Hydraulics & Pneumatics

Chapter 1: Hydraulics (Circuit Design)

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Lesson Outcome

- By the end of this lecture, student should be able to design and analyze basic hydraulic circuit both for single-acting and double-acting cylinder

Content

- Parameters in Hydraulic Design
- Control of Single Acting Cylinder
- Control of Double Acting Cylinder

Introduction

- Hydraulic circuit consist of a set of hydraulic components that performed a designed task.
- During the hydraulic circuit design, three factors must be considered:

1. Safety of the designed operation
2. Conduct the required function
3. Efficiency of the operation

Hydraulic circuit elements

- Each design must have following section
  1. Power supply section – pump, elec motor, engine, etc
  2. Power control section – valve, magnetic valve, plc, controller, etc
  3. Drive section – cylinders, motors

What do engineer need to know?

- Usually, the user specifies the final result of design
  - Eg: Customer need a hydraulic power pack to lift 3 tons load
- Engineer needs to get several answers before offer for hydraulic power pack:
  - For what application
  - How many cylinders
  - Nature of the work (lift/clamp/push etc)

Work out for the following info

- Bore size of cylinder
- Rod size of cylinder
- Stroke length
- Speed of movement required
- Expected load to take

Let customer's requirement

- Q: For what application
  - A: Special purpose of drilling
- Q: How many cylinders
  - A: two double acting cylinders (1 for clamping & 1 for drilling)
- Q: Nature of the work (lift/clamp/push etc)
  - A: Clamping cylinder acting first, followed by drilling

And the details from customer

- Bore size of cylinder (clamping = 80mm, drilling = 63mm)
- Rod size of cylinder (standard)
- Stroke length (clamping= 20mm, drilling = 120mm)
- Speed of movement (clamping = 1.5 m/min, drilling = 200mm/min)
- Expected load to take (clamping = 600kg, drilling = 500 kg)

Step 1: Pump capacity

- Calculate pump capacity for hydraulic power unit (Q=n.V)
- Capacity (cm^3/min) = Area of cylinder (cm^2) X Speed of movement (cm/min)

$$Aclamping = \frac{\pi}{4} d_1 (cm^2);\ d_1 = 8\,cm$$

$$= 50.24\,cm^2$$

$$Pump\ \ required = 50.24\,cm^2\ x150\ cm/\min$$

$$= 7536\ cm^3 \approx 7.5\,lit/\min \qquad (1000\ cc = 1 litre)$$

- For drilling, by using similar approach - pump req = 0.623 lit/ min; select 7.5 lit/min

Step 2: Working pressure

$$\text{Pressure} = \text{Force} \times \text{Area}$$

$$\text{Clamping pressure} = \frac{\text{clamping force (kg)}}{\text{clamping area (cm}^2\text{)}}$$

$$= \frac{600}{50.24} = 11.94\ kg/cm^2$$

$$\text{Drilling pressure} = \frac{500\ kg}{31.15} = 16.05\ kg/cm^2$$

Max. working pressure = 16.05 kg/cm2

Step 3: Horsepower

$$Power\ \ (kW) = \frac{PQ}{600};$$

$$P = working\ \ \ pressure\ \ (kg\ /\ cm^2)$$

$$Q = \ flowrate\ \ (lit\ /\ \min)$$

$$Power\ \ in\ \ \ kW = \frac{16.05(kg\ /\ cm2) \times 7.5(l\ /\ \min)}{600} = 0.2\,kW$$

$$= 0.26\,hp\,; \quad \frac{kW}{0.764} = hp$$

- Therefore we can choose the next standard size of electric motor; i.e. 0.5 hp, run at 1440 rpm

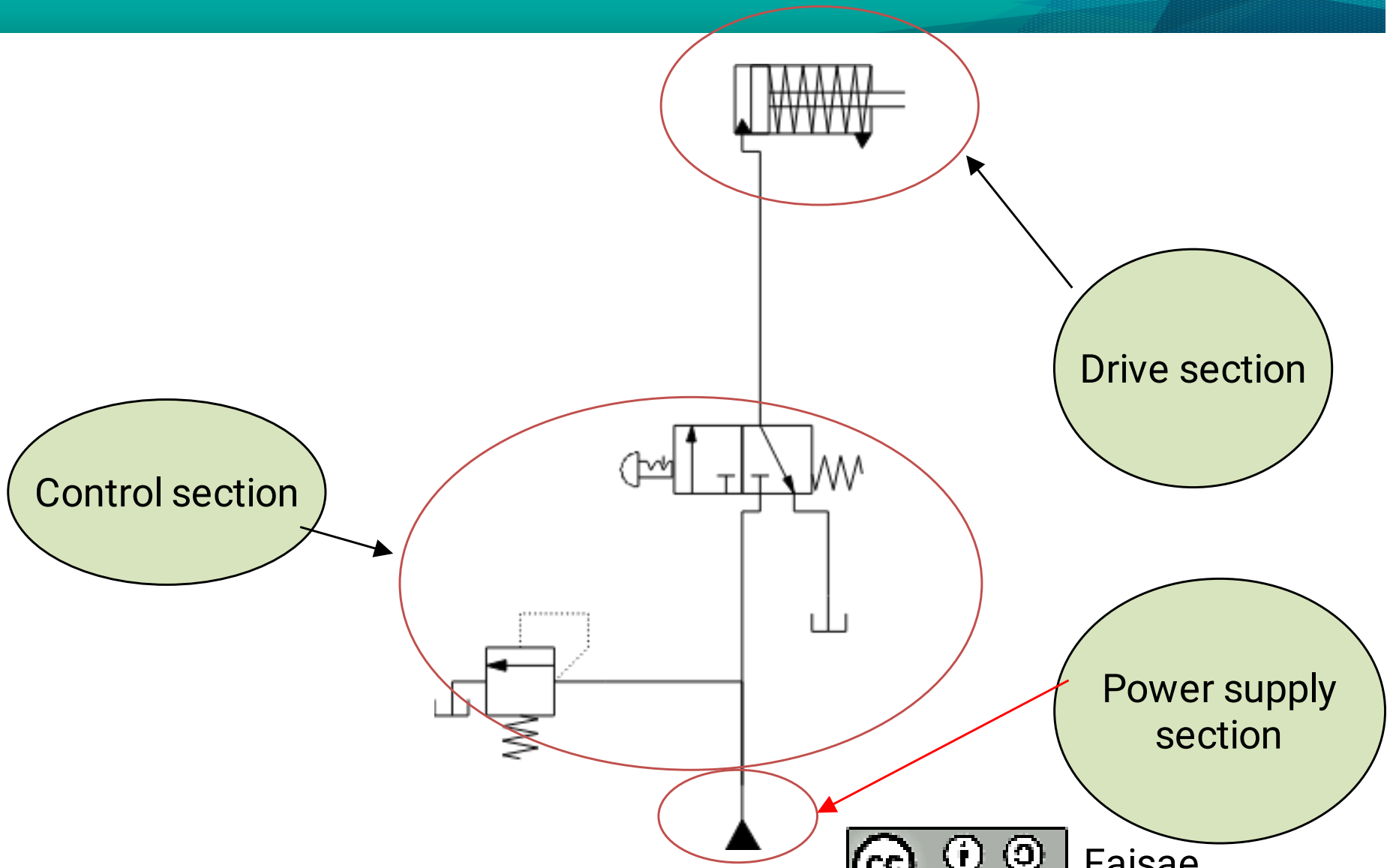
Step 4: Reservoir size

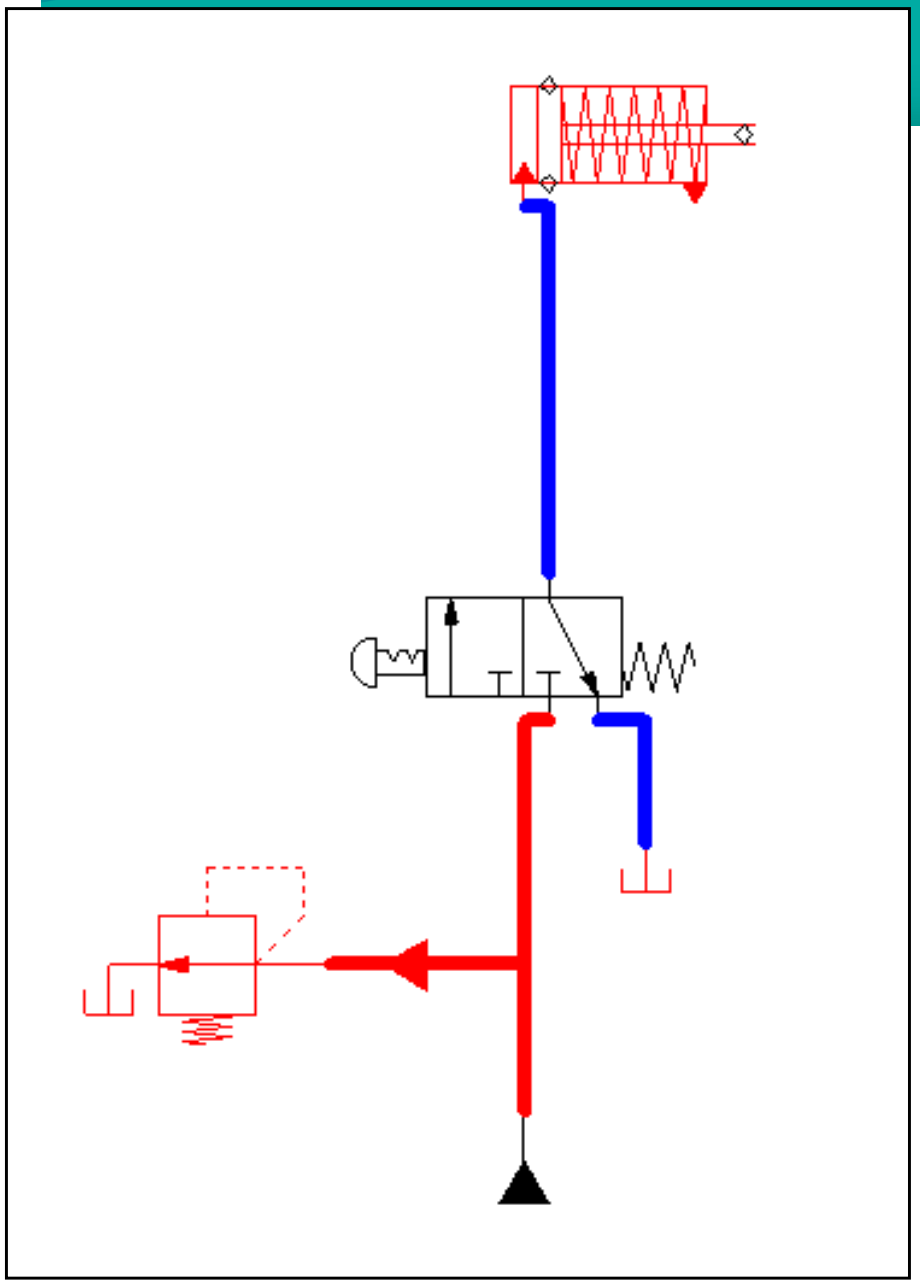
- Thumb rule: Reservoir should be 4 times of flow rate of the pump
- Here, pump flow rate = 7.5 l/min, therefore, the reservoir should be at least 30 litres
- Manufacturer standard size = 50, 75, 100, 125 litres, etc. So, 50 litres reservoir can be chosen

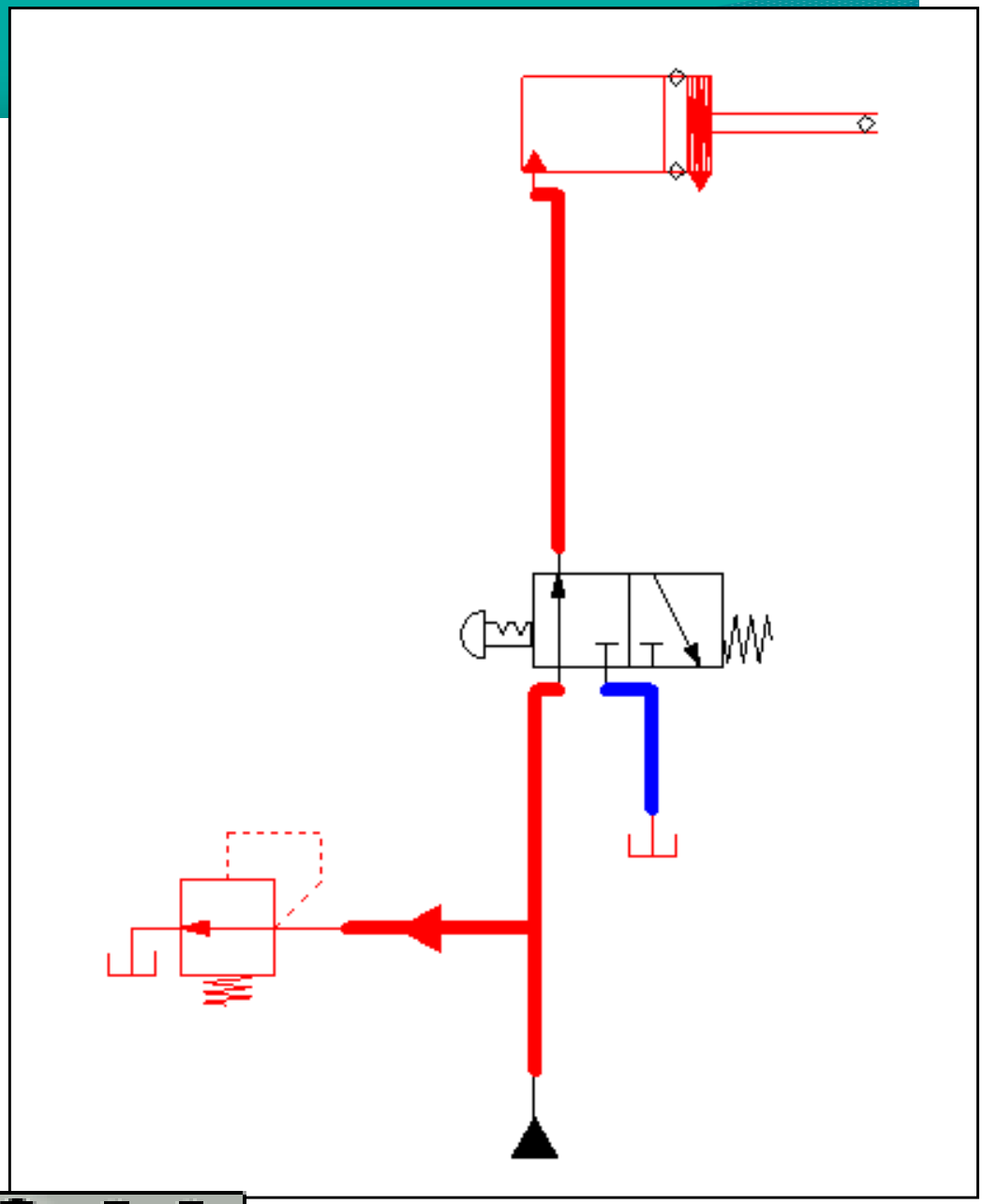
Summary of basic parameters

- Reservoir capacity = 50 liters
- Pump capacity = 8 lit/min (in lieu of 7.5 lit/min)
- Motor = 0.5 hp, 1440 rpm
- Working pressure = 20 kg/cm2

Control of Single-Acting Hydraulic Cylinder







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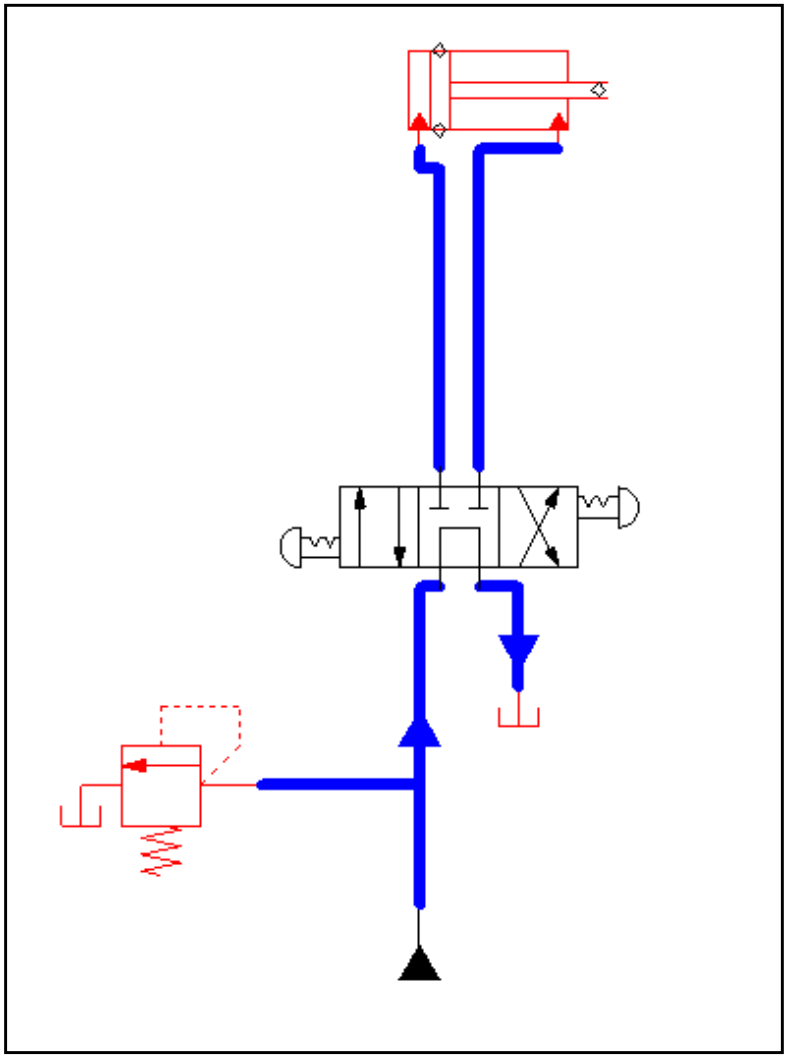
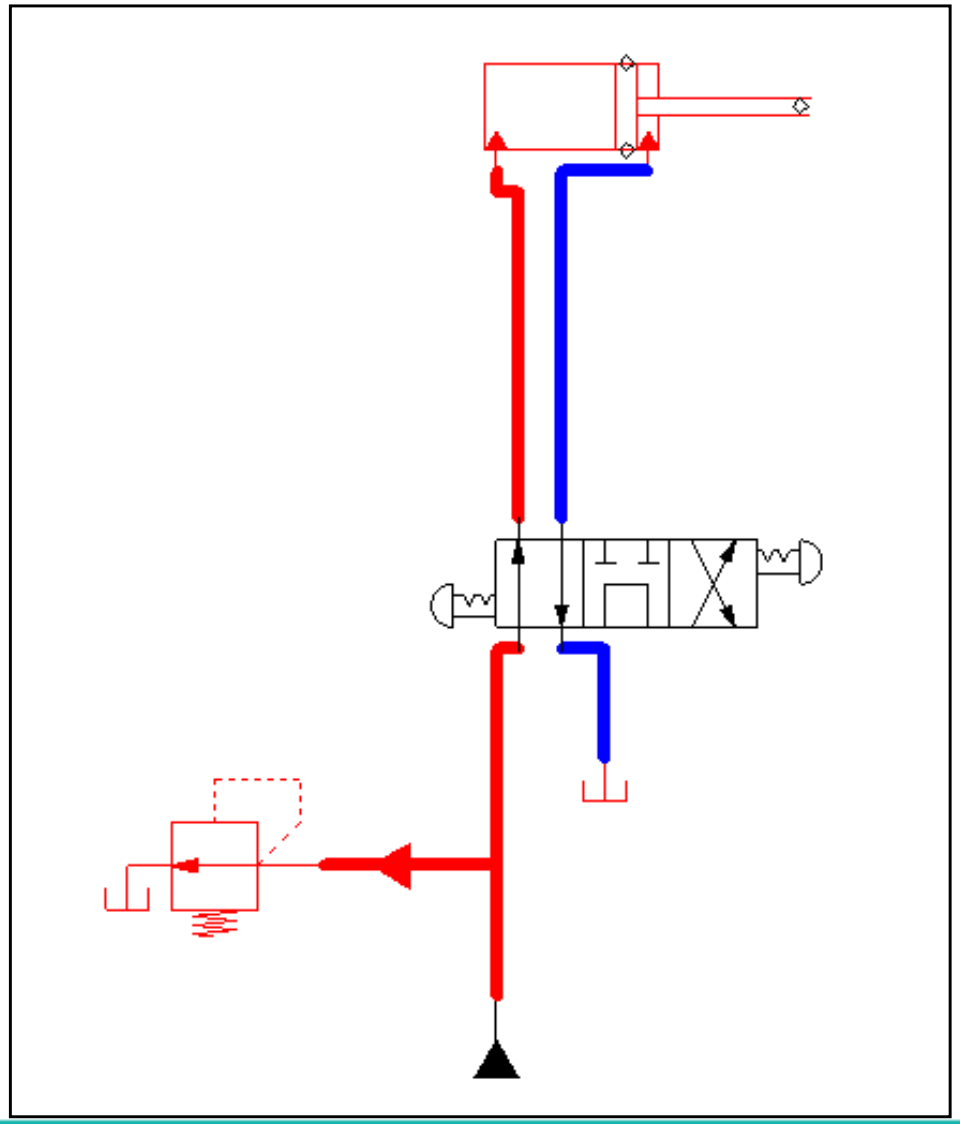
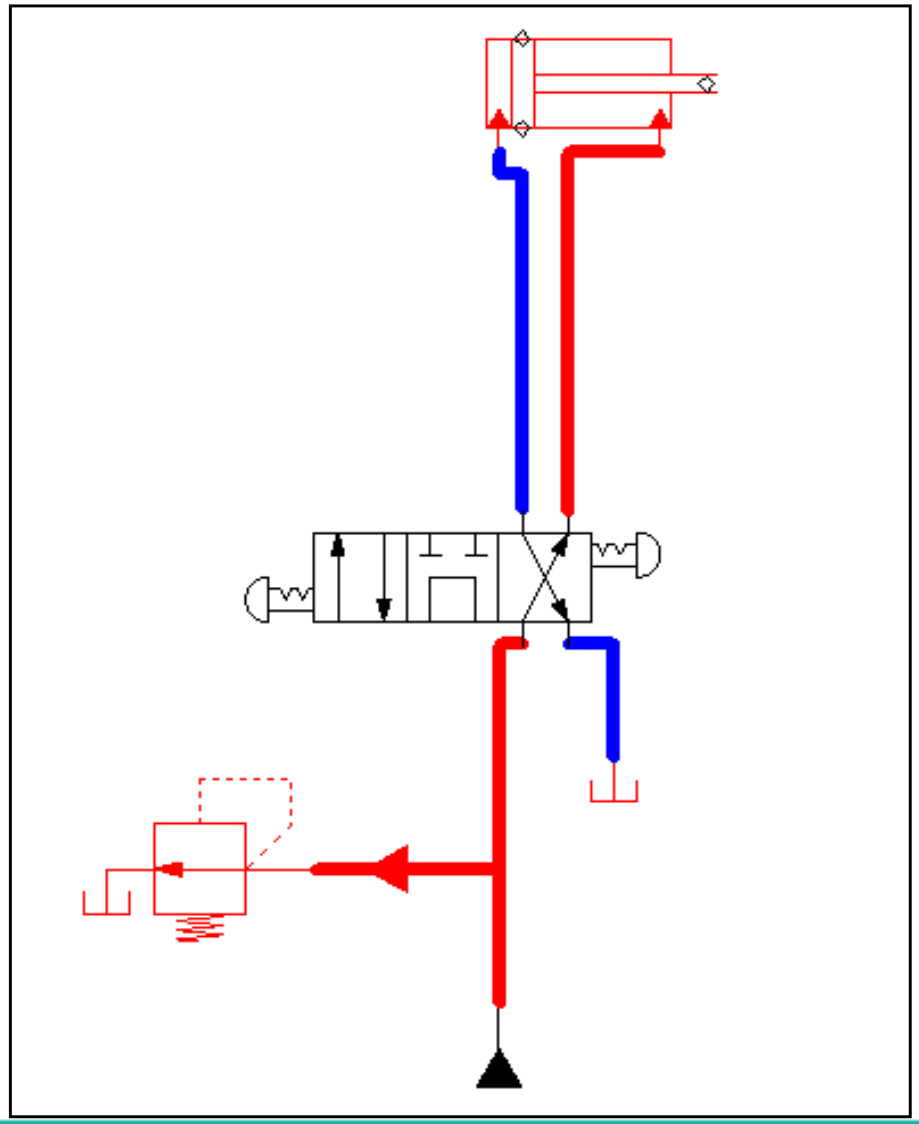


Control of Double-Acting Hydraulic Cylinder – Left position



Control of Double-Acting Hydraulic Cylinder – Right position



Lesson Summary

- In this lesson, we have learned how to design a hydraulic circuit for single and double acting cylinder