

Glasgow School of Art

MSc Product Design Engineering Major Project

Design a Cooling Panel for Gaming Laptop



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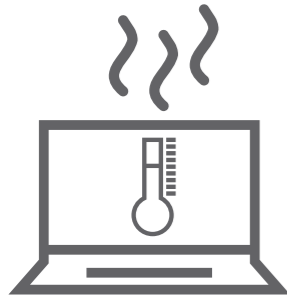
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Problem defined

-What's the problem? Why does it happened?

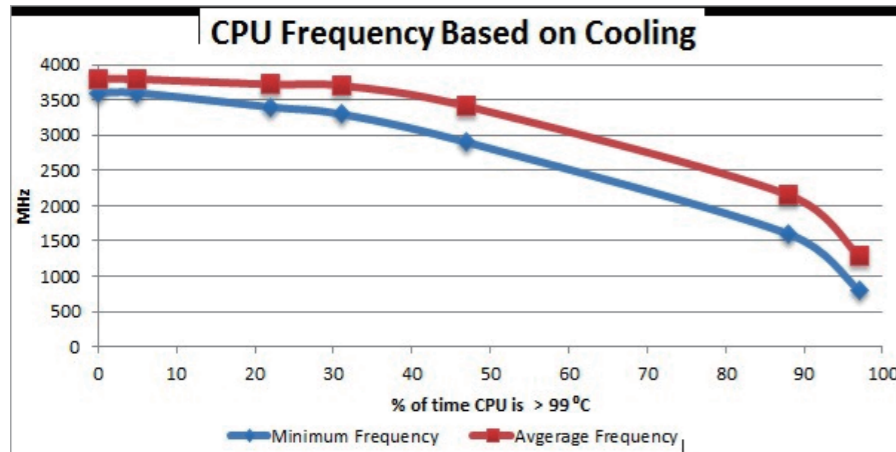


Key word: Temperature wall, Structure;



How would you do when you find your laptop is too hot?

For some laptops, after using a period. Especially for those users who use the laptop for playing the game or doing rendering jobs. And for those computers who working at a high temperature, the running speed will gradually slow, or even get stuc



What happened when laptop is too hot?

When the computer is running, almost all the electrical energy would be converted into heat energy, as a result, the temperature of some core parts (such as the CPU) will rise with the working time. When the temperature rises to a certain level (generally 95°C, also known as 'temperature wall'), the CPU will generally reduce its operating frequency to protect the core components. Therefore, for the core components to run steadily for a long time, it is necessary to use certain cooling methods to balance the heat production of the parts.

Generally, a possible solution is using a cooling panel, which could enhance the cooling efficiency of the laptop.

However...



The cooling panel could not solve the problem of the laptop overheat, it can just extend the time before it has happened. Most of the cooling panels, which with a fan inside them, could just enhance the situation that insufficient inlet due to the inlet design at the bottom of the laptop. moreover, its cooling efficiency is still determined by the laptop's cooling fan.



Most of the cooling panels cannot filter the dust, which might cause this dust to be easily accumulated inside the cooling fan and another part of the mainboard inside the laptop, which would further reduce the efficiency of the laptop cooling system.



Structure Analysis

Compare with a desktop which has almost the same hardware type, the laptop has integrated almost most of the important hardware (Such as CPU and GPU) on the mainboard and remove almost 80% of the whole cooling system compare to a desktop. This kind of design has successfully shrunk the laptop size, however, the shrink of the cooling system also brings the problem of heat accumulation.

The negative effect of this design has shown its bad performance of heat dissipation. During working, the rising of the temperature of the core part is much higher compared to the desktop. Moreover, the ventilation volume for the laptop is much smaller than desktop at one ventilation cycle (Change all the air inside the PC). The reduction of the ventilation volume and ventilation speed caused heat accumulation inside the laptop, which would force the CPU to lower its frequency to ensure safety.



-Is there any existed product? What is the user most care?



-What is the cooling panel?

The cooling panel is a support product that helps the laptop balance its heat production during running. It has wide suitability for different sizes of the laptop without modification and is generally powered by a USB port.



-What cooling panel can do?

Generally, a typical cooling panel could increase the laptop's cooling efficiency through absorb the heat through metal's heat conduction or increase the volume of the air, which could support the turbine fan's heat dissipation. Moreover, a part of cooling panels have the function which could adjust the height and of the screen to reduce the discomfort of the user's neck while using.

-What is a considerable price for the user?

Generally, the price range of the cooling panel is wide: from £15 to £90(Referring on amazon.co.uk).



Where does it use it ?

The using environment of the cooling panel is almost the same as the laptop, which mainly uses in a living room, office or library. That means most of the environment parameter is almost same as the laptop.

Environment temperature Range: 15°C ~ 25°C

Humidity: 30%~80%

Lighting: Normal, no direct strong light.

Portability requirement: Almost no requirement

Product Brands

Using Environment

Parallel Products

Market Analysis

Using Experience

For researching the existed product, through the main online shopping website(i.e. Taobao, Amazon, eBay), the existed product can generally be divided into two main types: fan type and metal type.

Fan type

Most existed products belonged, its structure is simplified, which has several fans inside the panel to increase the volume of the cold air which could be used in the laptop's cooling system. This product is suitable for various type of the laptop, no matter size, material or structure. However, it can only help the laptop's cooling efficiency close its ideal value, rather than beyond that value.



Metal type

Metal type relies on the heat conduction between metal to metal, which can only serve the laptop that has a metal shell.



Form the current market, the existed cooling panel is simple structured and has high similarity in its structure, moreover, there doesn't exist a brand for the cooling panel which could generate the brand effect. As a result, a new product that has a new structure or new function can be considered a competitive product.

-Who buys the product?

Through the research of the main user group of the cooling panel. Most of the users are owned or used a gaming laptop, which has a higher level of hard drive and higher heat production while using compare to the general laptop.

-What do they most care about while choosing?

The main reason they purchase this product enhances the cooling efficiency of their laptop, which means most of them are function-attracted users, which could consider the product's function and its performance as the most important point while choosing a product.

-What do they unsatisfied with the current product?

Considering feedback of the current user, what they are most unsatisfied about the existed product is its working efficiency, Especially when continuous running rendering software or game, the temperature still would reach "temperature wall" after 10-20 minutes.



-What do they care? What are they worried?



As the market research has shown, most of the cooling panel users are games laptop users. Which has a higher performance and higher heat production during running compared to the general laptop. According to the result of the market research, we decided to choose games laptop users as our target user group. For understanding what they care about and what they prefer, we made several offline interviews, after the interview, we reviewed all the results we have, and gives a general view of the target user and listed what they most care about.



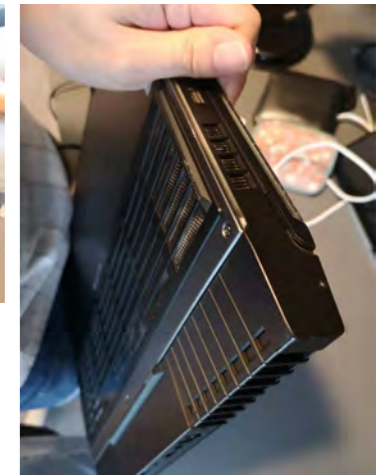
From all the interviewees, we've chosen 3 typical interviewees to analysis user needs and generating persona refer to the general feedback from the whole interview.



Gender: Female
Laptop Type: Typical Gaming(15.6 inches)
Using experience of the cooling panel: low, not frequent user
General using: Rendering, report writing
Overheat: general working after 10 minutes
Heat dispassion: low
External requirements: adjustable support

Gender: Male
Laptop Type: typical Gaming(15.6 inches)
Using experience of the cooling panel: frequent user
General using: Computing, gaming
Overheat: start the game (such as apex) after 15 minutes
Heat dispassion: medium
External requirements: adjustable support, external USB expansion

Gender: Male
Laptop Type: light Gaming(with external screen)
Using experience of the cooling panel: self-made, no external fan
General using: rendering, gaming
Overheat: start the game (such as apex) after 10 minutes (depend on season)
Heat dispassion: medium-low
External requirements: external USB expansion



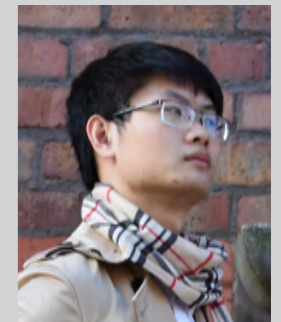
Besides the interview of the user, we also observe their laptop's structure and the most common problem caused by overheat.



Critical Feedback from the Interviewee
1, The weight of the product would not affect the choice of the cooling panel
2:The cooling panel will consider as a "fix" external, which means the user would not bring the cooling panel out frequently.
3:The function of ergonomic suiting is considered as an important part of the user, especially adjust the position of the screen to provide a suit position while using it
4:The cooling panel is needed for most gaming laptops if you want to keep the working temperature of the laptop stable
5: external function is considered as a good idea such external USB port.
6: The current cooling panel is not ideal, which doesn't have a significant change for laptop heat dispassion
7: The user has certain tolerance if the laptop needs to modify, which depends on the Maintainance service

Persona
Name: K
Gender: Male
Age: 23
Job/Status: University Student
Laptop type: Gaming Laptop(17.3 inch)
Cooling panel Using experience: 2-3 years

K is a university student. Consider the space and cost of purchasing a desktop, he chooses a gaming laptop as his main PC for his college life. To reach a similar user experience of using a desktop, he also purchased various external devices such as a screen, keyboard and mouse.
During these 3 years, or dealing with the production of high heat production, he purchased a cooling panel. However, this product didn't solve this problem, when using the laptop especially for gaming or do the rendering, the temperature still will rise to 95 and his laptop will slow down its running speed or even get stuck. As a result, he is looking for a new cooling panel that has the potential to solve these problems.

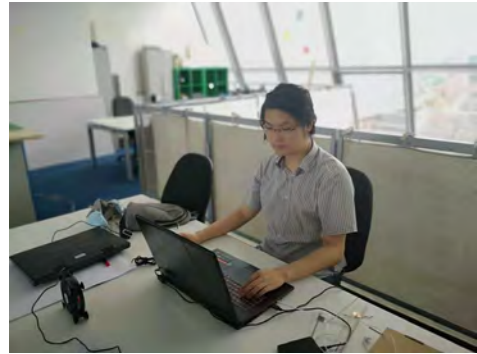


Storyboard/Key Opportunity

What Problem user might have? Where is the opportunity?



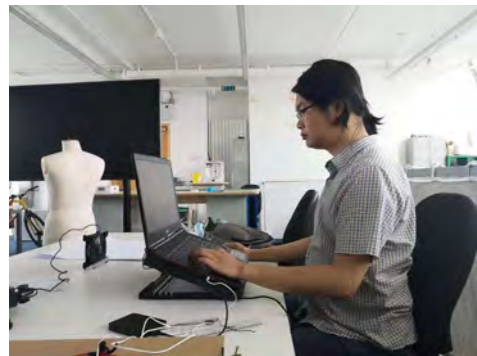
Key word: Functional, Efficiency



K is a games laptop user which has a high using frequency, however, there is something when using laptop has bordered him for a long time.



Generally, after using about 10-15 minutes, his laptop's core part temperature has rising to an incredibly value, which would possibly damage the laptop.



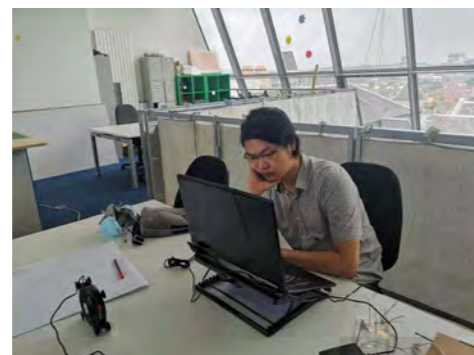
As a result, he started to use cooling pad to enhance this situation. However, this problem seems still exist...



After running several working software for about 15 minutes, the heat was accumulated inside the laptop again, even can feel with touching the plastic surface.



When the laptop's CPU temperature has risen to its highest value and its running frequency getting slower.



The laptop is getting stuck, and K feels very annoyed about this problem, he hope the cooling pad could absorb these heat with a higher efficiency...

Key Opportunity

Efficiency

Through the research of the main user group of the cooling panel. Most of the users are owned or used a gaming laptop, which has a higher level of hard drive and higher heat production while using compare to the general laptop. The main reason they purchase this product enhances the cooling efficiency of their laptop, which means most of them are function-attracted users, which could consider the product's function and its performance as the most important point while choosing a product.



The product should have a better performance on support laptop cooling, through new structure or new method.

Adjustable

From the observing of the current market, most of the cooling panel products could just suit for one size range product, which means for users who have different sizes of the product, they need to purchase more than one cooling panel with different size to suit each laptop. Moreover, due to the difference in the body dimension, some users have provided feedback about the uncomfortable using experience of the laptop with the cooling panel due to the posture limitation.



The product should have the function which could adjust the height and adjust the suiting size of the laptop.

Function

Most of the cooling panels on the existed market do not have extra functions. During user researching, a certain number of the participants agreed that the USB expansion function applied on the cooling panel is attractive and acceptable for them. The cooling panel generally needs a USB port for the power supply, which will decrease the port available for external devices such as the mouse and the keyboard.



The product should have some expansion function, such as USB expansion port, allowing for external devices to connect to the laptop.

Competition Opportunity analysis:

For the current existed product, there is almost no famous brand such as Rayzer in the mouse market and Cherry in the keyboard market, so the effect of a famous brand could not be considered as an important point. For the market competition, the main users are functional-attracted users, which means a functional product would be more attractive compare to a product that has a general function but with a fancy RGB light effect.

-What cooling method is suitable?



The figure show's the cooling system's working principle of the laptop. We can found that the 2 turbine fan inside the laptop takes most of the workload of cooling the whole laptop. How to increase the cooling efficiency can roughly start from three ways: increase the volume of the air ventilation, using other mediums such as liquid to transfer the heat and lower the air temperature before it goes into the laptop. The researched methods can be roughly divided into 4 types:

Cooling Mtehod: Fan

This method is relatively simple and considers the most widely used method for the existed product, which only use air to take the heat away, during my consideration, the cooling panel is the device that does not need to do modify the laptop shell. Adding an aluminum tower to the fan cooling system could increase the cooling efficiency by increasing the surface of cool- ing Has a higher efficiency and similar cost, but require directly touch the heat source, which would need to do the modification of the laptop.



The most efficient and cheapest way of cooling. Which efficiency only rely on the speed of the fan.



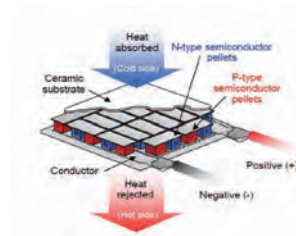
Adding an aluminium tower increases the touch surface of the air compared to the fan-only plan. Has a higher efficiency and similar cost, but require directly touch the heat source



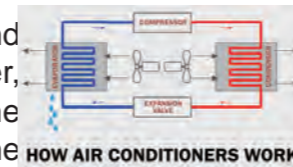
Adding a copper bar to transfer the heat to the aluminium tower compare to the previous one, but require directly touch the heat source.

This method relies on decrease the temperature of the air before it comes into the laptop. This method need to design extra devices to cool the air and it would have a higher cost and larger size

Cooling Mtehod: Pre-cool



The semi-conductor cooling has 50%-60% efficiency compare to its heating function and need to design extra heat-absorbing devices that ensure its working efficiency. Moreover, the overall working efficiency for a single semi-conductor chip is low, which require the multi-chip to reach an ideal efficiency. And this design's cost would be much higher than the original product.



Another plan is to design a tiny "air-conditioning" into the cooling panel, which could lower the air temperature before it is pumped into the computer. This plan requires an extra compressor and has a higher power requirement

Cooling Mtehod: Metal Conduction

The simplest method, which use the metal panel to conduct the heat outside the laptop, chipset, but has requirements to the computer's structure



Using a metal panel to transfer heat outside the computer is the cheapest solution. However, this panel is only suitable for the computer which has a metal shell. A plastic shell laptop is not suitable for this kind of product.

This method could bring the heat faster than a fan method. However, it requires directly to conduct the heat source, which is CPU and GPU in the laptop to transfer the heat. Moreover, this method is hard to cool the air temperature before the air goes into the laptop

Cooling Mtehod: Pre-cool



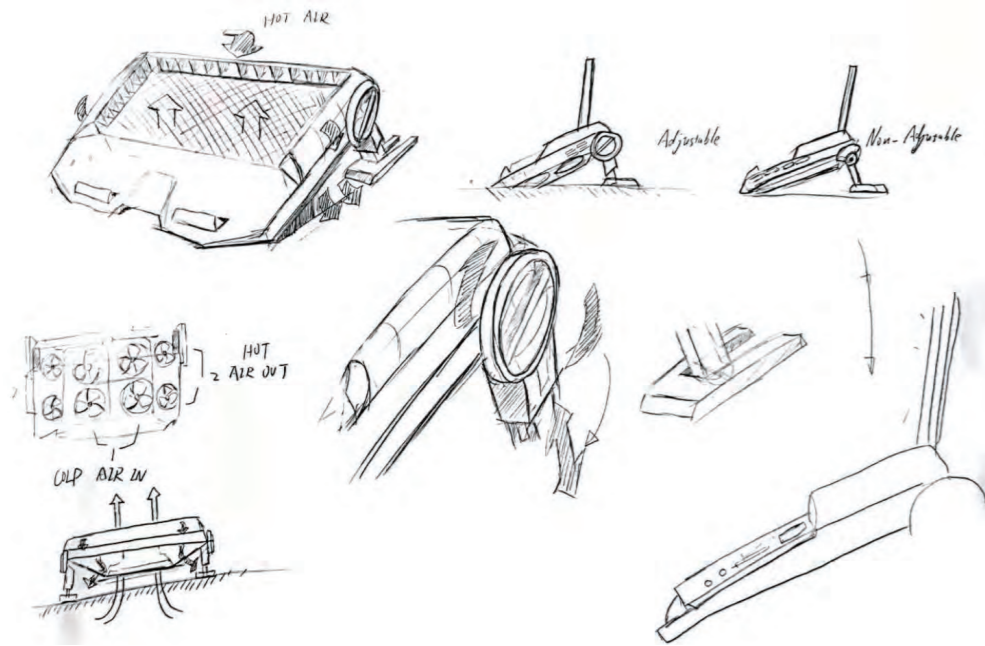
As a result, the water cooling product is considered as a backup plan in the product design, which is not suitable for the product could co-operate with the laptop manufacturers.

Conclusion

Considering the technical difficulty and the cost, the fan cooling and liquid cooling might be the suitable plan for my product, moreover, the existed product on the market is more focused on supporting the fan in the laptop to reach its ideal working efficiency. Our product should pay more attention to finding a new way to increasing cooling efficiency rather than only focus on structure or part development.



Concept 1



Cooling Method: Fan cooling

Height adjustment: allowed

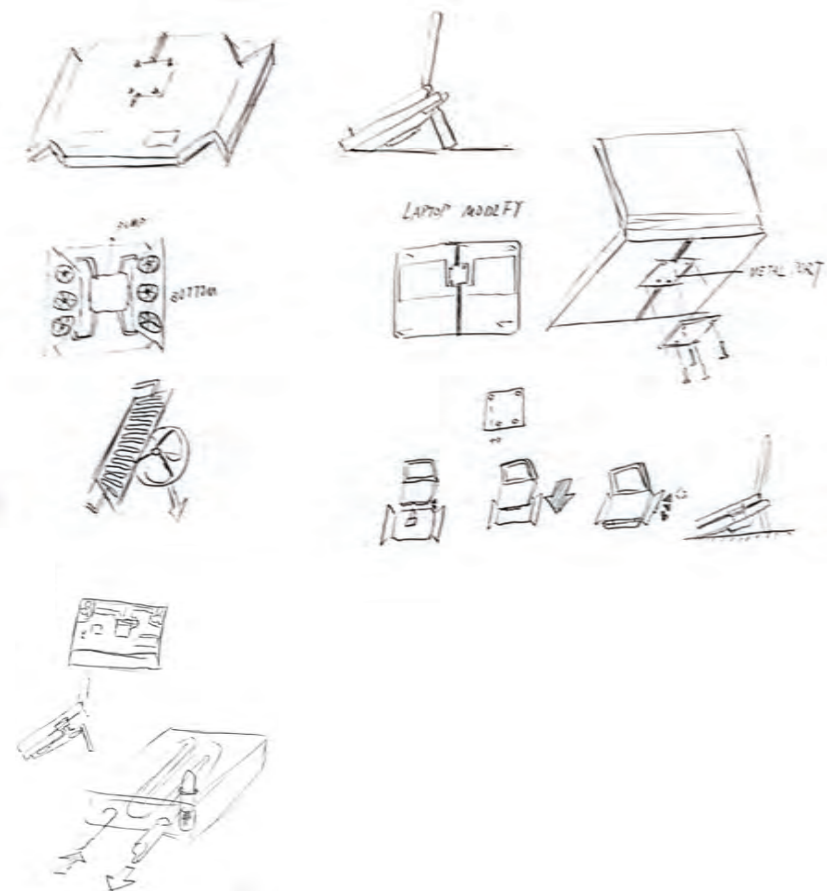
Size adjustment: no

Adjustment for laptop: no

Compare with the existed product, this concept has added another group of fans in order to avoid hot air accumulated inside the laptop due to the limitation of the laptop cooling system. As research result shown, most of the gaming laptop has set the fan and air exhasut port at back part of the laptop.

Moreover, due to the gaming laptop has a high possibility which requires to connect an external devices, which needs to use the connection port at the front part of the laptop, as a result, the hot air absorbing port would be more resonable if it was places at the back part of the cooling panel.

Concept 2



Cooling Method: Liquid cooling

Height adjustment: no

Size adjustment: no

Adjustment for laptop: yes, but limited

This concept is considerably aggressive compare to the first concept, which was applied to a liquid cooling device on the cooling panel and required a certain modification of the laptop shell.

The laptop shell would be added a part that could be removed at the bottom, when this part was removed, the internal connection port would be exposed, which directly connected to the cooling system. During the working condition, the connection port on the cooling panel would be connected with the laptop's connection port and secured by four eject latches. The heat would be transferred through two metal conduction ports, and be absorbed by the cooling liquid inside the cooling panel. The cooling liquid would be transmitted into the heat dissipation devices and eject heat with the help of the fan on the top of the dissipation panel.

Concept Evaluation



For concept one, several participants have admired its concept, however, they doubted the efficiency of design. Moreover, few participants pointed out that these might cause interference problems if the laptop was required to connect the power line.



For the second one, although a certain number of the participants was admired this concept, however, they worried about the safety of the liquid cooling which has a potential risk of liquid leaking. Another point is it has to apply the modification to the laptop, and this would cause the maintenance service unavailable provided by laptop manufactures.

Conclusion

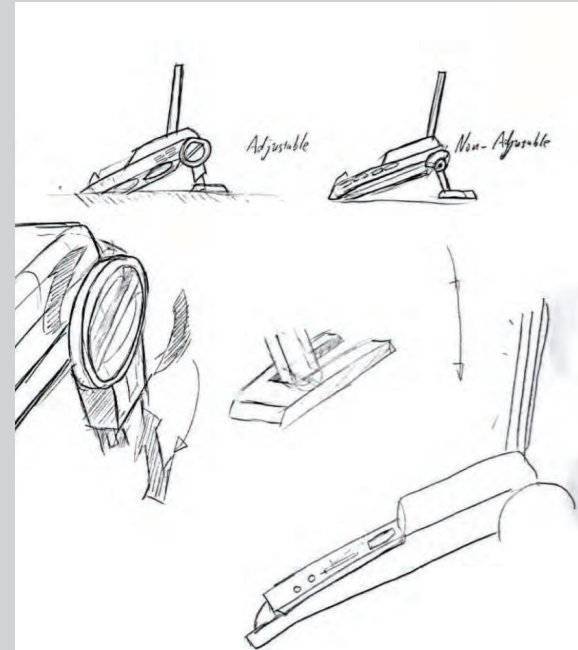
During the comparison of these two concepts, through concept 2 has a higher cooling efficiency, the problem of maintenance service was unacceptable by the participants. As a result, concept 1 was chosen and moved to the detail design stage.



Development

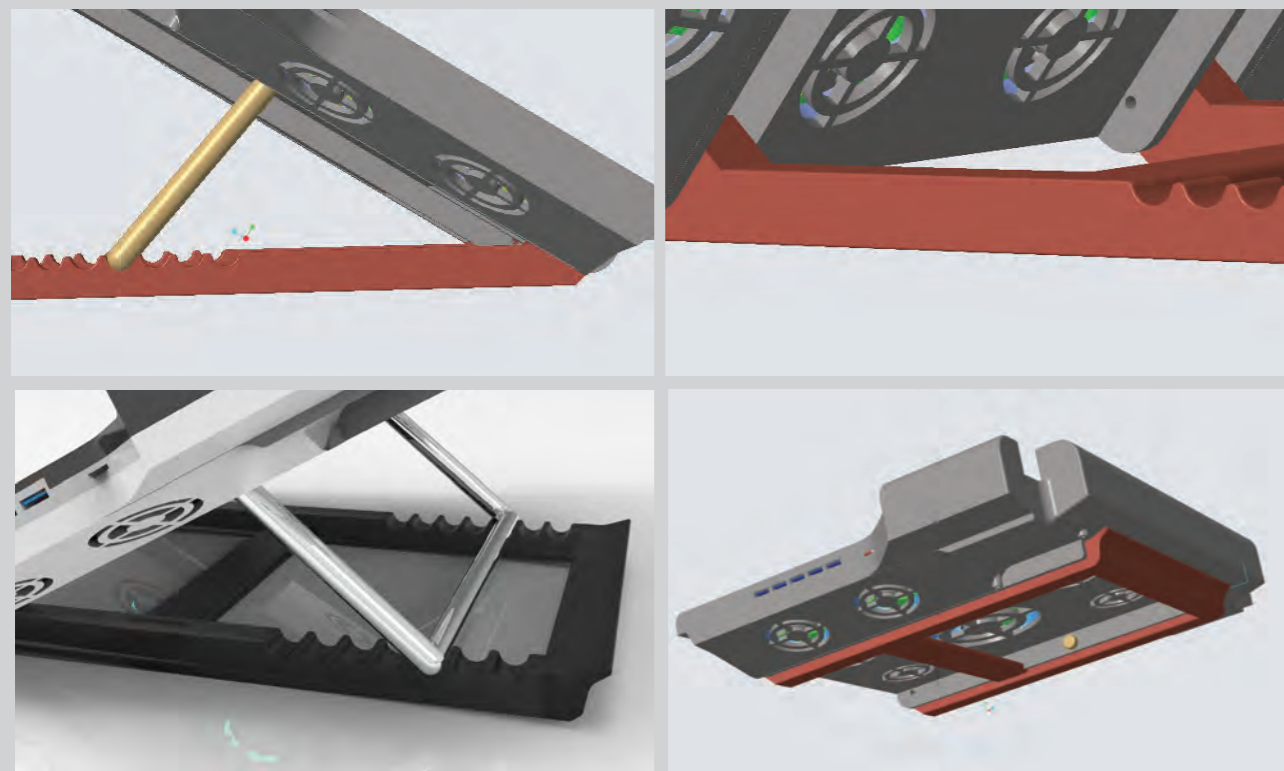
Why choose this? Is there a better plan?

Supporter Development



In the concept generation stage, the support that could adjust the height was realized through the design of an adjustable gear which would use the switch to change the height of the cooling panel, this part was too complex and the teeth of the gear need to support the weight of the cooling plate and the laptop. The teeth would have a high possibility to break down during use.

As a result, refer to the existed product, the new design of the support part is relatively simple: It was composed of a metal support part and a plastic base part. The support part was constructed by a metal bar, which is relatively simple and its mechanical performance is strong enough to support the main part of the cooling panel and the laptop. The base was constructed of plastic with several grooves. During use, the support part will be fixed into a groove at the base part, which could construct a stable triangle shape. Moreover, the support could move to a different groove to realize the function of height adjustment.

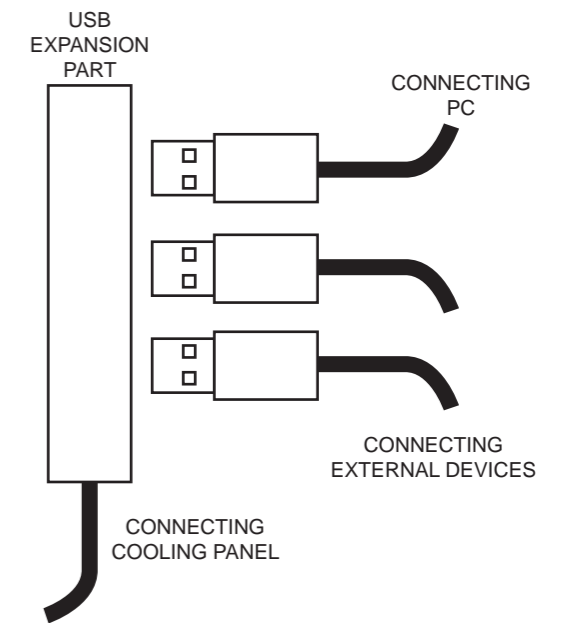
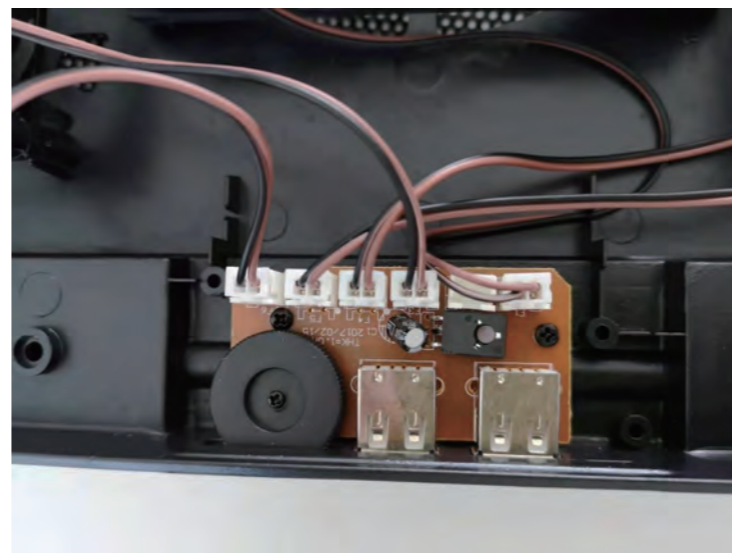


Connection Development



The expansion part's working principle is similar to the existed USB expansion product. For the USB expansion port, its internal circuit is not complicated, which has the potential to integrate with the cooling panel's working circuit.

In the development stage, we integrated the working circuit and the expansion circuit into one circuit board, moreover, the circuit has already connected to the cooling panel for the power supply. During working, the cooling panel could work normally whatever port has connected to the laptop.





Stage 1: Theory Certification

Generally, the certification would focus on verify the suggestion that “extra fans for helping hot air ejection could increase laptop cooling efficiency”.



The structure is relatively simple, which only applied two extra fans on the laptop exhaust port. During the experiment, the laptop would be running a rendering software for about 10 minutes and then compare the temperature of the CPU shown on detecting software. Here are the figures which shown the results:



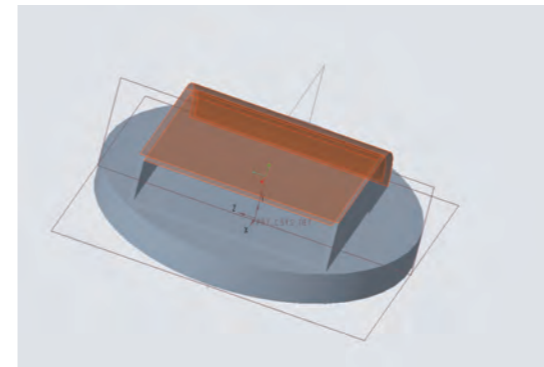
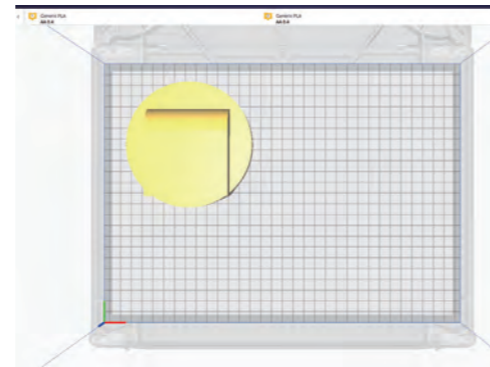
The highest temperature of the group with extra fans



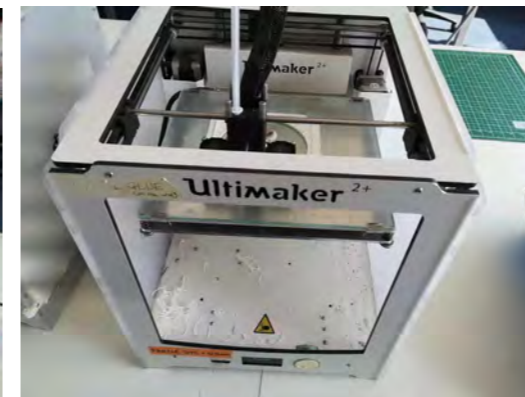
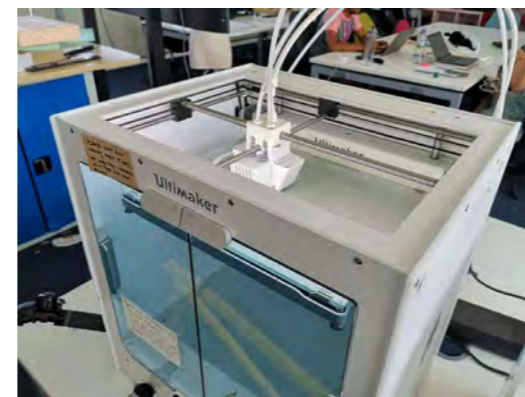
The highest temperature of the group without extra fans

The result has shown that the assumption of the concept is correct, which means extra fans for the exhaust port could effectively increase the cooling efficiency of the laptop.

Stage 2: Prototype Making



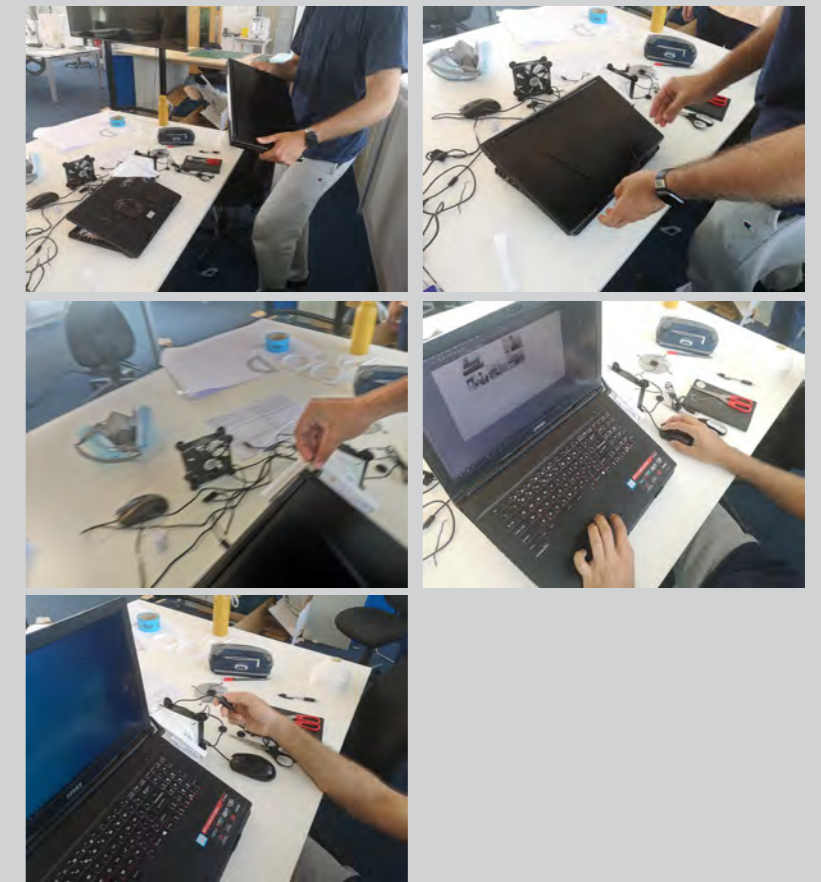
After verified the core theory of the design concept, the prototype making process could be started. The prototype is aimed to test its working efficiency and suitability for different sizes of the laptop. Considering the structure and the function of the prototype. Most of the parts would be manufactured through 3D printing.



Due to the limitation of available time for using a 3D printer, the prototype was designed as the simplest structure which still supports functional test.



Stage 3: Prototype Test



This functional prototype is focused on testing its working efficiency, usability and user-friendly, as well as the ergonomic test. For a more convincing result, the experimenter was chosen by the one who was not familiar with a similar product. This experimenter would complete the task with limited reminding about what he should do next.

After the result has confirmed that this product is easy to understand for the user and the prototype would not affect the laptop use its external connection port and would not border user while using.

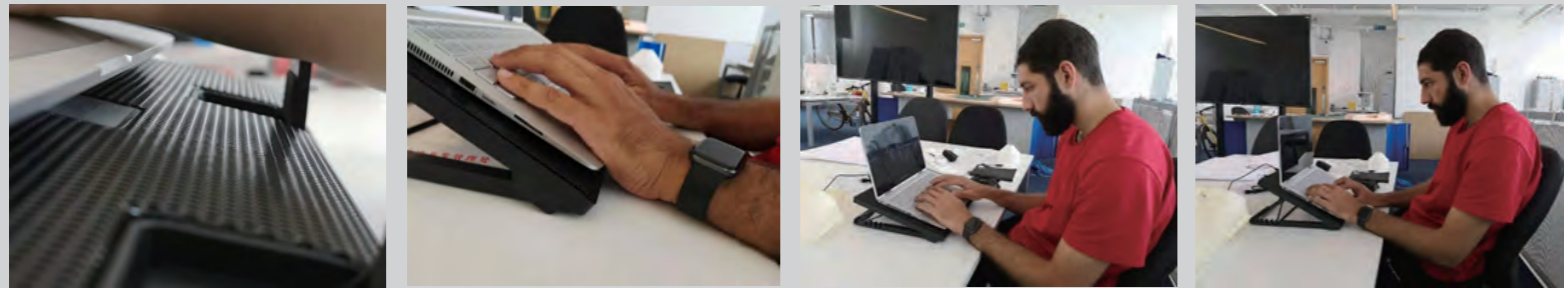
However, some negative feedback also be pointed. The design of the extension part which use to suit for different size of the laptop would cause interderencr while using. Moreover, the shrink of the cross-section area for ventilation tunnel close to the fan would decrease its working effeciency.



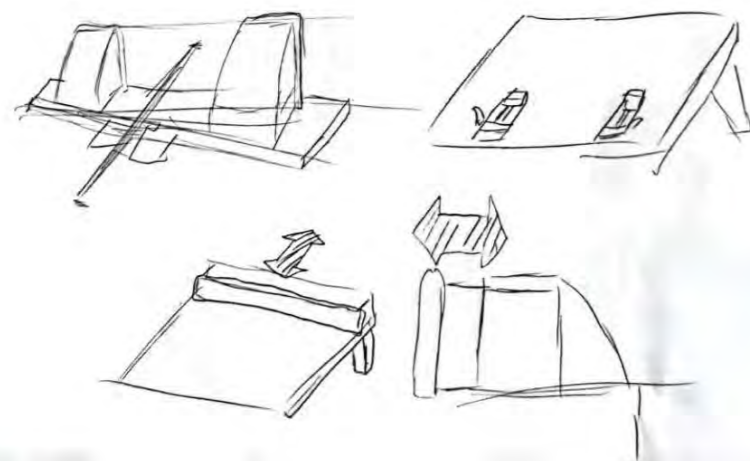
Blocker Development

At first, we planned to design an extend devices to suit different size of the laptop, however, we found the problem of interfering between the extend devices during user test stage. As a result, suitability for different size of the laptop might be better to realized through the blocker part.

User Position Research

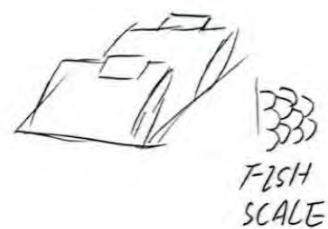


During this stage, several members were invited to have the test, each of the would-be required to use the laptop with the cooling panel at different height selection situations. As the figure show, during using a laptop with the cooling panel, the blocker might cause interference with the user's posture, and forcing the user to change posture to accommodate the blocker. As a result, during block design stage, a comlex device should consider its potential risk of the user posture interference.



At first, this concept has considered designing a blocker which could suit for different size of the laptop, as the position research show, a complex blocker design would cause the problem on interfering the user movement while using. Also, consider the manufacturing difficulty, this plan was finally been denied.

For another plan realizing this function requirement, if the blocker does not have the function for suiting laptop precisely, it can realize this function by providing several options for suiting a size range of the laptop. That means, it can set several groups of blockers on the product, each group suitable for a particular size range of the laptop.

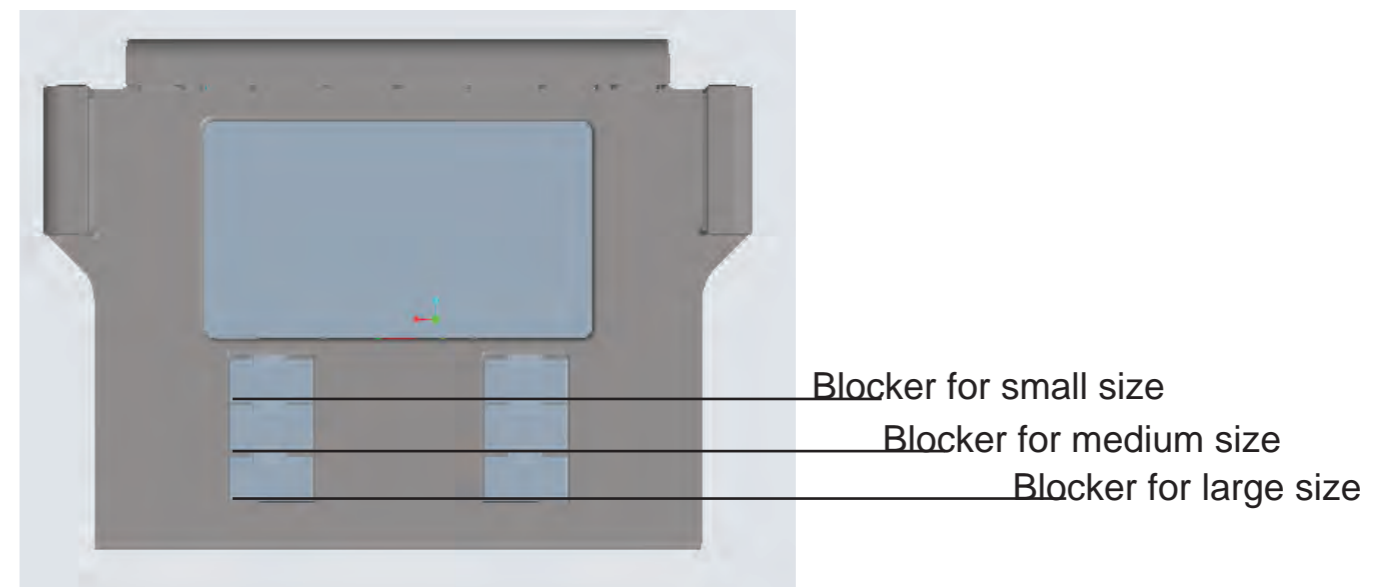


As the research result from the market, generally, the gaming laptop could be roughly divided into three ranges: small size, about 13 to 14 inches; Medium size, about 15-inch; For the laptop which is around 17-inch could be considered as the large size.

According to the plan for setting different groups for the different size range of the laptop, the new plan has come out as the figure shows:



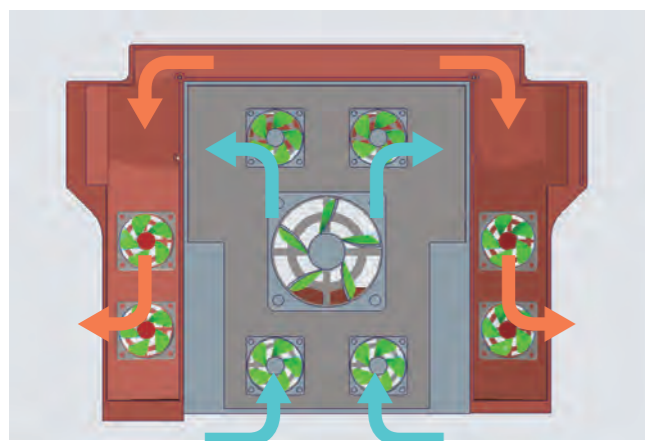
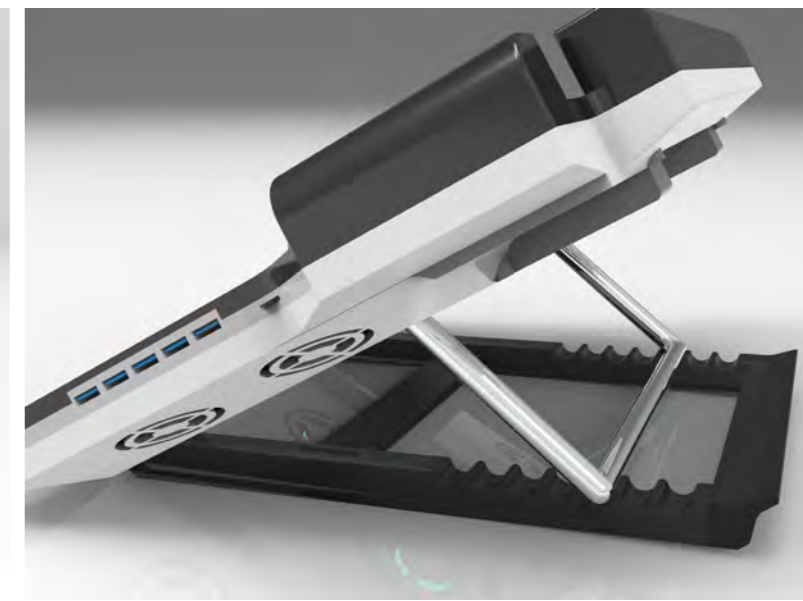
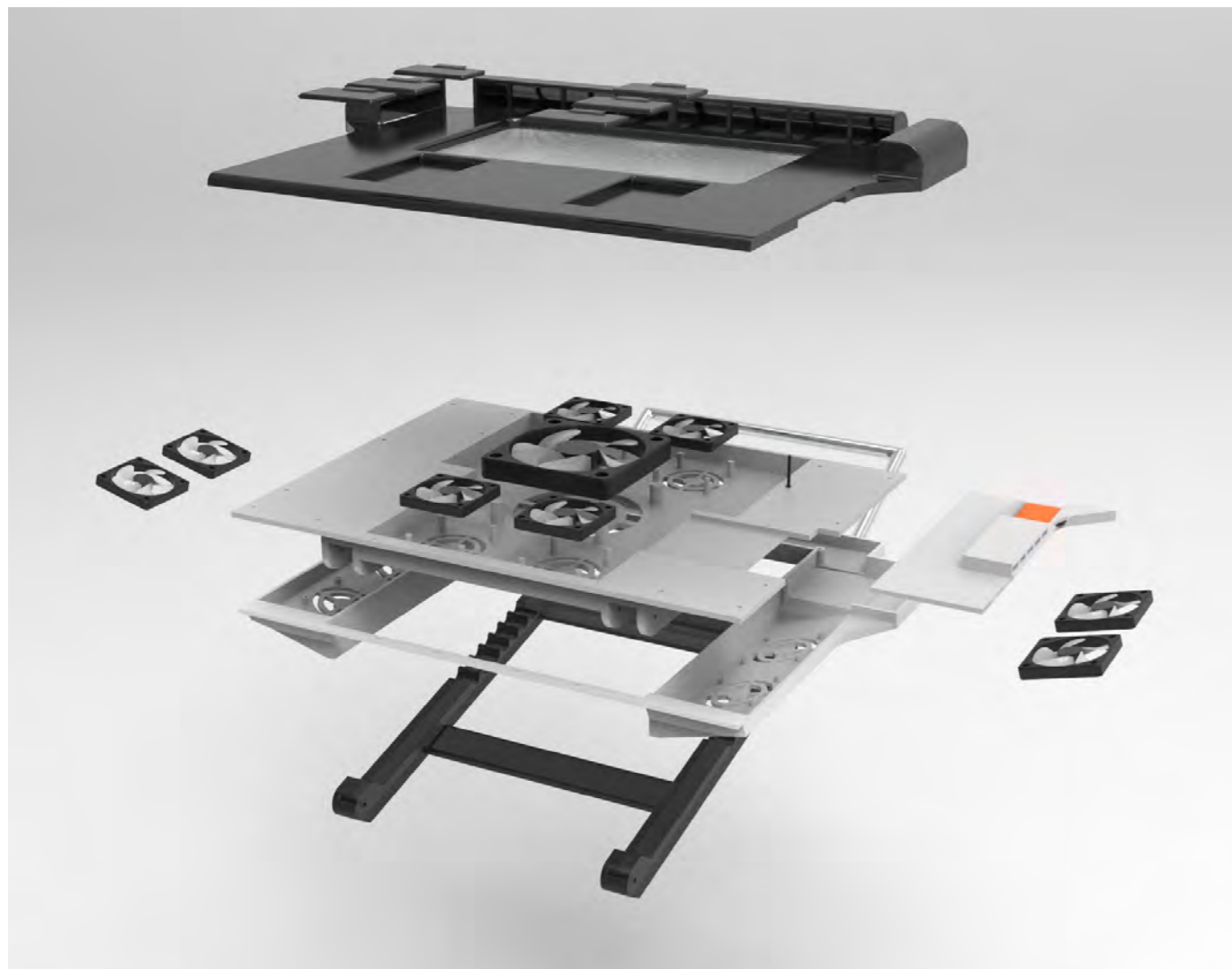
There are 3 groups of blockers, each of them could be opened separately. Its height when has been slightly larger than the height of the laptop base, for avoiding interference with the user's arm while using. The suitable size range for each blocker has been shown below:





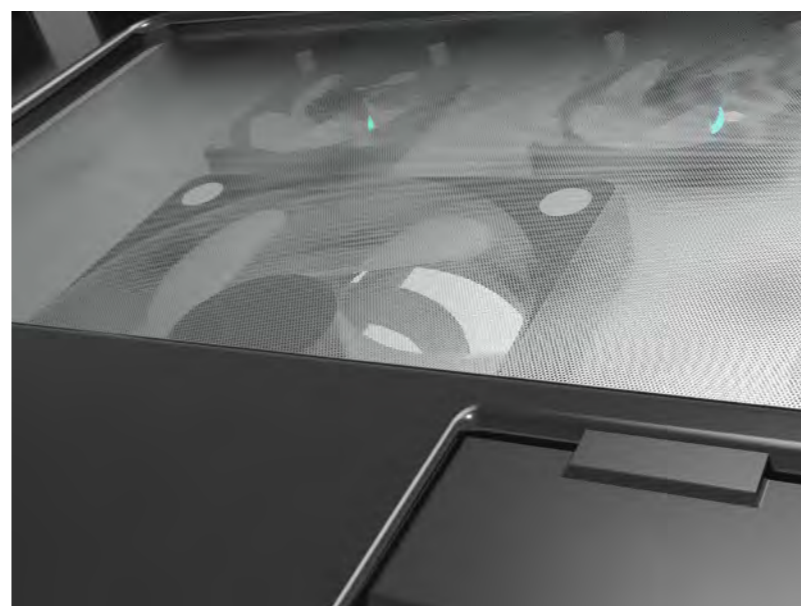
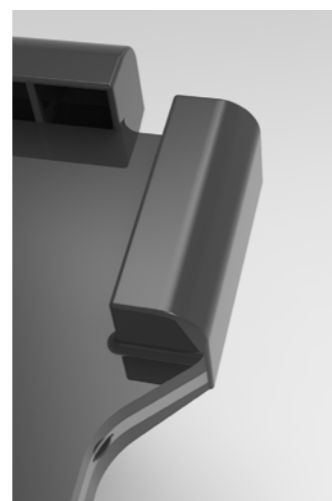
Final Product

How does it work? What does it look like?



The port on the surface of the panel has been connected to the hot air ventilation layer, which is isolated from the layer which aimed to send cold air into the laptop. The circulation path of the cold air and the hot air has been divided by different layer parts to prevent the air with different temperature hybrid accidentally.

The port for absorbing ejected hot air has left the space for laptop power line connection. Moreover, the adjustment button is on the right side of the cooling panel, which is much easier to touch compare to place the switch on the backside.



Anti-dust net, for preventing dust accumulation



Product Using Simulation

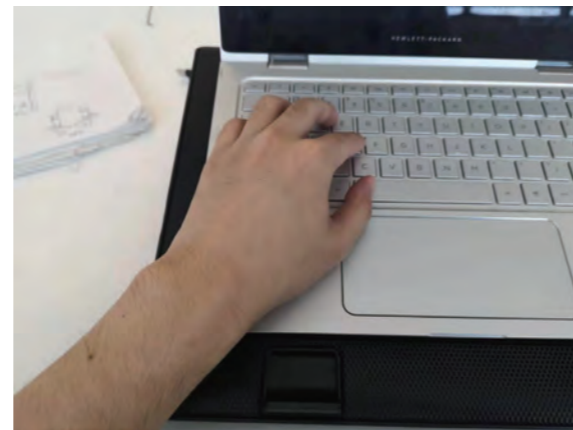
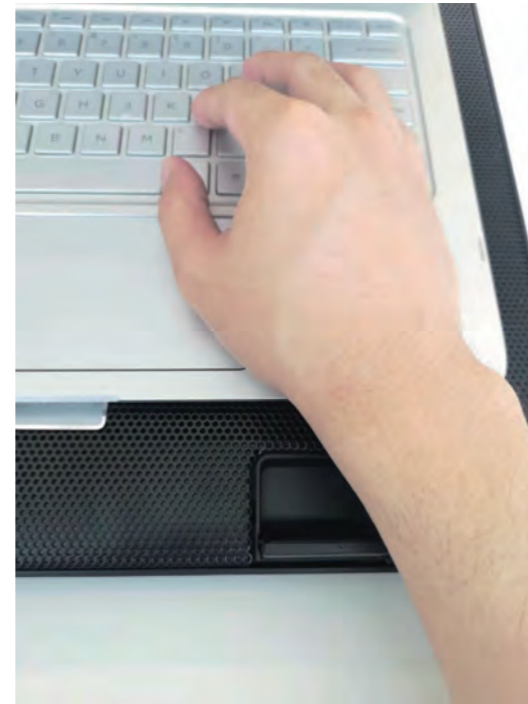
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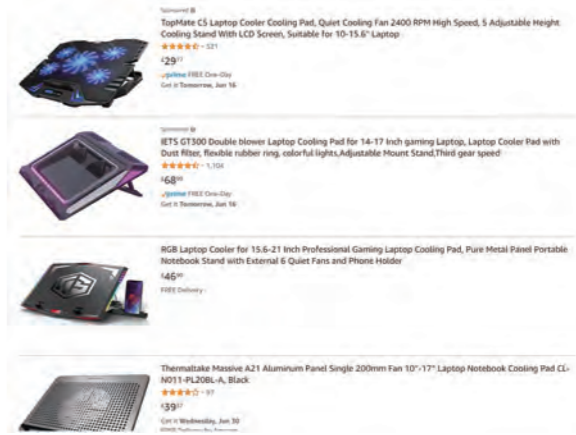
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User Position Test



Market Research



Product Structure Research

