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Thermal Performance of a Cylindrical Heatsink with a Chimney Installed Above Dropped Ceilings

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Extended Abstract

The geometries available for the cooling system of ceiling-mounted light-emitting diode(LED) downlights are limited. Hence, it is necessary to study the cooling performances of systems subjected to these limitations. We simulated various operating environments in limited spaces by calculating the thermal performance as we varied the height between the dropped ceiling and the structural ceiling, chimney height and heat. Numerical analysis using models of natural convection and radiative heat transfer model were conducted, then numerical results were experimentally verified.

The cooling performance was calculated by varying the height of the chimney which is an important cooling system component, then the causes of the changes in the cooling performance was evaluated using flow analysis. A chimney-like flow is generated at the cylindrical heat sink. However, the structural ceiling induces flow resistance by blocking the upper side of the chimney. As the flow resistance increases, the air-flow rate decreases; thus, the overall cooling performance deteriorates. In the case such that free boundary conditions are applied to the model, the thermal performance improved as the chimney height increased. However, when space is limited, the gap between the upper end of the chimney and the structural ceiling narrows as the chimney height is increased such that it exceeds the critical height. As a result, flow resistance causes the flow rate to decrease, leading to a deterioration in the cooling performance. Ceiling systems with greater internal heights can accommodate taller chimneys, but the optimum gaps between the chimney and the structural ceiling increase. The optimum gap is required to increase the flow rate of the discharge from the chimney. According to the calculations to evaluate the dependency of the cooling performance on the heat flux, the flow rate increases with the heat flux, thus increasing the size of the optimum gap.

We propose a correlation for predicting the thermal performance of a cooling system as a function of chimney height and heat flux when the height of the system is limited by a structural ceiling. the correlation that the maximum numerical error is below 15% was obtained by performing a regression analysis of 350 design points. The geometric parameters calculated using this equation are optimized to maximize the utilization of the chimney. Thus, the safety of ceiling-mounted cooling systems will be improved by the application of the suggestions presented in this paper to the design process.

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