Manipulation Devices (The Final Control Element)

- In process control systems, the final control element is the device that directly influences the process variable.
- There are many types of final control elements, such as pumps, motors, fans, compressors, heaters, dampers, and so on.
- Most widely used final control element for process control, however is the 'Control Valve'.

- **Control Valve Principle:**

Flow rate in process control is expressed as volume per unit time.

If a given fluid is delivered through a pipe, then volume flow rate is

$$Q = A v$$

- Q: flow rate (m^3/s)
- A: pipe area (m^2)
- v: flow velocity (m/s)

Control Valve Principle

- Purpose of control valve is to regulate the flow rate of fluids through pipes in the system.
- This is accomplished by placing a variable size restriction in the flow path, as shown below.

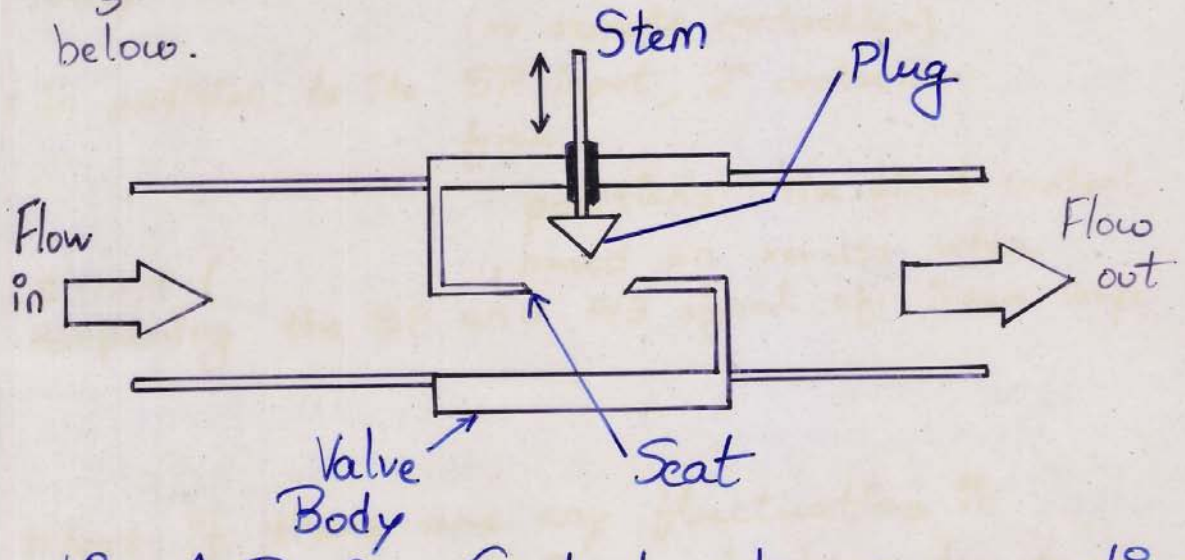


fig: A Basic Control-valve cross-section

- As the stem and plug move up and down, the size of the opening between the plug and the seat changes, thus changing the flow rate.
- Direction of flow is important for proper valve action.

Control Valve

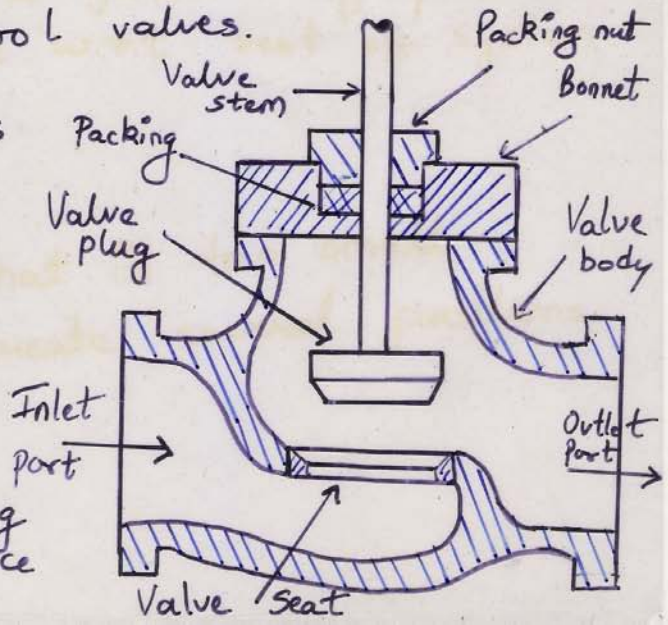
- Control valve is made up of two distinct parts:

1. The valve body, which becomes a part of the main process line by being connected to pipes through which the fluid in the system passes.
2. The valve actuator, which provides the force needed to physically change the size of the flow passage inside the valve body.

Control Valve Classifications:

- Control valve is usually classified on the basis of its 'body style' or its 'flow characteristics'.
- Sliding-stem globe valves and rotary motor valves are the most common and versatile types of flow control valves.
- Single-seated Valves

It consists of a single plug & seat. Fluid enters the port beneath the seat & creates an upward force against the plug. This design cause inlet pressure to pulse valve plug upward and aids the force from the actuator.



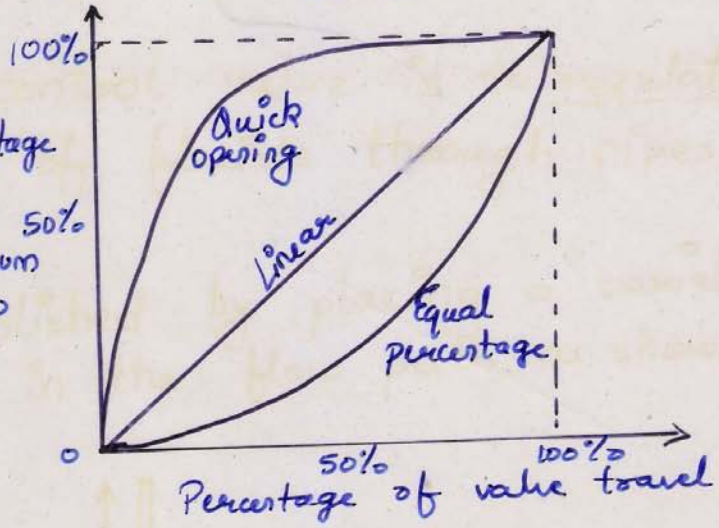
Selecting a Control Valve

When selecting the proper control valve for a particular application, two factors must be considered: valve capacity and valve characteristics.

- **Valve Capacity:**
  It refers to the amount of fluid that a valve is capable of allowing to pass. It's capacity is influenced by the physical size of flow passage within the body.
- The size of valve has an effect on the amount of system pressure that is dropped across its inlet and outlet ports.
- The amount of pressure differential needs for good control is a function of pressure drop across the valve w.r.t rest of system.
- Sizing valves incorrectly can cause them to operate at substandard levels.
- A control valve that is too small or too large create several problems.

Control Valve Characteristics

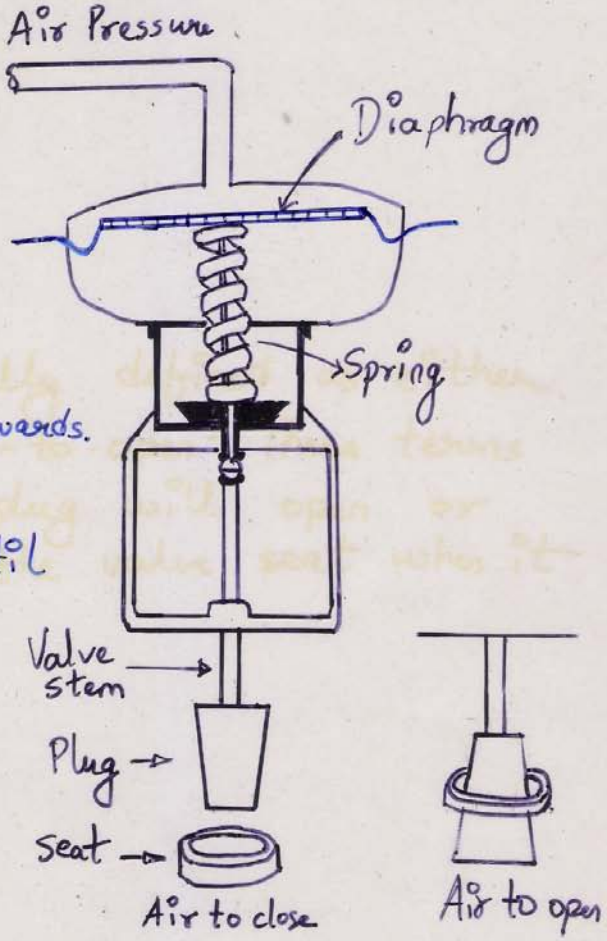
- Valve characteristics is the relationship of the change in the valve opening to the change of flow through the valve.



- The graph shows three characteristics curves that represent the most common operation of control valves used in industry.
- 'Quick oper valve' is used predominately for on-off control application. A relatively small movement of valve stem causes a maximum possible flow rate.
- 'Linear curve valve' has a flow rate that is directly proportional to the position of valve stem. It is used in applications where most of process system pressure drop is across its inlet and outlet ports.
- 'Equal perctange valve' curve is used in applications where the valve pressure is high at low flows or low at high flows. A given % change in the stem position causes an equal % change in flow.

Valve Actuator

- The mechanism that physically moves the element which restricts flow in a control valve, is the 'valve actuator'.
- There are two types of actuators, the 'spring-and-diaphragm' and the 'piston'.



Valve Actuator

- Air signal from controller enters the actuator housing above the diaphragm.
- When the pressure of control signal ↑ses, the diaphragm is moved downwards against a spring.
- The diaphragm moves until the spring creates an equal and opposing upward force due to its expansion. & the motion stops & the plug and valve stem are in a balanced state.
- For each different pressure of a controller sig, there is a corresponding plug position.

Valve Actuator Continue....

- When there is no air pressure the valve stem is pushed upward by the spring & when there is 15psi pressure the valve stem is forced downward. This type of valve is capable of exerting large forces.
- The amount of force depends on the size of diaphragm and how much air is applied to it.
- There are two different designs of spring & diaphragm valve actuator.
- Their action is generally defined as either 'air-to-close' or 'air-to-open'. These terms indicate whether the plug will open or close the port at the valve seat when it is actuated by air.
- For applications, where pressures exceeds the tensile strength of a spring, piston actuators (powered by air in both the upward and downward position) are used.
- When there is no air supply available, such as in a remote installation, electrical actuators are used.

Electric Actuators using Solenoid

- Actuation using the electrical method is performed in two different ways.
  1) using a solenoid.
  2) using a motor or Servomechanism.

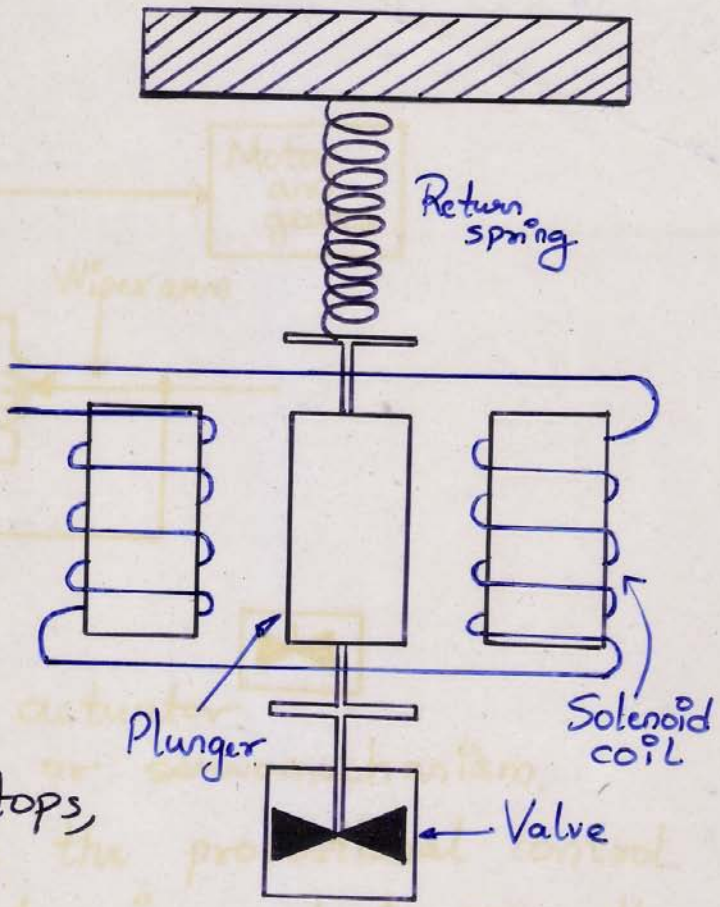


fig ① Electric Actuator using Solenoid

Last
- When current stops, the spring pulls the plunger in opposite direction.

- When performing the ON-OFF control mode, a Solenoid is used to switch the valve, such as one shown in fig①.
- When current flows through the coil, a magnetic field is generated, which moves the plunger downwards against the spring.

Electric Actuator using a motor or Servomechanism.

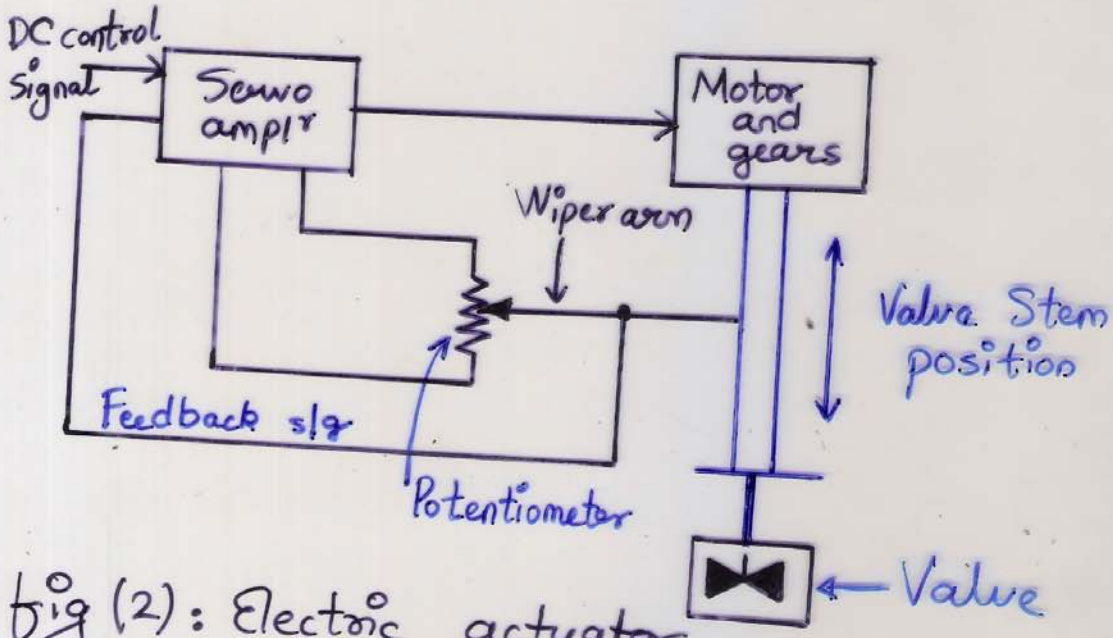


fig (2): Electric actuator using a motor or servomechanism.

- When performing the proportional control mode, a small motor is used to move the valve stem, as shown above in figure.
- A DC control signal is applied to a servo amplifier which drives the gear motor to move the valve stem.
- The wiper arm of a potentiometer, which is attached to valve stem, moves the valve stem and sends a Feedback s/g to servo ampl'r
- The amplifier drives the motor until there is no longer a difference between the control signal and the feedback signal.