SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

10.023 Designing Energy Systems 1D

10.023 Module

Cohort CC09

Assignment: 1D Report

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Abstract

This project aims to increase the power efficiency of a projector by improving its heat dissipation. The components were rearranged to increase the ventilation of the outer case. These changes were successful in increasing the power efficiency of the projector by 20% and achieving a longer lifespan.

Introduction & Approach

The device in question is a DC-Powered mini 12W projector. The power efficiency of the device was determined by the brightness of the image produced, since it had a fixed power input.

It was determined that the temperature of the device significantly affected the brightness and hence effectiveness of the projector. Research suggested that raising the temperature of the semiconducting element within the LED caused its light output to decrease (VL Lighting Solutions [1]). Hence, it was decided that the progression would involve modifying the case of the device to facilitate better airflow and heat dissipation through forced convection by the fan. In theory, this would allow the device to maintain lower temperatures and therefore output a brighter image for the same power input.

Modification Details

A new case with improved airflow was 3D printed, enabling the device to dissipate heat more effectively through forced convection by the fan. It consisted of shifting the speaker to make space for more and larger air vents to be cut out in front of the internal axial fans and heat sink (Appendix 2) to improve the ventilation of the system such that air could circulate more easily. Additionally, the heat sink was shifted such that the LED was positioned at the centre of the heat sink. This achieved the effect of increasing heat dissipation through conduction of the heat sink as well.

Schematic of Old vs New Casing

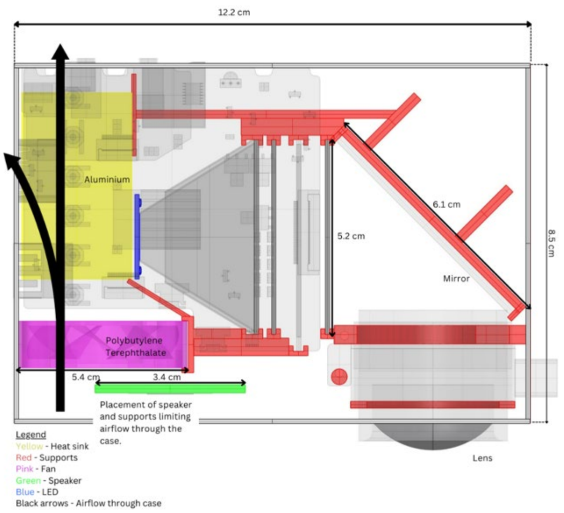


Figure 1a – Initial placement of components.

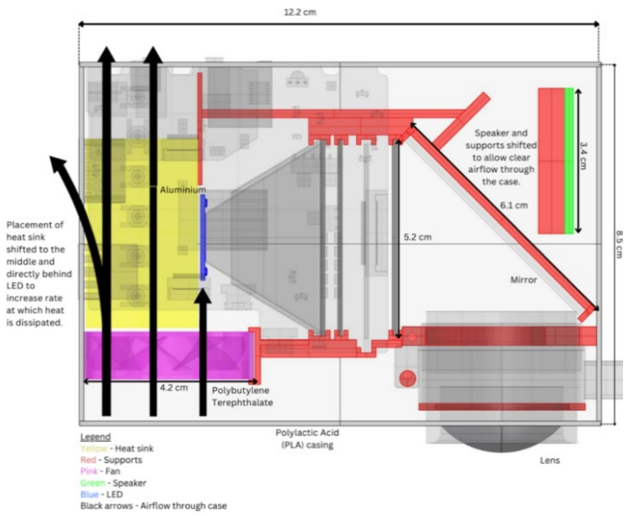
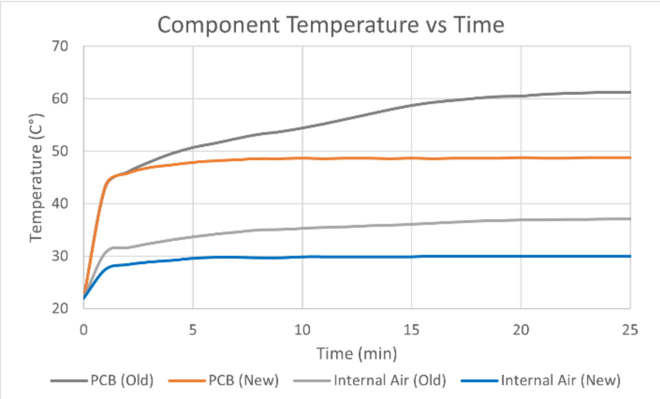


Figure 1b – Placement of components after modifications

Experimental Procedure

A thermocouple was used to measure the temperature of the PCB and Internal air. A luxmeter was also used to measure the brightness of the device. A power meter was connected between the power supply and projector to ensure the power input remained constant. The experiment was conducted with the old and new case, allowing for sufficient time to cool in between 3 sets of 25-minute readings for each case. The experiment was conducted in a dark room to minimise external light interference.

Results & Discussion



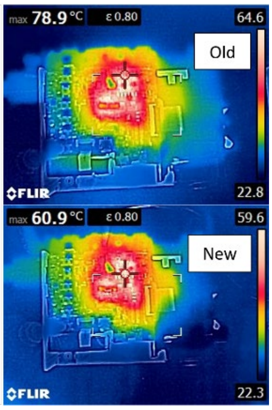


Figure 2a – Graph of component temperature against time. *Figure 2b – Thermal image of projector.*

All 3 sets of readings exhibited similar results, and the presented data is from the most recent set of readings. As seen from the graph in Figure 2a, the new case exhibited significantly better thermal performance, with PCB and Internal air temperature steadying out at 20% lower temperatures than before with the new casing as compared to the old one. Figure 2b also shows the highest temperature of the projector internals, with a 22% lower highest temperature point.

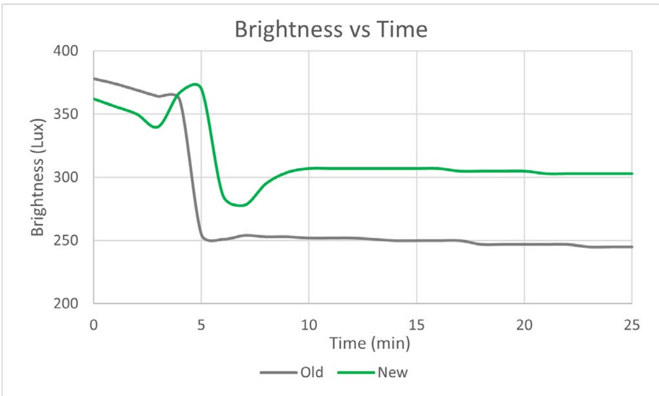


Figure 3 – Variation of projector brightness over time.

The improvements to the cooling efficiency were successful. As seen from the graph in Figure 3, the brightness steadied out at 20% higher than previously due to the lower operating temperatures. The initial difference in brightness may be attributed to imperfect aligning of the lens in the new casing.

Given that the power input remained the same while brightness increased, the modifications have resulted in better heat dissipation, and in turn has increased the power efficiency of the projector by 20%. In addition, the lower operating temperatures of the LED may increase the lifespan of the projector. The only compromise made was in the repositioning of the speakers of the device from the front to the side, which reduces the sound projection.

Future Improvements

Given more time and resources, further research would have been conducted with regards to different case materials to dissipate heat better. Additionally, further investigation into shifting the components within the case should also be made. This may involve a complete overhaul of the case design, all to promote better airflow. Lastly, higher quality fans and heat sinks could also be used, but they would likely increase the cost of the product as well.

Bibliography

1. *Valuelightdomain. (2019, September 11). How temperature affects led efficiency. VL Lighting Solutions. Retrieved December 7, 2022, from https://vllightingsolutions.com/how-temperature-affects-led-efficiency/*

2. *TAKAMATSU, H., MASUDA, N., LEE, J., NISHIMURA, Y., SAKAI, S., & TANI, Y. (2007). New Cooling Technology for a projector with a high ... - NEC global. NEC Global. Retrieved December 8, 2022, from https://www.nec.com/en/global/techrep/journal/g07/n03/pdf/t070321.pdf*

Appendix

1. Initial Experimentation

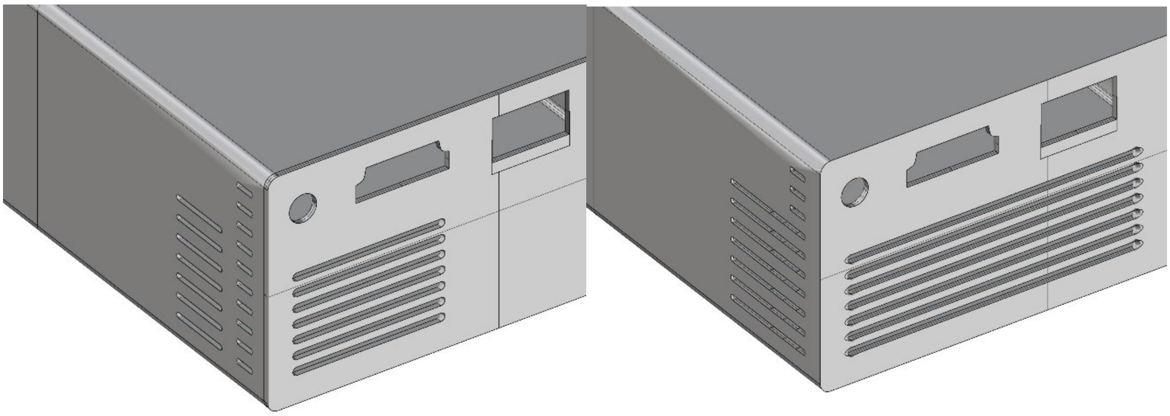
Initially, power efficiency of the device was attempted to be increased by removing the fan to see if the projectors performance was affected in any way, to determine if it was necessary for its operation. The initial testing involved connecting thermocouples to the device, allowing for measurement of the PCB and Internal air temperatures.

The device ran for 25 minutes, and readings were taken every minute during this period. The experiment was performed with and without the fan, cutting off any experiments if exceeding 80°C. It was deemed that running the device for an extended duration past this temperature may potentially damage the device.

As seen in Appendix 4b, the data showed that the fan was extremely important for the device to function. As depicted in the graph, the device reached steady state at a temperature of around 65°C, with the fan. Without the fan, the temperature spiked up extremely fast, hitting the 80°C limit within 6 minutes. It was also discovered that as the temperature of the device increased, the brightness of the LED noticeably decreased, affecting the quality of the image projected. As such, the approach was shifted.

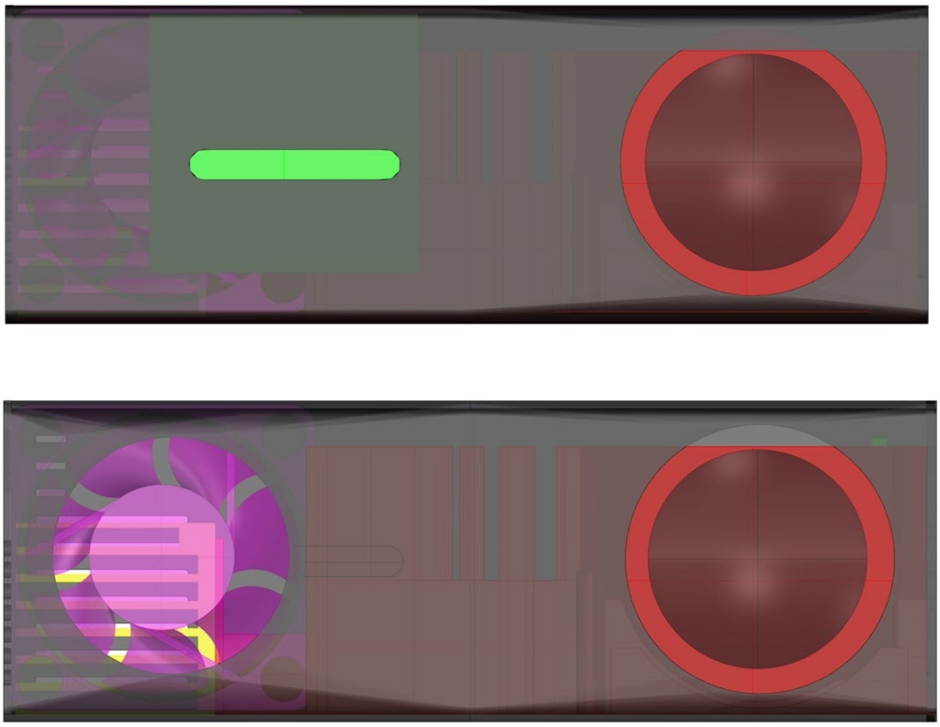
2. Modifications to Case

a) Side Air holes



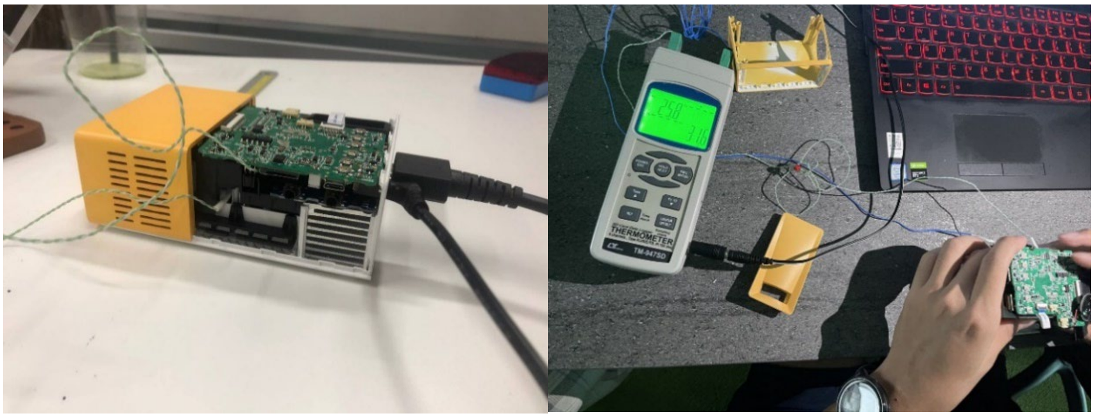
Old case (left) and new case (right) with extended air holes

b) Front Air holes



Old case (top) with limited airflow to the fan and new case (bottom) with larger hole cut out with netting in front of internal fan for better air flow

3. Experimental Procedure



Recording of temperature of PCB and internal air using thermocouple

4. Experimental Data (Refer to attached Excel sheet)