GNG2101 Deliverable E.1

Design Constraints

Introduction to Product Development and Management

GNG 2101

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Group Z13

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Abstract

In this deliverable, we will focus on two important non-functional design constraints: manufacturability, and ease of use. We will do an analysis on the following and provide proof to demonstrate the effectiveness of our changes in satisfying the constraints. Doing this will help us update our detailed design accordingly so that we can move on to build our second prototype. We determined that the manufacturability of our design would be easier by eliminating the need for welds, and the ease of use would be greatly increased by changing the end of the thumb screw design.

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Introduction

At our third client meeting, we will have the opportunity to meet our client and present the prototype we have developed so far. After the client meeting, we will work on identifying two non-functional design constraints that have come to light as we were developing our prototype. We will also explain how we will satisfy these constraints.

After gathering feedback from the client and speaking with Jason (a Brunsfield Center employee), we have made some minor modifications to our current design based on these suggestions, along with updating the budget and bill of materials.

In this deliverable, we will include a comparison of the original design and the modified design, as well as a detailed updated design and an analysis of the modifications. Any details about the second prototype will be shown in detail in deliverable E.2.

Non-Functional Requirements

The two non-functional requirements that play an important role in our prototype development are the manufacturability of the product, and its ease of use. The manufacturability of the product is an important aspect of product development. Given our limited manufacturing skills, manufacturability is paramount in our case, as it will allow us to deliver a final product to the client, and not limit us to presenting a half-finished prototype. The usability, or ease of use, of the product is arguably the most important non-functional requirement of our product. As the cup holder is meant to help wheelchair users secure their drink to their tray, we want the product to be easily attachable and removable for the employees, as well as the wheelchair users with sufficient hand capabilities.

Design Changes

After talks with an employee of Brunsfield Centre to get feedback on our first design, we received advice on manufacturability and on how to make our system easier to use. Our initial design consisted of multiple machining and welding processes. As welding can be difficult and lead to manufacturing errors with inexperienced welders such as ourselves, eliminating the need for welding is crucial for our product. We were then suggested to use a c-clamp and screw another piece of flat bar to the c-clamp to retain as much of our current design and functionality as possible. This would eliminate the need for welding, which also means we could opt for aluminum instead of steel, which would make the product lighter and more aesthetic. Figure 1 shows the difference between the two designs. It is clear to see that while the design is similar, the new one requires no welding of the 3 bars, and no welding of a nut, while being more appealing to the eye. Instead, three screws attach the c-clamp to the flat bar, and the bottom hole for the thumb screw is tapped. These new updates will satisfy our manufacturability constraint.

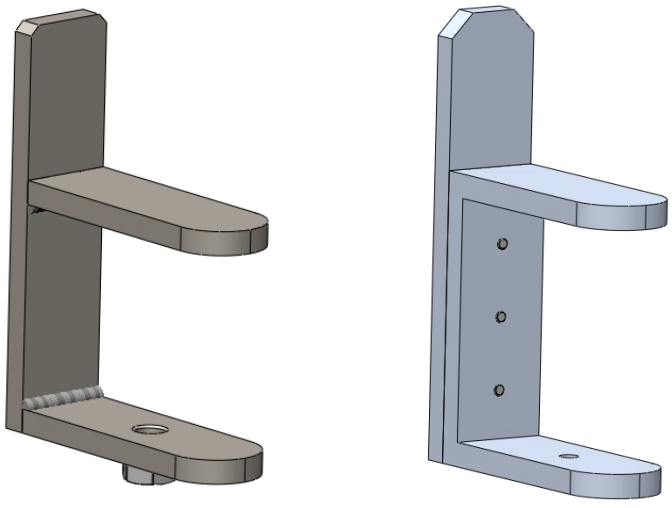

Figure 1. Initial Clamp Design (left) vs. New Clamp Design (right)

For ease of use, in our first detailed design, we opted for a thumb screw with a small round end, which we thought would work fine. It was brought to our attention that it would be more appropriate to have a different end for our screw. The recommendation was to have an end that would be easily twistable with your fingers (as shown in the picture below). Our plan is to switch the thumb screw to a hex head screw, which is easily accessible in Brunsfield or Makerspace. This will help lower our costs since we won't have to buy a full pack of screws in order to use one. We will then model the design in solidworks to ensure it fits well with our subsystem. This will help us satisfy the constraint of ease of use, making it easier for our user to attach the clamp onto the tray, and on the other hand, this will help us cut our expenses.

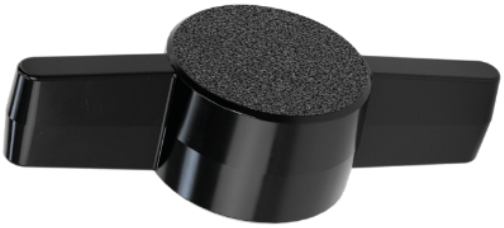

Figure 2. Thumb Screw Knob

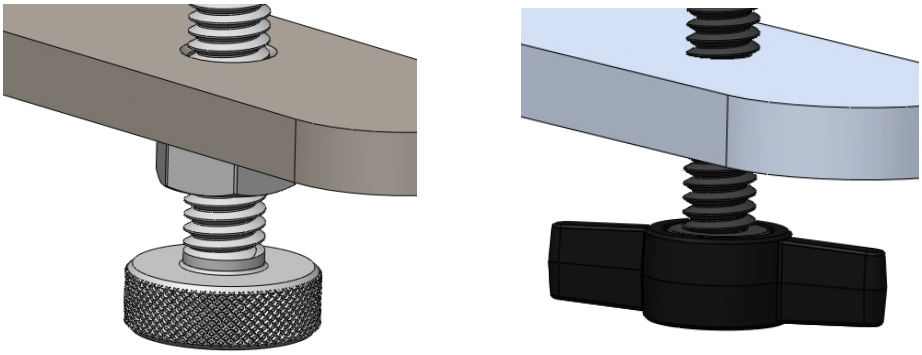

Figure 3. Initial Design (left) vs. New Design (right)

Analysis of Modifications

Changing the end of the screw from a small round knob to one similar to one of the pictures above will drastically improve the ease of use. Having a bigger knob with flanges that stick out will allow for the user to twist the bolt with less force, making it easier. This can be explained with simple mechanics. Since our fingers are further away from the centre, the torque applied is greater. Torque equals perpendicular force times distance, and with a bigger distance, we can reduce the force applied to twist the bolt. For example, if our initial design had a center distance of 0.375 inches, and we input a force of 2 lbs, our torque would be 0.75 lb-inch. In our new design, if we input the same amount of force (2 lbs), but we now have a longer center distance of 0.6 inches, we get a torque of 1.2 lb-inch. This is a 60% increase in torque. Therefore, this small change has made a huge impact on the ease of use, as it will take far less torque, and subsequently effort, to overcome friction and tighten the clamp to the tray. Furthermore, the chosen knobs are designed in a way to help with grip making it easier to twist than a small round metal piece.

According to multiple manufacturing technicians in the Brunsfield workshop, welding is very difficult for inexperienced people. Given no team member has welding skills, it would be unwise for us to manufacture a product that requires welding. This fact, along with research explaining the difficulties with welding was the reason for the changes made to the design. The process for implementing the changes revolved around modifying the design on Solidworks, and analyzing it visually to ensure the design would be manufacturable. Using methods in design for manufacturing and also design for assembly was a very useful process that helped us finalize a design that was suitable. Once the design was complete, the manufacturing technicians were able to confirm the suitability of our design and help us with the next steps, which was the physical

manufacturing. The reason for doing research on welding was to gain more knowledge on the difficulties of welding, which helped us in realizing the need to eliminate it.

Entire Updated Design

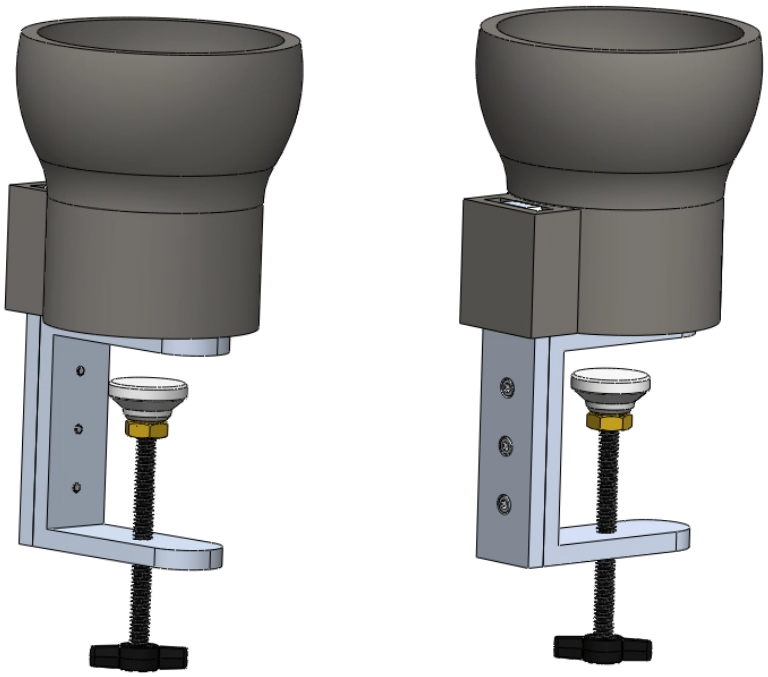

Figure 4. Two Views of New Design

Conclusion

The purpose of this deliverable was to identify non-functional design constraints that play an important role in our prototypes. This helped us modify our design in order to overcome these constraints. One crucial resource we had that helped us improve our design was knowledge from an expert employee in manufacturing. Thanks to this help, we were able to eliminate difficult manufacturing processes and focus on design for manufacturing and assembly. We were also able to significantly increase the ease of use of the prototype through calculations and

implementation of new parts. We can now move on to manufacture our second prototype, test it, and analyze the results.

References

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