ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

Basic Hydraulics and Pneumatics

Module 2: Actuators and directional control valves

PREPARED BY

Academic Services

August 2011

Module 2: Actuators and Directional control valves

Module Objectives

After the completion of this module, the student will be able to:

- Identify the types of Hydraulic Actuators.
- Identify the symbols of Actuators.
- Identify the functions of Actuators.
- Identify the types of directional control vlaves.
- Identify the function of directional control vlaves.
- Draw a basic hydraulic circuit diagram.
- Simulate the circuit diagram using FluidSim software.
- Assemble the circuit practically and check its operation.

Module Contents

1 Types of hydraulic actuators

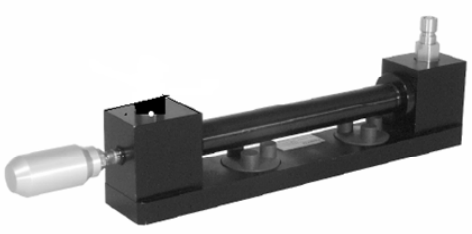
1.1 Single acting cylinders

The single acting cylinder, shown in Fig. 2.1.a, is used to convert hydraulic energy into mechanical energy (to give a linear force in one direction).

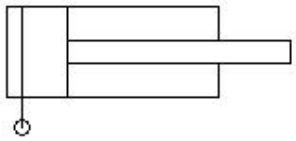
Forward stroke is achieved by hydraulic pressure.

Return stroke is achieved by the effect of the gravity or the load.

The ISO symbol is shown in Fig.2.1.b.



(a)



(b)

Fig.2.1 :(a) Hydraulic single acting cylinder. (b) ISO symbol of hydraulic single acting cylinder.

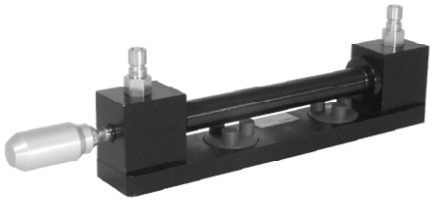
1.2 Double acting cylinders

The double acting cylinder, shown in Fig. 2.2.a, is used to convert hydraulic energy into mechanical energy in two directions.

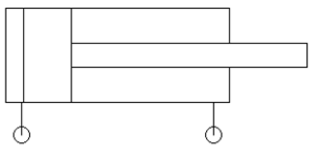
It produces a linear force in two directions.

Forward and backward strokes are achieved by the hydraulic pressure

The ISO symbol is shown in Fig.2.2.b



(a)



(b)

Fig.2.2: (a) Hydraulic double acting cylinder. (b) ISO symbol of hydraulic double acting cylinder

2 Hydraulic cylinder forces

Hydraulic cylinders transfer fluid pressure into mechanical motion. The force of this motion depends on if the cylinder rod is extending or retracting. A cylinder's extension force is greater than its retraction force because pressurized hydraulic fluid pushes on the entire surface of the piston to extend it. The piston rod takes up space during the cylinder's retraction cycle, so hydraulic fluid is not pushing on as large surface area

The generated force in the hydraulic cylinder is calculated by the following formula:

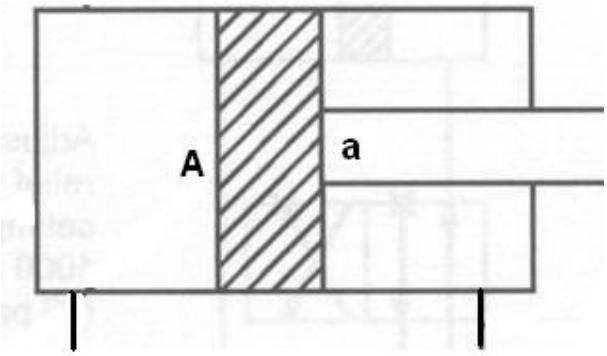
$$F = PxA$$

Where:

F: Force measured in Newton (N)

P: the hydraulic pressure measured in bar (Pa)

A: area of the piston measured in square meters m2



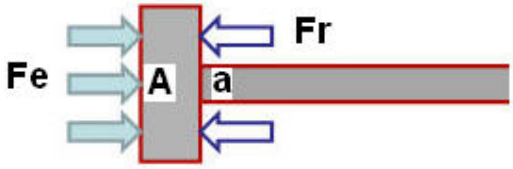


Fig.2.3:Cylinder forces

Extension force (Fe):

During the forward stroke the effective piston area is **(A)** and the produced force is **(Fe)** as shown in Fig.2.3.

$$Fe = P \times A$$

Retraction force (Fr)

During the backward (retraction) stroke the effective piston area is **(A- a)** (**a** is the piston rod area as shown in Fig. 2.3, the produced force is **(Fr)**

$$Fr = P\,(A - a)$$

From the above equations, it is obvious that the extension force (Fe) is greater than the retraction force (Fr).

This is an important factor that should be taken in consideration while designing the size of the piston rod.

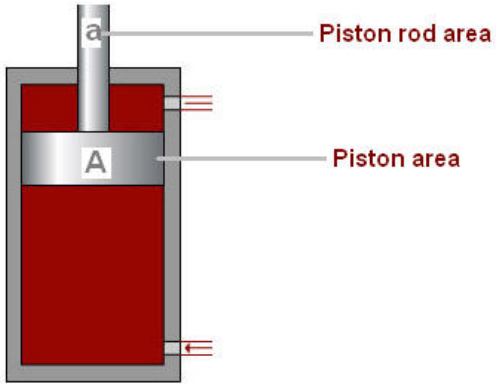
Example:

Calculate the forces (Fe) and (Fr) in the Figure below if you are given the followings:

A= 0.15 m2

a= 0.08 m2

P= 20 bar



$$Fe = P \times A$$

$$P = 20 \times 100000 \ \ Pa$$

$$Fe = 2000000 \ \ \times 0.15$$

$$Fe = 300000 \ \ N = 300 \ KN$$

$$Fr = P(A - a)$$

$$P = 20 \times 100000 \ Pa$$

$$Fr = 2000000 \ (0.15 - 0.08)$$

$$Fr = 2000000 \ \times 0.07$$

$$Fr = 140000 \ N = 140 \ KN$$

The above calculations show that the extension force is greater than the retraction force, which is due to the fact that the effective area in the forward stroke is greater that the effective area in the backward stroke.

3 Directional control valves

3.1 Definitions

They perform three functions:

a- Open

b- Close

c- Change the flow paths to control the direction of motion of actuators.

They are classified according to the number of ports and positions such as follows:

3.2 4/2 way valve

The valve is shown in Fig. 2.4.a
4/2 stands for:
(4) ports
(2) positions)

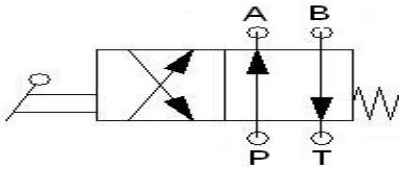
(A) and (B) are working ports. (P) is pressure port.
(T) is the tank connection.

It is actuated manually (lever) and returned by a spring.

Normal position: flow from **P to A** and from **B to T**.
Actuated position: flow from **P to B** and from **A to T.**

The ISO symbol of this valve is shown in Fig.2.4.b

(a)



(b)

Fig.2.4:(a) 4/2 way hydraulic valve
(b) ISO symbol of 4/2 way valve

3.3 4/3 way valve

4/3 valve is shown in Fig. 2.5.a,

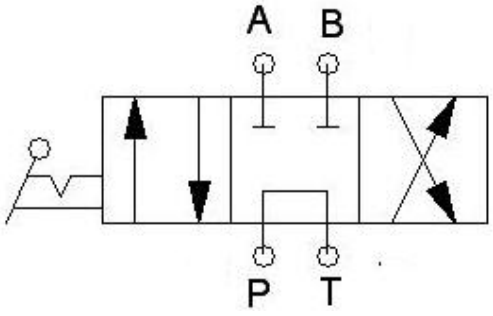
4/3 stands for:
(4) ports
(3) positions

It is manually actuated

Normal Position:
Ports (A) and (B) are blocked
Port (P) is connected to tank (T)

The ISO symbol of the 4/3 way valve
with mid position-pump-by–pass
is shown in Fig.2.5.b.

(a)



(b)

Fig.2.5: a) 4/3 way hydraulic valve
(b) ISO symbol of 4/3 way valve

4.1 Practical Task 1:

Controlling a double-acting cylinder using a 4/3 way valve.

Required components:

SR	Name	Qty
1	Double acting cylinder	1
2	4/3 way valve	1
3	Power pack	1
4	Shut-off valve	1
5	Pressure gauge	1
6	Pressure relief valve	1

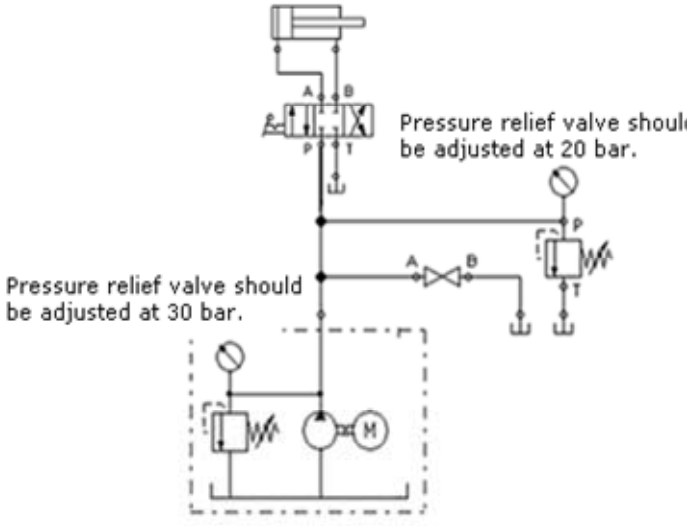


Fig.2.6: Shows a schematic diagram of the hydraulic circuit used to control a double acting cylinder with a 4/3 way valve.

Procedures
1-Prepare the components according to components list.

2- Install all components according to the hydraulic circuit shown in Fig. 2.6. (All components must be securely fitted).

3- Connect the hydraulic hoses according to the hydraulic circuit. (Check that all return lines are plugged and all hose lines are finally plugged in).

4- Check all parts are connected Properly with each other.

5- The operating pressure should not exceed 20 bars.

6- Switch on the electrical power supply first and then the hydraulic power pack.

7- Start the circuit by activating the three positions of directional valve and note what happens within the circuit.

8- Switch off the hydraulic power pack first and then the electrical power supply.

9- Make sure that the circuit pressure is zero (i.e. free of pressure).

10- Dismantle the circuit and tidy up.

The student should use the Fluid-sim software to simulate the above circuits.

Practical Task 2

4.2 Controlling a Furnace door

A furnace door is to be opened and closed by a double-acting cylinder. The cylinder is activated by a hydraulic valve with spring return. This ensures that the door opens only as long as the valve is actuated. When the valve actuating lever is released, the door closes again. See the position sketch shown in Fig.2.7.

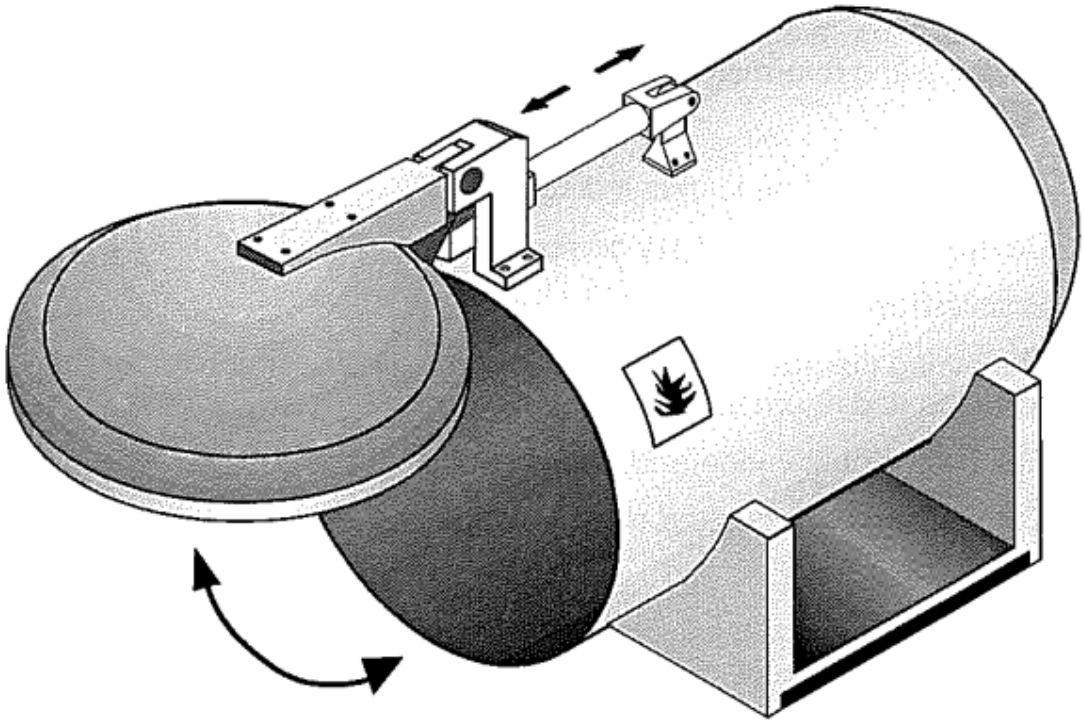
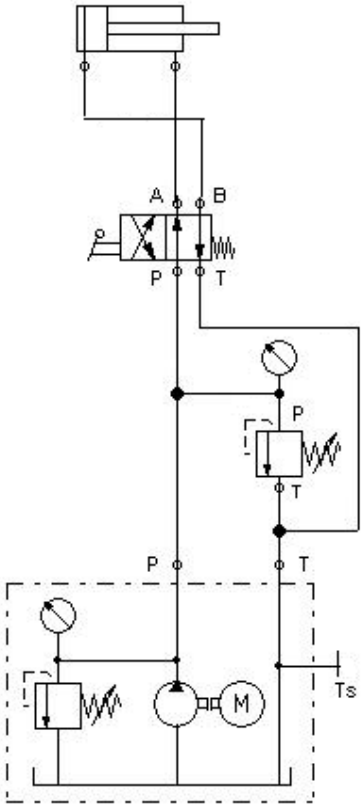


Fig.2.7: Positional sketch

4.2 Procedures of solution

1- Students should be divided in groups of 3- 4 students each.
2- Students should be asked to brainstorm the possible solutions.
3- Once they agreed on a specific solution, they should consult the teacher and discuss the given feedback.
4- Students should draw the hydraulic circuit.
5- Students should simulate the circuit using FluidSim software.
6- Students finally should assemble the circuit practically and check its functionality.



Note: the teacher should explain the purpose of setting the pressure of PRV in power pack unit to 30 bar and the circuit PRV to 20 bar.

5 Solution description

Once the circuit has been assembled and checked. The hydraulic power pack should be switched on and the system pressure set on the pressure relief valve to 20 bar. Pressure gauges should be used to measure the pressure.

When the hand lever of the 4/2 way valve is actuated, the piston rod of the cylinder will advance until the lever is released. The piston rod will immediately return to its retracted end position. Before the pressures and times are measured, the piston rod should be advanced and retracted several times to expel any air which may have entered the piston-rod chamber during the previous exercises.

6 General instruction

1- Prepare the components according to the circuit diagram.

2- Mount all components (All components must be securely fitted).

3- Connect hydraulic hoses according to the hydraulic circuit. (Check that all return lines are connected and all hose lines are securely fitted).

4- Check all parts are connected properly with each other.

5- The operating pressure should not exceed 20 bars.

6- Switch on the electrical power supply first and then the hydraulic power pack.

7- Start the circuit.

8- Check the operation.

9- Make the possible troubleshooting.

10- Write down your observation.

11- Switch off the hydraulic power pack first and then the electrical power supply.

12- Be sure that the circuit pressure is zero (free of pressure).

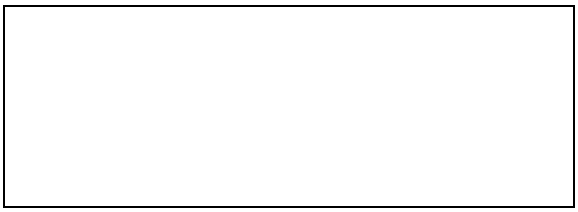
13- Dismantle the circuit and tidy up.

References

1. Festo Didactic hydraulic basic level textbook TP 501.
2. Oil and hydraulic systems, S.R. Majumdar, 2003
3. Different websites.

Work sheet 1

1- Draw the I.S.O. symbol of a single acting cylinder.

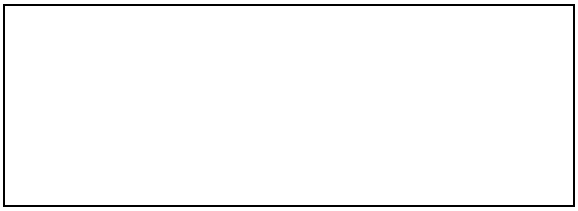


1- What is the function of a single acting cylinder?

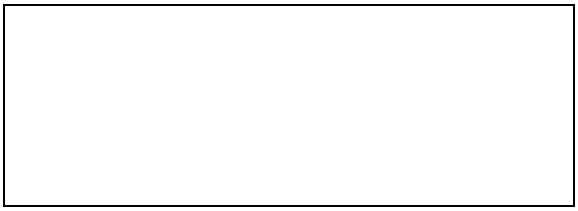
.....

.....

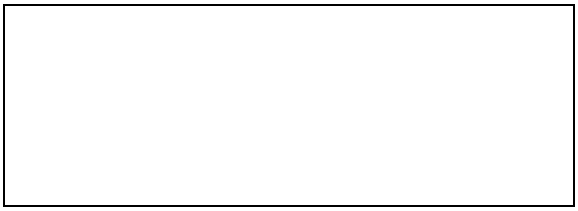
3- Draw the I.S.O. symbol of a 4/3 way valve, manually operated.



4- Draw the I.S.O. symbol of a 4/2 way valve, lever actuated, spring return.



5- Draw the I.S.O. symbol of a double acting cylinder.



Student notes