ODP 7: Final Report

Purifresh

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TABLE OF CONTENTS

LANDING PAGE:

https://llr638.wixsite.com/purifresh-1

DESIGN CHANGES:

1) Design Changes for Manufacturing

As shown in Figure 1a, the shaft is currently one piece with two sections: a notched segment where the straw cleaner is held, and a solid, curved end that allows the shaft to attach to the handle joint. This asymmetry makes it difficult to manufacture, and the length means injection molding is not preferable. We should split this into two pieces so that the notched segment (with a consistent cross-section) can be manufactured via extrusion and the end-cap manufactured via injection molding (Figure 1b). These can then be bonded together. Also, since sharp edges can create defects with plastic extrusion, we should fillet all edges when possible.

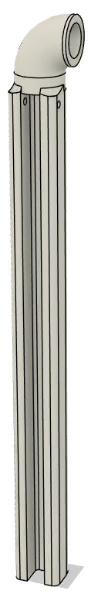


Figure 1a: Old shaft design.

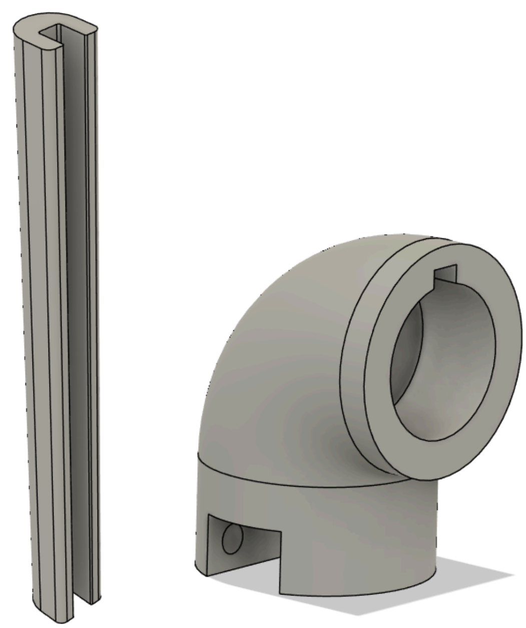
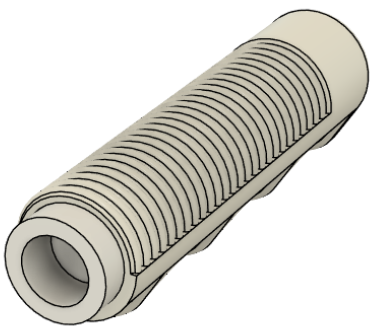


Figure 1b: Updated shaft with split components.

The brush connector needs to have precise geometry so that it both fits the shaft and allows the brush to snap into place. This would best be achieved with injection molding. This is a small enough piece that there should be no issues, but if warping occurs, we could make the walls thinner. Since the brush needs to exactly snap into place, we should account for shrinkage.

The handle is currently solid except for a cut-out circular section at the end to which the joint is glued. We plan to injection mold this piece. To make this feasible, we will make the handle hollow, as shown in Figure 2b. This will prevent long cooling times and also minimize the risk of warping that comes from injection molding a solid cylinder. Since the grip covers it, this modification will not be seen, and will make the final product more light-weight and cost-effective. Injection molding also allows the handle to have a notch (further described below in Design Changes for Assembly). This should not cause manufacturing errors as the edges do not have to be significantly sharp.



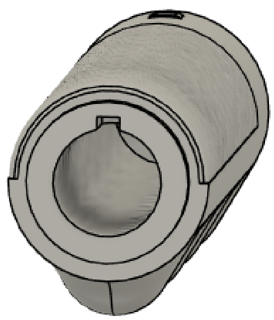


Figure 2a: Old handle. *Figure 2b. Updated completely hollow handle.*

2) Design Changes for Assembly

The first change for assembly to our product includes developing a better method to attach the straw cleaner to the shaft. Currently, we insert a small metal dowel through two small holes on the shaft as well as through the top loop of the straw cleaner. After the dowel is fully inserted, it is glued to securely fasten it. This method effectively holds the straw cleaner in place and allows it to rotate and move as needed; however, we found it quite difficult to line the dowel up and properly push it into place. Specifically, we found that we needed to have small holes with a tight tolerance to securely hold the dowel, but this made it challenging to slide the dowel in. Additionally, we often found it awkward to hold the straw cleaner in place so that the dowel would go through the loop while inserting the dowel.

To improve this, we are going to replace the dowel with a snap fit joint on the top of the straw cleaner. If we made the straw cleaner handle out of a light rod of plastic or metal, we could then add two small bumps to the top as well as two small holes in the main brush body. This part of the straw cleaner would be pushed into the body handle and would snap into place, requiring no additional fastener. This would significantly speed up the process of attaching the straw cleaner by eliminating the challenge of inserting the dowel as well as the gluing and drying time needed to fasten it. Furthermore, this would allow us to create replaceable straw cleaner parts for individuals who wish to replace their straw cleaner if damaged or overused. These updated components are shown in Figures 3b and 4.

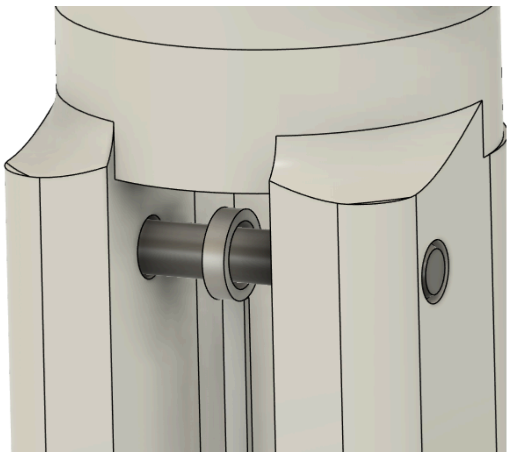


Figure 3a: Old straw cleaner connector.

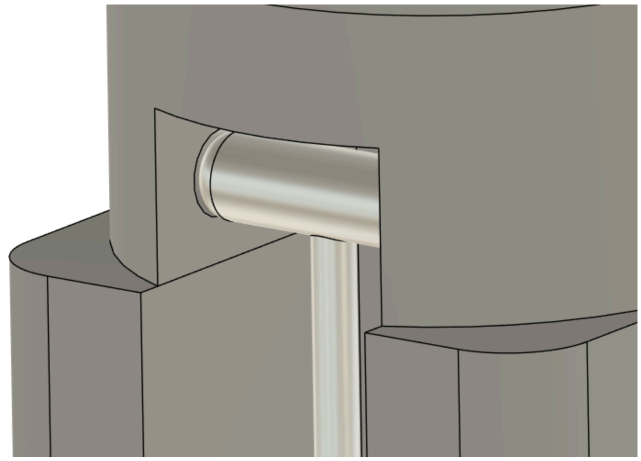


Figure 3b: Updated straw cleaner connector.

Our second and third changes to our product to improve the assembly process are to implement poke-a-yoke techniques to prevent incorrect assembly of the handle. Currently, the handle section is composed of three components: the joint, our 3D printed handle, and the rubber grip. During our assembly of our prototype, we found it easy to attach the grip in the incorrect orientation. To fix this we attached a notch to the handle and cut a slot into the rubber grip to allow for only one correct fit. This would eliminate the possibility of the grip being slid onto the handle in the wrong orientation. These changes are shown in Figures 6a, b, and c.

Similarly, the holes in the shaft and handle into which the joint attaches are both exactly circular as well. To prevent attaching the joint with the wrong orientation, we would add a keyway slot to the hole and a key on the joint (Figure 5). This would make only one fit of the joint to the shaft possible, and prevent incorrect assembly of the joint.

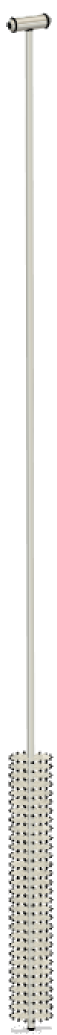


Figure 4: Updated straw cleaner.

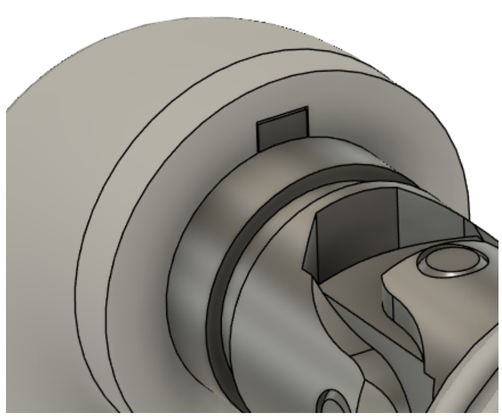


Figure 5: Updated joint with keyway slot.

To further improve our design, if we were to continue with the project, we may try to combine and get rid of components altogether to prioritize simplicity. However, we believe that these changes are a sufficient start to improve the assembly process of our product.

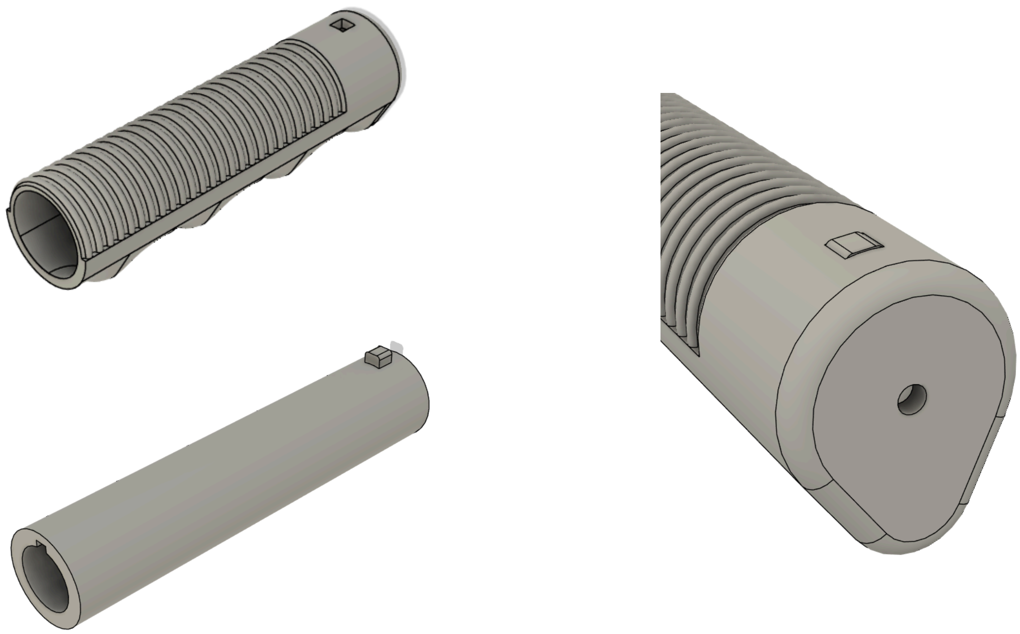


Figure 6a (top right): Updated rubber handle with slot.
Figure 6b (bottom right): Updated 3D printed handle with notch.
Figure 6c (left): Closeup of updated notch system.

3) Design Changes for Sustainability

We designed our product with sustainability and longevity in mind. Since brushes are constantly exposed to grime and water, the brush head is the first part to deteriorate to unusability in the time scale of months or less, either by becoming moldy, fraying, or breaking. In our product, the brush head can detach and be switched out, meaning customers will only need to replace the head and not throw out the entire brush. This cuts down on plastic waste as well as emissions generated to construct and ship an entire new cleaner.

Due to this design feature, we expect our product to last around five years. We chose stainless steel metal components to prevent rusting. However, there is always the possibility of the shaft breaking, and we also expect the grip to wear down over time. It is also important to note that the straw cleaner is not detachable and faces a similar problem as the brush head. Making the straw cleaner detachable would further incentivize customers to retain the main body of the brush, instead of throwing it out when the straw brush wears down.

Currently, our material choices are not the most sustainable. The majority of our design is plastic. The 3D printed shaft, brush connector, and handle are made from PLA. The core of the brush is made from recycled plastic, and the bristles on the head and the straw cleaner are nylon. The grip is a vinyl plastic. The dowel, straw cleaner wire, and U-Joint are stainless steel. Since our product is a combination of metal and plastic, it is difficult to separate materials and properly recycle. Thus, at its end-of-life, it will likely go straight to a landfill. This can be solved by reducing the materials used. Since our product does not have to sustain large forces, making most components plastic, including the joint, should not significantly affect its usability.

The 2030 calculator results are shown in Figure 7a for our product with no packaging and an assumed negligible energy cost associated with assembly, though whether this is true depends on our specific assembly process. We also assumed all outsourced parts to be from China.

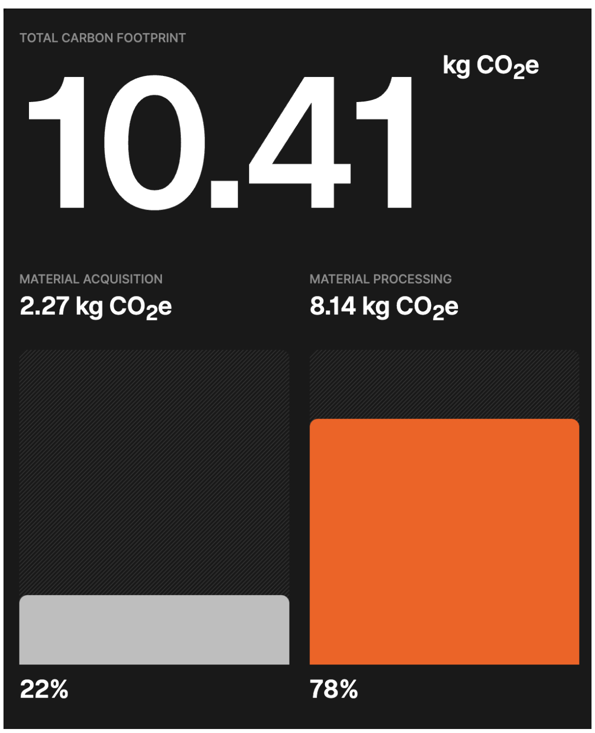


Figure 7a. Carbon footprint of current product.

Figure 7b. Carbon footprint without metal

Clearly, material processing is the biggest contributor to our carbon footprint. This is greatly influenced by our material choice. If instead of stainless steel and PLA we used polypropylene (PP) for all components except for the grip, straw brush, and the nylon bristles, the carbon footprint diminishes to 2.77 kg CO_2e (Figure 7b). PP is water-resistant and recyclable, making it a perfect fit for this product.

Thus, to reduce our carbon footprint and to allow for easy recycling, we suggest changing all viable components to PP. We also should allow the straw cleaner to be detachable and therefore replaceable to extend the lifespan of the product. This change also makes assembly easier and is shown in Figure 3b. Lastly, making the ergonomic grip from silicone rubber instead of vinyl plastic would cut down our carbon footprint, as silicone rubber forming requires only 0.1 kWH/kg of energy, as opposed to PVC injection molding's cost of 1.48 kWh/kg. Silicone rubber has the added eco-benefit of being more durable and not breaking down into microplastics.

FINAL DOCUMENTATION PACKAGE:

Breakdown of files:

“Final Prototype Components” - Folder that contains all final prototyped component STEP files named “Brush Connector”, “Handle”, “Shaft to Joint Connector”, and “Shaft”

“Exploded View Animation” - MP4 Exploded view animation for assembly.

“Final Render” - PNG Rendering of final product in Fusion.

“Instructions for Assembly” - pdf of Instructions for assembling the product.

“Purifresh BOM” - .xlsx Final BOM spreadsheet. Complete purchasing list for full ODP prototyping cycle.

“Purifresh Final CAD” - .f3z Final prototype Fusion Assembly.

FINAL RECOMMENDATIONS:

Purifresh provides unique features to consumers who clean their bottles. Our integrated straw cleaner, compatible handle, and changeable brush head sets us apart from standard cleaning devices. However, there is further testing and development that needs to be done before the product can be released to the market, specifically in the handle joint and brush head. In particular, our timeline would be as follows:

- Week 1: Collect and analyze interview data regarding preferred brush heads.
- Week 2: Begin designing the handle joint and brush head options.

- Week 3: Continue handle-joint and brush head development. Manufacture and outsource other parts of the brush.
- Week 4: Assemble and test the brush, making design changes if necessary.
- Week 5: Second iteration of testing with updated design.
- Week 6: Finalize design and introduce the product to the market.

The emphasis on handle-joint development arises from the lack of suitable joint options on the market. The ideal handle joint will mainly be composed of two parts: one that is attached to the handle and the other that is attached to the body. The joint will be able to pivot at the meeting point between the two parts; however, motion is constrained such that the joint can only move 90° starting from the body of the brush. The joint would also be able to lock in place to maintain the right angle when the brush is being used. Although the motion of the handle joint is relatively simple, its development was not accounted for during our initial and second design. As such, with our next iteration, a considerable amount of time would be allocated for the joint to complete the product.

We also plan on expanding our bottle brush to other branches of the cleaning industry by marketing it to work in conjunction with other products, such as other kitchen appliances, cars, and surfaces, to expand our customer base. Since the product features an exchangeable brush head, we aim to manufacture other brush head replacements (roughly 5) that could be used for products other than a bottle to promote its versatility. Options include: varying size, thickness and length of the current brush head, changing its shape, and exploring new materials; however, the specific type of brush head would have to be determined through consumer interviews and questionnaires to better understand the general needs and wants of adults who regularly clean. With the above alterations implemented, we believe Purifresh would make an impact on the cleaning industry through its versatility and compactibility.

REFLECTION:

We encountered many successes and some setbacks that we were able to solve together while designing Purifresh. During our brainstorming session, we developed numerous ideas, some of which were turned into scrappy prototypes that successfully brought our ideas to life. We then realized we were missing 2 moving parts, which brought us back to the drawing board. However, with the effort of the team and the advice of the TAs, we designed the first prototype that fulfilled the requirements. During testing, it became apparent that this prototype was not an ideal product due to the u-joint at the brush head and the ease of rusting on the metal components. Thus, we moved the u-joint and researched rust-resistant part options for our second prototype. The second iteration also had some difficulties that we addressed in this report.

As a result of the challenges in the product development process, we learned the importance of proper communication and understanding individual strengths and weaknesses. We recognized the need to express our opinions, so that every thought and thus possibility was considered in the product's development. Having a proper communication channel was also key when members of the team were unable to attend lab, as it allowed them to contribute where they could. Since we didn't have established internal deadlines, efficient communication was further emphasized as we occasionally had last minute meetings to discuss loose ends. We were also able to determine members that are most suitable for key roles, like CAD designer and sketch artist, by sharing our strengths and weaknesses. As such, the product development process was made simpler since we knew we had dependable members to fulfill these tasks. Therefore, in addition to the technical experience we obtained, we learned ways to effectively manage a project and work as a team.