Effects of flame detection performance on wire diameter of ion-probe

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■ Introduction

Visualization using high-speed cameras can be mentioned as technologies to measure high load combustion such as automotive engines. However, in visualization observation, the durability of the visualization window is inferior. Therefore, there are restrictions on experiments under practical combustion load conditions. On the other hand, when a pressure sensor is used, it is only possible to indirectly estimate the internal state from the time change of the internal pressure.

The dynamic behavior of the flame can be recorded by installing multiple ion probes. However, in the case of detecting a flame using a plurality of ion probes, the installation density of the ion probes is important. So it is necessary to use ion probes as thin as possible. In this study, the influence of the diameter of the ion probe on the flame detection characteristics was investigated. The wire diameter of the ion probe used four types of 0.1, 0.5, 1.0, and 2.0 mm. We investigate and report the influence on the detection characteristics of the ion probe. The test fuel, oxidant and diluent gas are methane, oxygen and argon respectively. The stoichiometric mixture of methane and oxygen is then diluted with argon.

■ Principle of ion probe

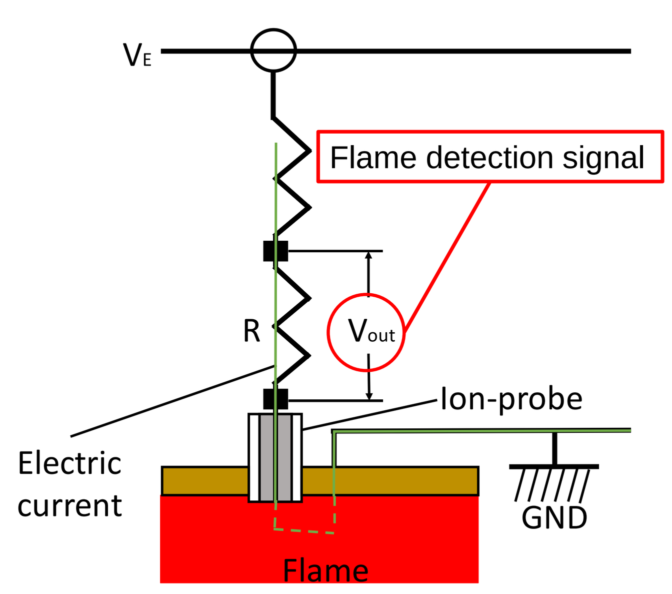


Figure 1. measurement principle

The measurement principle of the ion probe is described. The flame has weak electrical conductivity. 12 V is added to the tip of the ion probe, and when the flame touches the tip of the ion probe, the brass wall becomes ground and current flows, generating an output voltage, which is detected as a signal. The measurement principle is shown in Figure 1.

■ Experimental apparatus

Figure 2 shows a schematic of the experimental setup and the measurement section. The transition distance which is a detonation is shortened by the section of the disturbance ring in which eight ring shaped obstacles with an inner diameter of 46.3 mm and a thickness of 8.0 mm are equally spaced from the ignition end with an igniter up to 320 mm. The ion probe is installed on the right side which is the measurement section. The signal detected by the ion probe is transferred and stored in the oscilloscope.

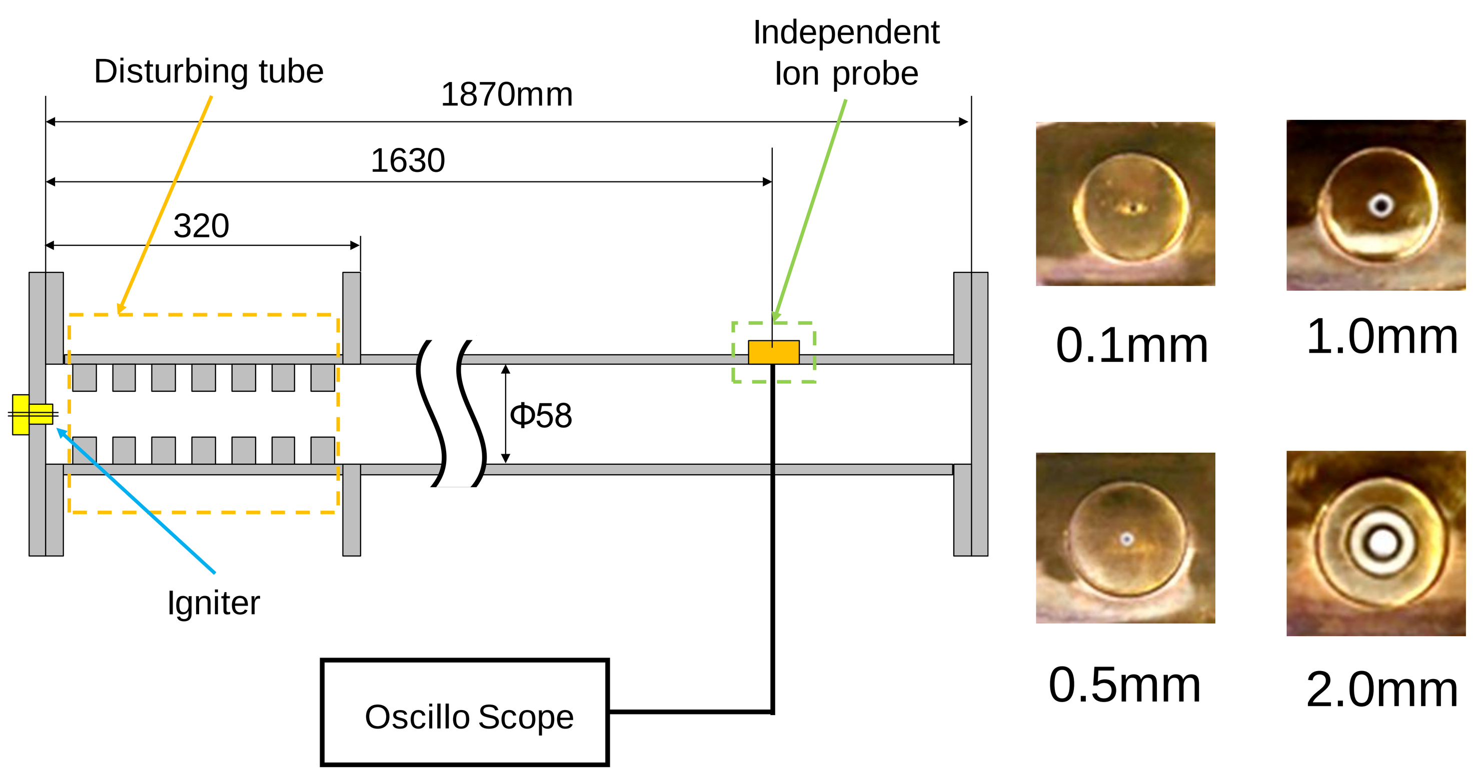


Figure 2. Experimental apparatus

■ Experimental conditions

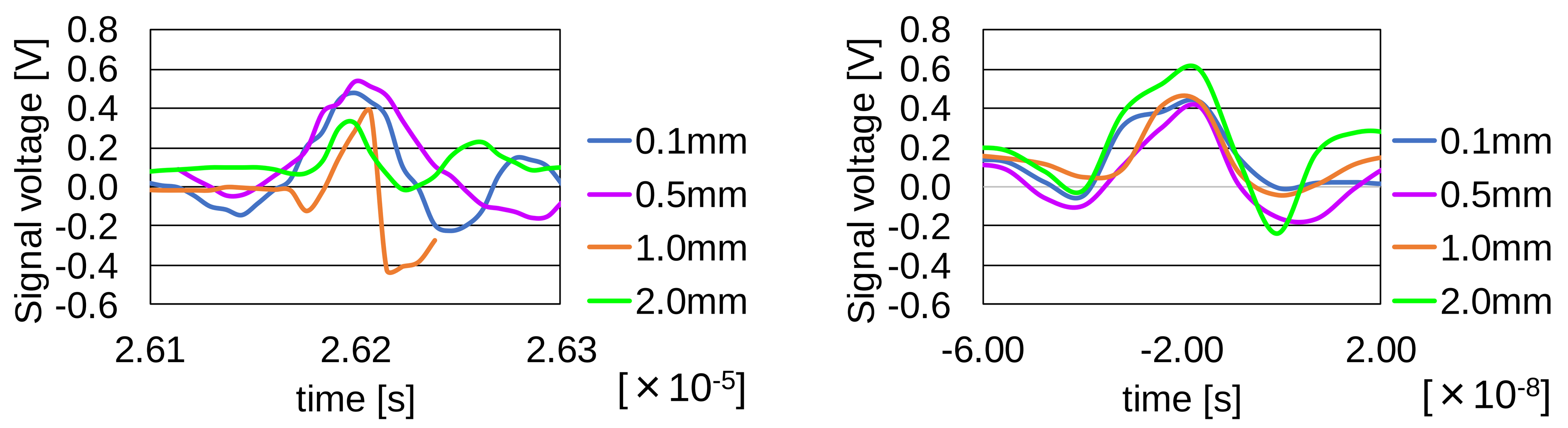
Table 1 shows the experimental conditions. The mixing ratio used two kinds of CH_4: O_2: Ar = 1: 2: 0, 1: 2: 0.45. After this, the argon mole fraction is expressed as AMF (Argon Mole Fraction). AMF = 0.45 is a limit dilution rate which is transitioned to detonation in the combustion pipe used this time.

Table 1. Experimental conditions

AMF(Argon Mole Fraction)		0	0.45
Mixing ratio	CH_4	1	
	O_2	2	
	Ar	0	2.5
Initial temperature [K]		293	
Initial pressure [MPa]		0.101	
C-J velocity [m/s]		2394	1977

■ Experimental results

Figure 3 shows an example of the waveform after the voltage output at the moment the flame touches the tip of the ion probe was amplified. For both AMF = 0.00 and AMF = 0.45, the output voltage showed almost the same value even if the wire diameter was increased. Even in the case of AMF = 0.45, the rising tendency and the duration of the output are not significantly different from those at AMF = 0.00. However, when the AMF was 0.00, the output voltage was larger than in the wire diameters of 0.1 mm and 0.5 mm as compared with 1.0 mm and 2.0 mm.



AMF=0.00 AMF=0.45

Figure 3. Example of waveform after amplification from ion probe

Figure 4 shows the peak value of the output signal from the ion probe for each wire diameter. The measured values in the figure show all measured data. Since variation was observed at a wire diameter of 0.5 mm, the median and the average value were determined. The median value showed no change in the output voltage even if the wire diameter was increased. As for the mean value, the value of 0.5 mm was a little large, but otherwise the same tendency as the median value was seen.

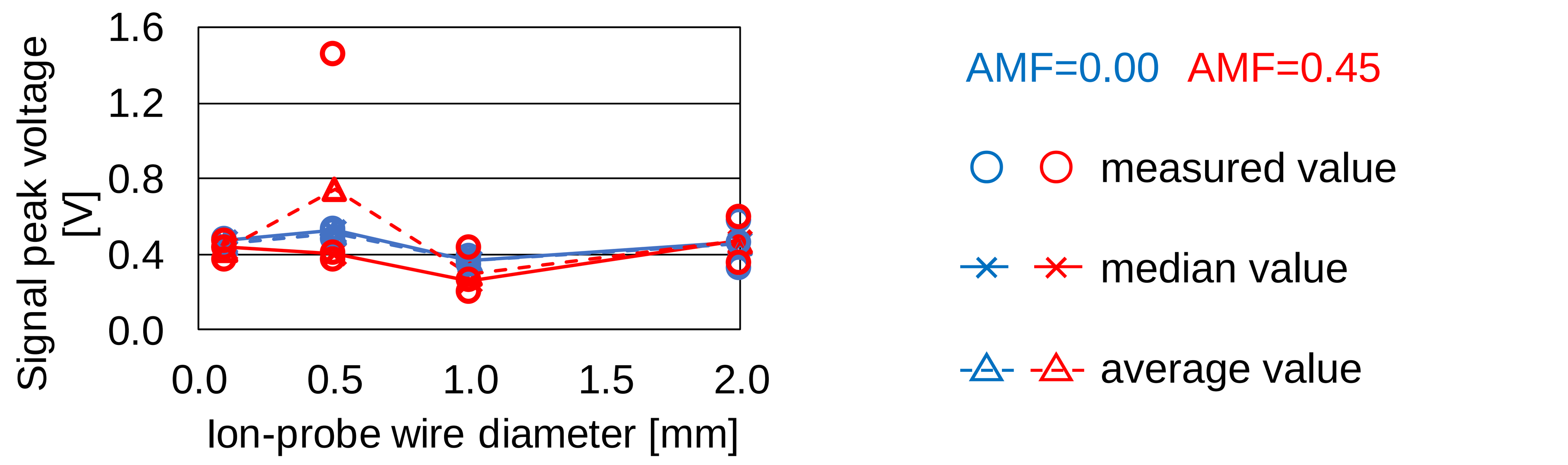
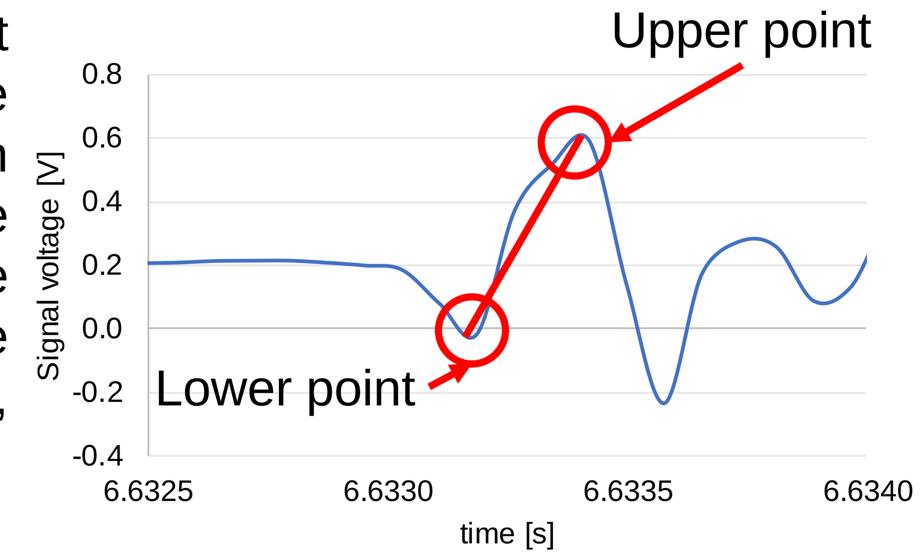


Figure 4. Peak value of output signal from ion probe and its median value and average value

Figure 5 shows the voltage change per unit time of the rising waveform with respect to the wire diameter. The waveform on the right is an example of the data measured this time, and the value of the slope of the red straight line connecting the two points is shown in the figure below. In the rising speed of the rising waveform, variation was seen for any wire diameter.



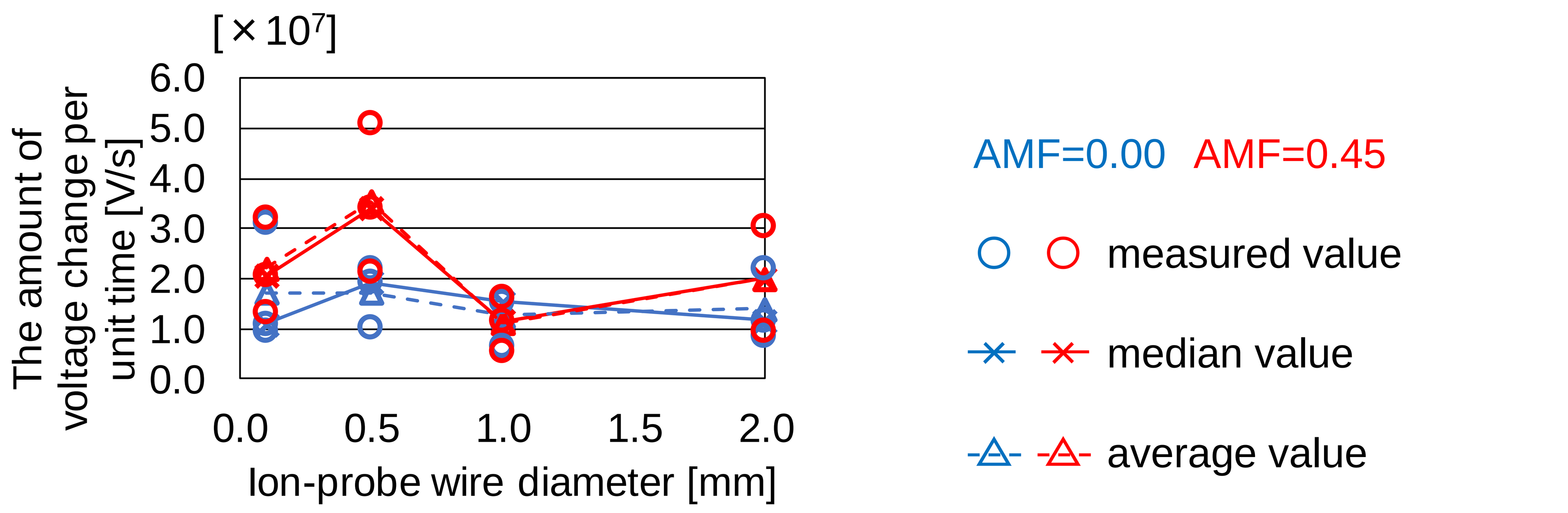


Figure 5. Median and average value of voltage change per unit time of each strand diameter

■ Conclusion

The influence of wire diameter of ion probe on flame detection characteristics of CH_4-O_2-Ar mixture was investigated. As a result of comparing output signals using four types of ion probes with wire diameters of 0.1, 0.5, 1.0, and 2.0 mm, the output voltage showed almost the same value even if the wire diameter was increased. From this, it was found that the output voltage did not increase even if a large diameter ion probe was used to obtain an increase in the output signal.

References

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