Hozhoni Button Maker

Preliminary Proposal

Dylan Oliva, Project Manager/Team Lead
Bryce Igo, Budget Manager
Ryan Torres, Customer Contact
Abdulah Almerri, Web Developer
Kristen Rieger, Primary Author

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Project Sponsor: W.L. Gore and Associates
Project Client: Hozhoni Foundation
Faculty Advisor: Dr. Sarah Oman
Instructor: Dr. Sarah Oman

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1 BACKGROUND

1.1 Introduction

The design team has been tasked with modifying a button making process currently employed at Hozhoni Foundation. The Hozhoni Foundation uses the button making as a means for their developmentally disabled clients to generate income by providing a service or product to the community. However, the current button making process and machine is not suitable for many of Hozhoni's clients, the physically and developmentally disabled, and only one client is currently able to operate the machine. By modifying the process and machine, or by creating an entirely new device, more clients at Hozhoni will be able to make buttons for a job and gain a higher level of independence, as well as a sense of purpose and value.

The project is sponsored by W.L. Gore and Associates, who will be providing the design team with the budget of $1500.00. W.L. Gore and Associates is well-known for supporting members of their community in a variety of ways, as well as providing projects and internships to engineering students. The client, the Hozhoni Foundation, will benefit from this sponsorship and project by obtaining an enhanced button making process that will give their clients a job and income. By enabling the clients to do this job, the sponsor and design team are providing Hozhoni's clients with a path to financial, social, and emotional wellness.

This project has great importance to Hozhoni's clients and the Hozhoni Foundation as a whole. The Hozhoni Foundation, founded in 1970 [1], provides education and vocational services to individuals in the community with developmental disabilities. Part of the foundation's commitment to the community and their clients is to match the clients with appropriate employment. The Button Maker itself was purchased for the foundation by the landlord of a former location, and it has since been used to fill orders for buttons for various community organizations. Hozhoni contracts with Five Star Printing in Flagstaff, and Five Star sends the printed patterns to Hozhoni to be made into buttons. Modification of the button maker will allow more individuals to participate in this job, increasing the ability of the Hozhoni Foundation to fill button orders and providing the clients with an income (typically minimum wage in a setting to which they are accustomed). The value of providing this job is more than economic; being able to do a job within the community provides the clients with a sense of importance and responsibility. The design team feels that the main purpose of the project aligns closely with Hozhoni's mission to advocate for and provide jobs to their clients.

1.2 Project Description

Following is the original project description provided by the faculty advisor at the beginning of the term[2].

> *Several of this coming year's capstone design projects will focus on assistive devices for people with disabilities. The Hozhoni Foundation is a local Non-Profit Agency (NPA) in our area that specifically provide work opportunities for people with disabilities. W. L. Gore and Associates (a global engineering company with local offices) will be funding the projects.*
> *Currently only one client at Hozhoni Foundation is able to use the Button maker due to precision and physical requirements (Figure 1). An assistive device is needed to either modify the existing set-up or create a brand new set-up that allows new clients to create buttons that they are contracted to make by numerous local Businesses.*
> *Issues with the current set-up include: need strength in at least one leg to push down the mechanism, need to precisely align the bottom portion (that contains the pin) with the top picture, need upper body strength to cut out the pictures, and finger dexterity to separate the pieces (plastic cover, picture, etc.).*

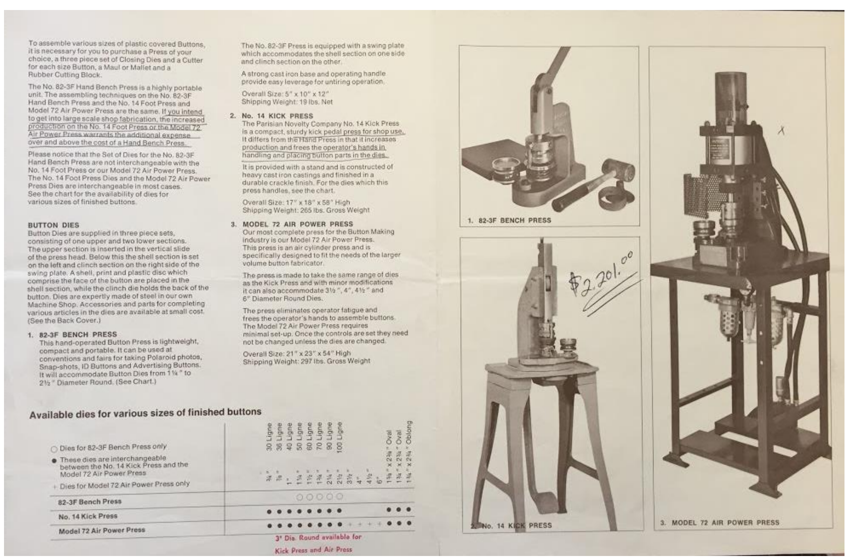
Figure 1: Cutting the Patterns

1.3 Original System

The design team is currently pursuing plans to modify the current button maker setup to increase access to clients of different abilities. The original button maker is detailed in the following sections.

1.3.1 Original System Structure

The Button Maker at the Hozhoni Foundation offices is a cast iron press. It was purchased from the Parisian Novelty Company in the early 1970's. Figure 2 shows the original brochure for the button maker, which was provided by the project customer contact. The brochure details the variety of die sizes available (for making various button sizes).



To assemble various sizes of plastic covered Buttons, it is necessary for you to purchase a Press of your choice, a three piece set of Closing Dies and a Cutter for each size Button, a Maul or Mallet and a Rubber Cutting Block.

The No. 82-3F Hand Bench Press is a highly portable unit. The assembling techniques on the No. 82-3F Hand Bench Press and the No. 14 Foot Press and Model 72 Air Power Press are the same. If you intend to get into large scale shop fabrication, the increased production on the No. 14 Foot Press or the Model 72 Air Power Press warrants the additional expense over and above the cost of a Hand Bench Press.

Please notice that the Set of Dies for the No. 82-3F Hand Bench Press are not interchangeable with the No. 14 Foot Press or our Model 72 Air Power Press. The No. 14 Foot Press Dies and the Model 72 Air Power Press Dies are interchangeable in most cases. See the chart for the availability of dies for various sizes of finished buttons.

BUTTON DIES
Button Dies are supplied in three piece sets, consisting of one upper and two lower sections. The upper section is inserted in the vertical slide of the press head. Below this the shell section is set on the left and clinch section on the right side of the swing plate. A shell, print and plastic disc which comprise the face of the button are placed in the shell section, while the clinch die holds the back of the button. Dies are expertly made of steel in our own Machine Shop. Accessories and parts for completing various articles in the dies are available at small cost. (See the Back Cover.)

1. **82-3F BENCH PRESS**
This hand-operated Button Press is lightweight, compact and portable. It can be used at conventions and fairs for taking Polaroid photos, Snap-shots, ID Buttons and Advertising Buttons. It will accommodate Button Dies from 1¼" to 2½" Diameter Round. (See Chart.)
The No. 82-3F Press is equipped with a swing plate which accommodates the shell section on one side and clinch section on the other.
A strong cast iron base and operating handle provide easy leverage for untiring operation.
Overall Size: 5" x 10" x 12"
Shipping Weight: 19 lbs. Net

2. **No. 14 KICK PRESS**
The Parisian Novelty Company No. 14 Kick Press is a compact, sturdy kick pedal press for shop use. It differs from the Hand Press in that it increases production and frees the operator's hands in handling and placing button parts in the dies.
It is provided with a stand and is constructed of heavy cast iron castings and finished in a durable crackle finish. For the dies which this press handles, see the chart.
Overall Size: 17" x 18" x 58" High
Shipping Weight: 265 lbs. Gross Weight

3. **MODEL 72 AIR POWER PRESS**
Our most complete press for the Button Making industry is our Model 72 Air Power Press. This press is an air cylinder press and is specifically designed to fit the needs of the larger volume button fabricator.
The press is made to take the same range of dies as the Kick Press and with minor modifications it can also accommodate 3½", 4", 4½" and 6" Diameter Round Dies.
The press eliminates operator fatigue and frees the operator's hands to assemble buttons. The Model 72 Air Power Press requires minimal set-up. Once the controls are set they need not be changed unless the dies are changed.
Overall Size: 21" x 23" x 54" High
Shipping Weight: 297 lbs. Gross Weight

Available dies for various sizes of finished buttons

○ Dies for 82-3F Bench Press only
● These dies are interchangeable between the No. 14 Kick Press and the Model 72 Air Power Press
+ Dies for Model 72 Air Power Press only

	¾" 30 Ligne	⅞" 36 Ligne	1" 40 Ligne	1¼" 50 Ligne	1½" 60 Ligne	1¾" 70 Ligne	2¼" 90 Ligne	2½" 100 Ligne	3½"	4"	4½"	6"	1⅝" x 2⅛" Oval	1¾" x 2¾" Oval	1¾" x 2¾" Oblong
82-3F Bench Press				○	○	○	○	○							
No. 14 Kick Press	●	●	●	●	●	●	●	●					●	●	●
Model 72 Air Power Press	●	●	●	●	●	●	●	●	+	+	+	+	●	●	●

3" Dia. Round available for Kick Press and Air Press

Figure 2: Parisian Novelty Company Brochure [2]

The button maker consists of a press, with two circular dies in which the button components (button back with pin, plastic covering, and picture or pattern) are placed, and where the assembly occurs. The press is activated by depression of a foot lever. Figures 3, 4 and 5 show the location of these features.

Figure 3: Button Maker Press

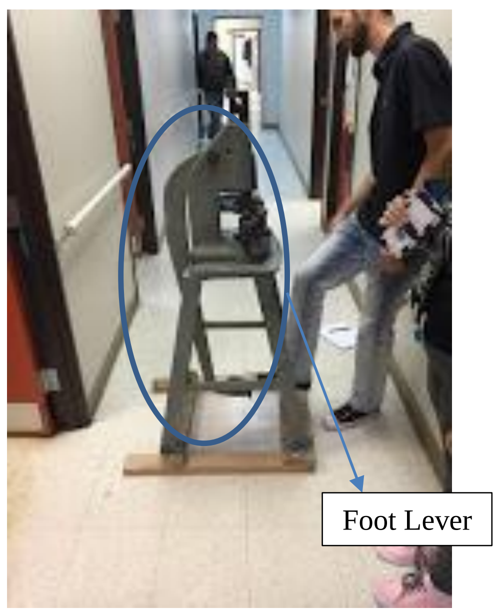


Figure 4: Button Maker Foot Lever

Figure 5: Button Maker Dies

The Hozhoni Foundation possesses dies in various diameters, providing the option for making different sized buttons, but currently Hozhoni only makes 2.25” diameter buttons. This is due to the difficulty of changing the dies in the press and the economic benefit of buying a large amount of button components for one diameter only.

1.3.2 Original System Operation

It should be clarified that the button maker used by Hozhoni Foundation is a device that creates buttons with a pin back that displays an image, logo, or message. These are NOT clothing buttons. In order to make a button, the pictures are first cut from the sheet as in Figure 1. An 8.5”x11” sheet is printed with the image by a local printing company with 6 images per sheet. The customer contact is currently the only one at Hozhoni that is able to complete this step of the process, due to the difficulty in aligning the cutting die and because the die is pounded with a heavy mallet to make the cut, an inherently dangerous task. After the patterns are cut, they can be taken to the button maker. The button components are placed into the dies of the press (Figure 4). Great care must be taken to ensure that the button backing with the pin is properly aligned. The casting swivels, and different button components are placed in one of the two castings on the swivel. The foot lever is pushed one time to capture the button backing containing the pin in the press, and once the picture and plastic covering are added and aligned properly, the lever is pressed again to completely assemble the button and release it from the press. This process may take up to a minute, although the Hozhoni client currently making buttons can assemble about 300 buttons in an hour.

1.3.3 Original System Performance

The performance of the Button Machine is completely dependent upon the dexterity and strength of the operator. As it is a completely manual machine, there are no power requirements. The accuracy of the machine, especially as it pertains to the alignment of the button components, requires manual dexterity, sufficient hand-eye coordination, and practice. The alignment of the button components, and of the dies throughout the process is especially important because the buttons must be made in such a way that the pin back lies completely horizontal while the image is upright on the wearer. Alignment issues are the single largest reason for rejects from the process.

The team is planning to obtain final measurements of necessary forces and limb extension at the next meeting at the Hozhoni Foundation.

1.3.4 Original System Deficiencies

The deficiencies in this process are numerous, especially when considering that the goal is make the process simple and accessible enough for clients with developmental disabilities or physical limitations to be able to do it.

First, cutting the patterns from the sheet is dangerous, requires significant arm strength, and must be done very accurately. For this reason, the customer contact is the only one able to do this part of the process. Next, it requires a fair amount of thought to assemble the button components in the proper order in the press, and they must be aligned precisely. This alignment and placement of components is difficult, even for a person who has average ability. The foot lever does not require significant force, but does require a very large leg extension. A person in a wheelchair or with limited use of their legs cannot use the machine for this reason. If a person has difficulty with balance, they may fall when operating the foot lever. These deficiencies are the focus of our solution, and the new design must address them.

2 REQUIREMENTS

The design team met with the customer contact, Justin, to discuss what he and the clients would like addressed in an improved button making process. The following sections discuss the requirements generated at this meeting and their relative importance.

2.1 Customer Requirements (CRs)

The following list of customer requirements were generated based on the stated needs and concerns of the customer contact. This list is preliminary and may be subject to revision or addition throughout the project. The listed weightings are out of a total of 250.

1. Create arm actuation for the button maker: **25**
   The addition of this feature will allow clients with limited or no use of their legs to operate the button maker.
2. Add alignment mechanism for button components: **30**
   Alignment issues are the primary cause of “rejected” buttons. Providing assistance in aligning components, both of the button maker and button components, will assist clients with poor dexterity or hand-eye coordination to create properly aligned buttons.
3. Enable clients to cut patterns: **25**
   By creating a cutting device or process that allows clients to reliably and safely cut the images from the sheets, a new job is created for clients and the customer contact will not have to spend his time preparing the patterns.
4. Decrease range of motion for foot lever: **20**
   As the range of motion needed for using the foot lever is large, this excludes clients who have limited use of their legs or poor balance.
5. Increase pattern cutting efficiency: **25**
   The customer would like to be able to cut more patterns from the sheet at one time.
6. Larger size range for cutting dies: **20**
   Because the button maker already has the ability to create buttons of different sizes, the cutting process should be modified to cut patterns corresponding to the various die sizes.
7. Allow Table Height to be Adjusted
   The height of the button maker may need to be adjusted to accommodate those who cannot stand.
8. Safety **35**
   Overall system safety
9. Reliability **30**
   The system should operate as intended, with minimal maintenance, every time it is used
10. Overall Efficiency **30**
    The system should be as efficient as possible, minimizing time to assemble buttons, cut patterns, and should be as simple and “straightforward” to use as possible.

2.2 Engineering Requirements (ERs)

Engineering Requirements have been developed to map the customer requirements outlined above to specific, quantifiable measurements. The engineering requirements are related to three areas of design focus: actuation of the button maker, the cutting process for the patterns, and the alignment of button components and the button maker dies.

1. Force required to operate hand actuation (in pounds)
2. Force to operate foot lever (in pounds)
3. Distance to depress foot lever (in inches)
4. Patterns cut per cutting operation (#)
5. Size range for patterns (in inches)
6. Size range for button maker dies (in inches)
7. Cost (in dollars)
8. Table height (in inches)
9. Time to Align Button Components and dies (seconds)
10. Pinch Points (#)
11. Time to cut one sheet of patterns (seconds)
12. Time to assemble one button (seconds)
13. Sheets cut through per cutting operation (#)
14. Necessary preparation time before cutting (seconds)

The target values for these requirements, along with tolerances, can be found in the House of Quality in section 2.5.

2.5 House of Quality (HoQ)

The House of Quality (HoQ) is a design tool useful in identifying customer requirements, engineering requirements, the relationship between the two and target values for engineering requirements. The HoQ in Table 1 will be refined as the design team continues to take measurements for target values.

Table 1: House of Quality

1.4.5 House of Quality (HoQ)																
Customer Requirement	**Weight**	**Engineering Requirement**	Force to operate hand lever (pounds)	Force to operate foot lever (pounds)	Distance to depress foot lever (inches)	Patterns Cut per Operation (#)	Size range, patterns (inches)	Size Range, Button Maker (inches)	Cost (dollars)	Table Height (inches)	Time to Align Button Components (seconds)	Pinch Points (#)	Time to cut one sheet of patterns (seconds)	Time to Assemble one button (seconds)	Sheets Cut Per Cutting Operation	Necessary Preparation Before Cutting (seconds)
1. Add hand actuation on button maker	25		9						9			6		3		
2. Increase Ease-of-Use for Foot Lever	20			9	9				3							
3. Add Alignment Mechanism	30							3			9	3		9		
4. Enable clients to cut patterns	25					9	9		9			3	9		9	9
5. Increase Pattern Cutting Efficiency	25					9	9						9		9	9
6. Larger size range	20					9	9	9	9				1		1	
7. Adjustable Table Height	10		3	3	3					9		3				
8. Safety	35		3	3	3							9				1
9. Reliability	30		3	3	3	3					3		3	3	9	
10. Overall Efficiency	30		3	3	3	3					9		9	9	9	9
Target(s), with Tolerance(s)			5±3	8±3	8±4	10±4	3.5±2	3.5±2	<1500	36±12	<10	<3	<25	<30	>6	<60

3 EXISTING DESIGNS

The team conducted a review of existing designs for making pin back buttons. There are industrial processes for creating these types of buttons, but the team identified that the button makers that are most relevant to the type of button making that takes place at Hozhoni, which is essentially a small-scale commercial operation, are button makers meant for personal or home use. Designs at the sub-system level were also researched in this way for the three areas of design focus.

3.1 Design Research

The type of existing design research pursued by the team consisted of extensive online research, or benchmarking. The team researched current button making machines on the market for personal or small-scale commercial use. Three areas of design focus have also been identified and these areas were researched for sub-system level benchmarking (alignment, actuation, and cutting the patterns). For some areas, it was more useful to research products on the market and for others it was more relevant to research processes, and these research methods and the results are detailed in the following section.

3.2 System Level

The team researched and performed benchmarking for small-scale, personal use button makers. The team discovered that personal use button makers may fall into either automatic (electric) button makers or manually operated button makers. As the team feels strongly that an automated solution to the button maker redesign defeats the principles and goals of the project as discussed with the customer contact and faculty advisor. Manually operated, small scale button makers have been researched and these designs are described below.

3.2.1 Existing Design #1

Figure 6 shows a manually operated button maker meant for personal use or small business applications. It relies on a lever mechanism to transfer the force supplied by the operator. This machine may be mounted to a desk or workbench to avoid movement and to provide stabilization. The short length of the lever arm increases the amount of force needed from the operator. This design, from American Button Machines [3]. This model also features swivel motion of the die cups, as does the button maker at Hozhoni. This model does not accept different sized or shaped dies, so the low price ($229) may not remain low if additional models must be bought to gain to ability to make different size buttons.

Figure 6: American Button Machines, Manual

3.2.2 Existing Design #2

The button machine company, Tecre, manufactures both automatic and manual button makers[4]. Figure 7 shows a button maker that uses a lever and a swivel die design as above, but is mounted on a platform that also features a graphic cutter. This offers the advantage of being able to cut the image, or pattern, with the same piece of equipment that will be used to assemble the buttons.

Figure 7: Tecre Mounted Manual Button Maker

3.2.3 Existing Design #3

Figure 8 shows a manual button maker from USA Buttons, Inc. [5]. This system is a compact machine with one distinct advantage over the above designs is that the lever changes position rather than the dies, eliminating any swivel action that can complicate the alignment of button components.

Figure 8: USA Buttons, Inc., Manual Button Maker

3.3 Subsystem Level

The team has decomposed the button making process into three areas of design focus: the cutting process, die and component alignment, and button maker actuation. These three areas of focus constituted our subsystem level benchmarking.

3.3.1 Subsystem #1: Cutting

The customer contact for this project has identified that it would be helpful to create a safe, usable system for cutting the images from the sheets (delivered from the printing company) that the clients could use. Because the customer contact is currently using a die and mallet to punch the images from the paper, and because the process is noisy and inherently dangerous, he would like to see the clients able to do this part of the button making process as long as it is safe and efficient. The team benchmarked methods and devices currently on the market for cutting small circles.

3.3.1.1 Existing Design #1

Figure 9 shows a graphic cutter made by Tecre [4]. This graphic cutter is similar to the cutter mounted on the combination system in Figure 7, but can be purchased separately. The sheet containing the images must be cut to slide into the cutter. A lever is used to “punch” through the sheet. Although several sheets may be cut through at one time, only one image per sheet may be cut at one time.

Figure 9: Tecre Graphic Cutter

3.3.1.2 Existing Design #2

The circle cutter shown in Figure 10 is made by Fiskars (available through Amazon.com, [6]). This circle cutter is placed directly over the image to be cut, and it is visualized through the clear acrylic dome. The advantage of this cutter is that it can cut different diameter circles, but it can only cut one image per sheet at one time and likely cannot cut through multiple sheets without wearing down the blade.

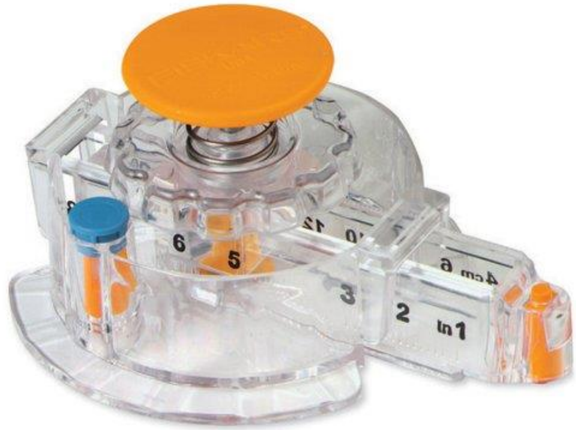


Figure 10: Fiskars Circle Cutter[6]

3.3.1.3 Existing Design #3

The “Foamwerks Foamboard Circle Cutter”, Figure 11 (available through engineersupply.com [7]), relies on a clear dome as with the Fiskars circle cutter, but instead of a punch it uses a rotating blade operated by a crank. This cutter is designed for foamboard, and as such may be able to cut through multiple sheets of paper, but as with the Fiskars circle cutter it can only cut one image on the sheet at a time. This type of device would also require good hand-eye coordination in order to center it, as well.

3.3.2 Subsystem #2

The next subsystem the team considered is the type of alignment mechanisms available for the button components and dies.

3.3.2.1 Existing Design #1

The manual button maker in Figure 8 from USA Buttons, Inc.[5], relies on rotating the lever arm actuator from one die to the other, eliminating the need for swiveling die cups. The swiveling of the die cups in the Hozhoni button maker make it difficult to place button components in the dies in such a way that they will be aligned AFTER they are swiveled into place.

3.3.2.2 Existing Design #2

Figure 12 shows a button maker from badgeaminit.com[8]. This button maker has the dies aligned in a linear arrangement, overcoming the problems caused by the swivel motion. As long as the pin back is placed in the crimping die with the pin straight, and the image is placed oriented “straight up and down”, the button will be properly aligned. This type of system does not ultimately assist the user in placing the components in the dies properly aligned.

Figure 11: Badgeaminit Button Maker

3.3.2.3 Existing Design #3

The “Economy Round Button Maker” from “makebuttons.com”[9] uses a die arrangement of one stacked on the other vertically. Although this would be an advantage over the current swivel system, there is a distinct lack of space in which to work and adjust the button components.

Figure 12: Button Maker from makebuttons.com

3.3.3 Subsystem #3

The final subsystem on which the team will focus is the actuation mechanism of the button maker. The Hozhoni button maker uses a foot lever, whereas most of the button makers on the market for personal or small-scale use are hand-actuation. A combination of both types of actuation will be implemented for the project redesign.

3.3.3.1 Existing Design #1

The button makers in Figures 6,7,8,11 and 12 all feature a lever for actuating the button maker and transferring the force from the user to the die press. Because the Hozhoni button maker is so much larger than these small, table-top devices, a hand lever would have to be quite large to deliver the necessary force.

3.3.3.2 Existing Design #2

The website "peoplepowerpress.com"[10] displays a button maker that is air powered, and a foot pedal is used to deliver the force from an external air compressor. This type of setup is more complicated and requires an air compressor, but the foot pedal requires very little limb extension or force from the user. This type of button maker is typically used for industrial applications where high volumes of buttons must be made.

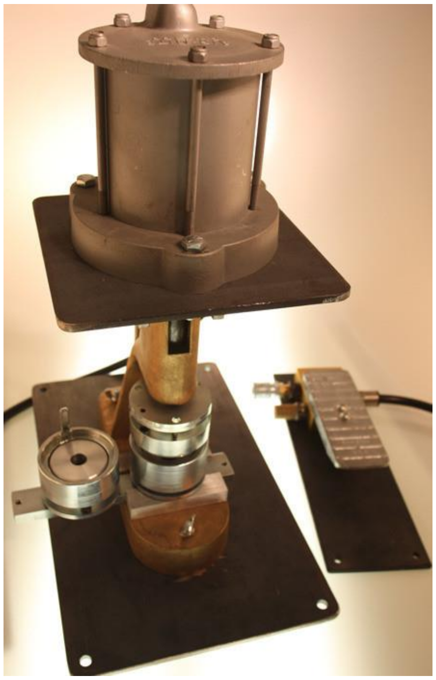


Figure 13: Compressor Powered, Foot Pedal Operated Button Maker

3.3.3.3 Existing Design #3

Tecre [5] also makes electric/automatic button makers. Although the team is not interested in automating the button making process, the team has considered if it might be advantageous to automate the the actuation of the press, meaning that the user would be responsible for aligning and placing components, and for actuating the automated portion of the process, but not for delivering the physical force to assemble the buttons. An automatic button maker from Tecre is shown in Figure 14.

Figure 14: Tecre Automatic Button Maker

4 DESIGNS CONSIDERED

The design team conducted a process of brainstorming using the following methods, both individually and as a group: external search, gallery method, and C-Sketch. Each teammate was responsible for generating 10-15 concepts in the three areas of design focus: actuation, cutting process, and alignment. The top scoring designs from the Pugh Charts (Appendix A.1) will be reported on in the following sections, with the final designs selected via Decision Matrix (Appendix A.2).

4.1 Designs #1-4, Actuation

Concept 1: Add extension to foot lever to decrease the limb extension necessary to actuate the press.

> Pros: Relatively simple, inexpensive solution for those clients that are better suited to using their legs than their arms to operate the machine.
>
> Cons: None

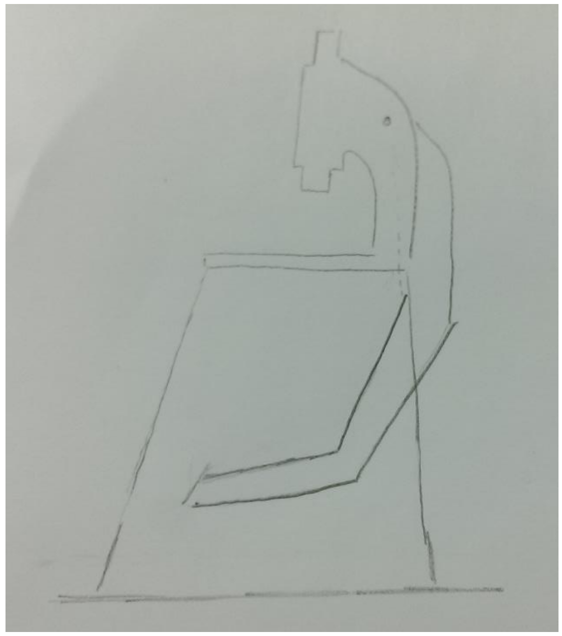


Figure 15: Foot Lever Extension, Concept 1

Concept 2: Attach U-Shaped Bar to the rear of the foot lever for arm actuation

Pros: Takes advantage of existing system for actuation; simple to construct, low machining costs

Cons: Requires significant overhead reach and arm strength to push the lever down.

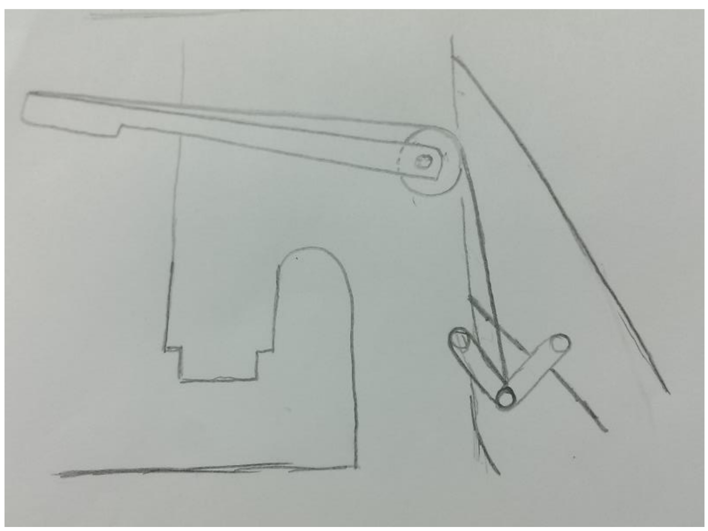


Figure 16: U-Shaped Bar for Arm Actuation (Concept 2)

Concept 3: Hand Crank with Gearbox and screws to actuate existing mechanisms for lowering/raising the press

Pros: Very little limb extension and arm strength needed to operate the press

Cons: Gearboxes can be complicated to design, machine, and assemble.

Concept 4: Bicycle crank with chain to move the press up and down

Pros: Little limb extension needed, needs only small force to operate

Cons: Difficult to integrate with the current system, possibly bulky, many pinch points

4.2 Designs #5-7, Cutting Process

Concept 5: Modify Small Arbor Press (Figures 15 and 16), adding cutting stencils and board to cut multiple images from one sheet at a time

Pros: Inexpensive materials, delivers adequate force to cut multiple images/sheets in one operation

Cons: May be difficult to make modifications, requires careful construction to ensure alignment with images on a sheet. Possible safety issues.

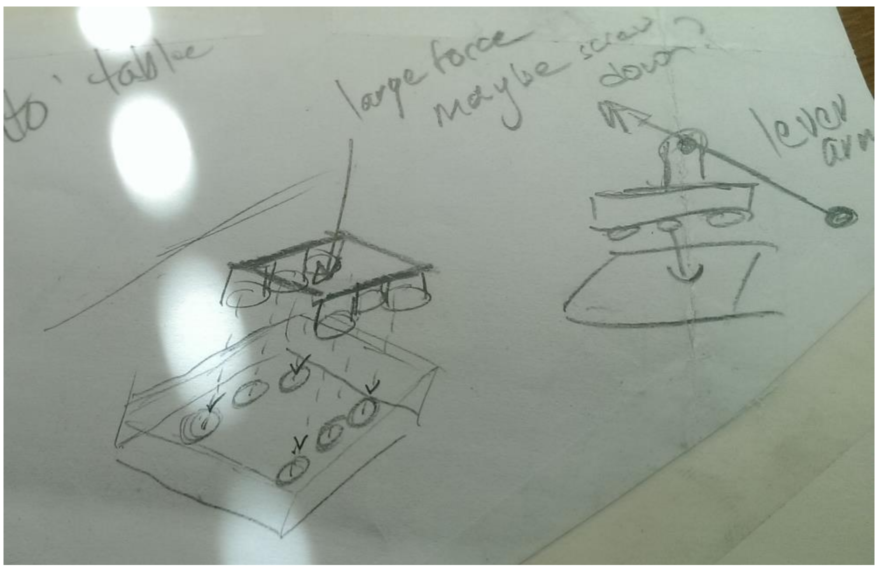


Figure 17: Image Cutter for Arbor Press

Figure 18: Arbor Press to be Modified[11]

Concept 6: Handheld Circle Cutter, Press Type (Figure 17)

Pros: Inexpensive, may cut different diameters. Handheld and will suit any layout of the images on the sheet

Cons: Requires careful placement over the image, cuts only one image on the sheet at a time, may not cut through multiple sheets in one operation

Figure 19: Handheld Circle Cutter, Press-type[6]

Concept 7: Handheld Circle Cutter, Crank Type

Pros: Blade will cut through multiple sheets at a time, offers flexibility to cut images from a sheet in any layout

Cons: Need separate cutter for different dimensions, difficult to align over the image, cuts only one image at a time

4.3 Design #8-11, Alignment

Concept 8: Arrange fixed dies in a linear layout rather than the angled layout requiring a swivel motion

Pros: Eliminates the need to adjust alignment to compensate for the swivel of the dies. Dies may be combined with color aids on the dies to assist with proper placement of components.

Cons: Does not offer a reliable, mechanical method for ensuring that the components are placed properly in the dies.

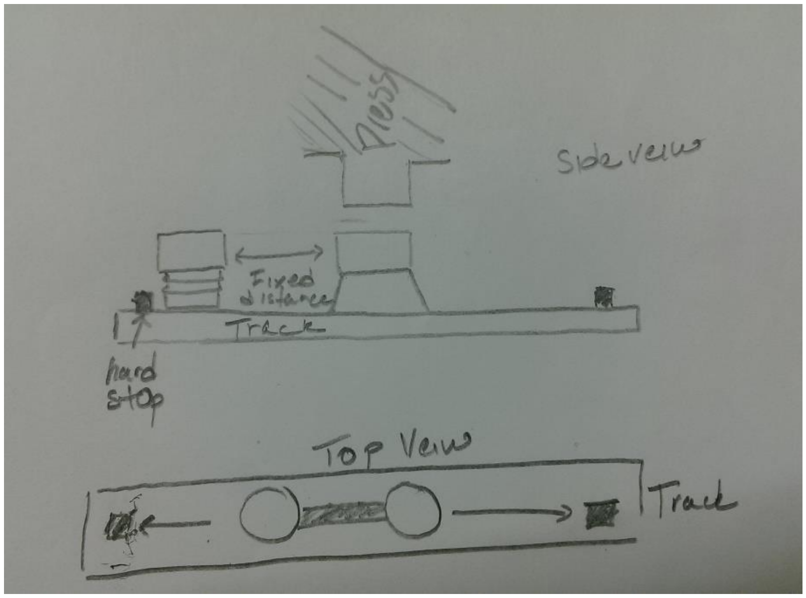


Figure 20: Linear Die Arrangement, Concept 8

Concept 9: Change to swivel pin-back; because the pin swivels 360 degrees, it would be impossible to misalign the image and the pin back

Pros: Eliminates the need to align components at all

Cons: More expensive to purchase, current inventory would need to be scrapped or used before implementing this concept

Concept 10: Change Die Shape to Square, the images would also be cut square

Pros: User would only have to ensure that images are placed with the image oriented vertically

Cons: Unsure if the dies could be modified in such a way that would still allow operation of the button maker

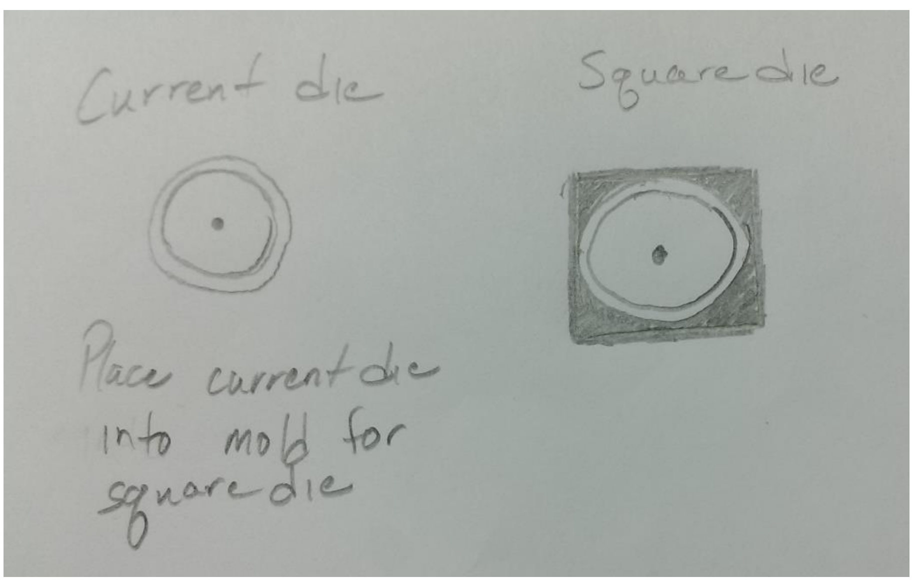


Figure 21: Square Die Shape (Concept 10)

Concept 11: Change the back fixation by placing a hard stop to prevent a very tight "crimp" of the button front to button back. If the fixation were secure, but allowed for the back to rotate, this would overcome alignment issues.

Pros: Eliminates the need to achieve careful alignment, reduces time to make one button, will work with current inventory

Cons: Difficult to achieve a fit that is secure but still allows rotation of the pin components.

5 DESIGN SELECTED

5.1 Rationale for Design Selection

According to the criteria in the Pugh Chart/Decision Matrices (Appendix A.1,A.2), the following designs scored the highest and were subsequently chosen by the team as the designs to be pursued in the testing/prototyping phase.

ACTUATION:

The team took the two highest scoring concepts from the decision matrix for actuation, as both concepts will need to be implemented to completely meet the needs of the clients. These concepts are adding the foot lever extension, and creating a hand crank attached to a gearbox for hand actuation (Concepts 1 and 3). Whether the user is better suited to using their legs or arms, the button maker will be modified to make that much easier and safer.

CUTTING PROCESS:

The highest scoring concept, according to the decision matrix for the cutting process, is the Modified Arbor Press (Concept 5). This method is relatively inexpensive, can be modified to cut multiple images from a sheet in one operation, can cut through multiple sheets in one operation, and requires small forces to operate. Safety issues will be addressed during detail design, testing, and prototyping to ensure that all users will be safe while using this device.

ALIGNMENT:

The highest scoring concept from the decision matrix for alignment is to change the back fixation (Concept 11). Although further testing is needed to ensure that this is feasible, this concept offers the most ideal solution as it eliminates the need for any alignment and it will work with the current inventory of Hozhoni (and Hozhoni will be able to continue to purchase the inexpensive button backs they currently use). This concept will also require only minimal modification of the button maker dies to achieve this. If it is discovered during our next client meeting that this solution is not viable, the team will refine and rescore our alignment concepts to select the next best option.

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APPENDICES

A.1 Pugh Charts

Pugh Charts were compiled for each of the three areas of design focus: Actuation, Cutting Process, and Alignment. Each team member scored the concepts against the criteria, and the average of the individual scores were taken, giving a '+', '-', or 'S' for each concept against each criteria. Top scores are highlighted in blue and were then scored in a Decision Matrix.

Table 2: Pugh Chart, Actuation

CRITERIA / CONCEPT	ADD EXTENSION TO FOOT LEVE	ATTACH ARM LEVER TO FOOT LEVER	PULLEYS FOR ARM ACTUATI	ATTACH HAND CABLE TO FOOT LE	HAND CRANK WITH GEA	BICYCLE CRANK	ADD WHEEL FOR ARM ACTUATION	U SHAPED BAR WITH HANDLES MOUNTED TO FOOT LEVER
Safety	"++++" = +	"++++"	S-+S	----	**DATUM**	"++++"	S+++	S+++
Reliability	"++++" = +	"++++"	----	"++++"	**DATUM**	"++++"	S++S	S++S
Efficiency	"+--S" = -	"++++"	----	"++++"	**DATUM**	"++S+"	S+SS	S++S
Force needed to operate	S+S = S	----	----	----	**DATUM**	"+++S"	S-S-	-+S-
Limb Extension Required	+	----	S+++	----	**DATUM**	"S+SS"	S+S-	----
Cost	"++++"	S-+-	S-SS	"+-SS"	**DATUM**	S-SS	S---	"++++"
Part Count	"++++"	"+-+"	S---	"+-SS"	**DATUM**	---	S--S	"+++"
Σ+	5	4	1	2		4	1	5
Σ-	1	3	4	3		1	1	1
ΣS	1	0	2	2		2	5	1

Table 3: Pugh Chart, Cutting Process

PUGH CHART: PATTERN CUTTING										
CRITERIA / CONCEPT	ARBOR PRESS	GIANT "HOLE PUNCH"	CIRCULAR MULTISIZED	HOLE PUNCH WITH LEVE	GRAPHIC CUTTER 1	GRAPHIC CUTTER	LASER CUTTER	HANDHELD CIRCLE CUTTER (crank)	HANDHELD CIRCLE CUTTER (Punch)	SCRAPBOOKING CUTTER
Safety	**DATUM**	+ +	+ +	+ +	S S	S S	- -	- -	+ +	+ +
Reliability	**DATUM**	S -	S S	S -	S S	S S	+ +	+ +	+ -	- -
Efficiency	**DATUM**	S -	- -	S -	S S	S S	+ +	- -	- -	- -
Time to Align	**DATUM**	S -	- -	- -	+ S	+ S	+ +	S S	+ -	+ +
Number of Steps to Align	**DATUM**	+ S	- -	S S	S S	S S	+ +	+ +	+ +	+ +
Sheets cut per Operation	**DATUM**	- -	- -	S S	- -	- -	+ -	- -	- -	- -
Preparation Required	**DATUM**	S -	- -	S S	- S	- S	- -	+ +	+ +	+ +
Patterns Cut Per Operation	**DATUM**	- -	- -	S S	- -	- -	+ S	- -	- -	- -
Cost	**DATUM**	- +	+ +	- +	+ +	+ +	- -	+ +	+ +	+ +
Σ+		2	2	1	1	2	5	4	4	5
Σ-		6	6	2	2	3	3	4	3	4
ΣS		1	1	7	6	4	1	1	2	0

Table 4: Pugh Chart, Alignment

PUGH CHART: DIE ALIGNMENT										
CRITERIA / CONCEPT	AXIS SYSTEM	KEY SLOT	AUTOMATED	CHANGE DIE SHAI	REVOLVER PROCES	LINEAR ARRANGEME	SWIVEL BACK BUTTOI	COLOR AIDS	CUTTER IMPARTS A FEATURE	CHANGE BACK FIXATION, ALLOWING BACK TO ROTATE
Safety	-+++	S+S	S+-	**DATUM**	S+S	S++	"+++"	"++-"	S++	"+++"
Reliability	"+---"	S-S	S+-	**DATUM**	S-S	S++	"+++"	"+--"	S--	"-+s"
Efficiency	"+---"	S--	S++	**DATUM**	S-+	S++	"+++"	"+--"	---	"-++"
Time to Align	"----"	---	S++	**DATUM**	"+-S"	S+S	"+++"	---	S--	"+++"
Number of Steps to Align	S+SS	-++	S-+	**DATUM**	S+S	S+S	"+++"	"+--"	---	"+++"
Cost	S+SS	S-S	---	**DATUM**	"+--"	S++	"+++"	"+++"	"+-+"	"+++"
Part Count For Alignment Syst	S+SS	S+S	---	**DATUM**	"+--"	S+S	"+++"	"+++"	"+-+"	"+++"
Works with current inventory	"+++"	"+-S"	---	**DATUM**	"+--"	"+++"	---	"+++"	"+-+"	"++"
Σ+	2	1	2		0	5	7	4	4	7
Σ-	3	2	3		3	0	1	4	4	0
ΣS	3	5	3		5	3	0	0	0	1

A.2: Decision Matrices

The top five scoring concepts from The Pugh Charts were scored in a decision matrix. One decision matrix was generated for each of the three design focus areas.

Table 5: Decision Matrix, Actuation

		CONCEPTS				
CRITERIA	**WEIGHT**	*Extend Foot Lever*	*Attach Arm Lever to Foot Lever*	*Bicycle Crank*	*Hand Crank with Gears*	*Bar Mounted to Foot lever*
Safety	0.2	9	9	9	9	8
Reliability	0.15	9	9	9	9	9
Efficiency	0.15	9	5	9	9	8
Force Needed to Operate	0.15	9	7	8	8	5
Limb Extension Required	0.15	9	3	5	8	4
Cost	0.15	9	7	6	6	7
Part Count	0.05	9	8	5	5	7
Sum, Raw Score (0-10)		63	48	51	54	48
Weighted Score		9	6.85	8.05	8.05	6.9

Table 6: Decision Matrix, Cutting Process

		CONCEPTS				
CRITERIA	**WEIGHT**	*Arbor Press*	*Laser Cutter*	*Handheld Circle Cutter (Crank)*	*Handheld Circle Cutter (Press)*	*Scrapbookin g Cutter*
Safety	0.12	8	7	6	8	9
Reliability	0.11	8	4	7	6	3
Efficiency	0.11	8	8	4	4	8
Time to Align	0.11	7	7	4	3	4
Steps to Align	0.11	7	7	3	3	6
Sheets Cut per Operatior	0.11	8	1	1	3	1
Patterns Cut Per Operatic	0.11	7	9	1	1	9
Preparation Required	0.11	7	7	7	8	7
Cost	0.11	6	2	10	9	7
	1					
RAW SCORE, SUM		66	52	43	45	54
WEIGHTED SCORE, TOTAL		7.34	5.79	4.79	5.03	6.03

Table 7: Decision Matrix, Alignment

		CONCEPTS				
CRITERIA	WEIGHT	*Change Die Shape*	*Linear Arrangement*	*Swivel Back Buttons*	*Color Aids*	*Change Back Fixation*
Safety	0.14	8	8	5	8	8
Reliability	0.12	8	8	8	4	8
Efficiency	0.12	7	7	6	4	7
Time to Align	0.13	8	9	9	5	9
Steps to Align	0.15	8	7	8	4	8
Cost	0.12	6	8	10	10	10
Part Count	0.12	7	6	10	10	10
Compatible with Current Inventory	0.1	8	10	0	10	10
Sum	1					
SUM, Raw Score (0-10)		60	63	56	55	70
WEIGHTED TOTAL SCORE		7.52	7.82	7.15	6.73	8.69