Study on wind direction and wind velocity measurement method
using correlation method in clean room – Ryoma Katayama

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1. Background

In the manufacture of precision equipment, I need to pay attention to particles and it is important to prevent particles on the air flow from adhering to the equipment.

Therefore, in this research, in order to prevent adhesion, measurement of airflow using correlation method based on scattered light intensity obtained from particle and it shows its effectiveness.

2. Cross-correlation method

In this research, we evaluate the fluctuation of scattered light at multiple positions. Calculate cross-correlation of scattered light intensities detected in each of two separated areas A and B. Figure 2.1 shows the scattered light intensities acquired in the separated areas A and B. First, the scattered light intensities in the detection areas A and B are Ia and Ib. Second, the differences in scattered light intensity at time t from the average of Ia and Ib are δIa and δIb. Finally, The scattered light intensity after τ seconds is I (t + τ). From these, the equation of the cross-correlation curve can be expressed as follows.

$$Gab(\tau) = \frac{\langle \delta\,Ia(t)\cdot\delta\,Ib(t+\tau)\rangle}{\langle Ia\rangle\langle Ib\rangle} \quad (1)$$

3. Experimental methodology

i) Experimental system

Figure 3.1 is a simple diagram of the experimental system. Light is irradiated into the space from a xenon flash lamp, the intensity of scattered light obtained from the particles passing through the irradiation region is observed using a CCD camera.

ⅱ) Division of measurement area and calculation of wind speed

In the experiment, the irradiation area was divided, the correlation value of each areas was calculated. After that, the wind direction was judged by comparing the maximum value of the correlation value obtained from each areas.

Wind speed is calculated using the distance between adjacent measurement areas in Figure 3.2 and the delay time τ in equation (1).

4. Results and discussion

Figure 4.1 shows a graph of the correlation value calculated in a certain region when the measurement range is divided into 16 parts. In the graph, it is understood that the area ① has a high correlation. Also, since the peak appears at the delay time of 0.0333 [s], it is considered that the air flows in the ① direction from the area ② of the movement time 0.0333 [s].

Fig. 4.2 shows the results of computing correlation values for all 16 areas and calculating wind direction and wind speed. In this result, it can be understood that the leftward wind with the wind speed 72.6 [cm / s] flows in the eight areas. In addition, the wind speed calculated by another method is 68.3 [cm /s], so the wind speed calculated by the correlation method is considered to be a result close to the true value.

As an application of this experiment, experiments were conducted with increasing the number of divisions of the measurement area. The experimental results are shown in Figure 4.3. From the results, it can be seen that more information in the measurement area can be calculated.

5. Summary

In this study, we verified the validity of the measurement using the correlation method in a clean room. In wind speed and wind direction measurement, the measurement error with another method was about 6%.It is assumed that accuracy can be improved by using a higher frequency CCD camera or a high illumination intensity xenon flash lamp.

6. Reference document

R.Arita"Development of particle monitoring correlation method enabling wind direction measurement" Kumamoto University Master's thesis
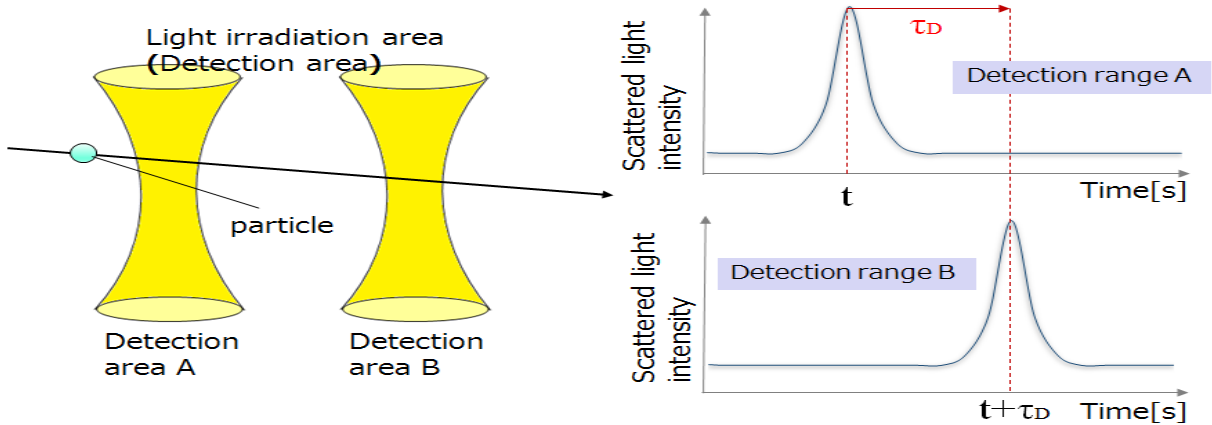
<DA-024>

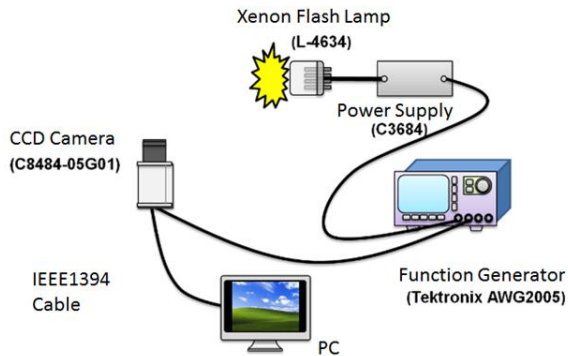図 2.1 Scattered light intensity in two detection areas

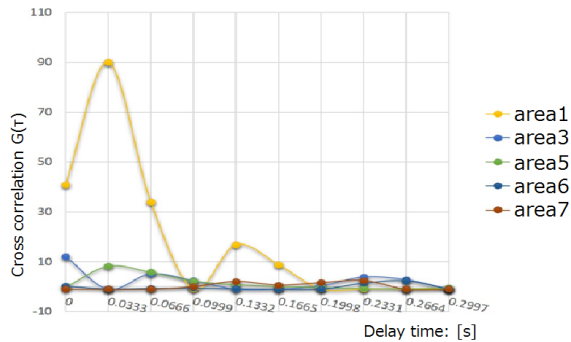図 3.1 Experimental system

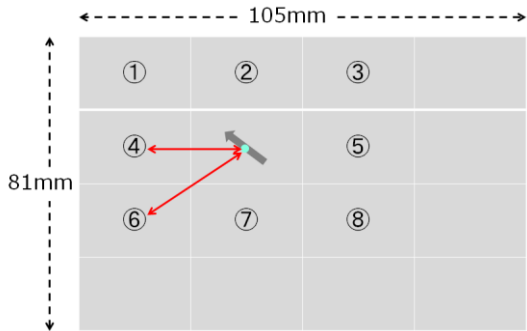図 4.1 Correlation value
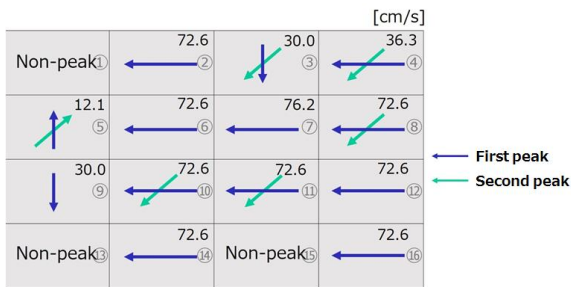in measurement area ②

図 3.2 Division of measurement area
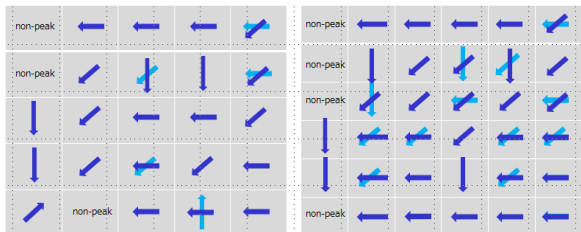

図 4.2 Wind direction and speed in each area

図 4.3 Wind direction and speed
in multi-division area