Part 1

Control Valve Actuator Options

Today's Actuators Offer Imposed Performance With Lower Life-Cycle Costs. The Challenge Is Choosing the Right One for the Application.

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This article is the first in a two-part series examining the state of the art in control valve actuators and their current application guidelines in the process industries. Part I deals with the mechanical aspects of valve actuator options. Part II, in next months issue of CONTROL, will cover the benefits of using the latest generation of smart, digitally controlled actuators.

Over the past several years, valve actuators have received relatively little at tention while process con trol specialists concentrated on controllers, sensors, and other components of the control loop. This is borne out by the unglamorous nickname "pig iron" assigned to the actuator/control valve unit. With the onset of the smart-valve generation, it suddenly appears that the control valve actuator may get more respect along with its new electronics degree.

Today the available actuator menu includes four basic types of mechanical actuators (Table 1) which recently have been enhanced with onboard micro-processors. Some of the improvements available to end users include a wider source of power options, quicker response, tighter control, easier maintenance, improved life cycle costs, and a host of others.

Selecting the proper actuator for a given application depends heavily on matching it to the valve or other driven equipment. The process control engineer is well advised to take advantage of vendors' experience gained over many years of selecting the most effective valve/actuator package for a wide variety of service requirements.

A good example of this is the recent rise in popularity of the pneumatic piston actuator and quarter-turn valve combination. The package offers many advantages (see Table II) along with excellent control, compact silhouette, easier maintenance, and most importantly, improved valve-stem emissions control.

Application checklist

A quick review of the actuator characteristics listed in Table I indicates which actuator type is best suited for a particular application. For example, the spring and diaphragm (S&D) and pneu-

Table I. Mechanical Valve Actuator Characteristics

TYPE SOURCE	POWER SERVICES	RANGE OF TORQUE CAPABILITIES	THRUST OR APPLICATION	VALVE TYPE	STIFFNESS	MATERIALS OF CONSTRUCTION
Spring and diaphragm	Air to 30 psig, spring return	Throttling, on-off general service	Light to moderate	Vertical direct, rotary with linkage	Low to moderate	Various elastomeric diaphragms and frame materials
Pneumatic Piston	Air to 50-150 psig, opposed pistons	Throttling, on-off general service	Moderate to high	Vertical direct, rotary with linkage	Moderate to high	Available in CS,SS, corrosion-resistant materials
Electric Motor Operated	Electric motor and gear train	Limited throttling good on-off service	Very high	Best on larger remote rotary valves	Very high	CS,SS, aluminum and epoxy filled composites
Electro-Hydraulic	Electric motor and pump	Good in throttling services	Moderate to very high	Vertical direct, rotary w/ linkage, handles dampers well	High	Available in various materials to suit environment

matic piston (PP) actuators are well suited for low to moderate thrust required by small to medium sized valves. This covers about 80% of process plant applications.

Electric motor and electrohydraulic Actuators' strong points are high thrust for larger valves where there is no convenient air supply. This makes them most appropriate in large utility, pipe line, and remote location services.

The lack of inherent fail-safe operation continues to limit the application of electrically-driven actuators from capturing more of the lower-thrust, hazardous-service applications that are so prevalent in process plants. Electrohydraulic actuators can meet the fail-safe requirement with an added spring in one of the pistons, so their use can he advantageous in solving some unique positioner applications within the process plant.

The key elements to consider when selecting an actuator/control valve combination include:

- Type of service-on/off or throttling;
- Power source-air, electric, or other;
- Loop stability requirements;
- Input signal compatibility;
- Actuator thrust requirements;
- Size and weight considerations;
- Safety requirements (e.g. fail-safe operation, area classification, etc.);
- Operating environment-heat, vibration, corrosion. etc.;
- Dead band and hysteresis factors; Use of accessories (e.g., positioners, micro switches, handwheels, microprocessors, etc.);
- Ease of maintenance; and,
- Economic factors-first cost, maintenance costs, and life-cycle costs.

The type of service has a direct bearing on the selection of the actuator for on/off or throttling service. Any of the actuators types listed in Table I are suitable for on/off service. Operating speed, tight shut-off, and fail-safe operation are also vital in this type of service.

Throttling action introduces the accuracy factor; the valve must be able to hold intermediate control points in response to a variable signal. The work-horse in this application for light thrust units is the S&D actuator, which may do the job without a positioner. If high thrust is required, a double-acting PP actuator with a suitable positioner will probably offer the most reliable and economical approach.

For high thrust, fail-safe operation-as well as close control in a difficult environment-the more expensive electro-hydraulic actuator may be appropriate. More challenging control application requiring greater loop stability might warrant consideration of a "smart" actuator with an onboard microcomputer. (These devices and their advantages will be covered in more detail in the second article of this series.)

Size and weight are the main disadvantages of the S&D actuator (and to a lesser degree the PP actuator) on large-sized valves. If the application area is not restrictive to a large silhouette, the S&D or the PP actuator is probably the way to go. The moderate cost of a supporting structure along with the higher actuator cost may still not be great enough to upset the economics of the S&D/PP selection.

One major area crucial to effective actuator selection is its ability to over-come stem resonance problems to maintain the process variable close to the control point. Factors affecting resonance (valve hunting) problems

FAIL SAFE ACTION	WEIGHT PER UNIT FORCE	PHYSICAL ENVELOPE	INITIAL COST	MAINTENANCE COST	AVAILABLE ACCESSORIES	RELIABILITY
Inherent due to built-in spring	high in large sizes	Require high vertical clearance	Low	Low handwheels,	Positioners, limit switches, technology microprocessors	Excellent, simple, mature technology
Require spring or reserve air cylinders	Low	Moderately compact	Low to moderate	Low to moderate	Positioners, limit switches, microprocessors	Excellent, mature technology
Require stand-by power source	Moderate to high	Compact	High	Low to moderate remote operators positioners	Limit Switches, microprocessors, mature technology	Good depending on power source,
Require stand-by power source or spring	Moderate	Require high vertical clearance	Highest	Highest switches	Positioners, limit enance, multiple moving parts	Higher maint-

Involve stiction (valve stem friction), Actuator stiffness, stroking speed, plug-head buffeting, hysteresis, and other factors. Most of these problem areas, which are inherent in various actuators to some degree, are handled by effectively matching the actuator with a valve positioner. The applications engineer should do the best possible job of picking the most suitable actuator for the service-don't unload any inherent actuator problems onto the positioner as a bolt-on cure-all.

Sound decision-making

Champion Paper, Inc. has discovered the importance of integrating a sound actuator/control valve unit in the control loops at its integrated paper mill in Houston, Texas. Champion's corporate goals of product improvement, customer satisfaction, and rightsizing led the controls group to the realization that control valve performance offered the best opportunity for improved mill performance with the least capital expenditure.

"We found that 80-90% of our control problems were in control valve performance," says control engineer Don Jordan. "Faulty control valve operation cannot be tweaked or adjusted out by the controller alone. Our approach has been to work with EnTech Control Engineering (a controls consultant based in

Table II. Valve Actuator Advantages and Disadvantages

ADVANTAGES	DISADVANTAGES
SPRING AND DIAPHRAGM	
Lowest first cost	Limited force output
Operating simplicity and reliability	Large size and weight per unit force
Throttles well without positioner	Low Stiffness
Inherent fail-safe operation	Does not handle high ambient temperatures well
Low air pressure supply	
Easily adjustable to local conditions	
Few moving parts	
Ease of maintenance	
Most mature technology	
PNEUMATIC PISTON	
High force and torque capacity	Requires spring or accessories for fail safe operation
Moderately compact silhouette	Must have positioner to function
Low weight to power ratio	Higher first cost than S&D actuator
Can stand high ambient temperatures	Requires high pressure air to operate
Fast stroking speed	
Good throttling control	
Few Moving parts	
Relatively high actuator stiffness	
Available in smart valve configuration	
Available in corrosion resistant materials	
ELECTRIC MOTOR DRIVE	
High force output	High first cost
Very high stiffness	Not inherently fail safe
Compact silhouette	Limited duty cycle of motor drive
Slow stroking speed (if required)	Multiple moving parts
Does not require air supply or I/P	
Corrosion-resistant seals and construction are available	
Infrared emote setting unit available	
Relatively mature technology	
Good on large valves in remote locations	
ELECTROHYDRAULIC	
High force output	Highest first cost
High actuator stiffness	Multiple moving parts, highest maintenance
Excellent throttling ability	Fails safe only with spring or accessories
Fast stroking speed	Least mature actuator technology
Does not require air supply or I/P	
Accepts harsh environments well	

This solar powered electrohydraulic Valve actuator develops 4,000-lb. of thrust and is used to control flow through a remote Venezuelan oil pipeline. (Rexa)

Toronto, Ontario) to do a plantwide audit on our control loops and train our people in correcting the problem areas. EnTech has developed a control valve dynamic specification, which we have found very valuable in solving our control valve tuning problems".

EnTech has found that most control valve problems start with erroneous control valve selection during initial design. These problems get worse over time due to poor tuning and maintenance. The primary design error occurs when pyramiding capacity safety factors are cranked into the original specification of the control valve. That forces the valve to operate in its lower range most of the time.

Even periodic bench testing is not a complete solution to control valve problems because bench conditions differ significantly from actual operation. Existing loop problems and valve-disk buffeting can cancel the best of bench testing intentions. Continual auditing of control valves under operating conditions offers the most reliable solution to catching most of the problems.