Colorado Science and Engineering Fair

2024 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: Enhancing Dry Cooling in Power Plants through High-Conductivity Thermal Ground Planes

Finalist's Name: Kelly Yang

School and City: Fairview High School, Boulder

Sponsor's Name: Dr. Yung-Cheng Lee

Category: Energy (ERGY)

Division: Senior (9th - 12th grades)

Abstract (250 words or less):

As global electricity demand increases, the majority of power is still produced by thermoelectric plants using fossil and nuclear fuels, despite the rising role of renewables like solar and wind. These plants typically dissipate roughly 60% of generated heat, often through water cooling, which poses sustainability issues due to significant water usage. With ongoing water shortages, there is a shift towards alternative dry cooling methods that use air, but these methods face efficiency challenges due to air's lower thermal properties. The study described here introduces novel high thermal conductivity thermal ground planes (TGPs) as fins in dry cooling systems to overcome these challenges. TGPs encapsulate a phase-change material and exhibit thermal conductivities tens to hundreds of times higher than metals, leading to rapid heat dissipation. My experimental results show TGPs achieving effective thermal conductivities up to 30,000 W/mK, significantly outperforming traditional aluminum fins. Statistical analysis using Student's t-Test indicated that while no significant difference between the means for temperature of TGP and aluminum was observed at 1.36 W ($t = 0.18$, $p < 0.05$), significant differences were found at higher power inputs (4.63 W to 18.58 W) with t-values ranging from 6.23 to 18.55 ($p < 0.05$). Simulation of TGPs in a standard 600 MW power plant's dry cooling system produced a 2.5°C reduction in turbine discharge temperature, a significant 0.8% efficiency increase, 1% lower coal consumption, and fuel cost savings of approximately $500,000 annually for the power plant. Replacing aluminum fins with TGPs not only reduces water dependency, but also enhances dry cooling efficiency, reduces resource consumption, and lowers operational costs in power plants.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature: Kelly Yang Date: 2/28/2024

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES o all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. A signed copy of this form must be included in your notebook.