Non-intrusive temperature measurement of curved surface using laser interferometer and computer tomography

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1. Introduction

In the temperature measurement of the molten polymer tube, an intrusive measurement by using thermometer such as thermo couples has difficulty because the molten polymer is too thin. Also the temperature measurement with infrared camera is not appropriate because the polymer film is lightly transparent for the infrared radiation. We proposed a novel method of non-intrusive temperature with laser interferometer and Computer Tomography (CT), and discussed its applicability for measuring the temperature distribution on a curved surface.

2. Experiment and Result

In order to measure the temperature profile on curved surface of the polymer tube, we measured the temperature of air surrounding the surface that is equal to the temperature of the surface temperature. Under the assumptions that both Gladstone-Dale relation and ideal gas laws can be applied to the fluid, the fluid temperature is defined as the function related to its refractive index.

The integration of the refractive index in tangential direction that was thrown by the interferometer was transformed to the index in radial distribution by using Computer Tomography.

After confirming the applicability of the CT reconstruction technique for a cylinder surface which has circumference temperature distribution, an experiment was conducted to confirm the feasibility of temperature measurement of curved surface in forced convection flow. The flow conditions were measured by PIV system. Figure 1 shows radial velocity distribution in the boundary layer under the forced convections. Flow rate A means that the velocity at the region 1.8 mm far from the surface is 0.3 m/s when the surface temperature is room temperature. B, C and D are defined 0.65 m/s, 0.85 m/s and 1.1 m/s respectively.

Figure 2 shows the comparison among the temperature estimated by the proposed method, the reference temperature captured by thermocouple fixed at cylinder and the extrapolated temperature in different flow rates (A-D) respectively. N means the blasting velocity was 0 m/s.

3. Conclusion

The accuracy of the method is a few degrees within the range from the room temperature to 100 °C in the flow rate N. It was also confirmed that the method could be applied to the measurement of surface temperature in forced convection flow of surrounding up to 2 m/s in the experiment.

The base error between the temperature measured by the method and the temperature captured by the thermocouple still remains. And the error increased with increasing the surface temperature and the flow rate. The error is reduced by extrapolating the gradient of the fringe curve near the surface by referring to the gradient at 0.48 mm far from the surface. From the practical point of view, it is concluded that this technique could be applicable to measure the temperature distribution of the polymer tube in manufacturing process of inflation film blowing.

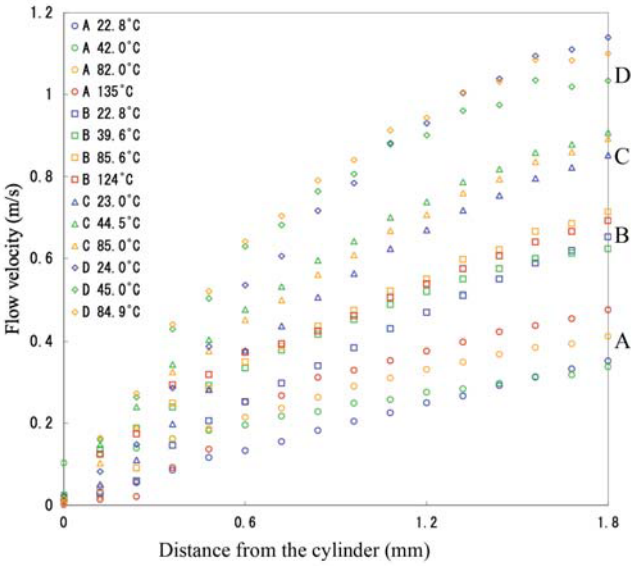

Fig. 1 Velocity distribution of difference flow rates near the cylinder surface measured by PIV technique.

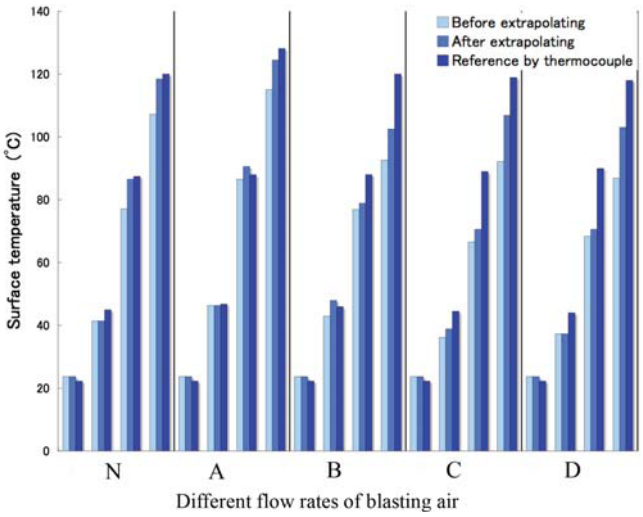

Fig. 2 The temperature comparison among the temperature estimated by the method, the reference temperature captured by thermocouple and the extrapolated temperature in difference flow rates respectively.