Development of Feedback System for Uniform Temperature Distribution in the Selective Laser Thermoregulation System

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In the Selective Laser Thermoregulation (SLT) system [1], a laser is scanned using the Galvano mirror system on a target at high speed to achieve 1,400 ℃ for heating test of high heat-resistant materials. In the previous study, we scanned the laser simply up and down between two points and have not yet been able to control heat distribution actively. Therefore, we developed a feedback system for active heat control in cyberspace in this study.

The system must calculate the feedback algorithm quickly because the scanning speed must be higher than 10 m/s. Therefore, our feedback system heats the position at the minimum temperature in the target region only if the maximum temperature is lower than the target temperature in each feedback loop. We solved the heat conduction equation to calculate the temperature distribution of the target considering laser absorption and heat dissipation through radiation and heat transfer to the air. These calculations used the material properties of SUS 304 stainless steel. The laser was configured as follows: 8.0 mm diameter, 400 W output, and 10 m/s scanning speed. The target size was 8 × 120 mm with a thickness of 3 mm. We set the heating and evaluation area to be the center of 8 × 40 mm of the target.

Figure 1 (a) and (b) show the temperature changes in the simulation of the SLT system without feedback and with feedback, respectively. Without the feedback system, the maximum and the minimum temperature at the end of the simulation were 1841.3 ℃ and 1445.0 ℃, respectively, and the difference was 396.3 ℃. There are two problems: excessive heating and non-uniform temperature distribution. In contrast, those with feedback are 1399.9 ℃, 1288.3 ℃, and 111.6 ℃, respectively. Therefore, this feedback solves the overheating problem and gives heating a more uniform temperature distribution.

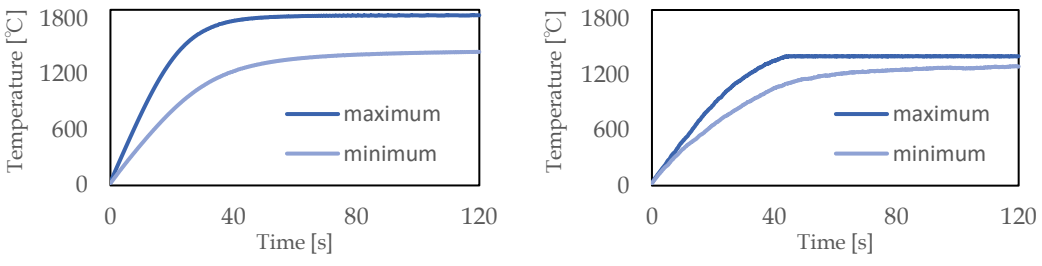

Figure 1: (a) Temperature changes without feedback, (b) Temperature changes with feedback.

References: [1] Hayato Koshiji, Tomomasa Ohkubo, Yuki Ueno, Ken Goto, and Yutaka Kagawa, "Selective Laser Thermoregulation System for Accelerated Degradation Test of SiC/SiC CMCs", JLMN-Journal of Laser Micro/Nanoengineering, Vol. 15, pp. 174-177, (2020).