Exploration and Application of Opt-Sonic Correlation Measurement Technology to Realize Energy Determination for Naturl gas

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Abstract

The traditional volume measurement method of natural gas is greatly affected by changes in temperament conditions, thus affecting the normal trade measurement, and can no longer adapt to the current domestic gas transmission status of multiple gas sources.In this context, this study proposes a Sound and light association method measurement technology not limited by the natural gas component to directly determine the natural gas heat generation, thus realizing energy measurement.Combined to the actual operation of natural gas station, the data of multiple multi-component gas standard substances and comparison with the results of chromatographic analyzer are analyzed，The accuracy of the sound and Sound and light association method for heat generation measurement and energy measurement is verified.Finally, the stability of heat measurement was verified by a 5-month interval test.The experimental results show that this technique is extremely useful in the field of energy measurement.

 keyword natural gas Energy measurement Sound and light association method

1. Introduction

With the rapid development of China's natural gas industry, the diversity of gas sources has become an inevitable trend, and the traditional long-term use of a single gas source has changed irreversible.Due to the change of temperament conditions, the traditional volume measurement method can not adapt to the current situation of multiple gas sources.It is more scientifically and reasonably to reflect the attributes and value of natural gas as a commodity that we use energy measurement, takeing into account the quality and volume of natural gas at the same time . Therefore, it is urgent need that the energy takes place of the volume for the measurement of natural gas . In 2019, the four national ministries and commissions issued a notice on the "Measures for the Fair and Open Supervision of Oil and Gas Pipeline Network Facilities", which requires the full implementation of natural gas energy metering and pricing. At present, the natural gas energy metering policy is gradually being implemented.

Energy (E) is the product of the gas volume (Q) and the corresponding calorific value (H). Among them, there are two correction methods for the accurate general correction of the volume. One is to use the AGA8-92DC calculation method (calculated by molar composition) to obtain the compression factor for correction, and the other is to use the SGERG-88 calculation method (calculated by the physical property value) to obtain the calorific value is measured in three ways: direct measurement (combustion method), indirect measurement (such as gas chromatograph), and related measurement technology.

Therefore, the accuracy of calorific value and volume correction calculation is the premise and guarantee to ensure the high quality implementation of natural gas energy measurement.Energy measurement is realized by Sound and light association method measurement technology,Accurate measurement of calorific value, CO2, and relative density is the key.The heat value of natural gas is linear with the visible refractive index and acoustic propagation velocity respectively,The refractive index and sound wave propagation velocity of natural gas are determined by optical sensors and sound velocity sensors,The corresponding heat source can be obtained by solving the relationship between the two together.Similarly, the relative density can be detected simultaneously, and the CO2 content can be detected in real time through the aid of the infrared principle.

Based on this, in this study, by performing alignment measurements of the multicomponent gas standard matter,And to compare the measured results with the chromatographic analyzer results,To verify the accuracy of the sound and light method in measuring heat generation,Combined with the field application and operation situation,A 5-month interval trial was

conducted,Verify the stability of heat generation measured by the sound-light association method.

2.Principle elaboration

The heat value of natural gas is linear with the visible refractive index and acoustic propagation velocity respectively.The refractive index and sound wave propagation velocity of natural gas are determined by optical sensors and sound velocity sensors,The corresponding heat source can be obtained by solving the relationship between the two together.Similarly,The relative density of natural gas is linear to the adjustable refractive index and the acoustic propagation velocity equation, respectively,Relative density was detected simultaneously with calorific detection,The Wobbe Index is calculated.N2, CO2, O2 and other components that do not contribute to the calorific heat generation and CO will have some impact on optical detection and sound speed detection,By detecting heat detected by optical sensors and heat detected by acoustic sensors and compensating for each other,To eliminate these interference effects without calorific value contribution components (N2, CO2, O2, etc.) and CO,Accurate calorific value detection results were obtained.Figure 1 shows a schematic diagram of the principle of natural gas heat generation determination by the speed of sound and visible spectral correlation method.
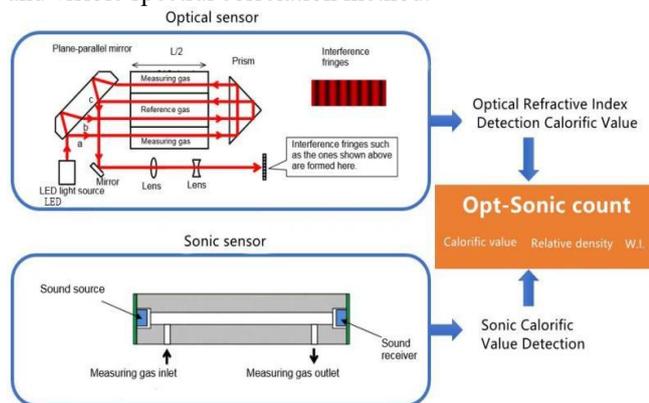

Figure 1 Principle of heat generation determination of natural gas by sound-light correlation method

The proportion of optical refractive index and acoustic wave propagation velocity to natural gas calorific value Q,The calculation formula for the correlation measurement of natural gas heat generation by the speed of sound and visible spectrum can be obtained:

$$H = H_{OPT} - \frac{H_{OPT} - H_{SONIC}}{1-\alpha} \quad （1）$$

Relative density of the same test:

$$d = d_{SONIC} - \frac{d_{SONIC} - d_{OPT}}{1-\beta} \quad （2）$$

In Formula (1) and Formula (2):

—— H_{OPT} For the heat value determined by the optical refractive index；

—— H_{SONIC} For the heat generation rate determined by the speed of sound propagation speed；

——opt For the relative density results detected by the optical sensor；

—— sonic For the relative density results detected by the sound speed sensor；

—— d For relative density；

—— α、β For constant 。

3.Field test part

To verify the accuracy and stability of heat generation and natural gas compression factors,Three test methods are adopted:

1) Carry out the comparison test with 12 different component gas standard substances;

2) Conduct a 5-month interval test with high, medium and low calorific value gas standard substances;

3) Alignment test with the chromatographic analyzer.

3.1 Comparison test

The comparison test was conducted using 12 multi-component gas standard substances and acoustic-light correlation meter.The heat generation of the gas standard matter as measured indirectly here,Refers to the content of each component provided according to the gas standard substance certificate,According to the calculation of ISO 6976 natural gas calorific value, density and relative density and compound Warper indexNatural gas - Calculation of calorific values, density, relative density and Wobbe indices from composition Or the standard method of GB / T 11062-2020 gas calorific, density, relative density and Volper index.The test results of high calorific of 12 multi-component gas standard substances are shown in Table 1 and Figure 2.
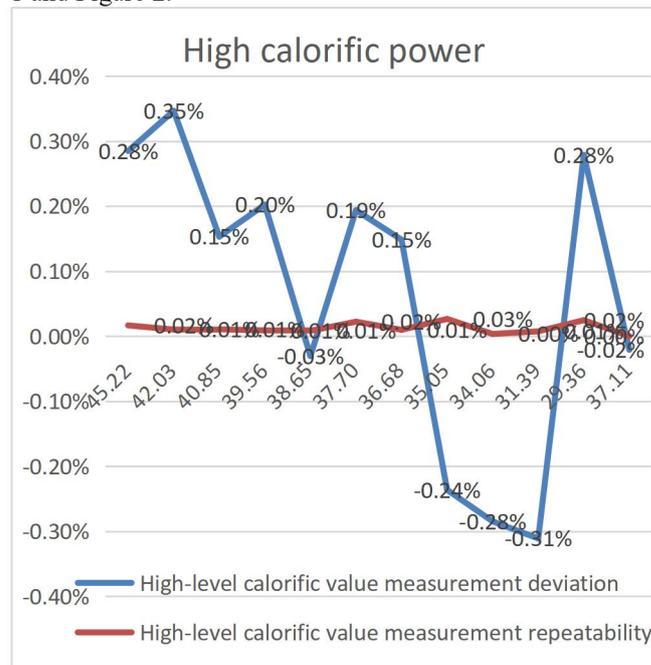

Figure 2 High calorific value measurement deviation and repetitive line plot

As can be seen from Figure 2:

The relative deviation of the high calorific measurement value and the calculated value obtained by the acoustic and optical correlation method is between-0.31% and 0.35%,repeatability Both are all below 0.03%, gross heating value；high calorific power The deviation is small between 36.68 MJ/m3 and40.85MJ/m3

The test results of the relative density, CO_2, and compression factors of the 12 multi-component gases are shown in Figure 3.
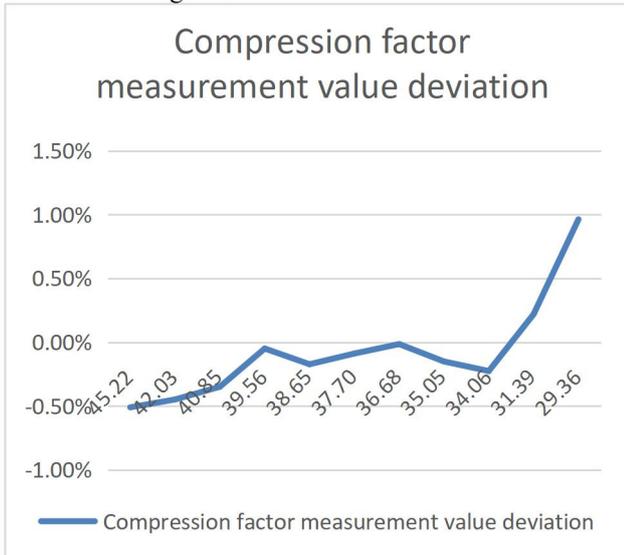

Figure 4 Line plot of the deviation of the compression factor measurements

Figure 3 show that:

1）During the (34.06 to 39.56) MJ / m3 period of the compression factor measurements during the period was between-0.05% and-0.23%,Its relative deviation change is small;

2）During the (37.11-45.22) MJ / m3 period of The relative deviation of the compression factor measurements is between-0.51% and 0.96%,The relative deviation of some of the test results varies greatly,The main reason is that the maximum limit of CO_2 measurement range in this test study was 5%,Leading to inaccurate CO_2 measurements,Thus, the relative deviation of the compression factor during this period is large.

3.2 Interval test

Using high calorific value gas standard material, medium calorific value gas standard material, low calorific value gas standard material,A 5-month interval test was performed,The content of each component of the gas standard substance is provided according to the gas standard substance certificate,The measured results are compared with the each component content of the gas standard material, and the alignment between the two adjacent measurements,See shown in Figures 3 and 4.
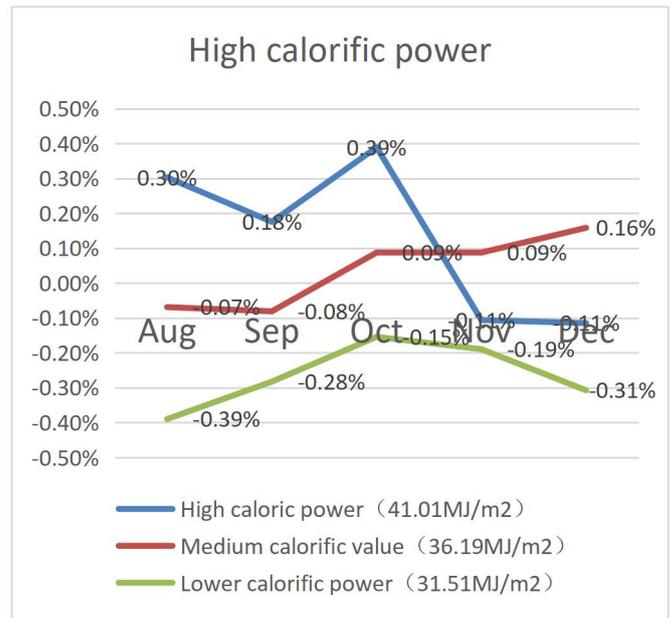

Figure 4 Deviation chart of deviation of high calorific value measurement and standard value

1) As can be seen from Figure 4:

The repeatability of high calorific value measurement is between 0.01% and 0.05%, the relative deviation of high calorific value measurement value obtained by the acoustic and optical correlation meter and the gas standard material value is between-0.39% and 0.39%,Its deviation is small;
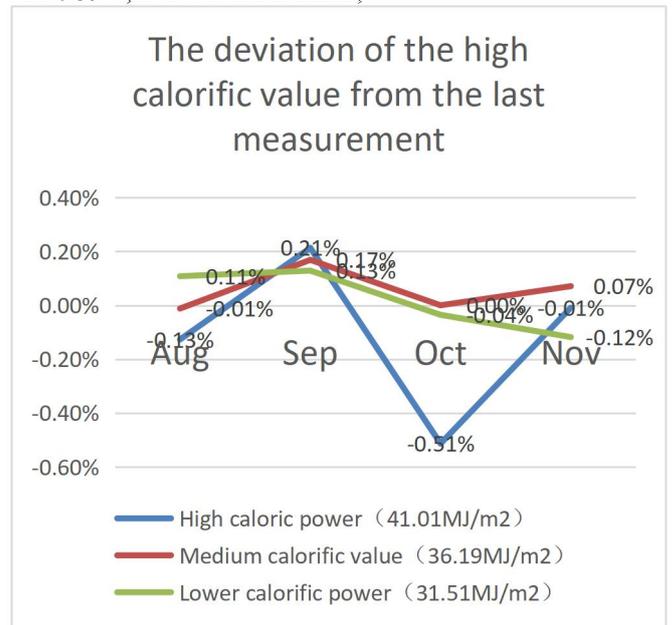

Fig. 4 Line chart of the deviation of high heat value from the last measurement

2) As can be seen from Figure 4:

The deviation of the high calorific value from the last measurement is between-0.13% and 0.51%,Since the high calorific value gas standard substance was used up during the third stability test,And replace the new high-calorific value gas

standard material at the fourth test,Therefore, the high calorific value compared with the last measurement value deviation is larger(Value is: 0.51%),Excluding the 0.51% deviation in November,The deviation of the high calorific value from the last measurement is between-0.13% and 0.11%(See Figure 4),The deviation of high calorific caloric stability is good.

3.3 Ato-optical correlation measurement and chromatographic analyzer comparison test

According to the actual operation situation of the natural gas station site,Adopt the same natural gas gas source,Using both acoustic and optical correlation method and chromatographic analyzer,Six sets of measurements in the same time period were randomly selected for comparison, The measurements are shown in Table 1 .

Table 1 Summary of measurement data of Sound and light association method meter and chromatographic analyzer

Group	High calorific power relative density	Relative deviation of the relative density	CO 2 relative deviation	Relative deviation of the compression factors
1#	0.21%	-0.18%	-6.27%	0.00%
2#	0.13%	-0.06%	-5.33%	0.00%
3#	0.11%	-0.04%	-100.00%	0.00%
4#	0.11%	-0.04%	-34.15%	0.00%
5#	0.10%	-0.01%	-11.64%	0.00%
6#	0.34%	-0.03%	-62.39%	0.00%

As can be seen from Table 1:

1) The relative deviation between the high calorific value value obtained by the acoustic-optical correlation meter and the high calorific value value obtained by the chromatograph is between 0.10% and 0.34%,Its relative deviation is relatively small;

2) The relative deviation of the relative density measurement value is between-0.18% and-0.01%,Its relative deviation is relatively small;

3) The relative deviation of the compression factor measurement value is all less than 0.00%;Its relative deviation is good;

4) The relative deviation of the carbon dioxide measurement value is between-100.00% and-5.23%,Its relative deviation is beyond the range.

5) As per the GB / T18603 requirements,The thermal value and relative density of the acoustic-optical correlation meter are compared to those of the chromatographic analyzer,Deviation degree requirement of 0.5%,Operating condition compression factor of 0.3%,High calorific value and relative density can basically meet the requirements,While the relative error is relatively large,It is mainly affected by the accuracy of the measuring instrument for carbon dioxide detection,The next step is being studied on the carbon dioxide detection technology in the meter.

4. conclusion and suggestion

Through the field test in this study,In the measurement of the high calorific value of natural gas,With an excellent stability,High calorific value accuracy is good.In addition, the relative density can be measured and the CO2,Then obtain the compression factor based on SGERG-88 calculation method (calculated by physical value),In combination with calorific measurement and conventional volume measurement,To realize the energy measurement of natural gas,Further studies will also be conducted in conjunction with the measurement of CO2,Improve its measurement accuracy and the accuracy of the compression factor calculation results.The exploration and application of energy measurement through acoustic-optical correlation measurement technology,In addition to the current way of achieving energy measurement based on chromatographic analyzer,Provides another method of energy measurement, research and technical exploration,This technology has a very high application significance in the comprehensive promotion of natural gas calorific value measurement and energy measurement.

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