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WHITE PAPER

MOTOR SELECTION FOR HVAC GAS VALVE ACTUATORS

HVAC systems require reliable and cost-effective fluid flow control through appropriate motor technology selection for valve actuation

The purpose of this paper is to highlight and compare motor technologies available for the actuation of gas valves used in heating, ventilation and air conditioning (HVAC) systems. HVAC systems include low cost, electronically controlled valves for fluid flow modulation and shut-off purposes, typically requiring medium torque at low speed. Motor technologies available for actuating these valves have different inherent characteristics that could be advantageous depending on the specific application requirements.

INTRODUCTION

HVAC systems are used to regulate temperature and air quality in enclosed areas, keeping people warm in winters and cool in summers. The heating system can include boilers, pumps, radiators, meters and other components that are usually driven by combustion of natural gas to heat air or water, which is then circulated around in the space to be conditioned.

The operation of an HVAC system revolves around accurate control and metering of gas/liquid flow through sensing and modulating elements. The modulation element can be achieved in a variety of ways, typically using some form of flow control valves and/or isolation (shut-off) valves.

BASIC WORKING PRINCIPLE OF FLUID FLOW CONTROL VALVES

In the example of a flow control valve, the valve stem is moved up or down inside the valve body. This causes the needle, or sealing element at the end of the stem, to restrict

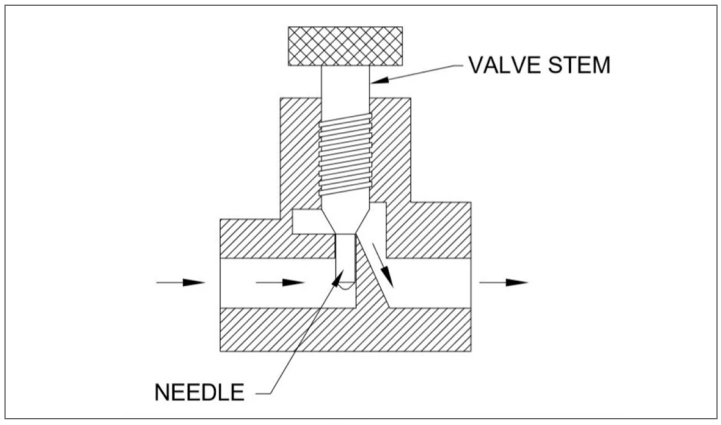


Figure 1 - Needle-type flow control valve

the flow of fluid to the desired level. In a stem-and-ball design valve, a ball, which rotates about the valve axis, has a cut-out that allows full-flow at one position and variable flow as the stem rotates to the shut position.

The movement of the valve stem can be designed for manual operation (an operator adjusting a screw-needle position), or as an electronic actuated version where an actuator moves the stem controlled by a motor and drive system.

TYPES OF ELECTRIC MOTION SYSTEM FOR GAS VALVE ACTUATORS

The available motion technologies that fit the performance and cost requirements of the gas valve actuator narrow down to either a brush or DC stepper motor. While both technologies have the necessary torque and speed capabilities for the application, to develop a complete motion solution the designer needs to determine the configuration of the overall system. At broader level, the electric motion system comprises of a motor and position system. Following are the options that need to be selected, based on the system design intent.

Options Available for Overall System Configuration

Motor Technology	Brush DC
	Stepper
Type of Actuator Motion	Rotary
	Linear
Position System	Closed Loop Control
	Open Loop Control

For the gas valve actuator, the combination of motor technology, type of motion and position system from the previous table options determine the complexity and cost of the complete motion solution. The various options of the electric motion system are:

- Brush DC motors provide rotary motion or linear motion through addition of an external lead screw (to convert rotary to linear motion). In both cases, any positioning requirements would require an encoder to provide closed loop operation.
- Stepper motors provide rotary motion or linear motion through addition of an external lead screw. In both cases, open loop control is possible directly with the driver. In case a closed loop control is required, an encoder is also required.
- Linear stepper motors provide an integrated lead screw into a single robust package for direct linear motion output with open loop control with the driver.

Possible System Configurations for Either Motor Technology

Motor Technology	Brush DC	Stepper/Linear Stepper
Type of Motion	Rotary or External Linear	Rotary, External Linear, or Integrated Linear
Position System	Closed	Closed/Open Loop
Torque/Speed	Very Wide Range	Limited Range
Cost	Medium to High	Low

MOTOR SELECTION FOR GAS VALVE ACTUATORS

DC Motor

DC motors are simple electric machines that rotate when DC power is applied. They do not require complex electronics to drive the motor. However, if linear motion is required for the application, a DC motor solution needs an additional lead screw and gearing system to convert rotational to linear motion. The DC solution would also need a feedback mechanism in the form of an optical sensor or encoder to accurately control the linear position. Some designers may also add a braking system to improve positioning accuracy, due to the high inertia of the motor's rotor.

- Torque: up to 160 mNm
- Speed 1k – 10k RPM
- Position control: external
- Rotary motion output
- Simple electronics for operation

Figure 2 - Brush DC Motor

Typically, DC motors (ideal for gas valve applications) have output speeds of 1,000 to 10,000 rpm and provide torque up to 160 mNm. Depending on the working load point of the application, a gear box and/or lead screw system can be added.

Stepper Motor

Stepper motor is a DC electric motor that is rotated through several small, equal and discrete increments called steps. Driving a stepper motor requires a dedicated control unit. Stepper motors have inherent characteristics owing to its construction and design that can be advantageous to the application. The motor can be operated in open loop with good accuracy provided motor is properly sized, giving the stepper motors built in positioning control (discrete steps). Further, the design of the stepper motor makes it possible to use the detent torque for holding position, and provides excellent response to start, stop and reverse the application.

- Torque: up to 170 mNm
- Speed: < 1k RPM
- Position Control: Open Loop
- Rotary Motion Output
- Driver Required For Operation

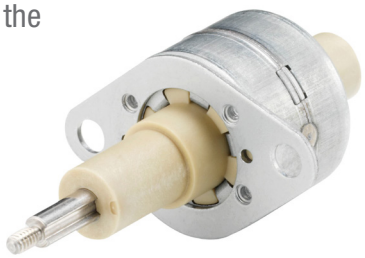
Figure 3 - Can Stack Stepper Motor

If linear motion is required for the application, a stepper motor solution needs an additional lead screw and gearing system to convert rotational movement to linear movement.

Typically, stepper motors can be used for output speed up to 1,000 rpm and provide torque up to 170 mNm. Actual torque and speed would also depend on driving mode (full step, half step or micro-step). Depending on the working load point of the application, gear box and lead screw systems can be added.

Stepper Linear Actuator

A stepper linear actuator is comprised of a can stack stepper motor with a threaded rotor and an integrated lead screw which provides direct linear motion in a compact package. The stepper linear actuator lead screw moves up and down in discrete step increments when electrical pulses are applied. One of the important advantages of using a stepper linear actuator is its ability to be accurately controlled in an open loop system, meaning no expensive feedback device or braking system is required for positioning.



- Force: up to 100 N
- Speed: up to 80 mm/s
- Position control: open loop
- Linear motion output
- Driver required for operation

Figure 4 - Stepper Linear Actuator

Typically, linear actuators can be used for output speed up to 80 mm/s and provide force up to 100 N. Actual force and speed would also depend on lead screw efficiency and driving mode (full step, half step or micro-step). Depending on the working load point of the application, a gear box can be added.

CONCLUSION

Comparison of Motion Solutions

Parameters	DC Motor Solution	Step Motor Solution
Speed	***	**
Force/Torque (at low speed)	***	**
Operating Temperature	**	**
Life	**	***
Cost Effectiveness	*	***
Simplicity of Motor Operation	***	**
Ease of Position Control	*	***
Efficiency	***	*

Key considerations for motor selection for valve actuation in HVAC application:

Gas valve applications will vary by valve stem type and desired operation and precision. The variety of application requirements that determine the best solution include:

- Maximum and running torque/force required
- Speed requirement: typically force/torque requirement is required at low speeds for valve applications.
- Price of complete solution
- Control system: typically closed loop control is not required
- Operating temperature of application environment
- Type of motion needed for actuation (rotary or linear motion)
- Expected lifetime of solution before replacement
- Linear or rotary resolution required
- Maximum current and voltage available

Based on the motion solutions available and HVAC application requirements, the stepper motion solution is most suitable for a rotary application, or the linear step motor for the linear application.

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