Multi-nozzle Closed Loop Spray Cooling Systems in Electronics Cooling

Abstract. This study presents two refrigerant closed loop spray cooling systems for two specific electronic cooling applications. A small system using a 3×2 nozzle array is developed to investigate the spray cooling performance on a concentrated heat source (2×1 cm^2) with a high heat flux. A big system uses a 9×6 nozzle array to cool a 6U card area (23.3 × 16 cm^2) with a moderate uniform heat flux. The experimented flow rate in the small system is maintained at 7.8~8.1 g/s corresponding to a spray mass flux of 3.9~4.05 $g/cm^2 \cdot s$ on the concentrated heat source, and the studied flow rates in the big system are monitored at 113 ± 4 g/s corresponding to a spray mass flux of 0.30 $g/cm^2 \cdot s$ on the 6U card surface area. The results show that the small system with a much higher spray mass flux can perform a spray cooling curve with a wide heat flux range. The big system with much less spray mass flux has performed a slightly better heat transfer coefficient due to its much better evaporation efficiency at the same degree of surface superheat.

多喷嘴阵列密闭环路喷雾冷却系统在电子冷却中的应用

摘要. 该论文讨论了适用于不同电子设备冷却应用的两个闭路制冷循环喷雾冷却系统，R134a 为工作制冷剂。其中小型喷雾冷却系统应用 3×2 的紧凑型喷射旋流喷嘴整列冷却具有高热流密度、低换热面积（2×1 cm^2）的高性能电子元件。大型喷雾冷却系统采用 9×6 的压力旋流喷嘴阵列均匀冷却尺寸为 6U（23×16 cm^2，）、具有中低热流密度且温度敏感性较强的电子设备。实验研究中，小型喷雾冷却装置的质量流量保持在 7.8~8.1 g/s 的范围内，其对应的喷雾质量流量密度为 3.9~4.05 $g/cm^2 \cdot s$。大型喷雾冷却装置的质量流量控制在 113 ± 4 g/s，其对应的喷雾质量流量密度为 0.30 $g/cm^2 \cdot s$。实验结果表明小型喷雾冷却系统具有较高的喷雾质量流量密度，其喷雾冷却曲线能覆盖较大的热流密度范围（10 ~ 126 W/cm^2），但是其制冷剂的有效蒸发率较低（< 32%）。大型喷雾冷却系统拥有较小的喷雾质量流量密度，其在相同的表面过热度下换热系数更高，其制冷剂有效蒸发率可达到 89%。