

A Handheld Multifunctional Vacuum Cleaner

Masters Project
Design Process Journal

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BACKGROUND

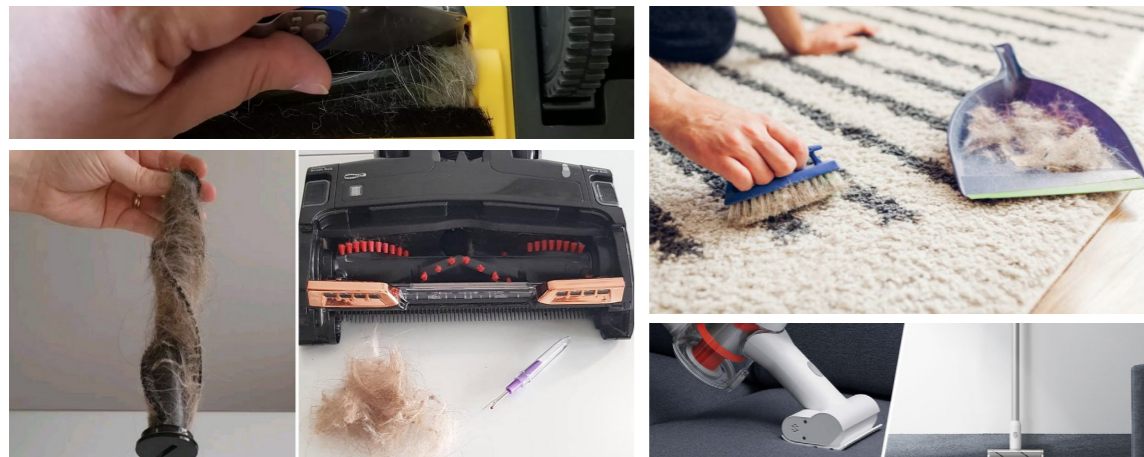


A recent study of 2,000 Americans, commissioned by ARM & HAMMER Clean & Simple, found that on average Americans spend 23 hours and 36 minutes on cleaning and housework per month.

The new research aims to reveal how the COVID-19 pandemic has affected the habits and household dynamics when it comes to cleaning. On average, American parents who live with a partner spend 23 hours and 36 minutes on cleaning and house work each month. That comes out to 5 hours and 54 minutes per week.

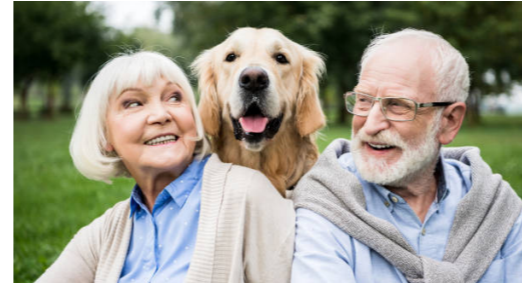
On the list of most time-consuming tasks: 50% of respondents said sweeping and dusting took the longest, 48% said cleaning the bathroom was the most time consuming and 44% reported laundry to be the time suck of their week.

EXISTING PRODUCTS ANALYSIS

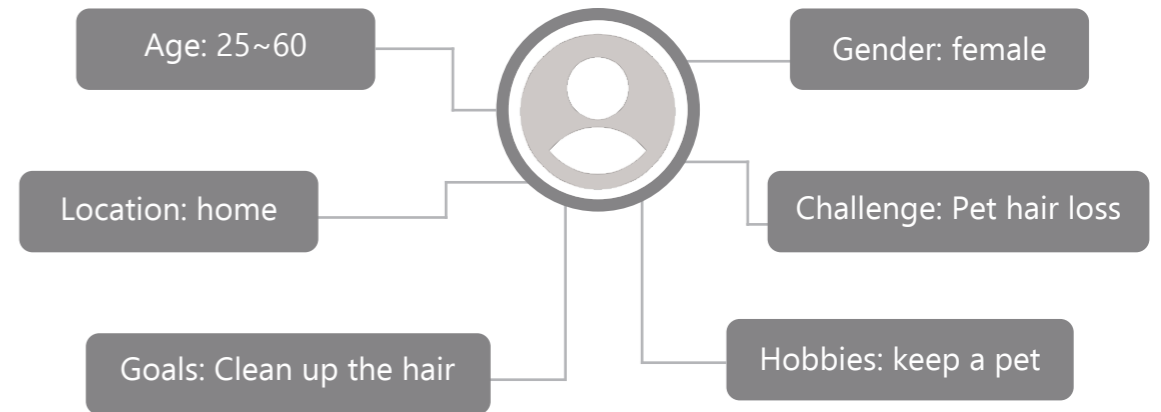


When these products are cleaning the floor or carpet, the roller brush is often entangled with hair and pet fur. And they can't adapt to work in a variety of environments, such as vacuum cleaner can only clean the floor, but can not be used to clean wet tiles. In addition, it is not convenient to clean the dust box after using these products.

MARKET



CUSTOMER PROFILE



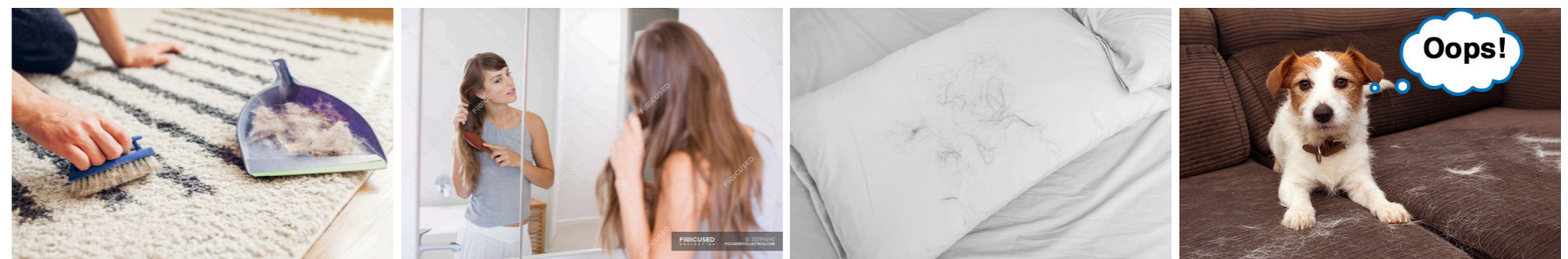
LIFESTYLE

The targeted users are housewives, women living alone, or elderly couples, they may have pets, and they often clean their homes. Women often shed some hair on the ground when they take care of their hair. Many pet cats and dogs also shed a lot of hair in spring and autumn. They need simple and convenient smart products to automatically collect these hairs.

ENVIRONMENT OF USE

The main use environment is at home.

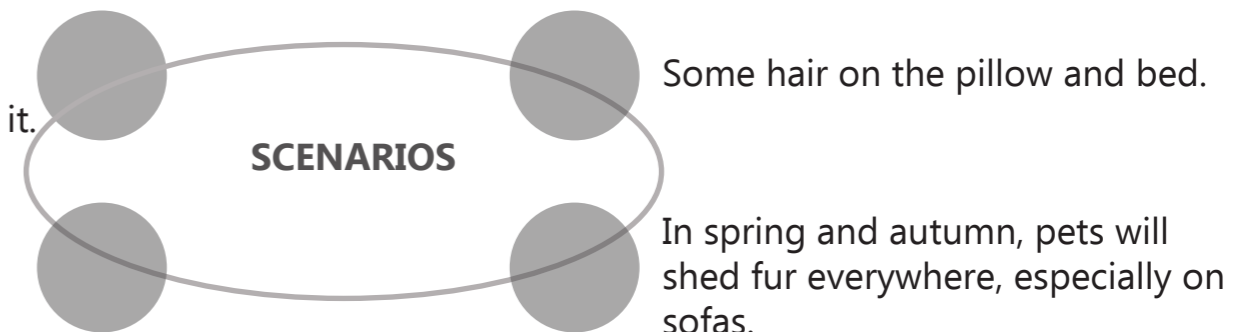
During household cleaning, we will find a lot of fallen hair, which may be on the floor of the bathroom, or on the sofa or bed or carpet. These hairs may come from people or pets. They are very small and difficult to be collected and cleaned.



When cleaning the carpet, someone needs to lie on the ground and use a brush to clean it.

Ladies will lose some hair when combing their hair.

SCENARIOS



PERSONA



Zijin Yao
24
Freelancer
Living with her mom

Bios

Lives in an apartment, 2 rooms, with her mother, Prepare for the exam at home, Raised a cat and a dog, after a long time of study, she likes to play with cats and dogs.

INTERVIEW

Wants & Needs

- Can quickly clean up cat hair on clothes, bed or sofa
- Can clean narrow and small places
- Can quickly clean up hair falling on the floor

User Empathy

"If you have a pet, you know how frustrating pet hair can be. My cat leave hair everywhere. I vacuum, dust and clean the house only to see new tumbleweeds of hair rolling across the floor. I go out to dinner and look down to find beautiful cat hairs firmly attached to my suit."

Frustrations

- Sometimes just hugged the cat before going out and need to clean up the cat's hair on my clothes. Don't want to spend too much time and effort to use a large vacuum cleaner.

USER EXPERIENCE



Where does she need to clean up the hair at home?

Sofa & Bed

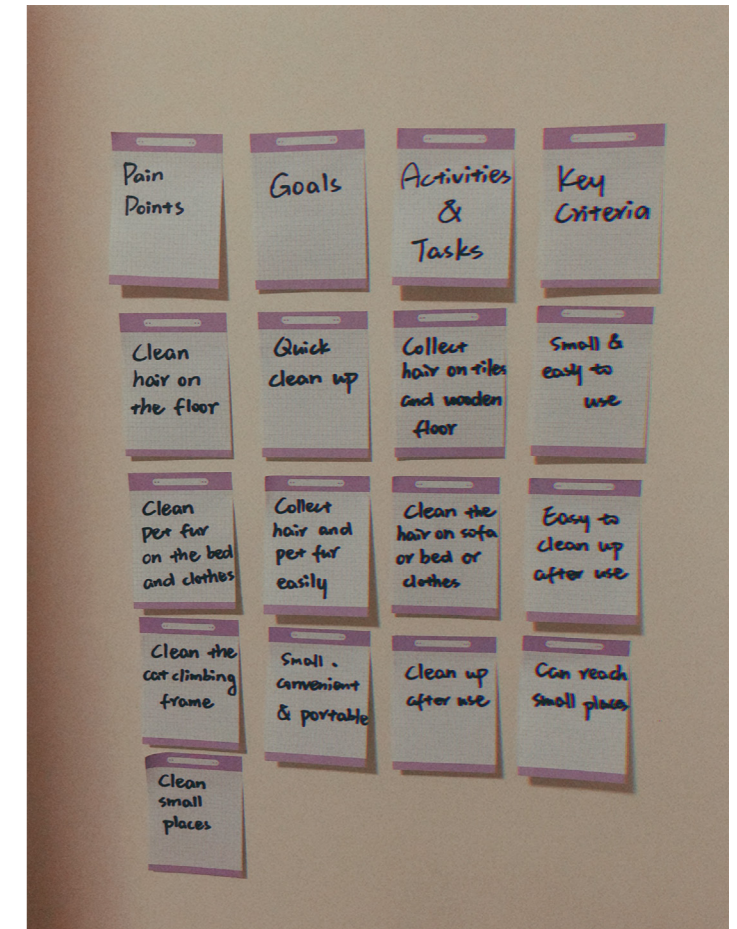
Floor

Clothes

Cat tree

- Use many kinds of tools to clean the hair and pet fur
- It is difficult to clean the hair on the bathroom floor
- Using tape to stick cat hair is very wasteful

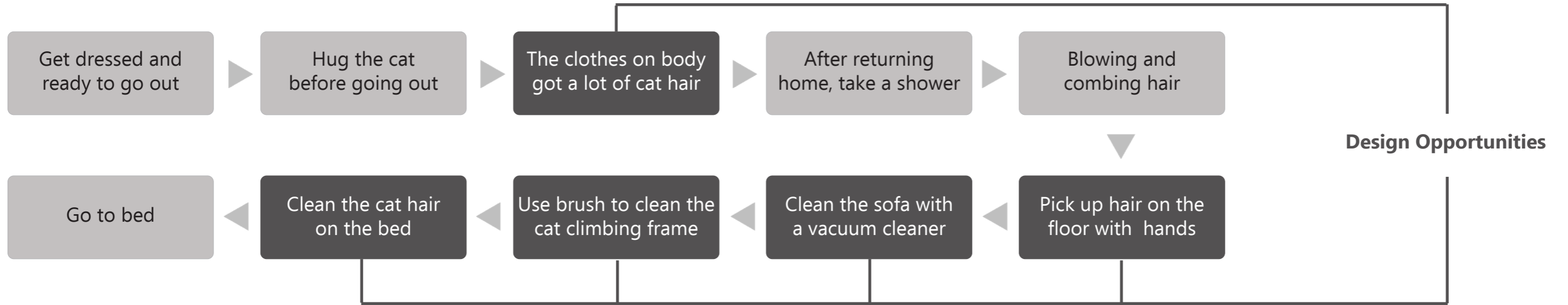
AFFINITY MAPPING



USER JOURNEY MAP

Phase of journey	After bath			Clean the room				
Actions	Mopping the floor	Combing hair	Clean the hair on the floor	Clean the wooden floor with a vacuum cleaner	Use a roller brush to stick the cat hair on the sofa	Find the hair on the pillow	Use a roller brush to clean bed and clothes	Use a brush to clean the cat climbing frame
Customer Thought	I lost a lot of hair	The tiles just mopped are very smooth	Hair that falls on the tiles is difficult to pick up	It is troublesome to use vacuum cleaner	Need a lot of tape, it's a waste	Can't see where the hair is	Takes too much time	Cannot reach small places
Customer Feeling	🤔			😞				
Opportunities	Collect hair on tiles	Replace the comb that is not prone to hair loss		Small and convenient product	Reusable	Quick clean up	Can reach small locations	

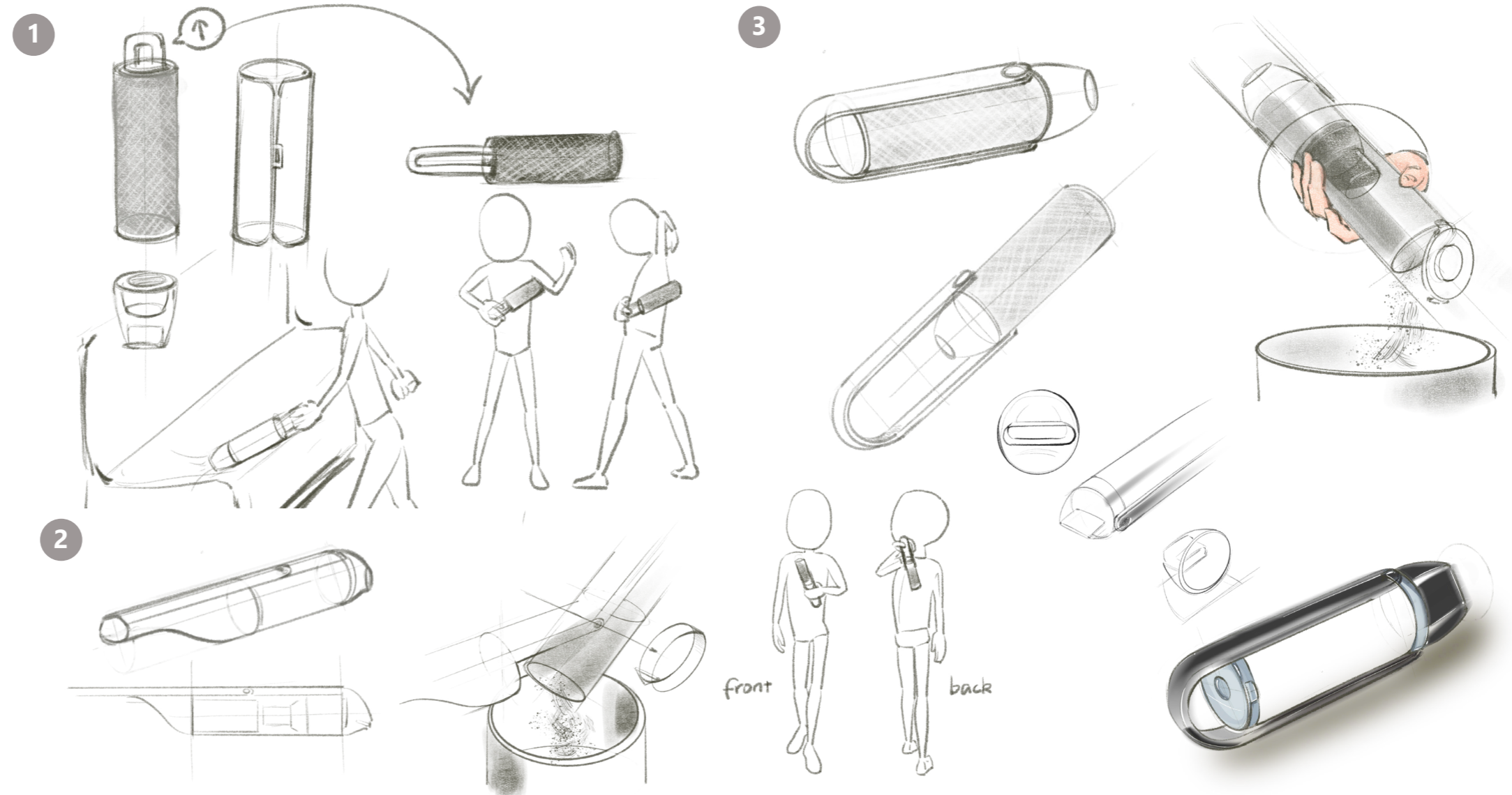
TARGET USER TASKS ANALYSIS



PRODUCT DEFINITION

1. This product acts as a small handheld household appliance.
2. The function is to help users quickly clean up hair and pet fur.
3. The size of this product should be made within 400mm* 60mm* 60mm.
4. The semantics of this product should be convenience, lightweight and with few attachments.
5. The product is located in a corner of the user's home, such as next to the shoe cabinet or on the bedside table.
6. This product should be suitable for cleaning different textile surfaces in the home.
7. The cost of this product needs to be lower.

PRODUCT DEVELOPMENT



PROTOTYPING



Concept 1 Model



Concept 2 Model



Concept 3 Model

CONCEPT EVALUATION



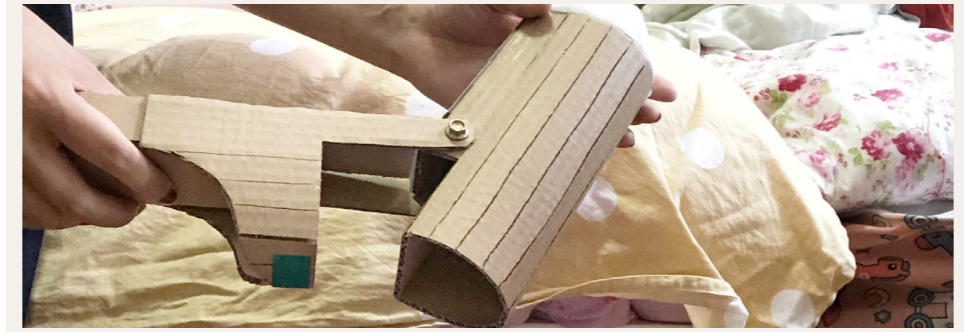
good things:
It is convenient to use a roller brush to clean clothes. Easy to store.

not good:
need to remove the front end to clean the vacuum cleaner.



good things:
It is very convenient to clean the vacuum cleaner after use.

not good:
The area of the hair removal brush is too small.



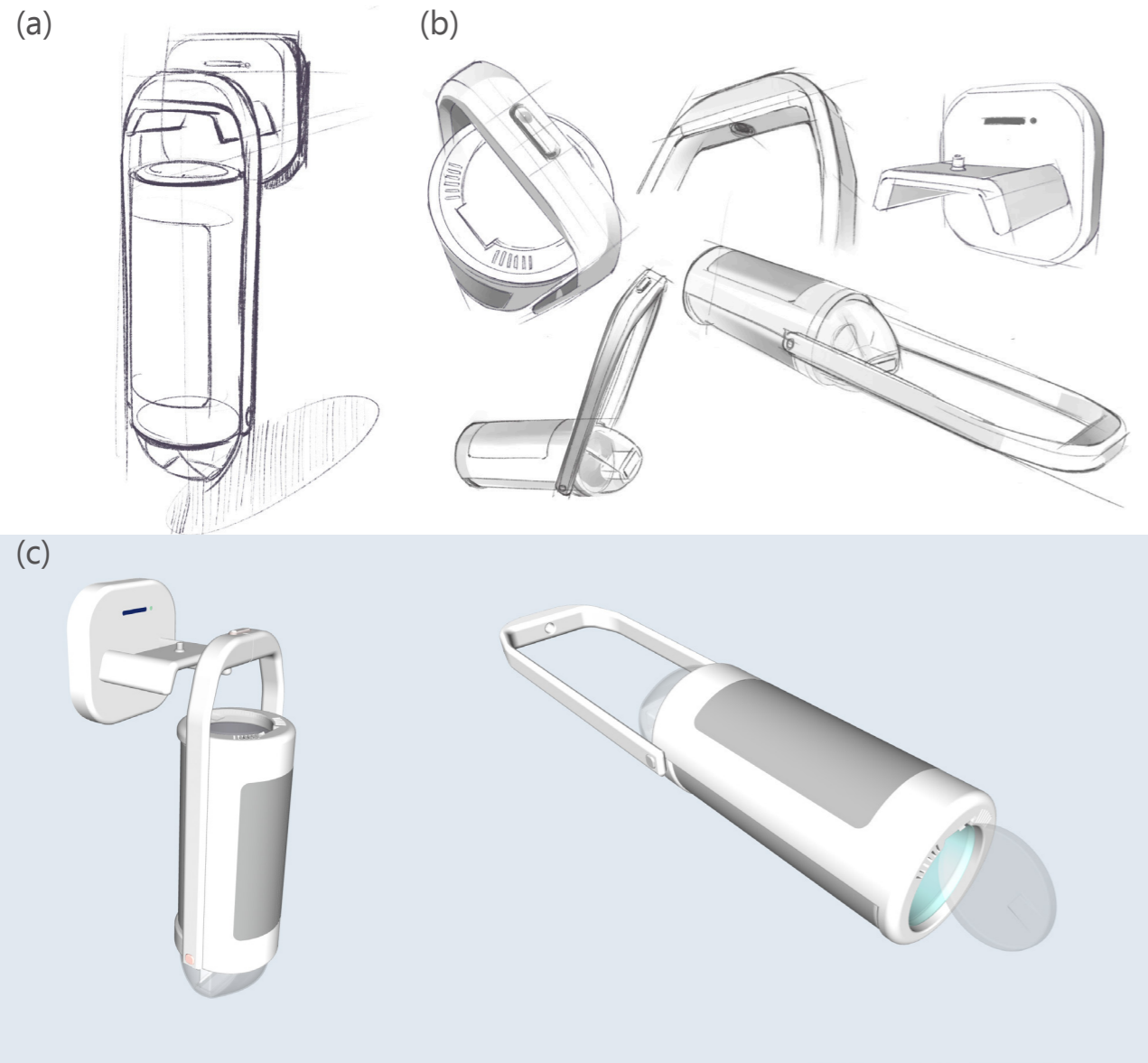
good things:
Easy to use roller brush, easy to clean vacuum cleaner. Easy to store.

not good:
The handle and small lid need to be durable.



SCALE LAYOUT

Explorative Sketch (a), Explanative Sketch (b), and Persuasive Sketch (c).

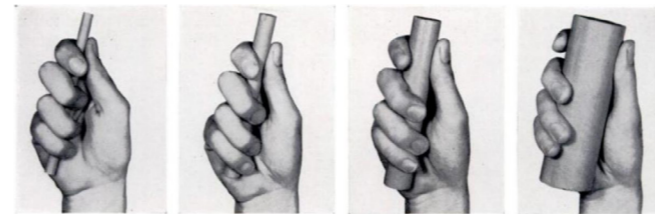


DETAILS

- This handheld vacuum drops into the wall-mounted charging dock, ready for next clean.
- The switch and charging port of the vacuum cleaner are at the top of the handle.
- The lid of the dust cup is transparent, so you can see if it needs to be cleaned.
- The shell integrates a sticky roller and a pet fur brush. When using these two parts, rotate the handle 180 degrees and hold the middle of the handle.

ERGONOMIC FOR DESIGNING HANDLE

Grasping of objects can be described by covering the variation of two grip types for a human hand activity: power grip and precision grip. The power grip involves a grasp with the palm of the hand and force from the thumb countered by force of the other fingers. The precision grip is a grip between the thumb and one or two other fingers of the palm.



Where there is little or none need for precision, the thumb wraps around the digits to help contribute to the grip force of the rest of the fingers.

Grip postures that do not require precision or require insufficient precision are shown in the figure below.



The diameter of a handle is one of the key parameters that affect user's ability to apply force. For a cylinder, shaped handles the recommendations are following:

- For women: 34 mm
- For men: 38 mm
- Acceptable range: 34 to 45 mm

Calculation

Assuming that the width of the grip part of the rotatable handle is 25mm and the height is 30mm, the perimeter of the section can be calculated.

$$C = (25mm + 30mm) \times 2 = 110mm$$

The suitable diameter can be calculated as:

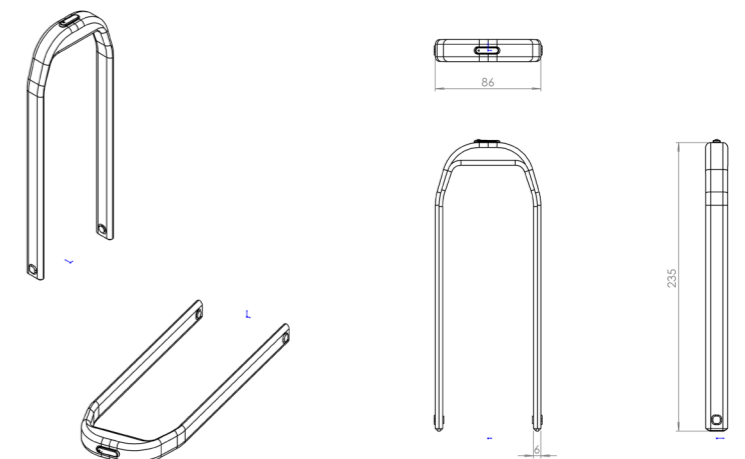
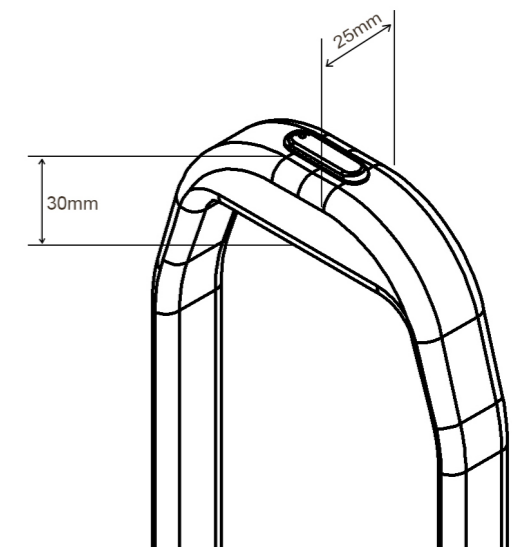
$$C_1 = \pi d_1 = \pi \times 34mm = 106.76mm$$

$$C_2 = \pi d_2 = \pi \times 45mm = 141.3mm$$

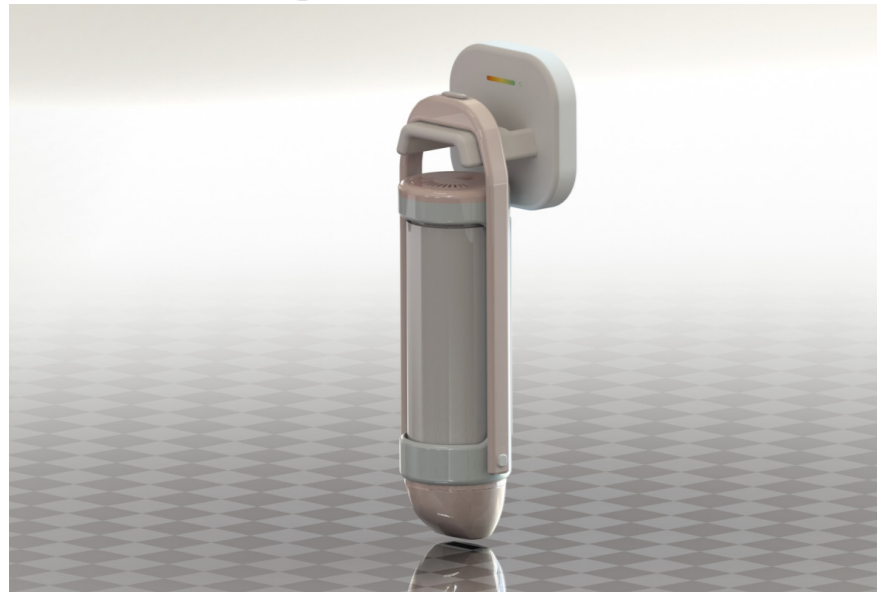
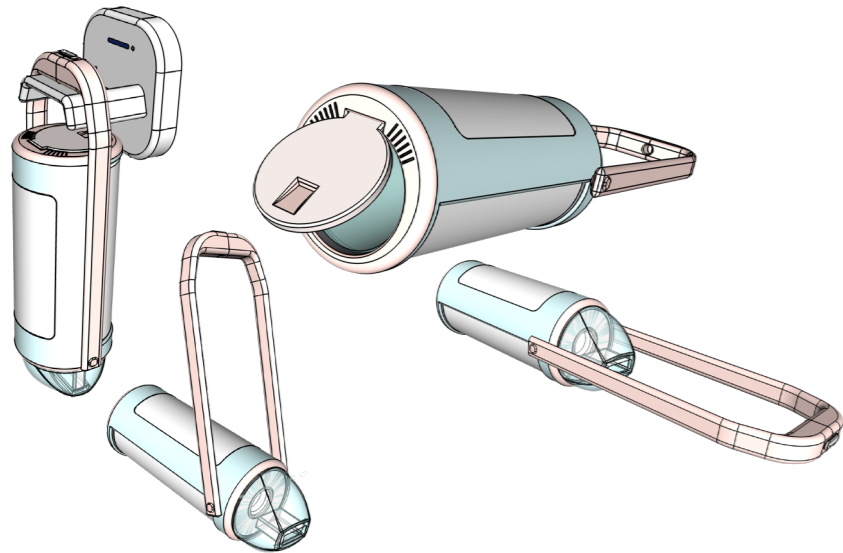
So,

$$C_1 < C < C_2$$

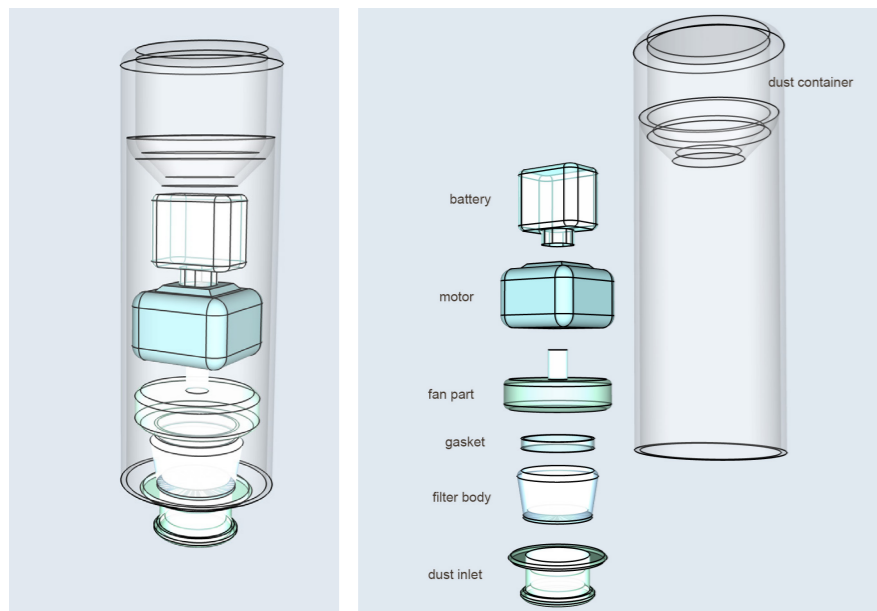
It is reasonable that the cross section of the handle part held by the hand is approximately a rectangular shape of 25mm*30mm.



PROTOTYPE MODEL



INTERNAL STRUCTURE

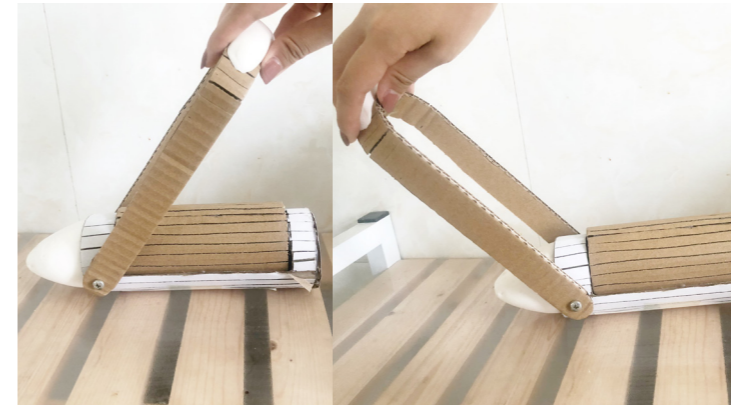


INTERACTIONS



Vacuum cleaner mode

After turning on the switch, hold the top of the handle with hand, and use it to clean the dust in the small gaps.



Change handle direction

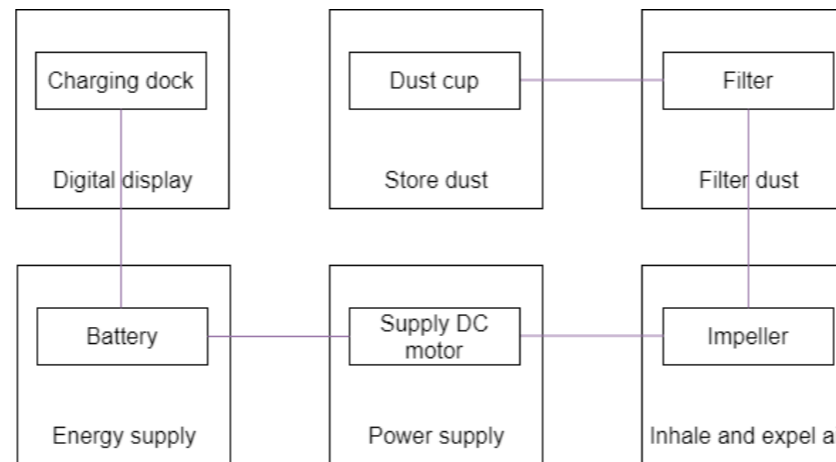
Press and hold the button to rotate the handle, after rotating to 180°, it will be stuck and stopped.



Roller & Brush mode

Holding the middle of the handle, you can use the sticky roller to quickly clean the hair on the surface of textile, or you can use the brush on the other side to comb the hair on the pet.

ARCHITECTURE INTERACTIONS



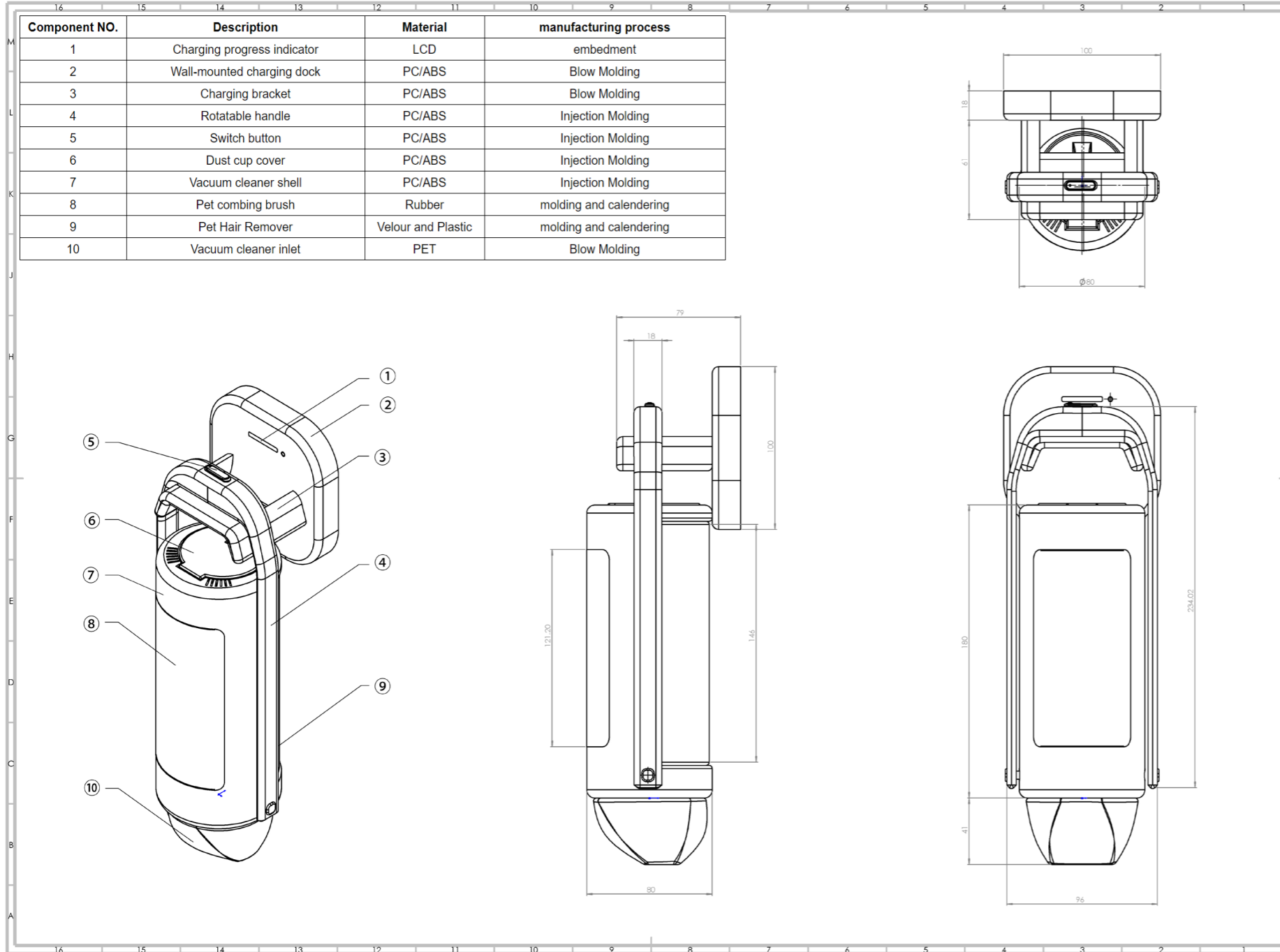
This handheld vacuum cleaner product architecture should be modular architecture. Each component could be selected from existing products.

The main part of the product is roughly divided into six parts. The wall-mounted charging dock is used for energy supply, and then the battery transfers the electric energy to the motor. The motor is connected to the impeller to inhale and exhaust air, filter out the dust through the filter, and store the dust in the dust cup.

TECHNICAL SPECIFICATIONS

Vacuum(maximum)	2.7kPa	Charging time	1.5 hours	Special funtion	Charging indicator light
Weight	1.3kg	Operation hours	20-30 mins		Rotatable handle
Dimensions(l*w*h)	275*96*80mm	Attachments	charging dock		Pet fur brush
Noise intensity(Lc IEC)	75dB	Power cord type	Cordless		Sticky roller

PRODUCT DESIGN DRAWING



POWER CONSUMPTION & COST

Both power consumption and costs have been major constraints within this project.

Power consumption

Assuming that the product is equipped with a rechargeable lithium-ion battery and fast charging technology, it can provide up to 20-25 minutes of continuous running time after fast charging.

The rated voltage of the battery is 16V, battery capacity is 650mAh.

$$\begin{aligned} \text{Rated energy} &= \text{battery capacity} * \text{discharge voltage} \\ &= 16V * 650mAh \\ &= 10.4Wh \end{aligned}$$

Assuming to use the product for half an hour after charging.

$$\begin{aligned} \text{Power} &= \text{Current in amps} * \text{Voltage (in volts)} \\ &= 650mAh / 0.5h * 0.001 * 16V \\ &= 20.8W \end{aligned}$$

Using cost

Cordless handheld vacuum running costs

Battery capacity (mAh)	Voltage	Cost to fully charge	Annual energy cost*
400	10V	0.11c	17.2c
500	14.4V	0.21c	32.8c
650	16V	0.29c	45.2c
700	18V	0.36c	56.2c
800	18.8V	0.43c	67.1c

According to the selected lithium battery data, the cost to use up the battery after being fully charged is:

$$\text{Cost} = 0.29c = 0.21 \text{ pence}$$

MATERIALS & MANUFACTURING

The mini handheld vacuum cleaner designed in this project mainly includes a rotatable handle, a dust cup, a nozzle, a vacuum cleaner shell, a sticky roller, a pet fur brush, etc.

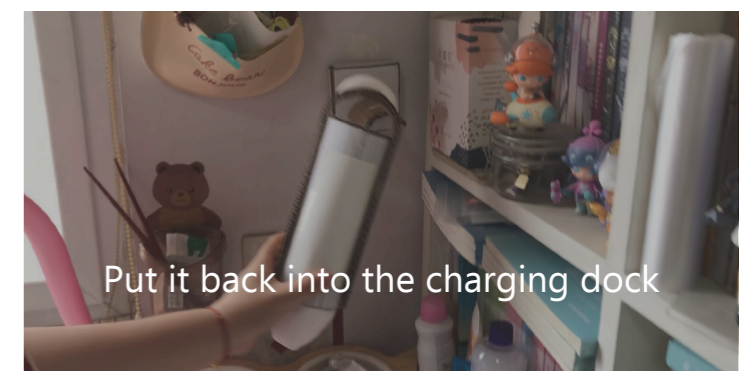
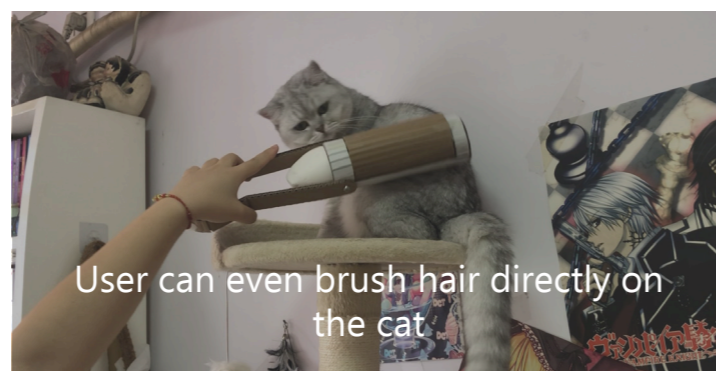
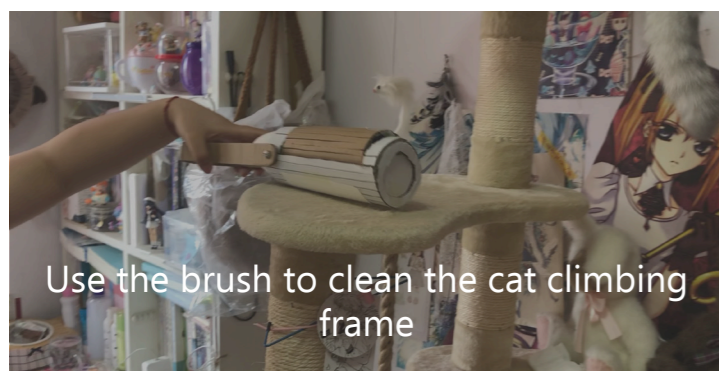
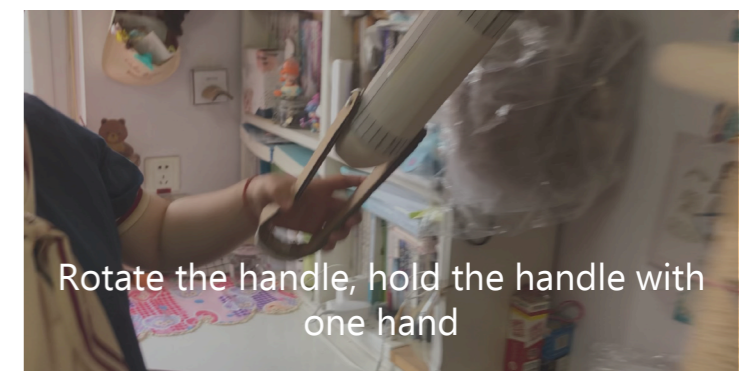
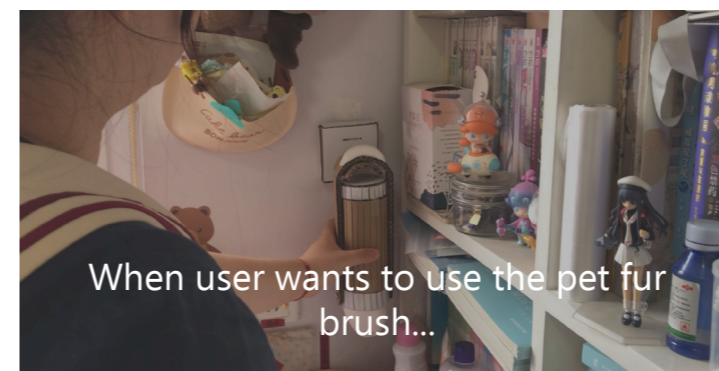
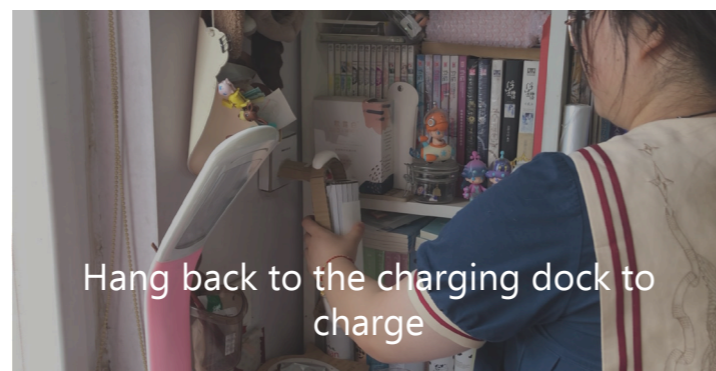
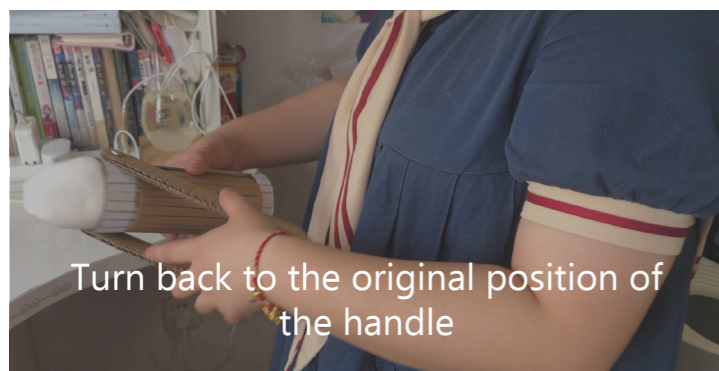
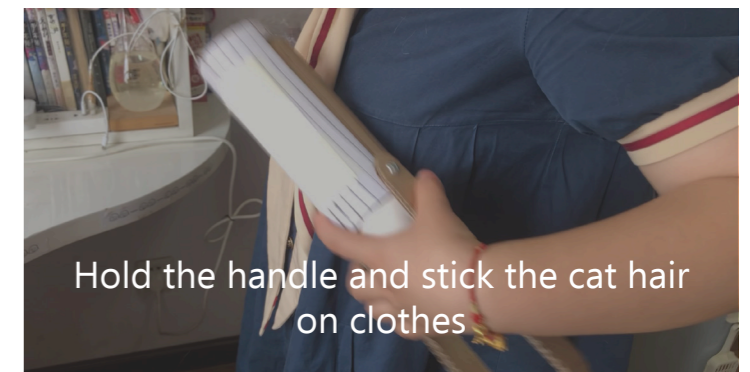
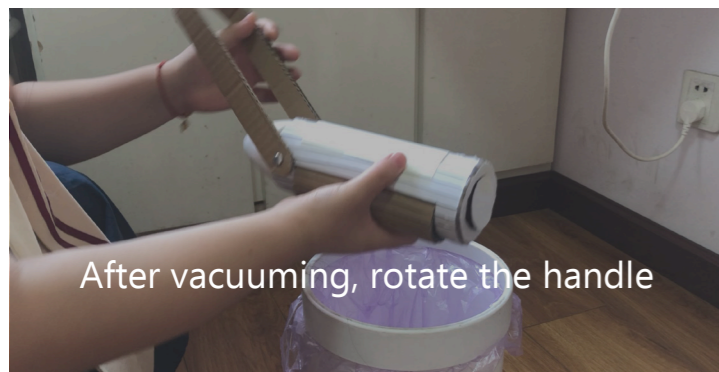
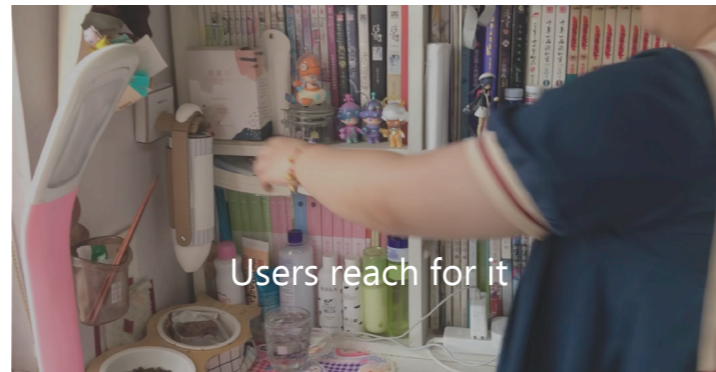
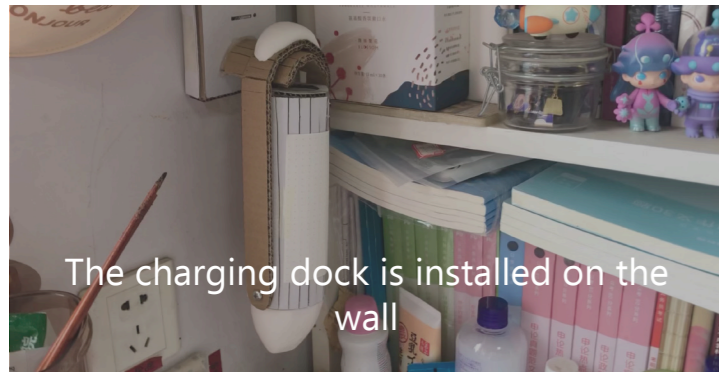
The sticky roller is made of Velour and Plastic, and the pet fur brush is made of Rubber.

The dust cup, the rotatable handle and the vacuum cleaner shell are made of PC plastic. PC plastic has good light transmittance, stable dimensions after molding, and good mechanical properties and impact properties. Manufactured by injection molding process.

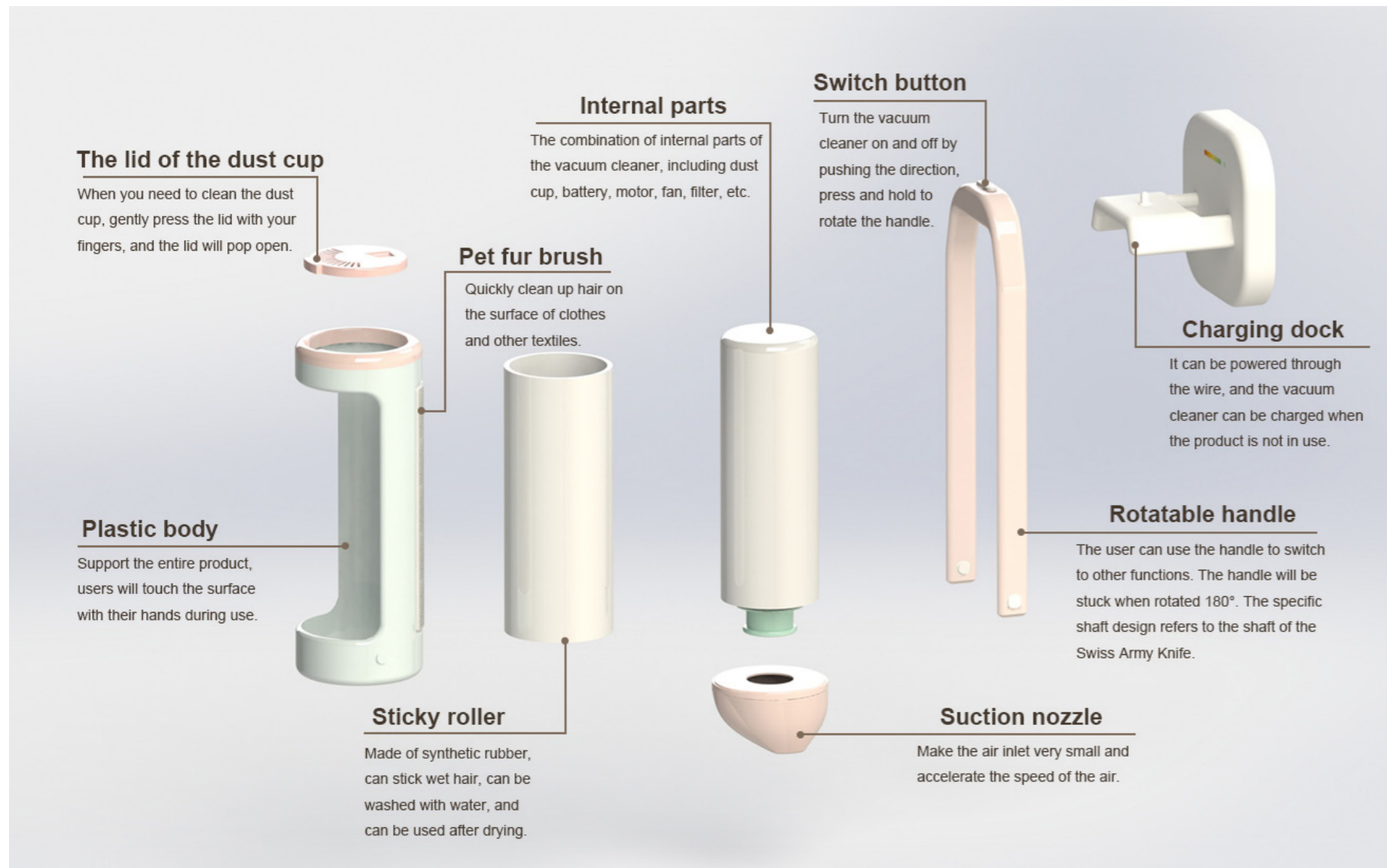
The suction nozzle is made of high-impact ABS plastic. The structure of the suction nozzle is more complicated, and ABS plastic has good molding processability and excellent mechanical properties. Manufactured by injection molding process.

USER JOURNEY

I re-created a roughly full scale prototype and asked my friend to do a user test.



ASSEMBLY



SUMMARY

The purpose of this project is to design a handheld multifunctional vacuum cleaner to meet the low consumption population with pets. This product combines the popular products currently on the market for cleaning pet hair, including sticky rollers and brushes. It is designed for users to use one product instead of multiple, which not only saves costs, but also saves storage space. The user gave positive qualitative feedback after testing the physical model, which means that this condition has been met.

FURTHER WORK

Since the project has a time limit of only three months, more technical details, such as internal component connection issues, need to be further determined in the next stage. At the same time, due to the characteristics of the peripheral structure of the rotatable handle, I couldn't actually test it in this project. Another very important point is how to clean the sticky roller. I assumed that the roller can be taken out, cleaned with water, and dried and then put in for use. However, the specific structure design has not yet been made, so the further work is to make the handle, the roller and the product body are better integrated.

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