Model F7M Micro Flow Rate Liquid Flow Meter: Improving Process Quality with High Accuracy Micro Liquid Flow Rate Measurement

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1. Introduction

Various methods of measuring flow rate have been proposed and applied to flow meters in the past, [1] each with its advantages and disadvantages, but there is no all-purpose method applicable to any fluid with any properties at any flow rate range. Several flow meters for micro flows of 50 mL/min or less have been put into practical use for limited applications. However, in general industrial markets and in the areas of semiconductor manufacturing, pharmaceutical manufacturing, and chemical analysis, options are limited when the actual use conditions and user's requests (for accuracy, size, installation conditions, etc.) are taken into consideration. [2] In addition, since various types of fluid are involved in processes where flow rate is measured, it may be necessary to input a correction value for each fluid type, depending on the measurement principle of the flow meter.

Under these circumstances, we developed and now sell the F7M thermal micro flow rate liquid flow meter, which can measure micro liquid flow with high accuracy.

Fig. 1. External view of model F7M

2. F7M Micro Flow Rate Liquid Flow Meter

2.1 Measurement Principle

The F7M is classified as a thermal flow meter, and measures flow rate by a power consumption method. A diagram of the measurement principle is shown in figure 2. A fluid temperature sensor is located on the upstream side of the glass tube which forms the flow path, and a heater sensor is located on the downstream side. The surface temperature of the heater is constantly controlled to keep it at a certain level above the temperature of the fluid. Consequently, as the flow rate increases, the amount of heat transferred to the fluid from the heater increases, so the power consumption of the heater is correlated with the flow rate. With this measurement principle, the flow rate is calculated from the consumption power of the sensor-equipped heater.

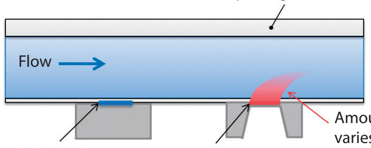

Fig. 2. Measurement principle of the F7M

2.2 Features

Table 1 shows the main specifications of the F7M.

Table 1. Model F7M main specifications

Model No	F7M9010	F7M9030	F7M9050
Measurable flow rate range	0.1 - 10 mL/min	0.3 - 30 mL/min	0.5 - 50 mL/min
Measurement accuracy (when the fluid is water)	±5 % rdg. (at 20 % FS or more) ±1 % FS (under 20 % of FS)		
Repeatability (when the fluid is water)	±1 % rdg. (at 20 % FS or more) ±0.2 % FS (under 20 % of FS)		
Size	Width 22 mm × height 60 mm × length face-to-face 122 mm		
Weight	Approx. 85 g		
Fluid pressure range	0 - 500 kPa		
Pressure resistance	700 kPa		
Protection rating	IP65		

The F7M has the following features.

(1) Micro flow measurement with high accuracy

The F7M has achieved a high accuracy of ± 5 % rdg. and high repeatability of ± 1 % rdg. for flow rates of 20% FS or more in the flow range. This enables reliable measurement of micro flow rates, which has been difficult to do with conventional methods, and contributes to manufacturing process control, quality improvement, and yield improvement.

(2) Smaller pressure loss because of straight flow path

The flow path for the fluid is composed of a fused quartz glass tube and fluororesin joints for the fluid inlet/outlet connections. The flow path is perfectly straight with no obstacles inside. Therefore, the pressure loss is less than 1 kPa even at the maximum flow rate. As a result, the fluid supply pressure can be reduced, contributing to simplification of equipment and energy conservation.

(3) No restrictions on installation location or fluid

The thermal MEMS sensor is on the outer surface of the glass tube, and does not contact the fluid. The fluid-contacting materials are only quartz glass and fluororesin, which are highly resistant to corrosion by various fluids. With an IP65-rating and no metal used on the exterior, the product has excellent durability even in environments where it is exposed to highly corrosive fluid droplets. This allows safe use in various applications.

(4) Compact, light-weight, easy to install

The main part of the flow meter is a compact 22 mm (width) × 60 mm (height) × 122 mm (face-to-face length) with a weight of about 85 g, and it can be installed on both horizontal and vertical pipes. This installation flexibility contributes to the miniaturization of equipment and devices.

2.3 Automatic Setting of Correction Coefficient When Changing Fluid

Depending on the measurement principle of the flow meter, the type of fluid (its physical parameters) may affect flow rate measurement, causing measurement error. Since the F7M uses a thermal power consumption method, the thermal conductivity of the fluid affects the flow rate output. Therefore, for correct measurement, a correction coefficient must be set for each fluid. If the thermal conductivity of the fluid is known, the correction coefficient can be estimated, but often the thermal conductivity of the fluid is unknown, presenting a difficulty.

Accordingly, the F7M has a function that automatically sets the appropriate correction coefficient for the fluid. The signal from the sensor when the fluid is motionless correlates with the thermal conductivity of the fluid (fig. 3.). To use this feature, one presses a button when the fluid flow is stopped to automatically set the correction coefficient for the fluid. This greatly simplifies the adjustment work needed to change fluid types.

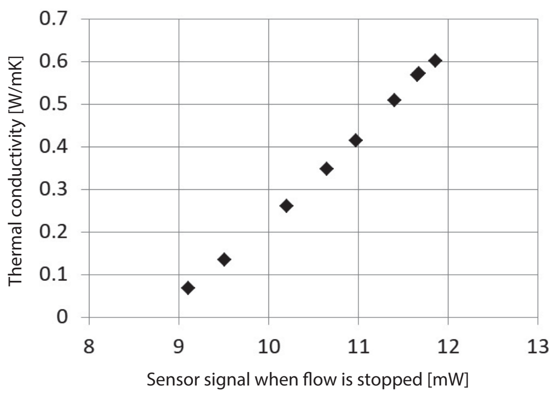

Fig. 3. Relationship between sensor signal and thermal conductivity when fluid is motionless

2.4 JCSS Accredited Laboratory

Calibration of model F7M is done as part of the production process by actually passing fluid (water) through the device. The company's standards for flow rate measurement are established by the Measurement Standard Section of our Technology Standardization Department. This section was certified in October 2019 as an accredited laboratory (reg. No. 0155) for micro flow rate meters for the Japan Calibration Service System (JCSS), which is the registration system for calibration service providers based on Japan's Measurement Act. This is the first JCSS registration certification in Japan for the micro flow rate range where the fluid is water.

Thanks to this certification, users have a high level of confidence in the quality of the F7M, and a measurement traceability system that can be used internationally is being established.

3. Conclusion

Although multiple measurement methods have been put into practical use in the measurement of micro liquid flow rates, the applications in which flow meters have actually been used have remained limited.

Due to its features, the F7M is being adopted for applications where flow meters could not be used until now. Figure 4 shows some recommended applications for the F7M.

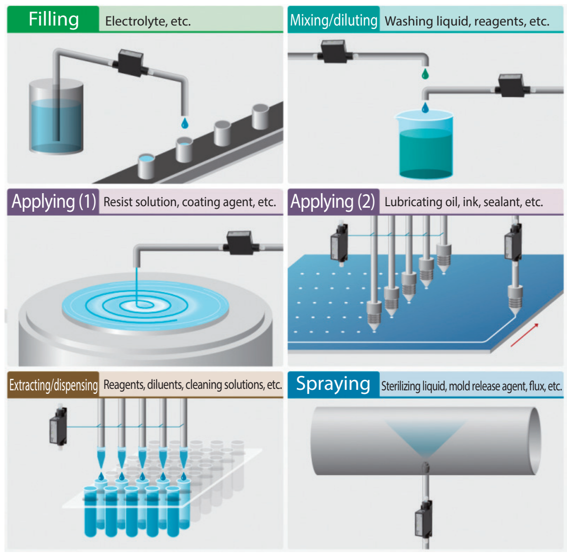

Fig. 4. Examples of recommended applications

In the future, we hope to help our customers to improve the quality of their processes by specification enhancements such as increasing the measurable flow rate range, enhancing responsiveness, and introducing a combined flow controller and flow control valve in order to provide a wider range of applications.

References

(1) Japan Measuring Instruments Federation. Practical Guide to Flowmeters (in Japanese), revised edition, 2012.

(2) Cheong, Kar-Hooi. "A Survey on the Present Circumstances of Small Liquid Flowrate Measurement and its Future Landscape" (Japanese with English abstract), National Institute of Advanced Industrial Science and Technology (AIST) Measurement Standard Report, Vol. 8, No. 1 (2010), pp. 15–43.

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