Candle Lighters: Maximizing Workflow of Assembly of Candle-Making Kits

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Abstract

Our clients, Sam and Clare, have cognitive disabilities that weaken their judgment skills. They began working at Durham Exchange Club Industries (DECI) in the hopes of overcoming vocational barriers in the local community. Their employment is contingent on their ability to carry out their job effectively and efficiently. We designed and developed a device and a workflow that enables Sam and Clare to perform one of their tasks (capping tin boxes) at a faster rate with higher accuracy, thus providing stability in their employment.

Introduction

DECI is a community rehabilitation program that enables individuals from a variety of backgrounds, including those with cognitive disabilities, to overcome employment barriers through vocational services [1]. As part of the vocational services offered, DECI employees help assemble candle-making kits. Our clients, Sam and Claire, participate in the tin capping task.

For the tin capping task, the clients need to manually close a round tin box with a lid. Currently, they have difficulty aligning the box with the lid and applying the correct amount of force without failing to close the boxes or damaging them. In addition, the current workflow is very disorganized. All the tin boxes are randomly placed on a narrow table. As a result, the process is inefficient and the clients are unable to systematically cap all the tin boxes.

Presently, there are no techniques or products being used to facilitate our clients' work. While there are commercially available arbor presses to help close bottles, there are none that are both compatible with the size or force required for capping the tin boxes [2].

Project Goals

In order to maximize the efficiency of the assembly of candle-making kits, the project goal for the tin capping task is two-fold. The first project goal is to design a mechanism that will allow our clients to correctly align the box with the cap, as well as apply the suitable amount of force that will close the box without damage. The second project goal is to develop a workflow that organizes the tin capping station such that the entire operation is streamlined.

Design and Development

The final device for the tin capping project has two main components: an alignment board, and a lever. To improve DECI's workflow, the device caps six tin boxes simultaneously. This allows one full set of capped tin boxes to be packaged at once. The first step in using the device is to place six tin caps and boxes in the alignment board, which ensures the correct alignment of the tin cap and box. The second step is to transfer the alignment board to the lever, which applies the correct amount of force required to cap all six tin boxes. The two components of the device will now be discussed in detail.

Alignment Board

The alignment board was 3D-printed to contain six funnel-shaped holes that align the tin cap and tin box (Figure 1A). The bottom of the hole is narrower than the top of the hole, so that the tin caps (which have a slightly smaller diameter than the tin boxes) can slide all the way down. The alignment board is used by placing tin caps upside down inside each of the six holes. Subsequently, tin boxes are also placed upside down on top of the tin caps (Figure 1B). The alignment board ensures that the tin cap and box can be correctly aligned in a short amount of time. There are four sizes of alignment boards, one for each size of tin boxes: 2, 4, 6, or 8 ounces (Figure 1C). The alignment boards are color-coded according to their size. In addition, each set of alignment boards can be stacked on top of each other for storage purposes (Figure 1D).

Figure 1A: Alignment board.

Figure 1B: Placing tin caps and boxes on alignment board.

Figure 1C: Four sizes of alignment boards (8, 6, 4, and 2 ounces from left to right).

Figure 1D: Storage of alignment board.

Lever

Once the alignment board is filled with all necessary tin boxes, it can be transferred to the base of the lever. The universal design of the lever makes it compatible with each of the four alignment boards. The lever is used to cap all six tin boxes by applying the correct amount of force to each tin box. The lever is comprised of three components: the base, the top board, and the arm.

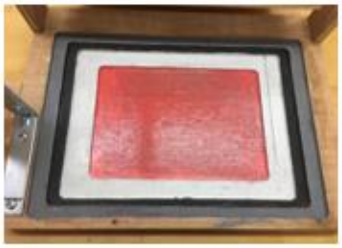

Figure 2: Base of the lever.

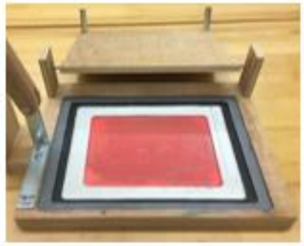

Figure 3A: Top board.

Figure 3B: Metal stopper.

Figure 4: Arm of the lever.

Base of the lever

The base of the lever can accommodate all four sizes of 3D printed alignment boards (Figure 2). Each board slides into its appropriate pocket, so that the height of the tin boxes once capped is constant across all sizes. Each pocket is color-coded to match the same color as its corresponding alignment board.

Top board and stoppers

The top board (Figure 3A) is attached to the base of the lever, and the stoppers (Figure 3B) are located on the top board. After the alignment board is placed in the base of the lever, the top board is flipped over so that it is on top of the filled alignment board. The top board will be used to distribute the point force of the arm across all six tin boxes. An additional feature that has been added to the device to prevent the tin boxes from being damaged are two metal stoppers located on the top board of the lever (Figure 3B). These stoppers have the same height of a fully closed tin box, which is equal across all box sizes. The stoppers ensure that the lever can never push the flat board past the aforementioned height.

Arm of the lever

After the top board has been placed over the alignment board, the arm of the lever (Figure 4) is pressed down on the top board. This applies a point force to the middle of the top board, which in turn uniformly distributes this force to all six tin boxes. The lever ensures that an appropriate amount of force is applied to the tin boxes so that they can be successfully capped without being damaged.

When used in conjunction, the alignment board and the lever allow six tin boxes to be successfully capped at once. This devices helps our clients Sam and Claire improve their job performance at DECI. The relevance of this project is that it enables individuals with disabilities to maintain employment, a prevalent issue in our community. The final device meets the project goals of maximizing the efficiency of the workflow (Figure 5A, 5B, and 5C) of the tin capping station.

Figure 5A: Aligning tin caps and boxes.

Figure 5B: Positioning the top board.

Figure 5C: Applying and distributing a point force to cap the tin boxes.

<u>New workflow</u>

The new workstation consisted of uncapped tin boxes lined up in center of the table with tin caps placed in a large container to the side of the table. The job was broken down into three steps, and the workers were lined up according to their tasks: placing tin boxes and caps in the 3D printed alignment board, capping the tin boxes using the lever, and packaging the capped tin boxes.

<u>Cost</u>

Table 1 below summarizes the cost of building our device. We built two devices for a total of approximately $100.

Table 1: Cost of production.

Part description	**Company**	**Part number**	**Use of part**	**Quantity**	**Unit price**	**Total price**
Heavy duty oak closet pole	The Home Depot		Lever handle	1	$16.58	$16.58
Sande plywood (1/2 in. x 4 ft. x 8 ft.)	The Home Depot		Lever base	1	$15.95	$15.95
Filaments for 3D printing, screws, washers	N/A	N/A	Assembly of lever, printing of alignment board	N/A	$70	$70
					Total cost	$102.53
					Cost per device	$51.27

Evaluation

The device was evaluated against our design specifications to ensure it met all the performance criteria. Three staff members were trained to set up the new workstation, and the device was tested with our two clients. Two surveys, for staff members and for clients respectively, were administered to evaluate the overall performance of the device. The survey results showed a very high satisfaction rate, and are summarized in Tables 2A and 2B. In addition, workflow efficiency prior to and after implementation of the device was quantified, and once again showed significant improvements. The rate at which tin boxes are successfully capped increased by approximately 18% (the rate of the initial workflow was 5.84 boxes/1person/1min, and the rate of the new workflow with our device was 6.90 boxes/1person/1min). The percentage of tin boxes with fingerprints on top was reduced by 47%. Lastly, the percentage of tin boxes that were capped properly without damage was 100%. Both clients and DECI advisors reported that the improvement provided by our device was meaningful and in accordance with DECI's philosophy and goals.

Table 2A: Results of staff survey.

Claim	**Average score (scale of 1 – 5, with 5 being the maximum score)**
1. The device is easy for staff to setup.	5
2. Clients can intuitively use the device without supervision.	4.7
3. The device encourages workflow and organization of the station.	5
4. Tin boxes are successfully capped faster when the device is used.	5
5. Fewer tin boxes are damaged when the device is used.	5
6. The device is safe to use.	5
7. The device fits well on the workstation and is easy to store away.	5

Table 2B: Results of client survey.

Claim	**Average score (scale of 1 – 5, with 5 being the maximum score)**
8. I like to use the device.	5
9. The device is easy to use.	4.5
10. It is easier to do my job with the device.	4.5
11. The device helps me and my coworkers work faster.	5
12. The device helps me stay focused on my job.	5

Discussion and Conclusion

The final device addresses our clients' need to successfully cap tin boxes without damage and at high speeds. Each component was specifically designed to eliminate uncertainty in the tin capping task, thus encouraging our clients to be independent workers. The tin capping device and new workflow allow our clients to perform their job with maximum efficiency and reduced staff assistance. The final price of the production of the device is approximately $50, making it easily reproducible for mass production to accommodate the entire workforce at DECI. Below is a statement from the lead coordinator at DECI regarding our device:

> "Typically, there were between 60-80 nonconforming lids at the end of an order. Yesterday, there were only 18. Most of the 18 were vendor-damages, not damages we made. Also, they used to be able to wrap about a palette a day but yesterday, they were able to wrap almost 3. It's running so much more efficiently. The device looks amazing, and it works so well. [Sam] and [Clare] (as well as others) are able to assist more in the process than ever before. It's nice to see what used to be such a disorganized, kind of cumbersome process have a flow and purpose, now. This device has offered us a way to engage people with varying disabilities and therefore, you see people become more proud of their work, even in the short day I watched them work with it. Finding pride in your work is priceless, and you have offered that to so many of our folks."

As illustrated by the statement above, the impact of our device is significant because it helps people with disabilities become an integrated part of our community by maintaining employment.

References

1. Durham Exchange Club Industries. (2016, November 10). Retrieved from http://www.deci.org/vocations.html
2. Capping machine. (2016, November 10). Retrieved from https://www.aliexpress.com/item/Jane-beer-capper-beer-bottle-capper-crown-cap-capping-machine-capping-machine/1670252361.html?spm=2114.40010408.3.56.laEfO4

Acknowledgements

We want to thank the following people for their help and guidance throughout this project: National Science Foundation grant CBET 3310005, project instructors Kevin Caves and Chelsea Salinas, DECI project advisors Tara, Trina, and Scott, and technical support Matt Brown, Marcus Henderson, Steven Earp, Greg Bumpass.