Achieving Affordable Precision Liquid Flow Measurement at Low Flow Rates

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In advanced research and development laboratory equipment, as well as in many critical processes, precise liquid flow measurement is required. Such applications need a cost-effective solution that provides accuracy (including linearity) of better than ±0.5% of full scale, especially at flow rates less than 10 liters per minute.

> A microturbine flow sensor can provide very repeatable analog outputs at a very affordable cost...

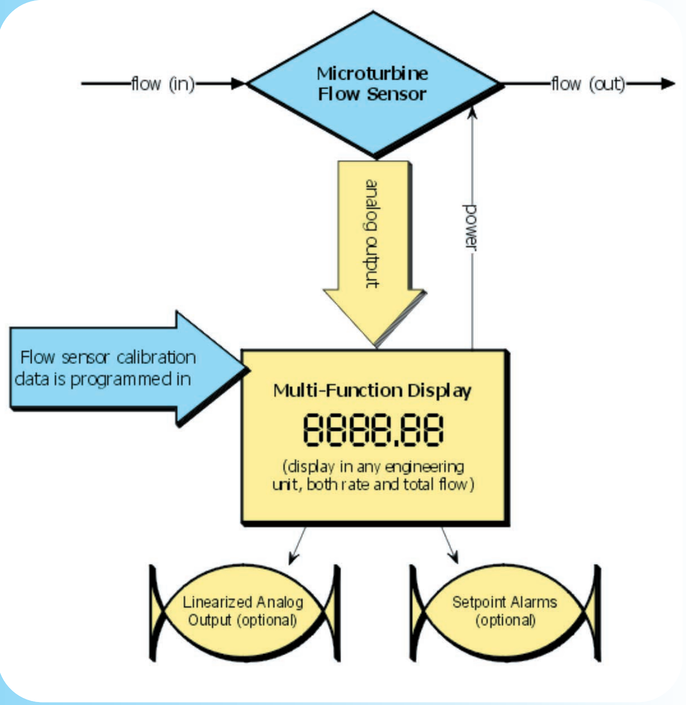

Figure 1. *The signal path of a system incorporating a microturbine flow sensor and multi-function display.*

Many technologies can provide accurate and linear flow measurement in the lower flow ranges, but the cost can be prohibitive. Coriolis, thermal mass, and other designs may be available that fit the required specifications, but the price of these can easily reach into the thousands of dollars (U.S.). It is not feasible for most laboratories, industrial facilities, or equipment manufacturers to spend such a large amount of funds on low-flow liquid flow measurement.

Exploring Other Options

In order to keep the price at a reasonable level, other options must be explored. Accuracy includes many different factors, such as linearity, repeatability, calibration errors, etc. In most cases, though, linearity makes up the most significant deviation. Since linearity is the crucial factor, it may be possible to start with an affordable sensor and feed that signal into a device to linearize it. This affordable sensor would have to measure the required flow ranges and provide a repeatable analog output. Repeatability would be crucial. It would ensure that the device always provides the same output when any given flow rate passes through the sensor. That repeatable output could then be fed into a device that could linearize the output, display it, and retransmit a linearized signal. By minimizing linearity errors, and using a sensor with excellent repeatability, accuracies of ±0.5% of full scale or better could be attained.

Many low cost liquid flow sensor technologies are available. Rotameters provide low cost flow indication, but do not feature repeatable analog outputs. Differential pressure flow sensors do provide analog outputs, but most incorporate a dual-sensor design, which can cause problems with zero drift and output offset.

A microturbine flow sensor would be able to provide the repeatable output. These flow sensors can provide very repeatable analog outputs (±0.2% of full scale

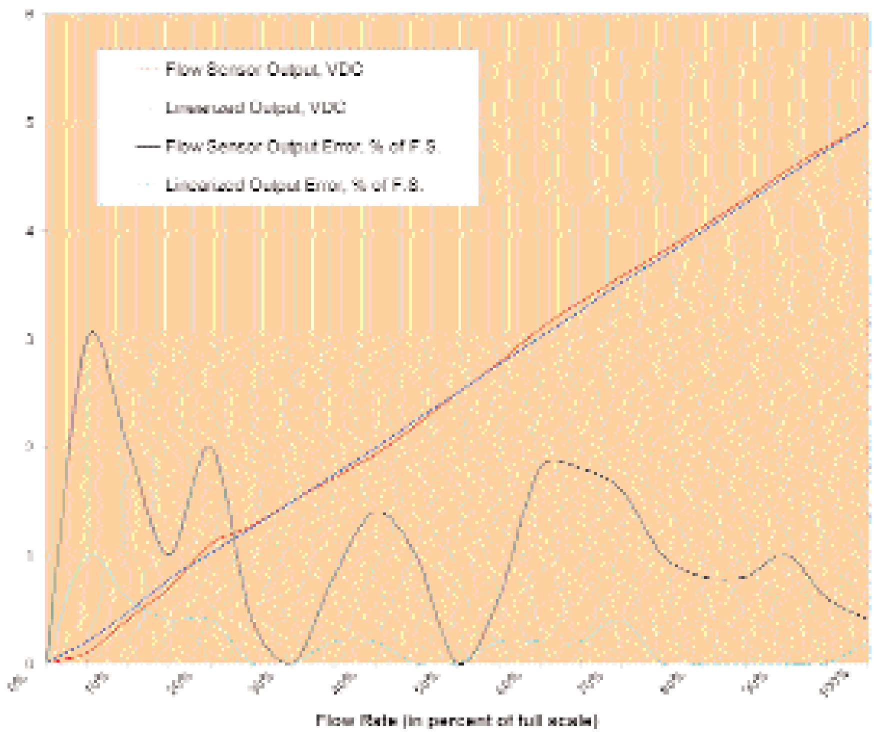

Figure 2. *Chart of typical improvements in linearity using multi-function display with microturbine flow sensor.*

or better) at a very affordable cost - often 20 times less than a comparable coriolis or thermal mass flow sensor. They are capable of measuring as low as 13 mL per minute, with flow ranges up to 10 liters per minute. They can be configured to work well with low viscosity fluids.

However, the standard accuracy (including linearity) of microturbine sensors is usually not ±0.5% of full scale or better, so another device would also be required to achieve the desired accuracy. A calibration data sheet usually accompanies each flow sensor, showing the actual output of the sensor at several points throughout the flow range.

Microturbine flow sensors, unlike coriolis sensors, are sensitive to changes in viscosity. Therefore, a sensor calibrated for water will not fall within stated specification for more viscous fluids, but will maintain stated repeatability. Therefore, an external device would be required to linearize the output.

A computer data acquisition system could accept the input of the microturbine flow sensor and linearize it. If this functionality is not already included within a piece of equipment, though, it can be quite costly and difficult to design and implement.

A multi-function display, with built-in linearization, would accept the input of the microturbine flow sensor, linearize it, and display the linearized data. Further, the display could retransmit the linearized signal should the application require a linearized analog output in addition to the display. Since such a display is designed for this function, the cost can be considerably less than other options. Figure 1 shows how such a system might be configured. This device could also be used to make adjustments for fluids of different viscosities.

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To reach the required linearity (better than ±0.5% of full scale), the display would have to allow the user to input several calibration points from the flow sensor calibration data sheet. The display would then have to generate a new output vs. flow curve and display the corrected results.

As an example, consider a flow sensor that provides a 0-5 VDC analog output across a range of 0-5 L/minute. This flow sensor outputs 4.10 VDC at 4.0 liters per minute, or an error of +2.0% full

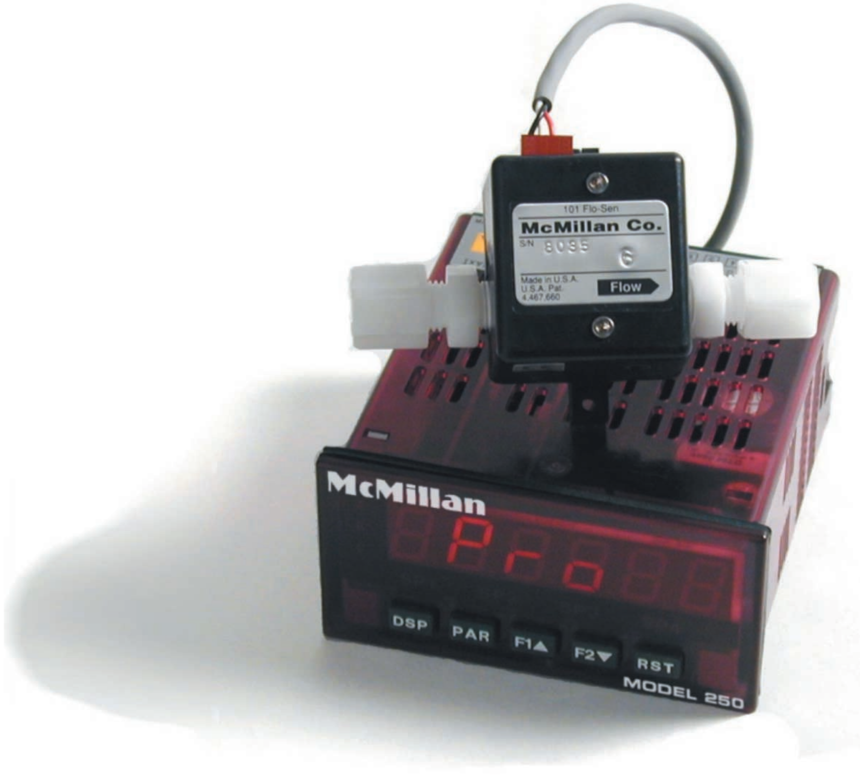

Figure 3. *Example of a microturbine flow sensor and multi-function display system. Shown are the McMillan Model 101 Flo-Sensor and the Model 250 Multi-Function Display.*

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scale. The user would program this information into the display. When the flow sensor outputs 4.10 VDC to the display, the display would correct the output and display 4.00 L/minute. It would also retransmit a 4.00 VDC signal. This same information could be entered into the display for up to 16 calibration points.

This information can be programmed into the display at the factory, so that the manufacturer or laboratory user would not need to calibrate the equipment before use. If fluids of different viscosities are being used, the factory could also enter this calibration information into the display.

In this way, the standard linearity of the microturbine flow sensor (±3.0% full scale) could be corrected, providing signal accuracy better than ±0.5% of full scale. Figure 2 shows a typical output of a standard microturbine flow sensor compared with that of the linearized, improved output using the multi-function display.

Conclusion and Application Concepts

A system composed of a microturbine flow sensor and multi-function display can meet these increasingly critical specifications of precision liquid flow sensing applications - at a fraction of the cost of other technologies. An example of such a system is shown in Figure 3.

Further, use of a multi-function display would add several other functions, including real-time flow display, total flow display, and setpoint alarm capabilities. The display could be programmed to display flow in any engineering unit, and can retransmit a linearized output signal. It would also allow for viscosity corrections when fluids other than water are being measured.

The display will also provide an excitation voltage that can be used to power the flow sensor, reducing the cost of the system by eliminating one power supply.

The microturbine flow sensor wetted parts could make use of several materials, including plastic or metal. For corrosive applications, units could even be made using PTFE or stainless steel. Compact size of most designs would allow for easy integration into existing or new equipment designs. Since microturbine flow sensors inherently feature excellent repeatability, they are an excellent choice for precision applications.

As laboratory equipment manufacturers continue to advance their technologies, more accurate and linear flow measurement of low flow rates will be required. In order to keep costs down and acquire this information, the use of highly repeatable microturbine flow sensors along with multi-function displays provide a simple, functional solution for such applications.

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