Experimental Investigation on Thermal Mass Gas Meter with Component Variations of Nature Gas

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Abstract. To carry out the metrological performance of thermal mass gas meters under different measurement conditions, an experimental setup has been designed, and six kinds of nature gas with different components and air are used as the measure medium. In this experiment, a roots flow meter is set as the standard meter. The experimental results show that after adding a component identification function, the measurement precision of thermal mass gas meters is much better than that without medium component identification function. Some suggestions are proposed on promoting the use of thermal mass gas meter according to the experimental results.

Keywords: thermal mass gas meter; metrological performance; different component of nature gas

1. Introduction

With the development of electronic and internet technology, the electronic measuring instrumentation, such as ultrasonic gas meters and thermal mass gas meters, have been pursued to supple or even eventually replace the conventional mechanical instrument (for example, the diaphragm gas meters) in the domestic gas measurement field. Thermal mass gas meters which appear with no moving parts, simple structure, small pressure drop, wide flow range, and high precision, have drawn much more attentions.

The thermal mass gas meter is based on the heat exchange principle between the gas medium and heat source, generally used in the measurement of gas mass flow. The passing gas flow takes away the heat from the heat source, once the surface temperature difference is measured, the mass flow of the gas will be calculated, corresponding.

However, the heat conductivity coefficient of the nature gas is changed with the components of nature gas which are usually different since the exploitation time and production place are different. As a result, the component variations have a significant impact on the measurement precision of thermal mass gas meter. Until now, a plenty amount of research and development work have been carried out to understand the effect of components of nature gas on the measurement precision of thermal mass gas meter. However, to the author’s best knowledge, the metrological performance of thermal mass gas meter under different component nature gas measurement conditions, from the standpoint of an institution of metrological technology, has not been addressed in literature yet.

In this paper, an experimental setup is designed in order to test the metrological performance of thermal mass gas meter, and six kinds of nature gas with different components are used as the medium gas. The experimental method and facility is introduced in section 2 in detail, and then the results and many

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more discussions are shown in section 3 and section 4. Finally, conclusions are summarized in the last section.

2. Experimental Method

Two thermal mass gas meters from a manufacturer in Zhejiang Province, China, are selected as the measured meters. Meanwhile air and six kinds of nature gas with different components are chosen as the medium gas. The detailed components of six kinds of nature gas are shown in Table 1.

|                    | CH4  | C2H6 | C3H8 | CO2  | N2  |
|--------------------|------|------|------|------|-----|
| Gas 1              | 95.373 | 0.197 | 1.81 | 2.62 | /   |
| Gas 2              | 84.73  | 9.22  | 1.42 | 1.81 | 2.82|
| Gas 3              | 79.39  | 9.95  | 3.00 | 3.02 | 4.64|
| Gas 4              | 92.76  | 0.20  | /    | 2.01 | 5.03|
| Gas 5              | 90.38  | 1.60  | /    | 2.99 | 5.03|
| Gas 6              | 97.795 | 0.208 | 0.369| 1.27 | 0.358|

At the same time, a root flow meter with the maximum relative error less than 0.5% is selected as the standard flow meter. To ensure safety, after flowing through all the meters, the nature gas are ignited by a gas stove. The schematic diagram of this experiment is shown in Figure 1.

![Figure 1. The schematic diagram of this experiment](image1)

Two experimental photos are shown in Figure 2.

![Figure 2. Experimental photos](image2)
The relative error $E$ of the experiment is calculated by the equation below.

$$E = \frac{V_t - V_s}{V_t} \times 100 \tag{1}$$

In Equation 1, $V_t$ is the measurement volume of the thermal mass gas meter, and $V_s$ is the measurement volume of standard flow meter.

3. Experimental Result

The thermal mass gas meters used in this experiment have the medium component identification function. For comparison, this component identification function is closed, firstly. The measurement results of thermal mass gas meters are shown in Table 2. Each gas is test as medium gas twice.

| Gas  | Thermal mass gas meter 1 | Thermal mass gas meter 2 |
|------|--------------------------|--------------------------|
| 3    | 35.43                    | 28.08                    |
| 5    | 14.71                    | 15.54                    |
| 6    | 14.64                    | 13.64                    |
| Air  | -0.20                    | -0.60                    |

Then open the component identification function, and the corresponding measurement results of thermal mass gas meters are shown in Table 3. Each gas are test as medium gas twice, too.

| Gas  | Thermal mass gas meter 1 | Thermal mass gas meter 2 |
|------|--------------------------|--------------------------|
| Air  (First) | -1.89              | -1.89                    |
| 1    | -3.27                    | -2.71                    |
| 2    | -4.24                    | -3.45                    |
| 3    | -4.78                    | -4.00                    |
| 4    | -5.97                    | -5.17                    |
| 5    | -6.23                    | -5.36                    |
| 6    | -3.48                    | -2.88                    |
| Air  (Last) | -2.79              | -2.69                    |

From the experimental results in Table 2, it is found that without component identification function the largest relative error is nearly 36%, which is unacceptable. Because of the big error, we only choose three kinds of nature gas as the experimental gas. The main reason for this phenomena is that, all kinds of medium gas are recognized as air without component identification function. However, after opening the component identification function, as shown in Table 3, all the six kinds of medium gas are test, the maximum relative error dropped to -6.23%. This is a big progress for the thermal mass gas meter. Moreover, it is revealed that if the thermal mass gas meters want to be widely
used in the domestic gas measurement in the future, the medium gas component identification function is the most necessary prerequisite.

4. Discussion

According to the experimental results in Section 3, it is found that after adding a medium component identification function, the measurement precision of thermal mass gas meter is much better than that without the medium component identification. This is a great progress towards the target that thermal mass gas meters be widely used in the measurement of domestic gas.

However, some problems are still existed and needed to be solved before thermal mass gas meters are in-service used.

a) Firstly, the measurement precision of thermal mass gas meter is still need to be improved. In China, it is required that for domestic gas the absolute value of relative error must no more than 1.5%. Nevertheless, in table 3, the minimum absolute value of relative error is nearly 2.7% even when the medium component identification function is applied. So more research should be carried out on the thermal mass gas meter to improve the measurement precision and stability.

b) Secondly, the energy consumption of thermal mass gas meters should be considered. In China, almost all the electronic gas meters are powered by battery. Larger amount of electric energy is needed during the medium component identification work process. So how to reduce electric consumption and extend battery life needs to be solved.

c) Finally, another obstacle for the widely in-service use of thermal mass gas meters is the import substitution rate of core components. Once the import substitution rate of core components is acceptable for the gas company in China, the thermal mass gas meter will be expected to replace the diaphragm gas meter and be widely in-service used.

5. Conclusion

In this paper, six kinds of nature gas with different components and air are selected as the medium to test the metrological performance of thermal mass gas meters. Without the component identification function, the maximum absolute value of relative error is up to 35%. After adding the media component identification, maximum relative error can be reduced to 7%. Though the media component identification can improve the measurement performance, but some problems, such as energy consumption, the import substitution rate of core components, still impede the widely use of thermal mass gas meter.

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