Development of aerial heater that converges infrared lights by use of WARM

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1. Introduction

Aerial display of light and heat using crossed-mirror array (CMA) has been proposed [1]. We have originally designed a square pipe array (SPA) as reflective imaging element with the aim of heating applications by convergence technology of infrared radiations [2]. In this paper, we propose double-layered arrays of rectangular mirrors (WARM) as a reflective imaging optics more suitable for heating applications. We present the principle of converging infrared rays and report to confirm infrared imaging by WARM. Furthermore, we conduct ray tracing simulations by use of Light Tools to investigate relationships between thickness and angle.

2. Principle of converging infrared by WARM

Fig. 1(a) shows structure of WARM. WARM features two layers and have a structure in which aluminum plates are placed at regular intervals. The principle of converging infrared radiation is illustrated in Fig. 1(a). The infrared rays from a heater are reflected twice at WARM. Then, the infrared rays are converged to the plane-symmetrical position of the heater regarding WARM.

3. Experiments on converging infrared radiations

We have investigated the temperature changes in the converging plane over one hour. Heat source is an electric stove. The size of heater is 230mm×200mm. An array of ping-pong thermometer is used in order to measure the temperature distribution in the air. Ping-pong thermometer is composed of a black ping-pong ball inside temperature sensor. Twenty ping-pong thermometers are placed in five by four, as shown in Fig. 1(b). Interval of thermometer is 250 mm. Fig. 1(b) shows the placement of infrared heater, WARM, and ping-pong thermometer array. The distance from WARM to the heater is 500 mm, which is the same as the distance between WARM and the thermometer array. Temperature changes in the air is shown in Fig. 2. The image position of heater is the number 5 thermometer when the reflection angle is 45 degrees. When the reflection angle is 45 degrees, the temperature locally increased 5.8 degrees at the number 5 position.

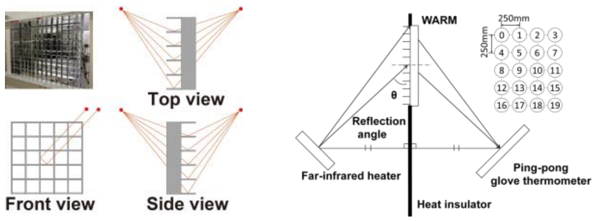
4. Investigation of thickness and angle dependence

We have conducted ray tracing simulations by use of Light Tools and examined the amount of incident light and the maximum illumination in the converging plane when the thickness of WARM and the reflection angle are changed. In this simulation, the reflection angle is varied from 25 degrees to 65 degrees by 5 degrees and the thickness of WARM is changed from 20 mm to 120 mm by 20 mm. Interval of aluminum plate is 40 mm.

Simulated results are shown in Fig. 3. Fig. 3(a) shows the amount of incident light. For example, when the thickness of WARM is 40 mm, peak is at 25 degrees. The peak of amount incident is shifted to the right when the thickness of WARM is increased. Fig. 3(b) shows maximum illuminations. Maximum illuminations show similar trend but the peak for 120-mm WARM is different. When the thickness of WARM is 120 mm, the peak for maximum illumination is at 25 degrees.

5. Conclusions

We have succeeded in converging infrared rays with our developed WARM. We confirmed dependent of thickness of WARM and reflection angle.



(a) (b)

Fig. 1 (a) Principle of WARM.
(b) Configuration to measure distribution of the radiation temperature.

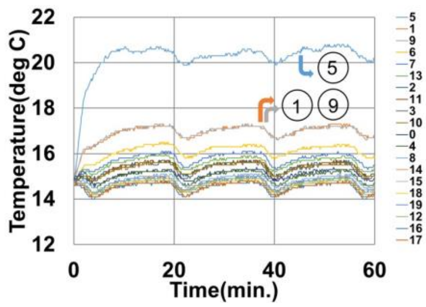
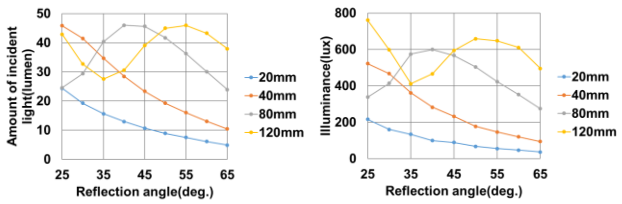


Fig. 2 Temperature changes in the air at 45 degrees.



(a) (b)

Fig. 3 Simulation results (a) amount of incident light,
(b) maximum illuminations.

References

[1] R. Kujime, S. Suyama, and H. Yamamoto, Proc. IDW/AD'12, pp. 1243-1246 (2012).

[2] T. Okamoto, K. Onuki, S. Onose, T. Itoigawa, H. Yamamoto, IMID 2016 Digest, accepted (2016).