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Detection of the ultrasonic propagation time shift in the clamp-on ultrasonic flowmeter for gas

ガス用クランプオン超音波流量計における伝播時間シフトの検出

Hiroshi Nishiguchi[1†], Toshiyuki Sawayama[2], and Kouki Nagamune[3]
([1]Kansai Electric Power Co.; [2]New Sensor Inc.; [3]University of Fukui)
西口博史 [1†]，澤山智之 [2]，長宗高樹 [3] ([1]関西電力, [2]ニューセンサー開発, [3]福井大学)

1. Introduction

Reduction of energy consumption is a very important social problem. At a factory or an office building, it is tried to manage the energy consumption. For energy management, it is required to measure the energy consuming. At a factory or an office building, gas energy is usually used. For a management of gas energy, it is required to measure the gas flow by a flowmeter. In order to install a gas-flowmeter, plumbing is required generally. However, plumbing is not easy because of a gas leak. Therefore, this situation requires the gas-flowmeter without the necessity for plumbing.

A clamp-on type ultrasonic flowmeter is able to measure a flow rate without plumbing [1]. However a clamp-on ultrasonic flowmeter is mainly used for liquids. It is rarely used for gas-flow measurement. In particular, there is no clamp-on ultrasonic flowmeter for low pressure gas such as an atmospheric pressure. Therefore, we are studying the clamp-on ultrasonic flowmeter which measures the flow rate of low pressure gas.

2. Method

In a clamp-on ultrasonic flowmeter, one pair of ultrasonic transducers is placed on the outside of plumbing. The schematic arrangement of a clamp-on ultrasonic flowmeter is shown in **Fig. 1**. An ultrasonic wave is generated from one ultrasonic transducer, and it is received by another side ultrasonic transducer. In a clamp-on ultrasonic flowmeter, it is necessary to shoot an ultrasonic wave into the internal gas from the plumbing outside. It is also required to detect the ultrasonic wave which propagates inside gas from the plumbing outside.

For a clamp-on ultrasonic flowmeter, an ultrasonic wave is aslant shot to a flow direction generally. An ultrasonic wave is accelerated when an ultrasonic wave is shot from an upper stream. An ultrasonic wave is slowed down when an ultrasonic wave is shot from the lower stream. Therefore, according to the flow velocity, the propagation time shift occurs. The flow velocity is measured by this propagation time shift.

So, we tried to detect the ultrasonic wave which propagates in the internal gas from the plumbing outside. Then, we tried to detect the time shift which was occurred by the gas-flow in plumbing.

3. Experiments

Experimental setup is shown in **Fig. 2**. In order to input an ultrasonic wave into the internal gas efficiently, we used the ultrasonic transducers which gave the curvature. The curvature of the ultrasonic transducers is the same as that of plumbing. We input the ultrasonic wave aslant to the flow direction in plumbing. We oscillated the ultrasonic wave by seven burst waves. We amplified the received ultrasonic wave and measured it with the oscilloscope. The diameter of plumbing is 60.5 mm and the wall thickness is 3.8 mm. In the inside of plumbing, atmospheric-pressure air exists. We generated the gas flow using the fan. For the comparison of an experimental result, we set the thermal type flowmeter in plumbing.

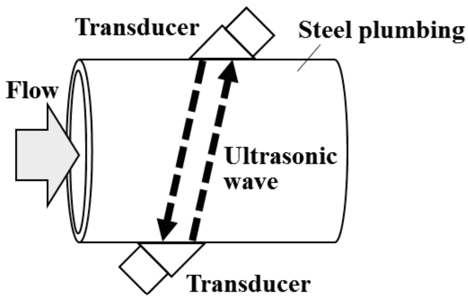

Fig. 1 Diagram of clamp-on ultrasonic flowmeter

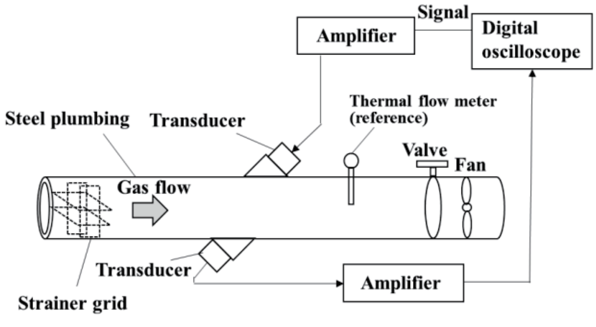

Fig. 2 Experimental setup

4. Results

The measured ultrasonic wave is shown in **Fig. 3.** The part of the region A is the ultrasonic wave which propagated in the internal gas in Fig. 3. We identified as follows that the ultrasonic wave of the region A was an ultrasonic wave which transmits the inside of gas. We insert an obstruction in the inside of plumbing. Thereby, the ultrasonic waveform of the region A disappears. We checked that the part of the region A was an ultrasonic wave which transmits the inside of gas.

The ultrasonic waveform which scaled up at the part of the region A is shown in **Fig. 4**. Since the burst wave is used for an oscillation of the ultrasonic transducer, a received signal is also a burst wave.

We generated the gas flow inside plumbing. At first, we generated the gas flow velocity of 2 m/s. The ultrasonic waveform in this case is shown in **Fig. 5**. We made the ultrasonic wave propagate from the lower stream side transducer toward the upper-stream side transducer. In this case, the ultrasonic wave propagation was slowed by the flow. When Fig. 5 was compared with Fig. 4, the reaching time of the ultrasonic wave was delayed about 0.2 microsecond.

We increased the gas flow velocity to 4 m/s. The ultrasonic waveform is shown in **Fig. 6**. When Fig. 6 was compared with Fig. 4, the reaching time of the ultrasonic wave was delayed about 0.4 microseconds. From these experiments, the propagation time of the ultrasonic wave changed when the gaseous flow velocity was changed. Thus, in the ultrasonic flowmeter for gas, we were able to detect the time shift of the ultrasonic wave propagation according to the internal gas flow velocity.

This is an important result as a clamp-on ultrasonic flowmeter for gas.

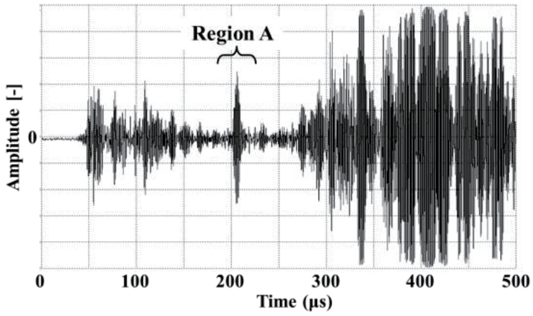

Fig. 3 Ultrasonic wave (Whole wave)

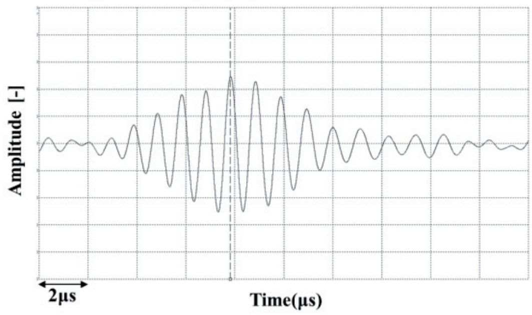

Fig. 4 Ultrasonic wave (Flow velocity: 0 m/s)

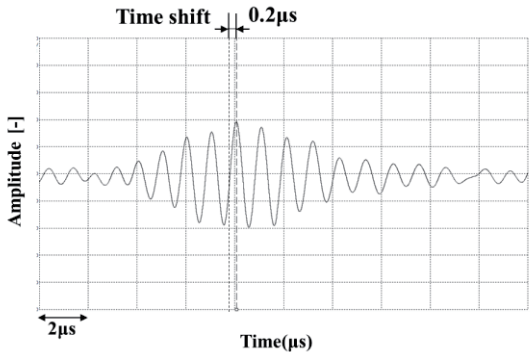

Fig. 5 Ultrasonic wave (Flow velocity: 2 m/s)

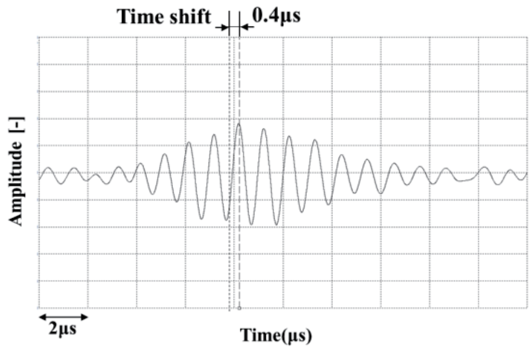

Fig. 6 Ultrasonic wave (Flow velocity: 4 m/s)

5. Conclusion

We are researching about a clamp-on ultrasonic flowmeter for low pressure gas such as an atmospheric pressure. We input the ultrasonic wave aslant to the flow direction in plumbing, and received the ultrasonic wave which propagates in the gas. According to the flow of gas, we detected the propagation time shift of the ultrasonic wave. This is an important result as a clamp-on ultrasonic flowmeter for gas.

References

1. Ryuryokei no Jitsuyo Navi (Practical Navigation of Flowmeter) (Kogyo Gijyutsusya, Tokyo, 2012) chap.7 [in Japanese]