Computerized Regulation of Corrosive Liquid Flow Rates

In certain segments of industry, it has been demonstrated that for every percent improvement in the maintenance and setting of a desired flow rate, process costs will be dramatically reduced. Thus, the incorporation of equipment designed to provide accuracy improvement will provide a very quick return. "Smart" flow controllers, operated by computer, are fulfilling the requirements for industry success.

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As industry relentlessly searches for more cost efficient methods, computerization of many industrial processes has become commonplace. Automatic regulation and control of very corrosive liquids in chemical, plating and semi-fab process applications is in demand. Requirements for higher levels of precision and tight control of liquid flow rates under widely varying process conditions are driving flow controller manufacturers to develop and offer micro-processor based "smart" controllers to meet commercial requirements.

For the large flow rates so common in the chemical industry, manufacturers of sophisticated flow controllers have largely fulfilled industry's current requirements. But there are still largely unfilled requirements to satisfy commercial needs for very low flow rate liquid flow controllers capable of being operated via computer. This article describes one such "smart" flow controller specifically designed to automatically control the flow rate of both high purity and corrosive liquids with a repeatability of ±0.25 percent full scale. This type of flow controller can precisely regulate flow rates as low as 15 ml/min to 8 or more liters/minute of low viscosity liquids such as hydrochloric or hydrofluoric acid. Flow controllers of this type are designed to function in process applications involving liquid mixing, blending and batching in addition to the precise regulation of liquid flow streams.

A typical corrosion resistant liquid flow controller consists of two integrally attached devices; a microprocessor based servo valve controller and a flow sensor that serves as the feedback element. Figure 1 shows a specific version of a low flow rate corrosive resistant "smart" liquid flow controller and its companion control unit. This particular flow controller automatically regulates and adjusts flow rates to set point values as commanded by the user's computer system. It has been designed to hold such flow rates even if up-stream or downstream line pressures vary widely. Accuracy levels of better than ±l percent full scale can be achieved. Sensor response is almost instantaneous, allowing controller to respond rapidly. All wetted surfaces are P.T.F.E. Teflon® sapphire with usage of Kalrez® "O" ring packings. Flare type tube fittings are incorporated to maintain the high level of purity of fluids passing through the flow controller.

The heart of the flow controller is the flow sensor, which uses a dynamically balanced P.T.F.E. Teflon® Pelton type turbine wheel to determine the flow rate. The rotation rate of the turbine wheel is linear over a wide flow rate dynamic range. The sensor utilizes an infrared photodetector to measure the flow rate. An

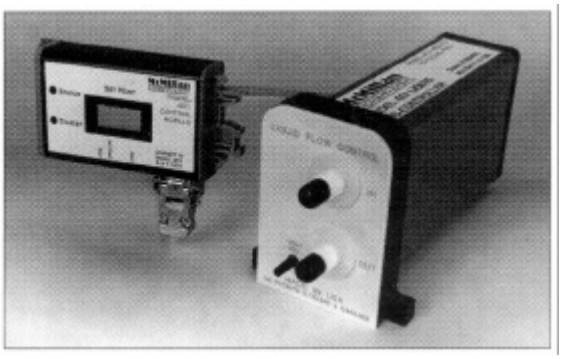

FIGURE 1. "Smart" liquid flow controller and companion control unit.

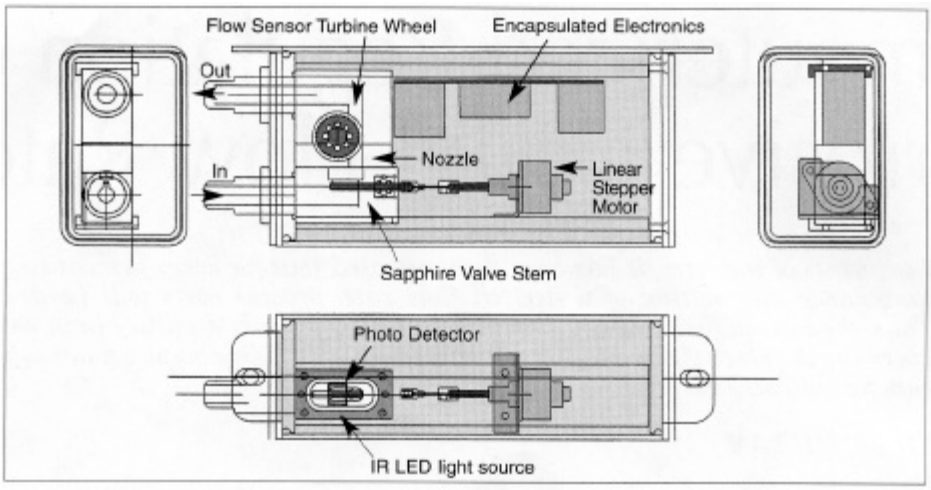

FIGURE 2. Key Features of Liquid Flow Controller.

infrared beam is interrupted by the turbine wheel as it rotates. Thus, on each rotation of the turbine wheel, electrical pulses are generated. Processing circuitry provides a feedback signal to the valve controller. A bidirectional stepper motor moves a small sapphire needle valve in response to any error between the desired flow and the actual flow rate as measured by the flow sen- sor. By means of this servo feedback loop arrangement, very precise flow rate settings may be set and maintained automatically over long periods of time. Figure 2 shows key features of the flow controller.

Figure 3 depicts a typical liquid blending system wherein five different liquids are automatically blended according to instructions fed to the flow controllers via computer. Note that each flow controller is remotely regulated by units mounted in a compartment separate from the corrosive fluid compartment that houses the flow controllers. All control units have a digital display to locally observe flow rate setting. Also, indicator LEDs inform operator of flow controller status and can detect problems, including low pressure to the flow controller, etc. Control units can operate independently, or serve as an interface to the process computer control system.

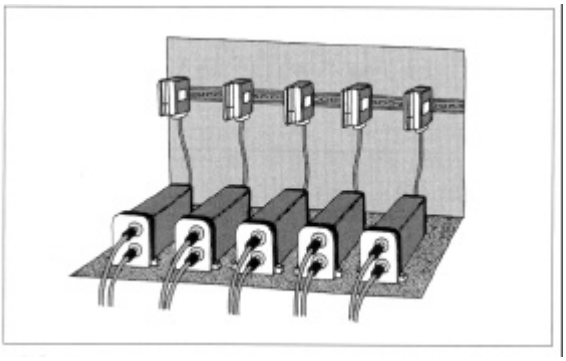
FIGURE 3. Showing five liquid flow controllers blending five different liquids automatically by computer control.

Continuous, active flow control of highly corrosive liquids by using "smart" liquid flow controllers such as the one described can vastly improve accuracy of flow rates. It has been shown that accurate mixing, blending and/or diluting can reduce waste of high cost chemical liquids.

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