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Investigation of a Natural Convection Heat Sink for LEDs Based on Micro Heat Pipe Array-Rectangular Channel

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Abstract : The exponential growth of the lighting industry has rendered traditional thermal technologies inadequate for addressing the thermal management challenges inherent to high-power light-emitting diode (LED) technology. To enhance the thermal management of LEDs, this study proposes a heat sink configuration that integrates a miniature heat pipe array based on phase change technology with rectangular channels. The thermal performance of the heat sink was evaluated through experimental testing, and the results demonstrated that when the input power was 100W, 150W, and 200W, the temperatures of the LED substrate were 47.64℃, 56.78℃, and 69.06℃, respectively. Additionally, the maximum temperature difference of the MHPA in the vertical direction was observed to be 0.32℃, 0.30℃, and 0.30℃, respectively. The results demonstrate that the heat sink not only effectively dissipates the heat generated by the LEDs, but also exhibits excellent temperature uniformity. In consideration of the experimental measurement outcomes, a corresponding numerical model was developed as part of this study. Following the model validation, the effect of the structural parameters of the heat sink on its heat dissipation efficacy was examined through the use of response surface methodology (RSM) analysis. The rectangular channel width, channel height, channel length, number of channel cross-sections, and channel cross-section spacing were selected as the input parameters, while the LED substrate temperature and the total mass of the heat sink were regarded as the response variables. Subsequently, the response was subjected to an analysis of variance (ANOVA), which yielded a regression model that predicted the response based on the input variables. This offers some direction for the design of the radiator.

Keywords : light-emitting diodes, heat transfer, heat pipe, natural convection, response surface methodology
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