IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND ANALYSIS OF HEAT DISSIPATING PHONE CASE

[1]Likith v

[1]Project Engineer

[1]Department of mechanical Engineer,

[1]Molex, Bengaluru, Karnataka, India

Abstract: The problem at hand revolves around the issue of traditional phone cases inadvertently trapping heat generated by smartphones during charging or intensive usage, such as gaming or video recording etc. This trapped heat not only hinders the smooth functionality of the devices, leading to performance issues like freezing or hanging, but it also has adverse effects on the long-term health of the battery. Additionally, the discomfort experienced when handling a heated device, whether stored in a pocket or held near the ear during communication, is a notable concern. In response to these challenges posed by conventional phone cases, incorporating the principles of a heat sink a new innovative heat dissipating phone case was devised. This design aims to address the heat-related drawbacks associated with regular cases. Extensive analysis conducted in Ansys Fluent software has validated the effectiveness of the design in dissipating excess heat, thereby regulating the temperature of the phone.

***Index Terms* – Heat transfer, Natural convection, Heatsink, Heat fin.**

I. INTRODUCTION

In this technologically driven society, people invest thousands of rupees in smartphones and it's very unlikely to see a person without a smartphone these days. The functionality and comfort of the device we use are given the utmost importance. We are bound to use multiple applications on our device to make our lives easier or even for entertainment purposes, but such rigorous usage leads to increasing the temperature of our phones, even charging our phones contribute to the built-up heat **[**1**]** (Kang, 2019). Basically, the phones are well designed to manage the heat they produce, but it's the phone cases that are used to protect them from outside, potentially harming the phones from inside. A recent study **[**2**]** (Eneh, 2021) has illuminated a noteworthy issue surrounding phone cases, revealing their potential hindrance to effective heat dissipation. This phenomenon can lead to the entrapment of heat within the case, ultimately impacting the long-term performance of smartphones. Notably, when smartphones, heated bodies in themselves, are held close to our ears during communication, they can induce a sharp and localized increase in skin temperature. Such abrupt fluctuations in skin temperature are a cause for concern, as they may have adverse implications for the well-being of users.

In response to the identified disadvantages associated with traditional phone cases, I have undertaken the design and development of a novel heat-dissipating phone case using Siemens NX Software and Ansys-Fluent. Through a rigorous design process, several models were generated, with the most promising design subsequently selected. To evaluate the efficacy of this innovative phone case, it underwent a comprehensive conjugate heat transfer analysis in Ansys Fluent software. The results of this analysis have yielded truly remarkable findings. The newly designed phone case has demonstrated significantly improved heat dissipation capabilities when compared to conventional cases. By leveraging this cutting-edge design, we are poised to address not only the safety and longevity of smartphones but also the well-being of their users.

2. Concept of heat sink:

A heat sink concept is that it increases the heat flow away from a hot device. It accomplishes this task by increasing the device's working surface area and the amount of low-temperature fluid that moves across its enlarged surface area. The working fluid passes across the surface of the warm heat sink and utilizes thermal diffusion and convection to remove heat away from the surface and into the ambient environment. Heat sinks are a kind of heat exchangers used for cooling the electronic devices due to the simplicity of fabrication, low cost, and reliability of heat dissipation. The extended surfaces from the heat sinks are either flat-plate fins or pins fins shapes. In the last decades, intensive attentions were spent on miniaturizing the electronic devices because of the high sophisticated micro- and nano-technology development. But the heat dissipation is still the major problem of enhancing the thermal performance the heat sink. **[**3**]** (Hamdi E. Ahmed, 2018)

3.Working of the model:

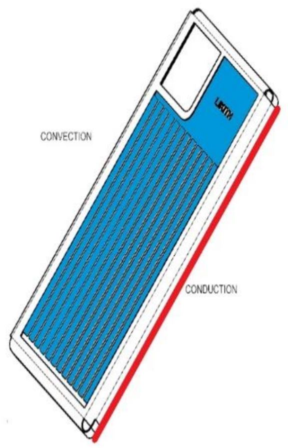


Fig.1

It is essential to grasp the functioning of the new design before diving into its specifics. There are three primary modes of heat transfer: conduction, convection, and radiation. For our analysis, we will disregard radiation as it exerts minimal influence compared to the other two modes.

Conduction involves the transfer of energy within solids, while Convection is the mode of energy transfer between a solid surface and the adjacent liquid or gas **[4]** (Thorat, n.d.). In this context, the energy transfer commences when the phone initiates heat dissipation. This heat is initially transferred to the phone case via conduction as highlighted in red in fig.1. However, as the case warms up, it transitions to dissipating heat through convection which is highlighted in blue color. The conventional phone case, typically made of plastic or silicone, hinders this dissipation by trapping the heat due to its low thermal conductivity.

In contrast, the new model, which boasts high thermal conductivity, effectively transfers the heat to its surroundings without retaining the produced heat.

4. Design process

By embracing the fundamental principles of a heat sink and meticulously considering the specific dimensions of a particular phone model, I undertook the design process within the NX software. This endeavor involved the creation of numerous prototypes, each meticulously crafted before ultimately identifying the most fitting design. In this intricate process, the selection of the material was a thoughtful and crucial decision, with a keen awareness of the significant role that weight plays in the realm of such products.

4.1 Dimension of the model.

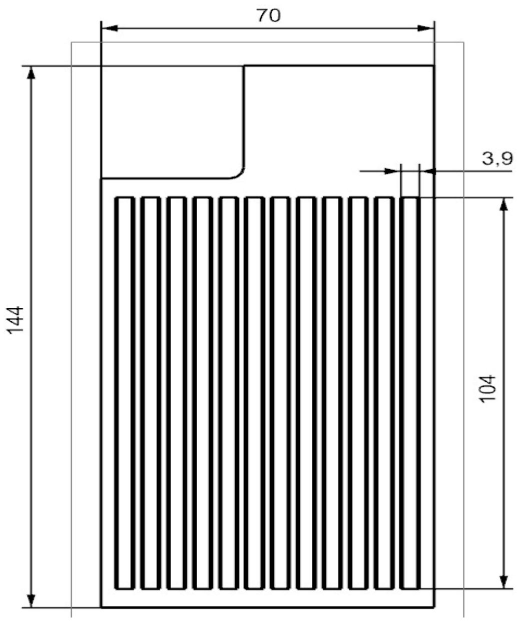


Fig.2 Dimensions of the new phone case**.**

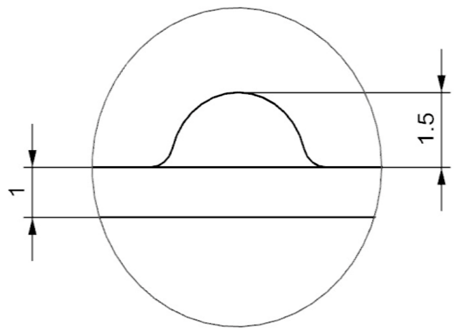


Fig.3 Thickness of aluminum plate and height of heat fin

Figure 2. shows the dimensions of the new model which is 144 mm x 70 mm (length x width) and the length of the heat fin, which is 104 mm, Figure 3 shows the thickness of the aluminum plate being 1mm and the heat fin having the radius or height of 1.5mm from the aluminum plate.

4.2 Percentage increase in surface area:

The surfaces area of the phone case was increased by making 12 elongated semicircular features with fillets on either side as shown in the fig.2.

Surface area of a regular phone case for the same dimension = 10,880 mm^2.
(Dimension of the regular phone case 144 mm x 70 mm (length x width), the thickness of the case being 1.5 mm)

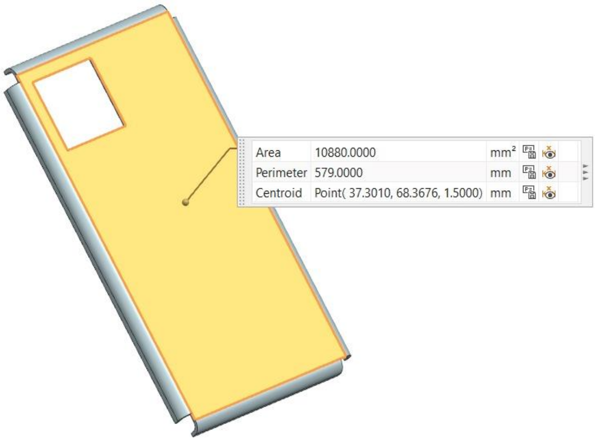


Fig 4. Surface area of regular phone case

Surface area of the newly designed phone cover: 9181 + 12(958) = 20677mm^2.
(12 because of the number of elongated heat fins)

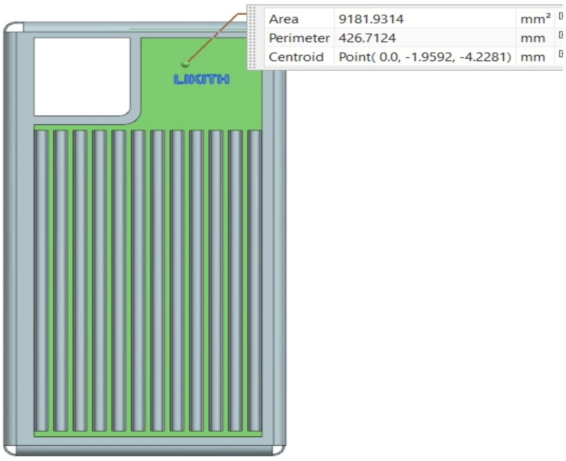


Fig 5. Surface area of new model

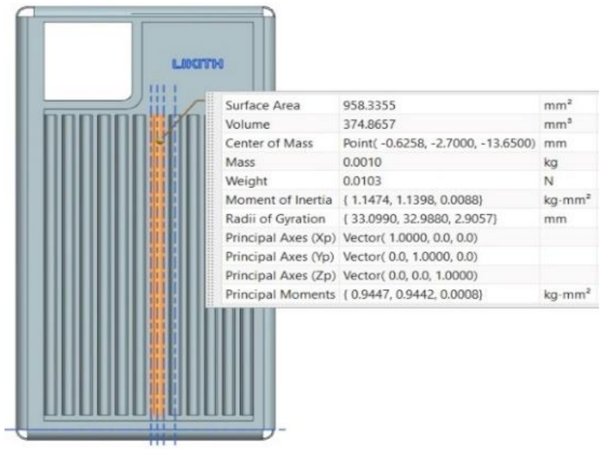


Fig 6. surface area of heat fin

In Fig.4 and Fig.5, the areas depicted represent only the surfaces where natural convection occurs. We do not need to account for the area of the side in contact with the phone, as it serves as a source of heat.

Percentage increase in surface area = (surface area of new case – surface area of regular case) / surface area of regular case * 100
= ((20677 – 10880) / 10880) * 100
= 90.0 % increase in surface area than the regular phone case.

4.3 Material selection

The weight of smartphones holds significant importance in the ever-evolving world of electronic devices, where numerous technological giants are diligently striving to reduce the weight of their products. In light of this overarching objective, my project required the careful selection of a material that not only aligned with the project's goals but also addressed the critical factor of weight reduction. In this selection process, due consideration was also given to the thermal conductivity of the chosen material, as it directly influences the phone's ability to dissipate heat effectively.

Hence copper and aluminum were shortlisted since they qualify for both the weight and thermal conductivity parameter, but owing to the high density of copper I had to go with aluminum which balanced both the above mentioned parameters.

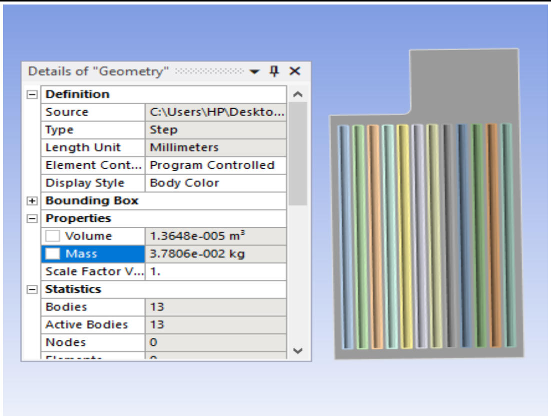


Fig.7 weight of aluminum model
Aluminum = 37g

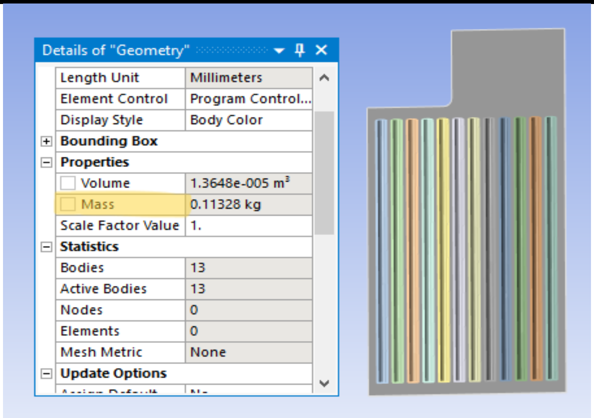


Fig.8 weight of copper model
Copper = 113g

(Density of aluminum = 2.7 g/cm^3
Thermal conductivity of aluminum= 237 W/Mk)
From fig.7 and fig.8, even though copper had higher thermal conductivity (398 W/Mk) aluminum was selected and considered for further process because of its low density.

5. Analysis

Following the design process, the model underwent conjugate heat transfer analysis in Ansys fluent workbench.
Ansys fluent workbench is widely used in industries such as aerospace, automotive, energy, and environmental engineering to address complex fluid flow and heat transfer problems. It provides a comprehensive suite of tools and features for accurate and efficient CFD simulations.

For the sake of our analysis, we are exclusively focusing on the natural convection method of heat transfer. Forced convection is not a pertinent consideration because, for instance, if a fan were to blow air towards the case, it is evident that it would facilitate heat transfer. In summary, the model is expected to perform effectively in a forced convection scenario, assuming the air is at room temperature.

To get the desired solution for a particular problem the model has to go through different stages in Ansys.
1.Geometry
2.meshing
3.Setup
4.Solution
5.Results

Accordingly let us go through the analysis process in Ansys,

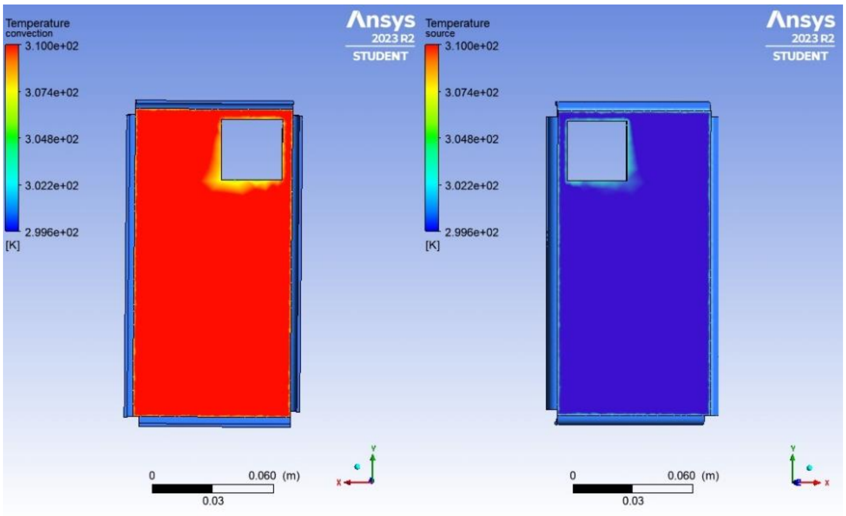
1. The model created in NX was exported as a STEP file.
2. The STEP file was subsequently imported into ANSYS Fluent Workbench.
3. Within the Geometry Workbench (SpaceClaim), topography of the model was shared to facilitate the efficient transfer of heat.
4. The imported geometry was then advanced to the meshing phase, where an element size of 0.05 meters was specified, resulting in the generation of 384,537 elements. It's important to note that increasing the number of elements enhances result accuracy, necessitating smaller element sizes (in the student version, its limited to 500,000 elements).
5. The model was named according to its role in the subsequent stages. In this case, the face in contact with the phone, where heat is generated, was labeled as "source." The sides opposite to this face, along with the heat fins, were designated as "convection" since they would experience convection at room temperature. The sides of the case that do not significantly participate in heat transfer due to their lack of contact with the phone's back were omitted.
6. Moving to the Setup phase, the energy equation was activated, and the laminar viscous model was selected, since the flow of fluid around the case would be having Reynolds number less than 2000, but K-Omega could also be considered to test the model in turbulent flow
7. The material for the model, aluminum in this case, was specified.
8. Setting up boundary conditions is a critical phase in the process. In this case, the boundary conditions were as follows:
- Source of heat = 310 K (considering the typical phone operating temperature limit of 35 to 40 degrees Celsius, equivalent to 36.85 Celsius or 310 Kelvin was taken)
- The heat fins and their adjacent faces were set to the convection mode for heat transfer, with a heat transfer coefficient of air at 25 W/m^2K and a free flow temperature of air at 293 K (representing standard room temperature ranging between 293 K to 298 K).
9. After configuring the boundary conditions, the process was initialized by selecting hybrid initialization.
10. The final step involved solving the problem by specifying the number of iterations. In this case, 100 iterations were set, with the understanding that increasing the number of iterations enhances result accuracy. Upon completion, temperature contours were obtained, facilitating result analysis.

The same process was used to simulate heat transfer for a regular phone case so that we can compare the results and see the efficiency of the newly developed heat dissipating phone case. (Thermoplastic material was used for the regular phone case model).

6. Results-Temperature contours.

After the calculations, the temperature contour for both regular and the innovative phone case was recorded individually.

6.1 Regular phone case being made of thermoplastic reduced the temperature from 310K (lower side) to 299.6K(upper side) (refer Fig.9.

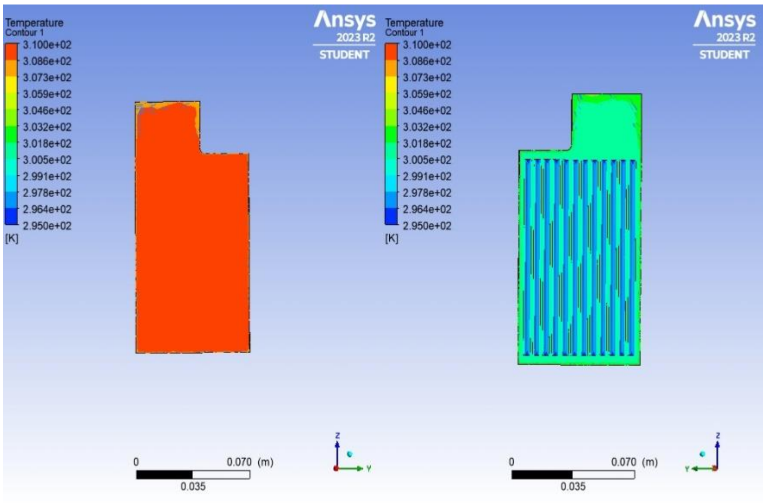


Back side **Front side**

Fig.9 Heat transfer analysis of regular phone case

Maximum temperature = 310 kelvin (since the source is directly attached to the lower face of the phone case)
Minimum temperature = 299.6 kelvin. (The front surface)

6.2 Whereas the new phone case model was able to decrease the temperature from 310K to 295K.



Back side **Front side**

Fig.10 Heat transfer analysis of new phone case

Maximum temperature = 310 kelvin (since the source is directly attached to the lower face of the phone case)
Minimum temperature = 295 kelvin. (the upper surface)
The new phone case model was able to decrease the temperature from 310K to 295k which is about 15k.
It clearly shows that the newly developed phone case addresses the issues that was mentioned in the introduction.

Summarizing the result,
Max temperature for both (source) =310 K
Minimum temperature of regular phone case = 299.6 K (26.45-degree Celsius)
Minimum temperature of newly designed phone case = 295 K (21.85-degree Celsius)
Hence, the newly designed phone case is more efficient in removing heat helping in the phone's functionality as well the comfort of the user. Since we have a clear winner, Let us now analyze how the new semicircular feature (heat fin) helped in decreasing the temperature.

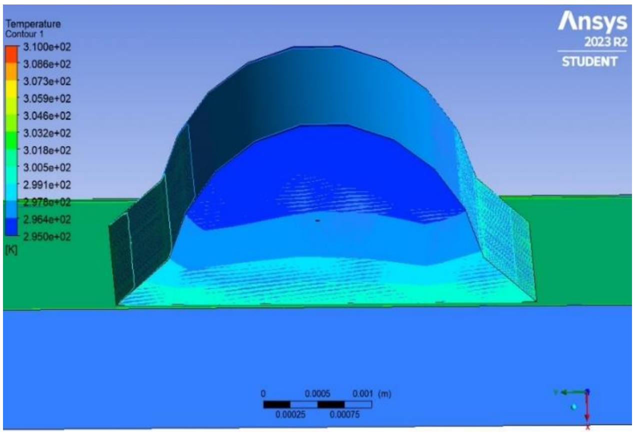


Fig.11 Heat transfer along the heat fin.

We can clearly see how the temperature has dropped from the bottom of the fin to the top, the surfaces adjacent to the fin which underwent convection shows similar temperature as the regular phone case i.e. 300 K but because of the high thermal conductivity of the material and increased surface area we can see the temperature gradually decreasing upwards.

7. Results - Total Heat transfer rate

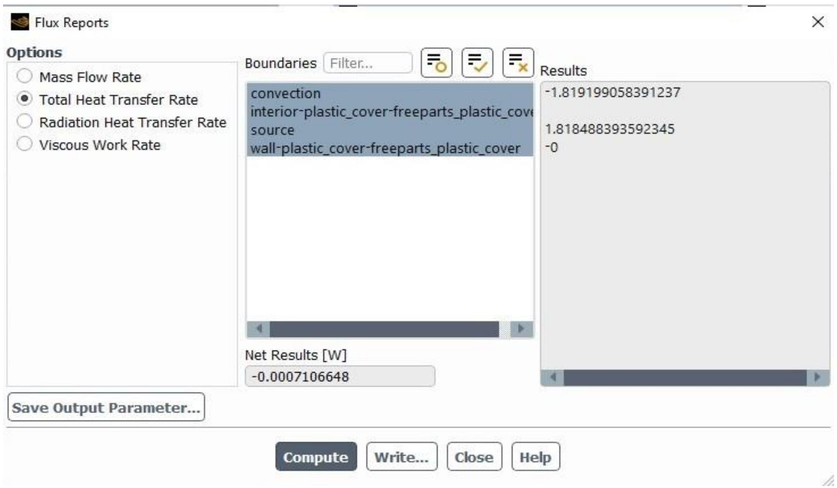


Fig.12 Total heat transfer rate for the regular plastic phone case.

Figure.12 shows that the net heat transfer from the plastic phone case being -0.00071 Watt.

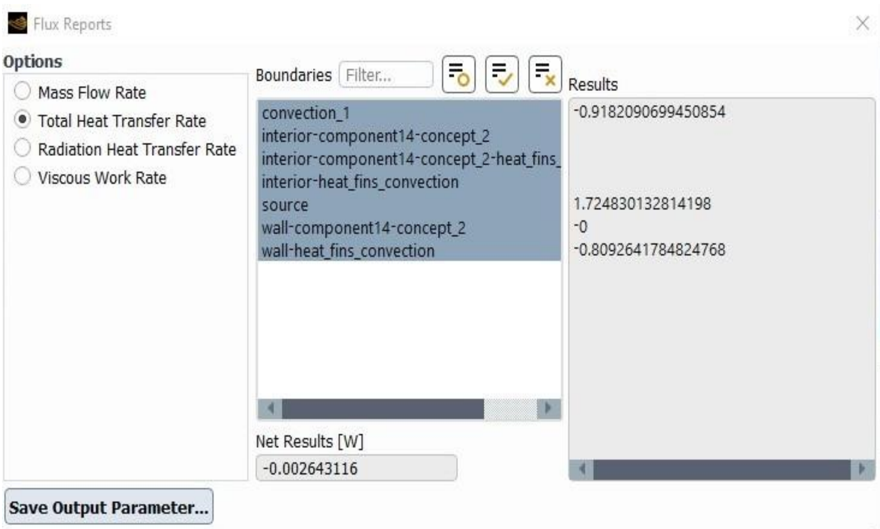


Fig.13 Total heat transfer rate for the new aluminum phone case.

Figure.13 shows that the source was providing around 1.725 Watts of heat (back side of the case) but due to convection -0.918 watts of heat was lost in adjacent aluminum plate and -0.809 watts of heat was lost through the 12 elongated heat fins.

Total heat transfer in the new phone case = 1.7248 – 0.9182 - 0.8092

= - 0.00264 Watt (Negative indicates heat lost from the body)

8. Conclusion

From the total heat transfer rate we can clearly make out that the new phone case is dissipating more heat (-0.00264 W) than the regular phone case (-0.00071 W),

Percentage increase in heat transfer rate,

= ((total heat transfer rate of new case – total heat transfer rate of regular case) / total heat transfer of regular case)* 100

= ((-0.00264 – (-0.00071)) / - 0.00071) *100

= 271% increase in total heat flow rate.

Hence, replacing plastic with aluminum which is having high thermal conductivity and by increasing the surface area by 90 % can lead to 271% increase in total heat flow rate compared to the regular plastic phone case.

9. Decorating the newly designed phone case

Aesthetic appearance of a phone case is as important as its functionality, keeping this in mind I have rendered the model using Keyshot software to fit into the market. The black casing outside holding the model together in Fig.14 can be rubber or silicone since it absorbs shocks and hold the mobile in place.

Fig.14 Final visual representation of the phone case

REFERENCES

[1] Kang, Soowon & Choi, Hyeonwoo & Park, Sooyoung & Park, Chunjong & Lee, Jemin & Lee, Uichin & Lee, Sung-Ju. (2019). Fire in Your Hands: Understanding Thermal Behavior of Smartphones. MobiCom '19: The 25th Annual International Conference on Mobile Computing and Networking.

[2] Eneh, Chibuoke & Njoku, Howard & Torbira, Mtamabari. (2021). Effects of Phone Covers on the Thermal Behaviour of a Smartphone when Performing Common Tasks.

[3] Hamdi E. Ahmed, B.H. Salman, A.Sh. Kherbeet, M.I. Ahmed,Optimization of thermal design of heat sinks: A review, International Journal of Heat and Mass Transfer,2018.(https://doi.org/10.1016/j.ijheatmasstransfer.2017.10.099)

[4] Sachin thorat (https://learnmech.com/introduction-to-heat-transfer/)