

## **Technical communication**

### **NEW ULTRASONIC PIEZOELECTRIC ROTARY VALVE FOR FAST AND ACCURATE FLOW CONTROL OF FLUIDS PROVIDES HIGH PERFORMANCE, ENERGY EFFICIENCY, AND IMPROVED SAFETY**

#### **Conventional motorized control valves**

*Motorized control valves are to be found wherever there is a need to regulate the flow of fluids - from natural gas pipelines to automobile fuel flow controls, to drug or food mixture dosing control systems. Many critical applications demand high accuracy and fast reaction times, combined with stringent requirements on reliability and safety. In all cases the ability to meet the requirements relies on the intrinsic characteristics of the control valve, and in particular its motor and control system. Conventional motorized valves have opening/shutting time of typically tens of seconds. Precise regulation of flow rate through the valve is determined by the angular resolution of the motor, which with traditional motorized valves is 1 to 5 degrees. The reaction (response to a demand) time for traditional valve systems is also slow (typically 1 or 2 seconds). Along with these limitations, traditional motor control systems can be large and heavy (e.g. 1 to 2 kg or more) and require quite high electrical currents, which can raise safety issues where inflammable fluids are concerned.*

*The limitations of conventional motorized control valves have very recently been addressed with the introduction by Discovery Technology International (DTI) of a brand new class of motorized valves based on a novel piezoelectric control. In this communication we discuss the performance characteristics of the new piezoelectric valve compared to conventional valve systems that rely on electromagnetic control.*

#### **Novel piezoelectric rotary valve**

The piezoelectric valve (patent pending) is based on a unique type of piezoelectric rotary motor (piezomotor) system. Its principle of operation is different from the conventional moving coil in a magnetic field system found in all electromagnetic (EM) motors. Instead, the piezomotor relies upon the piezoelectric effect to create rotation in a drive shaft. Its demand for electrical current is low and because it is constructed from ceramic material its weight is small compared with the copper coils and iron magnets used in EM motors. The principle of operation and construction result in basic characteristics that enable it easily to outperform the conventional electromagnetic motors used in valve control systems. (For further technical details on the new piezomotor see DTI's Technical Communication UPZM/02 - December 2008).

#### **Key performance features of piezoelectric valve**

##### *Operational range*

The special characteristics of the piezoelectric valve mean that just one valve could be used for both fast-action (cut-off) and precision-action (flow-control) applications, - which with conventional valves would require two different devices. For example, the non-reversible version (see below) of the piezoelectric valve offers a far superior performance as a cut-off valve than the conventional valve. These benefits include a 100-times faster response time and 10 times shorter cut-off (open/close) time. The reversible version of the new piezoelectric valve has the same response and open/close times, but in addition also has an angular resolution at least 50 times better than a conventional motorized valve system. It can therefore provide intrinsic accuracy in precision flow-rate control several orders of magnitude better than conventional (EM) motorized systems.

The reversible version of the new piezoelectric valve will therefore simplify and reduce the cost of flow-rate regulation and also of cut-off control systems by allowing a single (piezoelectric) valve control system to regulate both functions and moreover with a much superior performance in both situations.

*Reliability and safety*

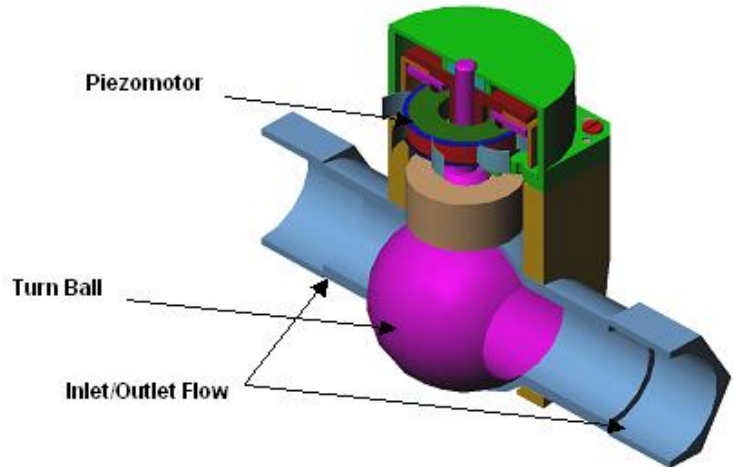
In the event of a stalled/jammed valve, unlike an EM motor, the piezomotor will not overheat or burn out. In addition, the piezomotor will not generate sparks; which is clearly an advantage in applications involving flow control of flammable fluids. The piezoelectric valve’s fast response and rapid “open/close” times considerably reduce the risk of uncontrolled spills in emergency shut-off situations, where flammable and/or hazardous chemical substances are involved.

*Power consumption*

The piezoelectric valve consumes minimal electric power, approximately 1 to 6 Watts, depending on whether it is in a stepper mode or continuous drive mode. This is commensurate with most requirements for remote site applications, where powering from small solar panels and/or dry cell batteries is desirable. The piezoelectric valve also consumes no power at all when in a fixed position, in contrast to conventional (EM) motors, which require electrical power to hold position. Furthermore, the full self-breaking torque of the rotary motor is applied at any fixed position, which ensures unprecedented stability.

**Design of the piezoelectric valve**

A design schematic of the non-reversible piezoelectric valve is shown in Figure 1. The piezoelectric valve consists of input and output tubes, a spherical saddle, a turn ball and a piezomotor with casing. The regulator function of the valve is performed by precise rotation of the turn ball attached to the piezomotor. In the non-reversible piezoelectric valve (“cut-off valve”) rotation is executed in steps of 90 degrees in one direction only, resulting in alternating conditions of open and closed. This facilitates a very simple design, as shown in Figure 1. This design employs a simple two-position encoder to sense the open/closed conditions.



**Figure 1. Non-reversible “cut-off” piezoelectric valve (depicted in the “Open” position).**

The reversible (two-way) version piezoelectric valve (not shown) enables rotation of the turn ball in either direction, providing continuous control of flow rate. An optical encoder mounted on the piezomotor shaft monitors its position, and the feedback is used to control precise overall regulation. The facility for external feedback under the separate control of the user may also be provided.

Figure 2 shows a prototype piezoelectric valve used with a standard 1/2 inch pipe. Typical specifications of the valve system include: -

- Response time.....50µs
- “Open/Closed” time.....< 1s
- Angular resolution .....1 arc-sec
- Voltage.....12V
- Stepping mode power (“flow control” mode).....1 W
- Continuous mode power (“cut-off” mode).....6 W
- Consumed power when static (in holding position).....0 W
- Weight (with the 1/2” valve).....250g
- Compatible pipe sizes - 1/2”, 3/4”, 1”, 1 1/2”, 2”, 3”, 4”, 5”.
- (Metric-size valves are also available).



**Figure 2. Prototype piezoelectric valve for a 1/2” pipe**

## Summary of piezoelectric valve advantages over a conventional flow-control valve

- 100 times better resolution (i.e. 1 arc-sec) and accuracy of flow control
- 100 times faster response to demand time (i.e. 50usec)
- 10 times faster “open/closed” speed of operation (i.e. <1 sec)
- Greater versatility - usable as fast action cut-off valve, or ultra precise flow-control, or both.
- Improved safety - no sparks lowers risk with flammable fluids
- Low operational power and low voltage with zero power demand when static
- Improved reliability – zero overheating or motor burnout even when valve is jammed/stalled.
- Reliable control – using either analog or digital controllers
- Lightweight design 3-4 times lighter than comparable conventional systems.
- Economical to implement and use
- Green motor technology, environmentally friendly design, energy efficient, scalable technology.

## Alternative Pinch Valve Design

An alternative pinch valve design (patent pending) has also been developed by DTI (not shown). The new pinch valve provides significant advantages over traditional pinch valves used in flow control applications. For further details contact DTI.

## Areas of application

The piezoelectric valve has a very broad range of industrial applications. These include food processing and pharmaceutical, gas/oil pipelines, power reactors, chemical reactors, steam/ water pipelines, and vacuum systems. In addition, the piezoelectric valve offers advantages in the further development of power systems (internal combustion, turbojets, steam and gas generators, and even in nuclear reactors), and hydraulic systems requiring both fast response and highly accurate control. The technology will also find uses in the development of “thermo-gas-hydraulic” systems working in real time flow-control mode.

In addition to the general industrial uses mentioned, the piezoelectric valve offers significant commercial potential at the domestic level. The valve would enable precise regulation of household water and gas supply with a noiseless, miniature and energy efficient control element. Moreover, it offers potentially significant improvement in safety margins.

**END**

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## Commercial inquires

Discovery Technology International would be pleased to consider commercial inquires for custom piezoelectric valve systems. Our engineering team is capable of developing custom solutions for providing novel piezoelectric valves with different sizes and parameters to meet many application requirements.

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