Talking about the influence of pressure deviation on the measurement results of natural gas flowmeter

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Abstract

Natural gas is a kind of clean energy. In the process of natural gas flowmeter verification, pressure, as a key parameter of flowmeter verification, has a direct impact on the verification result of natural gas flowmeter. In order to study the influence of pressure deviation on the verification results, the theoretical calculation method was used to analyze the influence of pressure deviation on the verification results, and then the natural gas flow test method was used for verification. Finally, the control measures and suggestions to ensure the accurate and reliable pressure were given.

1. Introduction

With the changes in my country's energy consumption structure, the need for clean energy to replace traditional polluting energy is becoming more and more urgent. As a clean energy, natural gas has been widely used in many industrial and civil fields. While promoting the development of the national economy, It is also important for environmental protection.

At present, the measurement of flowmeters is always one of the key issues in natural gas production, supply and sales. The accurate measurement of measuring instruments is directly related to the interests of production enterprises, sales enterprises and users, which puts forward higher requirements for the verification of natural gas flowmeters. requirements. The flow meter verification results will be affected by many factors, such as changes in medium temperature, pressure, changes in gas components, and the performance of supporting measuring instruments. As an important parameter, pressure has a great influence on the accuracy of flow measurement. In the actual measurement verification process, the pressure is easily affected by various factors such as residual liquid in the pressure pipeline, sediment, and pressure-sensitive diaphragm performance. There is a certain deviation in the measurement of pressure, which directly affects the accuracy of the verification result. In this paper, the influence of pressure deviation on the verification results is firstly analyzed by the method of theoretical calculation, and then further analyzed by the actual flow test, and finally the measures and suggestions to ensure the accurate and reliable pressure measurement are given.

2. Additional sections and subsections

2.1 Basic Information for Theoretical Calculations

In order to study the influence of different pressure deviations on the verification results of the flowmeter, the standard turbine flowmeter used in the calculation is used to verify the initial state of the flowmeter under test,as shown in Table 1.The standard turbine flowmeter is used to verify the chromatographic components of the tested flowmeter, as shown in Table 2.

Turbostandard table initial state	pressure (Mpa)	temperature(°C)	Q_v (m^3/h)
	6.0163	27.09	766.28
The initial state of the flowmeter under test	pressure (Mpa)	temperature(°C)	Q_{fv} (m^3/h)
	5.9134	26.85	774.96

Table 1： initial state of the calibrated flowmeter verified by a standard turbine flowmeter

name	N_2	CH_4	CO_2	C_2H_6	C_3H_8
component	1.254%	93.796%	0.628%	3.536%	0.583%
name	iC_4H_{10}	nC_4H_{10}	iC_5H_{12}	nC_5H_{12}	C_6+
component	0.063%	0.068%	0.017%	0.014%	0.039%

Table 2： chromatographic components for calibration of flow meters with Standard Turbine flowmeters

2.2 Theoretical calculation basis

2.2.1 The calculation formula of the standard flow value is as follows:

$$q_n = q_f \left(\frac{p_f}{p_n}\right)\left(\frac{T_n}{T_f}\right)\left(\frac{Z_n}{Z_f}\right) \qquad (1)$$

where:

q_n —Convert the volume flow of the standard device to the flow value under the working conditions at the flowmeter to be calibrated,m³/h；

p_f —is the pressure of the flowmeter under test，MPa；

Z_f —is the compression factor of the flowmeter under test；

T_f —is the temperature of the flowmeter to be tested，K；

p_n —pressure for standard unit，MPa；

Z_n —temperature for standard units，K；

T_n —temperature for standard units，K。

2.2.2 The calculation formula of the detected flow value is as follows:

$$q_f = 3600\frac{f}{K} \tag{2}$$

where:

q_f —Flow value of the flow meter，m³/h；

f —The flow meter frequency collected by the system；

K —Flowmeter meter factor；

2.2.3 The formula for calculating the compression factor is as follows:

$$Z=1+B\rho_m-\rho_r\sum_{n=13}^{18}C_n^*+\sum_{n=13}^{58}C_n^*(b_n-c_nk_n\rho_r^{k_n})\rho_r^{b_n}\exp(-c_n\rho_r^{k_n}) \tag{3}$$

where:

Z—compression factor；

B—second virgin number u；

ρ_m —Molar density；

ρ_r —contrast density；

b_n 、 c_n 、 k_n —constant；

C_n^* —Coefficients of a function of temperature and composition；

2.3 Analysis of theoretical calculation results

2.3.1 Influence of pressure deviation at turbine standard flowmeter

Assuming that there is no deviation in the pressure at the tested flowmeter, and the pressure deviation at the turbine standard flowmeter is analyzed, assuming that the deviation of the pressure is between(0~0.015)MPa, the relationship between the output value error and the pressure deviation is calculated as follows: Table 3 and Figure 1.

Pressure（MPa）	differential pressure（MPa）	compression factor	Tested flowmeter (m³/h）	Turbine Standard (m³/h）	error（%）	deviation（%）
6.016	0.000	0.8930	774.96	780.16	-0.67	-0.00
6.019	0.003	0.8930	774.96	780.59	-0.72	-0.05
6.022	0.006	0.8929	774.96	781.02	-0.78	-0.11
6.025	0.009	0.8929	774.96	781.45	-0.83	-0.16
6.028	0.012	0.8928	774.96	781.88	-0.89	-0.22
6.031	0.015	0.8928	774.96	782.32	-0.94	-0.27

Table 3：relationship between pressure deviation and indication error at Turbine flowmeter

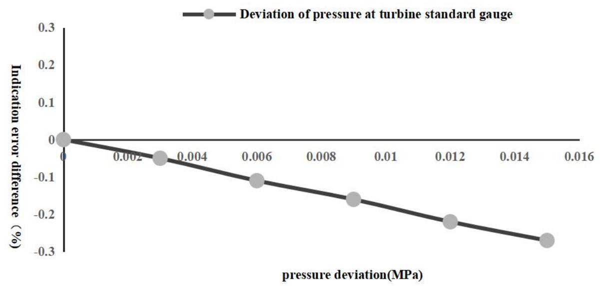

Fig. 1：relationship between pressure deviation and indication error at Turbine flowmeter

It can be seen from Figure 1 that the deviation of the pressure at the turbine standard flowmeter has a significant impact on the verification results, and the two basically maintain a linear relationship, that is, the greater the pressure deviation, the greater the deviation of the obtained indication error; when When the pressure at the turbine standard flowmeter deviates in the positive direction, the verification result also deviates in the negative direction. For example, when the pressure deviation at the turbine standard flowmeter is 0.015MPa, the indication error deviation of the verification result is -0.27%.

2.3.2 Influence of pressure deviation at the flowmeter under test

It is assumed that the pressure at the turbine standard flowmeter does not deviate, but the pressure deviation at the tested flowmeter is analyzed. Assuming that the deviation of the pressure is between (0~0.02)MPa, the relationship between the output value error and the pressure deviation can be obtained by calculation. As shown in Table 2 and Figure 2.

Pressure（MPa）	differential pressure（MPa）	compression factor	Tested flowmeter (m³/h）	Turbine Standard (m³/h）	error（%）	deviation（%）
5.913	0.000	0.8944	774.96	780.16	-0.67	0.00
5.916	0.003	0.8943	774.96	779.72	-0.61	0.06
5.919	0.006	0.8943	774.96	779.28	-0.55	0.11
5.922	0.009	0.8942	774.96	778.84	-0.50	0.17
5.925	0.012	0.8942	774.96	778.41	-0.44	0.22
5.928	0.015	0.8941	774.96	777.97	-0.39	0.28

Table 4：relationship between pressure deviation and indication error at flow meter under test

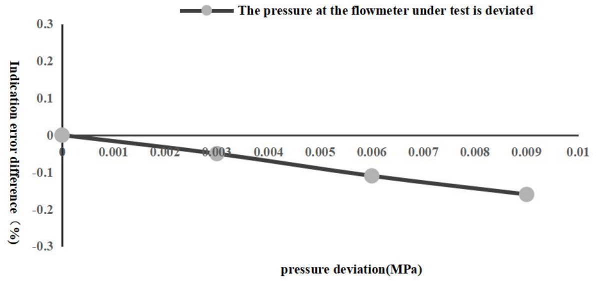

Fig. 2： relationship between pressure deviation and indication error at flow meter under inspection

It can be seen from Figure 2 that the deviation of the pressure at the tested flowmeter has a significant impact on the verification results, and the two basically maintain a linear relationship, that is, the greater the pressure deviation, the greater the deviation of the obtained indication error; When the pressure at the meter to be verified deviates in the positive direction, the verification result also deviates in the positive direction. For example, when the pressure deviation of the flowmeter under test is 0.015MPa, the deviation of the indication error of the verification result is 0.28%.

2.3.3 The influence of the simultaneous deviation of the pressure at the turbine standard flowmeter and the tested flowmeter

It is assumed that the pressures at the turbine standard flowmeter and the tested flowmeter are both deviated and deviated in the same direction for analysis. Assuming that the deviation of the pressure is between (0~ 0.015)MPa, the output value error and the pressure deviation are calculated through calculation. The relationship is shown in Table 5.

Turbine Standard Table pressure（MPa）	Tested flowmeter pressure（MPa）	compression factor	Tested flowmeter (m³/h）	Turbine Standard Table (m³/h）	error（%）	deviation（%）
6.016	5.913	0.8930	774.96	780.16	-0.67	0.00
6.019	5.916	0.8931	774.96	780.15	-0.67	0.001
6.022	5.919	0.8932	774.96	780.14	-0.66	0.002
6.025	5.922	0.8933	774.96	780.14	-0.66	0.003
6.028	5.925	0.8934	774.96	780.13	-0.66	0.004
6.031	5.928	0.8935	774.96	780.12	-0.66	0.004

Table 5： relationship between pressure deviation and indication error at Turbine flowmeter and inspected flowmeter

It can be seen from Table 5 that when the pressure at the turbine standard gauge and the tested flowmeter deviates in the positive direction at the same time, the pressure deviation of the turbine standard gauge just offsets part of the influence of the pressure deviation *at* the tested flowmeter on the verification result. , that is, the greater the deviation of the pressure in the same direction at the same time, the greater the deviation of the obtained indication error, but the deviation effect is not very obvious. For example, when the pressures at the turbine standard flowmeter and the flowmeter to be verified are simultaneously deviated by 0.015MPa, the indication error deviation of the verification result is 0.004%.

3. Live verification test

In order to verify the influence of pressure deviation on the verification results of the flowmeter under test during the actual verification process, the turbine standard flowmeter is used to test different flowmeters under test, and the qualified pressure transmitter and measurement performance are used at the flowmeter under test. Compare the pressure transmitter with larger deviation, and compare the indication error before and after the pressure deviation, as shown in Figure 3.

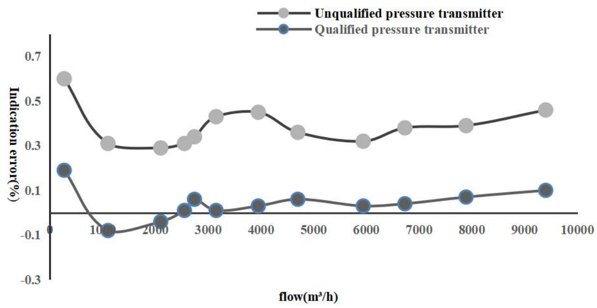

Fig. 3： relationship between pressure deviation and indication error of different flowmeters

By analyzing the test results, it is found that when the standard turbine flowmeter is used to verify the tested flowmeter, the deviation of the pressure also has a certain influence on the test results of different flowmeters, and the maximum deviation reaches 0.42%. It can be seen that in the actual flowmeter verification process, the deviation of the pressure has a certain influence on the verification result. Therefore, in the daily verification process, it is necessary to ensure that the collected pressure is accurate and reliable.

4. Suggest

In the actual verification process, the pressure will be affected by various factors, such as the performance drift of the pressure transmitter, the residual liquid in the pressure pipeline, the sediment, the performance of the pressure-sensitive diaphragm, etc. Therefore, daily inspection and maintenance must be done. , to ensure the accuracy of the pressure collected by the pressure transmitter:

(1) Periodically carry out the inspection of pressure transmitters, compare the deviation of each pressure transmitter, and repair or replace them in time if any abnormality is found;

(2) Regularly check the operation status of the pressure transmitter, discharge the pressure pipeline and check the leakage at each joint. If there is leakage, it should be

dealt with as soon as possible, and daily maintenance should be done well;
(3) If the value of the pressure transmitter has changed significantly, the number of inspections should be increased to ensure that the measurement performance of the pressure transmitter is accurate and reliable.

5. in conclusion

(1) The pressure deviation has a relatively obvious influence on the verification results of the flowmeter, and the two basically maintain a linear relationship, that is, the greater the pressure deviation, the greater the deviation of the obtained indication error; when the pressure at the turbine standard flowmeter When the deviation is in the positive direction, the test result is also deviated in the negative direction.
(2) When using the standard meter method gas flow standard device to verify the tested flowmeter, when the pressure at the tested flowmeter deviates in the positive direction, it will also cause the flowmeter verification result to deviate in the positive direction.
(3) When the pressure at the turbine standard gauge and the tested flowmeter deviate in the positive direction at the same time, the pressure deviation at the turbine standard gauge just offsets part of the influence of the pressure deviation at the tested gauge on the verification result, that is, the pressure At the same time, the larger the deviation in the same direction, the smaller the deviation of the obtained indication error, and when the two pressures deviate from the same pressure at the same time, the influence on the verification result can be basically offset. should address some of the opportunities or issues identified in the introduction.

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