Innovative Design of the Pump Dispensers for the Bottle with Viscous Liquid

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Abstract. The pressing pump head bottle of body wash, shampoo and liquid soap we use now that has some problems, that is the body wash or shampoo is used until only a little liquid is left, the liquid in the bottle cannot be pressed out by us, and liquid usually sticks to the body and mouth of the bottle. Based on these problems, this project collected the user feedback of existing products and made experiments on the existing products. Then improved the pump head and did experiments, and compared the experiments on existing products with the experiments on new design. In this design, in order to increase the utilization rate of liquid and improve the user satisfaction, this design changed the internal structure of the original pump head and added the shrink tube and rubber pad, so that the remaining liquid in the bottle can be pressed out, and the liquid outlet has also been changed. This project can help people reduce waste, and can be applied to various bottles for storing liquid. And this product will adopt the environment friendly material—Wheat Fiber Plastic, to achieve the purpose of environmental protection.

Keywords: pump head; innovative design; reduce waste; environmentally friendly

1 INTRODUCTION

Existing products such body wash, shampoo and liquid soap bottles all use the same pump head. The pump head of the existing product can't completely press out the liquid in the bottle (Fig. 1), when there is only a little liquid left in the bottle, it is hard to be pressed out, users usually turn the bottle upside down and let the bottom liquid flow out along the bottle wall, or add water, but it is inconvenient. And the liquid usually sticks to the body and mouth of the bottle. In order to completely press out the liquid in the bottle and solve the problems of existing products [1], this project improved the existing pump head products of body wash, shampoo and liquid soap bottle.

The twelfth goal Responsible Consumption and Production from the sustainable development goal of the United Nations. Sustainable consumption and production can do more, it can improve resource efficiency and promote sustainable lifestyle, and it can also help alleviate poverty and transition to low-carbon economy [2]. The sustainable development goal is changing our life [3]. This study can reduce waste to some extent and improve user satisfaction.

ADDT 2022, September 16-18, Nanjing, People's Republic of China

DOI 10.4108/eai.16-9-2022.2324871

In this study, the liquid at the bottle and the liquid on the wall of the bottle can be completely pressed out, and this pressing pump head design is suitable of all kinds of viscous liquids, for example body wash, shampoo and liquid soap…The objective of this project is to reduce the waste of shampoo, body wash and other liquids, or even achieve zero waste, and improve consumer satisfaction. This project will use of environmental protection material. Nowadays, there is an inevitable conflict between economic development and environmental protection, and environmental friendly materials are a new breakthrough and can play an important role in sustainable development [4, 5]. And Wheat Strow Plastic can achieve the purpose of environmental protection. Pursue the commercialization of wheat straw as commercial thermoplastic reinforced filler, preliminary results have been validated in laboratory scale and preliminary test [6]. The wheat fiber plastic is an environmentally friendly material, which is made of wheat straw, and can be make into cups, straws, plates and other daily necessities. This project focus on the problems of existing products, added and changed the structure (Fig. 2). Rubber pad and shrink tube are added, rubber pad can prevent liquid leakage, and there are many holes in the tube, it can allow air and liquid to pass through. And this design changed the shape of the pressing pump head, it is bowl-shaped, it can temporarily store a small amount of liquid.

In addition, nowadays, we are in the post-epidemic period, our use of alcohol has greatly increased, at the same time, some problems have been found in the pump dispensers used to store alcohol. A study shows that of the 166 dispensers put in the hospital, only 77% were in normal use 16 months after installation, the evaluation of alcohol-based hand rubs should consider not only the product characteristics, but also the design and function of the dispenser [7]. So the design of pump head is very important, good design can reduce waste and prolong the service life of pump head. In another project [8], the alcohol dispenser in hospital was also tested. The design and production quality of dispensers are important factors that affect the volume of pressing liquid.

The purpose of this project is to study how to press out the liquid that can’t be pressed out of the bottle and solve the problems of existing products.

Fig. 1. Existing product problems.

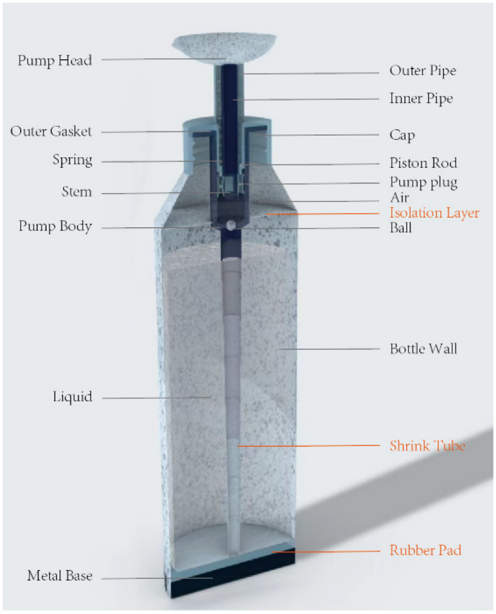

Fig. 2. This is a new structural design, this design adds rubber pad and shrink tube.

2 METHODS

2.1 User Survey

This project has conducted a survey [9], mainly aiming at the problems in the existing products. For example, when there is only a little liquid left in the bottle, it is hard to be pressed out by us, and liquid usually sticks to the body and mouth of the bottle. Another study showed that 76% of the 200 people surveyed found that the pump can no longer reach the liquid at the bottom [10].

In this project, the experimenter conducted a survey on 18 users of existing products. The main question of the survey is whether the user has encountered the problem that the liquid cannot be completely pressed out in the process of using the existing products, and whether the liquid sticks to the bottle. This survey also investigates whether users think these problems affect the use and whether existing products need to be improved. And this survey also asked the users' opinions on the existing traditional pressing pump head bottle and new automatic bottle.

2.2 Experimental Comparison (existing products)

This project did experiments on the existing products. In order to simulate the scene in real life, when we use the body wash, shampoo and other products, the liquid in the bottle cannot be completely pressed out. The experimenter randomly bought a cylindrical bottle of shampoo in the supermarket. The cylindrical bottle to be consistent with the design of this project. And the experimenter pressed the pump head and recorded the date. The recorded data is how many milliliters of liquid are left in the bottle, and the liquid cannot be pressed out smoothly, and how many milliliters of liquid are left in the bottle, the liquid cannot be pressed out. The experimenter calculated the volume of the remaining liquid in the bottle and the number of presses. By observing these data, This project has improved the existing products and made a new design.

2.3 Experimental Comparison (new design)

According to the problems of existing products, this project has made new improvements (Fig. 3).

The experimenter used 3D printing to make a shrink tube model and installed it inside the existing product, replacing the original pipe of the existing product, and a rubber pad is added at the bottom of the shrink tube. And according to the experimental data of existing products, the experimenter added a proper amount of shampoo liquid.

Then the experimenter presses the bottle, and record the pressing time and calculated the volume of the remaining liquid in the bottle. And the experimenter compares the experiment of new design with the experiment of existing products.

3 RESULTS

3.1 User Experience

Survey of user's problems with existing products (Table 1). The existing product has the problems that the liquid cannot be completely pressed out by the user and the liquid sticks to the body and mouth of the bottle.

The questions are:

A. Do you encounter the situation that the liquid can't be pressed out during use?

B. Do you encounter the situation that the liquid sticks to the bottle?

C. Do the above two problems affect the use?

D. Will you throw away the liquid that can't be pressed out?

E. Do you think the existing products need improvement?

F. Do you prefer to use traditional press pump head bottle or automatic bottle?

Focus on users survey of six problems of existing products in table 1. there are 18 users in total. In this survey, there are 14 users who can't completely press out the liquid, accounting for 77.78% of the total, and there are 12 users who have encountered liquid stick to the bottle body and mouth, accounting for 66.67% of the total. Ten of them think that above two problems affect their experience, accounting for 55.56% of the total. And three of the users surveyed would throw the liquid that cannot be pressed out, while the remaining 15 would add water to the bottle and continue to use it, with 16.67% and 83.33% respectively. All the users surveyed think that the existing products need to be improved, and half of them prefer to use automatic bottles.

Table 1. SURVEY OF USER'S PROBLEMS

Question1	Yes	No	Not care
A	14	3	1
B	12	4	2
C	10	8	
D	3	15	
E	18	0	
Question2	press	automatic	
F	9	9	

3.2 Existing Product Experiment

This project has done experiments on existing products (Table 2). The experimenter used a cylindrical shampoo pressing bottle as the experimental object. The experimenter recorded the pressing times and final remaining liquid that cannot be pressed out.

Take a cylindrical press bottle with a length, width and height of 6.6cm, 6.6cm and 14cm as an example. The volume of the cylinder is

$$V = \pi r^2 h \tag{1}$$

There are 480ml of liquid in this cylindrical bottle, after the experimenter pressed it about 168 times, 68.57ml of liquid remained in the bottle, about two centimeters of liquid, the liquid can be pressed out normally by the experimenter. Press again for about 14 times, and the liquid can't be pressed out smoothly by the experimenter during these 14 times, at this time about 34.3ml of liquid is left in the bottle, about one centimeters of liquid. Finally, about 34.3ml of liquid remained in the bottle cannot be pressed out by the experimenter. About 7% of the liquid will be wasted.

Table 2. EXPERIMENTAL COMPARISON

Press quantity	The remaining liquid in the bottle	Pressing situation
0	14cm / 480ml	Not use
about 168	Equal to 2cm / 68.57ml	Normal use
about 14	Less than 2cm / 68.57ml More than 1cm / 34.3ml	intermittence
0	Less than 1cm / 34.3ml	can't press it out

3.3 New Design Experiment

According to the problems in the existing products, this project has made some improvements to the existing products.

Here is a bottle with a length, width and height of 5.5cm, 5.5cm and 13cm (Fig.3). The experimenter installed the 3D printed shrink tube and rubber pad in the bottle. In order to simulate the situation that when we use shampoo and other similar products in life, a part of the liquid at the bottom of the bottle cannot be pressed out, the experimenter added about 47.5ml (2 centimeters) of shampoo. But liquid has buoyancy. In the course of doing the experiments, due to the buoyancy of liquid, shrink tube and rubber pad can't cling to the bottom of bottle, it moved up by 1.5 centimeters. At this time, the remaining liquid on the rubber pad is about 12ml. When the experimenter presses the pump head 7 times, the liquid on the rubber pad is pressed out, and the rubber pad also moved.

This experiment shows that the design of this project can make the liquid that can't be pressed out of the bottle be pressed out.

Fig. 3. new design with 3D printed shirk tube and rubber pad.

4 CONCLUSION

Limitations:

1. The shape of bottle

According to the uniqueness of this project design, the shape of the bottle is limited to cylindrical shape, which is a prerequisite, because the rubber pad of this design is connected with the shrink tube, the circular rubber pad can be well stressed, and the rubber pad needs to scrape the liquid on the bottle, so the shape of the bottle must be same as the rubber pad.

2. Buoyancy

During the experiment of this project, the buoyancy of liquid was not considered. The remaining liquid in the bottle that can't be pressed out, though it is very little, still has buoyancy. Because the experimenter neglected the factor of liquid buoyancy, this project should consider the problem of liquid buoyancy and increase the thickness of rubber pad in the future plan.

The problems of the existing products have affected the use, and the improvement of this project can solve these problems to some extent, but the new design didn't completely change the exiting products, because it didn't consider liquid buoyancy and other potential factors. In the future, the design of this project should be further improved so that it can completely press out the liquid in the bottle.

In addition, about the material use in this project. The bottle will use environmentally friendly material, it is wheat fiber plastic. Nowadays, this material is mainly used in the production of daily necessities, such as cups, chopsticks and bowls.

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