Influence of Medium Type on Measurement Performance for Vortex Flowmeter

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Abstract

The verification medium of vortex flowmeter in the laboratory is often different from the actual measurement. It is very important and necessary to quantitatively analyze the influence of the medium type on its measurement performance. So it is very important and necessary to quantitatively analyze the influence of medium type on its metering performance. The instrument coefficient and indication error of the same vortex flowmeter are verified by water, diesel and air at different flow velocity points, and the measurement performance difference is analyzed which caused by the medium type. The experimental results are that the instrument coefficients by three media are some different under the conventional flow velocity, but not exceed 1/3 of the maximum allowable error, and the indication error is below 1.0%, which meets the accuracy requirements. The conclusion is that the influence of the medium type on the measurement performance of the vortex flowmeter is small, and the result qualified by air, water or diesel can be used for other media, which can meets the requirements of the accuracy level.

1. Introduction

Vortex flowmeter measures the volume flow of fluid by the principle of Karman vortex. It is an immovable sensor, with small pressure loss, wide range ratio. It has immovable sensor, small pressure loss and wide range ratio, and its material has corrosion resistance and high temperature resistance. Therefore, the vortex flowmeter is a widely used flowmeter [1], which can measure single or mixed media such as various gases, liquids and steams. Especially in some high pressure and temperature occasions, the vortex flowmeter has become almost an irreplaceable flowmeter.

The verification medium of the vortex flowmeter should generally be close to the physical parameters such as the density and viscosity of the actual medium according to the regulations [2]. However, this requirement is often not well met limited by laboratory conditions. Therefore, It is an important method that quantitatively analyze the influence degree of the different medium type on the measurement performance for evaluate the applicability and reliability of laboratory test results in practical applications

Gu Yongwei [3] compared and analyzed the calibration results of air and steam, and obtained a coefficient within ±0.5% for air calibration, and the error for steam would be amplified to within ±2.5%. Xu Wenda [4] measured the indication error with different diameters and different flow points with air and steam, and found that the instrument coefficients of the two media were slightly different, but could not be quantitatively described. Liu Weiwei [5] used water, air and steam to calibrate the instrument coefficient of the same vortex flowmeter, and found that the instrument coefficient of air is larger than that of water for (0.5～1.4)%, and larger than that of steam for (1.6～2.0)%. Xing Juan [6] used the positive pressure gas device to test a vortex flowmeter under different air densities, and concluded that the instrument coefficient of the vortex flowmeter was hardly affected by the change of fluid density. Cheng Wei [7] calibrated the liquid vortex flowmeter with gas flow device, and concluded that the accuracy of the vortex flowmeter is little affected by the medium within a certain Reynolds number range.

It can be seen that the influence of the medium type on the measurement performance of the vortex flowmeter has attracted the attention and carried out many research by many scholars, but the conclusions are not the same or even diametrically opposite. In this view, this experiment uses water, diesel and air on the same vortex flowmeter, in order to obtain some conclusions by analyzing the measurement results.

2. Experimental program

A vortex flowmeter with DN80mm and 1.0 degree was selected for verification by three media of water, diesel and air in this experiment. The difference of the instrument coefficient and indication error are analyzed under each flow velocity point, so as to evaluate the influence of the medium type on the measurement

performance quantitatively. The parameters of the three flow standard devices are shown in Table 1.

Table 1: Technical parameters of standard devices.

Type of standard devices	Media	Measuring range	Expanded uncertainty
Static mass method	water	(0.01～2200)m^3/h	U=0.05%, k=2
Standard meter method	diesel	(0.1～1000)m^3/h	U=0.10%, k=2
Sonic nozzle method	air	(0.1～15000)m^3/h	U=0.25%, k=2

In view of the different velocity ranges of vortex flowmeter under different media conditions [8], the flow velocity points of the three medium experiments are some different and shown in Table 2. The experiment adopts the pulse method, and each flow velocity point is repeatedly measured 6 times for 60s each time. The instrument coefficient, indication error and repeatability are verified, and the arithmetic mean value is taken as the result.

Table 2: Selected flow velocity points

Flow velocity (m/s)	0.5	1.0	2.0	4.0	6.0	8.0	10	15	20
water	√	√	√	√	√	√	√	×	×
diesel	√	√	√	√	√	√	√	×	×
air	×	×	×	√	√	√	√	√	√

3. Figures Experimental results analysis

3.1 Instrument coefficient

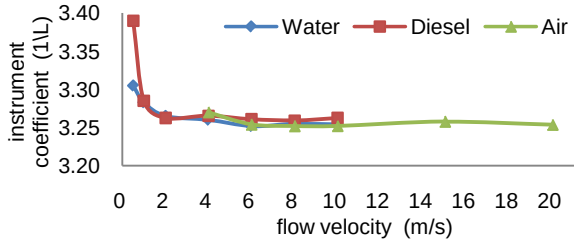

Figure 1: Instrument coefficient under three medium conditions.

As shown in Figure 1, the instrument coefficient of 0.5m/s varies greatly and deviates significantly from other points under the conditions of water and diesel medium. The main reason may be that the flow velocity is too low with low Reynolds number, and the vortex generated is not stable enough by the fluid [9]. At the same flow velocity point of the three media, the instrument coefficients are consistent within the range of 4m/s ~ 10m/s. The largest difference is between air and diesel at the 10m/s flow velocity point, with an absolute difference of 0.0104 1/L and a relative difference of 0.318%. The second one is between air and water at the 4m/s with the absolute difference is 0.0099 1/L and the relative difference is 0.303%. All differences are less than 1/3 of the maximum allowable error of the vortex flowmeter. The instrument coefficients of 15m/s and 20m/s are basically consistent with other flow velocity points Under the condition of gas medium.

3.2 Indication error and repeatability

The instrument coefficient of 3.2639 1/L is built into the vortex flowmeter for indication error and repeatability verification, and the results are shown in Figure 2. The minimum repeatability is 0.011% and the maximum is 0.180%. All of them are less than 1/3 of the absolute value of the maximum allowable error, which can meet the requirements so that the data are not listed.

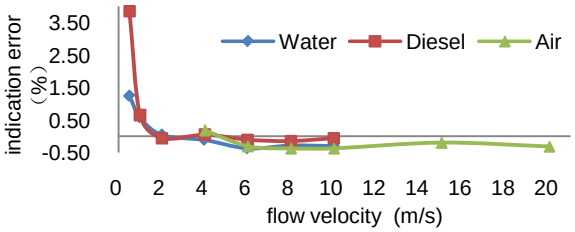

Figure 2: Indication error under three medium conditions.

As shown in the figure, the indication error at 0.5m/s is 1.250% and 3.860% respectively under water and diesel medium, which is significantly different from other flow velocity points. The indication error at other different flow velocity points is within 1.0% under three medium conditions except for 0.5m/s, meeting the requirement of 1.0 degree. At the same flow velocity point of the three media, the biggest difference of indication error is 0.316% between air and diesel at 10m/s. The second one is 0.299% between air and water at 4m/s. All the differences are less than 1/3 of the maximum allowable error of the flowmeter. It shows that the experimental vortex flowmeter has good measurement performance, and the medium type has little effect on the measurement performance of vortex flowmeter.

4. Conclusion and discussion

4.1 Conclusion

The instrument coefficient and indication error of a vortex flowmeter are verified at different flow velocity points under the three media of water, diesel and air. The influence of medium type on the measurement performance is analyzed quantitatively, and the conclusions are as follows:

(1) The instrument coefficient and indication error are not exactly the same at the same flow velocity under the three medium conditions, indicating that the medium type has a certain influence on the measurement performance of the vortex flowmeter.

(2) At low velocity, the Reynolds number is low, and the measurement results of instrument coefficient and indication error are quite different, so the measurement results are not referential. Except that, no matter the instrument coefficient or indication error, the difference is very small under the conditions of the three media, which is within 1/3 of the maximum allowable error. This shows that the vortex flowmeter has good

adaptability to the type of medium, and will not change greatly with the medium. In other words, the vortex flowmeter calibrated by air, water or diesel medium can be used for other medium types, and its measurement performance can meet the accuracy requirements.

(3) At the same flow rate point, the difference of the instrument coefficient and indication error is larger between air and diesel, air and water. Since the difference of density, viscosity and other physical properties between gas (air) and liquid (water, diesel), the measurement results should be quite different. The measurement results are consistent with the theory.

4.2 Discussion

(1) Due to the limited conditions, the vortex flowmeter cannot be calibrated on steam medium, so it is impossible to compare the measurement results with the three media above and analyze the difference and consistency of the instrument coefficient and indication error. The conclusions are also quite different drawn from different literatures [3-5], so further research is needed.

(2) Only one vortex flowmeter is tested in this paper, and the conclusion is that the medium type has little effect on the measurement performance, which is the same as most literatures [4, 6, 7]. However, the conclusion still has some limitations due to limited samples, and a large number of experimental studies are still needed.

(3) Some literature [5] proposed that the instrument coefficient of the vortex flowmeter has a large difference under the condition of air and water, which may need to consider the errors introduced by the measurement performance of the vortex flowmeter itself, such as stability, reliability, etc.

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