Thermal Analysis of Heat Dissipation Structure for Laptops using ANSYS

Jasmin Jamariya[1], Nishit Parmar[2], Reuben Manjaly[3], Krish Desai[4]

[1234]B Tech Student, Dept. of Mechanical Engineering, SVKM's DJ Sanghvi College of Engineering, Mumbai, India

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ABSTRACT

Heat fins are used for the enhancement of heat transfer for multiple purposes. There are two methods by which heat can be dissipated: either by natural convection or by forced convection. Though forced convection enables faster and greater heat dissipation than natural convection, it requires work input or a power source to drive the fan. Gaming laptops generate a tremendous amount of heat when they are at their peak performance, i.e., with extensive RAM usage for longer hours. Heat is drawn from the electronic circuits on the motherboard through forced convection via a fan at the bottom, which draws power from the laptop itself, draining its battery faster than usual. This study focuses on the heat transfer analysis of a heat dissipation structure, which draws heat from the laptop through conduction and natural convection rather than forced convection and reduces the load on the cooling fan. Appropriate permutation lengths of fins were selected in order to maximize effectiveness and efficiency as per their ML values. Aluminum was selected as the most appropriate material for multiple reasons, including its low cost compared to other materials, excellent heat conduction capabilities, and lower density, which reduces the overall weight. Experiments were conducted to validate the results and determine the actual heat transfer rates as well as the effectiveness and efficiency of the fins.

Key Words: Fins, Heat dissipation, Conduction, Convection, ANSYS

1. INTRODUCTION

The evolution of laptops has revolutionized the way we work, learn, and communicate. These compact computing devices have become essential tools for millions of people around the world, helping them stay connected and productive on the go. However, the increasing demand for high-performance laptops has also created some challenges, especially related to the dissipation of heat generated by the motherboard and components of the laptop.

Heat dissipation is an important criterion for the design of a laptop body. As laptops become more powerful and smaller, the amount of heat generated by internal components can increase, leading to overheating and poor performance. Overheating can also damage internal components and shorten their lifespan. Additionally, laptops that generate too much heat are uncomfortable to use and can pose a fire hazard due to the batteries used. Therefore, an effective heat dissipation solution is essential to ensure laptop reliability and safety [6].

This paper explores an approach to heat dissipation with the use of a laptop base stand consisting of heat fins. In particular, the focus has been on developing new structures that can effectively dissipate heat generated during the use of the laptop. The structure can include advanced materials such as carbon nanotubes and graphene, as well as innovative and complex designs that, however, may not be cost-effective.

1.1 Nomenclature

k - Thermal conductivity
L - Length of the fin
N - No of fins
W - Width of fin
t - Thickness of fin
Pr - Prandtl number
Nu - Nusselt number
T_{sur} - Surface temperature
T_s - Surrounding temperature
Q - Heat transfer
m - Square root of the ratio of the product of convective heat transfer coefficient and perimeter of the fin to the product of thermal conductivity of the material and cross-sectional area of fin S(derived constant)

Greek
ε - Effectiveness of fin
η - Efficiency of fin

2. LITERATURE REVIEW

The research group led by C. B. Sobhan, along with S. P. Venkateshan and K. N. Seetharamu, recently shared their findings through a paper titled "Experimental exploration of continuous free convection heat transfer from fins and arrangements of fins." In this publication, they detail the outcomes of their hands-on investigations. The study contributes novel experimental data that pushes the boundaries of understanding in this pivotal domain of research. The paper elaborates on the setup used for experimentation, involving a heated plate with multiple fins or arrays of fins connected to it. The team gauged the heat transfer coefficient by using thermocouples affixed to the fins. Additionally, they utilized infrared thermography to visualize the temperature distribution around individual fins and fin arrays.

Through their empirical findings, the researchers make comparisons among various kinds of fins and fin arrays, exploring their heat transfer efficacy across different operational circumstances. The authors delve into the effects of diverse parameters on heat transfer efficiency, including factors like fin spacing, fin length, and inclination angle. The results underscore the influence of these parameters on the heat transfer performance of fins and fin arrays, highlighting the varying effectiveness of different configurations. Furthermore, the researchers present the outcomes of a numerical analysis, aligning well with the experimental data. They also underscore the applicability of their study's findings in the realm of electronic device heat sink design, where proficient heat dissipation holds immense importance. In conclusion, the authors reveal that, both for single fins and multiple fin arrays, the highest local heat flux values are observed at a distance of 20-30% from the fin base. This trend mirrors findings from unsteady experiments conducted earlier. Notably, the efficiency of fins peaks when the heat flux per unit length of the base is at its maximum under a given heating level. In comparing the heat flux profiles of single fins and fin arrays, the study demonstrates that the latter exhibits an augmented local heat flux near the tip, a characteristic absent in individual fins. This enhancement appears to significantly contribute to the overall enhanced performance of the fin array.

Ambarish Maji and Gautam Choubey have authored a research manuscript titled "Advancements in Enhancing Heat Transfer via Fins: A Concise Survey of Recent Progress." This paper offers an in-depth examination of the latest strides in the realm of heat transfer facilitated by fins. The document underscores the crucial role fins play in augmenting heat transfer in a range of engineering contexts, while also underscoring the need to optimize the efficacy of finned surfaces. The authors commence by delving into the foundational principles governing heat transfer through fins, along with the variables impacting this process—such as material characteristics, fin configurations, and heat transfer coefficients. They highlight the potential for advancements through novel materials, innovative geometries, and optimization strategies to heighten the efficiency of finned surfaces. Recent investigations revolving around the incorporation of diverse materials into fins—carbon nanotubes, graphene, and nanofluids—are reviewed in detail by the authors. These materials, distinguished by their elevated thermal conductivity, have the capacity to profoundly augment heat transfer capabilities. However, the authors also address the challenges tied to these materials, encompassing elevated production expenses, fabrication complexities, and plausible environmental risks. The paper then narrows its focus on inventive fin geometries engineered to boost surface area while concurrently enhancing heat transfer efficiency. Among these novel designs are perforated fins, characterized by surface apertures that both increase the exposed area and promote fluid mixing. Likewise, the authors explore helical fins, which exhibit a spiral form that increases surface area and encourages turbulent flow—ultimately bolstering heat transfer. Subsequently, the authors delve into the methodologies employed for analyzing and designing fins. This includes techniques such as numerical simulations, empirical investigations, and optimization algorithms. These approaches demonstrate their efficacy in accurately forecasting heat transfer rates and refining fin configurations under specific conditions. The paper culminates with a summary by the authors, underscoring that porous fins outpace solid fins of equivalent size and weight in heat transfer capacity, attributable to the greater surface area available for convection. This validation supports the utilization of porous fins in contexts where weight is a primary constraint. In contrast to solid fins, perforated fins boast a significantly augmented contact surface with the fluid. Therefore, opting for perforated fins rather than their solid counterparts can substantially increase fin efficiency and heat transfer rates. The number of perforations in fins can be manipulated to observe the impact on heat transfer enhancement, albeit with the caveat of heightened friction and reduced pressure drop compared to solid fins. The authors stress that diverse perforation geometries impact heat transfer through fins, and examining the variation of key parameters—such as Reynolds number, Nusselt number, and pressure drop—across varying perforation configurations can yield valuable insights. Notably, heat transfer is found to improve with smaller perforations in fins.

Jungko Moni Chakma and Mohammad Zoynal Abedin have penned a research document titled "Exploring Heat Transfer Enhancement Using Rectangular Fins," which delves into diverse methodologies deployed to amplify heat transfer through rectangular fins. The authors kickstart their exploration by delving into the core principles of heat transfer, underlining its pivotal role across various industrial contexts. Their discussion subsequently turns to the pivotal function of fins in heightening heat transfer, with a specific focus on rectangular fins. A comprehensive breakdown of the manifold types of rectangular fins employed in heat transfer applications is provided, encompassing plain rectangular fins, perforated rectangular fins, and serrated rectangular fins. Further insights extend to the array of materials harnessed in the fabrication of these fins, spanning aluminium, copper, and steel. The authors delve into an elaborate exposition of techniques geared towards elevating heat transfer through rectangular fins. This encompasses strategies to augment the fin surface area, bolster its thermal conductivity, and enhance the heat transfer coefficient between the fin and the fluid. Each technique is expounded upon meticulously, elucidating the associated methodologies for their realization. The discourse extends to underscore the pivotal role of optimization in fostering heat transfer enhancement through rectangular fins. Optimization is defined as the iterative process of ascertaining the optimal combination of parameters—fin thickness, fin spacing, and fluid flow rate—to attain peak heat transfer performance. The authors furnish instances of optimization studies performed on rectangular fins, accompanied by the outcomes achieved. Numerical simulations emerge as a focal point in the study's conclusion, given their pivotal role in unraveling heat transfer mechanisms and facilitating the identification of optimum design parameters for rectangular fins. The authors present instances of numerical simulation analyses carried out on rectangular fins, shedding light on the insights gleaned from these simulations. The authors encapsulate their findings by affirming the direct influence of fin height and spacing on heat transfer rates within the conventional rectangular fin context. They highlight the decrement in heat transfer rates stemming from inadequate fin application, in contrast to cases devoid of fins. Moreover, it's noted that narrow fin spacing can heighten the heat transfer coefficient. Notably, duralumin fin arrays surpass stainless steel counterparts with similar geometries in terms of heat transfer performance. While the material's thermal conductivity has a marginal impact on heat transfer rates, the optimization of fin spacing emerges as paramount to maximizing heat transfer rate. The authors further elaborate that the heat transfer coefficient demonstrates an escalating trend up to a critical fin spacing value, beyond which it experiences a decline. The transformative impact of fin surface perforations is addressed, showcasing a surge in heat transfer rates in perforated rectangular fins. The inclusion of circular holes results in a 16.7% augmentation in heat transfer rate. A specific configuration—a perforated fin with a 12 mm hole and a 45° angle of orientation—notably propels heat transfer by 31% while concurrently reducing material weight by 30%. This shift translates into a substantial overall heat transfer rate increment of 38.9%, accompanied by a heat transfer coefficient surge of 31.8%.

Foued Chabane, Noureddine Moummi, and Said Benramache have authored a paper titled "Exploration of Heat Transfer and Thermal Performance Using Longitudinal Fins in Solar Air Heaters." Their objective is to delve into the impact of longitudinal fins on heat transfer and the overall thermal effectiveness of a solar air heater. The experiment centers on a flat plate collector featuring attached longitudinal fins on the absorber plate. This research evaluates the performance parameters across diverse operational conditions. The authors initiate their discussion by underscoring the significance of solar air heaters in tapping into solar energy for purposes like space heating and drying. They highlight the vital role of high-efficiency solar air heaters, which optimize heat transfer while curbing heat losses. To attain this balance, longitudinal fins are harnessed, thereby augmenting the surface area of the absorber plate and enhancing convective heat transfer. Findings reveal that the thermal efficiency of the collector, aided by fins, surpasses that of the finless collector, signifying improved utilization of solar energy. Likewise, the heat removal factor—indicative of collector heat loss—decreases in the presence of fins, indicating a reduction in heat losses. The temperature rise, an indicator of enhanced heat transfer caused by solar heating, is notably higher with fins, further confirming the boosted heat transfer. The authors further delve into the ramifications of air mass flow rate and solar radiation intensity on the collector's thermal efficacy. The research unearths that elevating the air mass flow rate yields a slight reduction in thermal efficiency, while exerting no influence on the heat removal factor or temperature rise. Conversely, heightened solar radiation intensity translates into across-the-board improvements in all performance parameters.

The study by Foued Chabane, Noureddine Moummi, and Said Benramache ultimately concludes that integrating longitudinal fins into solar air heaters engenders a positive impact on heat transfer and thermal performance. Future investigations could potentially concentrate on optimizing fin design for enhanced functionality and exploring alternate materials for absorber plates and fins to augment thermal conductivity. These enhancements, as outlined by the authors, would contribute to the advancement of proficient and sustainable heating systems across a multitude of applications. In closing, the authors stress that the efficiency of solar air collectors is markedly tied to solar radiation and collector surface geometry. As the mass flow rate escalates from 0.012 to 0.016 kg/s, there is a corresponding increase in efficiency. The solar air collector with a 45-degree angle attains the highest efficiency and air temperature rise, while the finless collector lags behind with lower values. The thermal efficiency spans from 40.02% to 51.50% with fins and from 34.92% to 43.94% without fins, at mass flow rates of 0.012 and 0.016 kg/s respectively.

3. METHODOLOGY

3.1 Thermal Analysis

The thermal analysis is conducted to get a constructive layout of the heat flux distribution across the laptop stand structure. It is used as a basis to compare two types of fin configurations:

1. Vertical
2. Horizontal

There is a need to have a basic 3D structure that represents essential features that will be present in the final model while at the same time being simple enough to give a close approximation of the results as the design is still in the development phase. The simplified model displays essential features like fin length, thickness, and number [1]. On these lines, a simplified CAD model is created on solid work for both configurations to be tested. In order to have a fair comparison, a few parameters need to be fixed between the two configurations: the size (length, width, and breadth) of the top and bottom plates, the distance between the top and bottom plates, and the number of fins between the two plates. The thickness and length of the fins in each configuration are set such that the volume occupied by the fins in each model is nearly the same [5]. The weight of the models is computed by adding the material in Solidworks; both configurations weigh almost the same (due to the approximately same volume), with an error of 0.055 percent.

3.2 Test on ANSYS

ANSYS is used to simulate the thermal heat flux distribution across the structure. It is preferred over Solidworks due to its high computational level solvers and variety of mesh options. The steady-state thermal work project is used to meet the requirements of the analysis.

1. Setup: Once the model is imported into ANSYS, the set-up process begins. First, a material is associated with the model geometry; this will determine how the geometry will behave during the course of the analysis. Aluminum 6061 T6 is used due to its light weight and high thermal conductivity; it is also easily procurable. Once material is set, a coordinate system is chosen that will be used as a frame of reference; in this case, it is kept outside the body to see the changes in the body relative to the surrounding area [1]. Then a mesh is generated, and the element size is set to 5mm for fairly approximate results.
2. Steady State Analysis: Now that the initial temperature is set to the environment and the geometrical structure, this is taken as a reference temperature or room temperature (about 25 degrees Celsius). The next input is a temperature spike or rise, which is added to the top plate in both configurations (about 60 degrees Celsius for high-capacity gaming laptops). This represents the laptop coming into contact with the surface of the structure. Due to the material properties, conduction through the structure takes place, followed by convection from the fins towards the surrounding area maintained at the reference temperature [4].
3. Results: Once the essential conditions are fixed, the results are computed for both configurations. The heat flux 3D map for both configurations of the structure has been solved and generated. It is noted that the maximum heat flux recorded in the horizontal and vertical configurations is nearly the same as represented in Fig -1 and Fig -2, respectively.

Along with having approximately the same maximum heat flux, both models display similar readings of heat flux at the fin surface available for convective heat transfer. As the convective heat dissipation is always perpendicular to the direction of the heat propagation, the available surface area per fin in the horizontal configuration is greater than that in the vertical configuration by about 84.375 percent. This results in the horizontal configuration having a larger surface area to dissipate the same quantity of heat flux. Therefore, the horizontal configuration displays an 84.375 percent increase in heat transfer rate at the fins as compared to the vertical configuration (the same percentage as that of area increase due to a similar quantity of heat flux). Another way to check which configuration would be most ideal is to take a close look at their geometry. The fins in the vertical configuration lead directly to the bottom plate, resulting in a higher temperature and transfer of heat directly to the bottom plate compared to the horizontal configuration. Thus, through software analysis and simple geometrical observations, the horizontal configuration proves to be the most efficient pattern.

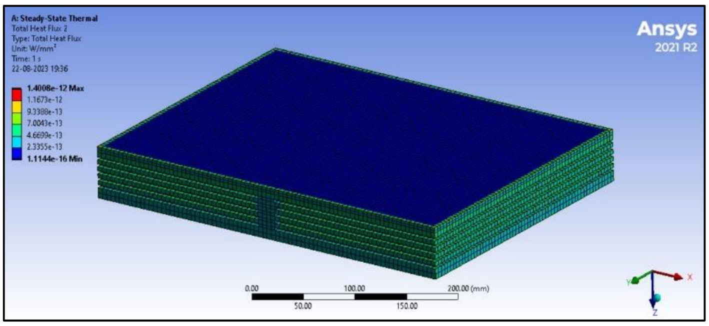


Fig – 1: Horizontal Configuration

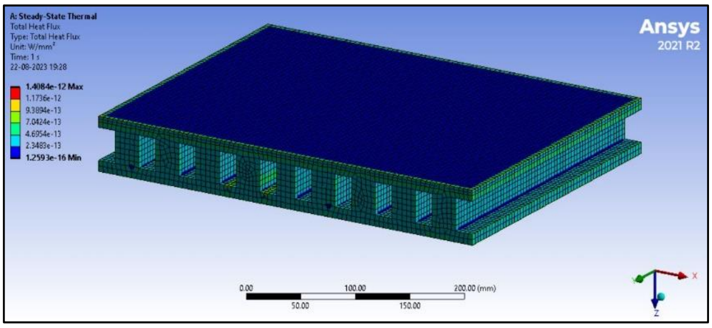


Fig -2: Vertical Configuration

4. FIN LENGTH CALCULATIONS

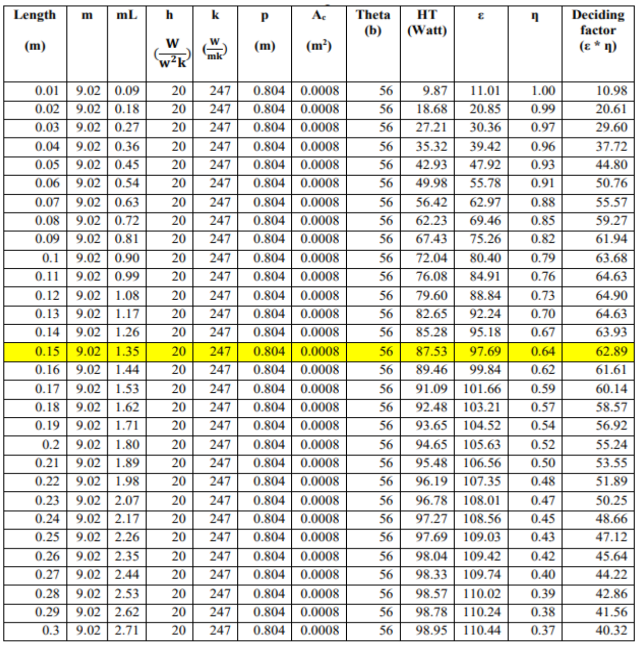
In order to maximize heat transfer, two heat fin parameters are contemplated: fin efficiency and fin effectiveness. Fin efficiency is the ratio of actual heat transfer to the maximum possible heat transfer, whereas fin effectiveness is the ratio of heat transfer through the fin surface area to the heat transfer through the surface area on which the fin is placed. Efficiency presents the exposure of closeness to the maximum heat transfer, and effectiveness protrudes the heat transfer relation during the appearance and absence of fins. The fin length selection is another important criterion that must be contemplated while designing. The length of the fin must be tabbed such that the heat transfer through it is reasonably high and the effectiveness of the fin is at least greater than 2. As the length of the fin increases, its mL value increases at the expense of a decrease in efficiency. At the same time, due to an increase in length, effectiveness increases due to a larger surface area available for heat transfer. Hence, the combination of effectiveness and efficiency must be tabbed in such a way that it proves maximum heat transfer at that particular length of the fin. A further increase in length must not visualize any considerable change in heat transfer. Various combinations of fin lengths are performed and their mL values are calculated, which determine the fin selection criterion on the basis of the deciding factor. Where, deciding factor is the product of effectiveness and efficiency for a particular fin length.

4.1 Ideal Fin Length Combinations

Efficiency and effectiveness are calculated for all the possibilities of fin lengths ranging from 10mm to 300mm. A deciding factor is tabulated in order to select a fin with maximum suitability [9].

The deciding factor is the product of efficiency and effectiveness [3]. A fin length of 150mm is selected as the most appropriate fin. The yellow shaded row in Table -1 represents the selected length of fin for the heat dissipation structure because it provides an optimum balance between the fin effectiveness and efficiency.

Table – 1: Fin Length Calculation



Length (m)	m	mL	h $(\frac{W}{w^2k})$	k $(\frac{w}{mk})$	p (m)	A_c (m^2)	Theta (b)	HT (Watt)	ε	η	Deciding factor (ε * η)
0.01	9.02	0.09	20	247	0.804	0.0008	56	9.87	11.01	1.00	10.98
0.02	9.02	0.18	20	247	0.804	0.0008	56	18.68	20.85	0.99	20.61
0.03	9.02	0.27	20	247	0.804	0.0008	56	27.21	30.36	0.97	29.60
0.04	9.02	0.36	20	247	0.804	0.0008	56	35.32	39.42	0.96	37.72
0.05	9.02	0.45	20	247	0.804	0.0008	56	42.93	47.92	0.93	44.80
0.06	9.02	0.54	20	247	0.804	0.0008	56	49.98	55.78	0.91	50.76
0.07	9.02	0.63	20	247	0.804	0.0008	56	56.42	62.97	0.88	55.57
0.08	9.02	0.72	20	247	0.804	0.0008	56	62.23	69.46	0.85	59.27
0.09	9.02	0.81	20	247	0.804	0.0008	56	67.43	75.26	0.82	61.94
0.1	9.02	0.90	20	247	0.804	0.0008	56	72.04	80.40	0.79	63.68
0.11	9.02	0.99	20	247	0.804	0.0008	56	76.08	84.91	0.76	64.63
0.12	9.02	1.08	20	247	0.804	0.0008	56	79.60	88.84	0.73	64.90
0.13	9.02	1.17	20	247	0.804	0.0008	56	82.65	92.24	0.70	64.63
0.14	9.02	1.26	20	247	0.804	0.0008	56	85.28	95.18	0.67	63.93
0.15	9.02	1.35	20	247	0.804	0.0008	56	87.53	97.69	0.64	62.89
0.16	9.02	1.44	20	247	0.804	0.0008	56	89.46	99.84	0.62	61.61
0.17	9.02	1.53	20	247	0.804	0.0008	56	91.09	101.66	0.59	60.14
0.18	9.02	1.62	20	247	0.804	0.0008	56	92.48	103.21	0.57	58.57
0.19	9.02	1.71	20	247	0.804	0.0008	56	93.65	104.52	0.54	56.92
0.2	9.02	1.80	20	247	0.804	0.0008	56	94.65	105.63	0.52	55.24
0.21	9.02	1.89	20	247	0.804	0.0008	56	95.48	106.56	0.50	53.55
0.22	9.02	1.98	20	247	0.804	0.0008	56	96.19	107.35	0.48	51.89
0.23	9.02	2.07	20	247	0.804	0.0008	56	96.78	108.01	0.47	50.25
0.24	9.02	2.17	20	247	0.804	0.0008	56	97.27	108.56	0.45	48.66
0.25	9.02	2.26	20	247	0.804	0.0008	56	97.69	109.03	0.43	47.12
0.26	9.02	2.35	20	247	0.804	0.0008	56	98.04	109.42	0.42	45.64
0.27	9.02	2.44	20	247	0.804	0.0008	56	98.33	109.74	0.40	44.22
0.28	9.02	2.53	20	247	0.804	0.0008	56	98.57	110.02	0.39	42.86
0.29	9.02	2.62	20	247	0.804	0.0008	56	98.78	110.24	0.38	41.56
0.3	9.02	2.71	20	247	0.804	0.0008	56	98.95	110.44	0.37	40.32

4.2 Reason for Ignoring the Intersection

The graph represented by Chart -1 shows the alteration of effectiveness and efficiency with respect to the deviation in length. The length must be selected at the intersection of efficiency and effectiveness in the graph. Here, at a length of 110 mm, both the curves interlace with each other, but as the length increases further, a considerable change in effectiveness is realized at the expense of an efficiency drop. The deciding factor shows no considerable drop till the length of 170 mm, which proves the effectiveness increases at a very high rate, compared to the efficiency and can compensate for efficiency for a certain length. Hence, a length of 15 mm is selected, ignoring the intersection of the curves, in order to extract the maximum out of it.

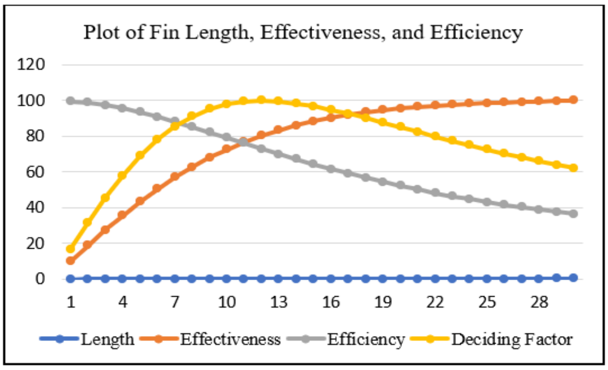


Chart -1: Plot of Fin Length, Effectiveness and Efficiency

5. DESIGN FOR MANUFACTURING (DFM) MODEL

5.1 Isometric Views

Fig -3: Isometric Top View

Fig -4: Isometric Bottom View

The DFM model is the final CAD model to be designed before manufacturing, containing every detail down to the nuts and bolts. The final design went through a variety of phases in which designs requiring complex manufacturing processes were explored, but in order to maintain simplicity and keep the cost down, a plated design was finalized. The plated design consisted of stacked plates with four holes for an M6 button-head bolt to fit into. The plates were cut from 3 mm thick Aluminum 6061-T6 plate using laser cutting technology [7]. The design consisted of a top plate with four circular cut-outs to accommodate the rubber spacers elevating each laptop from the ground. This ensures that the metal surface of the laptop comes into contact with the top plate for maximum heat transfer. The next plate in line consists of ribs and fins. The ribs separate the fins from each other and the fins from the top or bottom surface [2]. The fins have optimized dimensions generated through the numerical analysis to maintain a lower margin of error between the actual and theoretical performance [8]. A total of two ribs and fins are placed in the assembly. In order to reduce the weight of the final product and make it more user-friendly, huge hexagonal cutouts were made on the bottom plate with a wall thickness of 10mm between each cut to ensure that the structure will never collapse. These weight-saving methods helped save a considerable amount of weight in the Aluminum structure. More user-friendly features like rounded corners and de-burred edges were added to prevent injuries while using the product. The top and bottom of the DFM model can be seen in Fig-3 and Fig -4, respectively.

6. RESULTS

After using a laptop with an average processing power for two hours on the heat dissipation structure, the following results were obtained using an infrared thermometer, displayed in Table -2.

Table – 2: Actual Temperature Results

Time	Laptop Temperature (˚C)	Bottom Plate Surface Temperature (˚C)	Ambient Temperature (˚C)
30 min	38	31	31
60 min	42.1	31.6	31
90 min	45.1	31.3	31.2
120 min	45.3	31.5	31.2

Note: Initial laptop temperature is assumed to be equal to ambient temperature of 31 °C. Without the use of heat dissipation structure, the laptop temperature reaches 57 °C at 120 min after it is used for gaming for a continuous period of 120 min.

7. DISCUSSION

Heat fins, or thermal fins, play a crucial role in a number of industrial contexts where efficient heat dissipation is a necessity. As technology constantly progresses, an extensive arena emerges for further exploration within the realm of thermal fins. This pursuit aims to elevate their effectiveness to new heights. Not confined solely to industrial settings, heat fins also find applications within households, notably in air conditioning units, refrigeration systems, and heaters. Their integration serves to optimize these systems' performance while reducing energy consumption. The use of fins in domestic applications to enhance heat transfer rates can provide numerous benefits, ranging from cost savings to prolonged product life.

An important area of exploration lies in the domain of formulating novel materials tailored for fins. Such advancements possess the potential to amplify heat transfer rates while simultaneously reducing the weight and costs involved. This might have a profound impact on the geometric design of fins. This could be achieved by optimizing the geometric attributes of fins, encompassing variables like length, width, spacing, and contour. By varying these aspects, the pinnacle of heat transfer efficiency can be achieved. This could lead to a dual benefit of reduced costs and a greater functional lifespan of products, given the heightened heat transfer capabilities, which would make extravagant cooling mechanisms obsolete. The horizon of research also extends toward new domains, possibly with the development of highly effective heat exchangers for residential water heating or space heating systems. Beyond this, the synergy between fins and alternative heat transfer methodologies like phase change materials would require extensive research, considering the current state of such technologies.
The use of heat fins in electronic equipment has long been used to dissipate the heat generated by electronic components. Efficient cooling of electronic equipment is important to maintain the reliability and longevity of the device. The application of heat fins has been widely adopted not only in a variety of electronic devices, such as computer processors and graphics cards, but also in power supplies and LED lighting fixtures, among others. As discussed above, heat fins can be made from different materials, including aluminum, copper, stainless steel, or other alloys. The geometry and dimensions of the heat fins are designed to meet the specific cooling requirements of the electronic device. Hence, further research in the area of heat fins for electronic equipment cooling can focus on several areas. One of the primary areas would be the optimization of heat fin design for specific electronic devices to maximize the heat transfer rate and improve cooling efficiency.

The effect of different parameters, such as fin geometry, fin spacing, and material properties, on the heat transfer rate and cooling performance of the electronic device could be further investigated, especially for highperformance computing equipment that consumes a lot of power. Another area of research can focus on the development of advanced manufacturing techniques to fabricate heat fins with complex geometries and high precision. This can involve the use of advanced manufacturing processes, such as 3D printing, laser cutting, and microfabrication, to create heat fins with optimized designs for specific electronic devices. The future of heat fins in domestic and electronic equipment cooling is promising, and researchers can explore different avenues to optimize the design and manufacturing of heat fins for application-specific cooling requirements.

8. CONCLUSION

The use of laptop stands made of wooden or plastic materials can cause heat build-up inside the laptop, increasing the temperature of the motherboard surface after continuous usage for a certain number of hours. Although the laptop's cooling fan works continuously to remove this heat by forced convection, the fan(s) can become overloaded with continuous usage and draw more power from the laptop battery.

Heat buildup inside a laptop can also occur when it is placed on a mattress or used directly on the user's lap for extended periods of time. This happens because the movement of air entering the laptop is restricted by the mattress or the user's lap, which provides a sealing action for the air inlet vents. Using an overheated laptop directly on the user's lap can be dangerous due to the heat dissipated from the laptop, which can seriously affect the health of male reproductive organs. Prolonged daily exposure can even lead to serious health issues. The use of a heat dissipation structure for laptops reduces heat buildup by using fins that aid faster heat dissipation, and with aluminum as the material of choice, the overall light weight helps provide an ergonomic experience to the user. The heat dissipation structure provides a safe user experience even when the laptop is used directly on the user's lap. It also enhances the battery life of the laptop, as the cooling fan(s) are not overloaded and therefore draw less power from the battery.

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AUTHOR'S PICTURE


Jasmin Jamariya


Nishit Parmar


Reuben Manjaly


Krish Desai