The Status and Prospect of Gas Flow Value Dissemination System in China

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Abstract: This paper described current gas flow value dissemination system and its feature in China. The paper introduced some researching project and quantities unifying work. At the end, it did prospect about research direction in near future.

Keywords Gas flow; dissemination system

Introduction

Due to the wide needs for the flow metrology in China, more than ten hundred sets of gas flow calibration facilities which mainly are bell prover has been set up. We should have responsibility for the veracity and unity of their value.

1.Current Metrology System of Gas Flow

The metrological traceability system of gas flow shown in the figure 1 consists of relative calibration facility that can provide flow value, standard facility with original method, standard facility with dissemination method, working flowmeter and intercomparison between the facilities.

1).Quantities of Higher-level Standard

The quantities concerned with flow value include mass (or length), temperature, pressure and time, etc., and the flow value is traced from these quantities.

2).Standard Facility with Original method

The standard facility with original method (or called original class standard) for flow rate is an facility implemented according to the basic definition of flow, that is, to take length-measuring instrument and weighing device as the measuring equipment for volume V or mass m, so as to get the standard volume. The standard facility with original method is the one with the highest metering performance among flow facilities, because the quantities of flow calibration facilities and some flowmeters shall be determined by the standard facility with original method. For the standard facility with original method for gas flow, it mainly uses gas flow calibration facility with pVTt method, bell prover and gas flow calibration facility by piston, etc. All the standard facilities with original method of China are listed in the figure 1. In the following we'd like to introduce them one by one.

The gas flow calibration facility with pVTt method that is kept in the national institute of metrology (NIM) is founded in 1986, is primary standard for gas flow, and the experimental media is air. The facility mainly consists of standard container of $20m^3$,$2m^3$, $0.2m^3$, several temperature sensors placed in the standard container and upstream of the critical nozzle, as well as accessory display instruments, digital pressure gage, timer, atmospheric humidity meter, vacuum pump and air compressor, etc. The measuring range is $(0.1\sim1300)m^3/h$ and uncertainty is 0.05%,

k=2. The standard volume can get by weighing nitrogen and measuring the temperature and pressure. The facility is mainly for disseminating the value of critical nozzle, and the quantities of up to 100 sonic nozzle facilities in China are from the facility. Its basic structure is shown as figure 2.

The gas flow calibration facility by piston kept in the National Metrology Institute is founded at the beginning of this year. Its experimental medium is air. The facility consists of two piston systems with diameter 200mm and 800mm respectively. The pistons move in the piston cylinder up and down at even speed driven by the servo motor through ball screw, and the moving distance of piston will be determined by the grating. The sealing between piston and cylinder block is in mechanical way, lubricated by oil, and leakage-inspecting facility is furnished. The flow range is from 0.01 to 150 m^3/h and uncertainty is 0.05%, k=2. The standard volume will be worked out by the inner diameter of piston cylinder block and the down-moving height of the piston, all of which will be from dimensional quantities. Its basic structure is shown as figure 3.

The 10000L bell prover kept in the national flow station of crude oil of China is another gas flow facility with high accuracy, the experimental medium is air, and the uncertainty is 0.1%, k=2. The standard volume will be worked out by measuring size. It is mainly to calibrate high accurate flowmeter.

The gas flow calibration facility with pVTt method kept at Shanghai Automatic Instrument Research Institute takes air as experimental medium too, and the facility consists of standard container of $19m^3$, $1m^3$, and the uncertainty is 0.1%, k=2. It undertakes part work of calibration for critical nozzles.

There are more than 10 sets of bell provers with accuracy of 0.2% all over China, the nominal volumes are from 50L to 10000L, and they are distributed at different provinces in China, they are for measuring the gas flowmeters.

There are a lot of bell provers with accuracy of 0.5% distribute widely in China and the quantity is up to several hundreds.

In China, there are several sets of gas soap-film flow facilities which are disseminating the quantities of mini gas flow, the max. flow is 2000ml/min, the uncertainty is 0.5%, k=2.

3).Standard Facility with Dissemination Method

The standard facility with dissemination method takes the flowmeters as standard, which gets quantities from standard facility with original method and has good repeatability and stability. It will measure a flowmeter by comparing the readouts from the standard flowmeter and the flowmeter to be calibrated that are connected in serial. It is the intermediate chain between the standard facility with original method and working flowmeter, hence one can avoid use of the standard facility with original method frequently and guarantee its high accuracy. On the other hand, during application, the standard facility with dissemination method is more simple, more convenient than the standard facility with original method, this can improve the efficiency. For gas flow, the standard flowmeters mainly are critical nozzle, gas turbine flowmeter, etc. Up to several hundreds sets of the standard facility with dissemination method are being used in China at present, they are dominated by critical nozzles.

4).Working Flowmeter

The working flowmeter varied greatly in kinds, all of them can get quantities by standard facility with dissemination method or with original method. We should point out that many flowmeters at present can show directly the flow under standard state, however, we think that for most flowmeters in volumetric principle and speed principle, they shall show the flow under operation condition during calibration.

2.Works under Development

1).Intercomparison

As the quantity of gas flow facilities is high, and they are carrying out the mandatory calibration, but no interconnection has been established for their quantities, which is easy to produce systematic difference. So, we have tried to intercompare the gas flow in our country since 2001. After 2 comparisons in a small range and having found certain systematic difference, we have made comparison between 100L bell provers at 10 labs all over China in 2003~2004 to guarantee the consistency in quantities of gas meters which are as mandatory measuring apparatus. Two gas roots flowmeters were used during the comparison, tests were conducted at 5 flow points in a flow range of （0.6~6）m^3/h. In the figure, it shows the intercomparison result at one flow point of a standard flowmeter. From the figure, we can see that the data from some labs exceed the equivalent line, but no high systematic difference occurred. We have carried out technical analysis on the comparison data and thought that:

(a). About temperature control and correction

During the comparison, most labs corrected the gas temperature in the bell prover and that of flowmeter. But we think that we should control the difference between the gas temperature in bell prover and that at flowmeter, so as to reduce the heat exchange due to temperature gradient, hence the influence of temperature difference on measurement can be neglected. For example, we can make ambient temperature be stable, the gas entering into the bell prover approach to the ambient temperature as far as possible, don't install any device that may result in change in gas temperature such as electromagnetic valve on the pipeline between flowmeter and bell prover.

(b). About the sealing medium

According to the current national verification regulation, the sealing medium can be water or oil. But until recent, there is no test data that compared these two sealing ways, this time we added this kind of test during the comparison, and have got some preliminary conclusions.

First the test with different medium on the same bell prover was conducted. Firstly, we filled water in the liquid groove, calibrate the bell prover and test the flowmeters; then we change the sealing media into oil and complete the same test so as to compare the difference between them. The test results show that, when static volumetric method is used to calibrate the bell prover using different medium, it will have a difference of 0.3%~0.4%. But it has no such difference when using dimensional method. Therefore, through comparison, we demanded that the facility of 0.2% will use oil as sealing medium, and suggested that the facility of 0.5% will use oil as sealing medium. As for the difference due to the calibrating way, we will make further experiment and analysis to solve the problem.

2).Scheme design for gas flow calibration facility

With the development of gas flow metrology, many localities have established one after another gas flow calibration facilities with diameter less than 300 mm. To standardize the design and reduce waste, we have given a recommended mode for calibrating the common gas flowmeters. That is: considering the performance of all kinds of standard flowmeters, we recommend using combined critical nozzles as standard flowmeter if flow rate is less than $100m^3/h$. In this case, we use vacuum pump as power to pump air from atmosphere to pass in sequence the flowmeter to be checked and critical nozzles. For $100m^3/h$ and above we recommend to use gas turbine flowmeters as standard flowmeter, while we use blower as power to pump air from atmosphere to pass in sequence the turbine flowmeters and the flowmeters to be checked.

3.Target in the Near Future

1).Develop comparison

To guarantee the consistency of gas flow quantities, we plan to incorporate the comparison into the calibration of the facilities through several nationwide comparisons, so as to make it a routine work.. At present the comparing way has become almost mature. Because flowmeter is easy to have mechanical change during application and transportation, the possibility that the comparing data becomes ineffective is high when it is tested continuously in more labs. As a result, the comparison is conducted by circulation in minor labs.

2).Manufacture and research for bell prover

As bell provers are widely used as calibrating facilities in China, the research on its process structure and performance is of high importance. In respect to the structure of the facility, we will consider the use of encoder, influence of roundness of prover body, influence of guideway design and wobbling; In respect to calibrating way, we will consider the difference and comparison of dimensional way and volumetric way; In term of sealing media, we will consider the influence of water evaporation and humidity on the uncertainty of the facility. Therefore, we are planning to establish a high-accuracy bell prover of 1000L, and develop relative research based on this.

3).Establishment of tiny gas flow calibration facility

In the current national gas flow metrology system, the calibrating facility for tiny gas flow is soap film type facility, but its accuracy is far away from the required one, therefore we will set up a tiny gas flow facility by using glass steel as cylinder block, stainless steel as piston, and mercury as the sealing medium.

Standard of Higher-level

Mass	Temp	Pressure	Length	Time	Density

Standard Facility with Original method

Gas flow primary standard with pVTt technique 0.05%, k=2, flow range:(0.1~1300)m^3/h

Gas flow primary standard by piston 0.05%, k=2 flow range: (0.01～150)m^3/h

Gas flow calibration facility with pVTt technique 0.1%,k=2

Bell prover (10000L) 0.1%,k=2

Bell prover (50~2000) L 0.2%,k=2

Bell prover (20~2000) L 0.5%,k=2

Soap film facility 0.5%,k=2 (5～2000)ml/min

Gas flow calibration facility with standard flowmeter

Gas flow calibration facility with standard flowmeter: (0.1~5000) m^3/h 0.5%,k=2

Working apparatus

Working flowmeter

Figure 1 Gas flow calibration facilities in China

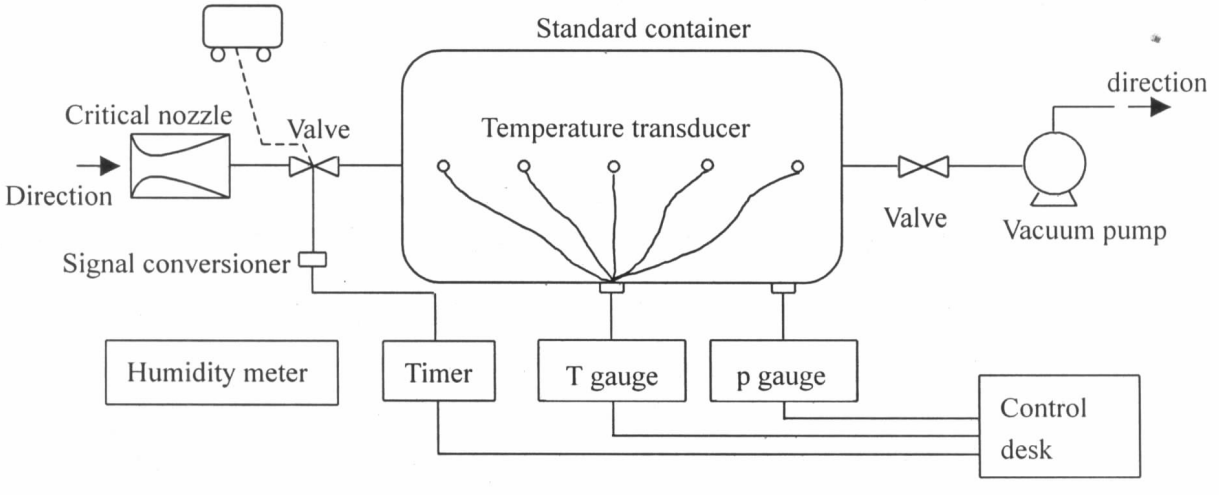

Figure 2 Structure of gas flow primary standard with pVTt method

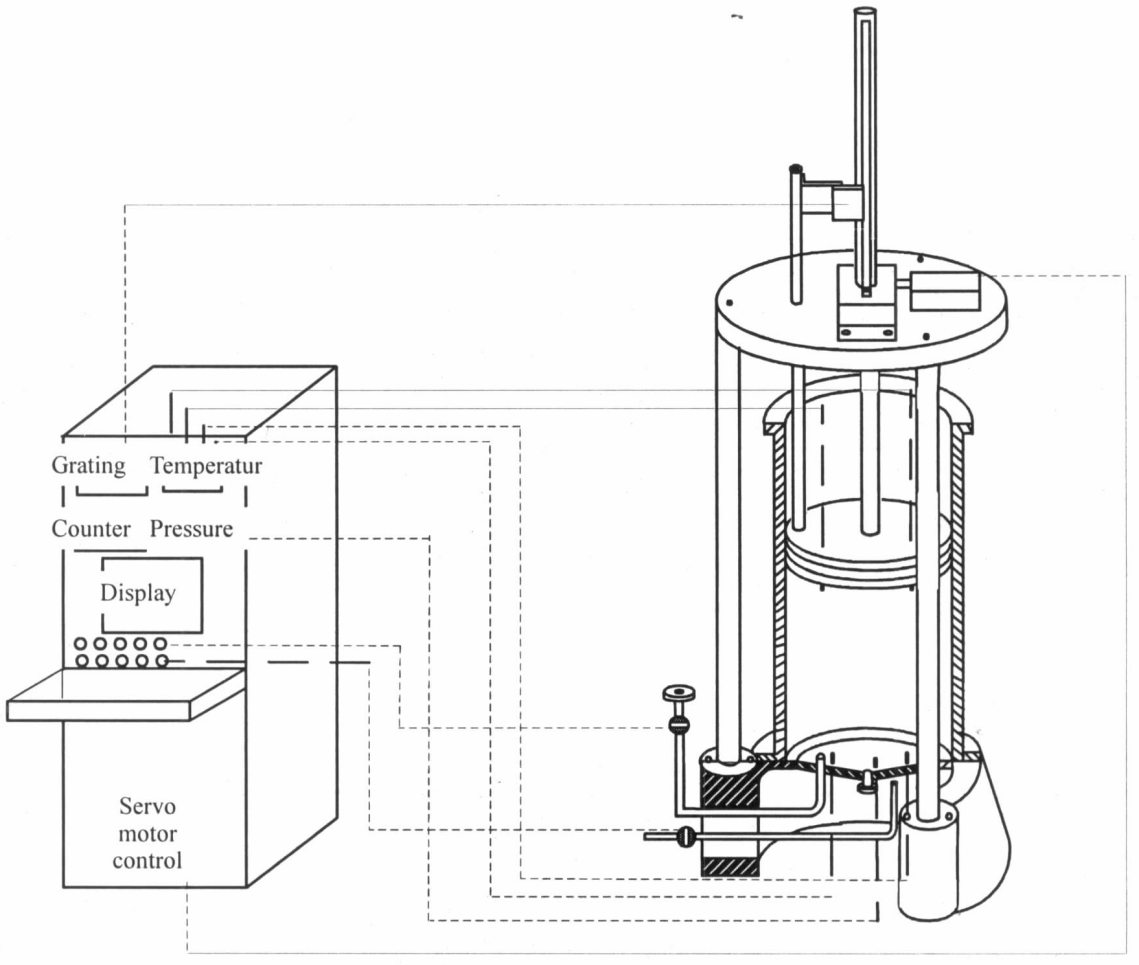

Figure 3 Structure of Gas flow primary standard by piston

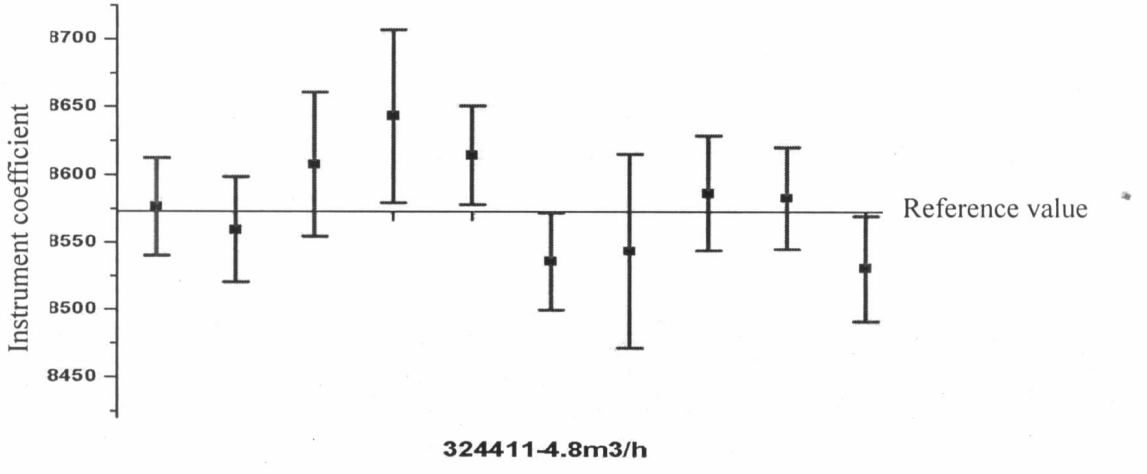

Figure 4 Result of comparison of bell prover in China