Valves The Final Control Element

The valve is one of the indispensable components of the modern technological society. It is essential to virtually all manufacturing processes, energy production and supply system. Thus, it is critical to ensure that the valves remain in prime condition, doing only what they are supposed to do. Into the nuances of practicalities….

No one knows when the idea of a valve was born. Perhaps somewhere, sometime in the ancient past, man learned to regulate the flow of a river learned to regulate the flow of a river or stream by blocking it with large stones or a tree trunk. However it developed, the invention was almost as important as the wheel, for now man could regulate the flow of water.

History speaks

The early Egyptian and Greek cultures devised several types of primitive valves to divert water for public consumption or crop irrigation. The Romans developed the plug valve, or stopcock, and may be even the check valves to prevent backflow. Leonardo daVinci designed some for the canals and irrigation projects he designed. However, the modern history of the valve industry parallels the industrial Revolution, which began in 1705 when Thoms Newcomen invented the first industrial steam engine. Since steam built up pressure that had to be contained and regulated, valves acquired a new importance. And as Newcomen's steam engine was improved upon by James Watt and other inventors, designers and manufacturers also improved the valves for these steam engines. Their interest, however, was in the whole project, and the manufacture of valves as a separate product was not undertaken on a large scale for a number of years.

Valve control

The valve is the final control element of a system. And being that is not an easy job. To start with, it is blamed for any and all problems that crop up in the process. Next, it is subjected to corrosion, high velocity, cavitation, flashing liquids, cryogenic temperatures, high temperatures, abrasion, and thermal shock. It is expected not only to throttle along through all this, but most likely, it is also being asked to act as a block valve and shut off tight.

A control valve only does what it is told to do. It is a power-operated device used to modify the fluid flow rate in a process system. Well, what happens if the power is cut off? When a control valve is sized or selected to do a particular job, one of the first questions to be considered is how it will respond if there's a loss of signal or power. This

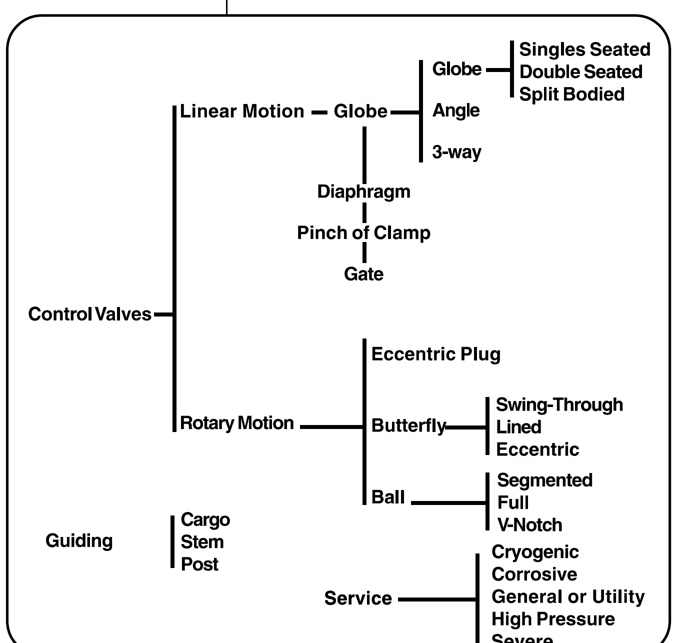

Figure 1

is called its 'fail-safe mode' and knowing the fail-safe mode is the key to troubleshooting it. In most applications (about 80 per cent), it is desirable for valves to fail closed. In other applications, it may be necessary for a valve to fail open or fail in place. Safety concerns and process requirements will mandate the fail mode of the valve.

When a valve is not sitting in its fail position, it is being told how and when to move by some external signal.

If a control valve is observed in an unstable condition or appears to not be responding correctly to and input signal, then there is something that is telling the valve to behave that way.

The spectrum

There are two basic types of control valves: rotary and linear. Linear-motion control valves commonly have globe, gate, diaphragm, or pinch-type closures. Rotary-motion valves have ball, butterfly, or plug closures. Each type of valve has its special generic features, which may, in a given application, be either an advantage or a disadvantage.

Linear Valve: some characteristics are:

- Tortuous flow path with low recovery
- Can throttle small flow rates
- Offers variety of Special trim designs
- Suited to high-pressure applications
- Usually flanged or threaded
- Separable bonnet

Rotary valve: This variety exhibits:

- Streamlined flow-path with high recovery
- Higher capacity
- Less Packing wear
- Ability to handle slurry and abrasives
- Flangeless with integral bonnet
- Higher rangability

In addition to linear and rotary, control valves are also classified according to their guiding systems and the types of services they are used in, (Ref to Fig1)

The valve actuator

The valve system comprises more than just the valve alone. There is the actuator and the valve positioner that work together to precisely control the flowing fluids. The valve actuator is a fluid-powered or electrically powered device that supplies force and motion to a valve closure member. Depending on the type of motion, the actuators are also divided into linear and rotational. The linear spring/diaphragm actuators are used with sliding stem control vavles: ie globe-style valves. This can be accomplished two ways:

- Fixed seat ring/plug orientation, where the springs are interchanged to either above or below actuator diaphragm
- Fixed spring orientation, where the plug and seat ring positions are reversed relative to each other. In the fail-open design, plug travel is above the valve seat. In the fail-closed design, plug travel is below the seat

The rotary spring/diaphragm actuators are used with rotary control valves;' ie butterfly, eccentric plug. Reversing the fail mode for this type of valve is normally accomplished by reversing the location of lever arm and plug. In order to maintain consistency, ATO-FC action will be considered as 'reverse' action for rotary or sliding-stem control valves.(Ref to Fig2)

Valve positioner

A valve positioner is a device used to increase or decrease the air pressure operating the actuator until the valve stem reaches the position called for by the instrument controller. Positioners are generally controller. Positioners are generally mounted on the side or top of the actuator. They are connected mechanically to the valve stem so that stem position can be compared with the position dictated by the controller.

A positioner is a type of air relay, which is used between the controller output and the valve diaphragm. The positioner acts to overcome hysteresis, packing box friction, and valve plug unbalance due to pressure drop. It assures exact positioning of the valve stem in accordance with the controller output.

Why use positioners

- Increase control system resolution; ie fine control
- Allow use of characteristic cams
- Minimize packing friction effects: ie high-temperature packing
- Negate flow-induced reactions to higher-pressure drops
- Increase speed of response to a change in process
- Allow split ranging

- Overcome seating friction in rotary valves
- Allow distances between controller and control valves
- Allow wide range of flow variation: ie operate at less than 10 per cent travel under normal conditions
- Allow increased usage of 4-20 mA electronic signal
- Increase fast venting (unloading) capability
- Permit use of piston actuators
- Facilitate operation when the higher number in the bench-set range is greater than 15 psig: ie 10-30 psig, 6-30psig, etc

The leakages

Rule of Thumb : there is no such thing as 'bubble tight.' Control valves are designed to throttle. This is not a perfect world, and control valves are also usually expected to provide some type of shut-of capability. A control valve's ability to shut-off has to do with many factors, the type of valves for instance. A double-seated control valve usually has a very poor shut-off capability. The guiding, seat material, actuator thruts, pressure drop, and the type of fluid can all play a part in how well a particular control valve shuts off.

There are actually six different seat leakage classifications as defined by ANSI/FCI 70-2-1976. But for the most part just two of them are of prime importance: Class IV and Class VI. Class IV is also known as 'metal to metal'. It is the kind of leakage rate expected from a valve with a metal plug and metal seat. Class VI is known as a soft seat classification. Soft seat valves are those where either the plug or seat or both are made from some kind of composition material such as Teflon.

Control valve packing

Packing is a sealing system which normally consists of a deformable material such as TFE, graphite, asbestos, Kalrez, etc. Usually the material is in the form of solid or split rings contained in a packing box. Packing material is compressed to provided an effective pressure seal between the fluid in the valve body and the outside atmosphere.

Once it was believed that the more packing you had in a control valve, the better it would seal. Since fugitive emissions have become a concern, extensive studies have been made which show that better sealing can be obtained by minimizing the

Comparing the actuator types

Spring and Diaphragm	
Advantages	***Disadvantages***
Lowest cost	Limited output capability
Can throttle without a positioner	Large size and weight
Simplicity	
Inherent fail-safe action	
Low supply pressure required	
Adjustability	
Easily maintained	
Pneumatic Piston	
Advantages	***Disadvantages***
High torque capability or addition of spring	Fail-safe requires accessories
Compact	Positioner required for throttling
Lightweight	Higher cost
Adaptable to high ambient temperature	High supply pressure required
Fast stroking speed	
Relatively high actuator stiffness	
Electric Motor	
Advantages	***Disadvantages***
Compactness stroking speed	Limited duly cycle slow
Very high stiffness	Lack of fail-safe action
High output capability	High cost
Electrophydraulic	
Advantages	***Disadvantages***
High actuator stiffness	complexity and maintenance difficulty
Excellent throttling ability	Large size and weight
Fast stroking speed	Fail-safe action only with accessories

Figure 2

number of pakcing rings. New standards are being developed to which manufacturers will be asked to test their control valves. This will allow a user to predict with some certainty how well a particular valve and packing combination will hold up.

Some of the common problems…

Consolidation: This can occur when the packing wears, cold flows, are subjected to thermal gradients, or if a non-uniform stress distribution in the packing exists.

Extrusion: When packing is loaded to its proper stress level it has a tendency to cold flow and will extrude between the stem and the follower. Any increase in temperature increases tendency of packing to cold flow. PTFE is very susceptible to this, as the hotter it is, the quicker it cold flows. As the packing tries to expand in the fixed volume of the packing gland, extrusion will occur. This material loss due to extrusion relieves the axial stress, which relaxes the radial stress and results in a loss of seal.

Migration: packing migration occurs when a portion of the packing is caught by a rough stem and is removed form the packing box as the stem slides in and out of the packing box.(Applies only to linear valves)

Solution: Some design principles that can prove helpful

- To minimise stem friction and wear on packing, the stem surface finish should be in the 8 to 16 rms range.
- The stem of the valve should be held concentric with the packing bore. This helps to uniformly compress the packing and is best accomplished by guiding the stem at the top and bottom of the packing bore.
- To minimise packing extrusion under load, the inner diameter of packing spacers should be held as close to the stem diameter as possible. Anti-extrusion washers can also be helpful in minimizing extrusion.
- It is desirable to use a wiping mechanism. The stem-wiping device should be at least a stroke distance away from the packing to prevent damage to the stem and packing by dragging particles and deposits into the packing area.

Some Practical tips

- When dealing with a corrosive fluid, choose the valve body and trim material to match the pump casing and impeller.
- Velocity is the key to handling abrasive materials. Normal city water velocity is about 7 to 10 FPS. (clean liquid). While handling an abrasive fluid, it is best to keep the velocity as low as possible-without having the particles drop out of suspension.
- Always sense pressure where control is necessary. Many control valves and pressure regulators do not function properly simply because they are sensing pressure at one point and being asked to control it somewhere else.
- Velocity is the key to handling noise. Noise is energy. When dealing with high pressure drop situations try always to keep the velocities below 0.3 mach. On the inlet pipe, valve body, and outlet pipe.
- While using a transducer in a control loop. Specify a positioner on the valve. Otherwise the transducer will rob the actuator of available thrust, and the valve will leak when it is supposed to shut off.
- In cavitating fluids-even if the control valve has cavitation trim in it- be sure to allow a straight run of downstream pipe after the valve. If there is a pipe 'T' or elbow immediately downstream, the flow will choke out and back up into the valve.
- While using a control valve with a bellows seal in it, try to sizes it so that its normal throttling position is near the bellows 'at rest' position. This will minimize wear on the bellows.
- Don't use a valve below 10 per cent of flow if at all possible. Even though it may have good rangeability, if it is used in an abrasive or erosive service (steam), it will not hold up unless it has hardened trim.
- If a PLC is being used to control the valves in a system, specify the valves with a linear flow characteristic.
- If a control valve is stared up and fails to respond – or goes to full open or full closed and stays there- check the controller and reverse the controller's action.

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