Experimental study of generation and measurement of gaseous fluctuating flow

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Abstract Though the fluctuating flow of the gas exists in the familiar, it has not come to the improvement of standardization and guideline sufficiently. On the other hand, the generation and control of pulsating flow using an isothermal chamber developed by the authors in the past showed a certain result for dynamic characteristic compensation of a flowmeter for gas. However, problems remain in measuring and controlling the fluctuating flow at higher speed, and the research of the technique based on another measurement principle has been continued. In this study, the high-speed solenoid valve with the responsibility of several milliseconds was made to be a main measurement object based on these backgrounds. And, the fluctuating flow was generated, and the measurement was tried as pressure change of the isothermal chamber and mass change by the precision balance. Finally, these results are discussed, and prospects are described.
Keywords: measurement, control, gaseous fluctuating flow, solenoid valve

1 Introduction

Though measurement and control of the fluctuating flow of the gas are important, the common problem and information sharing are difficult to advance, and it is often handled as an individual problem. Therefore, it is not possible to link it to standardization [1] and guideline improvement, and it has come to the present. On the other hand, in the research on unsteady flow rate measurement and control of the gas using the isothermal chamber [2][3], which the authors tackled before, it was one of the dynamic characteristic compensation methods of the flowmeter for the gas, and it was possible to achieve the considerable result. However, there are many restrictions in frequency and flow amplitude in the pulsation flow generator of the gas, and the proposal of the simpler measurement method has been desired. In addition, many high-speed solenoid valves with response of several milliseconds have recently been commercialized and distributed. Although the mechanical response performance has been drastically improved, unfortunately, the measuring method of flow rate has not been sufficiently constructed.
Then, in this study, it was tried that fluctuating flow is generated under various driving conditions and that it is measured experimentally, taking the high-speed solenoid valve with the responsivity of several milliseconds as a main object. Since there is no difference from the conventional method by simply filling an air flow containing fluctuating flow components into an isothermal chamber, the weighing method, which is often used in the development of flow standards, is returned and confirmed by both pressure change and mass change in the process while air is simply filled into the chamber. This is intended to be replaced in the future by the principle that the mass change or the flow rate change is converted to some physical quantity, and the measurement can be carried out more accurately and faster. In this paper, an isothermal chamber was connected to the downstream side of a high-speed solenoid valve, and this isothermal chamber was placed on a precision balance to measure the mass change and simultaneously measure the pressure change in the chamber. Here, the use of an isothermal chamber was utilized to simplify the discussion by absorbing temperature fluctuations easily, considering that the effect of temperature changes of air itself cannot be ignored when a small amount of air is filled and discharged into a certain volume space such as a chamber. The effect of the connecting line is also examined. The usefulness of the proposed method is verified and reported.

2 Experimental method

Several types of high-speed solenoid valves were prepared for the test. These mechanical specifications have

the responsivity of several milliseconds in open and closed. An overview of the test apparatus used for the evaluation is shown in Fig. 1. A photograph of the test apparatus is also shown in Fig. 2. Adjust the pressure from the compressed air source to a constant pressure with a pressure regulator and store the pressure in the buffer tank. A high-speed solenoid valve to be tested was connected to its downstream side, and air was induced to an isothermal chamber mounted on a precision balance by a nylon tube. A rectangular operation signal was supplied to the high-speed solenoid valve by a function generator, and the duty ratio was also changed variously.

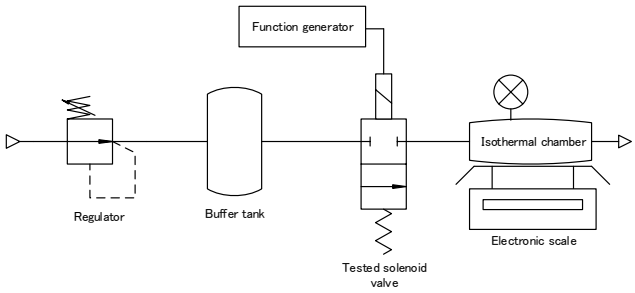

Fig. 1 Example of a figure caption

Fig. 2 Photograph of the test apparatus

3 Example of measurement results

This section presents the results of using a high-speed solenoid valve made by FESTO MHJ10 with a catalog specification response of 500 Hz. The square wave of the operation signal has a cycle of 1 Hz with a duty ratio of 1%. As a result, the valve is opened for 10 ms, and it is judged that there is no problem in the ON-OFF operation. However, from the measurement result of the mass change, the magnitude of the mass change was smaller than the assumption, and the validity of the measurement could not be confirmed. Of course, the response of the precision balance used may be a problem. In the future, the test will be carried out under the condition in which the period is slower, and the additional report will be made.

4 Conclusions

As a technique for measuring the fluctuating flow of the gas, pressure change and mass change in the isothermal chamber were simultaneously measured, and the result was examined. It is a difficult problem to directly measure the high-speed flow fluctuation, and the present measuring method could not sufficiently correspond. Especially, the capacity of the prepared isothermal pressure vessel is small, and the pressure in the vessel, that is, the pressure on the downstream side of the high speed solenoid valve rises in a short time, which complicates the problem that the air flowing through the solenoid valve is not in the choke condition. On the other hand, remarkable mass change could be measured depending on the driving conditions of the solenoid valve.
From these results, it seems to be possible to arrange the optimum measurement condition which this technique can utilize, and the problem will be tackled in future. And, by converting not only the mass change but also the change of volume, velocity and displacement, the construction of the more convenient and high-speed and high-precise measuring method can be expected, and the report is scheduled in near future.

References

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