The Value of Valves

Gavin Light, Emerson Process Management, presents the importance of control valves to the efficiency and financial performance of a refinery.

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Increase throughput; improve yields; enhance quality; conserve energy; eliminate waste; reduce downtime: these are the rallying points in today's processing world, as pressure grows to improve overall profitability. The key to this search for profit improvement is the final control element, the control valve. In fact, only within the last several years has the importance of the control valve in managing process variability, and thereby increasing profits, been recognised.

Consider this case in point: within a refinery, performance problems with the main feed valve to a cracking tower resulted in pressure fluctuations greater than +/-10 psi (+/- 0.7 bar), which repeatedly caused lifting of pressure relief valves. After attempts to run at reduced set points, the system operators eventually resorted to placing the loop in manual to avoid the pressure relief lifts. Subsequent tests revealed excessive dead band in the original main feed valve, therefore it was replaced with an alternative control valve ass-embly. The replacement globe valve reduced the pressure fluctuations to +/-1 psi.(+/-0.07 bar), and unit production increased by 2000 bpd, equivalent to Euros 1.9 million/yr.

As the preceding example shows, by minimising and controlling process variability, there are opportunities to improve a plant's financial performance. Being successful in achieving the required performance levels ultimately yields a first grade product that is available for immediate sale. It avoids the costs of:

- Reworking off spec product, which impacts plant capacity, throughput and energy consumption.
- Storing off spec product, which increases inventory expense and cycle time.
- Selling off spec product, which typically means a reduced price.
- Discarding off spec product, which means no profit contribution at all.
- Lost production time.

Figure 1. The Fisher FIELDVUE DVC6000 digital value controller combines value control with intelligence.

The control valve: a variability source

There are many causes of process variability, ranging from the improper design of a control system to instruments being out of tune. Reduced maintenance on the process device, without visibility to the health of process device, can also contribute to increased variability.

Despite these potential variability causes, the control valve can often be identified as the leading source of off spec product, reduced throughput and increased feedstock usage, plus a number of process control ills that drive operating costs up and operating profits down.

Process control analysis experts have found, after audits of thousands of flow control loops, that up to 40% of all process variability is caused by poorly performing control valves.

Performance impacted

Supervisory control and advanced control strategies have been considered important steps in achieving process optimisation. Yet, if optimisation looks only at control room equipment and software and does not consider the performance of field hardware, the true benefits of these investments will not be realised.

To better understand this argument, consider that little can be gained by developing a sophisticated control room architecture that is capable of performing to 0.5% accuracy, only to implement that control strategy on the plant floor with a final control element that may only be capable of 5% accuracy.

In more than 4000 process loops audited by Fisher, the performance of over one half of them could be enhanced significantly by improving the control accuracy of the final control element. Even in those loops that utilised advanced control strategies, the lack of control valve performance was a limiting factor. In fact, several audits revealed that the advanced control application had been turned off because the loop was not performing to expectations.

The selection of a valve capable of performing to the required level is, therefore, imperative. However, once one has selected a valve able to perform at the appropriate level, the key to sustaining this performance is the visibility of the performance of the valve from the control room.

Today's advantage

The modern control valve takes advantage of today's digital valve controllers and digital transmitters. These recent additions to the valve world offer several new operating and maintenance capabilities.

The digital valve controller, for example, provides two way digital communication that makes real time valve information available both at the plant floor and in the control room (Figure 1). This 'up to the second' data proves invaluable in reducing process variability and enhancing overall plant operation by:

- Helping operators keep processes tightly controlled within specifications.
- Optimising maintenance programs by providing advanced valve diagnostics, allowing remote visibility to valve health (including packing performance).
- Allowing remote and automatic instrument calibration to keep workers out of hazardous areas.
- Minimising process startup time through remote tag identification.
- Allowing improved conformance to environmental standards and documentation requirements.
- Protecting the operating integrity of the process with device alarms and alerts.
- Providing an audit log database for ISO quality standard support.

Time savings, personnel safety and higher performance levels all result. The impact of the digital valve controller has been significant, as it finds increasing use throughout the processing industries. Digital communication allows access to expertise on the end of a phone, not previously available at site. Services offered range from diagnostic interpretation to online product monitoring. Thanks to an ever increasing number of mounting kits being offered, the advantages of digital valve control can be applied widely within the plant, almost regardless of control valve age or brand.

Design advantages

Valve stem packing is another important area involving changes to long standing designs. The impetus to change was prompted by environmental concerns and legislation.

Valves and pumps are primary sources of fugitive emissions, with stem packing and flange gaskets being the main areas where leakage occurs. Considering that typical refineries and chemical plants each have thousands of control valves, it quickly becomes clear that a significant amount of emission could be occurring. Some of the material that reaches the atmosphere through a valve stem packing box or past a flange gasket might pose a threat to workers and the environment.

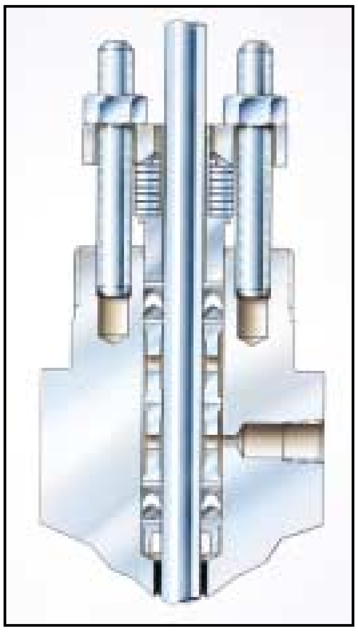

Figure 2. Environmental protection in action. The Enviro-seal packing system reduces fugitive emissions and is an option on all Fisher valve bodies.

The need to avoid such situations is paramount, with many countries considering legislation that will limit the volume of allowable fugitive emissions. These restrictions typically apply to a specific listing of volatile organic compounds. The response of both packing and control valve manufacturers has been a lineup of valve stem packing offerings, as well as several bellows seal products.

Most standard plastic or elastomeric packing sets installed today will meet the low leakage rates required by such governing bodies as the US Environmental Protection Association (EPA), but in many cases they will only do so for a short time. Graphite packing is susceptible to friction damage, and plastic and elastomeric packing may be damaged by extrusion loss. As a result, these packing sets require frequent maintenance and replacement to keep leakage low. Valves that stroke frequently and valves subjected to high or varying temperatures, are especially susceptible to high leakage and low packing life.

However, low leakage packing systems are marketed today that not only meet stringent low emission requirements but also do so with little to no maintenance attention over the life of the valve. Due to this long life and low maintenance, many plants use these new packing systems even if they are not required to monitor fugitive emissions (Figure 2).

When evaluating a packing system's emission control performance, one must pay attention to the following four basic principles:

- There is an effective mechanism in place to prevent extrusion of the packing materials.
- There is a mechanism in place (e.g. live loading via Belleville washers) that maintains packing stress.
- The valve stem has a smooth finish to prevent erosion of the packing, along with a guide bushing that keeps the stem aligned.
- The stem or shaft must be well guided. This is more frequently a problem in rotary valves than cage guided globe valves.

When both emission control and fire safety are essential, a graphite/PTFE system, which follows the preceding principles, can be the answer. In most instances, packing systems originally designed to meet stringent emission control requirements also yield an extended service life, reduce overall maintenance costs, and provide long term answers to control valve sealing problems.

Today's modern globe valve serves not only as the workhorse of most processing systems, but also incorporates many design features that can lead to high performance control, particularly when utilised with digital based controllers or positioners.

The foremost design advantage is interchangeable cage style trim. In this valve design 'platform', one basic valve body casting accepts different cage and valve plug configurations. In turn, this interchangeability lets the valve specifier/user more closely match each valve to its intended service conditions.

For example, the typical performance goal for a process control loop is to end up with a relatively linear installed flow characteristic. This result encompasses the characteristics of all the control valves and processing equipment within the loop. Because of its quick change trim capability, the cage style valve can be used to install a flow characteristic that compensates for the non linear characteristics within the loop. Typically, specified flow characteristics include quick opening, linear and equal percentage.

Besides determining the valve's flow characteristic, the 'cage' of the cage-style trim serves other purposes: to guide the valve plug and to secure the seat ring. Furthermore, since the cage 'drops into' the valve body, the relative term 'quick-change trim' takes on meaning during valve inspection and maintenance procedures. The valve body can be left in line whilst trim parts are removed and then replaced.

The cage approach offers additional advantages. The flow cage, valve plug and seat ring can be manufactured of hardened stainless steel to 'build in' excellent durability. Precision machining helps to ensure smooth valve operation and, since the cage provides massive guiding at the precise point of pressure drop, the valve can be throttled at maximum rated pressure drop without plug instability and premature guide failure.

Cage style trim proves especially advantageous when the valve specifier is faced with severe service conditions. Specially designed flow passages through the cage wall effectively reduce or avoid aerodynamic noise generation. Similarly, anti cavit-ation cage designs reduce or eliminate the damage potential in high pressure drop liquid applications. Different flow orifices can be positioned at different heights along the length of the cage to give staged cavitation protection to match service conditions during startup and operation. The flow cage, valve plug seals and seat ring combination allows specifying the required degree of shutoff, typically from ANSI/FCI 70-2 or IEC 60534-4 Class II to Class VI.

Many parts such as gaskets, valve stems, bonnets, packing sets and others are interchangeable between globe and angle body styles within the same valve design platform. This provides a definite saving on the number of total parts needed to maintain a spares inventory. Other savings arise when converting from one trim style to another since a minimum number of parts is involved. Often, this need for a minimal parts inventory is backed up by an express parts service from the valve manufacturer that makes parts available within hours of ordering.

Contoured passages within the cage style valve bodies offer greater capacity than conventional, single seated, post guided valve designs (often 30% or more). One may often achieve the flow needed and the control capabilities desired with a smaller valve size, providing a saving on the control valve investment.

Demanding problems: unique answers

The design flexibility inherent in the cage style valve trim platform comes to the forefront when faced with tough application requirements. An example involves excessive noise created by turbulent aerodynamic flow. Special flow cage designs in which the flow path has been carefully orchestrated have emerged as an effective way to keep noise levels within acceptable limits. These speciality cages prove successful to varying degrees.

A recent innovation in noise abatement trim, however, offers great promise. It combines several principles to reduce noise, vibration and resultant pipe fatigue (Figure 3). First, the new trim divides pressure drop (and, therefore, stream power) over two stages. Noise generated by the first stage is attenuated within the cage. The pressure ratio of the second stage is minimised, which results in the stream power exiting the second stage being significantly less than that of a single stage device.

The unique passage shape within the cage reduces flow turbulence entering the first stage and minimises shock associated noise. The innovative design also directs turbulent shear layers away from solid boundaries as flow exits the second stage, which further avoids dipole sound. Exit jets from the second stage are essentially parallel, thereby avoiding shock cell interaction between them.

The overall result can be noise reduction in the neighbourhood of 40 dBA, which surpasses earlier developed noise abatement trims by 5 - 10 dBA. The key to appreciating the noise reduction capability of a valve is to have an independent means of calculating noise, irrespective of supplier. IEC 534-8 has become the means to achieve this.

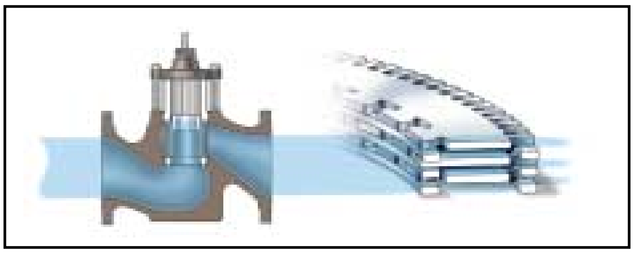

Figure 3. Whisperflo: a recent innovation in noise abatement trim combines several principles to reduce noise, vibration and resultant pipe fatigue.

Figure 4. The FloVue system combines unique actuator technology, the FIELDVUE digital valve controller and a selection of globe valves into a system approach to process control.

New techniques: new advantages

Changes in control valve design tend to evolve rather than explode onto the scene. An example of the latter, however, is given by an innovative new approach to control valve actuation that was introduced to the market in late 1996. New in appearance and certainly new in how it operates, the pneumatic actuator utilises an entirely new mechanism to create movement of the valve stem.

The actuator consists of a self contained power module that accepts a pneumatic signal from a digital valve controller. The air signal is fed through a manifold to an internal air chamber, which initiates movement of the canister upon an increase in the air signal. Springs within the canister oppose the air chamber and move the canister upon a reduction in the air signal.

The power module is compact and lightweight, allowing a similarly compact actuator profile. The lighter weight construction makes valve handling easier and safer. The integral mounting of the digital valve controller eliminates external linkages and tubing, simplifying valve installation.

Long term operating capability of this new departure in actuator design has been verified by extensive cycle testing and in field experience. The actuator, with its minimum number of parts and corrosion resistant fasteners and coatings, is designed to meet the tough environment of the typical plant floor (Figure 4).

Looking ahead

As stated earlier, changes within control valve design tend to be evolutionary. However, the auxiliaries that attach to the valve body, the actuators and instruments, undergo change at a faster pace. Digital instrumentation is at the forefront of control valve change at the moment. The digital valve controller is making great inroads into the traditional pneumatic and analogue based, valve mounted instrument arena. Moreover, as discussed earlier, it is proving to be highly effective at improving how a valve is controlled and maintained. The digital valve controller also provides an entrée to the advantages of fieldbus, which is rapidly becoming the control system strategy of the future.

Control valve design changes will occur and enhancements will be made, but the important role of the control valve as being essential to overall plant operation and profitability will remain constant.

Notes

Fisher-Rosemount is in the process of a name and identity change. It is renaming itself Emerson Process Management. The new identity is being introduced in stages around the world at a pace that preserves the long standing respect for the Fisher-Rosemount name amongst valued customers.