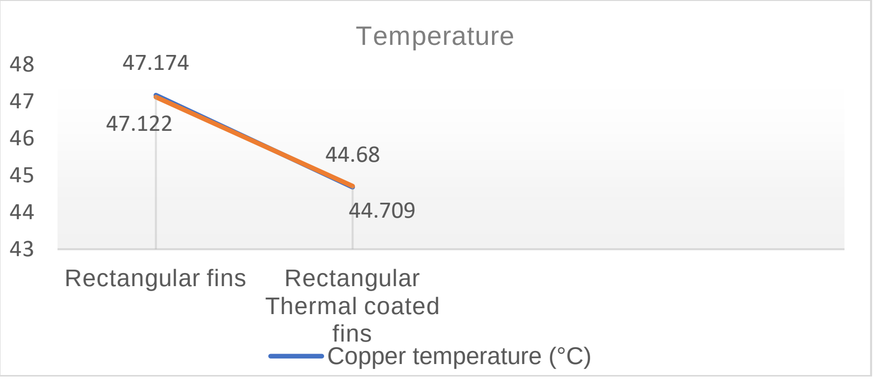

Fig. 10. Temperature Comparison for Copper and Al alloy

5.2 Heat flux comparison

Table 2. Heat Comparison

Constant convection coefficient 120 W/m^2 K	Copper - heat flux (W/mm^2)	Al-alloy - heat flux (W/mm^2)
Rectangular fins	0.0004663	0.00041628
Rectangular Thermal coated fins	0.00049359	0.00041766

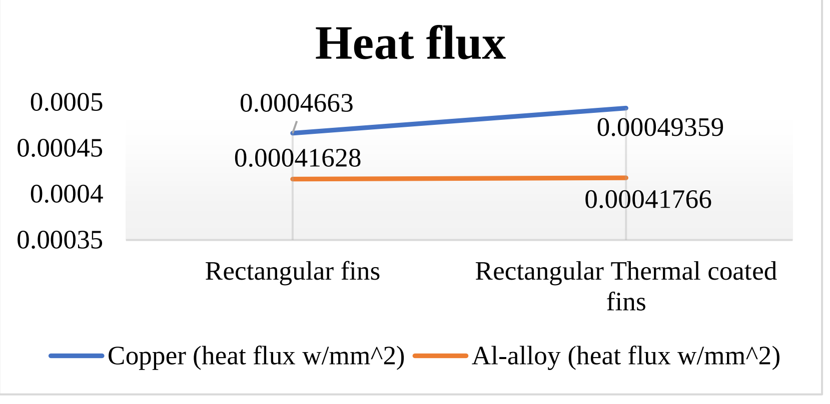

Fig. 11. Heat Flux comparison for Copper and Al alloy

The heat flux values show that rectangular cut fin shape is more effective in dissipating heat from the components as the heat flux values for rectangular are higher than those of conventional in both copper and Aluminium alloy heat sink designs.

5.3 Effect of thermal coating

The application of thermal coating has very minimal impact on the heat flux values for both copper and aluminum alloy in the rectangular cut fin configuration. There is only a slight difference between coated and non-coated.

5.3.1 Copper vs aluminium alloy

As copper has superior thermal conductivity, it can facilitate more efficient heat transfer. So as seen it exhibits higher heat flux values than aluminum alloy in heat sink configurations.

5.3.2 Temperature reduction

Lower operating temperatures are generally desirable, as they indicate that the heat sink is effectively cooling the components it is designed to protect. Components operating at reduced temperatures tend to have a longer lifespan and exhibit greater reliability, making efficient heat management crucial in electronic systems.

5.4 Result analysis

In this study, we conducted an in-depth analysis of heat sink designs using copper (Cu) and aluminum alloy (Al), incorporating a silicon dioxide (SiO_2) thermal coating. The investigation was carried out under a steady convection coefficient of 120 W/m² K on heat sinks with both standard rectangular fins and rectangular cut fins.

The application of the SiO_2 thermal coating has enhanced the thermal performance of the rectangular fin design. The coated fins exhibited a noticeable reduction in temperature for both copper and aluminum alloy materials. Specifically, the temperature of copper fins decreased from 47.174 °C to 44.68 °C, while the temperature of aluminum alloy fins dropped from 47.122 °C to 44.709 °C. These reductions indicate a marked improvement in thermal efficiency.

The observed temperature reductions-2.494 °C for copper and 2.413 °C for aluminum alloy-highlight the impact of the SiO_2 coating in enhancing heat dissipation capabilities. By comparing the initial and final temperatures, it is evident that the thermal coating is most effective to use for the heat sink as it improves the cooling performance of the system.

6 Conclusion

The results and discussion above show that the thermally coated rectangular fins achieve lower temperatures compared to the non-coated fins for both copper and aluminum alloy materials. This indicates that the application of the thermal coating considerably enhances the heat sink's heat dissipation capabilities, leading to reduced operating temperatures. In electrical and thermal management systems, Lower temperatures are advantageous, as they contribute to improved component reliability and lifespan. Among the thermally coated fins, copper consistently performed well compared to aluminum alloy in both rectangular and non-rectangular configurations. So this outcome is as per expectations as copper is considered to have superior thermal conductivity, which enables more efficient heat transfer. The efficiency improvements are quantified as a 5.29% increase for copper and a 5.12% increase for aluminum alloy. Higher heat flux values observed in the analysis further confirm the enhanced heat dissipation performance of the heat sink. These higher heat flux values reflect the system's ability to transfer heat away from components so indicating better thermal management capabilities. Thus, the use of thermal coatings, particularly on copper fins, proves to be an effective strategy for optimizing heat sink performance

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