Development of Movable Testing Device for Gas Flow Equipping with the Critical Flow Venturi Nozzles

Yi ZHOU[1], Zuoguang ZHAO[2], Fang DONG[2], Caihong SUN[3]， Zhi LI[3]

[1]Calibration and Testing Center for Gas Flow of Jiangsu, New District Yihoulu No.306, Zhenjiang,China
[2]Calibration and Testing Center for Gas Flow of Jiangsu, Zhenjiang, China
[3]Calibration and Testing Center for Gas Flow of Jiangsu, Zhenjiang, China
E-mail: able908@126.com

Abstract

In order to meet the requirements of rapid on-site verification / calibration of flow meters in our country's natural gas measurement field, we have jointly developed a movable gas flow testing device equipping with critical flow venturi nozzle . According to actual needs the device will be used in the different lab.In order to ensure the uncertainty of the device can meet the requirements of customers,the designer should fully demonstrates and considers the design in selecting the most suitable temperature and pressure sensor, and the processing of calculus.From technical point, we should control the possible impact on the measurement results of the movablegas flow testing device caused by environmental changes.

This paper introduces the control scheme of the possible influence of environmental conditions such as temperature on the uncertainty of the device,and try to use the actual experimental data of the completed device（model 1）to analyse and report the correlation between the temperature change, Reynolds number and flow value.

1. Manufacturing background

According to the JJG 1037-2008 *Verification Regulation of Turbine Flow Meter*, the relative expanded uncertainty of the standard device used to verify the gas flowmeters with accuracy class 1.0 is 0.33% （ k=2 ） .In order to meet the increasing verification and calibration needs of gas flow meters for natural gas measurement, it is urgent to develop a movable gas flow testing device（hereinafter referred to as "device"） with critical flow venturi sonic nozzle （hereinafter referred to as "nozzle"）. However, when using the nozzle as a standard parts, if the environmental conditions are different from those of nozzle verification, the environmental changes caused by the changes of temperature and pressure may produce additional errors. In order to ensure the high-precision use of nozzles based on the actual situation of gas measurement in our country and the user's demand for on-site testing, OVAL Corporation and Jiangsu gas testing center jointly developed a device to minimize the additional errors caused by environmental changes.

2 System design and equipment composition

Considering that the device will be used in different laboratories with different environments, the uncertainty of the device is still able to meet the needs of testing. In terms of device design, through the consideration of selecting temperature and pressure sensors that can response the environmental changes quickly, as well as the processing of related calculations. Strive to control additional errors caused by environmental changes. In the development of the device,（1）In order to improve the speed of response to temperature changes, the sheath for measuring resistance is as thin as（φ0.8mm）；（2） In order to improve the accuracy of pressure measurement, the combination of gage pressure gauge and barometer is used for compensation calculation;（3）In order to improve the speed of calculation and processing, the temperature and pressure changes response instantaneously;（4）In order to make the operation process accurate and fast, the approximate formula is used instead of table data in the operation.

Table 1 Main equipment composition of the device

Hardware	Technical specifications	Unit	Quantity
Vacuum pump	Vacuum degree: 4080mmaq, Flow rate: 35.1m^3/min	platform	1
Blower	175m^3/h at 50kPa，55Hz,11kW	platform	1
Large metering chamber nozzle	Accuracy class：0.2 32m^3/h，64m^3/h，128m^3/h，256m^3/h，512m^3/h	group	1
Small metering chamber nozzle	Accuracy class: 0.2 0.25m^3/h，0.5m^3/h，1m^3/h，2m^3/h，4m^3/h，8m^3/h，16m^3/h	group	1
Large metering chamber	Flow range: 64m^3/h ~ 1600m^3/h; Required critical back pressure ratio: ≤ 0.7	set	1
Small metering chamber	Flow range: 0.25m^3/h ~ 63.75m^3/h; Required critical back pressure ratio: ≤ 0.5	set	1
Pressure transmitter	（0~60）kPa, MPE±0.075 %	platform	3
	(75~110)kPa, MPE±0.025%	platform	1
Temperature measuring resistance	（0~50）℃, MPE±0.05 ℃	branch	3
Temperature and humidity transmitter	（0~90%）RH，MPE±1.5% RH； （90 ~100%）RH， MPE±2.5% RH	platform	1
Other auxiliary equipment	/		

3 Test and data result

In order to verify the consistency of the test results under the condition of temperature change, we tested the flow rate of nozzle and the flow rate test at the flow meter under the temperature environment of 16 ℃ ~ 28 ℃ for the device introduced in this paper. The summary of the test is as follows:

（1）Nominal flow of test nozzle:8m3/h; Accuracy class: 0.2, Outflow coefficient Cd:0.9760 ;

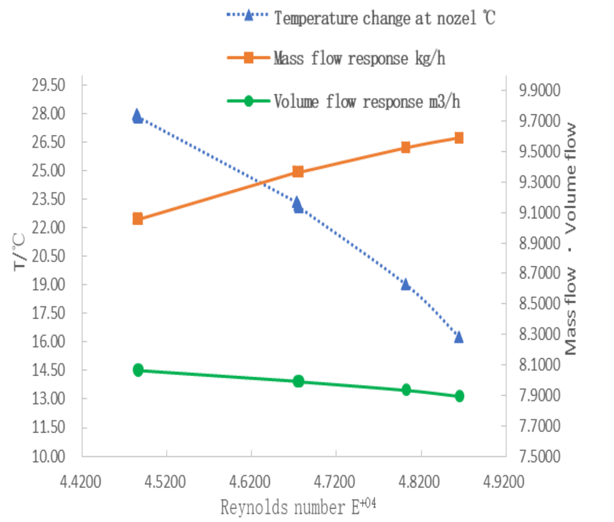
（2）Flowmeter used in the test， Name: Gas Volumetric Flowmeter;Model: IBMG16 DN40; No:20523145;Accuracy class: 0.2;

（3）Test times: 6 times per point, 60 s per time, take the average value.The average instrument coefficient of this laboratory is 42890 1/m3,The instrument coefficient calibrated by the third party is 42918 1/m3（NO.2022E70-10-3989203001）the flow meter test result can be used in our test.

（4） See Table 2,Fig. 4, 5 and 6 for the analysis of test results.

Table 2 Changes of temperature and flow

Project	Variation range
Ambient temperature change ℃ (measured)	16.75～28.25
Humidity change%RH (measured)	53.78～68.63
Temperature change at nozzle ℃(measured)	16.24～27.92
Pressure change at nozzle kPa	97.880 ~ 101.407
Reynolds number change at nozzle E^{+04} (software calculation)	4.4851～4.8656
Nozzle flow change kg/h (software calculation)	9.5929～9.0560
Flow change of nozzle m^3/h (software calculation)	7.8928～8.0642
Flow change at flowmeter m^3/h (software calculation)	7.8961～8.0814



ig 4: Changes of temperature, Reynolds number and flowrate at nozzle

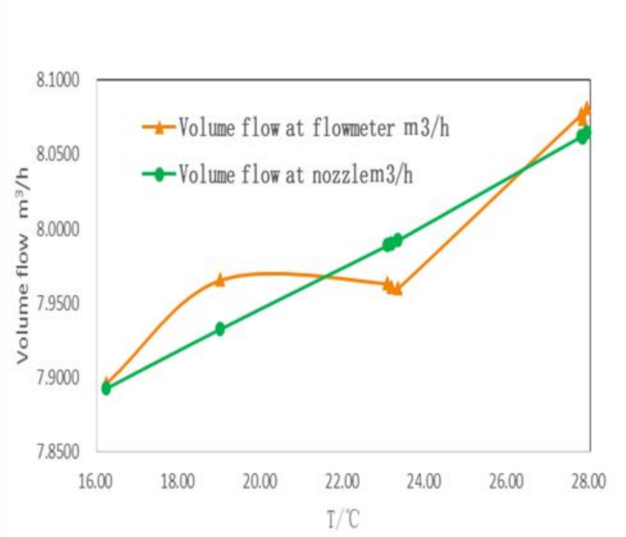


Fig 5: The flow at the sonic nozzle at 8m^3 flow point and the flow at the flowmeter are responsed

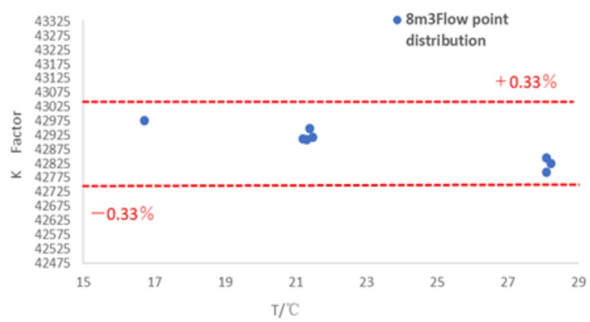
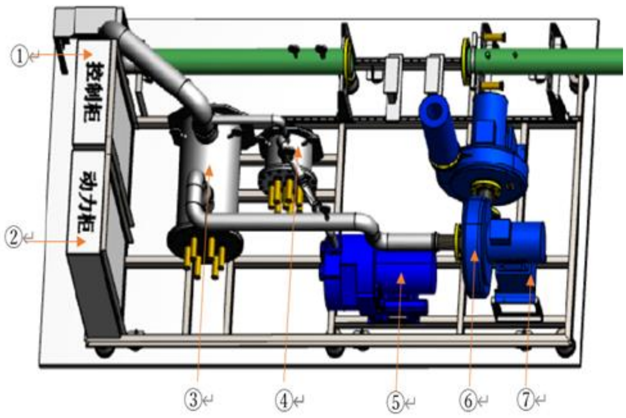


Fig 6: Distribution of flowmeter coefficient at 8m^3



①Control Pane l②Power Paner ③Large Chamber
④Litter Chamber⑤⑥⑦Blower
Fig7: Device structure drawing

Fig8: Physical drawing of device

4 Result analysis

1. Investigation on the influence of temperature change on the flow rate of critical sonic nozzle

In this report, the simulation diagram of mass flow value, volume flow value and Reynolds number change of nozzle at 8m3 flow point is shown in Fig 4, and the comparison of flow rate between flow meter and sonic nozzle is shown in Fig 5 (temperature and pressure are collected from measured values)

2. Distribution of test results of the tested flowmeter

As shown in Figure 6, the distribution of the instrument coefficient of the tested flowmeter is always within the range of 0.33% of the relative uncertainty of the gas movable test device between the 8m3/h flow point (one 8m3/h nozzle) within the variation range of the ambient temperature of about 16 ℃ ~ 28 ℃. 8m3/h average instrument coefficient: 42890 1/m3, Uncertainty caused by reproducibility:0.05%, less than the expanded uncertainty of the device 0.33%.

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