Influence Factors Upon Verification Of The Ultrasonic Heat Meter

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abstract

The ultrasonic heat meter are more and more used in the supply heating system.The paper gives the principle of the ultrasonic heat meter and analyze influence factor when verifying the ultrasonic heat meter,it includes balance,thermostatic bath,standard Pt resistance,water density, sonic velocity,and etc. It emphasizes the influence of sonic velocity to verification.

keywords: ultrasonic heat meters;temperature;sonic velocity;density;air bubbles.

1. Introduction

With the development of China's modernization, Chinese society is increasingly converting from energy-waste type community to energy-saving, energy metrology has been more and more widely concerned. The ultrasonic heat meter,as a relatively new type of the heat meter,are widely used in heat energy metrology. More and more manufacturers began developing and producing the ultrasonic heat meter.

In this paper, the working principle of the ultrasonic heat meter is described,and according to it,influence factors about the ultrasonic heat meter's verfication are studied.

2. The ultrasonic heat meter's working principle

The ultrasonic heat meters's working principle is: the paired temperature sensors are installed in the heat exchange loop entry and exit of the pipe, the flow sensor is installed in the inlet and outlet pipe,the flow signal is collected by the flow sensor, the temperature signals are collected by the paired temperature sensors , the calculator compute heat energy according to the flow signal and temperature signals,then show heat energy.

Firstly,let's see the working principle of the ultrasonic heat meter's flow sensor. Flow signal is got mainly by means of sound transmission speed difference method (real-time differential measurements), two beams of ultrasound are emitted by the two ultrasonic transmitter,one is downstream,another is upstream,they arrive at each other receiver, when ultrasonic propagate in the fluid, it will be influenced by flowrate, downstream and upstream transmission speeds is superimposed on the same flow rate.

Based on the ultrasonic heat meter's flow measurement principle,flowrate is calculated by using the following formula.

$$t_1 = \frac{L}{c + v} \qquad (1)$$

$$t_2 = \frac{L}{c - v} \tag{2}$$

$$\Delta t = t_2 - t_1 = \frac{2Lv}{c^2 - v^2} \approx \frac{2Lv}{c^2} \tag{3}$$

$$v = \frac{c^2 \Delta t}{2L} \tag{4}$$

$$q = vS = \frac{c^2 \Delta t S}{2L} \tag{5}$$

thereinto:

L – distance of ultrasonic transducer between the transmitter and receiver, m;

t_1 - downstream ultrasonic propagation time, s;

t_2 - ultrasonic counter-current transmission time, s;

c - sound propagation velocity in the fluid, m/s;

v - average fluid velocity, m / s;

S – pipe's cross-sectional area, m^2;

$$c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.010T)(S - 35) + 0.016D \tag{6}$$

thereinto:

c - sound propagation velocity in the fluid, m/s;

T - temperature,℃;

S - salinity;

D - depth,m.

Without considering the salinity, water depth case, the relationship between water temperature and the speed of sound is approximately:

$$c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 \tag{7}$$

When water temperature is 50℃ and 60℃ respectively,the sonic velocity is accordingly:

$$c_{50} = 1449.2 + 4.6 \times 50 - 0.055 \times 50^2 + 0.00029 \times 50^3 = 1578.0 m/s$$

$$c_{60} = 1449.2 + 4.6 \times 60 - 0.055 \times 60^2 + 0.00029 \times 60^3 = 1589.8 m/s$$

3. The heat meter verification facility

Static mass method is usually used as the flow standard by the heat meter verification facilities. Thermostatic bath is served as simulated temperature field.Two standard platinum resistor thermometer were placed in bath A and bath B as the temperature standard. When the heat meter is verified, its temperature sensor probes

of the entrance and the exit are placed in bath A and bath B respectively,and its flow sensor is installed in the pipe.Verified heat energy is got by the heat meter. At the same time,the standard heat energy is got by the heat meter verification facility.So heat energy error is got.

4. Influence factors upon the ultrasonic heat meter's verification

4.1 Sonic velocity

It can be seen that when measuring heat energy, the heat meter's flow sensor and temperature sensor are placed in the different location,not like in the use state, the flow sensor is placed together with the temperature sensor.

According to verification regulation of heat meters, it shows that verification of heat meters required to simultaneously measure flow and temperature. Temperature is measured at thermostatic bath.But from ultrasonic heat meters's working principle,measuring flow need to know the medium temperature, so there must be a platinum resistance temperature sensor in the pipe,if one platinum resistance temperature sensor is in the pipe, then the temperature difference can not be measured, so heat can not be measured correctly. But heat energy is what we want to get and is the most important parameter to the heat meter's use.Therefore both two temperature sensors should be placed at thermostatic bath.So a problem comes into being. The measured temperature from temperature sensor is not same with temperature near flow sensor.For water medium,different water temperature has different density,so even if same water mass,the volume is different.

When water temperature in the pipe is 50℃, simulated water temperature in thermostatic bath is 60℃, the heat meter is verified by weighting method, the default temperature of flow sensor is approximately equal to 50℃, error δ_q caused by the simulated temperature in thermostatic bath different from in the pipe is:

$$\delta_q = \frac{q_{60} - q_{50}}{q_{50}} \times 100\% = (\frac{q_{60}}{q_{50}} - 1) \times 100\% = \left(\frac{c_{60}^2 \Delta t S / 2L}{c_{50}^2 \Delta t S / 2L} - 1 \right) \times 100\% = 1.5\%$$

From above analysis,we know that sonic velocity is a very important influence factor upon the ultrasonic heat meter's verification,further more,water temperature is relevent to sonic velocity.So how to keep temperature in similar state is very important to get correct measure result.Then let's see other influence factors.

4.2 water temperature's measure of different location

Standard facility's water temperature measurement location is not same with actual location of flow sensor in the pipe.It is supposed that standard facility's water temperature is 51℃,when water flow foward,it is cooled a little,for example the heat meter's flow sensor is 50℃,then their density is different.The density error is:

$$\delta_\rho = \frac{\rho_{51} - \rho_{50}}{\rho_{50}} \times 100\% = -0.05\%$$

Heat energy computation formula is as follows from heat meters verification regulation:

$$Q = \int_0^V k \cdot \Delta\theta \cdot dV$$

Keeping temperature difference constant,the formula is simplified as follows :

$$Q = k \cdot \Delta\theta \cdot V = k \cdot \Delta\theta \cdot \frac{m}{\rho}$$

Accordingly,the heat energy's error is:

$$\delta_Q = \frac{Q_{51} - Q_{50}}{Q_{50}} \times 100\% = -0.05\%$$

4.3 Air bubbles

When air bubbles exist in the pipe,actual water volume flowing through flow sensor is less than being calculated.If there are air bubbles,then flow measurement accuracy will be influenced also.So it is very important to eliminate air bubbles.Vents are fixed in proper location to eliminate air bubbles,after water in the pipe is in single-phase and flow is stable,the heat meter is verified.

5. Conclusion

From above discussion,we know that there are many influence factors upon the ultrasonic heat meter verification.So how to get exact measurement data of the heat meter lies in reducing influence of these factors.As the ultrasonic heat meter are used more widely,more experience will be acquired about the verification.

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