Heat Management of a LED High Power Light Panel

By

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Objectives and Cooling Techniques

LED lights can reach a very high temperature that deteriorates their efficiency and lifetime. Both active and passive cooling techniques are available

Active cooling techniques (electric fans and liquid pumps) are not favoured because of their power requirement and maintenance.

Passive methods are preferred that include heat sinks The efficiency of the heat sink heavily depends on the material used and their optimum characterization.

The objective of the current work was

- To design an optimum heat sink and use it to conduct heat management on a high-power LED panel.
- To investigate the impact of the environment humidity and temperature on the performance of the heat sink

Hypothesis: Active or passive cooling of an high-power LED panel will lead to a reduction in its operating temperature.

LED Lights in Agriculture

The LED provides artificial sunlight for the plants to grow. This was proven more effective by Philips Lighting, where they tested this in Japan.

The plantation grew 12,000 heads of lettuce daily. The reason this is more effective is that the LED lights can be altered with. The farmers have complete control over the intensity of the light, humidity, temperature and other key aspects to growing an ideal crop.

With these lights being at high temperatures, a coolant is required to keep the greenhouse a safe environment. This is where both active and passive techniques can make a difference.

Heat Sinks: An Introduction

A heat sink gets rid of unwanted heat generated from a system, which may be a computer or a high power light source.

A thermal adhesive such as thermal paste is usually used to improve the heat transfer between the LED panel and the heat sink surface. Trapped air between two surfaces can offer great resistance to heat transfer.

Heat sinks use both conduction and convection to transfer heat from the source to environment.

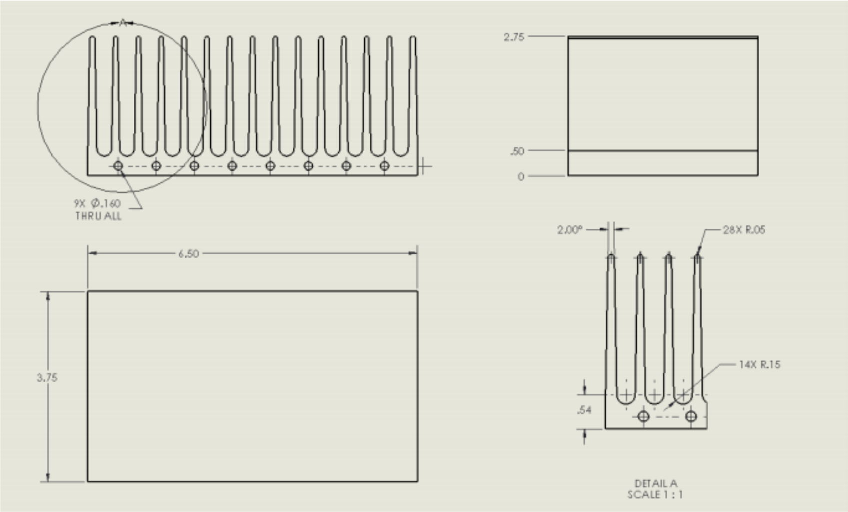
Conduction depends on the material and the geometry of the heatsink whereas the convection takes place due to air circulation between the fins and the main surface of the heat sink.

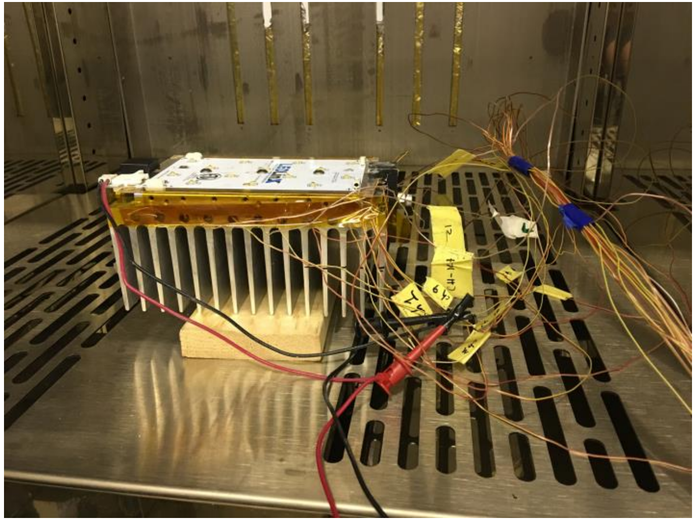
Fourier’s law equation - $Q = -kA(dt/dx)$ where Q is the heat flow rate, k is the thermal conductivity, A “is the cross-sectional area normal to the direction of heat flow”, dt/dx is the temperature gradient.

Equipment: Heat Sink

Was machined from a billet of 6061 aluminum alloy.

It incorporated 13 tapered fins. Spaced 5.8mm apart, thickness 0.2mm

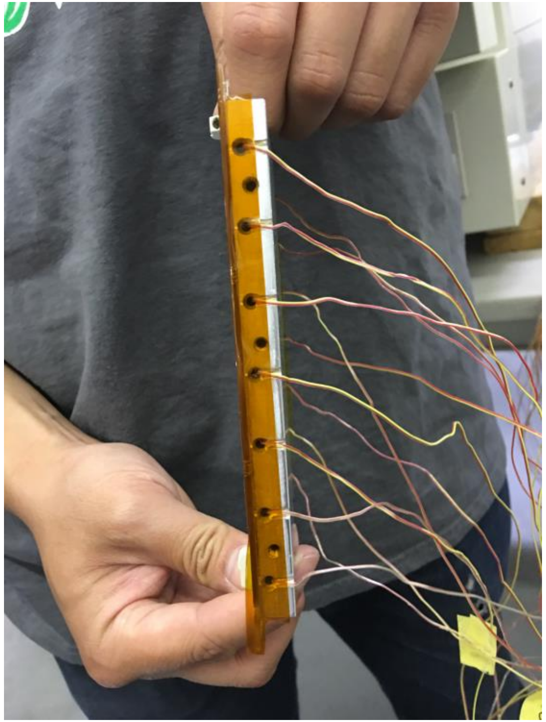




Equipment: Thermocouples/DAQ

14 K-type thermocouples were chosen as the thermal sensors for the experiments, because they are relatively inexpensive, have a large temperature range, and have a suitable range of error, about +/- 2°C, for these experiments.

The thermocouples were connected to a KeySight (Agilent) 34970A Data Acquisition Device (DAQ). This DAQ was used to take readings of all 14 thermocouples every ten seconds and store the data within the internal memory. The DAQ system is paired with the BenchVue software provided by Keysight, which exports the data into a spreadsheet



Equipment: LED Linx Panel

The LED panel used in this testing was a LEDLinX (#AB0038) panel. This panel contains 14 LED's and has an operating temperature of -40 to 90 °C.

Experimental Procedure

Experiment #1: Measure LED's operating temperature

- Use an LED panel and measure the temperature increase with time by mounting k type thermocouples directly underneath each LED light source
- Use the DAQ to collect temperature data over a period of an hour
- Plot Temperature vs Time graph to observe the variation in temperature for each LED light source

Experiment #2: Temperature distribution using a base plate

- Mount an aluminum base plate underneath the LED panel and repeat the experiment
- Thermal paste was used between the LED panel and the base plate to reduce the resistance to the heat transfer from the panel.

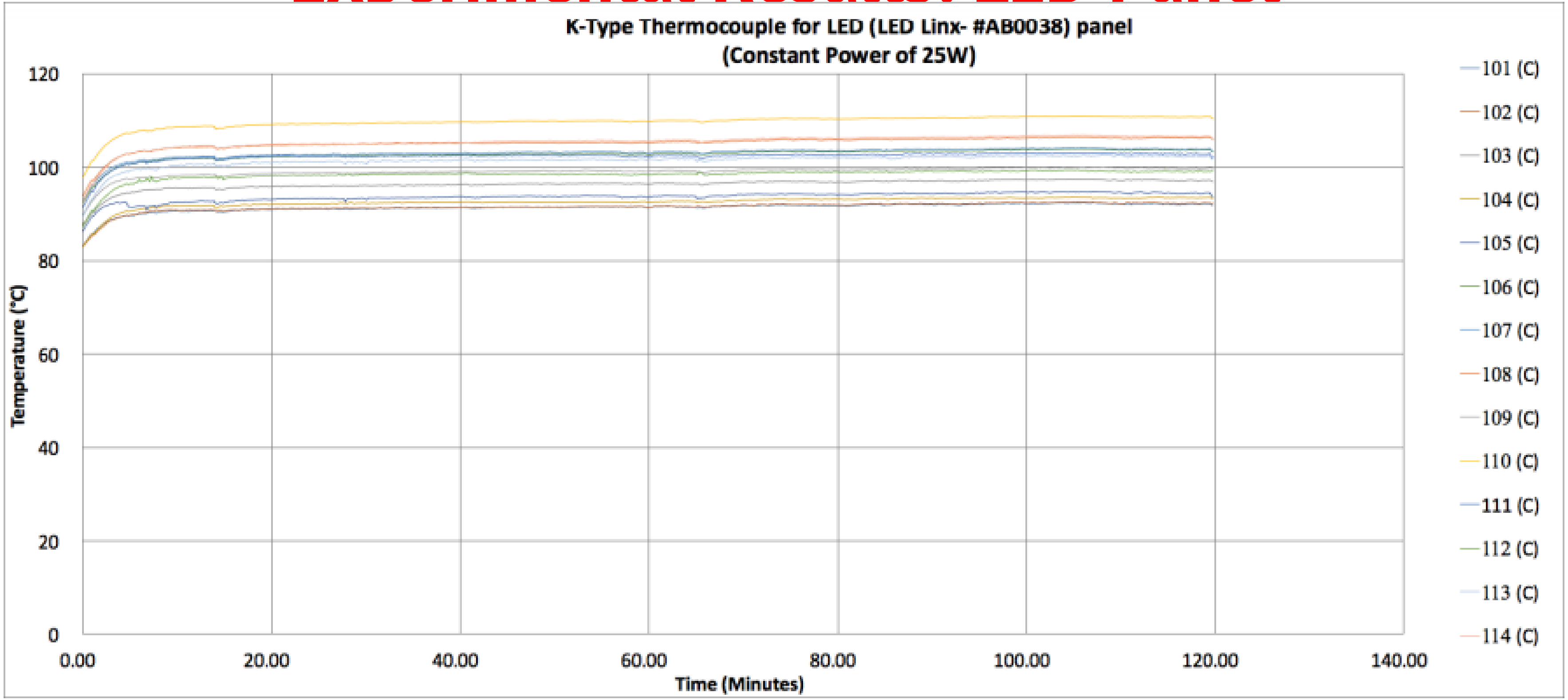
Experiment #3: Temperature measurements with heat sink

- Mount the LED panel with the base plate on a heat sink
- Place the thermocouples in the designated lots of the heatsink
- Repeat the experiment

Experiment #4: Impact of environment humidity and temperature on the performance of heat sink

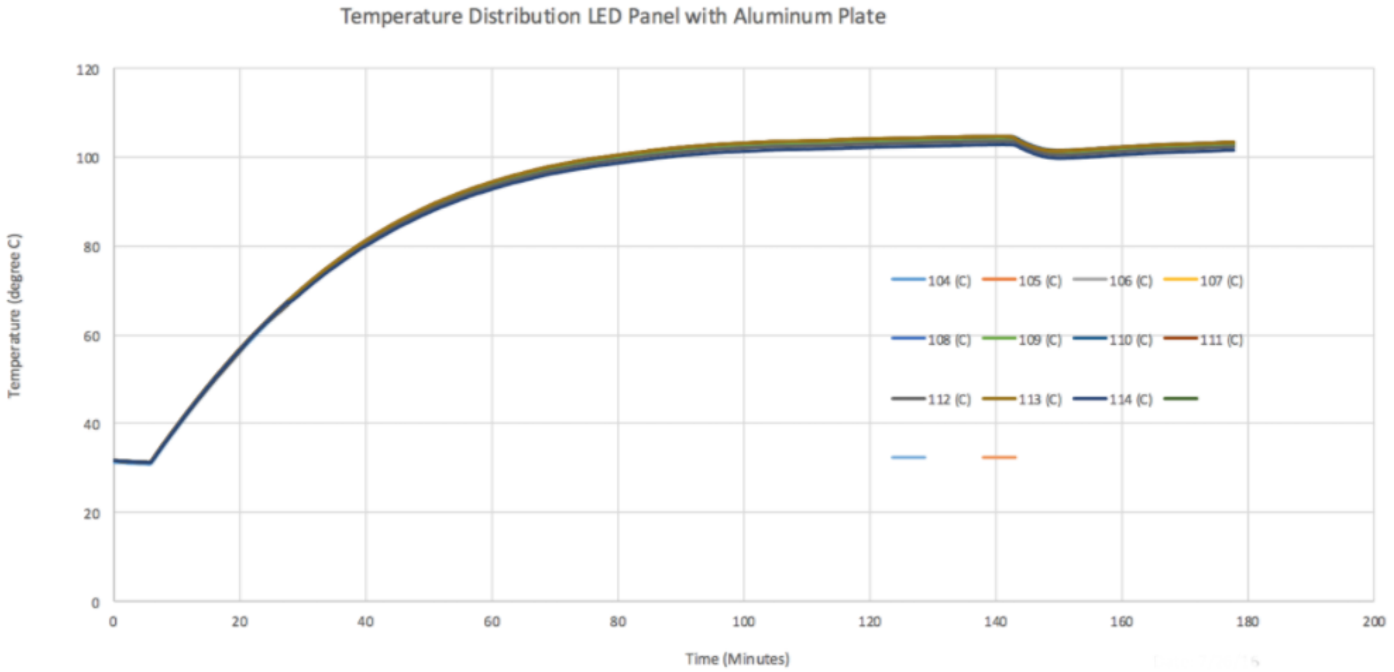
- Place the heatsink setup in the Hastest Test Chamber
- Choose variable like humidity and environment temperature and conduct the experiment again to investigate the impact of these factors on heat conduction
- Plot the results and compare to all previous results

Experimental Results: LED Panel



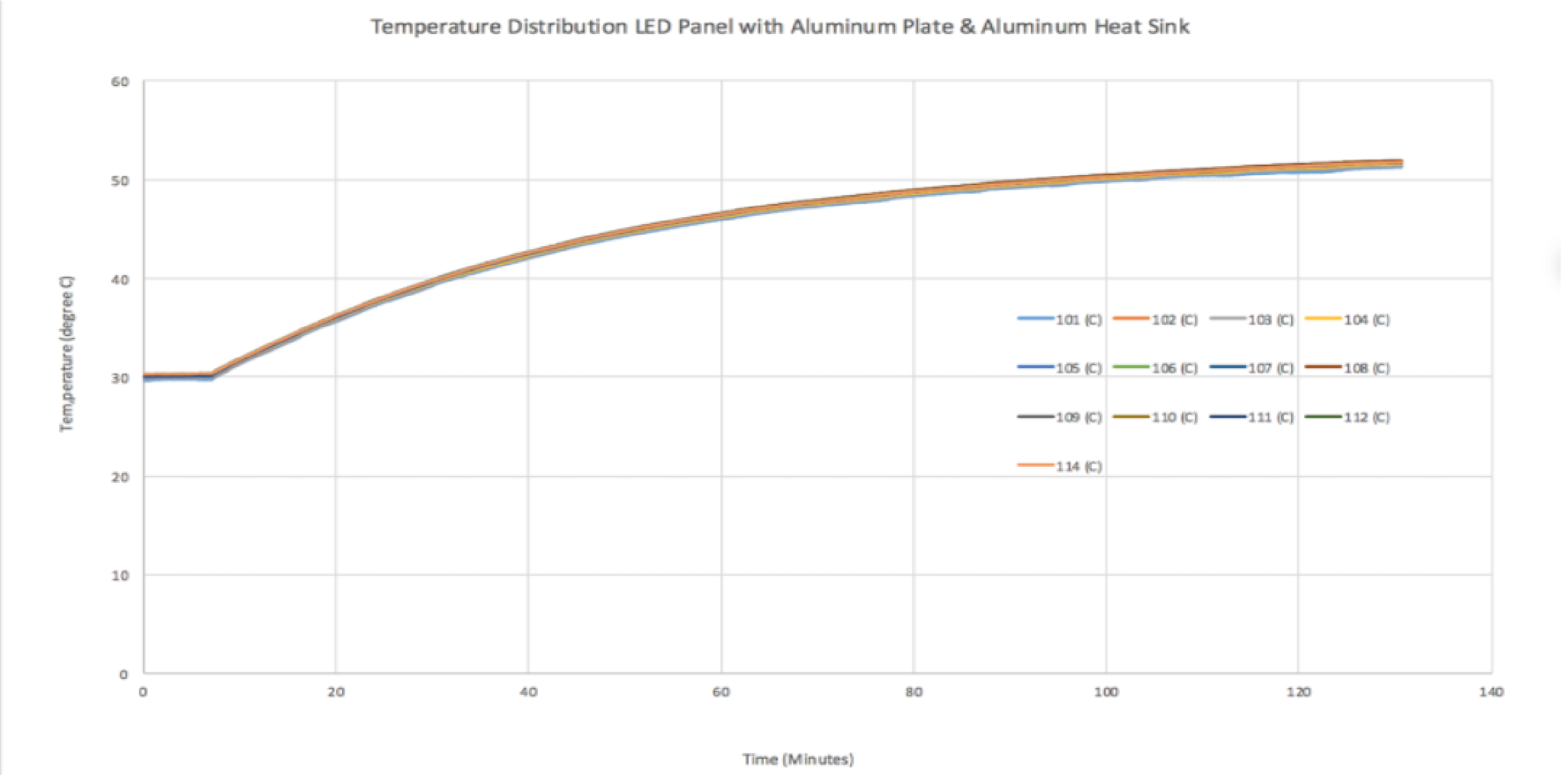
Within twenty minutes, temperature on the average varied from 90C to about 110C for various thermocouples

Experimental Results: LED Panel + Base Plate



A base plate was used to mount the LED panel and in this case, all thermocouples collectively reached to an average temperature of about 92.1 C as shown

Experimental Results: LED Panel + Base Plate + Heatsink



A sharp decrease in temperature from 92.1C to an average value of about 55.3C giving a 40% reduction in the operating temperature of the LED panel

Conclusions

- The purpose of this experiment was to investigate the combined effective of two passive cooling techniques that incorporated a heat sink and seven heat pipes simultaneously
- Experimental results clearly indicate 58.6% reduction in temperature values
- Sharp decrease in the operating temperatures of the LED panel will increase the lifetime of LED
- Optimization of its operation for varying environmental conditions especially in agriculture applications can be performed without anomaly. Even at a significantly increased temperature, the LED heat released by the panel-heat sink setup was much lower than the LED panel alone in room temperature