylinders.
2. State the function of the two basic types of hydraulic cylinders.
3. Identify the basic cylinder components.

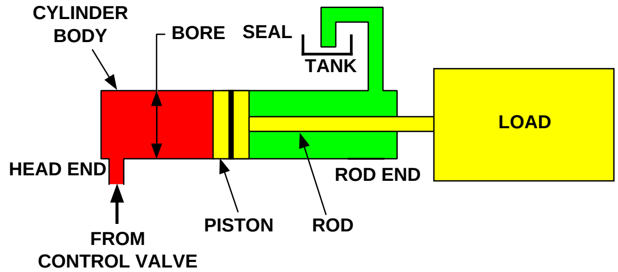

Fig. 3.7.1 Single Acting Cylinder

Single Acting Cylinders

Figure 3.7.1 shows a single acting cylinder.

The tubular outer housing is the cylinder body. Inside the cylinder body are the piston, piston seal and the rod. The bore refers to the inside diameter of the cylinder body. The head end (sometime called the blind end) refers to the piston end of the cylinder. The rod end refers to the end from which the rod extends and retracts.

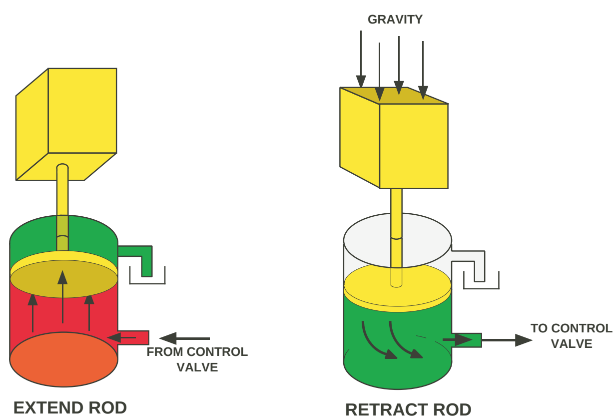

Fig. 3.7.2 Vertical Lift Gravity Return Operation

Vertical Lift Gravity Return Operation

The single acting cylinder is often used on vertical lift gravity return operations as shown in Figure 3.7.2. The control valve directs oil to the head end of the cylinder. The oil pressure acts upon the piston to extend the rod and lift the load. Gravity acting on the load is used to retract the rod and lower the load.

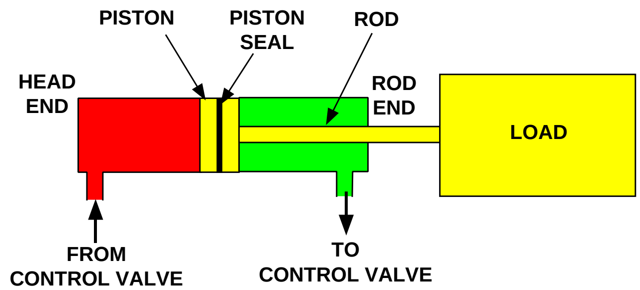

Fig. 3.7.3 Double Acting Cylinders

Double Acting Cylinders

Figure 3.7.3 shows a double acting cylinder. The double acting cylinder is the most common hydraulic actuator used today. The double acting cylinder is used on the implement, the steering and other systems where the cylinder is required to do work in both directions.

Since tie rod cylinders are the most common double acting cylinder, the National Fluid Power Association (NFPA) guidelines are used for the standards in bore size, mounting style and overall dimensions. This allows tie rod cylinders from different manufacturers to be interchangeable when they have the same description. However, it must be remembered that cylinders may be equal in size without being equal in quality.

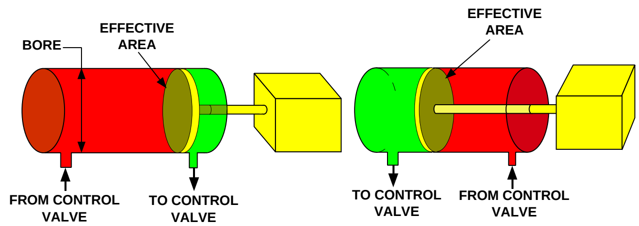

Fig. 3.7.4 Effective Area of a Cylinder

Effective Area of a Cylinder

The bore size of the cylinder refers to the inside diameter of the cylinder. A cylinder with a large bore size creates a larger volume per unit of length than a cylinder with a small bore size. The large bore size cylinder takes more oil to move the piston the same distance than the small bore size cylinder. Therefore for a given flow rate, a large bore size cylinder moves slower than a small bore size cylinder.

The effective area of a cylinder is the surface area of the piston and piston seal upon which the oil pushes. Because one end of the rod attaches to the piston and the opposite end extends out of the cylinder, the rod end effective area is less than the head end effective area. The oil can not push against the area of the piston that is covered by the rod.

The volume of oil needed to fill the rod end of the cylinder is less than the volume of oil needed to fill the head end of the cylinder. Therefore, the cylinder rod retracts faster than the cylinder rod extends for a given flow rate.

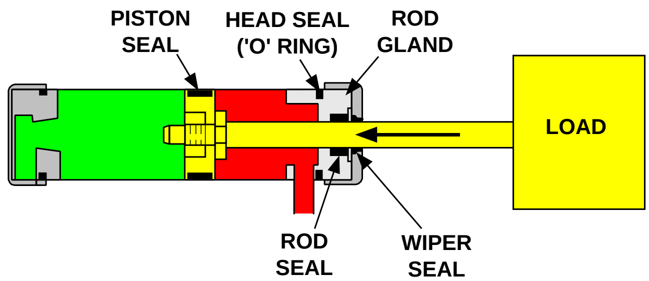

Fig. 3.7.5 Seals

Seals

Seals are used in various places throughout the cylinder as shown in Figure 3.7.5.

The piston seal is used between the piston and the cylinder wall. The design is such that oil pressure spreads the seal against the cylinder wall, thus the greater the pressure the greater the sealing force.

The head seal ('O' ring) prevents oil escaping between the rod gland and the cylinder wall.

The rod seal is a "U" shaped or u-cup shaped seal that prevents oil escaping between the rod and the rod gland and wipes the oil off the rod as the rod is extended from the cylinder.

The wiper seal is fitted to the cylinder and prevents dirt or grit being drawn into the cylinder as the cylinder rod retracts.

Seals are made of polyurethane, nitrile or viton. The material should be verified to be compatible with the fluid used and the operating conditions.

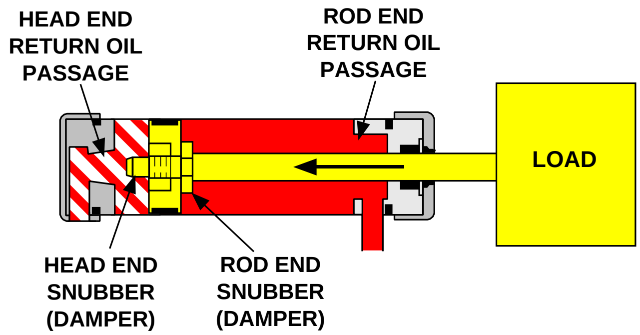

Fig. 3.7.6 Cylinder Equipped with Snubbers

Cylinders Equipped with Snubbers (Dampers)

Figure 3.7.6 shows a cylinder equipped with snubbers (dampers).

When a moving cylinder runs into a dead end (as at the end of the cylinder's stroke), the concussion is called "shock loading." When cylinders are subject to shock loading, snubbers are used to minimize the effect.

When the piston approaches full stroke, the snubber moves into the return oil passage and restricts the return oil flow from the cylinder. The restriction causes an increase in the return oil pressure between the return oil passage and the piston. The increase in oil pressure provides a "cushioning effect" which slows the piston and minimizes the shock that occurs at full stroke.

Some cylinders may require a head end snubber, some may require a rod end snubber, while others may require both head end and rod end snubbers.

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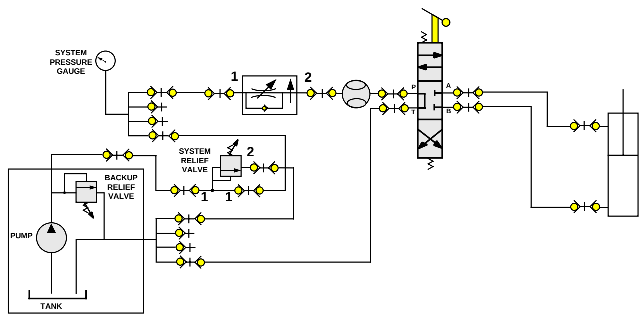

Fig. 3.7.7 Circuit

LAB 3.7.1: COMPARE THE OPERATING SPEEDS OF TWO CYLINDERS

Purpose

To compare operating speeds of two cylinders of known bore sizes.

Material Needed

Basic Hydraulic Training Unit.

Stop Watch

Procedure

1. Construct the circuit shown in Figure 3.7.7 include the 1 1/16" bore cylinder.
2. Adjust the system pressure to 5856 kPa (850 psi).
3. Turn ON the training unit.
4. Adjust the flow control valve so that the flow meter reading is .2 gpm.
5. With the cylinder rod fully retracted, fully extend the cylinder rod. Record the extension time in the chart (Figure 3.7.8).

CYLINDER	EXTEND TIME	RETRACT TIME
1 1/16" BORE		
1 1/2" BORE		

Fig. 3.7.8 Chart

LAB 3.7.1: COMPARE THE OPERATING SPEEDS OF TWO CYLINDERS (continued)

6. With the cylinder rod fully extended, fully retract the cylinder rod. Record the retraction time in the chart (Figure 3.7.8).
7. Time the cylinder extension and retraction times again to confirm your data.
8. Turn OFF the training unit.
9. Disconnect the 1 1/16" bore cylinder and connect the 1 1/2" bore cylinder.
10. Turn ON the training unit.
11. With the cylinder rod fully retracted, fully extend the cylinder rod. Record the extension time in the chart (Figure 3.7.8).
12. With the cylinder rod fully extended, fully retract the cylinder rod. Record the retraction time in the chart (Figure 3.7.8).
13. Time the cylinder extension and retraction times again to confirm your data.
14. Turn OFF the training unit and disconnect the hoses.
15. Which time was fastest for the 1 1/16" bore cylinder?

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16. Which time was fastest for the 1 1/2" bore cylinder?

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17. State the reason for the answer in questions 15 and 16.

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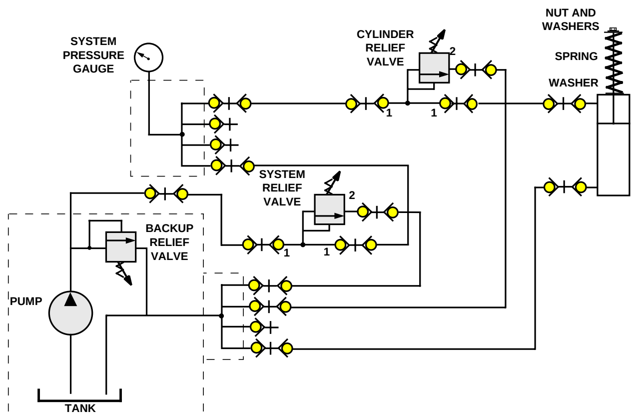

Fig. 3.7.9

LAB 3.7.2: COMPARE THE OPERATING FORCES OF TWO CYLINDERS

Purpose

To compare the operating forces of two cylinders of known bore sizes.

Material Needed

Basic Hydraulic Training Unit

Procedure

1. Build the circuit shown in Figure 3.7.9.
2. Reverse the hoses to the cylinder (rod end hose to the head end and the head end hose to the rod end).
3. Turn the cylinder relief valve fully counter-clockwise.
4. Adjust the system pressure to 5856 kPa (850 psi).
5. Turn ON the training unit.
6. Using the cylinder relief valve, increase the system pressure enough to fully extend the rod on the 1 1/16" bore cylinder and install the load spring.
7. Measure the length of the load spring and record the measurement on the chart in Figure 3.7.10.
8 Turn OFF the training unit.
9. Connect the cylinder hoses as shown in Figure 3.7.9.
10. Turn ON the machine.
11. Turn the cylinder relief valve screw clockwise until the system pressure gauge reads 2756 kPa (400 psi).

LAB 3.7.2: OPERATING FORCES OF TWO CYLINDERS (continued)

12. Measure the length of the load spring and record the measurement on the chart in Figure 3.7.10.
13. Turn OFF the training unit. Reverse the hoses as in No. 2.
14. Turn ON the training unit and extend the cylinder.
15. Turn OFF the training unit
16. Remove the load spring from the 1 1/16" bore cylinder and install the load spring on the 1 1/2" bore cylinder (Extend the cylinder if needed).
17. Measure the length of the load spring and record the measurement on the chart in Figure 3.7.10.
18. Turn ON the training unit.
19. Measure the length of the load spring and record the measurement on the chart in Figure 3.7.10.
20. Turn OFF the training unit.
21. Calculate the approximate retraction force of the two cylinders on the training unit. Disregard rod areas for these calculation.

BORE SIZE	STARTING SPRING LENGTH	ENDING SPRING LENGTH	RETRACTION
1 1/16"			
1 1/2"			

Fig. 3.7.10

Calculate the areas and the forces.

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