Senior Project – Mechanical Engineering - 2020

A Cooler Solar Panel:

The Effect of Passive Cooling on the Efficiency of Photovoltaic Panels

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Intro

Solar energy is becoming increasingly popular due to the vast number of locations in which they can be installed and the decreasing cost. The downside to solar energy comes from relatively low conversion efficiency of around 15-20%. If this efficiency increases, the photovoltaic (PV) array will produce more power and PV systems will have a shorter payback period. One reason PV panels are inefficient comes from overheating. As the PV panel's temperature increases, the efficiency decreases at a rate of about 0.4-0.5% per degree Celsius. If the heat generated in the PV panels and the overall temperature can be reduced the panels will produce more energy and be more cost-effective.

Methodology

The first experiment was a consistency test conducted on a rooftop lab to ensure the PV panels used have no discrepancies. This is very important because some unknown deviation in the panels could result in false conclusions that indicate certain methods of cooling performing much better or worse than they actually do.

Once it was confirmed the panels being used had very similar power output they were setup for indoor lab testing.

Indoor lab testing used three halogen lamps located 65 cm from the panel. Testing was conducted for 40 minutes for each cooling technique as well as with a control. The thermocouples were applied at the same location, seen in Figure 1, for each test except point 3 was located directly under the vapor chamber for the vapor chamber test.

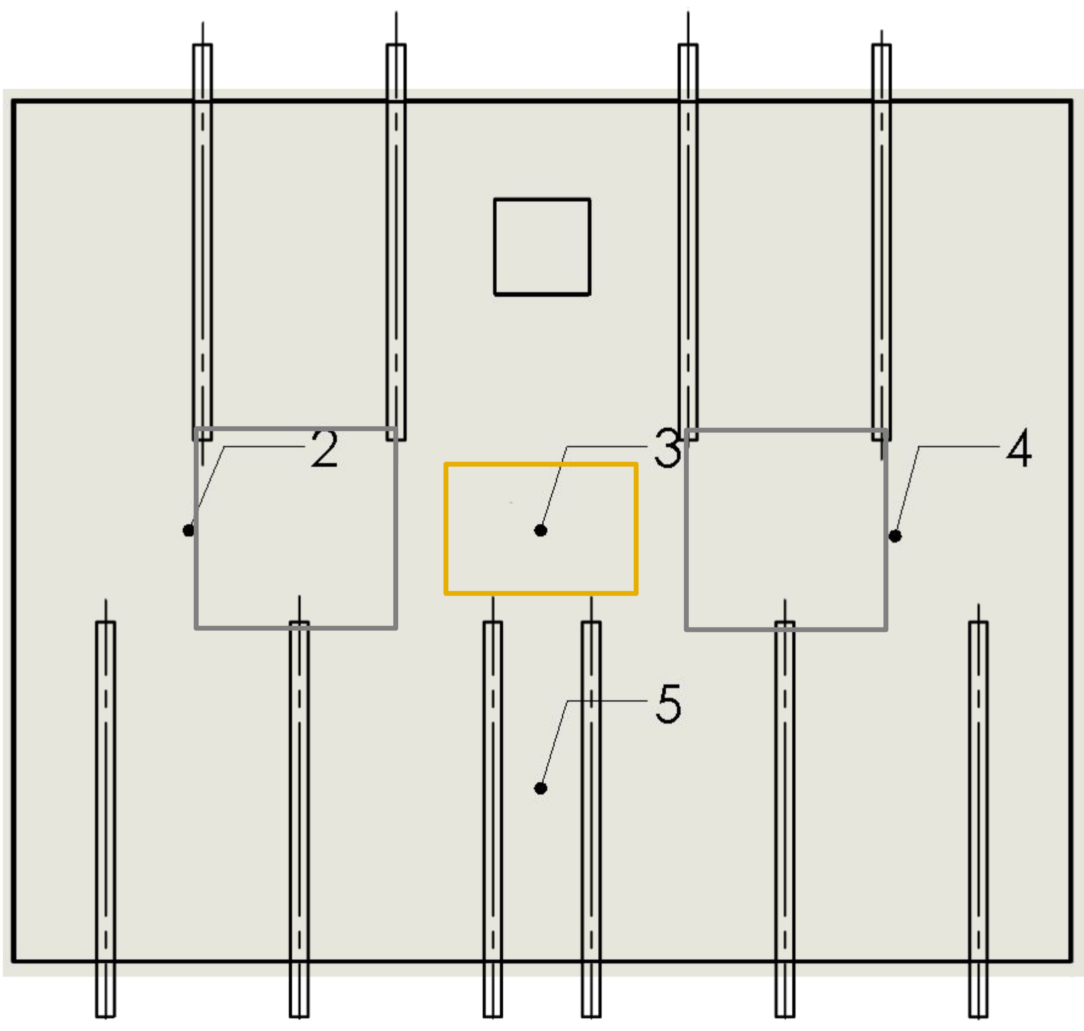
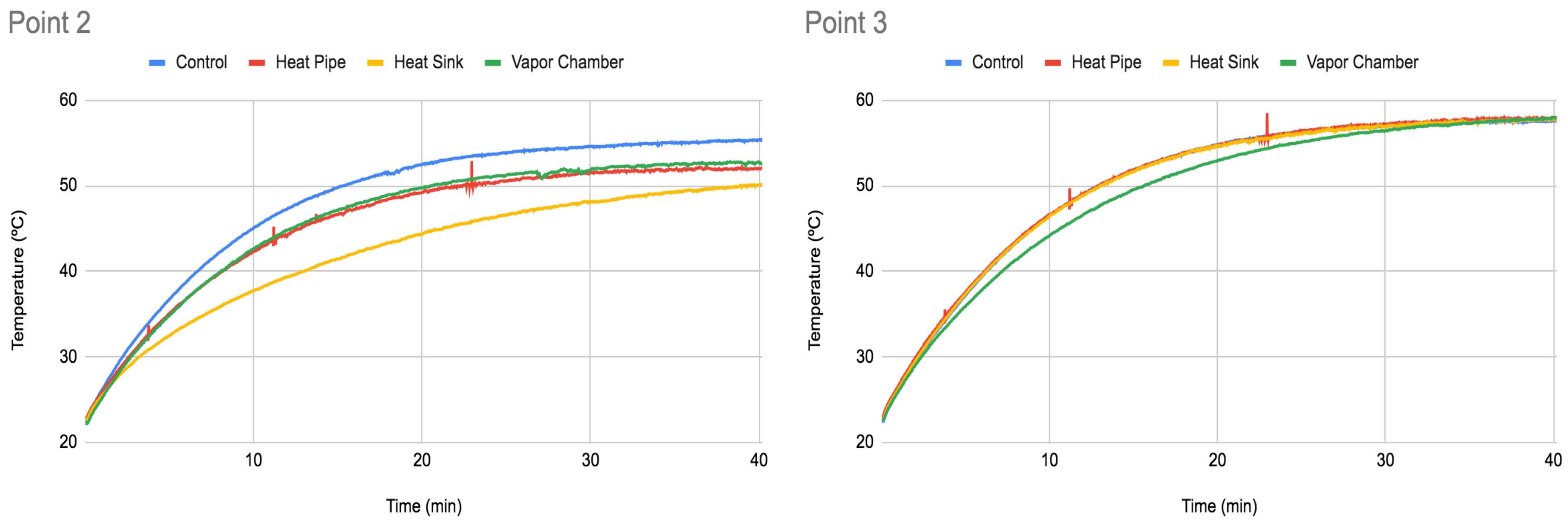


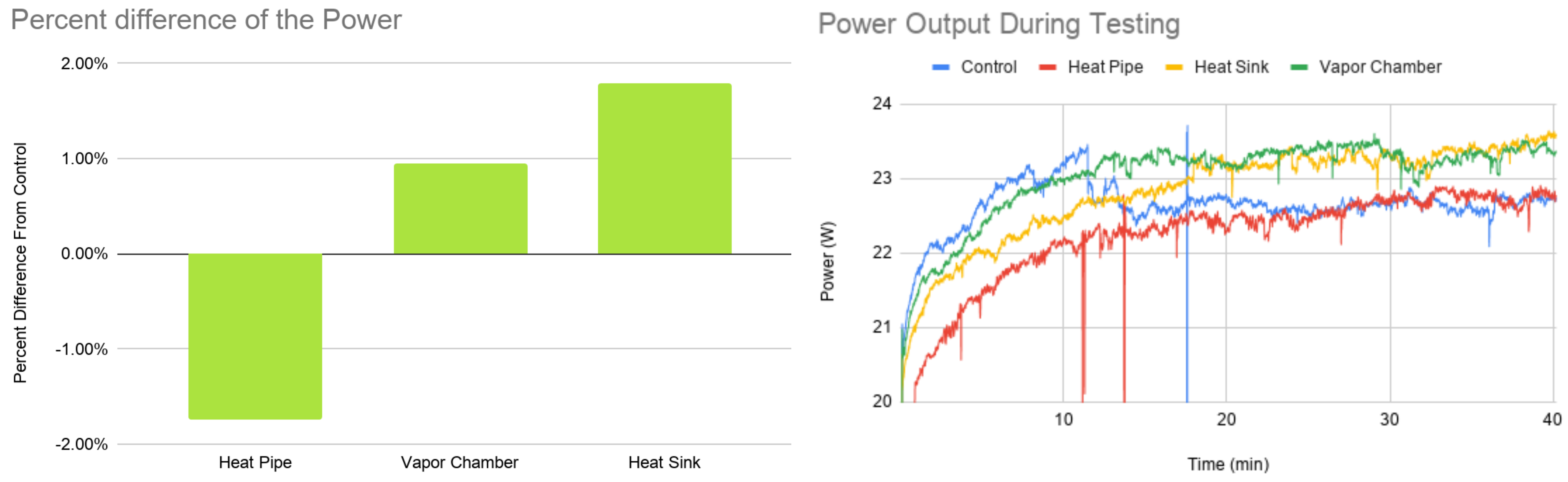
Figure 1. Location of thermocouples on the PV panel during testing along with location of cooling equipment for each test. The heat sinks are represented by the two grey squares, the heat pipes are shown by the long black rectangles, and the vapor chamber is represented by the orange rectangle. Testing was conducted one cooling method at a time.

Results & discussion

The rate at which the panels heat up and how the power output fluxgates is important to find how the effective each cooling technique is.



Figures 2 and 3. Temperature data from points 2 and 3. Point 2 was located directly next to a heat sink and point 3 was located directly below the vapor chamber.



Figures 4 and 5. Power output of each cooling technique test compared. The percent difference of the total power output shows how effective each cooling method is compared to no cooling.

Conclusions and Future Work

The temperature of each of the panels except the heat sink at point 2 are about the same with the heat sink being significantly lower. A similar effect happened for point 3 and the vapor chamber. Because the lower temperatures are from the tests with the cooling hardware fixed very close to the point it was concluded that the cooling is effective but only locally. The heat sink and vapor chamber also showed a higher total power output showing that they are effective ways to increase the panels efficiency and heat pipes are not effective in increasing power output. This is also shown in Figure 5 at the end when a steady state is reached at the end of the trial. Due to this testing only being done using a halogen lamp to simulate the sun the conclusions have some uncertainty and the experiment should be redone with real sunlight.

Acknowledgements

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