IDC School of Design
अभिकल्प विद्यालय

Non-evaporative Compact Cooler for Students

P2 Project Report

Guided by

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Submitted by

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Approval Form

This is to certify that the Industrial Design Project entitled "Non-evaporative Compact Cooler for Students" by Souvik Das (22M2222), is approved for the partial fulfillment of the Master of Design Degree in Industrial Design.

Prof. Avinash Shende
[Project guide]

Signature of the
Chair person

Signature of the
Internal examiner

Signature of the
External examiner

Declaration Form

I, declare that this written report represents my ideas in my own words, and where others' ideas or words have been included, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted, or fabricated any idea, data, facts, or source in my submission.

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Souvik Das

Signature:

Name: Souvik Das
Roll No.: 22M2222

Acknowledgement

I extend my sincere gratitude to my guide, Prof. Avinash Shende, whose indispensable assistance has been a guiding force throughout the entirety of this project. Special appreciation is owed to the professors of the Industrial Design Department for their insightful critiques and invaluable guidance. My heartfelt thanks extend to all the instructors, staff, and fellow students at the Industrial Design Centre (IDC) for their unwavering assistance, valuable advice, and constructive suggestions. Finally, I express deep gratitude to my family and friends for their constant and unwavering support, which has been a source of motivation and encouragement throughout this endeavor.

Abstract

This project introduces an innovative solution tailored to the cooling needs of students residing in hostels and paying guest(PG) accommodations, where the luxury of full-fledged air conditioning is often financially prohibitive.

Unlike conventional evaporative coolers, this innovative system operates effectively in high-humidity environments. it ensures optimal thermal comfort without relying on water evaporation, making it a suitable and reliable solution for regions with elevated humidity levels.

This project seeks to enhance the living conditions of students in hostel and PG environments by providing an effective, affordable, and humidity-resilient cooling solution. By making such innovations accessible, the goal is to improve the overall well-being and productivity of students while promoting energy efficiency and environmental responsibility in humid climates.

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Introduction

Why cooling is important?

In India, where the temperatures can soar to extreme levels, ensuring indoor spaces remain cool is not solely a matter of personal comfort; it is fundamentally linked to our well-being and overall happiness. This becomes particularly crucial during the intense summer months, characterized by scorching heat. The ability to cool our homes isn't a luxury; it is a necessity.

Cooling indoor environments goes beyond individual comfort; it is integral to establishing conducive living and working spaces, especially as urbanization continues to grow. Additionally, in the face of a changing climate and the subsequent rise in temperatures, it becomes imperative to adopt intelligent strategies to address these challenges.

So, why is cooling indoor spaces essential in India? This is the question we will delve into, exploring how it contributes to our health, enhances productivity, and helps us adapt to evolving weather conditions.

1.1 Climate Study of India

India experiences diverse tropical climates characterized by persistent warmth, with temperatures seldom dropping below 18 °C (64 °F). The nation encompasses two primary climatic subtypes falling under this category: the tropical monsoon climate and the tropical wet and dry climate.

The tropical wet climate, often referred to as the tropical monsoon climate, dominates a strip of southwestern lowlands along the Malabar Coast, the Western Ghats, and southern Assam. Featuring moderate to high temperatures year-round, even in foothill regions, this climate witnesses seasonal yet substantial rainfall, typically exceeding 2,000 mm (79 in) annually. The majority of rainfall occurs between May and November, sustaining lush forests and swampy areas throughout the predominantly dry year.

Conversely, the tropical wet and dry climate is more prevalent across inland peninsular India, excluding a semi-arid rain shadow region to the east of the Western Ghats. This climate is notably drier than the tropical monsoon type. Winter and early summer constitute prolonged and dry periods with temperatures averaging above 18 °C (64 °F). Summers are intensely hot, with temperatures in low-lying areas occasionally surpassing 50 °C (122 °F) in May, leading to deadly heatwaves. The rainy season spans from June to September, with annual rainfall averaging between 750 and 1,500 mm (30 and 59 in) across the region. Following the onset of the dry northeast monsoon in September, the most significant precipitation occurs in Tamil Nadu and Puducherry, rendering other states comparatively dry. This climatic diversity in India holds profound implications for agriculture, water resources, and the overall well-being of its inhabitants.

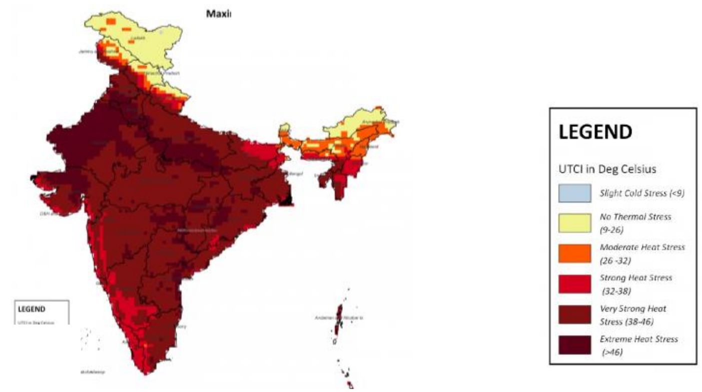


Fig 1.1: Summer Heat map of India

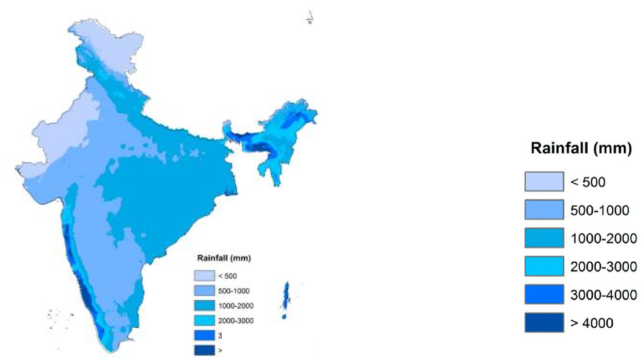


Fig 1.2: Annual Rainfall map of India

source: www.wikipedia.org

source: www.wri-india.org

1.2 Impacts of heat

Temperature extremes most directly affect health by compromising the body’s ability to regulate its internal temperature. Loss of internal temperature control can result in various illnesses, including heat cramps, heat exhaustion, heatstroke, and hyperthermia from extreme heat events. Temperature extremes related to heat can also worsen chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease, and diabetes-related conditions.

Understanding the Cognitive Impact of High Temperatures

High temperatures can significantly impact students, particularly in terms of their cognitive abilities. The discomfort associated with elevated temperatures often leads to reduced concentration and attention span, making it challenging for students to stay focused during classes. Additionally, heat stress has been linked to a decline in memory retention, hindering students' ability to absorb and recall information effectively. Problem-solving skills may also be impaired, as the heat can make it more challenging for students to analyze complex issues and formulate solutions. Furthermore, the cognitive processing speed may slow down, affecting how quickly students can comprehend and respond to information. The emotional toll of uncomfortable temperatures, including increased irritability and stress, can further compromise cognitive abilities and overall academic performance. Sleep quality may also be impacted, as high temperatures during the night can disrupt sleep patterns, influencing memory consolidation and cognitive function. Ultimately, addressing the impact of heat on students' cognitive abilities is crucial for creating learning environments that promote optimal engagement and academic success.

source: www.niehs.nih.gov

02

Cooling systems

Cooling systems are essential devices designed to lower temperatures in indoor spaces, providing comfort and maintaining a conducive environment. These systems function by removing excess heat from an area, preventing discomfort caused by high temperatures. Commonly used in homes, offices, and various commercial settings, cooling systems come in different types, such as air conditioners, evaporative coolers, and refrigeration systems. They play a crucial role in enhancing the quality of life, particularly in regions with warm climates, by creating comfortable living and working conditions. The effectiveness of cooling systems lies in their ability to regulate and manage temperatures, contributing to a more enjoyable and productive indoor experience for occupants.

2.1 Diachronic study

The history of cooling systems is a fascinating journey that spans centuries, reflecting humanity's ingenuity in seeking ways to mitigate the effects of heat.

Ancient Methods

Ancient civilizations, renowned for their architectural ingenuity, employed a range of innovative techniques to mitigate the effects of heat and cool indoor spaces. The Egyptians and Romans, in particular, demonstrated a remarkable understanding of passive cooling methods that utilized the natural environment and locally available materials. One notable method involved circulating water through the walls of buildings. In ancient Egypt, for instance, the construction of homes often incorporated a system of channels or pipes through which water flowed. As the water moved through these structures, it absorbed heat from the interior, subsequently evaporating on the outer surfaces. This process had a cooling effect, helping to moderate indoor temperatures, especially during the hot and arid Egyptian summers.

Additionally, ancient civilizations harnessed the cooling properties of natural materials, such as clay. The use of clay in construction materials, such as bricks, helped regulate indoor temperatures. Clay has inherent thermal mass properties, meaning it can absorb and store heat during the day and release it gradually during the cooler evening hours. This natural insulation effect played a crucial role in maintaining a more stable and comfortable climate within structures.

These ancient cooling methods, rooted in a profound understanding of local climates and environmental conditions, exemplify the resourcefulness of early societies. While the technologies may seem rudimentary by modern standards, the principles of passive cooling and the use of natural materials laid the groundwork for the development of more sophisticated cooling systems throughout history.

Fig 2.1 The Frigidarium (Roman bath house)

source: www. guaranteed.com

Evolution of Fans

The evolution of fans traces an intriguing journey from ancient hand-operated devices to modern, sophisticated cooling solutions. Millennia ago, cultures in China and the Middle East ingeniously crafted intricate hand fans, not just for cooling but also as symbols of status and fashion. The 17th century brought a pivotal shift with the invention of mechanical fans, manually operated to create airflow. The 19th century saw the advent of electric fans, a revolutionary development by inventors like Schuyler Wheeler and Philip Diehl. Ceiling fans and oscillating fans became household staples in the 20th century, enhancing indoor comfort. Recent decades witnessed the rise of bladeless fans, showcasing cutting-edge air multiplier technology. The continuous innovation in fan technology mirrors humanity's unwavering quest for convenient and effective cooling solutions, blending tradition with modernity. Today's diverse fan market caters to varied preferences, embodying a fascinating evolution in pursuit of optimal indoor comfort.

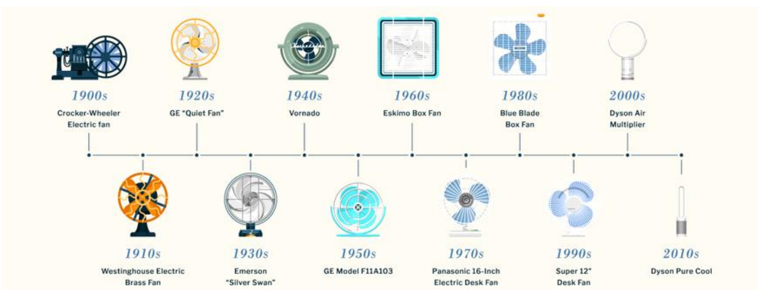


Fig 2.2 The evolution of electric fan

source: www.aireserv.com

Refrigeration Pioneers

The 19th century witnessed a remarkable evolution in refrigeration technology, propelled by the pioneering efforts of inventors Oliver Evans and Jacob Perkins. In this transformative era, Evans, renowned for his contributions to steam power, ventured into refrigeration, conceptualizing innovative refrigeration machines. Simultaneously, Jacob Perkins made groundbreaking strides by patenting early refrigeration systems based on vapor compression. These inventors played instrumental roles in shaping the trajectory of cooling methods. Their visionary work laid a solid foundation for the development of modern refrigeration technology, influencing how we preserve perishable goods, store vaccines, and maintain comfortable indoor environments today. The 19th-century advancements by Evans and Perkins remain pivotal in the ongoing quest for efficient and sustainable cooling solutions, shaping the way societies interact with and benefit from refrigeration in the contemporary world.

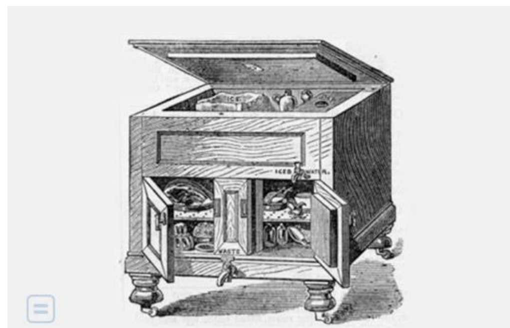


Fig 2.3 Jacob Perkins' Refrigeration Machine

source: www.isequalto.com

Willis Carrier's Invention

In 1902, Willis Carrier revolutionized the way we experience indoor comfort with his groundbreaking invention of the modern air conditioning system. Originally conceived to address humidity control issues in a printing plant, Carrier's ingenious solution had an unexpected but transformative side effect – it cooled the air. This serendipitous discovery marked the birth of air conditioning, fundamentally altering the dynamics of human living and working environments. Carrier's invention not only made workplaces more conducive but also reshaped the design of homes, theaters, and public spaces. The advent of air conditioning significantly enhanced our quality of life, particularly in regions with challenging climates. Willis Carrier's pioneering work remains a cornerstone in the history of technology, illustrating how an innovative solution to one problem can have far-reaching and unforeseen impacts, fundamentally changing the way we approach and inhabit our indoor spaces.

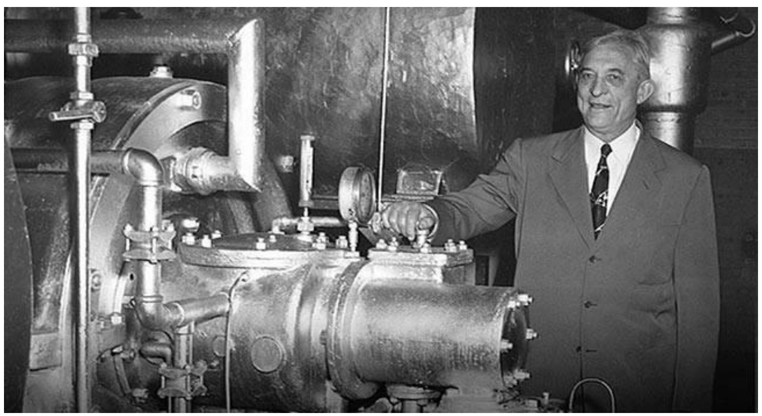


Fig 2.4 Carrier's first patented modern air conditioner

source: www.wired.com

Residential Air Conditioning

In the 1920s and 1930s, air conditioning systems emerged as a technological marvel, finding initial application in movie theaters and commercial spaces. The allure of cooled, comfortable environments quickly spread, and by the mid-20th century, residential air conditioning became a transformative force, reshaping living conditions across the globe, especially in warmer climates. This widespread adoption of residential air conditioning marked a pivotal shift in lifestyle, enhancing home comfort and fundamentally altering architectural design. The ability to control indoor temperatures not only provided relief from oppressive heat but also influenced societal patterns, fostering the development of warmer regions and influencing migration trends. Residential air conditioning stands as a testament to the profound impact of technology on our daily lives, making our homes havens of comfort irrespective of external weather conditions.

Fig 2.5 Window planted Air conditioner

source: www.wikipedia.org

Evaporative cooler

The evolution of swamp coolers, or evaporative coolers, represents a dynamic journey in the realm of climate control technology, particularly in regions characterized by arid conditions. Originating in the early 20th century, the initial designs were straightforward, employing basic components like water-soaked pads and fans. These rudimentary systems found applications in industrial and agricultural settings, offering a pragmatic solution to combat extreme heat.

As technological advancements unfolded, swamp coolers underwent significant improvements. Innovations in materials, including durable cooling media and corrosion-resistant components, contributed to enhanced efficiency. The integration of variable-speed motors and digital controls allowed for more precise temperature and humidity regulation, increasing the adaptability of these cooling systems.

In recent years, a renewed emphasis on sustainability and energy efficiency has steered the evolution of swamp coolers. Modern models feature programmable thermostats and water management systems to optimize performance while minimizing water consumption. Their eco-friendly attributes, utilizing water as a natural coolant and consuming notably less energy compared to traditional air conditioning, position swamp coolers as a sustainable alternative in contemporary climate control.
They continue to evolve as a cost-effective and environmentally conscious solution, demonstrating the adaptability of this technology to meet the changing needs of arid climates.

Fig 2.6 Frigidaire's 25th Anniversary

source: www.wikipedia.org

source: www.flickr.com

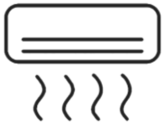
2.2 Synchronic study

Centralized Air Conditioner

Centralized air conditioners cool large spaces through a single unit outside, distributing cooled air via ducts. Efficient and customizable, they are common in commercial buildings, offering consistent temperature control and reduced indoor noise. Installation and maintenance usually require professional assistance.

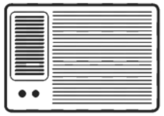
Split Air Conditioner

A split air conditioner comprises an indoor unit for cooling and an outdoor unit for heat dissipation. Efficient and space-saving, it's commonly used in residential and small commercial spaces. Installation requires minimal disruption, providing both cooling and heating options for individual rooms.



Window Mounted Air Conditioner

A window air conditioner is a compact cooling unit designed to fit in a window or a dedicated opening. It cools a room efficiently and is easy to install, ideal for small spaces.



source: www.energy.gov

Portable Air Conditioner

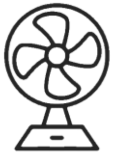
A portable air conditioner is a versatile cooling unit on wheels, offering flexibility in room placement. It requires minimal installation and cools small to medium spaces. Ideal for renters or those without built-in systems, it provides convenient and temporary climate control wherever needed.

Evaporative Cooler

An evaporative cooler, or swamp cooler, is an energy-efficient cooling system that employs water evaporation to cool indoor air. Ideal for arid climates, it provides cost-effective and eco-friendly cooling, making it a popular alternative to traditional air conditioners.

Split Air Conditioner

An electric fan is a simple, effective cooling device powered by electricity. Consisting of rotating blades, it circulates air to create a cooling effect. Portable and easy to use, electric fans are popular for providing immediate relief in various indoor environments.



2.3 Technologies of cooling systems

Cooling methods vary from traditional vapor compression to cutting-edge technologies like thermoacoustic and magnetic cooling. As we navigate through different technologies, we unveil the intricate dance of thermodynamics and engineering.

Evaporative Cooling

Water evaporation occurs without heat exchange with the surroundings, enhancing cooling efficiency. Commonly used in air conditioning systems and cooling towers, it's energy-efficient and environmentally friendly.

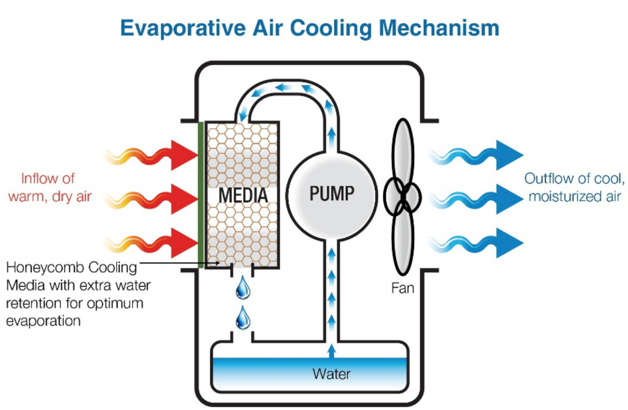


Fig 2.7 Diagram of an evaporative cooling process

source: www. wikipedia.org

Vacuum Cooling

Vacuum cooling is a rapid cooling method used in the food industry. By lowering the pressure, water boils at lower temperatures, extracting heat and cooling products quickly. This process preserves food quality, reduces spoilage, and extends shelf life, making it valuable for fresh produce.

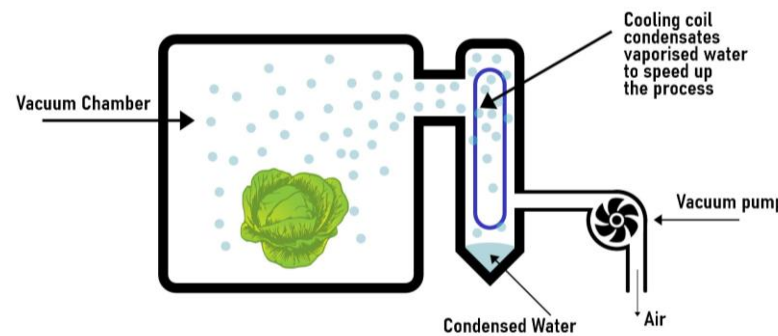


Fig 2.8 Diagram of a vacuum cooling process (food preserving)

source: www. heuch.com.au

Absorption Refrigeration

Absorption refrigeration uses a heat source to drive a refrigeration cycle, typically employing ammonia-water or lithium bromide-water solutions. This technology is often used in industrial and large-scale cooling applications, providing an alternative to compression-based systems with lower environmental impact.

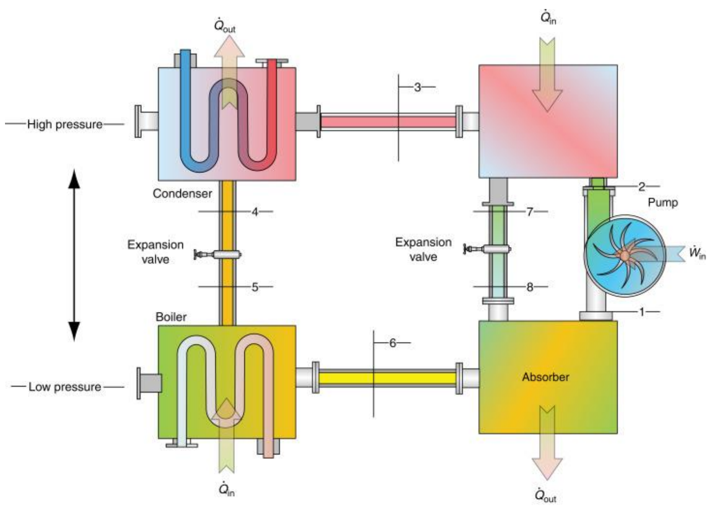


Fig 2.9 Diagram of absorption refrigeration system

source: www.sciencedirect.com

Vapor Compression Cooling

Vapor compression is the most common refrigeration technology, utilizing a compressor to circulate refrigerant through a cycle of compression, condensation, expansion, and evaporation. Widely used in household refrigerators, air conditioners, and commercial cooling systems, it efficiently extracts heat from the enclosed space.

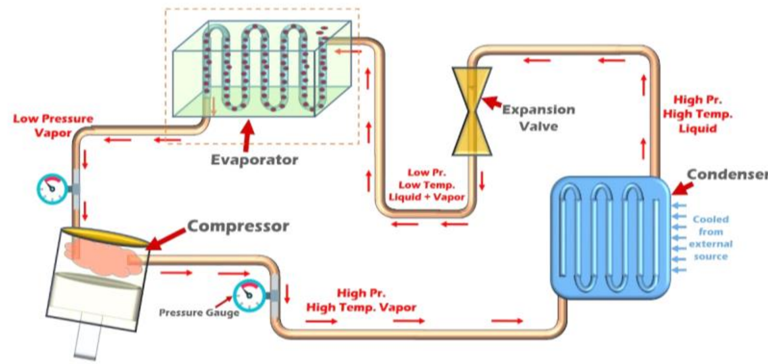


Fig 2.10 Diagram of vapor compression refrigeration process

source: www.science.org

Thermoelectric Module (Peltier effect)

Thermoelectric cooling relies on the Peltier effect, where a voltage applied to semiconductor materials creates a temperature difference. It's commonly used in small-scale cooling applications, such as portable coolers and electronic devices, offering compact and energy-efficient solutions.

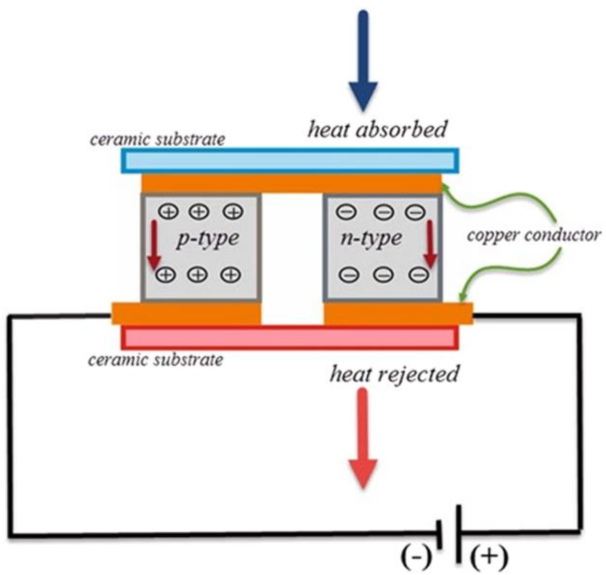


Fig 2.11 Diagram of thermoelectric module

source: www.nature.com

Cryogenic Refrigeration

Cryogenic refrigeration involves extremely low temperatures, typically below -150°C (-238°F), using gases like nitrogen or helium. Common in industrial processes, medical applications, and scientific research, it achieves ultra-low temperatures for freezing and preserving materials, including biological samples.

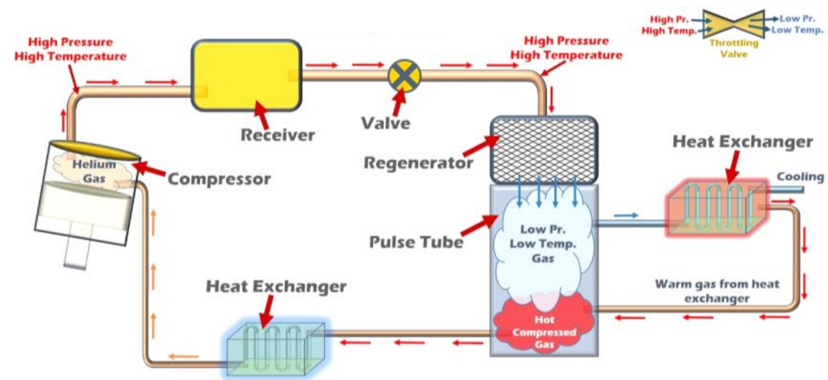


Fig 2.12 Diagram of cryogenic refrigeration process

source: www.science.org

Magnetic Refrigeration

Magnetic refrigeration utilizes the magnetocaloric effect, where a magnetic field induces changes in temperature. This emerging technology shows potential for energy efficiency, reduced environmental impact, and quiet operation. Magnetic refrigeration is being explored for various cooling applications, including household appliances.

Thermoacoustic Cooling

Thermoacoustic cooling utilizes sound waves to produce cooling effects. High-intensity sound waves induce compression and expansion cycles in a gas, facilitating heat absorption and release. This promising technology presents energy-efficient and eco-friendly alternatives for refrigeration and air conditioning, with potential applications in various cooling systems.

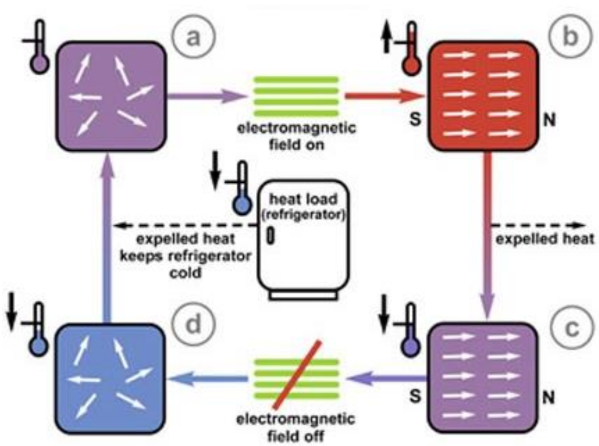


Fig 2.13 Diagram of magnetic refrigeration

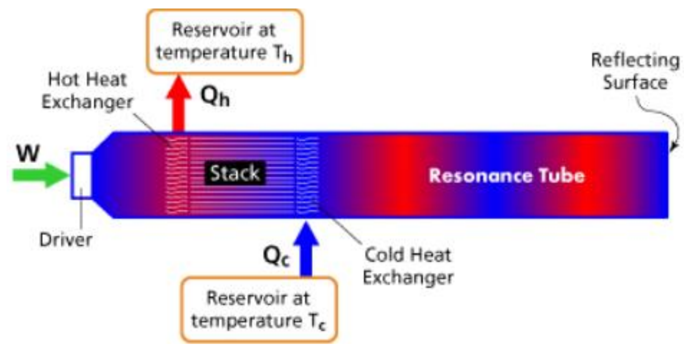


Fig 2.14 Diagram of Thermoacoustic cooling

source: www.led-professional.com

source: www.wikipedia.org

03

Technology exploration

Finding the best way to cool a small cooler in humid places is crucial. Regular cooling methods struggle in high humidity. Choosing the right method involves carefully looking at different options, considering things like saving energy, limited space, and making sure it removes humidity well. It's all about getting a good balance between a small design and strong humidity control. The goal isn't just to cool things down; it's about creating a solution that works well in humid areas, making sure it's comfortable and effective with every smart innovation.

3.1 Analysis of various methods

Evaporative Cooling

Cons

- Evaporative cooling is not effective in different climates
- Evaporative cooling may introduce additional humidity to the air
- Simple but requires regular maintenance

Pros

- Evaporative cooling systems are energy-efficient
- This relies on water eliminating any synthetic refrigerants
- Lower energy consumption results in cost savings on electricity bills

Vapor Compression

Cons

- The initial installation cost can be relatively high
- Use of refrigerants with high global warming potential
- The systems can be complex with multiple components

Pros

- Vapor compression systems are recognized for their efficiency
- Suitable for a wide range of applications and in various climates
- The technology is well established and mature

Adiabatic Cooling

Cons

- The initial installation cost can be relatively high
- Use of refrigerants with high global warming potential
- The systems can be complex with multiple components

Pros

- Vapor compression systems are recognized for their efficiency
- Suitable for a wide range of applications and in various climates
- The technology is well established and mature

Peltier Module

Cons

- Peltier modules may have limited cooling capacity compared to traditional methods
- Peltier modules generate heat on one side
- A low range of cooling capacity

Pros

- Peltier modules are solid-state devices with no moving parts
- Peltier modules have a compact and lightweight design
- Peltier cooling does not involve traditional refrigerants

Vacuum Cooling

Cons

- The initial setup cost for a vacuum cooling system can be relatively high
- Requires a complex system of components, including a vacuum pump

Pros

- Vacuum cooling enables rapid cooling of products due to lower pressure

3.2 Experiments

To determine the optimal cooling process for specific purposes and evaluate method efficiency, a series of experiments were conducted using tailored setups and simulated scenarios. Rigorous analysis of these experiments aimed to discern the most effective cooling method, ensuring precision and reliability in the selection process for practical applications.

Experiment 1: Adiabatic cooling

The objective was to guide air through a progressively narrowing path, promoting gradual compression before experiencing a sudden expansion upon exiting the outlets. This intentional compression and expansion sequence leads to a cooling effect on the air. A similar principle is applied in the expansion valve of an air conditioner, where controlled compression and subsequent expansion contribute to the overall cooling process.

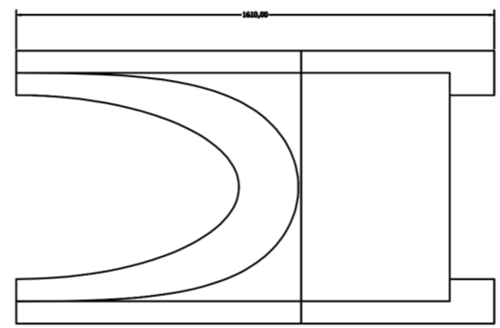
Initial room temperature.

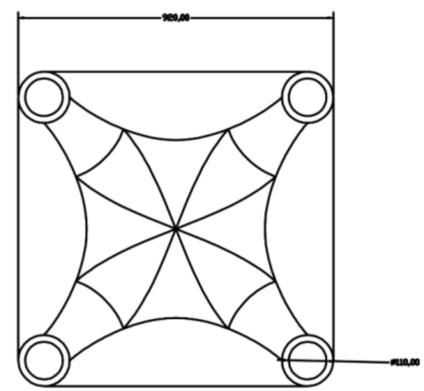
Temperature of outlet air.

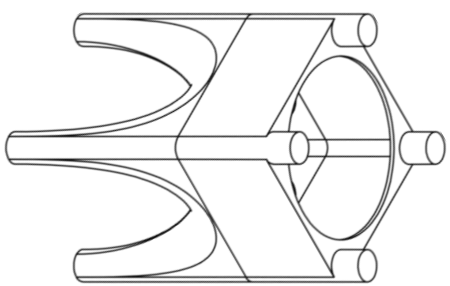
Leanings

1. Effective air compression demands a high-powered fan. In this experiment, the utilization of a less potent DC fan allowed for backflow, hindering the proper compression of the air. The insufficient force exerted by the fan compromised the compression process, preventing the air from being compressed adequately. This limitation underscores the importance of a sufficiently powerful fan in achieving the desired compression for optimal results in similar experiments or applications.

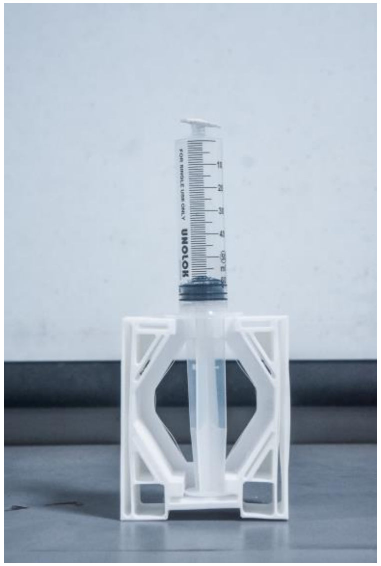
2. The necessity for a robust fan in the final product may introduce noise, an undesirable quality for an item intended to sit on a student's desk. Noise levels can significantly impact user comfort and concentration. Ideally, a favorable noise level for a desk product is around 40 to 50 decibels, ensuring a quiet environment conducive to studying. Thus, striking a balance between the fan's power and noise output becomes crucial to create a product that effectively cools while maintaining a peaceful workspace for students.



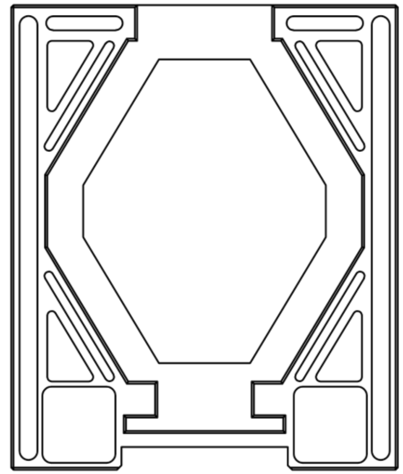


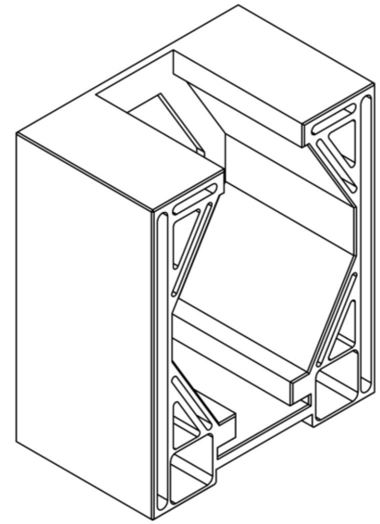


Experiment 2: Vacuum cooling



The objective was to draw 10ml of water into a syringe, seal it, and fully retract the plunger, creating a vacuum within. This induced a pressure drop, prompting the water to boil at a lower temperature, utilizing its stored energy and consequently reducing the overall water temperature. If the piston were made of a conductive material, it would facilitate further cooling of the water by efficiently dissipating heat through conduction, enhancing the vacuum cooling process. This approach harnesses the principles of thermodynamics to achieve effective and controlled cooling, demonstrating the intriguing interplay of pressure and temperature dynamics.

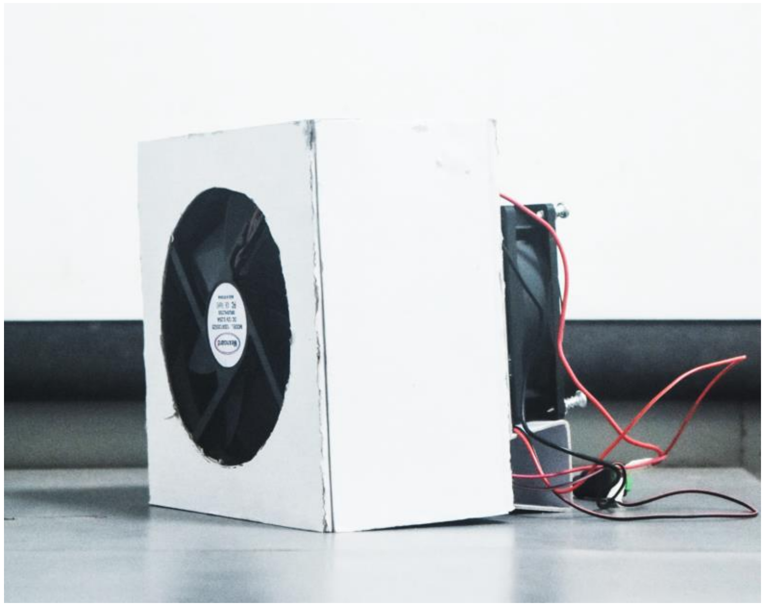




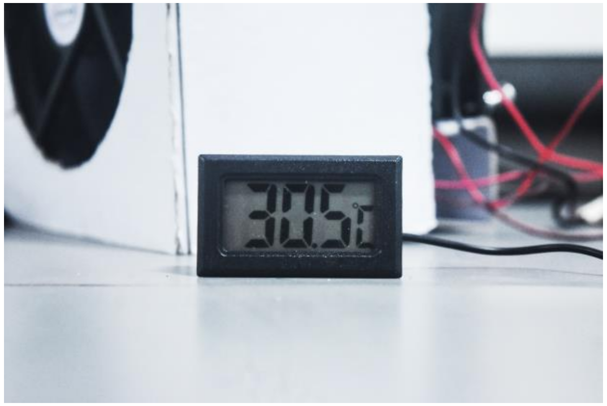
Leanings

Maintaining a vacuum chamber within a compact setup poses significant challenges. The intricacies of sustaining a vacuum, coupled with the need for repetitive processes, add to the complexity of this technology. Achieving efficient coldness extraction from the fluid further compounds the difficulties. The intricate nature of these tasks highlights the nuanced challenges inherent in implementing this cooling method, underscoring the importance of careful design and precise execution in overcoming these obstacles for practical applications.

Experiment 3: Thermoelectric cooling



Creating a cooler with a Peltier module involves a straightforward process. Start by securing a Peltier module, a heat sink, and a fan. Attach the Peltier module to the heat sink, ensuring good thermal conductivity. Connect the hot side of the module to the heat sink and the cold side to the surface you want to cool. Place the fan on the heat sink to dissipate heat efficiently. Supply power to the Peltier module, and it will create a temperature differential, transferring heat from one side to the other.



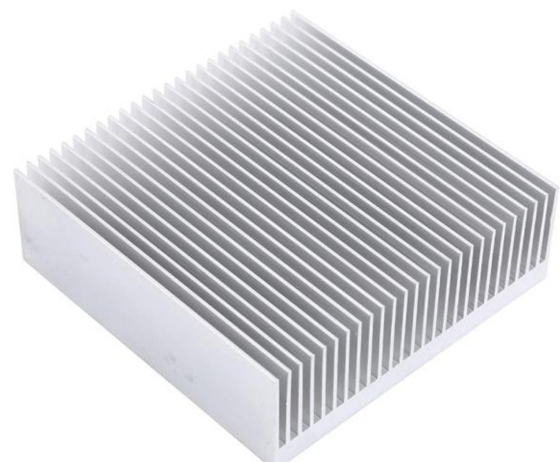
Initial room temperature.

Temperature of the cold sink.

Leanings

1. The experiment utilized a single 12V 6Amps Peltier module, but its capacity fell short of generating the intended level of cooling. Additionally, the effectiveness of the cooling process was hindered by the insufficient duration of air contact with the cooling surface. Achieving the desired temperature required a more robust Peltier module or potentially exploring the optimization of the cooling surface design to enhance the efficiency of the heat transfer process. These observations underscore the importance of appropriately dimensioning components to match the cooling requirements and considering the time factor in the cooling mechanism.

2. Hence, among all the experiments conducted, this particular one emerged as the most promising, holding substantial potential to efficiently fulfill the project's objectives. With thoughtful design interventions, there exists ample room for further enhancement in efficiency, allowing for optimal functionality. A noteworthy advantage was the absence of moving parts, excluding the fan, which significantly reduced noise levels. This low-noise characteristic adds another valuable dimension, especially considering the intended purpose of the project, emphasizing the success and practicality of this particular experimental approach.



04

Project Brief

The project entails developing a compact cooler tailored for students in hostels and paying guests located in humid regions, where the installation of traditional air conditioners may not be feasible due to infrastructure constraints. The chosen cooling technology for this innovative solution is thermoelectric cooling, leveraging the Peltier effect. This method allows for efficient cooling without the need for elaborate infrastructure, providing an accessible and effective solution to enhance comfort in indoor environments, specifically designed to address the unique challenges posed by humid climates in student accommodations

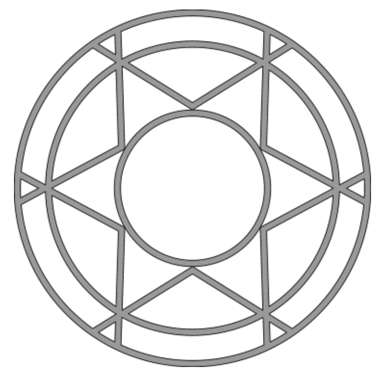
05

Design Interventions

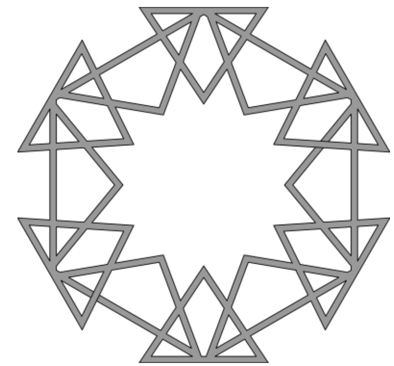
To optimize the cooling performance of the product, a series of strategic interventions were implemented. This chapter meticulously details each intervention undertaken to enhance the product's functionality in real-world scenarios. By delving into the specifics of these interventions, the aim is to ensure that the product operates at its maximum potential, meeting the demands of practical applications with heightened effectiveness.

5.1 Cold sink

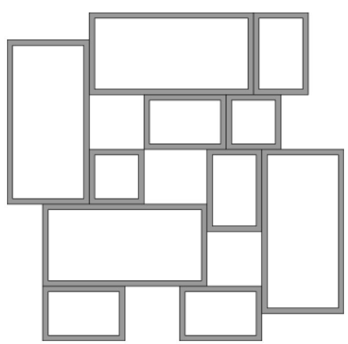
The primary objective centered on augmenting the surface area of the cold sink, a pivotal element in facilitating greater contact with the flowing air. By expanding the surface area, the goal was to enhance the cooling process, lowering the air temperature and consequently elevating overall efficiency. This strategic enhancement aimed to optimize the interaction between the cold sink and flowing air, ensuring a more effective and robust cooling performance. The design specification emphasizes the incorporation of flat surfaces on the outer extremities to accommodate thermoelectric modules with dimensions measuring 40mm by 40mm. This deliberate choice in design not only facilitates seamless integration of the modules but also prioritizes ease of manufacturing. The flat surfaces serve a dual purpose, providing an optimal mounting platform for the thermoelectric components while ensuring a practical and straightforward manufacturing process for the overall product.



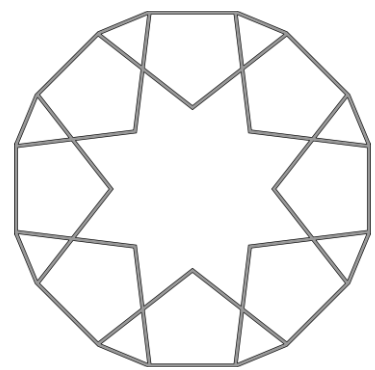
Concept 2, 2 mm wall thickness



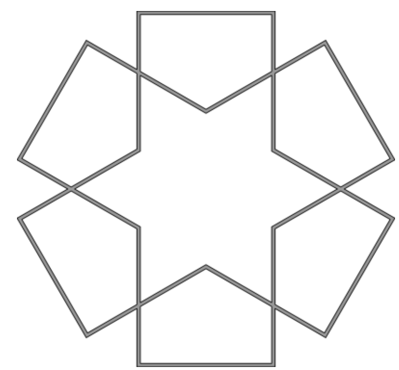
Concept 3, 2 mm wall thickness



Concept 1, 2mm wall thickness

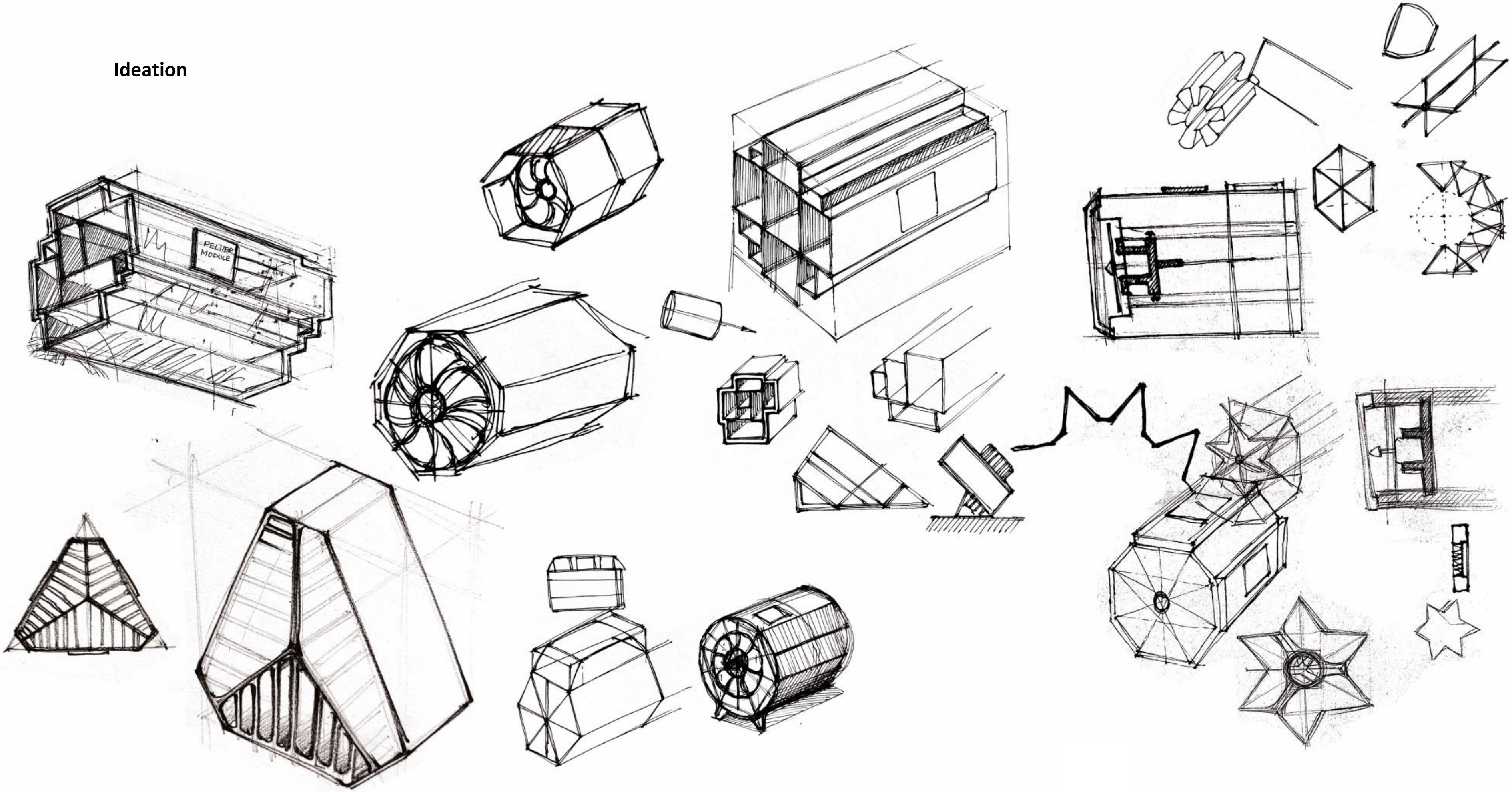


Concept 4, 1mm wall thickness



Concept 5, 1 mm wall thickness

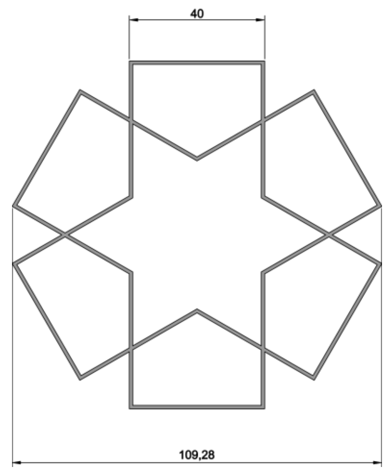
Ideation

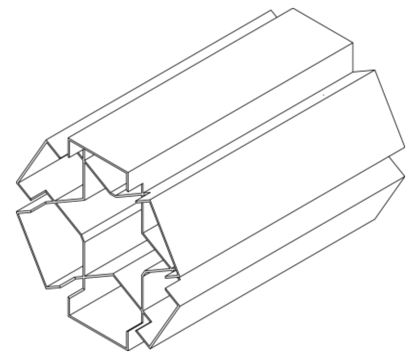


Selected concept

The chosen design successfully meets all the essential criteria necessary for the product's functionality. It has undergone a thorough evaluation against predefined benchmarks, ensuring that it aligns with the specified requirements and standards.

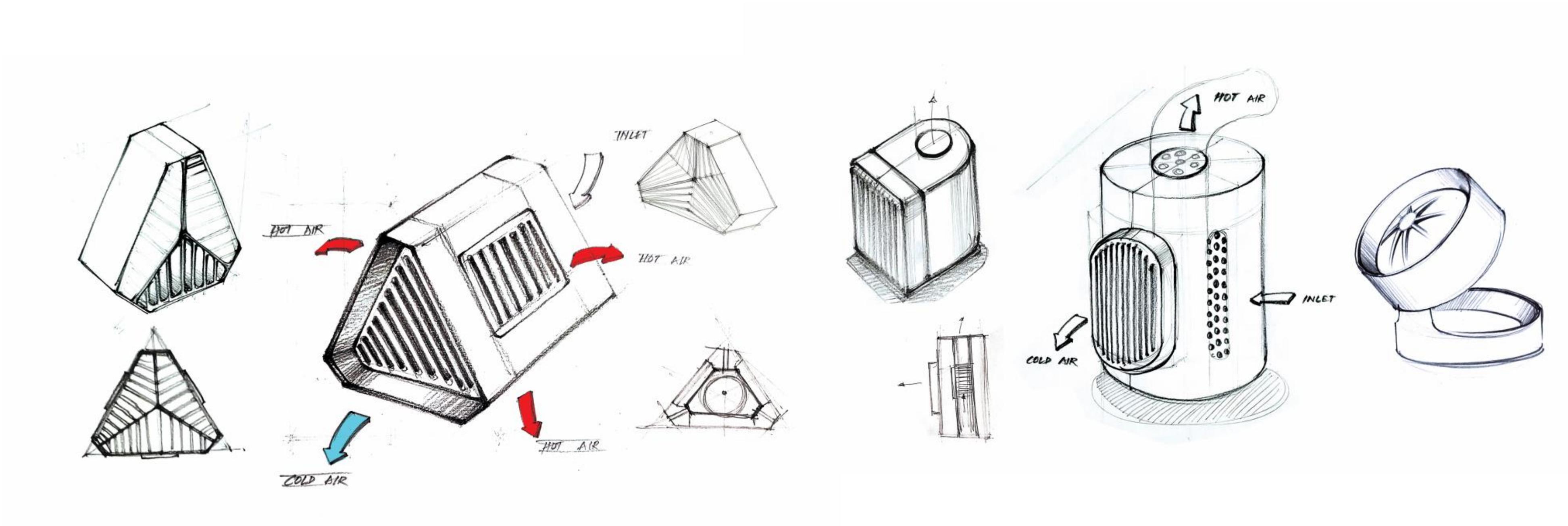
Material: Aluminum
Manufacturing: Aluminum extrusion



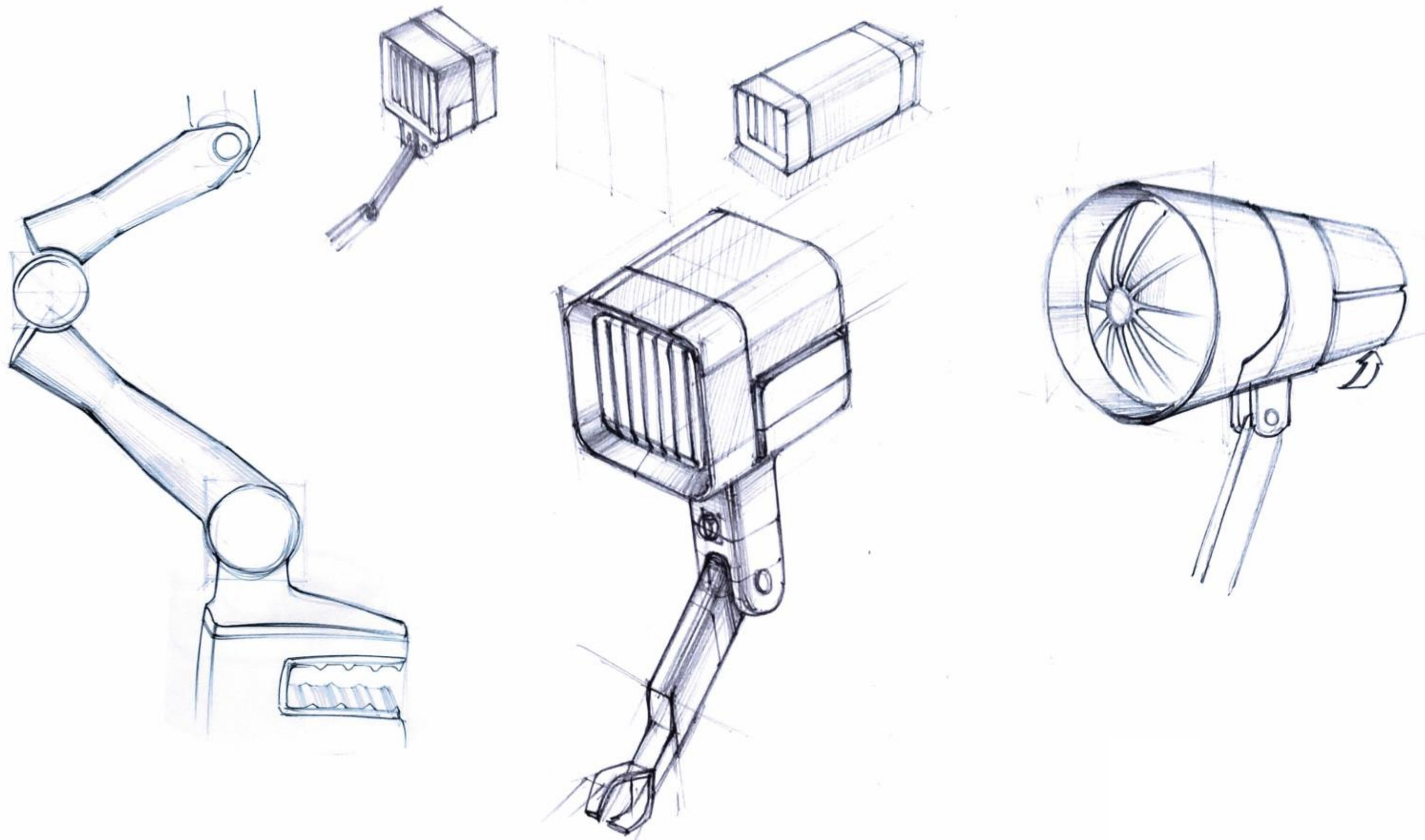


5.2 Product ideation

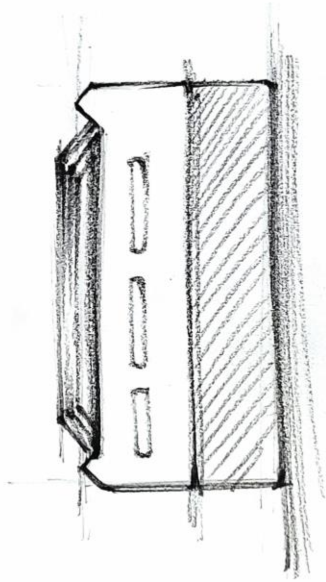
Desk top

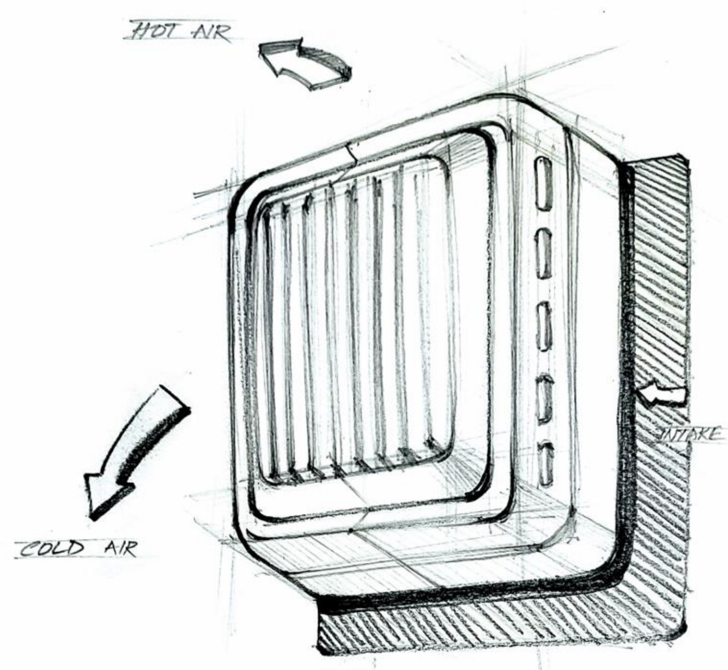


Desk mounted



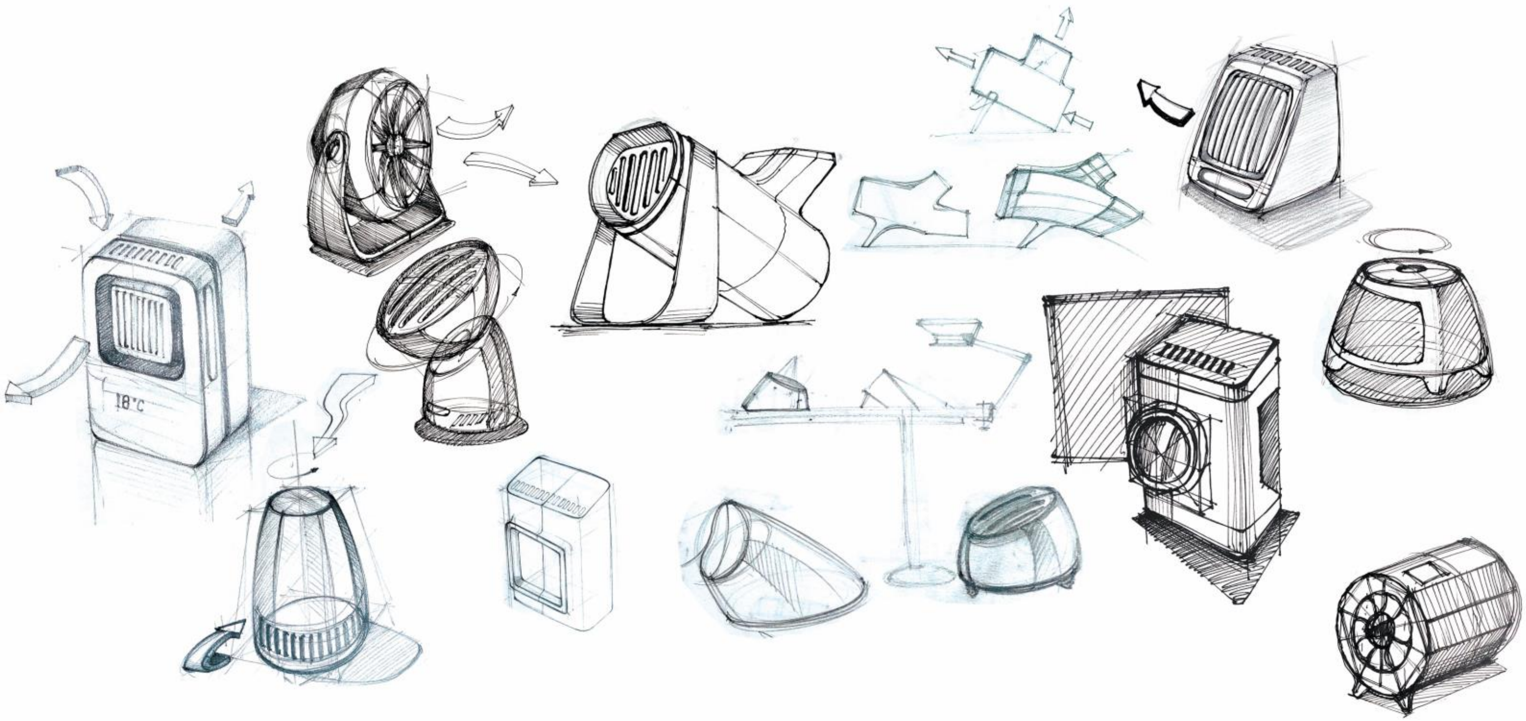
Wall mounted





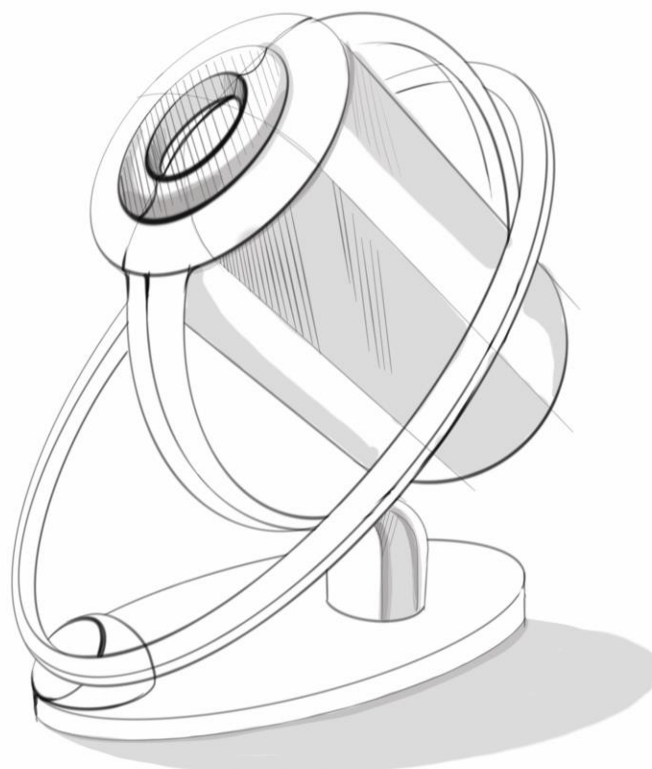
5.3 Form ideation

Final Concept: Desk top



5.4 Final form

Final Concept: Desk top



06

Final Design

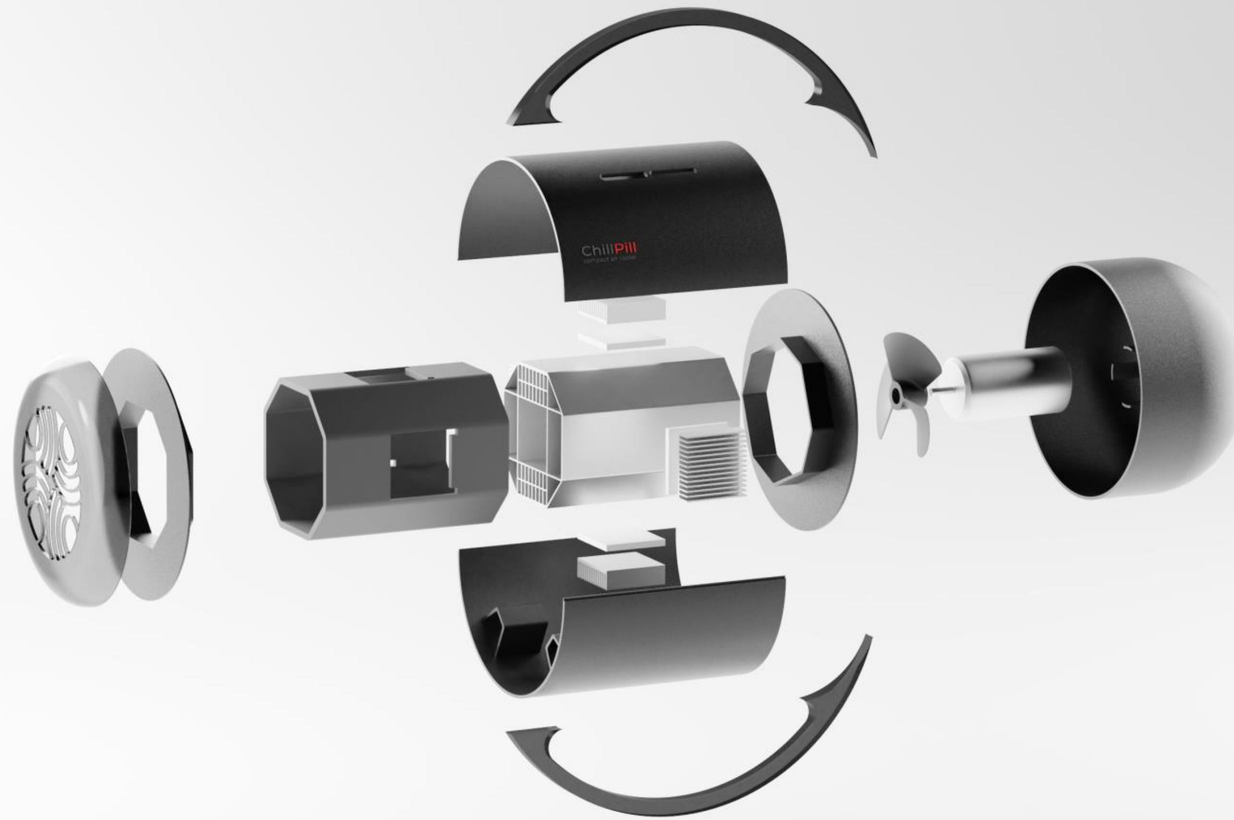
Principle

The underlying principle supporting this concept is rooted in the idea that, when a student acquires this product and places it on their desk, it should transcend mere functionality and evolve into a product that encapsulates a lifestyle. The form factor of the product elevates it to the status of a user's lifestyle accessory, surpassing its fundamental functionality.

Adjustable angle

The screw may be intentionally loosened, enabling the user to adjust the angle as per their specific requirements with the assistance of the accompanying ring. This functionality provides users with an engaging means of interacting with the product, deviating significantly from conventional methods of performing similar tasks.

Exploded view



07

Prototype

Components

The prototype was built using readily available internal components, resulting in a close approximation to the final product but slightly lacking in precision.





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