Deliverable F

GNG1103 B005

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Reema Adan, Lauren Coffin, Nora Jordan,

Sonya Pastorek, Nadia Rahman,

Abstract:

This report delves deeply into the intricate process of prototype development, outlining a robust test plan for a second prototype. Its primary purpose is to collect indispensable customer feedback to enhance the design and functionality of the solution. The report underscores core objectives, including the seamless integration of client feedback, the prototype development, the detailed analysis and changes of critical components, and the active solicitation of feedback from potential clients and users. Additionally, it places strong emphasis on the critical importance of defining precise measurement criteria and acceptable fidelity parameters, all thoughtfully tailored to the unique objectives of the prototype, ensuring a comprehensive understanding of the project's essence and direction. This report serves as a beacon of guidance through the complex process from concept to realization, marking a transformative phase in the project's development.

Contents

1. Introduction:

This report summarizes the approach to creating a prototype and formulating a robust test plan for a second prototype. Since this will be the team's first prototype, the primary goal in this initiative is to seek invaluable client/student feedback—a driving force behind shaping design decisions and enhancing the overall quality and effectiveness of the solution. The focus is on creating a basic proof of concept, constructed from materials and components that are cost-effective, thus keeping expenses to a minimum. This report will delve into the intricacies of the team's work for the first prototype, highlighting the integration of client feedback which influenced the process of prototype development, and comprehensive analysis and changes of functional pieces. These facets collectively lay the foundation for a successful prototyping process, one that balances both the team's perspective and the client's vision.

2. Deliverable E Design Drawing

2.1. Feedback on Design Drawing:

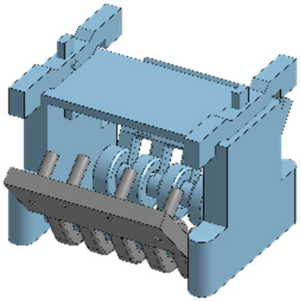

Figure 1. Assembly 1: First iteration of the assembly of parts based on last deliverables first round of CAD documents for the preset plates and the jig casing.

2.2. Simple Systems analysis

Most of the analysis of the current system will be done through physical testing of the device. This includes the speed at which the clamps can be used, the ease at which the jig is used, its practicality and the long-term durability and reliability. In particular, the size of the paddle required to ensure that the clamps can hold up the jig is currently not feasible. The downward force of the clamps is unknown so it could not be compared to any calculations done. However, certain markers can be analyzed using only the CAD design. This includes the final prototype's weight, depth of drilling, the short-term durability of the material, and drill clearance.

Currently, the detailed design has a volume of 54.987 in^3. Considering the material chosen for prototype 3 was primarily CSA G40.21 44W /300W stainless steel or in Canada, A36

Hot rolled steel, the final weight is 15.609 lb. This is much heavier than the target specification. Possible alterations include switching to a lighter material such as an aluminum alloy or plastic or making certain parts of the jig hollow. The cost was outlined in the previous deliverable and is expected to be approximately 60 dollars. This is well within the 100-dollar budget. No costs are associated with the materials used for prototypes 1 and 2 as they will be materials from personal or university resources.

Regarding the durability of the material, it will be made from steel which is an extremely durable material. It has a high elastic modulus and good behaviour during the Charpy impact test. Therefore, drops or rough handling of the device or short-term durability should not be an issue. Additionally, the manufacturing center is indoors so slight expansion of the jig due to temperature is not a huge problem. Even so, the value of thermal expansion is 11.7×10^{-6} and considering the fluctuation of internal temperature to be between 5 to 10 degrees Celsius the accuracy after expansion or contraction is still well within $1/32^{nd}$ of an inch.

When to stop drilling is an important system to the design and currently the depth of drilling is approximately 1 inch. This was calculated using the stop collar length, adding it to the plate depth, and then subtracting this total from the drill bit length. One inch is within the general guidelines; however, a more specific length is to be asked from the client for future prototypes. Regarding the clearance of the drill, there are some adjustments that need to be made. This considers whether the drill can fit inside the cavity and use the opposite guide. Currently, the head of the drill is far enough from the body to not be impeded by the rails that hold the guides. However, the head of the drill is too thick to fit inside of the jig and drill the holes on the very edges of the 5-inch hinge. This can be fixed by making the hinge longer by approximately half an inch.

3. Prototype 1 development

3.1. Testing plan for prototype 1

Table 1: Prototype 1 + Deliverable F

Oct 29	Oct 30	Oct 31	Nov 1	Nov 2	Nov 3	Nov 4	Nov 5
					Deliverable E DUE		
Build prototype 1 (P1) initial cardboard prototype							
				Test, record, and report on P1			
					Meet to discuss changes to P1 for P2		
						Write formal report on P1 incl. Changes for P2 and why	
							Deliverable F DUE

The prototype testing plan drafted in Deliverable E was closely followed. This ensured we had adequate time to gather feedback on our prototype, as well as draft the necessary changes for prototype 2.

3.2. Results (Images included)

Figure 2.1. Left corner angled view of nonfunctional protype 1, first iteration.

Figure 2.2 Forward view of nonfunctional protype 1, first iteration.

Figure 2.3 Top view of nonfunctional protype 1, first iteration.

3.3. Analysis

The initial non-functional prototype did not consider the cushioning aspect requested by the client. Effectiveness of the cushioning will be evaluated with secondary functional prototypes. The preliminary prototype is not entirely to scale, with exaggerated clamping compared to the hinge dimensions. Considering this is to be used for qualitative analysis through user feedback, the larger scall allows for more effective visualization of the mechanism to determine its applicability.

The preset plates correspond to the expected actual size of the final design. The simplicity of their use can be assessed with the preliminary prototype. The materials used in this case are insufficiently rigid for meaningful performance testing or collection of quantitative data. The stop collars on the prototype facilitate user understanding of the design for collection of feedback.

Because of the thorough level of information provided by the client, very little information needed to be assumed for the construction of the prototype. The diameter of the drill bit was assumed based on the information supplied by the client, stating that the drill bit was the same width of the standard screw used in the door manufacturing process later on. With some research, it was found that, assuming a standard #12 screw used on hinges (not accounting for the special door styles, like fire and tornado), the diameter turned out to be 0.219 inches.

3.3.1 Feedback on prototype 1

Table 2: 1st Prototype Testing

Test ID	Test date	Feedback
1	2023-11-03	-"It's nice" -Individual expressed confusion with how to lift preset for drilling*.
2	2023-11-03	-Individual expressed concern with robustness and durability of the design in a harsh industrial environment. -Precision brought up as a priority for the design. -The adjustability of the clamping system, as well as specifications with set sizing is to be considered.
3	2023-11-03	- "Pretty neat design" -Most important aspects of the design have been considered. -No problems with weight distribution are expected due to symmetry of design. -Design on right track. -Individual expressed concerns with the drill fitting inside of the constraint of the jig.

Considering the first prototype is non-functional, the most effective way to measure the quality of the design is receiving qualitative feedback from a diverse pool. The group was made up of students in mechanical, chemical, and civil engineering at undergraduate and graduate levels. The non-functional aspect of the prototype made it difficult for the individuals that made up the testing pool to visualize the implementation of the prototype in an industrial setting*. Individuals were prompted for specific feedback regarding simplicity of design and ease of implementation.

Overall, individuals were impressed with the design and were satisfied that the jig would not hinder the speed and effectiveness of the client's process. Feedback on creativity and ingenuity expressed by the design was positive. To reinforce confidence in the jig's robustness, qualitative feedback of a functional prototype will be requested. Specifications on the typical drill size used by the clients will be requested to ensure the jig can be used simply.

Moving forward, measurable, quantitative data is targeted for the second prototyping phase.

Based on the information provided in the qualitative feedback, it would be prudent to in the future, test for feasibility of the product (prototype and final iteration), functionality, and how well the jig can reduce time spent of the preparation process. Initially measured as a Boolean, as compared to the current figures describing the in house conditions and output (eg. Time currently spent on complete door preparation for hinge ~ 30 minutes; does the jig reduce time to 20 minutes or below? Pass/Fail . If pass, then evaluate by what margin in percent, calculated against the decided upon parameter). See example provided below.

Table 3: Altered Prototyping Test Plan (Reduced for clarity, will be expanded upon in next deliverable)

Test ID	Test Objective	Prototype Description & Basic Test Method (What)	Results Description & Usage (How)
1	Functionality	Does a drill fit through the holes and does it drill straight	Pass/fail, used to determine changes for the next iteration of the prototype,
2	Meet spec expectations	Does the prototype complete print to specifications in the onshape docs	Pass/fail, does the prototype print, are the specifications met. Used to determine the feasibility of the solution, if changes need to be made
3	Reduce time to less than 20mins	Mark out a general backset for comparison and use the jig as intended in the workshop setting, timed, output determines pass or fail	Pass /fail, degree of efficiency based on % improvement from the current workshop time of 30 mins and calculated again against 20min goal. Dictates how to change the prototype to be more user friendly and useful. Too narrow, bulky,flimsy...

4. Updated Design Specifications

Considering the issues and feedback cultivated from various sources, certain updates were made to the design that will be in effect for prototype 2. Due to the time constraint of producing a functional prototype by Tuesday Nov. 7 not all mentioned issues will be fixed. Material issues may not be addressed as prototype 2 is expected to be 3-D printed. This is a relatively light material so weight will not be a problem. Additionally, due to time constraints, issues regarding the fitting of the drill in certain plate holes will be adjusted later. It is not a pressing issue and does not impede the jigs' general function. The drill is able to fit into most holes and the rest can be adjusted at a later date.

Commented [RA1]: Add what target specification were changed _->time and stuff like that

There were two major adjustments made. The first was for the casing. It was made hollow to decrease the general weight of the jig and the shape of the clamping paddles was adjusted. They were made longer and larger to improve the grip onto the door and their design was simplified. The clamping mechanism is still being considered and will be an important aspect of the second prototype. Currently, it is a simple pin and hole mechanism. This is not the intended final design but a placeholder until a spring-loaded design can be finalized. Secondly, to reduce complexity and material on the preset plates, the number of loops around the end of the hinge plates from 6, to two per plate as well as extending the edge of the loop on the 4.5” plate past the edge of the plate itself to fit snugly against the inner walls of the jig casing, whereas before each side, lengthwise was 4.5” exactly. The original idea would have left room for error and left the plate sliding and unstable on the pin, which could lead to reduced effectiveness and ultimately waste time for the user.

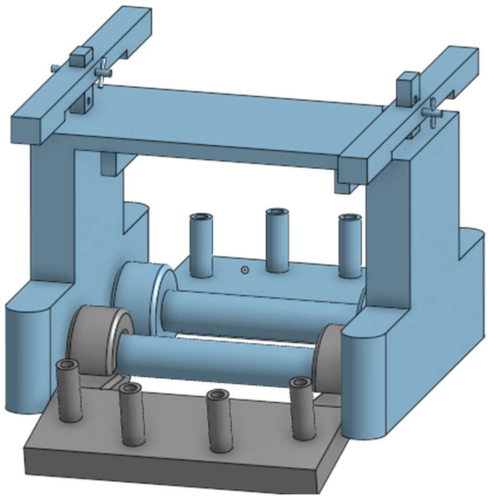

Figure 3. Front angled view of prototype 1, Assembly 2, iteration 2. Grey hinge plate indicates 5" hinge preset. Blue hinge plate indicates the updated 4.5" hinge plate preset.

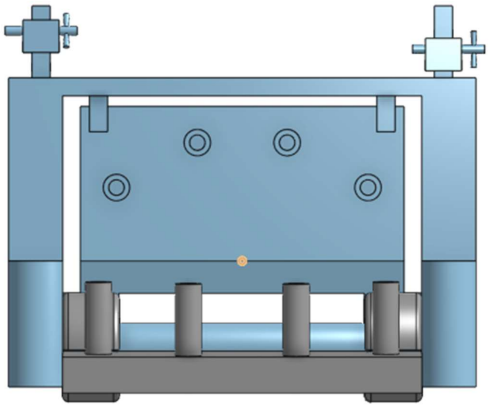

Figure 4. Front view of prototype 1, Assembly 2, iteration 2. Showing example of front view of 4.5" plate while in use. Grey denotes preset of 5" hinge plate.

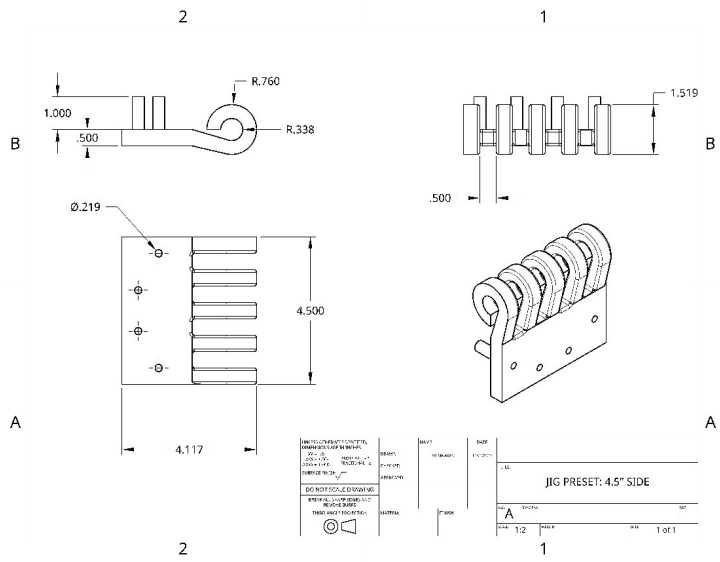

Figure 5. Deliverable E specifications for 4.5" hinge plate preset.

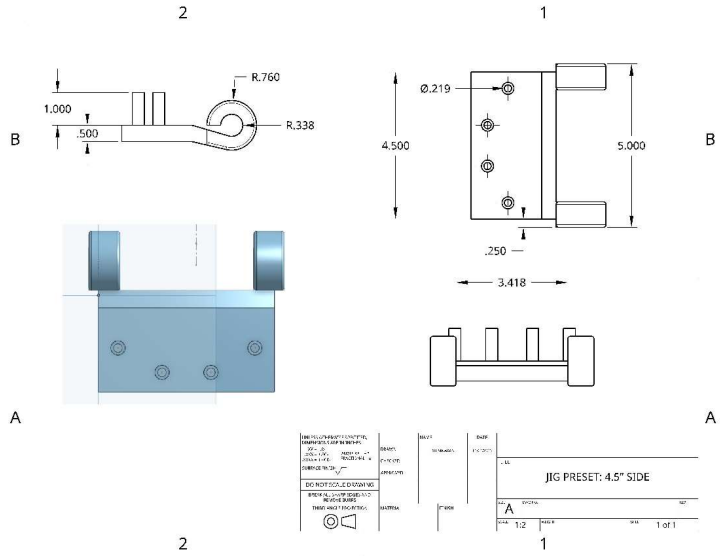

Figure 6. Updated specifications for 4.5" hinge plate preset.

5. Prototype 2 testing plan

Table 4: Prototype 2 + Deliverable G

Nov 5	Nov 6	Nov 7	Nov 8	Nov 9	Nov 10	Nov 11	Nov 12
Build prototype 2 (P2) based on observed complications with prototype 1 (P1)							
		Client meeting 2, get feedback	Test, record, and report on P2 and the changes				
					Meet to review public opinion and draft final changes		
					Write formal report on P2		
							Deliverable G DUE

5.1. Stopping Criteria

When a new product enters the prototype and testing phase, it is important to clearly lay-out parameters for when the product us ready or "stopping criteria." Stopping criteria in this context would denote a product we are ready to take to a manufacturing stage. A few factors we could name for this would be:

- Accuracy of the hole placement for each respective hinge size, regardless of configuration
- Ability to be clamped accurately to each individual backset
- Entire process (clamping, drilling, tapping, unclamping) can be completed in < 5 minutes
    - Ability to be used effectively by members of the public < 10 minutes
- Ability to hold its own weight

The above criteria can be measured through product testing. To ensure that our product is as straight forward and efficient as possible, we will have both members of the public, and trade professionals use the jig and provide feedback. While they execute the installation and full use of the jig, we will record how long the process takes. Once we can optimize our jig to have 90% of people within our desired stopping window, we will consider the product ready for final presentation to Ambico.

Conclusion

In conclusion, the project's initial phase has been successful from the development of the first prototype, crafted from cardboard, and from feedback from both clients and students. While the quantitative feedback from clients and students served as the primary measure for evaluating this prototype, it is acknowledged that the prototype's technical testability was limited. To address this constraint, the project has strategically shifted its focus towards the creation of the second prototype, which will integrate advanced 3D printing technology, providing a more robust platform for technical testing. Moreover, in response to the invaluable feedback received and in the pursuit of heightened functionality, significant design refinements have been introduced. Most notably, the arrangement of clamps has been reconfigured, with stationary clamps now situated in the upper section and movable clamps in the lower portion. This modification is intended to enhance the operational efficiency and ergonomic aspects of the jig. Additionally, a

refinement has been made to the hinge mechanism, resulting in a reduction of the number of loops from six to just one or two, thereby ensuring a simplistic, seamless and compatible fit between the hinges. These design enhancements exemplify the project's proactive approach to addressing user feedback and align with its commitment to make it user-friendly. As the project advances, these strategic design adaptations and prototyping methods are poised to make the project's final prototype successful.

Wrike snapshot:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=BIw7yRjD6570OVmbFcOqqajBBu4qfz5l%7CIE2DSNZVHA2DELSTGIYA