International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 05 | May 2024 www.irjet.net p-ISSN: 2395-0072

Design, Analysis & Optimization of Heatsink

Mr. Aniket Dnyaneshwar Gaikwad[1]
Mr. Shubhankar Suhas Ghosalkar[2]
Mr. Prasad Dilip Ingole[3] ,
Prof. Amol Zope[4]
Dr. Mridul Malakar [5]
Mr. Amit More[6]

[1-3]BE Mechanical Students, Mechanical Engineering Department, Pune Vidyarthi Griha's College of Engineering and Technology and G.K. Pate (Wani) Institute of Management, Pune – 411009
[4]Project Guide & Assistant Prof. Mechanical Engineering Department, PVG's COET & GKPIOM, Pune – 411009
[5]EV-Manager (R &D), Belrise Industries Ltd. Pune – 411005
[6]Design and Development Manager, Belrise Industries Ltd. Pune – 411005
Maharashtra, India

***

Abstract - *This project focuses on the optimization of a heatsink designed for application in electric vehicles (EVs) manufactured by Belrise Industries Private Limited. Utilizing ANSYS simulation software, comprehensive analyses were conducted to evaluate the heatsink thermal performance, including its capacity and maximum operating temperature under varying conditions. Through iterative simulations and analysis, areas for enhancement were identified, leading to the development of an optimized heatsink design. This report outlines the methodology, findings, and recommendations derived from the simulation-based optimization process, aimed at enhancing the thermal efficiency and overall performance of the heatsink for EV applications.*

Key Words: Optimization of heatsink, thermal performance Increases.

1. INTRODUCTION

Belrise Industries Ltd. recognized the critical importance of optimizing their heat sink to mitigate the risk of overheating in their system. High temperatures posed a significant threat to the reliability and performance of their equipment, necessitating a proactive approach to thermal management. The need for improved heat dissipation arose from concerns over system stability, potential component failures, and associated maintenance costs. Addressing this need was essential to maintain competitiveness, ensure product quality, and meet customer expectations for reliability and durability

2. PROBLEM STATEMENT

Belrise Industries Ltd faced a pressing challenge of effectively dissipating heat generated by their system components, particularly under high load conditions. Suboptimal thermal management led to elevated temperatures within the system, compromising performance, reliability, and operational lifespan. Inadequate heat dissipation exacerbated thermal stresses on critical components, increasing the risk of premature failure and downtime. The problem extended beyond immediate operational concerns to encompass long-term sustainability, regulatory compliance, and customer satisfaction objectives.

3. DEFINITION OF PROBLEM

The primary issue cantered on the inefficiency of the existing heat sink design in transferring heat away from critical components to the surrounding environment. Thermal resistance within the system hindered the effective dissipation of heat, resulting in temperature gradients and localized hotspots. Consequences of the problem included reduced system efficiency, impaired functionality, and potential safety hazards in extreme cases. Failure to address these thermal management challenges could jeopardize Belrise Industries Pvt Ltd. market position, brand reputation, and profitability.

4. COMPANY GIVEN HEATSINK DETAILS

Material	:	Aluminium 6061
Length	:	225 mm
Width	:	145 mm
Mass	:	449.84 Grams
Type Of Fin	:	Rectangular Fin

Surface Area : 270291.24 mm^2
Working-Load : 115 Watts

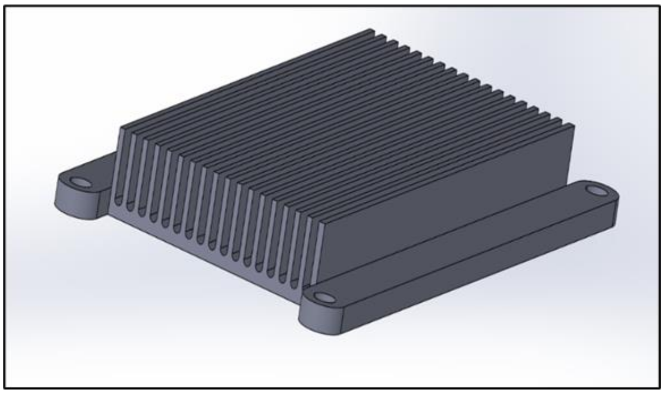

Fig -1: Heatsink Geometry

5. STEADY STATE THERMAL ANALYSIS OF COMPANY GIVEN HEATSINK

Steady-state thermal analysis is a method used to evaluate the temperature distribution within a system when it has reached thermal equilibrium, meaning temperatures remain constant over time. This analysis is crucial in understanding the effectiveness of heat dissipation in components such as heatsinks. By applying the principles of heat transfer, specifically conduction, convection, and radiation, steady-state thermal analysis allows engineers to predict how heat will spread through a material or assembly under consistent operating conditions. Utilizing tools like ANSYS, this type of analysis provides insights into the thermal performance of designs, helping to optimize configurations for improved cooling efficiency and reliability in electronic devices.

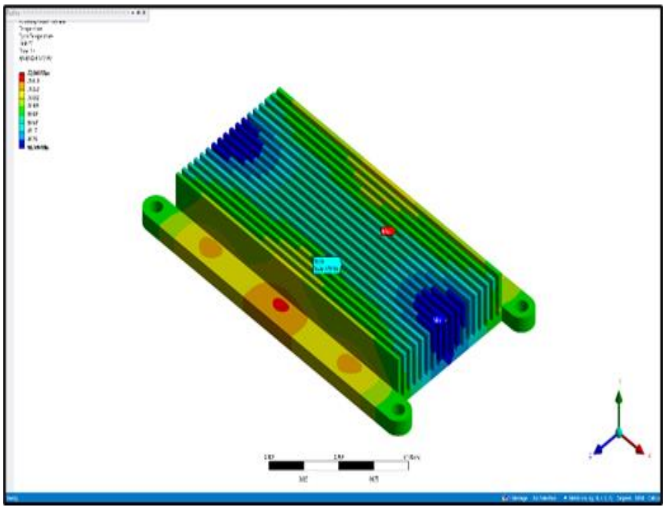

Fig -2: Steady State Thermal Analysis of Heatsink

6. TRANSIENT THERMAL ANALYSIS OF COMPANY GIVEN HEATSINK

Transient thermal analysis is a method used to evaluate the temperature distribution and heat flow within a system over time, capturing how temperatures change dynamically in response to varying thermal loads. Unlike steady-state analysis, which assumes a constant thermal condition, transient analysis considers the temporal evolution of heat transfer, accounting for the effects of time-dependent sources, sinks, and boundary conditions. This analysis is essential for understanding how systems respond to thermal transients, such as startup, shutdown, or fluctuating operational conditions. By using simulation tools like ANSYS, engineers can model the thermal behavior of materials and components under varying conditions, providing critical insights into their thermal management strategies, ensuring reliability, and preventing thermal fatigue or failure in electronic devices.

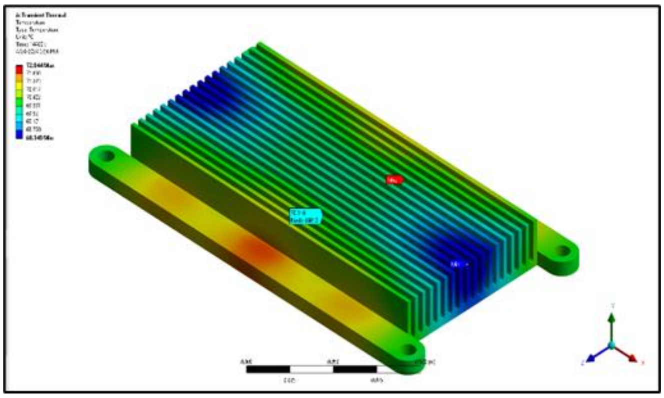

Fig -3: Transient Thermal Analysis of Heatsink

6.1 Temperature Vs Time Graph

The temperature vs. time graph reveals how quickly the heat sink can respond to thermal loads, which is crucial for maintaining optimal operating temperatures.

The rapid initial rise in temperature highlights the need for efficient heat dissipation mechanisms in the early stages of operation.

Initial Phase: The temperature rapidly increased as the heat load was applied, indicating the system's initial thermal response.

Intermediate Phase: The rate of temperature increase began to slow as the heat sink started dissipating heat to the surroundings.

Final Phase: The temperature curve flattened, approaching a steady-state temperature of approximately 72°C after a certain period.

The graph is obtained from transient thermal analysis (Showing achievement of steady temperature in nearly 5000 seconds).

The given input for time is 14,400s which is roughly 4hrs.

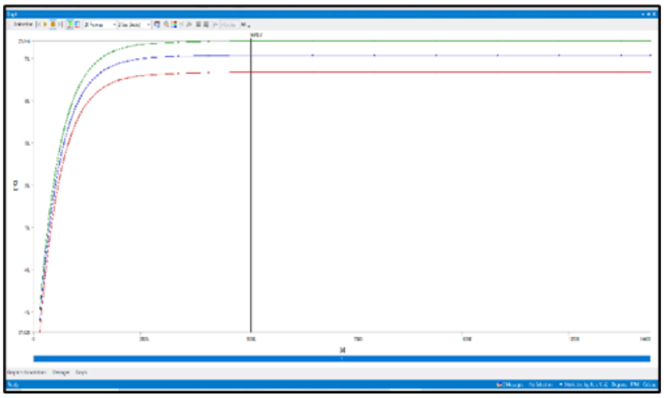

Chart -1: Temperature vs Time Graph

7. OPTIMIZED HEAT SINK

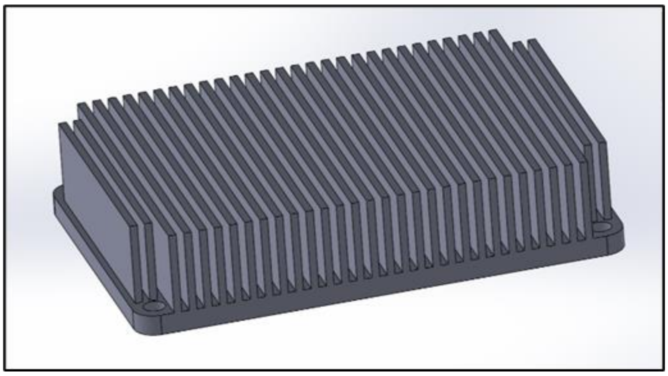

Fig -4 Optimized Heat Sink Geometry

Material	:	Aluminium 6061
Length	:	225 mm
Width	:	145 mm
Mass	:	953.93 grams
Type of fin	:	Rectangular fin
Surface area	:	442854.9 mm^2
Working load	:	115 Watts

7.1 Steady state analysis of Optimized Heatsink

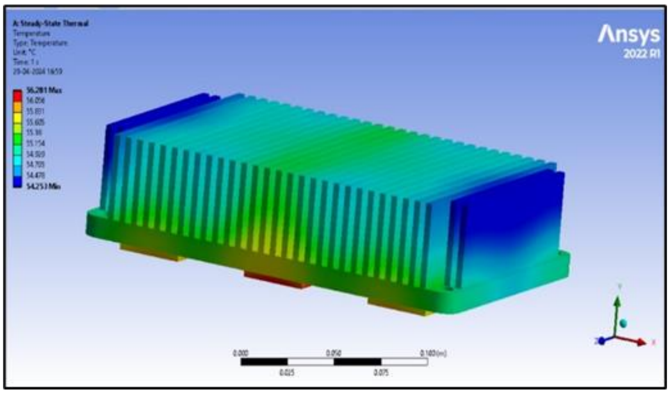

Fig -5 : Steady state analysis of Optimized Heatsink

The optimized heat sink achieved a maximum temperature of 56.2°C, a substantial reduction from the baseline design's 72°C.

The temperature distribution across the heat sink was more uniform, indicating improved heat spread due to the increased surface area and optimized fin orientation.

8.COMPARATIVE STUDY OF COMPANY GIVEN HEATSINK AND OPTIMIZED HEATSINK

PARAMETER	OLD HEATSINK	NEW HEATSINK
Max Temperature	72.043 ^{0}C	56.2 ^{0}C
Mass	449.84 grams	953.93 grams
Surface Area	270291.24 mm^2	442854.9 mm^2
Orientation	Flow along length	Flow along Width
Thermal Resistance	0.35 ^{0}C/W	0.22 ^{0}C/W
Number Of Fins	18	32
Manufacturability	Easy	Complex
Power Rating	115 Watts	115 Watts

9. CONCLUSION

Our optimization of the heat sink for a 115-watt power rating, using ANSYS simulations, significantly improved its thermal performance. By doubling the surface area through strategic fin reorientation, we reduced the maximum temperature from 71.6°C to 56.2°C. Although the heat sink's mass increased from 449.8 grams to 953.9 grams, the enhancements in thermal efficiency justify this change. This project highlights our effective use of simulation-driven design to achieve superior thermal management

ACKNOWLEDGEMENT

We are acknowledging **Dr. Mridul Malakar** (EV-Manager, Belrise Industries Ltd. Pune), **Mr. Amit More** (Design and Development Manager, Belrise Industries Ltd. Pune), **Prof. Amol Zope** (Project Guide, Mechanical Department, PVG's COET, Pune), Prof. Dr. **M. M. Bhoomkar** (HOD Mechanical Department, PVG's COET, Pune) for kind guidance and support.

REFERENCES

[1] Rajput, R. K. (2015). Heat and Mass Transfer (6th ed.). S. Chand Publishing.

[2] Çengel, Y. A., & Ghajar, A. J. (2015). Heat and Mass Transfer: Fundamentals and Applications (5th ed.). McGraw-Hill Education.

[3] Elenbaas, W. (1942). "Heat Dissipation of Parallel Plates by Free Convection." Physica, 9(1), 1-28.

[4] Zhang, L., & Lee, H. P. (2011). "Optimization of Heat Sink Design for Electronics Cooling Using Computational Fluid Dynamics and Response Surface Methodology." Journal of Electronic Packaging, 133(4), 041008.

[5] A. kumar and K. Londhe, “Heat sink design for optimal performance of compact electronic appliances-a review,” Research gate, October 2017.

BIOGRAPHIES

Aniket Dnyaneshwar Gaikwad
BE Mechanical student at PVG’s COET, Pune.

Shubhankar Suhas Ghosalkar
BE Mechanical student at PVG’s COET, Pune.

Prasad Dilip Ingole
BE Mechanical student at PVG’s COET, Pune