Energy Transition Specialization Summer School Report

Materials for advanced cooling technologies – Passive Radiative Cooling for Thermal Management of Drones in Harsh Environments

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Abstract

This internship focused on exploring the passive radiative cooling of drones as a sustainable approach to temperature regulation. During the internship, We developed essential research and data analysis skills by conducting experiments and analyzing thermal performance data. The primary objective was to investigate the effectiveness of radiative coatings in reducing surface temperatures of drone materials. The results demonstrated that the application of radiative coatings can significantly lower the surface temperature, highlighting their potential to enhance drone performance and longevity through passive cooling. This experience provided valuable insights into experimental research methods and the practical implications of energy-efficient cooling technologies.

1. Introduction

This internship focused on exploring the passive radiative cooling of drones as a sustainable approach to temperature regulation. During the internship, I developed essential research and data analysis skills by conducting experiments and analyzing thermal performance data**.**

2. Objectives

The primary objective was to investigate the effectiveness of radiative coatings in reducing surface temperatures of drone materials.

3. Current Progress and Milestones Achieved

So far, I have successfully prepared the radiative Material sample we found on a published research paper and completed both laboratory and outdoor testing. Using the FTIR spectrometer and UV–Vis spectrometer, I measured the sample's optical properties and gathered data to assess its reflectance and emittance.

One significant milestone was overcoming the inability to fly drones with the attached data logger (it always gets tangled). Following my professor's advice, I suspended the drones outdoors under direct sunlight, enabling me to collect accurate thermal data despite the flight restriction. These results have been analyzed and compared against PDMS and commercial coating samples, with all work documented to support ongoing analysis and final reporting

In summary:

- Prepared a radiative coating sample based on research literature.
- Performed reflectance and emittance tests with FTIR and UV–Vis spectrometers.
- Designed and conducted outdoor experiments to test coating performance in real conditions.
- Collected and analyzed temperature data from field trials.
- Compared results for radiative coating, PDMS, and commercial samples.
- Maintained organized records for future use.

4. methodology and approach

The internship at CREST followed a clear process combining material preparation, laboratory measurements, and outdoor testing. I began by recreating a radiative material sample (PDMS) based on materials from published research. In the lab, I used the **FTIR spectrometer** to measure reflectance and emittance, and the **UV–Vis spectrometer (Lambda 950)** in the Core Lab for detailed spectral analysis.

As I mentioned before when it became clear that the drones could not be flown for a long time while carrying the data logger due to weight and safety restrictions. Under my professor's guidance, I adapted the approach by suspending the drones outdoors directly under the sun, allowing me to collect reliable temperature data without flight. This adjustment ensured realistic exposure conditions while overcoming the operational limitation.

5. Preliminary results or findings

- The radiative coating sample showed higher reflectance across measured wavelengths compared to PDMS and commercial coatings.
- Higher reflectance suggests the radiative coating absorbs less heat.
- Outdoor temperature data showed the commercial coating retained heat longer and reached the highest temperature among all samples tested.
- The radiative coating maintained a lower surface temperature compared to the commercial coating and the uncoated surface.

- Temperature trends from outdoor tests aligned well with laboratory spectral data.

- These findings suggest the radiative coating has strong potential for passive cooling and thermal management.

6. Challenges and obstacles encountered

During the internship, several challenges arose that required careful attention. One common issue was the thermocouples, which easily became tangled and were difficult to position in hard-to-reach areas when coating the drones. Additionally, we faced some confusion while exporting data, particularly distinguishing between measurements for the commercial coating and the uncoated samples. On one occasion, one of the data loggers unexpectedly stopped working during an outdoor test due to a lack of sunlight, forcing us to repeat the experiment.

There were no significant problems with the equipment itself, but time constraints were present, and all necessary materials were available to complete the project.

To address these challenges, We secured the thermocouples to prevent movement during testing and used smaller brushes to more precisely coat difficult areas on the drones. Despite these obstacles, the overall experimental approach remained consistent without major changes**.**

7. Next steps and future work

The next phase of the project could involve conducting large-scale outdoor experiments over extended periods and in broader areas to evaluate the coating's long-term performance. This would help determine whether the material requires renewal or reapplication after a certain time.

In the future, the potential applications of this coating can be expanded beyond drones. For example, applying the coating to building roofs could help reduce electricity consumption for air conditioning. Similarly, coating cables exposed to direct sunlight could improve their efficiency by lowering their operating temperature, and applying it to water pipes could help keep water cooler, reducing heat-related losses.

8. Resources and tools used

Instrument \ Device	**Used for**
FTIR Spectrometer	for measuring reflectance and emittance of coating samples
UV–Vis Spectrometer (Lambda 950)	for detailed spectral reflectance measurements

Thermocouples	for recording surface temperatures during outdoor experiments
Data Loggers	for continuous temperature data collection

References

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