Deliverable G: Prototype II and Customer Feedback

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Introduction

For the initial prototype, 3D printing employed a 0.8 mm nozzle to address the delicacy of the teeth in both the jig and cut-out template. Due to size constraints, the jig was printed in two separate halves, later joined using duct tape, as the 3D printer lacked the capacity to accommodate the entire length of the jig.

The primary goal of this deliverable is to enhance Prototype II based on insights gained from Prototype I. This improvement involves reinforcing the fastening system by increasing the thickness of the jig's design wall to allow for a threaded hole. Additionally, a premade screw clamp, with a thread attached to the jig's hole for an improvised threaded opening, was utilized. The effectiveness of the clamp was evaluated by securely affixing the jig to the door and subjecting it to rigorous shaking. To measure the setup duration, a timer was initiated upon aligning the mark for flush bolt placement, securing the jig precisely to the designated point.

Analytical, Numerical, or Experimental Model

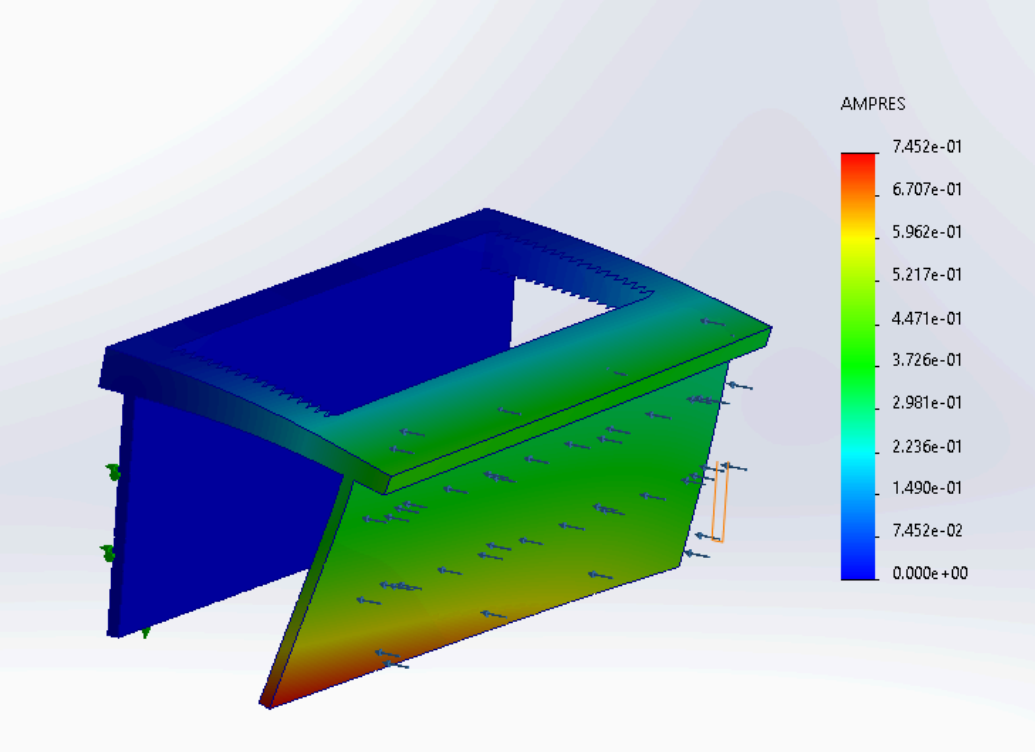

Figure 1. Analytical Model of Jig

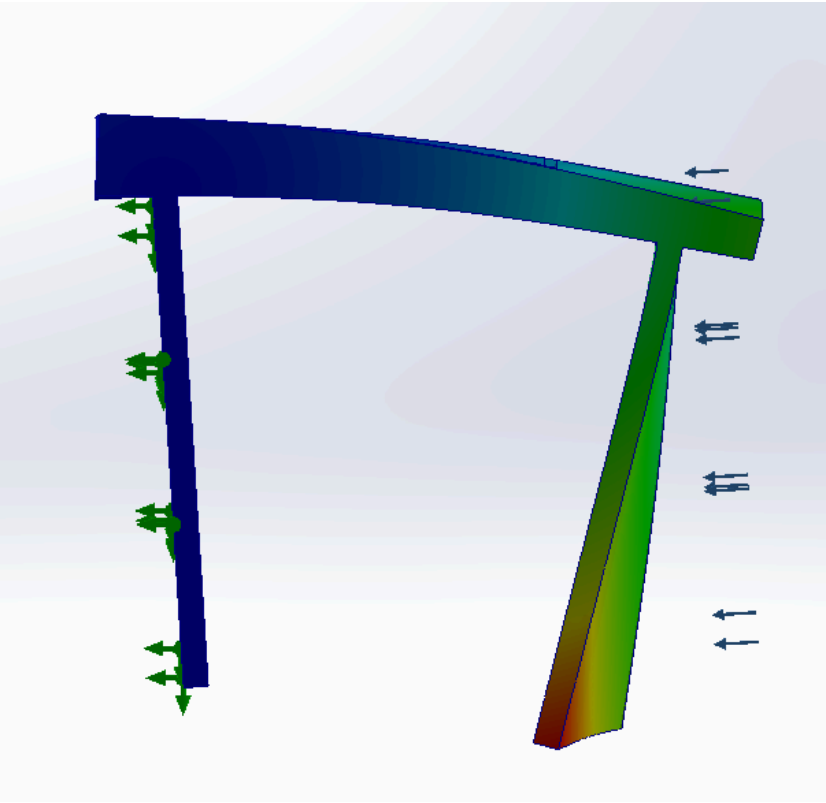

Figure 2. Analytical Model of Jig (Side View)

Figures 1 and 2 above represent a force applied to the side of the jig which has the threaded rod inserted into it. As shown, the maximum deformation acquired based on a ~25N force is 2.05 mm, which is the red section of the model.

Prototype 2 Test Results

- **Test 1**

Three timed tests were conducted to observe the time it takes to fasten the jig to a door. An additional timed test was done to test how long it would take to go through the full process of setting up the jig. The thickness of the door used in all tests is 1 3/8 in. The starting position of the screws was set further away with each test. The times collected are 42.89 seconds, 45.16 seconds, and 53 seconds. The time for the full setup is 1 minute, 10 seconds. The times obtained for fastening the jig to the door are longer than the times collected during the previous prototype testing. The change could be due to using a thinner door or to the properties of the different screw clamps used.

- **Test 2**

This test was performed by fastening the jig to the side of a door to observe the performance of screw clamps. The observations from the test showed fastening the screw was a smooth and straightforward process.

- **Test 3**

Test 3 was done by having a team member pull and shake the jig that had been fastened to the side of a door. No movement of the jig was observed. The results of the test show the screw clamps on the prototype are capable of creating a secure attachment to the door.

- **Test 4**

Test 4 was done by having a team member put the cutout plate into place. During the test, the cut-out plate fit easily into place without being loose. This demonstrates that the cutout plate is easy to install and is functioning as intended. One issue that was observed was that the bevel of the top plate caused a gap between the door and the cutout plate that could cause problems during the routing process.

- **Test 5**

The test was performed by pushing and wiggling the cutout plate while the jig was attached to the side of a door. When conducting the test, the cutout plate did not move. This shows that the cutout plate is secure in the jig.

- **Test 6**

This test could not be performed because we were unable to find a beveled door. However, the angle was measured using a protractor, and the measurement aligned with the angle specified by AMBICO.

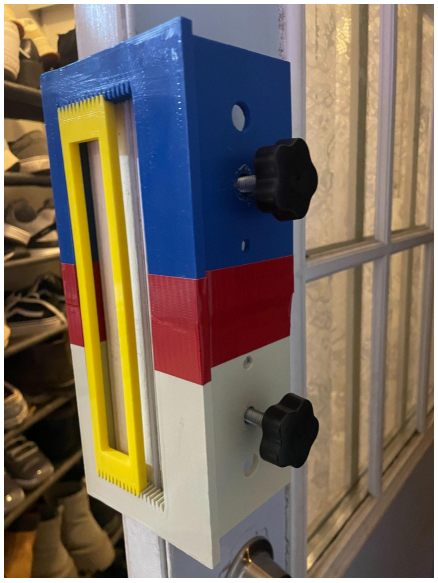

Figure 3. Prototype Fastened onto Door

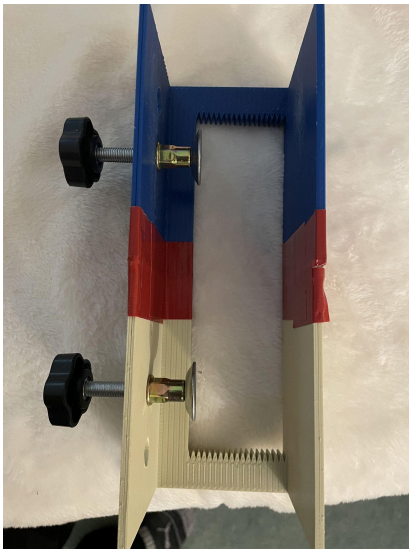

Figure 4. Bottom View of the Prototype

Customer Feedback

After the second client meeting, it was recommended by the client to add written increments on the jig near the teeth to guide the user on which increment must be used for which door thickness. Additionally, the client brought to our attention that 2 more teeth need to be added to accommodate larger door thicknesses.

Revision of Specifications, Design, and BOM Following Test Analysis

The main jig part needs further adjustment to accommodate the cutout plate more comfortably, as its current size is too tight for proper fitting. The screw holes require resizing to match the diameter of the purchased screws. Either new screws with soft rubber ends will be purchased to protect the door, or rubber caps will be obtained or made to fit over the existing screws.

Table 1 below outlines the bill of materials (BOM) for the second prototype. Similar to the first prototype, the two halves of the jig were printed, but this time they featured a beveled edge and several holes with varying diameters to determine the best fit for the screws. The same 3D printed cutout plate from prototype 1 was utilized, along with the same duct tape roll to secure the two halves of the jig. In contrast to the first prototype, screws were purchased instead of being 3D printed, as the printed ones were found to be unreliable. The final design will also incorporate two additional teeth to accommodate larger door sizes that were previously missed. The teeth will be marked with increments to assist the user in easily determining where to place the cutout plate based on the door thickness they are working with.

Table 1. Bill of Materials Spreadsheet for the Second Prototype

BOM			
Part	**Quantity**	**Cost ($)**	**Provider**
First 3D printed half of the jig (beveled)	1	0	Makerspace
Second 3D printed half of the jig (beveled)	1	0	Makerspace
3D printed cutout plate	1	0	Makerspace
Duct tape roll	1	1.41	Dollarama
Screw Clamps	1	19	Amazon

Third Prototyping Test Plan

Table 2. Prototyping Test Plan for the Third Prototype

Test ID	Test Objective (Why)	Description of Prototype Used and Basic Test Method (What)	Description of Results to be Recorded and How These Results Will be Used (How)	Estimated Test Duration and Planned Start Date (When)
1	Test setup time of the full prototype design. The test will allow the team to learn the approximate setup time for the final design.	The third prototype will be employed for this test. Prototype #3 features enhancements over prototype #2, incorporating a fully 3D printed beveled design for both the main part of the jig and the cutout plate. Additionally, it includes store-bought screws that fit securely and snugly within the jig. The setup time will be assessed by having one person handle the jig as a user would, while another person records the time it takes for fastening/tightening the screws onto the door and correctly placing the cut-out plate at the designated increment for the door thickness used in the test.	The results of this test consist of the time taken to set up the jig at various door thicknesses. The results of this test will help the team verify that the set-up time for the jig falls within the time limit necessary for the jig to be efficient for AMBICO.	The planned start date is March 15, 2024, and the test should not exceed 30 minutes.

		The test will be performed on various door thicknesses.		
2	Test the reliability of the fastening system. This test aims to assess the fastening system's capability to securely hold the jig in place on the door without damaging the surface when tightened.	The system to be tested consists of the newly purchased screws designed to fit perfectly into the new holes on the jig. It also includes rubber or soft material ends for the screws designed to prevent damage to the surface of the doors. The evaluation of the fastening system will include tightening and loosening the screws multiple times across various door thicknesses and wood types to assess reliability. The stability of the jig will be tested by shaking it vigorously to check for any movement. Observations from this test will be recorded by one team member.	The recorded results will verify the expected reliability of the screws staying secure on the door without damaging the surface, as well as assess the ease of fastening using the screws.	The planned start date is March 15, 2024, and the test should not exceed 5 minutes.
3	Test the stability and reliability of the beveled cutout plate. This test is designed to check the beveled	The test will incorporate the 3D printed beveled design of the cutout plate, precisely crafted to fit seamlessly within the jig.	The recorded results will help the team verify the smooth insertion and removal of the beveled cutout plate, ensuring	The planned start date is March 15, 2024, and the test should not exceed 5 minutes.

	version of the cutout plate's ability to remain in place and ease of use.	The evaluation will involve one person inserting the cutout plate into the jig at each increment of teeth.	its proper fit across various door thicknesses. Additionally, observations will be made regarding the stability of the cutout plate during shaking.	

Conclusion

After assessing both the passed and failed tests of the second prototype, several changes have been identified for implementation in the second prototype. These modifications include modifying the holes for the screws so that they perfectly accommodate the diameter of the screw clamp and the screw clamp that was used was a premade screw.

Furthermore, there will be adjustments to resize the jig for an optimal fit with the cutout plate. Additionally, the thickness of the jig's wall will be increased to enhance the secure integration of the screw clamp with the jig. Two additional teeth will be incorporated into the cutout plate. The hole diameter will be adjusted to align with the diameter of the screw thread. Finally, written markings for incremental measurements will be added to the jig.