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RESEARCH ARTICLE OPEN ACCESS

# Characteristic Investigation of Motorized Control Valve

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**Abstract**
The research describes practical procedure to investigate Characteristic of Motorized control valve. Motorized control valve These valves are used to shut off flows just like gate valves and ball-cocks. However, they are also suitable for the fine regulation of flows of materials.
experimental procedure is gone on G.U.N.T test rig RT 396 which can determine the characteristic Motorized control valve according to the recommended procedure.

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## I. Introduction

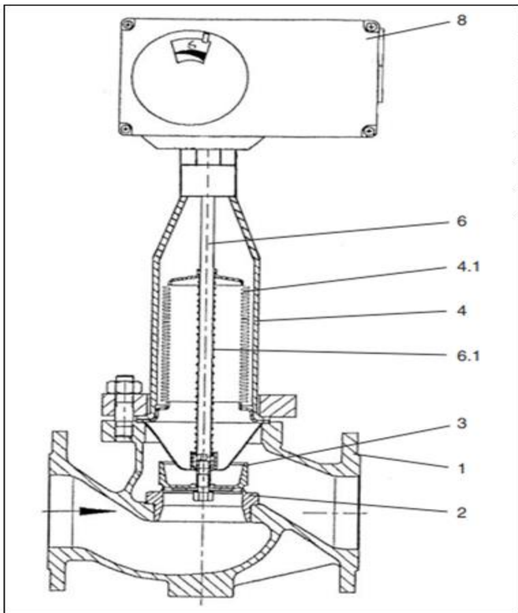
Motorized Control Valves called (MCV) are used for district heating and cooling, HVAC and central heating systems ensure accurate and stable control of water, glycol mixtures and steam. Which improves temperature control and reliability and increases the energy efficiency of the heating system. All of which adds up to increase comfort for the user. The MCV range comprises both regular and pressure-relieved control valves designed to operate in the most demanding applications.

companies offer a comprehensive range of control valves and actuators for virtually every application: central and decentralized heating systems, domestic hot-water systems, district heating and steam.

## II. Advantages of Motorized Control Valves

- Excellent control performance
- Proven lifetime cost effectiveness
- Easy handling and installation
- Increased reliability and operational safety

## III. Construction Of Motorized Control Valves




| | |
|---|---|
| 1 | Valve body |
| 2 | Seat |
| 3 | Disk |
| 4 | Backing housing |
| 4.1 | Bellows backing |
| 6 | Stem |
| 6.1 | Spring |
| 8 | Solenoid actuator |

(Fig. 1) Solenoid actuated control Valve

## IV. Literature survey

4-1 "ISA75.05, Control Valve Terminology," [Online].

A control valve is a power operated device which modifies the fluid flow rate in a process control system. It consists of a valve connected to an actuator mechanism that is capable of changing the position of a flow controlling element in the valve in response to a signal from the controlling system" ISA S75.05 [1].

**4-2** E. Chappel, "ResearchGate: Difference between Pressure Control & Flow control valve," 3 March 2017. [Online].

Flow control is achieved in a system when a liquid is passed through an orifice, creating a drop in pressure & increase in Velocity (Kinetic Energy). But the flowrate on inlet and outlet would be same. In this way pressure can be controlled keeping the flow constant. A flow control valve delivers a constant flow regardless of the pressure drop through the valve. [2].

**4-3** Chapter 1 - Introduction to Control Valves | Global Spec. [Online].

A control valve is a variable restriction, which is capable of being modulated, in a conduit that contains a flowing fluid. ISA S75.05 offers a more formal definition: "A control valve is a power operated device which modifies the fluid flow rate in a process control system. It consists of a valve connected to an actuator mechanism that is capable of changing the position of a flow controlling element in the valve in response to a signal from the controlling system [3]

## V. CONTROL VALVE FUNDAMENTALS

The flow regulation in a valve is accomplished by the varying resistance as the valve is stroked, i.e. its effective cross-sectional area is changed. As the fluid moves from the piping into the smaller diameter orifice of the valve, its velocity increases to enable mass flow through the valve. The energy needed to increase the velocity comes at the expense of the pressure, so the point of highest velocity is also the point of lowest pressure (smallest cross section). The point where the pressure is at the lowest is called "vena contracta". To display the general behavior of flow through a control valve, the valve is simplified to an orifice in a pipeline as shown in the figure below: As the liquid passes the point of greatest restriction (vena contracta); its velocity reaches a maximum and its pressure falls to a minimum. Hence, we would expect the highest velocity at the internal to the valve than on upstream and downstream. Beyond the vena contracta, the fluid's velocity will decrease as the diameter of piping increases. This allows for some pressure recovery as the energy that was imparted as velocity is now partially converted back into pressure (refer pressure-velocity profile below).[7]

## VI. Test Rig

The pump and valve test rig (Figure 2) permits the determination of characteristic Motorized Control Valve Three digital displays show:

- speed (2)
- electrical power (3)
- Flow rate (4).

The unit is equipped with four pressure gauges:

- Differential pressure gauge (5).
- Differential pressure gauge (6).
- Delivery pressure gauge (7).
- Suction pressure gauge (8).


(Figure 2) Test rig

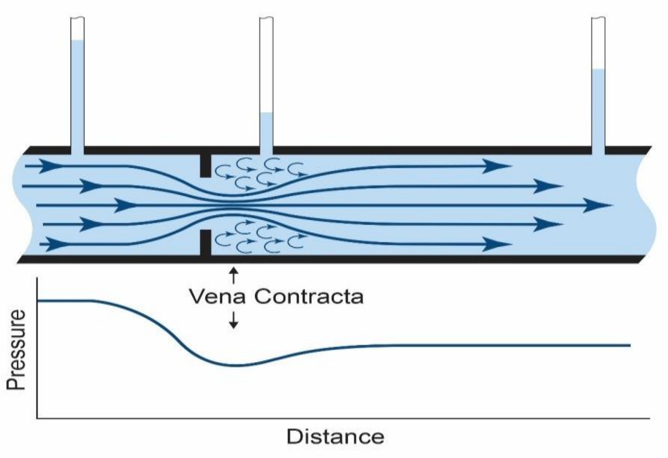
## VII. Equations Describe Valve Flow:

**7-1 continuity equation:**

It is important to understand how the pressure-velocity conditions change as the fluid passes through the restriction. This is best described by the continuity equation:

$$A_1 \times v_1 = A_2 \times v_2$$

Where:
v = mean velocity and
A = flow area.
• Subscript 1 refers to upstream conditions
• Subscript 2 refer to downstream conditions




(Figure 3) (vena contracta)

**7-2 Flow Coefficient ($k_v$).**

For sizing a control valve, we are interested in knowing how much flow we can get through the valve for any given opening of the valve and for any given pressure differential. The relationship between pressure drops and flow rate through a valve is conveniently expressed by a flow for incompressible fluids like water, a close approximation can be found mathematically by the following equation.

$$K_v = Q \times \sqrt{\left(\frac{\Delta p_o \times \rho}{\Delta p \times \rho_o}\right)}$$

Were,
Here:
$\Delta p_o$ : Pressure loss in valve under standard conditions (98100 Pa, in practice 100 000 Pa = 1 bar)
$\rho_o$ : Density of water under standard conditions in kg/m$^3$
$\Delta p$ : Pressure differential at valve with operating conditions in Pa
$\rho$ : Density of fluid with operating conditions in kg/m$^3$
Q : Flow through valve with operating conditions in m$^3$/h
$K_v$ : Flow under standard conditions in m$^3$/h
H : Valve Stroke

## VIII. Experimental Procedure

8-1 **start up;**

1. Switch on the pump .
2. Adjust the pump speed to 2900 rpm.
3. Start the globe valve at 100 % stroke .
4. Record readings for Q , Δ p.
5. Calculate Kv from equation

$$K_v = Q \times \sqrt{\left(\frac{\Delta p_o \times \rho}{\Delta p \times \rho_o}\right)}$$

6. Repeat step 2 to speeds 2600,2300,2000 r.p.m
7. Repeat step 3 to strokes 80 , 60,40,20 %

8-2 **Measured values and calculations**

| Valve Stroke 100 % | | | |
|---|---|---|---|
| Pump speed r.p.m | Q .m$^3$/hr | Δ p bar | $K_v$ m$^3$/hr |
| 2900 | 560 | 1.55 | 25.6 |
| 2600 | 505 | 1.4 | 25.7 |
| 2300 | 436 | 1.05 | 23.6 |
| 2000 | 396 | 0.9 | 25.0 |
| $K_v$ mean | | 24.99 | |

| Valve Stroke 80 % | | | |
|---|---|---|---|
| Pump speed r.p.m | Q .m$^3$/hr | Δ p bar | $K_v$ m$^3$/hr |
| 2900 | 506 | 1.75 | 22.96 |
| 2600 | 460 | 1.5 | 22.54 |
| 2300 | 410 | 1.15 | 22.95 |
| 2000 | 356 | 0.95 | 21.92 |
| $K_v$ mean | | 22.59 | |

| Valve Stroke 60 % | | | |
|---|---|---|---|
| Pump speed r.p.m | Q .m$^3$/hr | Δ p bar | $K_v$ m$^3$/hr |
| 2900 | 420 | 1.95 | 18.05 |
| 2600 | 376 | 1.75 | 17.06 |
| 2300 | 360 | 1.55 | 17.35 |
| 2000 | 297 | 1.05 | 17.39 |
| $K_v$ mean | | 17.46 | |

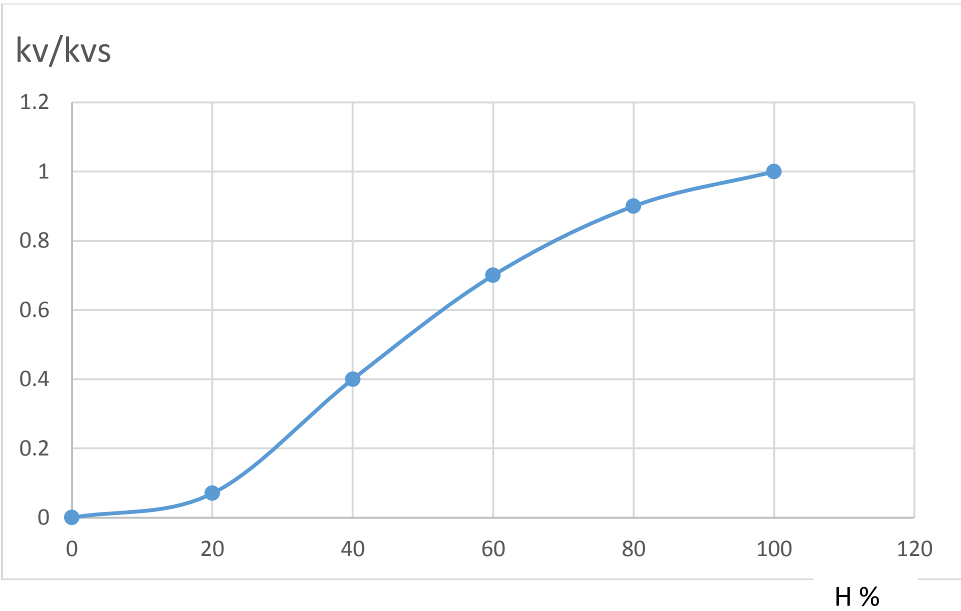
| Valve Stroke 40 % | | | |
|---|---|---|---|
| Pump speed r.p.m | Q .$m^3$/hr | Δ p bar | $K_v$ $m^3$/hr |
| 2900 | 245 | 2.2 | 9.91 |
| 2600 | 218 | 1.9 | 9.49 |
| 2300 | 194 | 1.5 | 9.5 |
| 2000 | 171 | 1.15 | 9.57 |
| $K_v$ mean | | 9.6 | |

| Valve Stroke 20 % | | | |
|---|---|---|---|
| Pump speed r.p.m | Q .$m^3$/hr | Δ p bar | $K_v$ $m^3$/hr |
| 2900 | 47 | 2.35 | 1.84 |
| 2600 | 42 | 2.1 | 1.74 |
| 2300 | 38 | 1.75 | 1.72 |
| 2000 | 32 | 1.3 | 1.68 |
| $K_v$ mean | | 1.75 | |

**Measured values and calculations**

The valve characteristic curve is created from the averaged $k_v$ values. $k_v$ is referred to $k_{vs}$. Here $k_{vs}$ is the averaged kv value with a valve stroke of 100% (valve fully open): $k_v$ = 24.99

| **H % stroke** | **20** | **40** | **60** | **80** | **100** |
|---|---|---|---|---|---|
| **$K_v/K_{vs}$** | **0.07** | **0.4** | **0.7** | **0.9** | **1** |




Motorized valve characteristic curve

## IX. Conclusion

- The experiment results are not typical to valve charts of factory. The fitter fits the motorized actuator drive to the valve at the factory. Here divergence may occur on installation of the plug stem or other components so that the valve cone may no longer be able to execute the full valve stroke of 12 mm.
- The valve characteristic curve is more or less linear with a stroke between approx. 60% and 100%. It also tends to be linear with a valve stroke between 20% and 60%, although the slope is greater here

- The equation shows that the flow rate varies as the square root of the differential pressure across the control valve. Greater the pressure drop, higher will be the flow rate.

## X. Recommendation

The flow regulation in a valve is accomplished by the varying resistance as the valve is stroked, i.e. its effective cross-sectional area is changed. As the fluid moves from the piping into the smaller diameter orifice of the valve, its velocity increases to enable mass flow through the valve. The energy needed to increase the velocity comes at the expense of the pressure, so the point of highest velocity is also the point of lowest pressure (smallest cross section). The point where the pressure is at the lowest is called “vena contracta”.

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