CONTROL VALVES ACTUATORS

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Summary

The role of actuators in process control systems is outlined and different types of actuators are described. The advantageous features and limitations of different types of actuators are presented, together with certain guidelines for the selection of actuators for practical application.

1. Introduction

An actuator is part of a control package. In a process control loop an actuator controls the valve closure member position in accordance with the variation of the signal transmitted by the controller. The main feature, which distinguishes the control valve actuators from those used in the on-off valves, is their capability to transform a well-defined signal change into a correspondingly well-defined mechanical displacement. A control valve can perform its function only as effectively as the actuator can handle the static and dynamic loads placed on it by the valve. Actuators are classified into pneumatic, electric and hydraulic types according to the power source from which they derive their actuating power.

2. Pneumatic Actuators

Pneumatic actuators may be classified according to the type of movement, design and mode of action.

According to the type of movement:

(a) Linear type
(b) Rotary type

According to design:

(a) Diaphragm type
(b) Piston type
(c) Other types

According to the mode of action:

(a) Single-acting
(b) Double-acting

2.1. Diaphragm Actuators

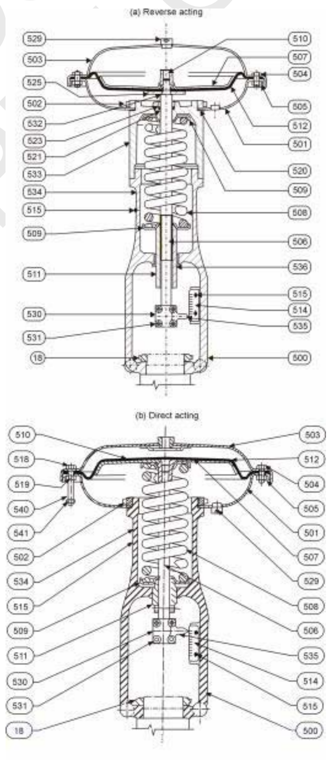

Figure 1. Typical spring and diaphragm actuators.

These are undoubtedly the best known and most widely used due to their simplicity and economical performance. Usually they are equipped with an opposing spring which returns the valve in closed or open position in the absence of power supply. They are available in both direct-acting (air/stem downward motion) and reverse-acting (air/stem upward motion) types, as they are needed for valves for fail-safe action. Figure 1 shows their operational and constructional features.

2.1.1. Operation

When air is supplied to the upper air-tight chamber (503) of the direct-acting actuator, the increase in pressure deforms the rubber diaphragm with a force which moves the stem (506) downward which in turn compresses the spring (508).

When the air pressure fails, the energy of the compressed spring is released and the actuator stem moves upward.

In the case of air pressure failure, the actuator spring will move the plug into its fail-safe position.

During operation, the only metal parts coming into contact are the stem (506) and the guide bushing (511), fitted in the spring adjuster, which is made of plastic or other low friction material. This results in very low friction, smooth operation and gives rise to fast response.

The linearity errors in the signal-travel relationship are caused by the following factors (which may be additive or opposing): spring characteristics and diaphragm efficiency.

The rate of the spring may change during compression, while the force exerted by the diaphragm does not have the same magnitude along the travel, as shown in Figure 2.

Net actuator forces - N/psi						
Type		250	310	390	450	600
Stroke (mm)	17	160	250	420	680	
	25		240	420	680	1190
	34			415	670	1167
	45			390	660	1130
	50				640	1090
	75					1050

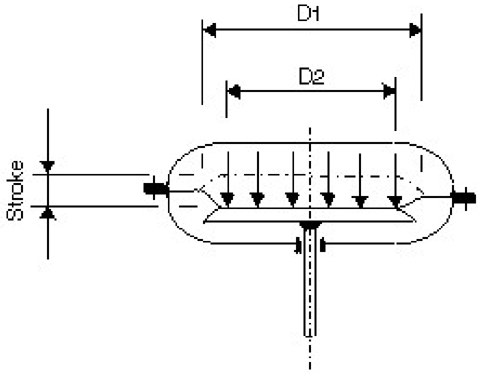

Figure 2. Diaphragm efficiency versus stroke.

The diaphragm has greater surface area coming into contact with the diaphragm plate (507) (which is to transmit the diaphragm generated force to the stem) when it is in the upper position than when it is in the lower position. This disparity may be reduced by using a shaped diaphragm, which guarantees constant contact surface area over the entire stroke of the actuator. Operation of the reverse-acting actuator (as shown in Figure 1) is similar, with the exception that the spring ends rest on one side directly against the yoke cavity, and on the stem on the other. Air is supplied in the lower air-tight chamber, in order that air pressure action will result in an upward motion of the stem, while spring action will tend to move the stem downward.

2.1.2. Manufacturing Features

The yoke (500) is usually made from gray iron castings, which are known to be both cheap and capable of absorbing vibrations. Therefore, if properly designed, such yokes may appreciably protect the commonly supplied auxiliary equipment such as positioners, solenoid valves, microswitches, etc.

When special features are required such as impact tolerance (nautical applications), or seismic strength (nuclear plants) or ability to function well at very low temperatures (below -20°C), gray iron should be replaced by carbon steel or nodular cast iron.

Usually, lower and upper cases (501) and (503) are made from cold die cast plates, the maximum thickness of which is 7-8 mm, due to the particular process of deep drawing.

This manufacturing process is economically advantageous in mass production. However, it limits the application of these actuators which cannot withstand an operating air pressure of about 4 bar (less than 60 psi).

Neoprene with one or more reinforcing plies is the standard material used for diaphragms.

Such a material should be able to withstand pressure, have sealing capability, have resistance against wear due to continuous sliding on metal surfaces and be chemically resistant against hydraulic fluids carried by air.

2.1.3. Advantages and Disadvantages

Diaphragm actuators are in wide use by virtue of the following advantages:

1. Low cost in mass production of the main components by die-casting.
2. Simple to maintain due to the small number of parts in a simple assembly and calibration.
3. Easy to manufacture due to the absence of wear, lubrication, calibration and checking problems and to the small number of spares.
4. High reliability due to few moving parts: the most critical ones have been widely tested and guarantee good performance even in difficult and dusty environments and under severe thermal conditions.
5. Low friction leading to total absence of dead band.
6. Suitability for installation of several available accessories (manual operators, positioners, transducers, etc.) without any variation of the main parts of the basic

actuator.

7. Adaptability to operating conditions by virtue of the "range" springs permitting actuator operation even without a positioner or booster.
8. Positioner not mandatory. Its standard design foresees the use of properly suited springs to receive signal directly from the controller.

The main disadvantages of diaphragm actuators are:

1. Short stroke: 100 mm is the maximum stroke, generally capable of covering conventional control valve requirements (globe, angle valves) up to 14 inch in size. Special or rotary motion valves may require greater strokes.
2. Limited force: Limitations in both the maximum control pressure and the range spring restoring force add to reduce the diaphragm actuator performance. Also in cases of large casing actuators (outside diameter of approximately ≅ 600 mm) the net force of air pressure cannot exceed 40 000 N, and the force obtainable by the spring is 20 000 N.

It can be further noted that for rotary valves applications these actuators are required to develop large values of thrust to obtain high values of torque due to their limited stroke.

Nevertheless, under the same torque requirements an actuator with a longer stroke (this means a longer arm) and a lower thrust is preferred, in order to reduce the radial force components loading the shaft supports (see Figure 3).

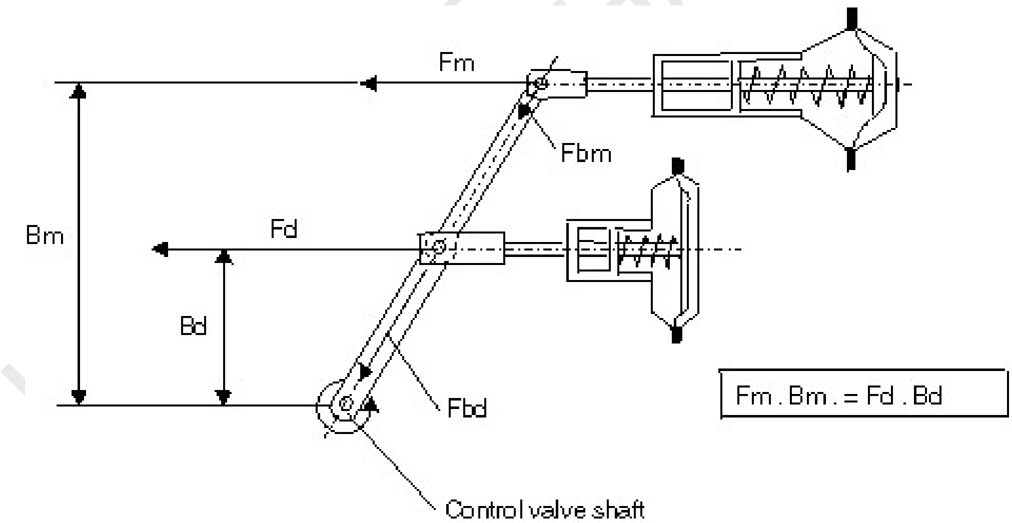

Figure 3. Different actuators applied on a rotary control valve.

1. Large dimensions: Low operating pressures require a large diaphragm area, which in turn requires large casings.
2. Moderate operating speed: In the intermediate working positions of the actuator, a large volume of air exists in the air tight chamber above the diaphragm.

In fact this disadvantage is not significant because very short control valves stroking times (>15 mm s-1) are seldom needed.

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