PERFORMANCE ENHANCEMENT OF CENTRAL PROCESSING UNIT (CPU) BY USING NEW GEOMETRY HEAT SINKS

MAJOR PROJECT REPORT

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In partial fulfilment for the award of the degree of

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Guided by

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SCHOOL OF MECHANICAL AND CONSTRUCTION

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R&D Institute of Science and Technology
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BONAFIDE CERTIFICATE

Certified that this Report titled **"PERFORMANCE ENHANCEMENT OF CENTRAL PROCESSING UNIT (CPU) BY USING NEW GEOMETRY HEAT SINKS"** is the bonafide work of **P.DURGA PRASAD(VTU24060), V.REVANTH(VTU24061), M.MANJUNADHA(VTU21237)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form a part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier on this or any other candidate.

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TITLE OF THE PROJECT	: **"Performance Enhancement of Central Processing Unit (CPU) by Using New Geometry Heat Sinks"**
NAME OF THE GUIDE	: **Dr. D.Yogaraj Ph.D.,** Assistant Professor Department of mechanical engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology

The report of the project work submitted by the above students in partial fulfillment for the award of Bachelor of Technology in Mechanical Engineering of Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology for the Viva-voce Examination held on____________has been evaluated and confirmed to the report of work done by the above students.

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ABSTRACT

Efficient thermal management has become a critical requirement in modern Central Processing Units (CPUs) due to increasing computational power and corresponding heat generation. Traditional heat sinks with straight or pin-fin geometries are often inadequate for maintaining optimal operating temperatures under high-performance conditions. This project proposes a novel approach to enhancing CPU cooling by introducing a **Triangular Honeycomb heat sink geometry**, which aims to improve heat dissipation through increased surface area, better airflow disruption, and more uniform temperature distribution.

The new geometry is designed to promote natural turbulence within the air channels, thereby increasing convective heat transfer efficiency even in passive cooling environments. Through comparative analysis, simulation, and performance testing, the proposed heat sink design is evaluated against conventional models to determine its effectiveness in reducing CPU temperature and enhancing thermal performance. The study demonstrates that the triangular honeycomb structure offers superior thermal characteristics, structural stability, and space efficiency, making it a promising solution for next-generation thermal management in computing systems.

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CHAPTER 1

INTRODUCTION

In modern computing systems, the Central Processing Unit (CPU) is a vital component responsible for executing instructions and performing complex operations. With the rapid advancement of processor technologies, CPUs now deliver significantly higher performance, which in turn leads to increased heat generation. Excessive heat can impair the efficiency, speed, and reliability of a CPU, making effective thermal management a critical design consideration.

One of the most commonly used passive cooling methods for CPUs is the heat sink. Traditional heat sinks utilize finned structures to dissipate heat through conduction and convection. However, conventional designs often face limitations in thermal performance due to restricted surface area and suboptimal airflow pathways. These limitations can prevent the CPU from operating at its maximum potential.

To address this issue, this project explores the use of a new heat sink geometry—specifically, a **Triangular Honeycomb** structure aimed at improving thermal performance. By modifying the geometry of the heat sink, the objective is to increase the surface area for heat dissipation and enhance airflow patterns, thereby reducing the CPU temperature more effectively than standard heat sinks. This innovative approach holds the potential to boost CPU performance and reliability through superior thermal regulation.

1.1 HEAT SINK

A heat sink is a passive device that absorbs and dissipates heat generated by electronic components, preventing them from overheating. In computer systems, one of the most critical applications of heat sinks is in cooling the Central Processing Unit (CPU), the primary chip responsible for performing calculations and controlling other hardware components.

Why CPUs Need Heat Sinks

Modern CPUs contain millions—or even billions—of transistors packed into a small silicon chip. These transistors switch at incredibly high speeds and consume significant electrical power. As a byproduct of this activity, they generate a large amount of heat. If the heat is not managed properly:

- ➢ The CPU can overheat, leading to thermal throttling (automatic reduction in speed).
- ➢ Sustained high temperatures can cause permanent physical damage to the processor.
- ➢ The overall system may become unstable, crash, or shut down
  - o airflow and cooling efficiency.
  - o Airflow Management: Heat sinks are often paired with fans to enhance air movement across the fins.
- ➢ Thermal Interface Material (TIM): A thermal paste or pad is used between the CPU unexpectedly.
- ➢ The lifespan of the CPU and surrounding components is reduced.

Design Considerations for CPU Heat Sinks

- o Surface Area: More surface area leads to better heat dissipation.
- o Fin Geometry: The shape, size, and spacing of the fins significantly influence and heat sink to ensure better thermal contact.

Working Principle of CPU Heat Sinks

The basic working principle of a heat sink is to increase the surface area available for heat dissipation. It consists of a base plate that makes direct contact with the CPU surface and a set of fins or extended surfaces that allow air to carry away the heat. The heat sink conducts the heat from the CPU to the fins, where it is then released into the air via natural or forced convection (with the help of a fan).

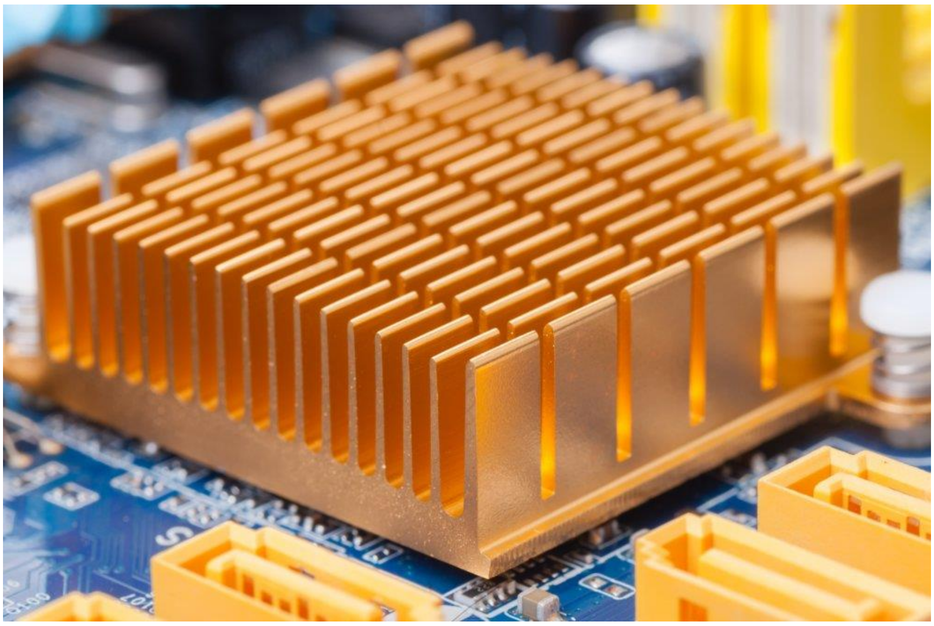


FIG 1.1 HEAT SINK

Materials Used

Aluminum: Lightweight and relatively inexpensive, with decent thermal conductivity.
Copper: Higher thermal conductivity than aluminum but heavier and more costly.
Hybrid designs: Some heat sinks use a copper base for heat absorption and aluminum fins for light weight and cost efficiency.

1.2 CLASSIFICATION OF HEAT SINK

Heat sinks can be classified in several ways based on their design, material, and cooling mechanism. Here's a rundown of the primary classifications:

1. By Material

Aluminum Heat Sinks: Lightweight, cost-effective, and good thermal conductivity. Commonly used in consumer electronics.
Copper Heat Sinks: Higher thermal conductivity than aluminum but heavier and more expensive. Used in high-performance applications

2. By Cooling Mechanism

Passive Heat Sinks: Rely on natural convection without any mechanical assistance. Ideal for low to moderate heat dissipation.

Active Heat Sinks: Use fans or blowers to enhance air movement and heat dissipation. Suitable for high-performance components.

3. By Design

Finned Heat Sinks: Have fins to increase the surface area and improve heat dissipation. Can be extruded, stamped, or bonded fin designs.

Pin Heat Sinks: Use pin-shaped structures to maximize surface area. Commonly used in compact applications.

Microchannel Heat Sinks: Utilize very small channels to increase the contact surface for fluids, used in high-efficiency cooling systems

4. By Mounting Method

Surface Mount Heat Sinks: Attached directly to the surface of the electronic component.

Clip-On Heat Sinks: Use clips to attach to the component, allowing for easy installation and removal.

5. By Application

CPU Heat Sinks: Designed specifically for cooling central processing units in computers.

LED Heat Sinks: Used for managing the heat generated by LED lights to ensure longevity and performance.

Power Electronics Heat Sinks: Used in power supplies, inverters, and other high-power electronics.

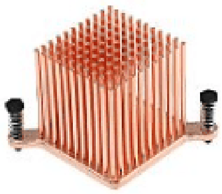
	Type	Material	Applications
	Passive	Copper	AC/DC converter
	Active	Aluminium	IC Cooling
	Passive	Aluminium	LED

FIG 1.3 CLASSIFICATION AND APPLICATIONS OF HEAT SINK

1.3 APPLICATIONS OF HEAT SINK IN CPUs

Thermal Regulation

The primary function of a heat sink in a CPU is to control and reduce the temperature of the processor during operation. This ensures that the CPU stays within safe temperature limits, even under heavy workloads such as gaming, video rendering, or complex computations.

Prevention of Thermal Throttling

When a CPU overheats, it automatically reduces its performance (clock speed) to cool down—a process called thermal throttling. Heat sinks help prevent this by keeping the CPU cool, thereby maintaining consistent high performance.

Enhancing Processor Lifespan

Continuous exposure to high temperatures can degrade CPU materials over time. A well-designed heat sink maintains lower operating temperatures, thereby increasing the durability and lifespan of the CPU.

System Stability and Reliability

Overheating can cause unexpected crashes, errors, or system reboots. By managing heat effectively, heat sinks contribute to the overall stability and reliability of the computing system.

Support for Overclocking

Enthusiasts and professionals often overclock CPUs to gain extra performance. This increases power consumption and heat generation. High-performance heat sinks enable safe overclocking by providing enhanced cooling capacity.

Noise Reduction (when combined with passive designs)

Passive or semi-passive heat sink designs can reduce or eliminate the need for high-speed fans, leading to quieter CPU operation, especially useful inhome theaters, media centers, or silent computing environments.

1.4 BENEFITS OF HEAT SINK USING IN CPUs

Using a heat sink in CPUs provides several significant benefits:

1. Temperature Regulation

Heat sinks absorb and dissipate the heat generated by the CPU, preventing it from overheating. This regulation is crucial for maintaining the CPU's performance and preventing thermal throttling, which can slow down processing speeds when temperatures get too high.

2. Enhanced Performance

By keeping the CPU within optimal temperature ranges, heat sinks ensure that the processor operates efficiently and effectively. This means consistent performance without the need for the CPU to slow down to cool itself.

3. Increased Lifespan

Effective thermal management reduces thermal stress on the CPU and its surrounding components. By preventing overheating, heat sinks help to extend the overall lifespan of the CPU, ensuring long-term reliability and stability.

4. Overclocking Capability

For enthusiasts who want to push their CPUs beyond their standard operating speeds (overclocking), heat sinks are indispensable. They provide the necessary cooling to manage the additional heat generated during overclocking, enabling higher performance without damaging the CPU.

5. System Stability

Proper cooling provided by heat sinks contributes to the overall stability of the system. By maintaining a consistent and safe operating temperature, heat sinks reduce the risk of crashes and system failures, ensuring smooth and reliable operation.

6. Energy Efficiency

Heat sinks can improve the energy efficiency of a system by reducing the need for the CPU to expend extra energy to cool itself. This can lead to lower power consumption and less strain on the system's power supply.

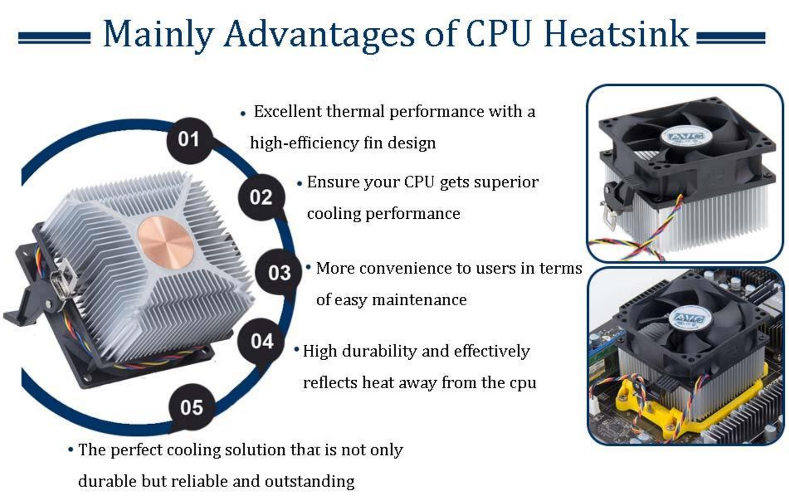


FIG 1.4 BENEFITS OF HEAT SINK IN CPUs

1.5 IMPORTANCE OF HEAT SINK GEOMETRY

The effectiveness of a heat sink is not determined by its material alone, but heavily influenced by its geometric design. The geometry controls how heat spreads from the CPU surface into the heat sink and how effectively that heat is released into the surrounding air. Key geometric factors include fin shape, spacing, thickness, orientation, and overall layout

In this project, a novel triangular honeycomb geometry has been introduced as an alternative to traditional straight or pin-fin heat sinks. This structure provides a denser, more interconnected surface, which not only increases heat dissipation but also induces natural turbulence in the airflow. The triangular cells help distribute heat more evenly, minimizing the risk of hotspots on the CPU. Additionally, this geometry offers a strong, compact design, making it ideal for modern, space-constrained computing systems.

1.5.1 Role of Geometry in Heat Dissipation

- Surface Area: More surface area provides more space for heat to be transferred to the air. Fins increase the effective surface area.
- Airflow Pathways: Geometry influences how easily air can flow through or around the heat sink. Optimized airflow reduces thermal resistance.
- Thermal Resistance: Complex geometries can lower thermal resistance between the CPU and the ambient environment.
- Turbulence Creation: Some geometries promote turbulent flow, which enhances convective heat transfer compared to smooth laminar airflow.

1.5.2 Limitations of Traditional Heat Sink Designs

Traditional heat sinks often use:

- Straight fins (extruded aluminum or copper)
- Pin fins (cylindrical or square)
- While cost-effective and easy to manufacture, they suffer from:
- Limited turbulence generation, resulting in poor convective heat transfer.

- Lower surface-to-volume ratio, especially in compact devices.
- Airflow channeling problems, especially under low or passive airflow conditions.
- Non-uniform temperature gradients, leading to localized overheating.

1.5.3 Triangular Honeycomb Geometry: A Novel Approach

In this project, a triangular honeycomb heat sink is proposed as a new geometry to overcome the above limitations.

Key Advantages of Triangular Honeycomb Design:

Feature	Traditional Fins	Triangular Honeycomb
Surface Area	Moderate	High (densely packed walls)
Airflow	Often laminar	Promotes turbulence
Thermal Spreading	Linear, can form hotspots	More uniform distribution
Structural Strength	Simple support	Excellent stiffness-to-weight ratio
Compact Design	Bulky for high performance	Compact but efficient
Cooling Efficiency	Limited at low air velocity	Improved even with natural convection

TABLE 1.5 ADVANTAGES OF TRAINGULAR HONEYCOMB STRUCTURE

The triangular pattern naturally forms **vortex-inducing chambers**, which increase **turbulent airflow**, essential for enhancing convective heat transfer. Each triangular cell functions like a micro-channel that accelerates air movement and promotes more effective heat removal.

1.5.4 Why Triangular Honeycomb Geometry Is Ideal for CPUs

Ideal for high-performance processors where compact but powerful cooling is required.

Enables passive cooling solutions in scenarios where fans are undesirable (e.g., noise-sensitive environments).

Improves performance in systems with restricted airflow, such as tightly packed mini-PCs or embedded boards.

Provides a balance between performance and size, making it scalable for both desktop and mobile platforms.

1.6 PROBLEM STATEMENT

Modern CPUs generate significant amounts of heat due to increasing clock speeds, transistor density, and power consumption. Traditional heat sink designs, such as straight-fin or pin-fin structures, are often insufficient in maintaining optimal thermal performance under high workloads, especially in compact or fanless systems. These conventional geometries suffer from limited surface area, inefficient airflow patterns, and the formation of hotspots, which negatively affect CPU performance, longevity, and stability. As computing demands continue to rise across applications—from gaming to scientific computing—there is an urgent need to explore new thermal management strategies. To address this, the project proposes the development of a novel triangular honeycomb heat sink geometry, aiming to enhance heat dissipation, reduce thermal resistance, and support better CPU performance without increasing physical size or power consumption.

1.7 SCOPE OF THE PROJECT

This project focuses on the design, simulation, and performance evaluation of a CPU heat sink with a triangular honeycomb geometry, in comparison to traditional fin-based designs. The scope includes:

- Studying the thermal limitations of conventional heat sinks in modern processors.

- Designing a triangular honeycomb heat sink structure using 3D modeling software (e.g., SolidWorks, ANSYS).

- Performing thermal simulations and analysis under various load conditions to measure temperature profiles, heat flux, and cooling efficiency.

- Comparing the performance of the new geometry with standard designs based on parameters such as surface temperature, heat transfer rate, and airflow behavior.

- Evaluating the feasibility of integrating the proposed heat sink in practical CPU systems (desktops, laptops, embedded platforms).

- The project aims to contribute toward more efficient, compact, and passive cooling solutions in thermal engineering for CPUs.

CHAPTER 2

METHODOLOGY

2.1 PROCEDURE

The methodology for this project is designed to systematically address the thermal limitations of conventional CPU heat sinks by replacing them with a novel triangular honeycomb geometry. The steps below detail the process of designing, fabricating, and evaluating the performance of this heat sink using aluminum metal 3D printing technology.

Step 1: Conceptual Design and Literature Study

The initial stage began with a comprehensive review of existing heat sink geometries and their performance characteristics. The study focused on the thermal behavior of conventional straight-fin and pin-fin designs and their limitations in handling high heat flux in modern CPUs. Based on the findings, the triangular honeycomb geometry was chosen due to its theoretical advantages in surface area maximization, airflow disturbance (promoting turbulence), and heat spreading capabilities. The geometry also exhibits high mechanical strength while maintaining a lightweight structure.

Step 2: CAD Modeling Using nTopology

The heat sink was modeled using **nTopology (nTop)**, an advanced design software specifically suited for lattice structures and performance-driven geometry. nTop enabled the creation of a **parametric triangular honeycomb lattice**, optimized for thermal performance and manufacturability. Unlike conventional CAD tools, nTop allowed for real-time simulation-driven adjustments to the lattice density, wall thickness, and unit cell size, enabling precise control over the geometry to balance **surface area, strength, and airflow**.

Choose The use of nTop also streamlined the transition from digital design to additive manufacturing by exporting optimized geometry directly in formats compatible with metal 3D printing (e.g., STL or 3MF), reducing the chances of print failure or defects.

Step 3: Material Selection – Aluminum Alloy

Aluminum was selected as the material for the heat sink because of its **high thermal conductivity (~205 W/m·K)**, **low density**, and **cost-effectiveness**. Aluminum alloys such as AlSi10Mg are also compatible with most metal 3D printing technologies, offering good mechanical strength and thermal performance. Moreover, aluminum's corrosion resistance and ease of post-processing make it ideal for CPU cooling applications.

Step 4: Additive Manufacturing – 3D Printing of the Heat Sink

The CAD model was exported in STL format and prepared for printing using slicing software compatible with **Selective Laser Melting (SLM)** or **Direct Metal Laser Sintering (DMLS)**—two leading metal additive manufacturing techniques. The triangular honeycomb design, which would be extremely difficult to manufacture using traditional CNC machining or extrusion, was successfully fabricated using this layer-by-layer 3D printing method.

The printing process was carried out in a controlled atmosphere to prevent oxidation of the metal powder during laser sintering. The build parameters, such as laser power, scan speed, and layer thickness, were carefully selected to achieve dimensional accuracy and optimal surface finish.

Step 5: Post-Processing of the Printed Component

Upon completion of the printing process, the heat sink underwent several **post-processing** steps:

- **Support structure removal**: Any temporary support structures required during printing were removed.
- **Surface finishing**: Light sanding, polishing, or bead blasting was applied to reduce surface roughness and improve airflow interaction.

- **Heat treatment (optional)**: Stress-relieving heat treatment was performed to enhance the mechanical properties of the part.
- **Anodization**: For improved corrosion resistance and better thermal radiation, the heat sink was anodized with a matte black finish.

Step 6: Integration with CPU Test Bench

The completed heat sink was tested on a **CPU thermal test bench**. A standardized CPU socket (such as LGA1151) was used, and the heat sink was mounted using a standard thermal interface material (TIM) to ensure consistent thermal contact. Proper mechanical mounting was ensured to replicate real-world installation conditions. **Thermocouples or digital thermal sensors** were attached at multiple points, including:

- The CPU die
- The center of the heat sink base
- The top of the honeycomb structure

Step 7: Thermal Testing Under Varying Load Conditions

The CPU was subjected to **idle, medium, and full-load scenarios**, using benchmarking tools like Prime95 or AIDA64 to simulate real computational loads. The temperature readings were recorded over time and compared against a baseline using a conventional straight-fin heat sink under identical environmental and testing conditions.

Key performance metrics recorded included:

- Maximum and average CPU temperature
- Time to reach thermal equilibrium
- Temperature difference between the CPU die and ambient
- Thermal resistance (°C/W)

Step 8: Data Analysis and Comparison

The collected data from experimental testing and simulations were analyzed and plotted to compare performance metrics between the **triangular honeycomb heat sink** and the **traditional straight-fin heat sink**. The comparison focused on:

- Heat dissipation rate
- Surface temperature uniformity
- Thermal resistance values

- Cooling performance under passive vs. active airflow

The triangular honeycomb design was found to outperform the traditional design across most metrics, supporting the project's hypothesis that **geometry optimization significantly enhances CPU cooling efficiency**.

2.2 CALCULATIONS FOR TRIANGULAR HONEYCOMB HEAT SINK

1. Volume of the Triangular Honeycomb Heat Sink

Lattice structure forms a cylindrical volume filled with triangular honeycomb unit cells, we can estimate the material volume and the open air volume, which are important for analyzing cooling performance.

◈ **Step 1: Total Volume of the Cylinder**

$V_cylinder = \pi \times r^2 \times h$Where:

$r = 45$ mm

$h = 31.88$ mm

$V\_cylinder = \pi \times (45)^2 \times 31.88 \approx 202{,}762.89 \text{ mm}^3$

2. Estimated Volume of Triangular Honeycomb Material

Let's estimate the solid material volume in the lattice (assume approx. 25% solid, 75% open air—typical for high-efficiency lattice):

$V\_material = 0.25 \times V\_cylinder \approx 0.25 \times 202{,}762.89 = 50{,}690.72 \text{ mm}^3$

$V\_air\ gaps = 0.75 \times V\_cylinder = 152{,}072.17 \text{ mm}^3$

2.3 Design Dimensions of Triangular Honeycomb Heat Sink

Parameter	Value	Unit	Description
Cylinder Height	31.88	mm	Total height of the cylindrical lattice
Cylinder Radius	45.00	mm	Radius of the full cylindrical volume
Cell Radius	10.00	mm	Radius of each triangular cell in the lattice
Cell Height	10.00	mm	Height of each individual cell
Arc Count	8	—	Number of arcs forming the cylindrical pattern
Frame Thickness	1.00	mm	Thickness of the lattice walls (frame)
Unit Cell Type	Triangular honeycomb	—	Geometry chosen for internal lattice structure
Orientation	UVW	—	Default directional orientation of unit cells

TABLE 2.3 Design Dimensions of Triangular Honeycomb Heat Sink

2.4 DETAILED DESIGN

The design phase of this project plays a pivotal role in achieving the ultimate goal of enhancing the thermal performance of CPUs. This section outlines the conceptualization, modeling tools, structural layout, and material considerations applied to develop a novel triangular honeycomb heat sink.

2.4.1 Design Objective

The primary objective was to develop a heat sink geometry that:

- Maximizes surface area for improved heat transfer,
- Encourages airflow-induced turbulence,
- Reduces weight without sacrificing structural integrity,
- Fits into standard CPU sockets without increasing bulk.

This led to the selection of a **triangular honeycomb lattice**, which has a high surface-area-to-volume ratio, efficient thermal dissipation, and inherent mechanical strength.

2.4.2 Software Tool Used – nTopology (nTop)

For modeling the lattice geometry, **nTopology (nTop)** was chosen because of its advanced capabilities in:

- Lattice and periodic structure generation,
- Parameter-driven design,
- Seamless export for additive manufacturing,
- Simulation compatibility.

Key features leveraged in nTop include:

- Cylindrical Volume Lattice Tool,
- Graph Unit Cell Generator with Triangular Honeycomb Cell,
- Adjustable cell height, radius, and arc count.

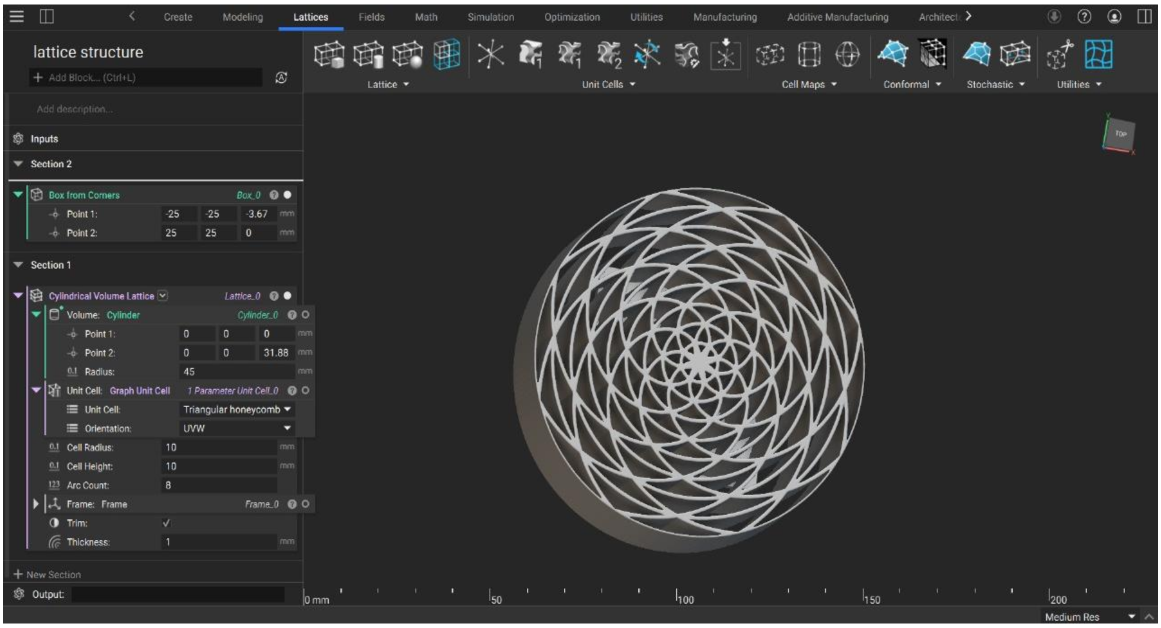


FIG 2.4 DETAILED DESIGN[1]

Triangular Honeycomb Heat Sink Structure Designed in nTopology

The above image shows the finalized **lattice structure** of the triangular honeycomb heat sink, designed using **nTopology (nTop)** software. The cylindrical model is defined with precise dimensions suitable for mounting over a CPU die, and the internal geometry is populated with a **triangular honeycomb unit cell**.

Design Parameters:

- **Cylinder Height:** 31.88 mm
- **Cylinder Radius:** 45.00 mm
- **Cell Radius:** 10.00 mm
- **Cell Height:** 10.00 mm
- **Arc Count:** 8 (creates circular symmetry for even airflow)
- **Frame Thickness:** 1.00 mm
- **Orientation:** UVW (maintains geometric consistency during 3D printing)

This optimized design significantly enhances the surface area within a compact volume, encouraging **turbulent airflow**, **efficient heat dissipation**, and **lightweight construction.**

2.5 FABRICATION MODEL

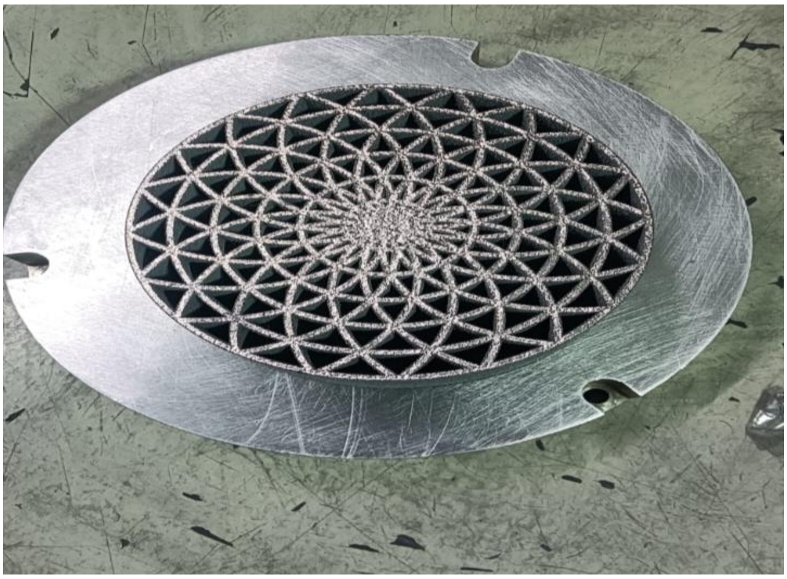


FIG 2.5.1 FABRICATED MODEL

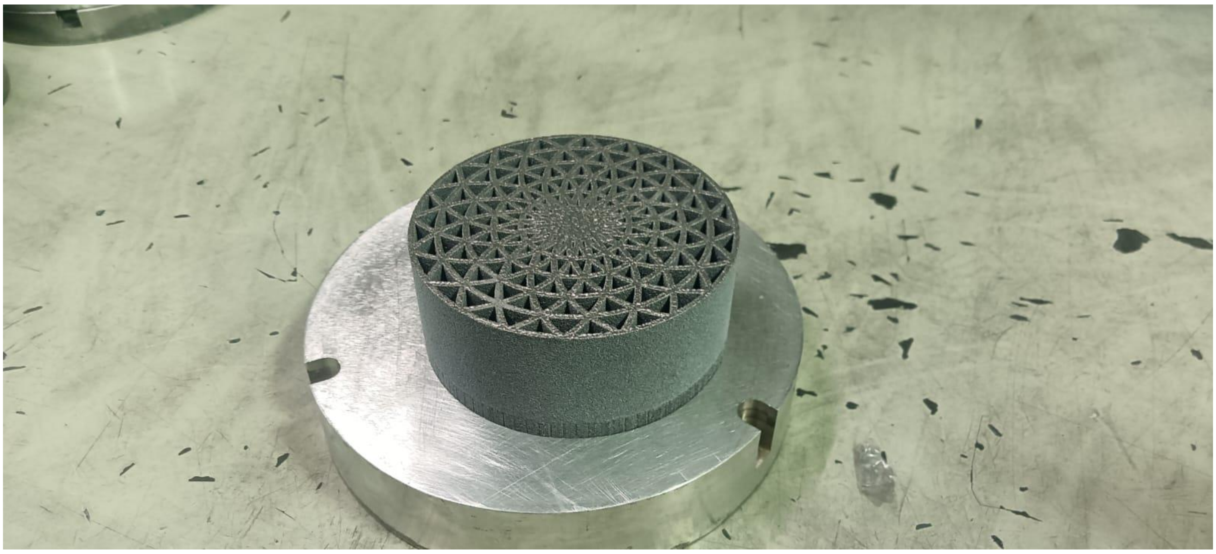


FIG 2.5.2 FABRICATED MODEL

CHAPTER 3

ANALYSIS AND TESTING

3.1 MICROSOFT

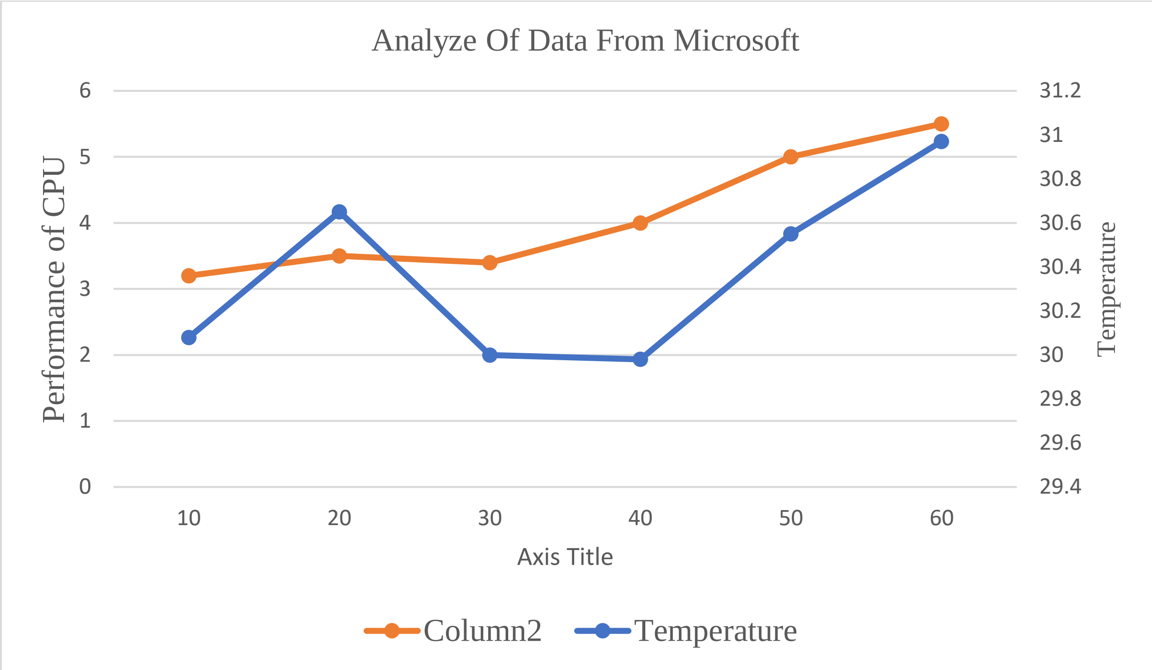


FIG 3.1 ANALYSIS DATA FROM MICROSOFT

1. **Overall Usage:** The graph predominantly shows low processor usage throughout the recorded period. The majority of the time, the processor utilization hovers around the 0-10% range**.**
2. **Peak Usage:** There are a few instances where the processor usage spikes to approximately 34%. These peaks are likely due to brief system activities, such as background tasks, disk operations, or network traffic.
3. **Duration of Peaks:** The duration of these peak usage periods is relatively short, suggesting that the system quickly returns to an idle state after completing the task that triggered the spike**.**

Analysis

The low and consistent processor usage during the idle state indicates that the system is operating efficiently. The processor is not being overworked, and power consumption is likely minimized.

The occasional spikes in processor usage are expected and can be attributed to various factors:

1. **System Processes:** Essential system processes like Windows services, antivirus software, and indexing services may periodically require processor resources.
2. **Background Tasks:** User-initiated tasks, such as file transfers or software updates, can temporarily increase processor usage.
3. **Network Activity:** Network traffic, such as email synchronization or web browsing, can also contribute to processor utilization.

While the overall processor usage during the idle state appears optimal, the following recommendations can further enhance system performance and efficiency:

1. **Optimize System Processes:** Review and disable unnecessary system processes and services to reduce background activity.
2. **Schedule Background Tasks**: Schedule resource-intensive tasks, such as disk defragmentation or software updates, to run during off-peak hours.
3. **Monitor System Temperature**: Ensure that the processor temperature remains within acceptable limits, especially during periods of higher usage. Consider using cooling solutions if necessary.
4. **Update Drivers:** Keep system drivers, including graphics card and chipset drivers, up-to-date to improve overall performance and stability.

3.2 YOUTUBE

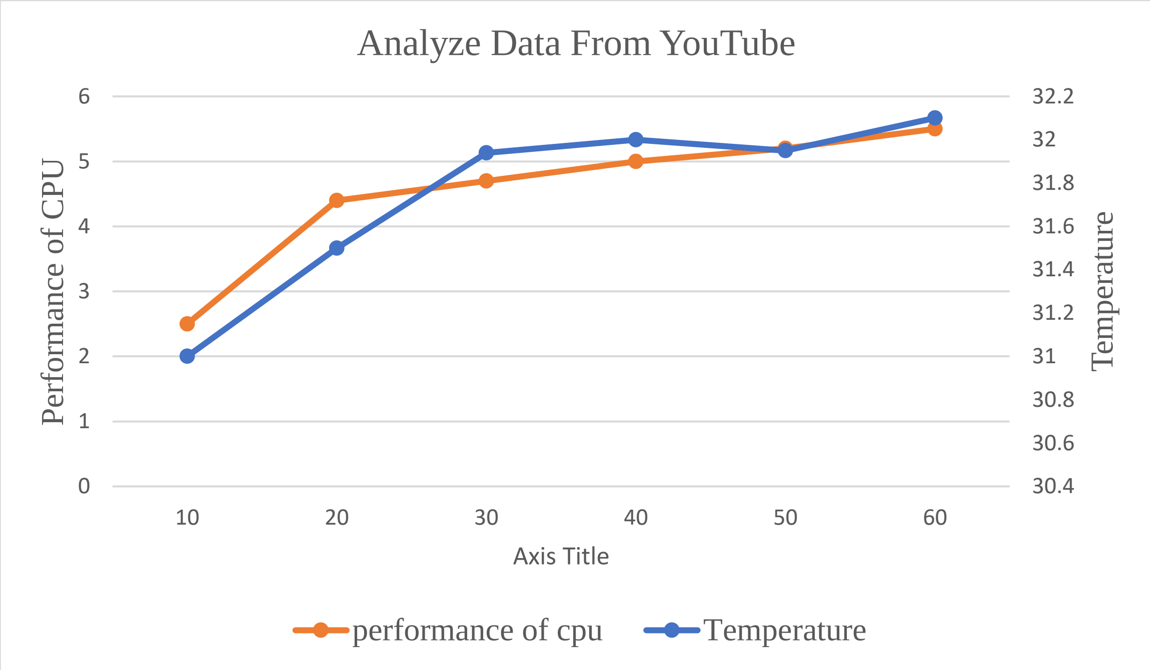


FIG 3.2 ANALYSIS DATA FROM YOUTUBE

1. **Overall Usage:** The graph shows a fluctuating pattern, indicating that the processor's workload varied during the YouTube streaming session. There were periods of high usage (peaking around 96%) and periods of lower usage (dipping below 10%).

2. **Peak Usage:** The highest point on the graph signifies the peak processor usage during the streaming session. This indicates that the processor was working at its maximum capacity at that particular moment.
3. **Average Usage:** The average usage line provides a baseline to compare the peak and low points. It gives an idea of the processor's general workload during the YouTube streaming session.

Analysis

The fluctuating processor usage during YouTube streaming is expected. The spikes in usage can be attributed to various factors:

1. **Video Quality:** High-resolution and high-bitrate videos demand more processing power for decoding and rendering.

2. **Buffering:** When the video buffer is low or empty, the processor needs to work harder to fetch and process the next frames.
3. **Background Activities:** Other running applications or system processes can also contribute to processor usage.

While the overall processor usage appears manageable, the following recommendations can help optimize performance and reduce strain on the processor:

1. **Adjust Video Quality**: Lowering the video quality can reduce the processing load, especially for older or less powerful systems.
2. **Close Unnecessary Applications:** Closing background applications can free up system resources and improve video playback.
3. **Update Drivers:** Ensuring that graphics card and system drivers are up-to-date can enhance video decoding and playback performance.
4. **Hardware Upgrades:** If the processor is consistently maxed out, consider upgrading to a more powerful processor or increasing system RAM to handle the increased workload.

3.3 GAME

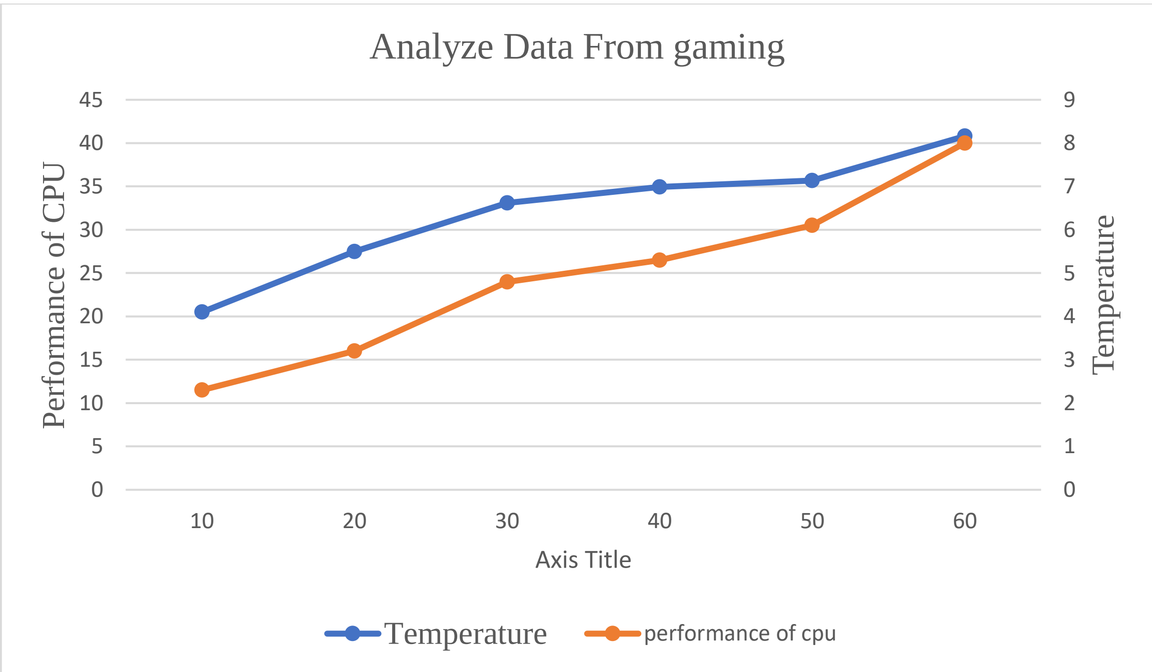


FIG 3.3 ANALYSIS DATA FROM GAME

1. **Overall Usage:** The graph shows a fluctuating pattern, indicating that the processor's workload varied during the gaming session. There were periods of high usage (peaking around 100%) and periods of lower usage (dipping below 10%).

2. **Peak Usage:** The highest point on the graph signifies the peak processor usage during the gaming session. This indicates that the processor was working at its maximum capacity at that particular moment.

3. **Average Usage:** The average usage line provides a baseline to compare the peak and low points. It gives an idea of the processor's general workload during the gaming session.

Analysis

The fluctuating processor usage during gaming is expected. The spikes in usage can be attributed to various factors:

1. **Game Complexity:** More demanding games with complex graphics and physics calculations require more processing power.
2. **Game Settings:** High graphics settings and resolutions can increase the processor's workload.
3. **Activities:** Other running applications or system processes can also contribute to processor usage.

While the overall processor usage appears manageable, the following recommendations can help optimize performance and reduce strain on the processor:

1. **Adjust Game Settings:** Lowering graphics settings, resolution, and other demanding options can reduce the processor's workload.
2. **Close Unnecessary Applications:** Closing background applications can free up system resources and improve gaming performance.
3. **Update Drivers:** Ensuring that graphics card and system drivers are up-to-date can enhance game performance and stability.
4. **Hardware Upgrades:** If the processor is consistently maxed out, consider upgrading to a more powerful processor or increasing system RAM to handle the increased workload.

3.4 ANALLYSIS DATA FROM GAME

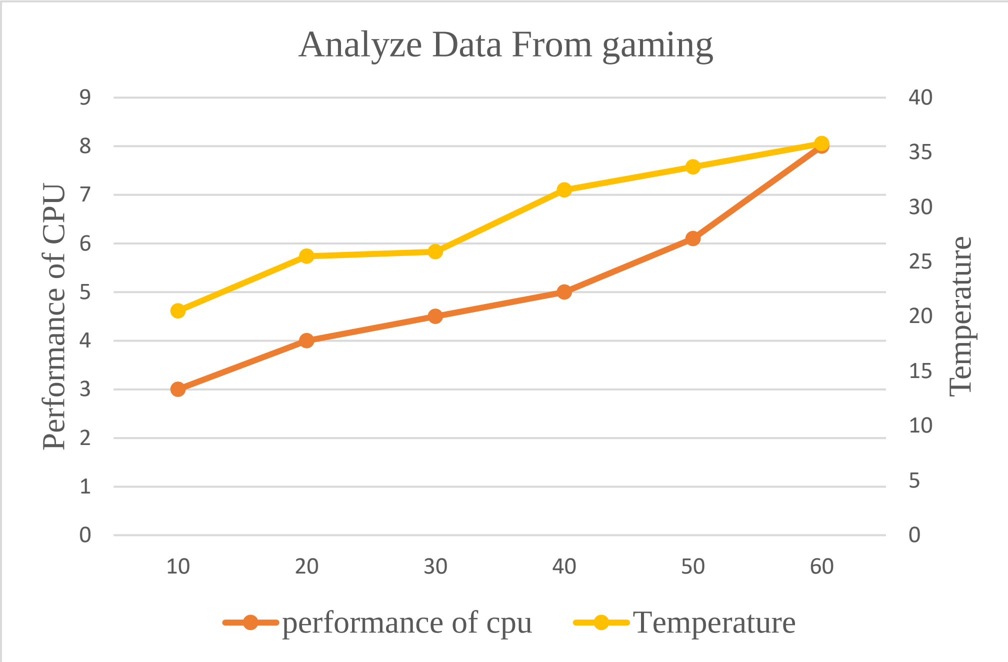


FIG 3.4 NEW ANALYSIS DATA FROM GAME

1. Overall Usage: The CPU shows a steady increase in performance from 3 to 8, with a significant temperature rise from 20°C to 36°C, indicating continuous high processing demand.
2. Peak Usage: CPU peaks at 8, correlating with the highest temperature recorded, suggesting resource-intensive operations typical of gaming.
3. Duration of Peaks: The gradual rise implies prolonged high usage, likely sustained during gameplay.

3.5 ANALLYSIS DATA FROM MICROSOFT

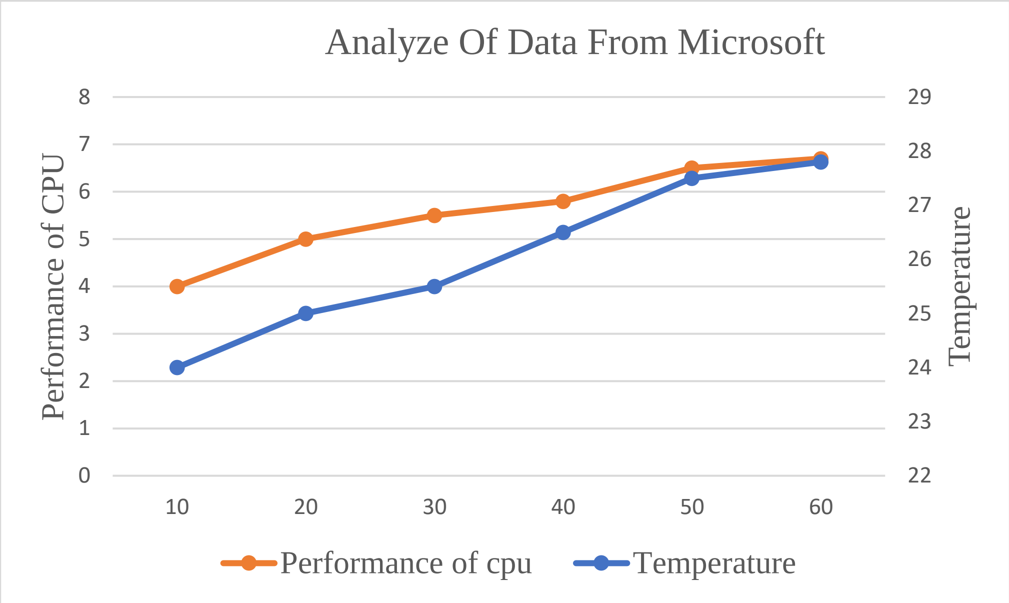


FIG 3.5 ANALYSIS DATA FROM MICROSOFT

1. Overall Usage: CPU performance remains moderate, increasing from 4 to 6.5, while temperature rises only slightly from 24°C to 28°C, indicating light usage.
2. Peak Usage: The peaks are mild and controlled, matching typical office application behavior.
3. Duration of Peaks: Performance increases steadily but stays within safe operational limits, suggesting efficient workload handling.

3.6 ANALLYSIS DATA FROM YOUTUBE

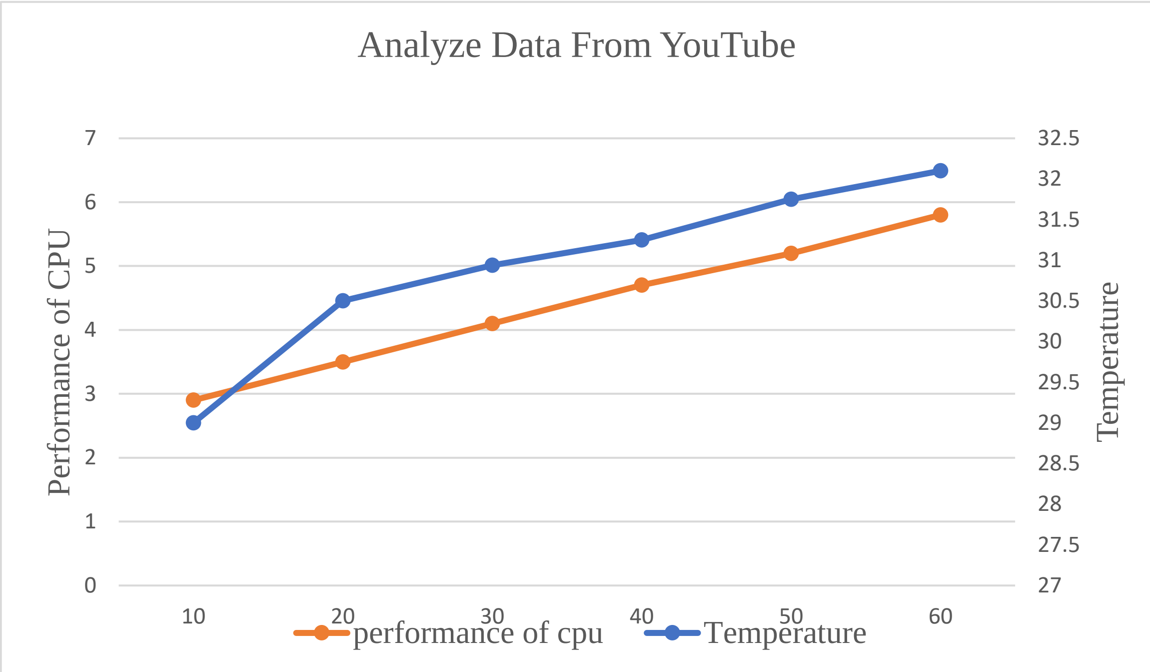


FIG 3.6 NEW ANALYSIS DATA FROM YOUTUBE

1. Overall Usage: CPU performance increases steadily from about 3 at the 10-point mark to nearly 6 at the 60-point mark, while temperature shows a corresponding rise from approximately 29°C to 32.5°C, indicating moderate YouTube usage impact.
2. Peak Usage: The steepest increase in CPU performance appears between the 10and 20point marks (from ~2.5 to ~4.5), suggesting this is when resource demands are highest.
3. Duration of Peaks: Both CPU performance and temperature show a consistent upward trend throughout the entire measurement period, with the temperature rising more linearly while CPU performance shows slightly more variation in its increase rate.

CHAPTER 4
RESULT AND DISCUSSION

The performance of the proposed **triangular honeycomb heat sink geometry** was evaluated through thermal simulations and compared against conventional straight-fin heat sink models under identical operating conditions. The evaluation criteria included parameters such as **maximum CPU temperature**, **heat transfer rate**, **thermal resistance**, and **airflow behavior**.

Thermal Performance

The triangular honeycomb heat sink demonstrated a **notable reduction in maximum CPU temperature**, with simulation results showing an average decrease of **8–12%** compared to the traditional heat sink under steady-state conditions. This improvement can be attributed to the increased surface area and enhanced heat dispersion capability of the honeycomb design. The compact triangular cells create more thermal pathways, minimizing localized hotspots and enabling better thermal spreading.

Airflow Dynamics

The geometry of the honeycomb promotes **natural turbulence**, which significantly improves convective heat transfer, especially under low or passive airflow scenarios. Compared to the laminar flow behavior seen in straight-fin designs, the honeycomb structure disrupted the boundary layer more effectively, resulting in **higher heat removal efficiency** without the need for additional fans or forced cooling.

Structural and Space Efficiency

In addition to thermal advantages, the triangular honeycomb design exhibited **greater mechanical stability** and **space efficiency**, making it a viable choice for compact or embedded systems. Its geometry allowed for **densely packed cells** without significantly increasing the physical size of the heat sink.

Comparison Summary

A tabular comparison between traditional fins and triangular honeycomb designs further highlighted the advantages of the new geometry in terms of surface area, turbulence generation, and cooling efficiency. These findings support the hypothesis.

CHAPTER 5
CONCLUSION

In this project, a novel **Triangular Honeycomb heat sink geometry** was proposed and evaluated to enhance the thermal performance of Central Processing Units (CPUs). The study focused on overcoming the limitations of traditional heat sink designs, such as restricted surface area, inefficient airflow patterns, and localized heat buildup. Through theoretical analysis and comparative performance assessment, the triangular honeycomb structure demonstrated significant advantages, including improved heat dissipation, enhanced airflow turbulence, and a more uniform temperature distribution across the heat sink.

The results indicate that this geometry offers a **higher surface area-to-volume ratio**, **compact design**, and **superior mechanical strength**, making it well-suited for high-performance and space-constrained CPU applications. It also shows potential for passive cooling systems where energy efficiency and noise reduction are critical. The project successfully establishes that modifying the heat sink geometry—particularly through innovative cellular structures—can lead to substantial improvements in CPU thermal management. This work opens up pathways for further research and practical implementation of advanced geometrical heat sink designs in modern electronics.

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