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Detection of ultrasonic wave signal in clamp-on ultrasonic flowmeter for low pressure city gas

低圧都市ガス用クランプオン超音波流量計における超音波信号検出

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 the energy consumed in office buildings or factories is required. In order to reduce consumed energy, an energy management system is installed. At office buildings or factories, gas energy is often consumed, and gas meters are used for gas energy measurement. However, only one gas meter is usually installed in one site for fee counting. When two or more gas appliances are in one site, it is necessary to install a gas meter for every appliance. To install a gas meter, gas plumbing work is required. However, gas plumbing work is not easy for a gas leakage. Therefore, the measurement method which does not need gas pulmbing work is necessary.

A clamp-on ultrasonic flowmeter can measure a flow rate without pulmbing work. However, a clamp-on ultrasonic flowmeter is usually used for liquid. It is seldom used for gas. There is no clamp-on ultrasonic flowmeter for low pressure gas such as atmospheric pressure.

Therefore, we are studying about a clamp-on ultrasonic flowmeter for low pressure gas.

2. Method

We have tried flow-rate measurement by the propagation time difference method. The schematic arrangement of a clamp-on ultrasonic flowmeter for propagation time difference method is shown in **Fig. 1**. As shown in Fig. 1, a pair of ultrasonic probes are installed on the outside of a pipe. The ultrasonic probes are aslant set to the flow. The ultrasonic wave is oscillated from one ultrasonic probe and received by the other ultrasonic probe. The ultrasonic wave from the upper stream is accelerated and the ultrasonic wave from the lower stream is slowed down. Thus, propagation time difference occurs by the flow. By measuring this propagation time difference, the flow velocity is measurable.

In a clamp-on ultrasonic flowmeter, the ultrasonic wave is inputted from the pipe outside, detected from the pipe outside again. Especially in the clamp-on ultrasonic flowmeter for low pressure gas, the intrinsic acoustic impedances differ greatly in the metal pipe and the internal gas. Thus, the ultrasonic waves which propagate in the metal pipe reach the receiving probe without decreasing. Therefore, it is important to detect the ultrasonic waves which propagate the internal gas.

We have tried to measure the flow velocity of atmospheric pressure air with a clamp-on ultrasonic flowmeter in our laboratory [1, 2]. In this paper, we tried to detect the ultrasonic wave for low pressure city gas plumbing at an actual site.

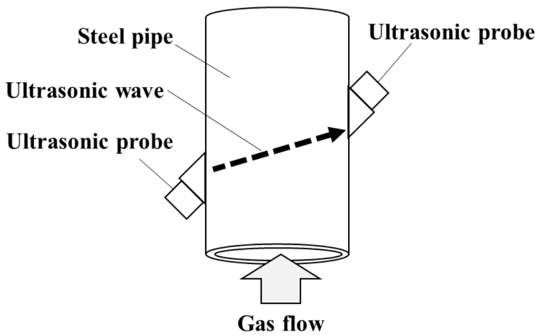

Fig. 1 Diagram of clamp-on ultrasonic flow-meter

3. Experiments

The experimental condition is shown in **Fig. 2**. The photograph of the measurement site is shown in **Fig. 3**. The measured city gas was type 13A supplied from the Osaka Gas company. The main component of the city gas was methane. It was almost atmospheric pressure. The gas pipe was installed in the outdoors and connected to the boiler for air-conditioning of the building. At the measurement section, the pipe was perpendicular and straight. In this experiment, the gas boiler was turned off, and so there was no gas flow. Only when checking the ultrasonic wave which propagates the internal gas, we turned on the gas boiler. The outer diameter of the gas pipe was 60.5 mm. It was made of steel and zinc-galvanized. We set the ultrasonic probes aslant to the gas flow. The center frequency is about 900 kHz. We used 6 burst ultrasonic waves. We amplified the received ultrasonic waves and observed them with the oscilloscope (Pico Scope 3205A).

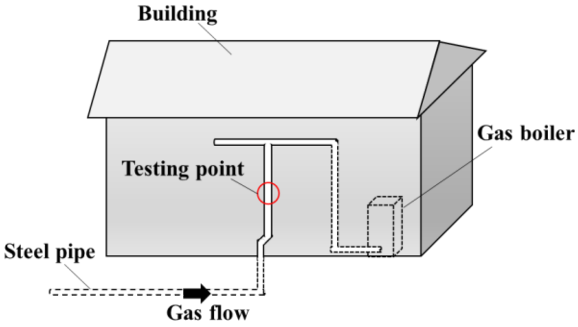

Fig. 2 Schematic diagram of measurement site

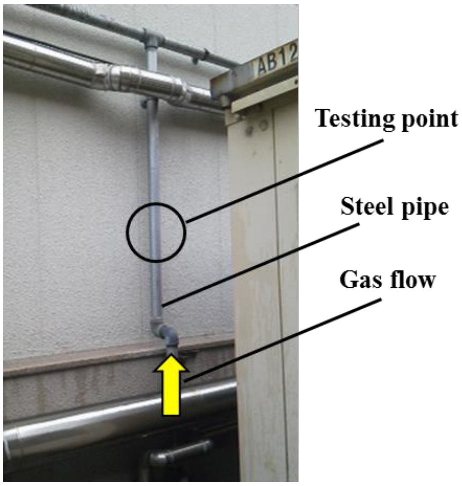

Fig. 3 Photo of measurement site

4. Results

The observed ultrasonic wave is shown in **Fig. 4**. From the velocity of the ultrasonic wave, we thought that the ultrasonic wave of the region A was the ultrasonic wave which propagated in the internal gas. The waveform which is scaled up the region A is shown in **Fig. 5**. Since burst waves was applied, the received wave was also burst waves.

We detected the ultrasonic wave which propagated the internal gas by the difference of the sound velocity. Sound velocities differ greatly in the metal pipe and the internal gas. The main component of the city gas is methane. The sound velocity of methane is 455 m/s and that of steel is 5,940 m/s (longitudinal wave) [3]. Therefore, the ultrasonic waves which propagate the metal pipe is about 13 times as fast as that propagate the internal gas. For this sound velocity difference, it was possible to separate the ultrasonic waves which propagate the metal pipe and the internal gas. The ultrasonic waves before the region A was that propagate the metal pipe. Next, the ultrasonic wave which propagates the internal gas was detected in the region A. After the

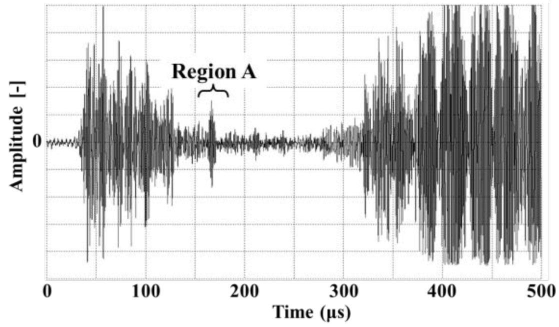

Fig. 4 Ultrasonic wave (Whole wave)

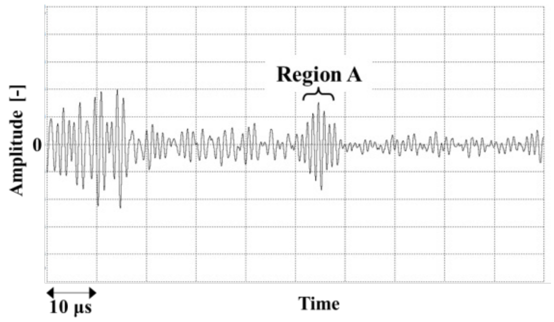

Fig. 5 Ultrasonic wave (scaled up)

region A, the ultrasonic wave which had reflected at the bend of the pipe was observed.

In order to check that the region A was the ultrasonic wave which propagates the internal gas, we turned on the boiler and generated the gas flow. In this case, the ultrasonic waveform of the region A changed. This showed that the waveform of the region A was the ultrasonic wave which propagates the internal gas.

Thus, in the actual site, we were able to detect the ultrasonic wave signal propagated the low pressure city gas with the clamp-on ultrasonic flowmeter.

5. Conclusion

We are studying the clamp-on ultrasonic flowmeter for low pressure gas. We detected the ultrasonic wave signal in the low-pressure city gas at a real site. This is a useful result in the development of a clamp-on ultrasonic flowmeter for low pressure gas.

References

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