



Household appliance in circular economy

Msc Product design engineering

Anqi Zhuo

BACKGROUND

Small household appliances have become an indispensable product in people's lives. In 2020, the global sales of small household appliances were 3.883 billion pieces, and the market revenue was 224.1 billion dollars.

But behind the economic development and convenience of life brought about by small appliances are the electronic waste that increases by 2.5 million metric tons per year and the limited resources that are constantly being consumed.

CLASSIFICATION

Small household appliances generally take up relatively small power resources or have a relatively small body. According to the usage scenarios, small household appliances can be divided into 3 categories:



Kitchen appliances



Personal care appliances



Living appliances

WASTE PHENOMENON

The current waste of resources involved in small household appliances can be summarized as follows:

1. Difficulty to repair makes the product life short
2. Lack of a sound recycling system, causing users to discard waste products at will
3. Fast iteration speed but inability to upgrade leads to high obsolescence rate of small appliances



INITIAL RESEARCH

There are many participants in the entire process of small household appliances from production to scrap. From the perspective of circular economy, I researched related policies, corporate behaviors, and users to find out the root cause of waste of small appliances.

Legislation



By consulting the literature and the laws of various countries for the recycling of e-waste, it is found that 78 countries have made regulations on e-waste recycling, most of which are centered on the EU's Extended producer responsibility.

However, the liability definition is not clear in the regulations, and due to the wide variety of small household appliances, it is difficult to give clear recycling details. Therefore, the recycling regulations for small household appliances are basically vacant in all countries.

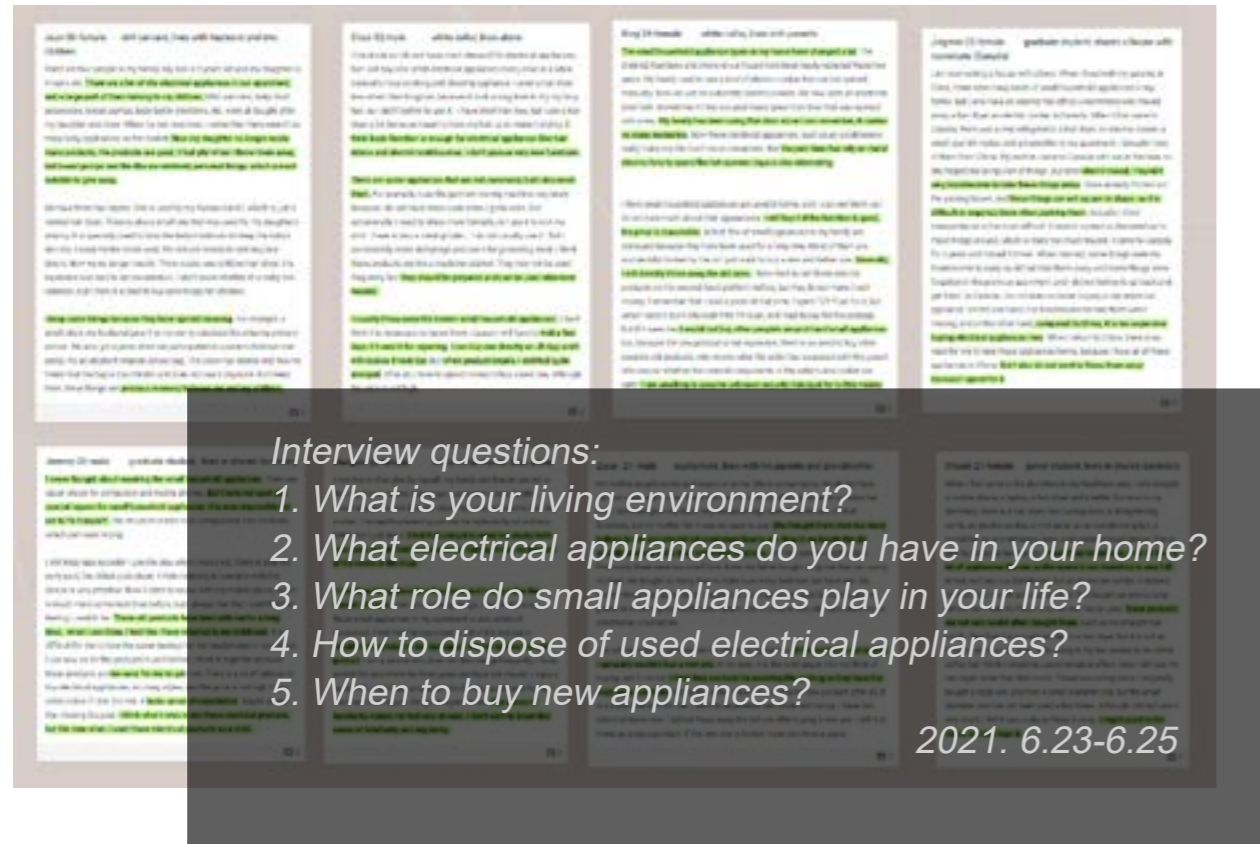
Corporate Behavior Analysis

As producer of small home appliances, gaining benefits is the fundamental goal of an enterprise. Through research and analysis, summarize the reasons why companies refuse to participate in recycling and manufacture products that are difficult to repair and upgrade.

1. Small household appliances are small in size, and there are few recyclables that can be disassembled. The cost of collecting and disassembling waste products is far greater than the profit of recycling.
2. In order to promote user consumption, enterprises use build-in obsolete to stimulate users to buy new products.
3. Competition in the small home appliance market is fierce. Enterprises attract customers through rapid iterations of technology and product appearance to seize market share.
4. In order to protect business interests, maintenance documents and key information are kept confidential.
5. The difficulty of disassembling and repairing the product also reduces the safety risk caused by the user's self-repair to a certain extent.

User Interview

In order to understand the relationship between users and small appliances, I interviewed 8 users of different ages and genders living environment.



Interview questions:

1. What is your living environment?
2. What electrical appliances do you have in your home?
3. What role do small appliances play in your life?
4. How to dispose of used electrical appliances?
5. When to buy new appliances?

2021. 6.23-6.25

Summarizing the interview results, I extracted common points as follows:

People's demand for small household appliances is constantly changing

People discard old appliances because of broken or backward technology

People refuse to buy second-hand small appliances because they are unwilling to take health and safety risks

People often refuse to repair small appliances because of high price and time costs, and most people do not have the ability to repair small appliances.

Some old products will arouse people's emotions and memories

Case Study

I sorted out and analyzed the existing business cases related to circular economy. These cases are very consistent with the characteristics of the corresponding products. The practice of seeking design opportunities by digging out product features provides inspiration for the circular design of small home appliances.



OFO sharing bicycles

Leasing economy--reduce resource consumption



Uber

Sharing economy--improve resource utilization



Saturnbird Coffee--project return

Material reuse--promote recycling



Gerrard Street Earphone

Modular design--extend product-life

Some small household appliances like hair dryer and electric shaver are very private and are frequently used in daily life. Therefore, sharing strategies may affect the convenience and privacy of small household appliances.

Household appliances are not fast consumption products like food packaging, so using fully degradable biomaterials may reduce the robustness of household appliances.

Circular Economy Method Chose

There are many methods of circular economy, involving technical and biological aspects. Due to the short lifespan fast iteration of small household appliances, I found that only recycling waste products cannot solve the problem fundamentally. It is necessary to reduce the circulation rate of resources from the source. According to the theory of circular economy, 'slowing loops' is suitable for this project.

DESIGN PURPOSE

There are many types of small home appliances. According to the sales volume of small home appliances on Amazon and Alibaba's online shopping platforms, I decided to design the hair dryer with the highest sales volume. Through the redesign of the hair dryer, explore the coexistence of small household appliances in terms of environmental resources, corporate interests, and user needs.

PARALLEL PRODUCT ANALYSIS

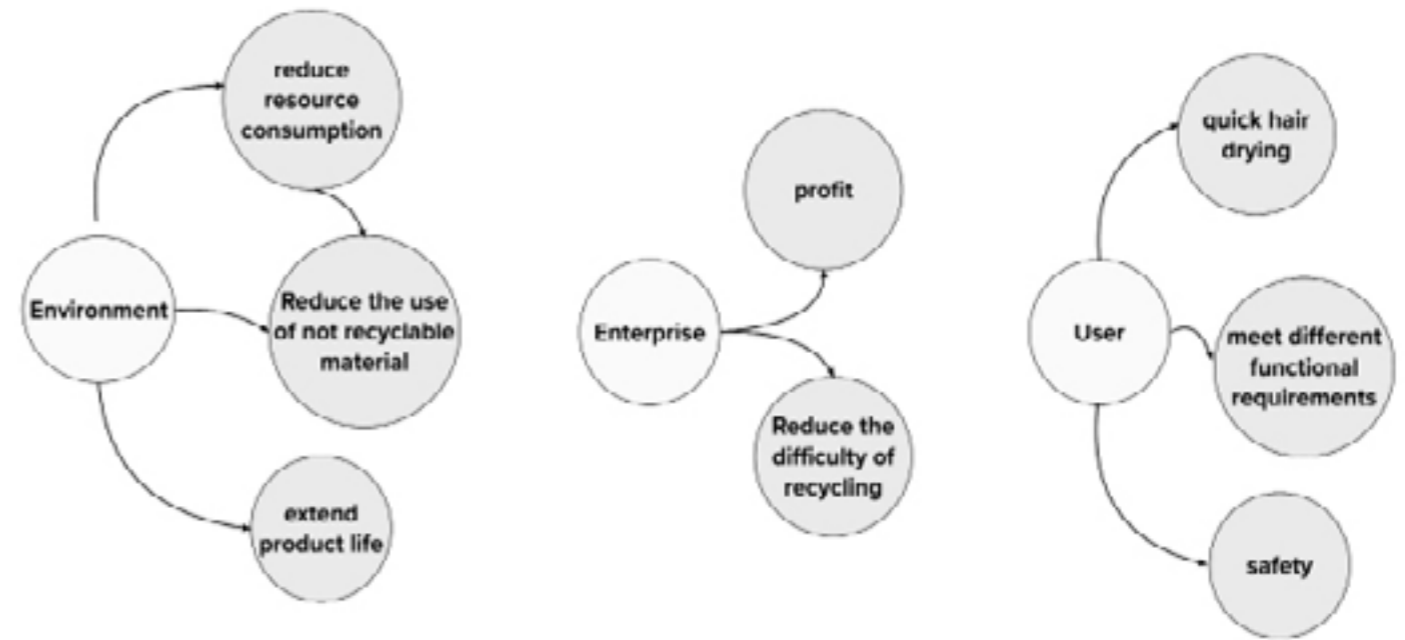
Hair dryers on the market can be divided into the following four categories according to their functions, with prices ranging from £5 to £300.

			
<i>General hair dryer</i>	<i>Children hair dryer</i>	<i>Negative ion hair dryer</i>	<i>Temperature control hair dryer</i>
Low temperature and low power	Has an anion emitter	Has an NTC intelligent temperature control sensor.	

After checking 12 different price brands of hair dryers on China's Taobao shopping platform, it was found that most of the low-priced brands do not provide maintenance services. Some high-priced brands provide repair services, but users need to fill in a multi-page information form. After the appraisal, users pay high repair costs, which takes a long time, and even fails to get satisfactory repairs result.


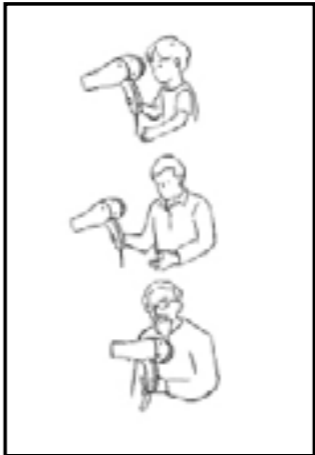
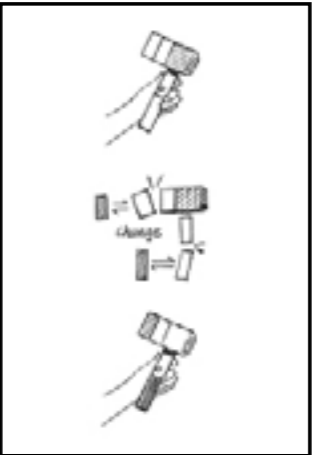
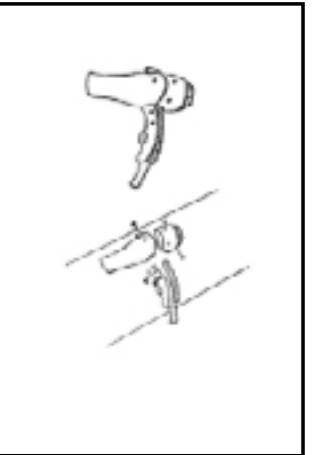
It can be seen that the current after-sales maintenance service process of the hair dryer is cumbersome, which affects the user's choice of maintenance products.

DEMAND OF HAIR DRYER



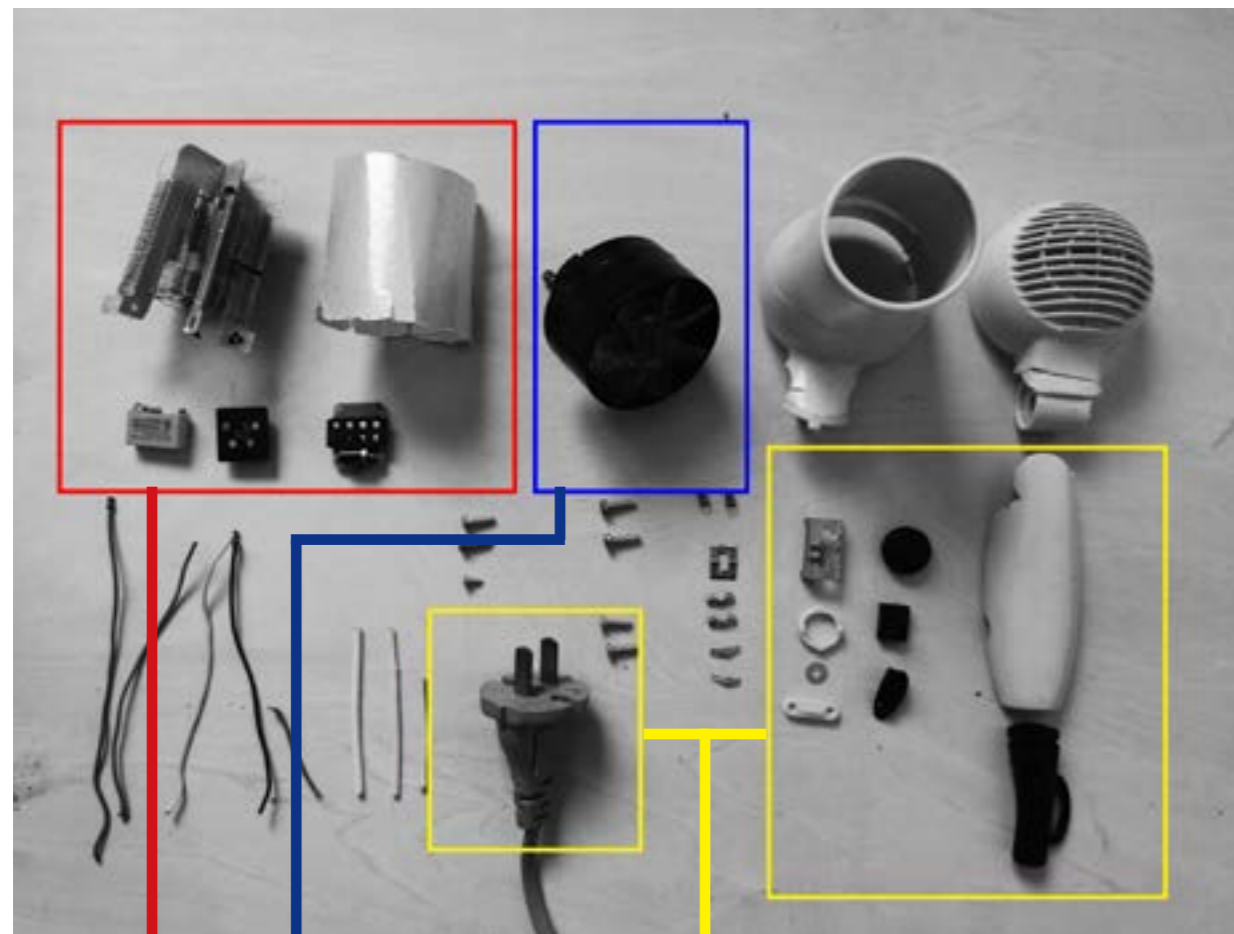
IDEA EXPLORATION

According to the preliminary research, four inspirations were obtained. After a comprehensive assessment of the three aspects of enterprise, environment, and user benefits, it was decided to choose modular design for in-depth exploration.

			
Shared module	Affective Sustainability	Modular design	Active disassembly
Environment ■ ■ ■ □ □ □	Environment ■ ■ ■ ■ □ □	Environment ■ ■ ■ ■ □ □	Environment ■ ■ □ □ □ □
User ■ ■ □ □ □ □	User ■ □ □ □ □ □	User ■ ■ ■ □ □ □	User ■ □ □ □ □ □
Enterprise ■ ■ ■ □ □ □	Enterprise ■ □ □ □ □ □	Enterprise ■ ■ □ □ □ □	Enterprise ■ ■ ■ ■ □ □

PRODUCT DISASSEMBLY EXPERIMENT

In order to understand the internal structure of the hair dryer and determine the division of the modules, I thoroughly disassembled three hair dryers with different functions. Some problems with current hair dryers are found through disassembly



Main switch and power supply line

Motor and fan, core element of the hair dryer, responsible for generating air flow

The heating wire is connected with the fuse, responsible for heating the airflow



All the parts of the hair dryer are connected together in the same housing. For users, once a part is damaged, the entire product must be discarded, even if the remaining parts are functionally intact.



Difficult to disassemble. Disassembled this hair dryer requires multiple screwdrivers of different blade types, including rare special-shaped screws.



There are many electrical components inside the hair dryer. Most users do not have engineering knowledge to repair circuits, so for users, disassembly and repair will be potentially dangerous.



Some connection structures use glue or anti-disassembly buckle connection, so that after disassembly and reassembly, the product shell inevitably leaves disassembly traces, which affects the appearance of the product.

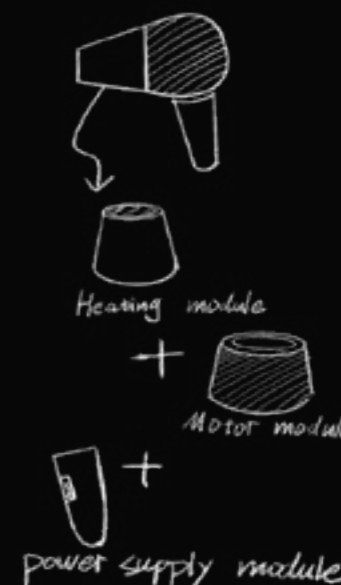


The casing of the product is mostly plastic. As time goes by, the outer casing is worn out and aging. And in the recovery phase, it can only be downgraded for recycling.

DESIGN GOAL

1. The user does not need to touch the circuit, and does not need to have engineering knowledge to repair the hair dryer.

2. Allow users to replace the damaged module by themselves instead of throwing away the entire hair dryer



Divide the hair dryer into three modules:

- Thermal module**
- Motor module**
- Power supply module**

The three modules exist independently and are used in combination.

PERSONA



Juan Li

GENDER female

AGE 32

OCCUPATION accountant

KIDS one daughter

Juan's life is busy and regular. After taking a shower in the morning, she uses a hairdryer to quickly dry her hair. For her, the hair dryer is an indispensable product in life. Lijuan is usually busy at work, so whenever a small electrical appliance at home is damaged, she will buy a new product directly from the Internet and never consider repairs the old products. For her, it takes too much time to send the product to the repair point. And she does not have any engineering knowledge to support her to repair products on her own.

SAFETY CONSIDERATION

Before carrying out specific design work, need to anticipate the hazards that the product may cause, so as to avoid hazards during the design process.



Electrical safety

The connection between the modules is not stable, which may cause the user to accidentally get an electric shock during use.



Heating safety

Hair dryer contains an electric heating element, so functional heating will inevitably occur during use. If complete heat insulation treatment is not carried out, there will be a risk of burns to the user and even a fire.



Mechanical injury

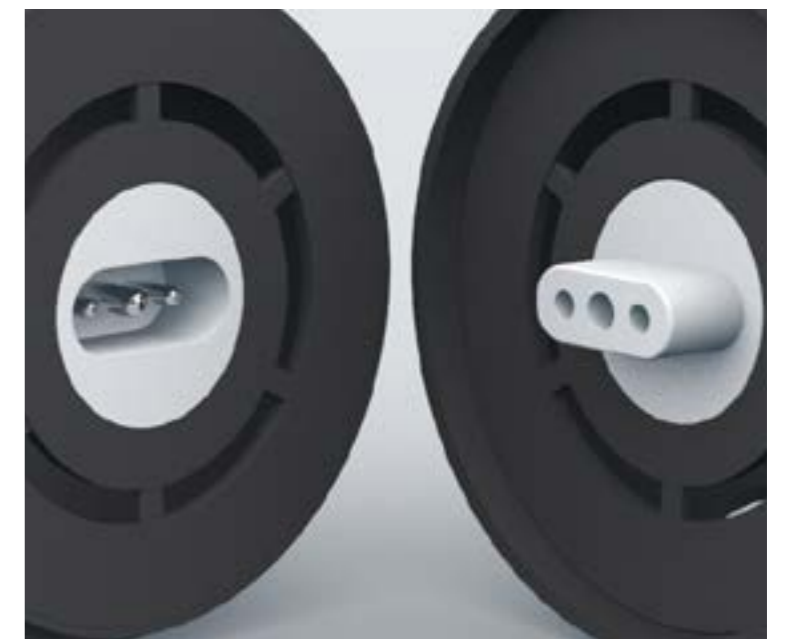
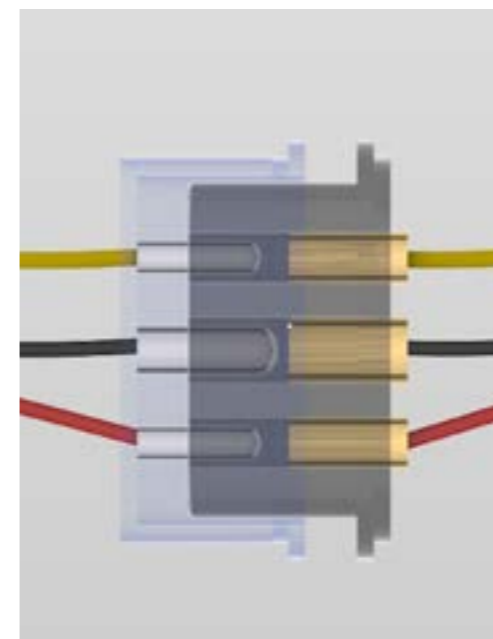
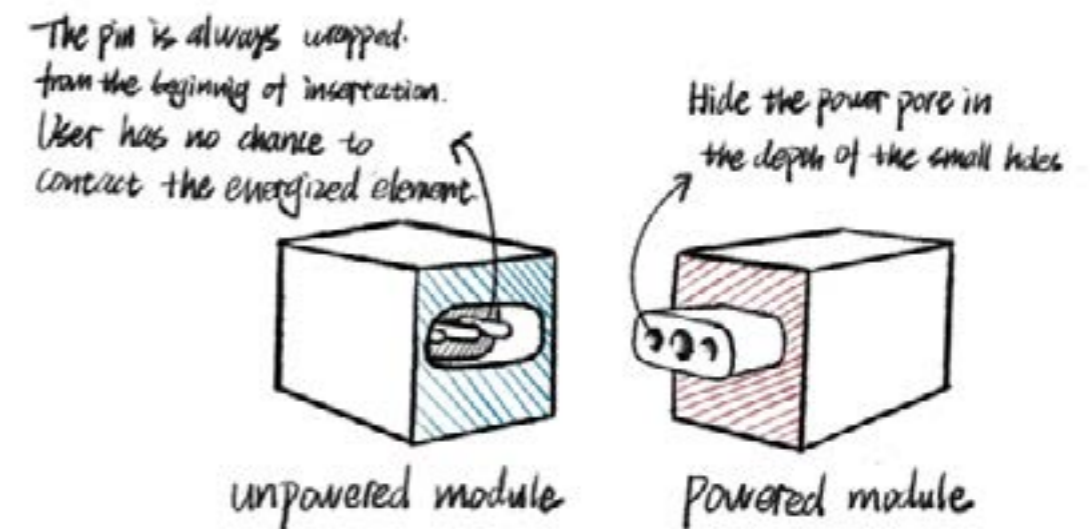
The product contains a motor and a rotating fan, if the installation is not firm, vibration will affect the stability of the product, cause component failure and potential electric shock hazards.

CONNECTOR DESIGN

Since the connection of the module involves power supply, the power-on interface must be hidden in accordance with **electrical safety standards** to prevent users from directly contacting the live interface.

Therefore, before exploring the specific connection method, the power supply interface is first designed. The female part of the connector is set on the power supply module, and the male part is set on the module that be energized.

In addition, the power supply contact point is set in the deep part of the protruding female head, so that the needle is tightly wrapped by the connector structure from the beginning of the module connection, preventing the user from touching the power-on original

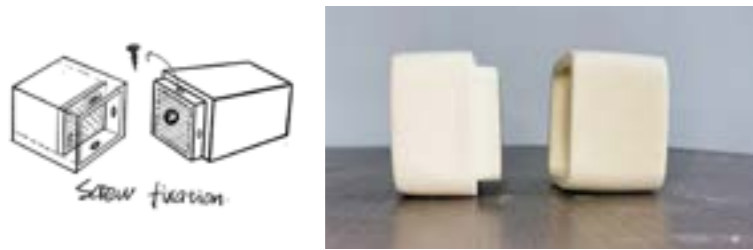


CONNECTION EXPLORE

Hair dryers have a life expectancy of about 200-300 hours. If users use 15 minutes to dry hair everyday, a new hair dryer should be retired after 2 years.

According to the service life of the hair dryer, it can be judged that the module of the hair dryer **does not need to be disassembled frequently**. The connection between the modules should be more **focused on the electrical safety and mechanical stability**.

Concept 1



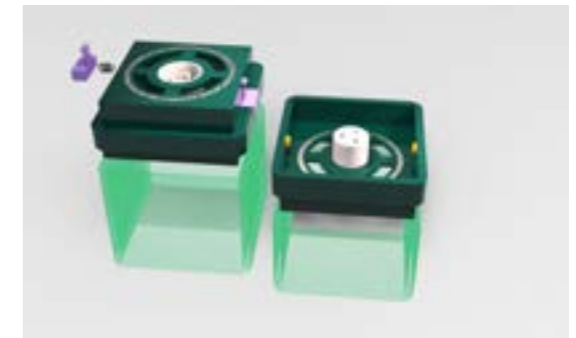
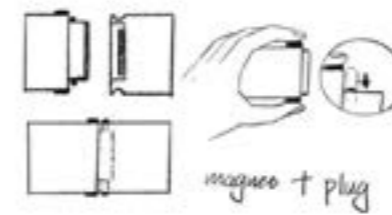
Fasten the two modules together with four screws.

Concept 2



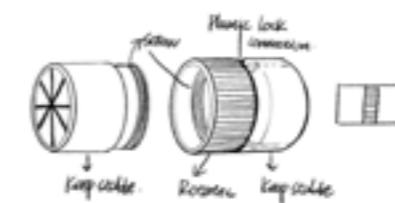
Use the sliding buckle to prevent the module from moving upwards. The lateral movement of the module is limited by the power supply interface.

Concept 3



Connect the two modules by pressing the buckle. Add a magnet ring between the two modules to enhance the connection between the modules.

Concept 4



A ring with internal threads is fixed on the module by round snap. The buckle limits the axial movement of the ring, but does not affect the circumferential movement of the ring. The surface of the other module has external threads. By rotating the ring, the module is connected.

Concept 5



Directly connected by threads. Leave a sufficient gap between the power supply interface and the housing to ensure that the power supply interface remains fixed when the housing rotates, and to ensure sealing, a rubber ring needs to be added.

Concept 6



The two modules are plugged together through the power supply interface. Subsequently, a ring with protrusions and internal threads on the inner is sleeved from the module with the shoulder, and the other module is connected by threads.

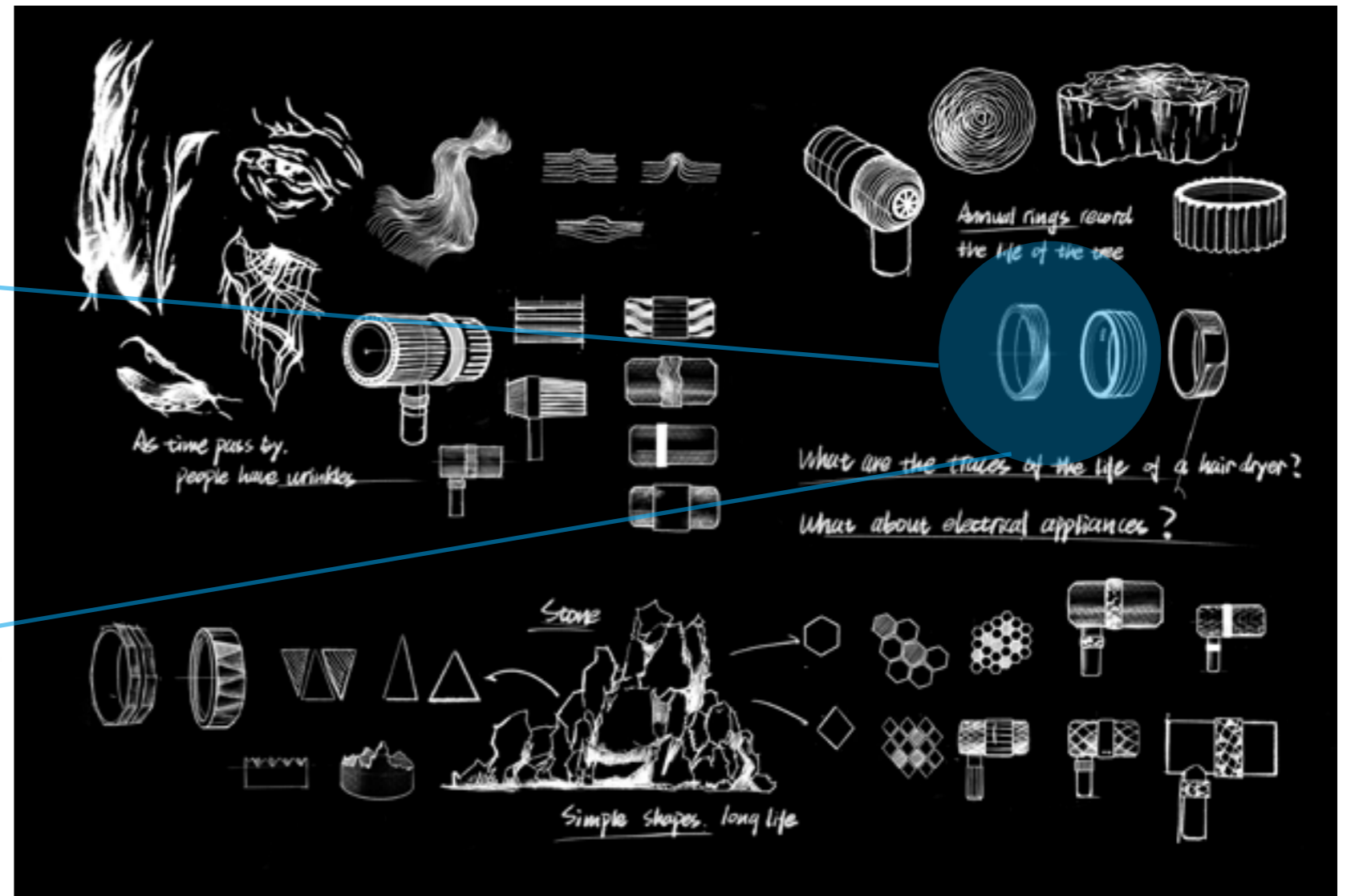
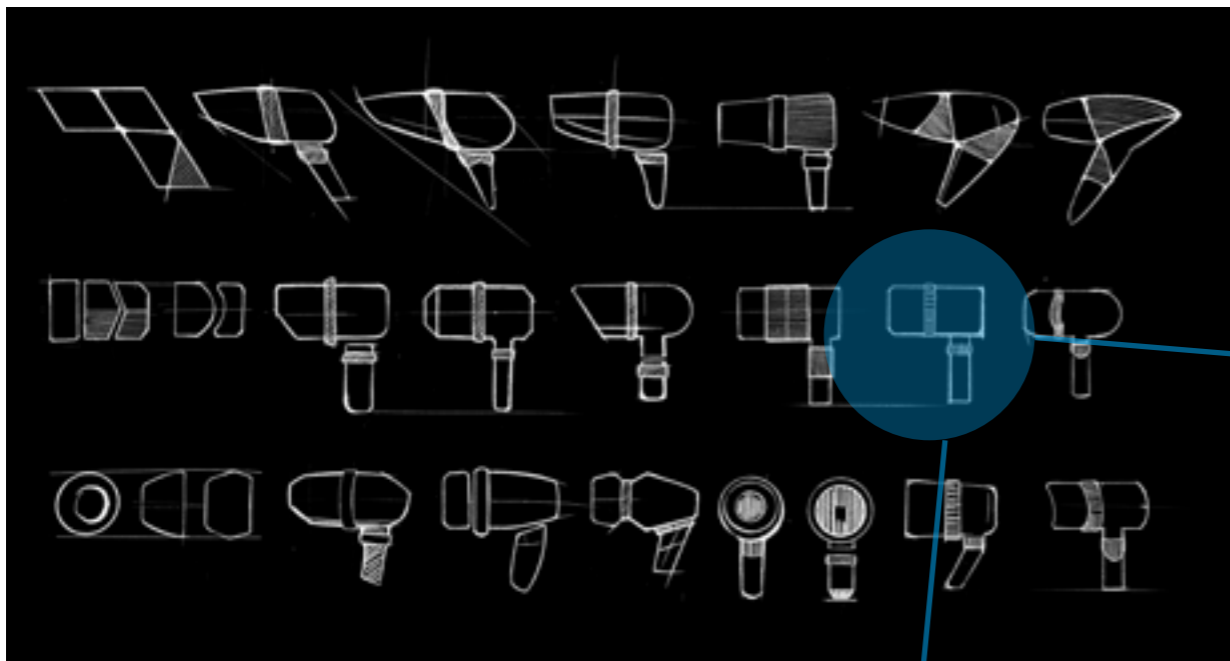
I adopted the PUGH decision matrix to comprehensively evaluate the six connection methods. Concept 6 got the

	weight	1	2	3	4	5	6
manufacturing cost	1	1	0	-1	1	-1	1
Recycle cost	1	1	1	-1	1	-1	1
Impact on aesthetics	1	0	1	0	1	1	-1
Safety (stable)	3	1	-1	1	1	1	1
User acceptance	1	-1	1	1	0	1	0
Influence on internal structure	2	-1	-1	0	-1	-1	1
Durability	1	1	0	-1	-1	1	1
TOTAL SCORE	10	3	-2	1	3	2	7

MOOD BOARD



SHAPE AND TEXTURE EXPLORATION



DESIGN REFINEMENT

Ergonomics



Through disassembly experiments and measurement of the handles of 9 hair dryers on the market, it is found that the diameter of the handles of the hair dryer is between 33-38mm. Therefore, directly use the existing product as a reference, and the handle diameter is designed to be 35mm.

Make a 1:1 foma model, change the length of the handle between 12-20 cm, and install the movable buttons in multiple positions on the handle, and then perform user tests. According to the test results, the more comfortable handle length is 15cm, and the button position is the most comfortable between 12-13cm.

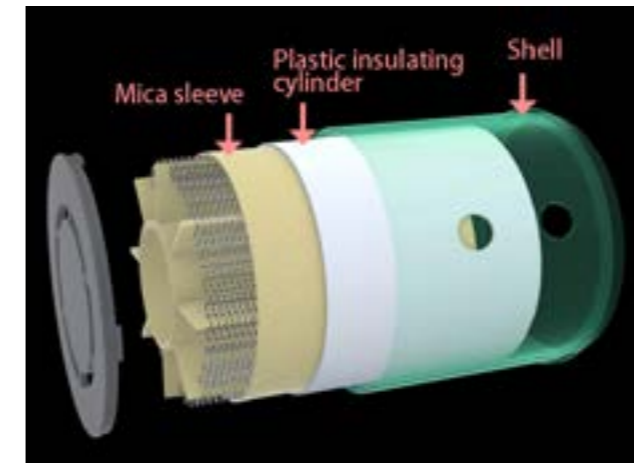
Prototype test

After using computer aided design, the 3D model of each part was established, and then 3D printing was carried out at a ratio of 1:1. Carry out assembly tests to verify the rationality of the structure.



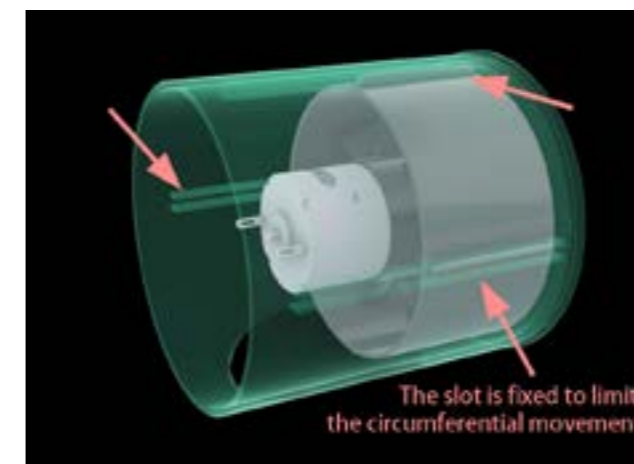
Moudle structure

According to the possible electrical hazards, thermal hazards, and mechanical hazards listed in the 'safety consideration', the thermal module, motor module, and power supply module are all structurally designed to ensure user safety.



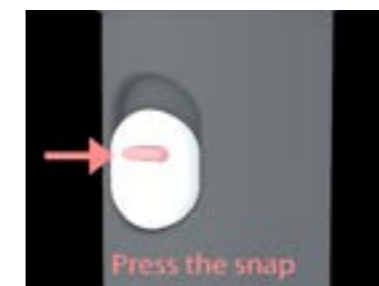
Heating Moudle

In order to ensure the heat insulation effect, a mica sleeve is added outside the heating wire, and a plastic insulation cylinder is added between the mica sleeve and the air duct shell to ensure the thermal insulation and also electrical insulation.



Motor Moudle

In order to fix the motor and the fan blades, a fixed cylinder is added between the module housing and the motor. The inner wall of the cylinder has a slot, and a protrusion matching the slot is added on the outside of the fan blade. The circular motion of the motor is restricted by the positioning



Power Supply Moudle

In order to prevent the user from accidentally touching the switch of the power supply module during the process of removing or installing the module, a movable buckle is added to the switch of this module. Only by pressing the buckle can the switch be turned on. as the picture shows.

FINAL DESIGN



SWITCH

Heating module and motor module have individual switches. It is available for users to adjust the wind power and control the hot and cold air flow.

HEATING & MOTOR MODULE SHELL

Made of aluminum alloy, which is durable and can be completely recycled without affecting the performance. In order for safety, there are plastic insulation cylinders in the heating module and the motor module. It not only plays the role of insulation but also ensures the strength of the structure.

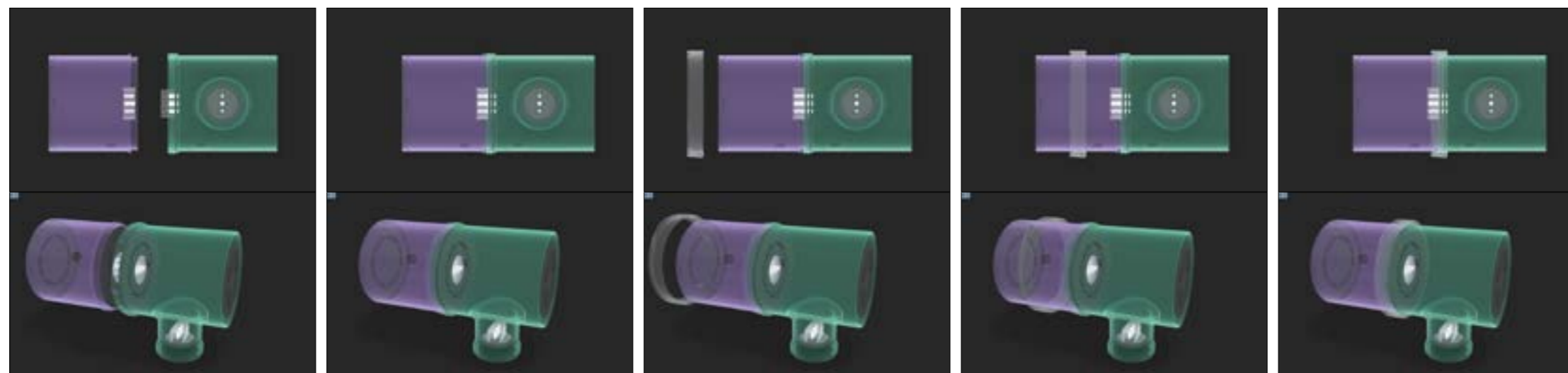
FIXED RING

Made of aluminum alloy and is engraved with the factory time of the hair dryer, user can also choose a personalized engraving service. Drawing lessons from the shape of the Mobius belt, the arc design on the outside of the ring echoes the theme of circulation. In the subsequent user replacement of the damaged module, no matter how many modules the user has replaced, this ring will always be kept.

POWER SUPPLY MODULE SHELL

Made of ABS plastic. This module is directly connected to 240V voltage, the risk is the highest. Therefore, ABS is used to ensure insulation, and ABS is more suitable for gripping than metal.

Steps for connection

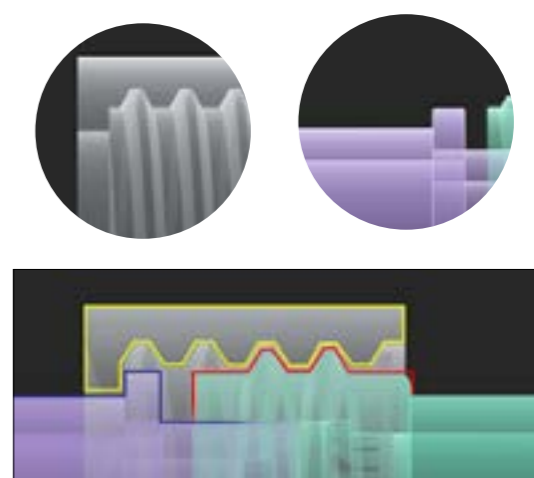


STEP 1 Connector insertion

STEP 2 Sleeve into the fixed ring

STEP 3 Rotate the fixing ring, tighten the thread, and complete the fixation

stuck and pressed



USER FLOW



Why it is more circular?

For Environment

It can reduce the consumption of resources. Each module of the hair dryer can play its role to the greatest extent, slowing down the circulation of resources and alleviating the pressure on resources. Secondly, the product shell is made of aluminum alloy, which is more durable and wear-resistant than plastic. In theory, metal can be recycled to 100% without affecting material performance. Finally, users will take the initiative to return the discarded modules to the company, which reduces the difficulty and cost of recycling old products for the company to a certain extent, and can drive the company to participate in recycling through benefits. Therefore, the project has a positive impact on the environment.

For Enterprise

Increase user stickiness and ensure market share. Traditional small home appliance companies attract users to buy their own products through rapid modeling iterations and functional updates to ensure profitability. However, the market for small home appliances is fierce. Users do not be obsessed with buying products of a certain brand after the product is damaged. Therefore, enterprises are always facing the risk of market competition. But for this modular hair dryer, when a module is damaged, in order to match the undamaged module, there is a great possibility that users will continue to buy products of the same brand instead of consuming products of other brands. Although the company's product sales may decrease, the increased user stickiness will make up for this. In the long run, it will help build a positive brand image of the company.

FURTHER WORK

In this project, users will return waste products to the company by mail to help recycling. This seems to be beneficial to the environment and resources, but I found that this method may incur a lot of mailing costs, increase the consumption of mailing packaging materials and the energy consumption of transportation products, which may cause an increase in the potential carbon footprint.

If I do not make rigorous calculations and obtain data, it is difficult to perfect a circular economy project. Therefore, I think what I need to further think about is how to measure the carbon footprint of the entire process from production to recycling, how can I compare the environmental footprints of existing products and circular design products with accurate digital data. Doing so will make this project more convincing.

For Users

This hair dryer gives users the opportunity to repair and upgrade the product without having to have circuit knowledge or disassembling the product shell. The user only needs to replace the damaged module or the module that needs to be updated to extend the service life of the product. While realizing environmental protection, it also meets the needs of users for functionality and economy. For traditional hair dryers, when the components are damaged, users will often directly discard the entire product and purchase a complete new product. When products with upgraded features appear, some users will also choose to discard the old products and buy new products. These actions all lead to the waste of resources, that is, the products that have been produced are not fully utilized, but new products are being produced continuously consuming limited raw materials. This is, to some extent, an overproduction. The design makes the ultimate use of the value of the product, so that the product can complete the entire planned service process.