Energy Saving: Using Thermal Dispersion Air Flow Meter in Wastewater Treatment Plants

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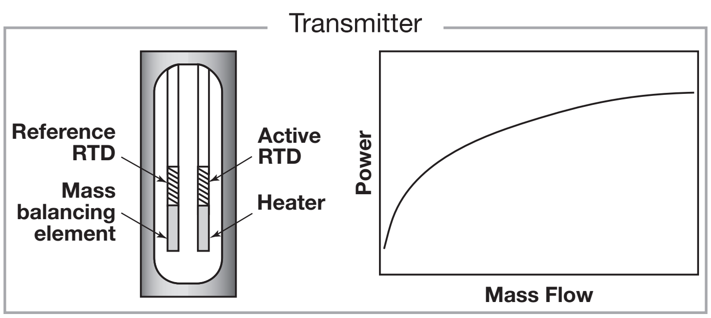
Wastewater treatment plants use various types of processes to remove organic pollutants in their wastewater. Activated Sludge Systems are currently the most widely used biological treatment. In the ***Activated Sludge Process***, a portion of the activated sludge (frequently from the secondary clarifier) is returned to the Aeration Basin. Wastewater flows continuously into the aeration basin where air is injected into the wastewater to mix it with the activated sludge. This also provides the oxygen needed for the microorganisms to break down the organic pollutants.

Compressed air is normally used to provide air into the basins. Controlling the amount of air that is released is very important since it controls the growth and the health of the microorganisms. Flow meters are typically installed in the pipes to measure and control the amount of air to run the system properly.

The cost of energy to produce compressed air has increased tremendously due to the high cost of fuel. Regulating and controlling the air injection not only reduces the amount of energy consumed but also optimizes the operation of the plant.

While there are many technologies to measure the flow rate of air, most of these methods measure the flow rate at the actual operating pressure and temperature, and require pressure and temperature correction to obtain the mass flow. Traditionally, the most common benefit of thermal dispersion flow measurement is the inherent ability to directly measure the mass flow without need for pressure and temperature correction, as required with volumetric gas flow measurement. This not only provides a more useful flow measurement, but also makes thermal very cost-effective.



A Look Into the Technology

Thermal dispersion technologies are based on the operational principle that states the rate of heat transfer by a flow stream is proportional to its mass flow. The flow measurement is accomplished by precisely measuring the cooling effect as the mass (molecular) flow passes the heated sensor. The sensor consists of two elements: the reference, which measures the temperature of the gas, and a second element, which is heated at a variable power to maintain the desired temperature difference between the two sensors.

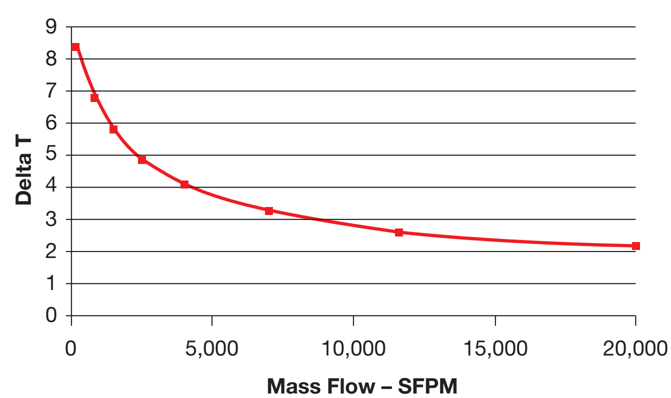
The illustration below left shows the amount of power required to maintain a constant temperature difference between the two sensors. Under low mass flow conditions, there is minimal cooling and little power is required. As the mass flow increases, more power is required. This provides excellent low flow sensitivity and high turndown capabilities.

Different Types of Thermal Mass Flow Meters

There are two different technologies utilized for thermal mass flow measurement.

Constant Power

This technology uses a constant power to the heater. The instrument measures the temperature difference between the heated sensor and the process temperature measured by the reference sensor. At low flow rates, the temperature difference between the sensors is greatest. As the flow rate increases, the temperature difference decreases. A curve of temperature difference versus mass flow rate is shown below.



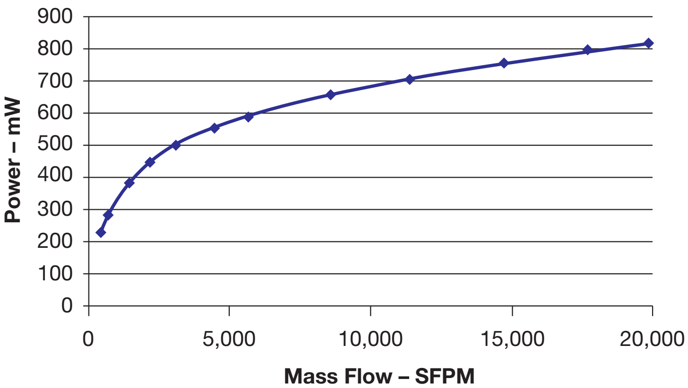
The change in temperature difference with mass flow rate is very large at the low flow rates—this provides the excellent low flow sensitivity.

As the flow rate increases, the temperature difference decreases in a non-linear manner. The curve still shows good sensitivity at very high flow rates, providing high turndown capabilities.

Constant Temperature Difference

This technology maintains a constant temperature difference between the heated sensor and the reference sensor. This temperature difference is determined during the calibration. The instrument controls the amount of power to the heater to maintain this temperature difference. As the flow rate increases, more power is required to maintain this desired temperature difference.

The following curve shows the typical relationship between the power to maintain a constant temperature difference and the flow rate.



As shown, at low mass flow rates, there is little heat transfer, and thus the amount of power required to maintain the desired temperature difference is low. As the mass flow rate increases, the amount of power required to maintain a constant temperature difference increases.

As with the constant power operation, changes in heat transfer are greatest at low velocities thus providing excellent low flow sensitivity. As the mass flow rate increases, the power increases as shown. This permits flow measurement at very high flow rates providing high turndown capabilities.

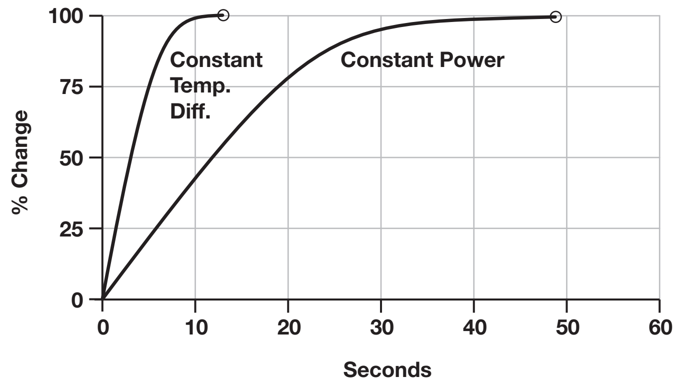
Response Time

Both technologies use the same sensor. There is an inherent time response for the thermal mass of the sensor to heat up or cool down when there is a change in the flow rate. The primary disadvantage of the constant power operation is the slow response time to changes in flow. The difference in response time between the two technologies can be explained.

Constant Power operation is a passive operation. The response time to a change in flow is dependent upon how long it takes the heated sensor to reach thermal equilibrium at the new operating conditions.

The Constant Temperature Difference operation has a faster response time to changes in flow. There is a PID control circuit which varies power to the heater to always maintain a constant temperature difference between the reference RTD and the RTD measuring the temperature of the heater. Because of the control circuit, the constant temperature difference technology provides a faster response.

The response time of constant power and constant temperature difference flow meters are shown in the chart below.



Temperature Compensation

Thermal Mass Flow Transmitters measure heat transfer and infer the mass flow based upon calibration information.

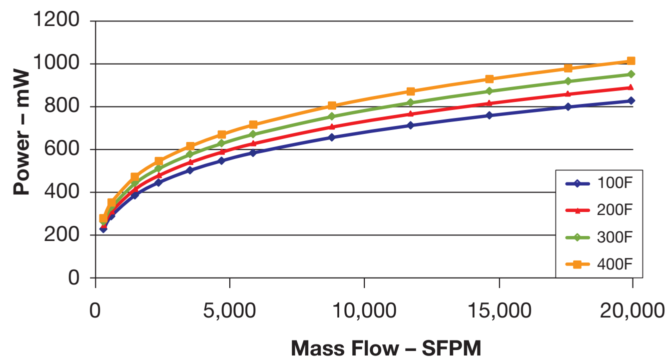
However, the gas properties that affect convective heat transfer are affected by changing temperature.

Magnetrol® has done extensive testing and analysis on the effect of changes in flow at different temperatures and has developed a proprietary method of providing temperature compensation over the entire operating range of the instrument.

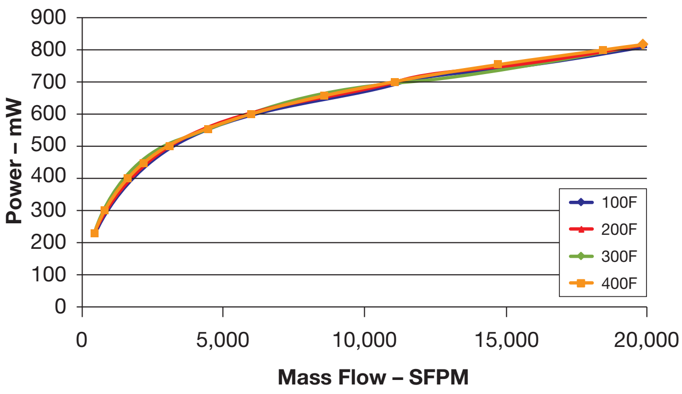
MAGNETROL realized the importance of temperature compensating the mass flow measurement based upon changing temperatures.

Using the powerful microprocessor electronics, the instrument is able to adjust the mass flow measurement for changing temperature.

This curve shows how the power varies as the temperature changes.



Using our temperature compensation, the curves fall on top of each other. MAGNETROL provides temperature compensation as a standard.



Some thermal mass flow manufacturers compensate temperature only at the electronic circuit. What these manufacturers overlook is that the gas properties that affect convective heat transfer are temperature dependent. Therefore, changing temperature changes heat transfer. MAGNETROL provides real-time temperature compensation that measures the temperature of the gas, and automatically corrects the mass flow measurement based on temperature variations.

Without real-time temperature compensation, the accuracy of the flow measurement will degrade with temperature changes. In some competitive designs, the rated accuracy is only within 50° F of the calibration temperature.

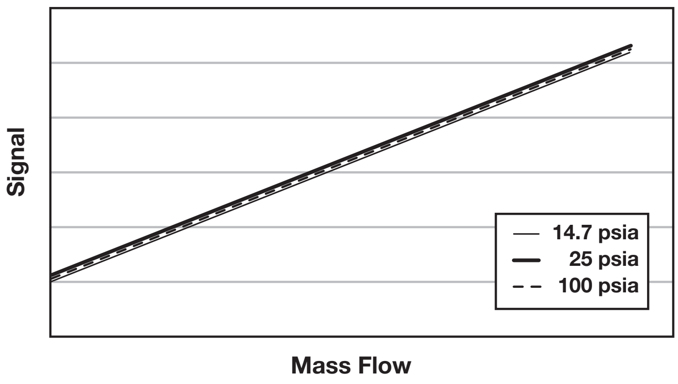
If the instrument does not provide a temperature measurement, the instrument cannot provide real-time temperature compensation. This is especially a consideration with other manufacturer's constant temperature difference operation; these designs have a reference RTD and a self-heated RTD. The reference RTD is used in the electronic circuit and does not provide temperature measurement. Thus, these instruments are unable to provide real-time temperature compensation.

Real-time temperature compensation is an important feature which provides superior performance in applications with varying process temperatures.

Pressure Effects

Heat transfer is affected by changing temperature. This is based upon both theory and the experience of MAGNETROL. However, heat transfer is not affected by changing pressures. The chart below demonstrates that pressure does not affect thermal mass flow measurement.

An increase in pressure will increase the gas density—there is the same amount of heat transfer with a low velocity, high density gas as there is with a high velocity, low density gas.



Technology Benefits

Thermal Mass Flow offers many advantages over other traditional technologies:

1. Mass flow measurement based upon heat transfer, no correction of the gas flow rate for pressure or temperature is required.
2. Excellent low flow sensitivity, velocities down to 10 standard feet per minute.
3. Excellent turndown, 100:1 or more depending upon the application requirements and calibration of the instrument.
4. Low pressure drop. The insertion probe has little blockage of the pipe, therefore, creating very low pressure drops.
5. Ease in installation. The insertion probe can easily be installed in a pipe or duct.
6. Low installation cost. When considering options to measure mass flow, thermal dispersion has the lowest installed cost while providing excellent performance. No additional instrumentation is required to obtain a mass flow measurement.

Calibration

Each instrument is calibrated to determine the relationship between mass flow and power. Calibration is performed for the type of gas over the desired flow rate.

Calibration involves flowing through a known amount of gas over the sensor and measuring the signal. This is repeated for at least ten different flow rates. A curve fit of the data versus flow rate is developed and then loaded into the instrument. The calibration is NIST traceable. A calibration certificate is included with the instrument and all calibration data is retained at MAGNETROL for future reference.

When installed and placed into operation, the instrument measures a signal, and then converts that signal to the flow rate for the user's application. The instrument adjusts for differences in area and blockage effect between the calibration fixture and the field installation.

Each instrument has its own unique calibration. The sensor and the electronics are a matched pair—each has a serial number to enable matching the units in the field. Previously, if the probe needed to be replaced, the probe and associated electronics had to be calibrated together as a unit. There are tolerances in both the probe and the electronics which effect the calibration. With the development of the TA2, MAGNETROL has developed a method by which the probe (or circuit boards) can be field-replaced. A new calibration certificate will be provided with the replacement probe and the user will enter these new probe calibration factors into the instrument using the keypad and display, via HART® or PACT*ware*™.

The cable length is independent of the calibration. This enables the customer to provide their own cable or to change the cable length in the field. Units that require the instrument to be calibrated with the specified cable length will affect the accuracy if the length is changed.

Calibration Verification

The calibration of a thermal mass flow meter determines the relationship between heat transfer and mass flow. It is important to remember the factory calibration in a TA2 is permanent and recalibration is not required. However, some users may want to periodically check calibration. True calibration can only be performed with a flow bench.

Since the primary method of measurement is based on heat transfer. MAGNETROL has developed a procedure to permit the user to check the heat transfer characteristics of the sensor under two sets of controlled conditions: zero flow and a simulated high flow. If the heat transfer characteristics are the same as originally received, the TA2 is still in calibration and there is no need to send it back to the factory for recalibration.

Conclusion

Thermal Mass Flow Transmitters are cost-effective and proven instruments, while offering many benefits, including direct mass flow measurement, easy installation, low pressure drop, and excellent low flow capabilities.

Improved process optimization and reduced energy consumption are the main benefits of selecting the proper flow meter for your plant.

MAGNETROL has designed the TA2 taking into consideration the customer's best interest by minimizing the cost of maintenance and installation.

MAGNETROL TA2 allows the customer to perform calibration verification and configurations in the field. There are multiple ways to measure air and gas flow rates; Thermal Mass should be considered as one of the proven and acceptable methods of measuring air and gas flows in the wastewater industries.

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