



Influence of elbow pipe on gas measurement accuracy of ultrasonic flowmeter and improvement

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Abstract

When the fluid passes through the elbow, it is easy to produce secondary flow, eddy flow, etc. The velocity distribution in the sonic flow channel is not symmetrical, which has an impact on the measurement accuracy of the flowmeter. In order to study the influence of turbulence on flowmeter by means of modelling and simulation, the measurement effect of G16 single-channel flowmeter is firstly studied under this condition. The condition is that the inlet pipe is double-bend pipe and half-moon double-bend pipe, and calculate the flow error in the two cases relative to the straight pipe. The single-channel flowmeter is installed with the elbow, the influence of the turbulence has brought a large error to its measurement results. In order to reduce this error, the model of G16 double-channel flowmeter was established, and the simulation experiment was carried out under the same conditions. Finally, the data obtained is compared with the corresponding data of the single-channel flowmeter. By developing real prototype units, we calibrate several the single channel and double channels ultrasonic gas meters on the sonic nozzle calibration system. Comparison of error accuracy curve and repeatability, the double channels are much better than one channel units. The conclusion: Compared with the single channel design, the double channels one greatly improves the influence of turbulence caused by the elbow and the measurement accuracy is improved.

1. Introduction

Ultrasonic gas meter has high measurement accuracy, large range ratio, stable performance and no pressure loss in pipeline. Compared with traditional gas meter, ultrasonic gas meter has significant advantages and has been widely used in the field of natural gas meter [1]. How to improve the measurement accuracy of ultrasonic gas meter is the key point of research and development in this field. As a velocity flow meter, its measurement accuracy is greatly affected by the flow channel, so the ideal situation is that the flow channel is in a fully developed state [2]. However, in the actual installation process, the flow channel is difficult to achieve this state due to the influence of installation devices such as front elbow and switch valve. Research shows that, at the entrance of gas meter installation sufficiently long straight pipe can effectively improve the situation, but in reality, because of the limitation of the installation space cannot meet the requirements of lead long straight pipe, so usually needs to lead bend, but front bent pipe can cause secondary flow and vortex turbulence, such as the uneven distribution of flow velocity in the runner [5]. At present, the G16 model single flow channel used by some domestic ultrasonic gas meter manufacturers has the following shortcomings: the ultrasonic probe can cover a small range, close to the front and back wall of the flow channel has a large part of the flow rate

cannot be measured. Therefore, when the inlet pipe of the gas meter with this channel is a bend, the measurement result will be inaccurate. This article first to use the flow of gas meter measuring precision, gas meter inlet pipe installation of straight pipe, double double bend bend and half moon, will be installed after the three kinds of pipeline gas meter respectively import FloEFD simulation software simulation, the simulation results show that the installation of double bend and half double bend gas meter of relative error is bigger, It shows that the bending pipe has a great influence on the measurement accuracy. After G16 model based on the disadvantages of single port on the structure, to improve and increase the port number, building shuangliu G16 type ultrasonic gas meter, and through the gas meter with the single runner under the same conditions of simulation experiment prove the shuangliu way of ultrasonic gas meter disturbed flow resistance is superior to the disturbed flow resistance of the single passage ultrasonic gas meter. Through the gas meter verification device test, the measurement accuracy and repeatability of the two-channel ultrasonic gas meter is better than that of the single-channel ultrasonic gas meter, and it is more favorable for the application of natural gas trade settlement occasions.

2. Principle of ultrasonic gas meter

The velocity measurement of ultrasonic gas meter is mainly based on time difference method, and the line between transmitter and receiver transducer is used as the transmission path of ultrasonic [6]. Direct - pointing and reflection are the two most common mono layout. Using in-line arrangement, vortex flow and cross flow resistance is weak, and reflection type track decorate can effectively overcome the negative influence of complex flow field, the length of the track at the same time increase the measurement of transit time is more accurate, so in small pipe flow measurement using this arrangement can play to the advantages of large [7]. In this paper, the channel is used in the reflective channel layout. Its measurement principle diagram is shown in Figure 1:

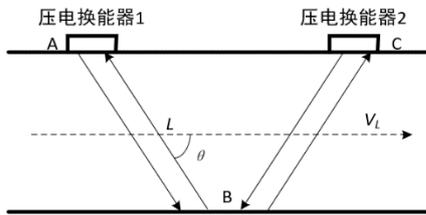


Figure 1: Principle diagram of time difference reflection channel measurement.

The fluid from A to B is taken as the research object to simplify the derivation of the formula. The transmission time of ultrasonic wave from A to B and from B to A is:

$$t_{up} = \frac{L}{c + V_L \cos \theta}, \quad (1)$$

$$t_{dn} = \frac{L}{c - V_L \cos \theta}, \quad (2)$$

In function:

c —transmission speed of ultrasonic wave in fluid medium;

θ —Angle between ultrasonic propagation direction and fluid flow direction;

L —The propagation distance of ultrasonic wave from A to B;

V_L —Average flow velocity of fluid line in flow passage;

Thus, the average flow velocity of the fluid line is:

$$V_L = \frac{L}{2 \cos \theta} \times \left(\frac{1}{t_{up}} - \frac{1}{t_{dn}} \right) \quad (3)$$

3. Simulation of installation effect of inlet pipe

In reality, the gas meter is equipped with a switch valve in front of the intake pipe, and a partition board is installed inside the pipe. When the intake pipe is double-bent and the partition board is half-open, the influence of turbulence is the greatest. Under such installation conditions, if the simulation effect is still ideal, it represents the good measurement performance of the gas meter. Therefore, in addition to straight pipe and double - bend pipe, half - moon double - bend pipe is added. The nominal diameter of the pipe is $D=46.5\text{mm}$, and the length of the straight pipe is $5D$. The radius of the bend in the double elbow is $R=1.5D$, the inlet buffer pipe is $5D$, and the outlet buffer pipe is $3D$. The half-moon double elbow increases the half-tube area plate between the two elbows, with the opening facing the external radius of the first elbow. The pipeline model is shown as follows:



Figure 2: Front view of straight pipe.

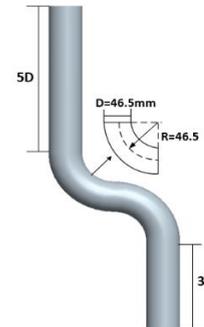


Figure 3: Front view of double elbow pipe



Figure 4: Longitudinal section of half-moon double bend pipe

4. Simulation of installation effect of inlet pipe

Below are the transverse velocity contour lines and vector sections of the above three inlet pipes. The installation direction of double elbow and half moon double elbow is left, the inlet volume flow is $25\text{m}^3/\text{h}$, and the measurement section is set at the bottom of



the downstream straight pipe. From the simulation diagram of straight pipe installation effect, it can be seen that the pipe velocity is low around the pipe, and the fluid flows to the middle of the pipe with uniform flow velocity distribution, and the overall effect is ideal. In the simulation diagram of installation effect of double elbow pipe, the distribution of secondary flow velocity symmetric vortex can be seen, indicating that the air flow through the double elbow pipe not only has axial velocity along the pipe, but also generates radial velocity [8-9]. In the simulation figure of installation effect of half-moon double elbow, it can be seen that the velocity on the axial side of straight pipe near the upstream of double elbow is lower and the velocity on the other side is higher, and there is also secondary flow velocity vortex distribution. It shows that the flow through the elbow will form turbulence, and the flow field distribution in the flow passage will be affected, thus bringing errors to the measurement results.

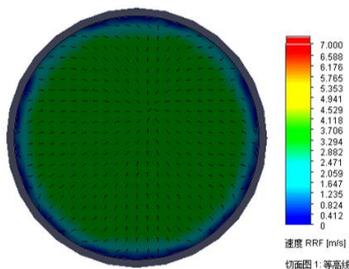


Figure 5: Front view of double elbow pipe

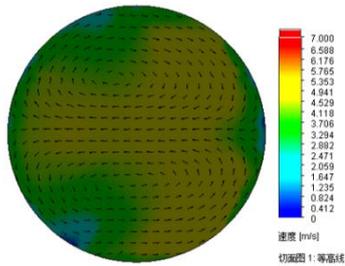


Figure 6: Simulation diagram of double elbow installation effect

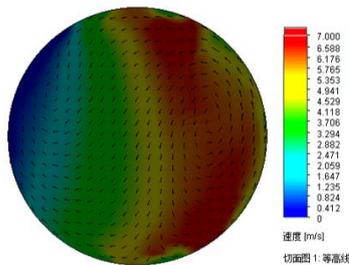


Figure 7: Half moon double elbow installation effect simulation diagram

4. G16 single channel ultrasonic gas meter simulation and calibration test

4.1 Model Establishment

Creo modeling software is used to build G16 single-channel ultrasonic gas meter model as shown in FIG. 8, in which the main components are flow channel, inlet valve and outlet channel connected with flow channel. The flow channel model is shown in FIG. 9. The length of the rectangular channel is 132mm, the internal width of the channel is 45.3mm and the height is 22mm. A pair of ultrasonic transducers are mounted on the upper side of the flow channel to form a reflective mono channel measurement mode. 23 rectifiers are installed inside the flow passage. The thickness of the baffle is 0.3mm, the length is 51.2mm, and the distance between the baffle is 1.6mm. The metering effect of the gas meter will be studied through simulation.

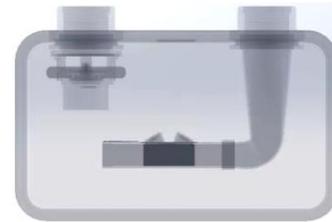


Figure 8: G16 single channel gas meter model diagram

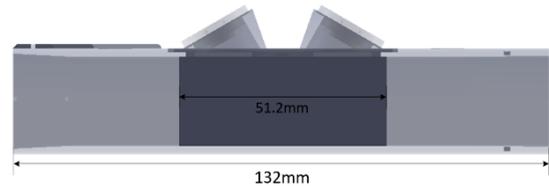


Figure 9: Main view

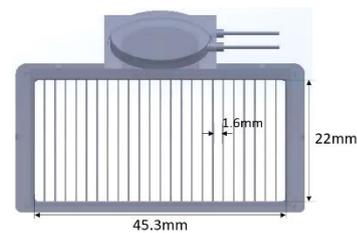


Figure 10: Side view

4.2 Simulation

Computational fluid dynamics (CFD for short) is a combination of numerical mathematics and computer science to realize the simulation and analysis of convective dynamics, which can intuitively and effectively reflect the state of fluid flow [10]. The G16 single-channel ultrasonic gas meter is installed with straight pipe, double bend pipe and half-moon double bend pipe inlet pipe, the installation direction of the bend pipe is left, and the outlet is installed with straight pipe. Then the three gas meter models were imported into FloEFD



simulation software for simulation. G16 national standard commercial ultrasonic gas meter, volume flow range is $0.16\sim 25\text{m}^3 \cdot \text{h}^{-1}$. Set the boundary conditions for room temperature $20\text{ }^\circ\text{C}$, 10 kpa pressure, determine traffic simulation, 5 respectively: Q_{\min} , $0.1Q_{\max}$, $0.4Q_{\max}$, $0.7Q_{\max}$, Q_{\max} .

Taking the simulation when the inlet volume flow is $25\text{m}^3/\text{h}$. As an example, the horizontal contour section of the middle position of the flow passage of the three gas meters as shown in the following figure is obtained. When the inlet pipe is straight, the velocity distribution in the flow passage is the most uniform and the measurement result is the most accurate. Therefore, the data obtained in the case of straight pipe is selected as the standard value. The flow field distribution is not uniform and the flow velocity decreases when the inlet pipe is double bend pipe and half moon double bend pipe. It is proved once again that the flow field distribution is affected when the turbulence caused by the bend enters the flow passage. Although the rectifier plays a role in rectifying the flow field, the influence still exists.

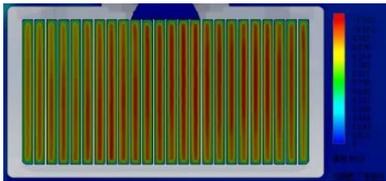


Figure 11: Section view of straight pipe mounting runner

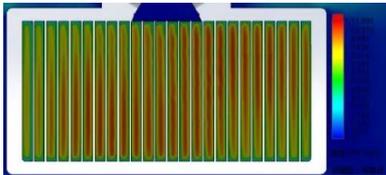


Figure 12: Section view of double elbow mounting runner

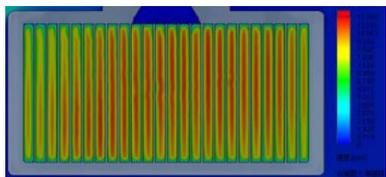


Figure 13: Section view of half moon double bend installation runner

According to the principle of reflection channel measurement by the time difference method, a line should be drawn from the corresponding points of the two ultrasonic transducers to connect to the bottom wall of the flow channel to form a reflection channel. However, the flow rate of the two lines itself has symmetry, so one side line segment can be used to calculate the linear velocity. The drawn line segment needs to be located in the center of the flow channel, because the position close to the rectifier has viscous blocking effect, resulting in low flow rate and unrepresentative. As the upper end of FLOMEKO 2022, Chongqing, China

the drawn line segment must be located on the bottom surface of the ultrasonic transducer, at most four connecting lines can be drawn to simulate the propagation path for calculation. The analog channel connection diagram is shown in Figure 13. While the figure 11 and figure 12 shows that when the inlet pipe is bent pipe, the flow passage of the velocity distribution is uneven, four lines of speed and can cover the range of small, close to the port before and after the wall has the most velocity cannot be measured, affect the measuring accuracy of gas meter, so also for later shuangliu ultrasonic gas meter design provides a train of thought.

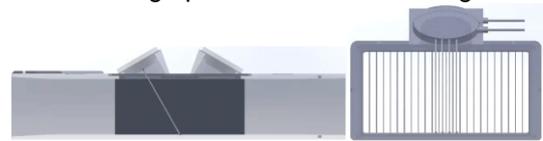


Figure 14: Flow channel simulation channel wiring diagram

Taking the simulation results under the condition that the flow point is $25\text{m}^3 \cdot \text{h}^{-1}$ and the inlet pipe is straight pipe as an example, the curves of the linear velocities of the four velocity measurement line segments changing with distance are shown as follows:

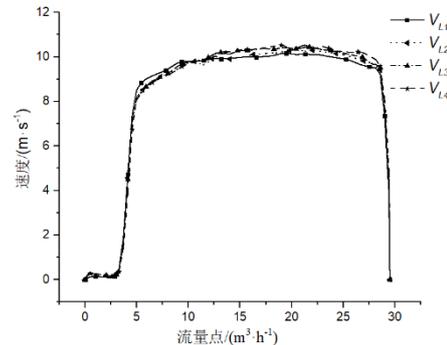


Figure 15: $25\text{ m}^3/\text{h}$ straight pipe line speed distribution diagram

A section with low velocity appears at the most front end of the propagation path, which is caused by the vortex formed by the airflow in the gap of the probe. When the airflow is close to the wall of the flow channel, due to the blocking effect of viscosity, the velocity will rapidly approach 0, while in the middle part of the flow channel, the velocity reaches the maximum. The line integral is applied to the curve to obtain the line average velocity:

$$V_L = \frac{\int V(x)dx}{l}, \quad (4)$$

Where, l is the length of propagation path (all the four paths have the same length, 29.511mm). Due to the uneven distribution of flow velocity in the flow channel, it is necessary to calculate the average line velocity of the four paths again as the final result. The calculation formula is:



$$\bar{V}_L = \frac{V_{L1} + V_{L2} + V_{L3} + V_{L4}}{4}, \quad (5)$$

Where V_{L1} 、 V_{L2} 、 V_{L3} 、 V_{L4} and are the average linear velocity curves calculated according to Formula (4).

The theoretical flow can be calculated from the average flow velocity in the inner line of the flow passage $Q_{理}$:

$$Q_{理} = \bar{V}_L \cdot A, \quad (6)$$

Where, is the cross section area of the flow passage. According to Equations (4), (5) and (6), the inlet pipe is straight pipe, and the theoretical flow is 25.5469m³·h⁻¹ when the flow point is 25m³·h⁻¹. According to the simulation results, the theoretical flow at each flow point is obtained, and the results are summarized as follows:

Table 1: Each flow point of the three gas meters corresponds to the theoretical flow value table

Simulation	Flow point (m ³ /h)				
	0.16	2.5	10	17.5	25
Straight pipe	0.191	2.933	11.237	18.66	25.546
Double elbow	0.189	2.829	10.841	18.433	25.194
Half moon	0.189	2.841	10.806	18.426	25.179

4.3 Correction of flow error curve linearization

In the actual measurement, there is a correction relationship between the actual flow rate and the theoretical flow rate in the flow channel:

$$Q_{实} = Kc \cdot Q_{理}, \quad (7)$$

Where: $Q_{实}$ is the flow point set for simulation.

Thus, the flow correction coefficient Kc :

$$Kc = \frac{Q_{实}}{Q_{理}}, \quad (8)$$

The correction coefficient corresponding to each flow point was calculated according to the simulation results, and Kc 6 significant digits were reserved. The results are shown in Table 2 below: Axis labels should be in a single line and not extend beyond the boundaries of the graph. An example is shown in Figure 2.

Table 2: Each flow point corresponds to the correction coefficient

Flow point (m ³ /h)	Correction factor
0.16	0.833646
2.5	0.852372
10	0.889873
17.5	0.937686
25	0.978594

The error curve linearization correction function is fitted by piecewise quadratic curve, and the flow fitting points are respectively:

$$Q_{min}, 0.1Q_{max}, 0.4Q_{max}, 0.7Q_{max}, Q_{max}.$$

Where $Q_{min}, 0.1Q_{max}, 0.4Q_{max}$ is the fitting of the first paragraph.

$0.4Q_{max}, 0.7Q_{max}, Q_{max}$ is the fitting of the second paragraph.

The error correction equation is:

$$Kc_i = A_i \times Q_i^2 + B_i \times Q_i + C_i, \quad (9)$$

Where, i is the number of segments, and $i=1, 2$.

$Kc_1, Kc_2, Kc_3, Kc_4, Kc_5$ flow points $Q_{min}, 0.1Q_{max}, 0.4Q_{max}, 0.7Q_{max}, Q_{max}$, respectively, and the corresponding correction coefficient Q_1, Q_2, Q_3, Q_4, Q_5 the flow point corresponding flow respectively.

Calculation of coefficient A_i, B_i, C_i :

$$A_1 = \frac{1}{Q_2 - Q_3} \times \left[\frac{Kc_1 - Kc_2}{Q_1 - Q_2} - \frac{Kc_1 - Kc_3}{Q_1 - Q_3} \right], \quad (10)$$

$$B_1 = \frac{Kc_1 - Kc_2}{Q_1 - Q_2} - A_1 \times (Q_1 + Q_2), \quad (11)$$

$$C_1 = Kc_1 - A_1 \times Q_1^2 - B_1 \times Q_1, \quad (12)$$

$$A_2 = \frac{1}{Q_4 - Q_5} \times \left[\frac{Kc_3 - Kc_4}{Q_3 - Q_4} - \frac{Kc_3 - Kc_5}{Q_3 - Q_5} \right], \quad (13)$$

$$B_2 = \frac{Kc_3 - Kc_4}{Q_3 - Q_4} - A_2 \times (Q_3 + Q_4), \quad (14)$$

$$C_2 = Kc_3 - A_2 \times Q_3^2 - B_2 \times Q_3, \quad (15)$$

By substituting the data in Table 2, the revised equation is obtained as follows:

$$Kc_1 = -0.000305Q^2 + 0.008814Q + 0.83224, \quad (Q \leq Q_3) \quad (16)$$

$$Kc_2 = 0.000061Q^2 + 0.008063Q + 0.81538, \quad (Q_3 < Q \leq Q_5) \quad (17)$$

According to the piecewise correction equation, the correction coefficients corresponding to any flow points between Q_{min} and Q_{max} can be obtained. Then the modified flow formula is:

$$Q_{修} = Kc \cdot Q_{理}, \quad (18)$$

In the formula, $Q_{修}$ is $Q_{理}$ the flow value obtained after Kc correction. The corrected flow is the actual flow, which has the same meaning with the set current point $Q_{实}$, but the value is different. This is



caused by the measurement error caused by external conditions, and the correction cannot reach very accurate. Thus, the closer the two values are, the more accurate the correction is and the smaller the error is [11-12].

In this paper, the corrected flow value in the case of straight pipe is taken as the standard value, so the correction coefficient obtained by him under five flow points is also taken as the correction coefficient of the corresponding flow points of the gas meter in the inlet pipeline of double bend pipe and half moon double bend pipe. According to the simulation results and formula (18), the corrected flow rate of each flow point of each gas meter can be obtained, and then the error degree can be calculated. The error calculation formula is:

$$E = \frac{Q_{\text{弯修}} - Q_{\text{直修}}}{Q_{\text{直修}}} \times 100\% \quad (19)$$

Straight pipe error calculation formula:

$$E = \frac{Q_{\text{直修}} - Q_{\text{实}}}{Q_{\text{实}}} \times 100\% \quad (20)$$

According to Equations (19) and (20), the relative errors of flow points corresponding to the three gas meters are shown in the following table:

Table 3: Relative error of flow point corresponding to three gas meters

Flow (m ³ /h)	$E_{\text{直管}} / \%$	$E_{\text{双弯管}} / \%$	$E_{\text{半月双弯管}} / \%$
0.16	-0.01458	-1.448	-1.392
2.5	0.000283	-3.515	-3.121
10	0.000368	-3.524	-3.837
17.5	0.000368	-1.23	-1.268
25	0.000172	-1.381	-1.439

Accuracy grade is 1.5 ultrasonic gas meter, the national standard: when $Q_{\min} \leq Q < Q_f$, the maximum allowable error is $\pm 3\%$, when $Q_f \leq Q < Q_{\max}$, the maximum allowable error is $\pm 1.5\%$. The relative error line graph obtained according to Table 3 is shown in Figure 16:

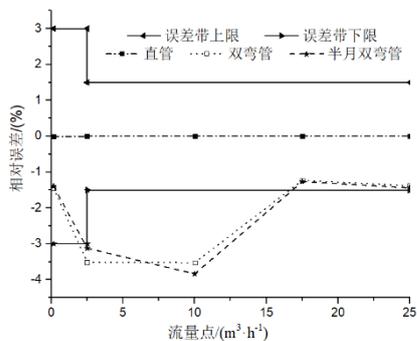


Figure 16: Line chart of relative error of single channel gas meter in different pipeline

It can be seen from FIG. 15 that the corrected error degree of the gas meter with straight pipe is close to 0, while the relative error of the gas meter with double elbow pipe and half moon double elbow pipe does not meet the national standard at two points. It can be seen that the elbow has a great impact on the measurement accuracy of this single flow channel ultrasonic gas meter. However, as a precision measurement tool used in a large number of commercial applications, the gas meter must constantly strengthen its anti-turbulence ability and improve its measurement accuracy under different inlet pipeline installation modes.

5. G16 double channels ultrasonic gas meter simulation and calibration test

5.1 Mathematical Modeling

Based on the shortcomings of G16 single channel in structure, G16 double channel is designed. In addition to the change of flow channel structure and outlet channel, the other components of the gas meter are the same. The length of the rectangular flow channel is 107mm, the internal width of the flow channel is 21.7mm, and the height is 25mm. Channel form is still reflective mono - channel. The flow passage is equipped with 9 rectifier plates, the thickness of the plate is 0.3mm, the length is 58.6mm, the distance between the plate is 1.9mm, under this condition, the rectifier effect is the best. The gas meter and flow channel model structure is shown as follows:

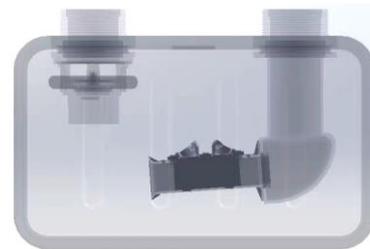


Figure 17: G16 double channel gas meter model diagram

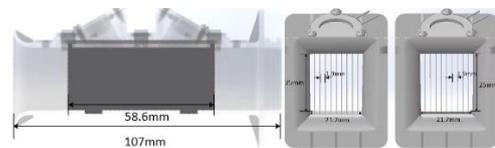


Figure 18: G16 double channel module model diagram

5.2 Simulation

The G16 double channel ultrasonic gas meter is also installed with straight pipe, double bend pipe and half moon double bend pipe, and then imported into FloEFD simulation software for simulation. The volume flow range is 0.16~25m³/h, the boundary condition is set as 20 °C at room temperature, and the pressure is 10kPa. Five flow points are selected for simulation, respectively: Q_{\min} , $0.1Q_{\max}$, $0.4Q_{\max}$, $0.7Q_{\max}$, Q_{\max} .



For entry volume flow simulation of 25 m³/h, for example, are shown in the figure below three gas meter runner contour transverse sectional drawing, central position and Figure 11, Figure 12 and 13, compared to the three sectional drawing differentiation is not obvious, this is due to the use of the shuangliu structure, reduced due to the bending of the influence of uneven distribution of flow field, However, it can still be seen that when the inlet pipe is straight, the flow velocity distribution is the most uniform, while when the inlet pipe is double bend pipe and half moon double bend pipe, the flow field is not uniform and the flow velocity slows down. It is preliminarily concluded that the influence of elbow on the measuring accuracy of double channel gas meter is less than that of single channel gas meter.

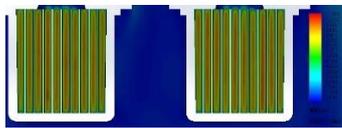


Figure 19: Section view of straight pipe mounting runner

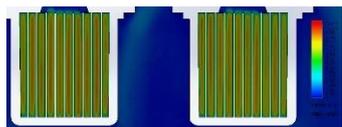


Figure 20: Section view of double elbow mounting runner

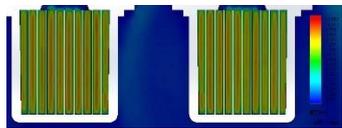


Figure 21: Half moon section view of double elbow mounting runner

Per flow passage can draw four line is used to simulate the propagation path, shuangliu way that there are eight, compared with single runner G16, doubled, and its near port on both sides of the wall before and after not covered by ultrasonic range decreases, and thus speculate that G16 shuangliu tao gas meter measurement error will be less than the measurement error of G16 single port gas meter. The analog channel connection is shown as follows:

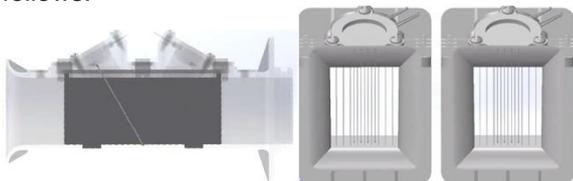


Figure 22: Flow channel simulation channel wiring diagram

The formula for calculating the average flow velocity is:

$$\bar{V}_L = \frac{V_{L1} + V_{L2} + \dots + V_{L8}}{8}, \quad (21)$$

Where V_{L1} , V_{L2} , ..., V_{L8} Respectively are the average linear velocity curves of eight routes calculated according to Formula (4):

Table 4: Each flow point of the three gas meters corresponds to the theoretical flow value

Flow point	0.16	2.5	10	17.5	25
Straight pipe	0.1666	2.633	10.274	16.988	22.883
Double Elbow	0.1651	2.596	10.148	16.793	22.715
Half moon	0.1643	2.575	10.004	16.793	22.660

5.2 Correction of flow error curve linearization

The linear correction method of the error curve of the two-channel gas meter adopts the piecewise quadratic curve fitting exactly the same as that of the single-channel gas meter. According to the simulation results and Formula (8), the corresponding correction coefficient of each flow point is calculated as follows:

Table 5: Each flow point corresponds to the correction coefficient

Flow/(m ³ /h)	Correction factor
20	1.058
25	1.057
30	1.057
40	1.057
45	1.056

The modified equation can be obtained from Equations (9)~(15):

$$Kc_1 = 0.001546 * Q^2 - 0.01439 * Q + 0.962647$$

$$(Q \leq Q_3) \quad (22)$$

$$Kc_2 = 0.000049 * Q^2 + 0.006214 * Q + 0.906247$$

$$(Q_3 < Q \leq Q_5) \quad (23)$$

According to the above subsection correction equation, the correction coefficient corresponding to any flow point between Q_{min} and Q_{max} can be obtained.

Finally, the relative errors of the corresponding flow points of the three gas meters are obtained from Equations (19) and (20), as shown in the table below:

Table 6: Relative error of flow point corresponding to three gas meters

Flow (m ³ /h)	$E_{直管} / \%$	$E_{双弯管} / \%$	$E_{半月双弯管} / \%$
0.16	0.00002	-0.897	-1.38
2.5	0.000525	-1.403	-2.027
10	0.0017	-1.231	-2.631
17.5	0.000065	-1.149	-1.151
25	0.000192	-0.736	-0.976

According to the simulation results and table 6, the theoretical flow at the corresponding flow point of



each gas meter is obtained. The final results are summarized as follows:

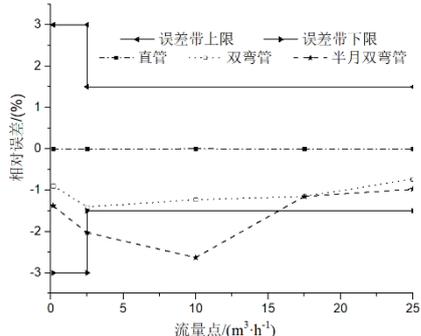


Figure 23: Line chart of relative error of double channel gas meter under different pipelines

FIG. 23 shows that the inlet pipe is a gas meter of straight pipe, and the relative errors of each flow point are close to 0 and all meet the national standards. The inlet pipe is a gas meter with double bends, and the relative errors of each flow point all meet the national standards. For the gas meter with half-moon double-bent pipe in the inlet pipeline, the relative error does not meet the national standard at 2.5m³·h⁻¹ and 10m³·h⁻¹. Compared with FIG. 15, it can be seen that the error brought by the elbow to the double-channel gas meter is less than that of the single-channel gas meter in this paper. The flow channel has been improved, but it can still be further improved.

6. Actual airflow flow test on calibration system

6.1 G16 single channel ultrasonic gas meter calibration test

For monophonic G16 ultrasonic gas meter, calibration test is carried out on the actual calibration device to test the actual measurement accuracy and repeatability data of ultrasonic gas meter.



Figure 24: G16 calibration test



Figure 25: G16 calibration test

Three samples were tested, with serial numbers of SN21080001, SN21080002 and SN21080003 respectively. The internal flow channel was designed as a single flow channel, and the test device was a sonic nozzle method gas flow verification device. The flow of the device ranges from 0.06m³/h to 40m³/h, and the synthetic relative expansion uncertainty of the device is U_{rel}=0.31% (k=2). Calibration tests are carried out on three prototype meters from the minimum flow of 0.16m³/h to the maximum flow of 25m³/h. The specific data are shown in Figure 24 below:



Figure 26: G16 single channel meter calibration data

According to the analysis of the test data of three prototypes, the error of the gas meter near the flow point of 0.2q_{max} is beyond the error range of the 1.5 level meter. In addition, the repeatability of the gas meter is poor near the maximum and minimum flow, and there are certain fluctuations in the measurement process.

Analysis reasons, although in theory, the gas flow in the straight pipe, air flow is evenly distributed in the flow passage of state, but in the process of actual calibration test, because of the influence of the structure, will have certain disturbance airflow, and ultimately affect the mono ultrasonic gas meter of the effect of measuring accuracy and error fluctuation.

6.1 G16 double channels ultrasonic gas meter calibration test

In the same way, three dual-channel G16 ultrasonic gas meter samples were made, with serial numbers SN21080004, SN21080005 and SN21080006, respectively. The three samples were verified and tested in the same sonic nozzle method gas flow verification device.



Figure 27: G16 double channels meter calibration data



In terms of test data, compared with the single-channel G16 ultrasonic gas meter, the accuracy of the gas meter is more accurate and closer to the reference line of error 0, and the repeatability of the gas meter error is also significantly improved, without error fluctuation. Analysis of the reason is that the design of the double channel, so that the airflow distribution in the flow channel is more uniform and stable, so that the ultrasonic measurement process is stable, so as to ensure the accuracy and repeatability of the gas meter.

6. Conclusion

This paper for the installation of straight pipe, double pipe bending and half double bend G16 single entrance pipe flow simulations with ultrasonic gas meter, according to the results of simulation to calculate flow value, through the way of fixed flow value and calculate the relative error, verify the bend to this single port gas meter measuring accuracy, a larger impact based on the single port after the disadvantages of gas meter, G16 dual-channel gas meter was established, and simulation experiments were conducted under the same conditions. Finally, data were analyzed and compared, and conclusions were drawn:

1.Secondary flow, eddy current and other turbulence will be generated when the airflow passes through the elbow. When it reaches the flow passage, the flow field is not evenly distributed, which will affect the measurement accuracy of the gas meter.

2.G16 single flow channel ultrasonic gas meter, in the installation of double elbow and half a double elbow, the influence of turbulence is great, the flow field distribution in the flow channel is not uniform, and the ultrasonic can cover a small range, the measurement accuracy is not high enough, the relative error is large.

3.G16 double channel ultrasonic gas meter, in the case of the installation of double bend pipe and half moon double bend pipe, effectively improve the impact of turbulence, flow field distribution in the flow channel is more uniform than that of the single channel gas meter, ultrasonic coverage increases, measurement accuracy improves, relative error decreases.

4.Through the sonic nozzle verification device of the actual test, G16 two-channel ultrasonic gas meter, in the measurement accuracy and error repeatability, better than the single channel ultrasonic gas meter.

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