UNHINGED

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Abstract

This document outlines a design plan for the fabrication of the prototype of the portable jig to the client's (AMBICO) specifications. This document will provide an overall design of the proposed final product along with three prototype plans and a breakdown of materials and costs. In addition, the document will list any risks identified in the proposed design and manufacturing plan. The purpose of this document is to obtain an overview of the updated design plan in preparation for manufacturing the first prototype.

Detailed Design

From Deliverable D, it was decided that the structure will be a U-shaped clamp that can be attached to the door with a rubber band mechanism to keep the clamp in pressure with the door frame. To pull the U-shaped clamp, a handle will be included for the jig user to simply hook one side into the door and pull with one hand to secure the clamp to the door.

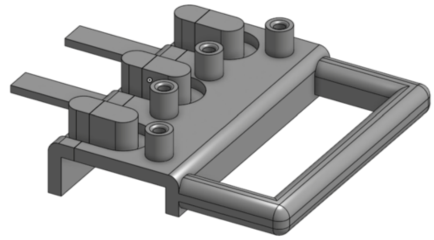

Figure 1 Prototype design

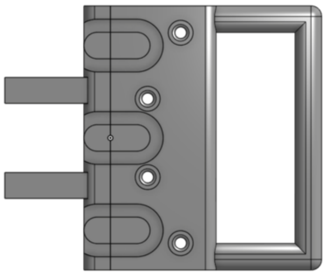

Figure 2 Prototype design

At the top of the clamping device are drilled holes with extended guides for the drill bit. This guide will help the worker to keep the drill straight and make it able to align with the desired point easily and quickly on the door frame. This design is primarily made of steel due to its strength and ease of use and the cost effectiveness and availability of the material. Also, for the two different types of hole patterns there will be two separate jigs in order to reduce complexity in the design so that the design will have a longer useable life.

This jig will be useful and beneficial to workers because it will save them time, as it now takes an estimated 30 minutes per door to drill all the holes. Workers will easily understand the jig and will be able to use it without training, which means they are more likely to use the device. This means that because the jig will save time per door, the factory will be able to produce more doors, which will make the company more money overall and amortize any lower costs this jig may have. This jig is designed to be simple and have no unnecessary moving parts, which means life cycle is a priority. The complexity of the designs often causes them to fail over time, but due to the simplicity of this jig, it will most likely have a very long lifespan.

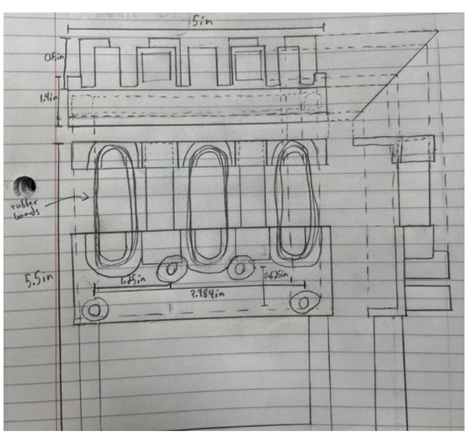

Figure 3 Clamp Detailed Design

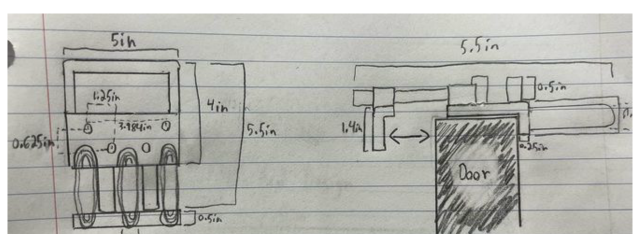

Figure 4 Clamp Detailed Design

Project Risks

We have divided the risks into three groups in order to propose alternatives or contingency plans and minimize them as much as possible in our final prototype design, these three groups are: general design, structural system, and non-functional system.

General design

Risks are present at every step of the design process and, as such, must be identified and mitigated. One such risk is the size of the jig plate (the part that connects to the gate and is drilled by the operator). Our AMBICO customers mentioned that, to minimize operator error, the jig should be sized slightly undersized so that the operator has to slide the part until it makes contact with the edge of the hinge cutout. This alerts the operator that it is in the correct position, and he can begin drilling. If the plate is too large (due to design or manufacturing error) an oversize fit may occur which could result in incorrect holes being drilled.

Structural System

Another risk arises in the mechanism of the product. Namely, the system that handles the tensioning and locking mechanism. The mechanism that was chosen was some sort of elastic bands that will stretch to conform to the placement and then compress and lock into place once external pressure is removed from the operator. Since the locking mechanism has not yet been tested, it is important to determine the exact amount and placement of the rubber bands so that the jig will have a uniform ideal fit. If the tension/compression is not adjusted correctly, the jig could have a loose fit that will result in installation inaccuracies or a very tight fit that could be difficult for the operator to remove and cause delays. In addition, the use of elastics can lead to reliability risks, as the constant tension and compression of the bands can deteriorate the elasticity and cause a loose fit over time. For these risks, a system can be created to quickly replace any damaged elastic. Another solution is to find a better and more reliable material. If we discover that this elastic method is no longer ideal or cannot be easily corrected, we run the risk of having to design an entirely new mechanism to replace the functionality of the elastics.

Non-functional System

The last risk that arises is the short service life of the product. Although not directly related to the performance of the device, it is still important for our customer to save money and time. This can occur for several reasons. Firstly, the material chosen is not strong enough; to save costs, we decided that the main material to be used will be plastic, with the exception of the nozzles, which are made of metal. This may cause the device to break down over time. Secondly, the assembly is not good. While the main part will be 3D printed to save on cost, the nozzle will be metal and the assembly of these two parts will have to be done by hand, which is prone to errors. Thirdly, the elastic system used is not compatible with the system, this means that if the elasticity is too strong, the worker will have to pull hard on the elastic, which will degrade it over time.

Prototyping Plans

The plan for making this prototype is to make sure it will meet our customer's requirements. That's why this list may change between now and the final prototype. It is a good reference of what we are looking for in our prototype. The first meeting with the customer went very well, we had good feedback and discussed the things they will be looking for in our final design. Conducting these tests will ensure the best possible door hinge jig for our customer. The testing schedule may also change. We hope to be able to run these tests earlier than the stated dates, thus giving us more opportunity to make changes if needed. Therefore, this table is only a rough estimate of our plan.

Table 1 Prototyping Test Plan

Test ID	***Test Objective (Why)***	***Description of Prototype used and of 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 durability of the overall jig. Can handle a rough environment	The material we choose to make it out of will have to be durable. Maybe use a hard plastic or 3D printed material. Could use steel but might be too heavy.	A good jig will withstand drops from the table or getting the jig of the door if it is dropped. Should be strong also against being hit against a door when working.	November 14, 2023
2	Test that the jig will be able to clamp on the door and stay there.	This can be tested using a drill at the maker pro at school or using a household drill. We will clamp the jig down and see what happens when we start drilling.	The jig will need a strong enough clamp to latch onto the door and withstand the vibrations from the drill and when put the drill into the nozzles must not move.	November 20, 2023
3	Test that the nozzles are big enough for the drill bit and tapper.	We will find the right drill bit size and tapper size and test that the nozzles will be wide enough to fit the drill bit without getting worn down by the friction of the drill. This can be done when testing the jig clamp.	This will show us if we need to resize the nozzles or not. They should fit perfectly with a little bit of room.	November 20, 2023

Test ID	***Test Objective*** ***(Why)***	***Description of Prototype used and of 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)***
4	Test the nozzles can withstand the drills friction and won't break during the drilling	This will be able to test the different materials we need for the nozzles. The nozzles might have to be steel while the body can be plastic or something else. This will be done when testing the hole size.	It should be able to withstand the drilling friction on the side walls of the nozzles. It will help decide the best material to use.	November 20, 2023
5	Test that the holes are drilled straight using the nozzles.	This is to ensure the drilled holes are straight and not on an angle. If the holes are crooked the door will need to be restarted. This is an important thing to get right. We will do the same time as the ID 2, 3 and 4. When testing the nozzle size we can test the straightness of the drilling as well as test the straightness of the drilling.	This should be straight as an arrow and in the middle of the holes so the hinges will fit perfectly.	November 20, 2023
6	Test that it will be easy to use for the workers.	This can be done by getting someone who's not in our group to try out the jig as if they were the workers, just to see how someone new handles it.	This should be an easy prototype to use. It should be simple, quick and efficient. We are trying to maximize the efficiency of the jig.	November 21,2023

Costs of Production

The major part of the cost of production is the materials from which the product is made. The material must be anti-wear and solid, at the same time, the object with which it comes into contact must not be damaged by the product itself. Here are some possible solutions provided:

1) Use of plastic materials for the whole structure

Advantages

The advantages are obvious, due to the characteristics of the material itself. The weight of the product is light and soft. It is easy to customize with manufacturers, who are able to provide final production decisions in a short time. 3D printing can be produced on a small scale and have faster interactive versions.

- Low cost (relatively).
- Light weight.
- Easy to customize small-scale products.
- Convenient for later modifications and upgrades, with small trial and error costs.

Disadvantages

The drilling missions will cost a lot of wear and tear, causing the product to have poor sustainability. The heat produced by friction may damage the product, especially the nozzle part. In addition, products made of this material tend to have large errors. The use of better materials and processes of the same type will reduce this situation but will increase the cost.

- Low anti-wear property.
- Low high thermal resistance.
- Poor sustainability.
- Material limitations can lead to slight errors.

Estimate Cost

In general, most likely due to the manufacturing process of our product are compression molding, perfusion molding, and 3D printed. They need to contact the model manufacturer to determine the model and test generation, this leads to the final mass production reliable type of products. The final costs are related to:

- Mold customization cost +
- Raw material cost +
- Technology/Process +
- Other costs (taxes, labor, model modification, customization, etc.)

Table 2 Approximate Costs Model 1

Cost Index	resinous/plastic-like materials
Raw material cost	$20-$40 per kg
Mold customization	$50 per set
Manufacturing technique	$20 for plastic-like / $40 for resinous materials
Total	**$110 estimate**

2) The use of metal materials for the total structure and the addition of rubber gasket to prevent the door from being damaged and the slide due to low friction on the door and product surface.

Advantages

Metallic materials have a great advantage in terms of sustainability, and their production error is low.

- Wear resistant.
- Accuracy, extremely low errors.
- High sustainability.

Disadvantages

Normally, metallic materials have a high weight. Although corrosion and oxidation can be solved with a coating, its cost is high. Even the material (metal) is more expensive than plastic products.

- Heavy.
- Difficult to handle.
- Corrosion and oxidation.
- High cost (relatively).

Estimate Cost

The product can be manufactured by metal pouring and metal cutting. These shapes have a long fabrication life but extremely low errors once measurements are unsafe. Coatings may incur additional cost. Better alloys will also increase costs. The final costs are related to:

- Mold customization cost +
- Raw material cost +
- Technology/Process +
- Coating cost +
- Other costs (taxes, labor, calibration, customization, etc.)

Table 3 Approximate Costs Model 2

Cost Index	Metallic materials
Raw material cost	$15 per kg
Mold customization	$70 per set
Manufacturing technique	$50 for metallic materials
Coating cost	$20 per sq.m.
Total	**$155 estimate**

3) Use of plastic materials in the body of the product, use of metallic materials on the surface that are easy to wear, such as the surface that comes into contact with the drill rod (nozzle).

This type of product combines the relative advantages of the two previous solutions. The overall weight of the product is light while maintaining the quality. The most important feature is the possibility to replace key parts. Parts (nozzle) that are heavily worn due to the drilling process can be replaced and are made of metal/alloy. This is a challenge of manufacturing technique. The combination of different materials requires low production tolerances and material joining characteristics, as well as having the highest cost. But everything is guaranteed. The final costs are related to:

- Mold customization cost +
- Raw material cost +
- Technology/Process +
- Coating cost +
- Cost of model modification +
- Calibration cost +
- Other expenses (taxes, labor, custom costs, etc.)

Table 4 Approximate Costs Model 3

Cost Index	Composite materials
Raw material cost	$20-$40 per kg / $15 per kg
Mold customization	$100 per set
Manufacturing technique	$40 for plastic-like / $60 for resinous materials/ $50 for metallic materials

Coating cost	$20 sq.m.
Calibration fee	$10 per time
Total	**$300 estimate**

List of equipment

For the creation of our prototypes, we have the help of different graphic design software and hardware. In the following table we will be able to demonstrate these different equipment and programs used.

Table 5 List of equipment

	Software/Hardware	Utilization
1	Onshape (CAD Software)	We used Onshape to generate our prototype. This tool is a CAD (computer-aided design) software that allows us to make an online 3D version of our prototype. This allows us to make modifications and correct errors in the prototype before 3D printing it; this saves us money on printing multiple prototypes and gives us an idea of what the final design will look like.
2	3D Printer (Hardware)	The 3D printer is a machine that makes a design from scratch by printing different layers on top of each other. This machine helps us to print our designs. It is beneficial to see the design as it is in reality and find any errors, also this allows us to show our progress to the customer and get feedback from them.

3	Excel (Software)	This tool allows us to make cost tables and see how we are doing according to our budget. It is a really practical tool as it allows an interactive way to interact with the tables and organize all the necessary information in one place.
4	Word (Software)	This tool allows us to write and organize our deliverables. It is a necessary tool to review grammar and professionally organize all the information in one place and ready to be sent.

Reflection

In conclusion, we have remained consistent with the design proposed in Deliverable D: Conceptual Design and we have outlined a plan to begin manufacturing and testing a prototype. We have identified potential design risks for the prototype, namely the sizing of the manufactured product, the tension/elastic band mechanism, and the reliability of the materials chosen. We have proposed a prototype plan with testing methodology that will span from November 14, 2023, to November 21, 2023. Since the feedback from our customers has been positive so far, we will focus primarily on fine-tuning any design flaws and ensuring that the prototype performs as planned.