HEAT DISSIPATION IN SMARTPHONE CASE

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Abstract— Since power dissipation in miniature devices is inversely correlated with their functions, thermal management of mobile electronics has been implemented due to improved application processor performance. There have been a number of research on thermal evaluations of mobile electronics with the aim of enhancing analytical techniques and cooling plans to ensure device safety. Despite these efforts, the inability to regulate thermal energy, particularly in smartphones, has led to explosions because thermal behaviors in the device under diverse operating situations have not been thoroughly conducted. Therefore, a number of scenarios that led to the failure of the thermal management of the smartphone were examined in order to gain a better understanding of the thermal design and determine the factors that influence the device's thermal management. Recent thermal runaways and explosions are thought to have been caused by overcurrent in the battery as a result of the power management system malfunctioning or by the application processor receiving excessively more functionality than it needs. It was also determined through the investigations that the battery's heat generation, which was not given much consideration in earlier research, is real.

Keywords— *Smartphone, Heat transfer*

I. INTRODUCTION

Nowadays, using a smartphone is a way of life. The processing speed must be increased as more apps (Apps) are loaded into the phone. In addition, the fierce competition among producers to increase sales and boost profits results in cost reduction, which directly affects the materials used. Higher processing speeds and higher storage capacity in the constrained smartphone environment (maximum 5.5-inch display) place enormous strain on the phones' heat dissipation capabilities. From an electronics perspective, heat dissipation is crucial because, at high temperatures, material properties change and performance suffers as a result. Additionally, greater temperatures cause user pain and related health problems. Better heat management in smartphones is driven by these problems. Due to their size, weight, and ever-increasing processor speeds, smartphones are prone to heat transmission issues. This research looked at heat transport in a Redmi Note 10 smartphone model.

For the components of mobile electronic gadgets to function properly, operating temperatures must be kept within acceptable bounds. Because the functionality and needed levels of power dissipation are expanding while the sizes of the devices are being reduced, heat management is a frequent obstacle in smartphone development. Component performances will suffer if the device overheats as a result of poor thermal management. This poses a concern to user safety and has the potential to be lethal if thermal runaway and battery explosion occur along with it. The proliferation of smartphones is one of these recent examples. Analysis of the thermal behaviors of cellphones.

II. METHODOLOGY

The device's body measures (67mm x 150mm x 5mm), which is a standard size for a smartphone.

Mathematical Formulation:
Coefficient of thermal spreading (CTS)

CTS =
$$\frac{T_{avg} - T_{ambient}}{T_{max} - T_{ambient}}$$

Tavg - Average Temperature(K)
Tambient - Ambient Temperature(K)
Tmax - Maximum Temperature(K)

Convection equation
$$q = hA\,(T_1 - T_2)$$

h-heat transfer coefficient(W/(m2K))
q-heat transferred(W)
T1-Temperature of object before pores(K)
T2-Temperature of object after pores(K)

III. LITERATURE REVIEW

Thermal analysis for phones has been considered by previous researchers.
Lee et al. [1] examined the effect of the volume-to-size ratio on-chip temperature rise for mobile devices. It has been observed that when the size of the handheld system increases, the device's surface temperature (skin temperature) decreases. Thermal case upgrades were also taken into account.

Luo et al. [2] took measurements on a real phone and created a detailed numerical model and a model of the phone's resistance network. Higher thermal conductivity materials are suggested for thermal improvements, however, no outcomes are provided. The intricate numerical model is based on conduction and makes use of estimates for the surface-level heat transfer coefficients of the phone.

Grimes et al. [3] the incorporation of a moving fan into a tiny phone was looked into. Using the fan with realistic flow obstructions, up to 60% more power might be dissipated under the same constant surface temperature limitation.

Saroj et al. [4] found that a silicon chip's reliability would fall by around 10% for every 2°C increase in temperature. Temperature rise (55% of the time), as opposed to other factors like vibration, humidity, and dust, which account for 20%, 19%, and 6% of the time that an electronic chip fails. Therefore, it presents a significant challenge to packaging engineers to effectively remove heat from the electronics.

Victor Chiriac [5], et al of Qualcomm Technologies(2015) CTS (Coefficient of Thermal Spreading), a brand-new dimensionless thermal spreading effectiveness statistic for mobile devices, has been presented. The CTS value is a unique statistic to enhance the thermal design that quantifies the internal thermal spreading of mobile devices.

Yusuke Tomizawa [6] et al of Beijing (2015), examined how PCM sheets are used in mobile phones. They came to the conclusion that since PCM sheets had better thermal conductivity than PE sheets, the user will experience less discomfort as a result of the outside case's temperature rise.

Haoshan Ge [7] and Jing Liu of Beijing (2013)
It was noted that because gallium's melting point is 29.76°C, it cannot be utilized as a PCM in situations when the ambient temperature is above 30°C. Due to their extremely low melting points, conventional PCM materials including paraffin, n-icosane, and sodium sulfate decahydrate cannot be used as PCMs. As an alternative, liquid metal alloys with various melting points might be used. Siva

P. Gurrum [8] et al of Texas Instruments Dallas(2012), It has noted that gap filler pads and metallic spreaders can produce the thermal channels required for reduced connection temperatures. He came to the conclusion that large skin temperature reductions were attainable using middle plates and gap filler pads with higher thermal conductivity.

Maciej [9] of Poland (2011) concluded that PCM-based heat sinks with straightforward PCM containers performed substantially worse than PCM-based electronics cooling with the addition of PCM (phase change material). A modest amount of PCM may accomplish all of this. R. Grimes,

Ed Walsh[10] et al of Ireland (2009) Although the use of a fan increased the amount of heat that could be dissipated by around 75%, 20% more electricity was consumed as a result. This would necessitate frequent smartphone recharge.

Egan, Eric, Amon and Cristina. H[11]., (2000), Analysed finite element numerical simulations, practical testing, and analytical models were used to explore the thermal design space and comprehend the thermal phenomena of embedded electronics design. The findings demonstrate that the conductivity of the substrate and the exposed surface area of the heat spreader are the crucial factors influencing the thermal performance of the embedded electronic artefact.
Additionally, experiments were carried out using physical replicas and disassembled cell phones.

Simionescu, F., Meir, A. J., and Harris, D. K. [12] of France (2006), The top surface of a flat thermal spreader with an electronic chip on top was explored. The electronic chip is cooled by convection on the opposite surface. They discovered an ideal convective heat transfer coefficient that produced a maximum amount of heat removal from the chip and an ideal control method. They use the convective boundary condition to regulate the solution of the heat equation, using the heat transfer coefficient as the control. In order to resolve the optimal control problem, they employed a conjugate gradient method. The findings indicate that compared to those corresponding to the uncontrolled solution, the temperature distributions for the controlled solution are lower and have a flatter profile.

T.T Lee [13] of Beijing (1998found that putting a heat spreader within the cell phone lowered the temperature of the component. He also paid no attention to the phone's internal airflow, but using heat spreaders would make the phone heavier. He used an experimental setting in which he built a mock-up cell phone to validate the simulation results.

IV. RESULT AND DISSCUSION

CASE 1: With a normal phone case

Region	Temperature	Ambient Temperature
Before playing games	34.1^0C	32
After playing games	41.05^0C	35
Battery Drained	25-26%	

CASE 2: With pores on phone case

Region	Temperature	Ambient Temperature
Before playing games	32.4^0C	32
After playing games	39.45^0C	35
Battery Drained	20-21%	

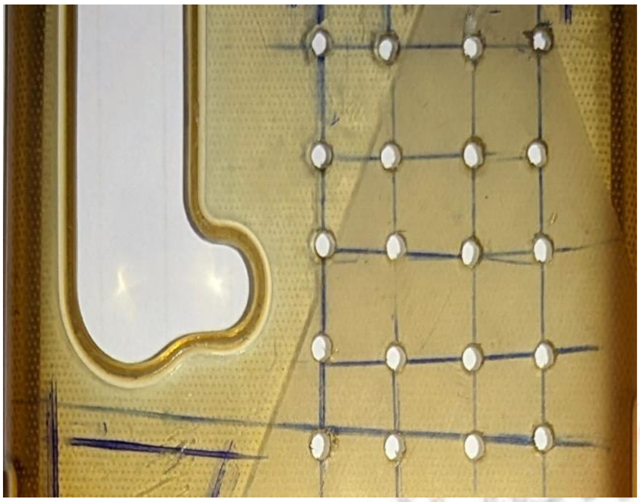

FIG 1

CASE 3: With a cut section on the phone case

Region	Temperature	Ambient Temperature
Before playing games	34^0C	32
After playing games	38.6^0C	35
Battery Drained	18-19%	

FIG 2

FIG 3

V. OUTCOMES

- After an hour of playing games on the phone, case 2 reaches a maximum temperature of 39.45^0C. Due to the pores in the phone case's body, there is a 1.6°C decrease from case 1 and a 5% reduction in battery usage.

- After an hour of gaming, the maximum temperature in case 3 is 38.60^0C. Due to the cut area on the phone cover's body, there is a drop of 80C compared to case 1 and battery usage is also decreased by up to 7%.

VI. FUTURE SCOPE

- When it comes to heat dispersion, the placement of the AP and battery is a crucial design factor because of the potential for heat focusing, which would raise the area temperature.

- Perforations on the outside improve airflow, which helps to remove heat.

- The thermosphere performance layer gathers heat and dissipates it away from the apparatus.

- Reduced costs and improved heat absorption are two benefits of using ABS and 3D printing.

- The internal heat generation of the LIB must be taken into account while performing a thermal analysis of the smartphone.

- The Printed Circuit Board (PCB) offers a lot of room for thermal management enhancement in cell phones.

CONCLUSION

The competitive addition of functionalities in mobile electronics required higher energy density in their compact arrangements. Recently, smartphone explosions were occurred, though various cooling strategies have been studied and equipped to maintain their safety and appropriate operation. Although there are many possible scenarios resulting in the smartphone explosion, the failure of thermal management in the device has not been sufficiently highlighted as a main issue. Therefore, the thermal management of the smartphone model was analyzed profoundly in this study to deduce the scenario, which could cause a smartphone explosion, with the observation of the limited capacity of existing cooling strategies and the effect of component arrangement on thermal management. As a result of it, the following remarks are obtained, and these findings must be considered in future analyses and design of electronic devices in terms of thermal management.

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