O-RING INSTALLATION DEVICE

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ABSTRACT

Team Mechanical Masters undertook the task of developing devices to increase work productivity for employees with disabilities. SW Resources is the NPA to be assisted. The specific task addressed is the installation of three different sized O-rings onto the component parts of a syrup dispenser for a fountain drink machine. Our goal is to increase worker productivity by 30-40% so that the customer can meet the target of 30,000 dispenser assemblies per day. The devices are designed to be used by employees with a wide range of disabilities although we are focusing on helping employees with less severe disabilities.

This report summarizes the design work and results of Team Mechanical Masters. We present our three final designs, focusing primarily on only one of the designs we developed. We also present the results of the customer evaluation of the prototype to show that our customer’s needs were realized.

BACKGROUND

The company to be assisted is SW Industries, a branch of SW Resources located in Parkersburg, West Virginia. They provide services to the business community through the talents of individuals with disabilities (“clients”) in the Mid-Ohio Valley [1]. SW Resources is CARF (Commission on Accreditation of Rehabilitation Facilities) accredited and is also a NISH affiliated NPA. Their services include packaging, shipping, and light assembly projects that some businesses may find tedious. Enhancing one of their light assembly processes is the focus of our project.

According to data published by the US Census Bureau, 12.3% of Americans aged 16-64 have at least one disability and only 37.2% of these persons are employed [2]. In fact, the percentage of the population with disabilities is unusually high in West Virginia compared to other states, so we are providing a service for a geographic area where the need for assistive technology is potentially the greatest.

STATEMENT OF THE PROBLEM

SW Resources clients with varying levels of disabilities need a device to assist with handling and installing O-rings. Through on-site visits and e-mail communication, we were able to determine the needs of the customer. Some of the disabilities we identified are: limited hand dexterity, limited use of mental faculties, and limited arm mobility. These disabilities caused the clients to drop O-rings onto the floor, orient parts incorrectly while installing O-rings, or install multiple O-rings onto the same part. These problems lengthen the amount of time it takes these individuals to install the O-rings. Because the wages of these clients depends upon their productivity relative to the industry standard, increasing their productivity 30-40% will increase their wages by the same proportion. We are targeting our design towards clients with less severe disabilities, to improve their productivity. Each syrup dispenser consists of three parts, each of
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which contains an O-ring. Thus, to meet SW Resources’ production goal of 30,000 dispensers assembled per day, a total of 80 SW Resources clients must be able to use our designs to install a total of 90,000 O-rings per day.

Since the clients must install three different sized O-rings onto three separate parts (each part has a distinctive size and orientation), we decided to develop three unique devices to install the O-rings. Our goal for each device was that three or fewer steps would be required for O-ring installation. Because we sought to design these devices for a wide range of clients, the design can be produced for our customer to assist more individuals performing the same or similar tasks in the future.

RATIONALE

We performed a background search to look for existing solutions to similar problems. We found that no existing solution was appropriate to the design problems that we faced. Existing solutions included fully automated O-ring installation and tools for installing inner O-rings. Our solution needed to be both simple and inexpensive.

The first and most important factor in employee safety was choosing materials that can easily be disinfected. The fixture will be sprayed and wiped down at the end of each day, so materials which met sanitation standards and which have good wear resistance. In order to ensure that the devices were simple, we decided that no more than three steps could be required for O-ring installation. Another important aspect for our designs is that they greatly reduce or even eliminate the time the clients spend handling the O-ring, thereby reducing the chance that clients would drop O-rings onto the floor. To ensure that the devices were inexpensive, we opted for small devices made of durable, yet inexpensive materials. The devices were designed to be small enough that our customer could easily clean and transport the devices.

Once we selected the final designs for each device, we constructed and tested prototypes for each design. For the purposes of this report, we restrict our discussion to only one design (that for the largest O-ring) and prototype due to some its unique challenges.

DESIGN AND DEVELOPMENT

Design Function

The large O-ring fixture was the most challenging to design because the geometry of the part, (see Figure 1), does not allow the O-ring to simply slide into its seat. The flat, round face and its large diameter, will not allow the O-ring to be pressed on the part. The biggest challenge is to find a way to easily install the O-ring while keeping the number of steps to a minimum. By testing a series of concepts, the team finally ended with a working solid model (Figure 2). This is the final design for the Large O-ring Fixture.

Figure 1: Shaft with Installed O-Ring
The device uses forces applied from stretching rubberbands to slide the O-ring in place. Two custom rubber bands are wrapped around the outsides of two stainless steel rods, pulling the rods together, while also helping to hold the rods into place, (Figure 2). The rod-fixture consists of an angled face, a pocket for the rods, and two bosses in the center of the part, to keep the rods separated by a predetermined distance. The rods were cut slightly longer, so that they overhang enough to allow the head of the shaft to roll between them. The O-ring is placed on top of the rod ends, and aligned by a cutout in the tray, along with a groove cut into the platform. The shaft is placed directly over the O-ring. As the platform holding the shaft is pushed down, the O-ring catches the bottom section of the groove, in the shaft. The rods then roll the O-ring over the face of the shaft, into the desired position. A compression coil spring (not shown in Figure 2) is attached to the base and platform, to return the platform to the starting position. The base extension prevents the fixture from tipping over when it is bumped slightly by the user.

While the fixture may appear complicated, it is simple to use. The supervisor will empty a bag of O-rings onto the tray and provide a bag of parts for the worker. The first step for the worker is to slide an O-ring down the tray and into the round cutout in the tray, locating the O-ring directly above the two rods (Figure 3). Next, the worker slides a shaft part into the fixture as seen in Figure 4. The third step is for the worker to push down on the shaft-holder, installing the O-ring. The part can then be removed when the spring is compressed and the platform will return to its initial operating position (Figure 5).
Material Selection

Given in Figure 3 is a list of parts for the fixture. The base, platform and steel rod holder are all fabricated out of high density polyethylene (HDPE). HDPE is FDA approved and provides relatively good strength, yet is lightweight and inexpensive. The HDPE platform, spring bosses, base and angled rod holder were all made out of a 4”x12”x3” block of HDPE. The O-ring tray and tray bracket are both fabricated out of a 15”x18” sheet of Lexan®. This plastic was chosen for its high durability. The rods are both stainless steel for sanitation purposes. Brass inserts are necessary for the screws because plastic threads could possibly be stripped under higher stresses.

Employee Safety

The primary safety considerations are pinch points and sharp edges. While these could not be eliminated entirely for this design, we kept the number of such hazards to a minimum. The Lexan® tray covering the steel rods keeps the worker from getting any fingers stuck between the metal rods. Obviously, if a user gets a finger stuck underneath the platform while pushing down with the other hand, the user’s hand will get pinched. While it is possible that a finger may get stuck, this is unlikely because the springs, fixed to the base and platform, act as a permanent stop, leaving a gap at its fully depressed position. To eliminate sharp edges, all edges of the fixture were rounded to 1/8 inch for the final design.

EVALUATION

This fixture was designed to increase the productivity of the customer in terms of installing more O-rings over a certain amount of time. Figure 7 presents the results of our customer’s evaluation of the Large O-ring Fixture. The evaluation was based upon our design criteria and is on a scale of 1-5, with 5 being the best.

The number of assembled parts completed with and without the fixture was not recorded due to the fact that 5 or 6 clients place assembled parts into the same bin. The supervisors evaluated the performance of the fixtures and noted an increase in productivity of the clients who used the fixture. We had developed a process which would provide us with quantitative data comparing productivity rates of the same clients for the manual process and using the Large O-ring Fixture; however, due to miscommunication between our team and the customer, this data is not yet available.

<table>
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<tr>
<td>8-32 Brass inserts</td>
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<td>1” – 10-32 socket cap screws</td>
<td>5</td>
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Figure 6: List of Parts and Material Cost

| Customer Performance Evaluation: Large O-ring Fixture |
|-----------------------------------------------|-------|
| User-friendly                                | 4     |
| Size                                         | 2     |
| Consistent operation                         | 4     |
| Increases productivity                       | 4     |
| Safety                                       | 4     |
| Easy to clean                                | 4     |

Figure 7: Qualitative Customer Evaluation
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Although the large O-ring fixture allowed them to assemble more parts faster, the most beneficial characteristic of the fixture was its ability to decrease the wear on the employee’s hands. Over the course of the day each employee will assemble O-rings on over 1,000 parts. The ability of our fixture to decrease the wear in the hands of the clients at SW Resources will benefit our customer the most, and in the long run, increase their productivity and lend to a more enjoyable work environment.

DISCUSSION AND CONCLUSIONS

The customer was pleased with the performance of the design. Although we do not have enough data to date to quantitatively demonstrate productivity increases, the customer feedback we have received indicates that productivity levels are improved using our device. The device is much easier on the clients’ hands, making it comfortable to use. The ability of our fixture to decrease the wear in the hands of the clients at SW Resources will benefit our customer the most, and in the long run, increase their productivity and lend to a more enjoyable work environment. The clients liked the design and the device kept them interested in the task. The supervisors were also pleased with the design and indicated that they were pleased with its consistent performance.

Proposed Design Modifications by Customer

A few minor changes were suggested by the customer to enhance the device’s performance to better suite their needs. Specifically, the customer was not fully satisfied with the relatively large size of the O-ring tray. Our customer has asked us to make the O-ring tray smaller to prevent the workers from attempting to install multiple O-rings on a single part. We have begun incorporating this in the design (see Figure 8). Also, our customer indicated that an automatic ejection mechanism system for the part (once the O-ring is successfully installed) would improve productivity. We are currently working on adding this feature to our design as well (see Figure 9). To prevent sliding on the table surface, rubber feet will be added to the bottom of the device.

ACKNOWLEDGEMENTS

We would like to thank Dr. Greg Kremer, our advisor, for continued support and guidance throughout the year; Randy Mulford for his assistance in the machine shop during the prototype manufacturing and fabrication process; Greg Goetz and Dave Althausen for their advice on the design process and the importance of scheduling; and Kellie Conrad from SW Resources for her cooperation and enthusiasm to work with us on this project. Finally, we would like to thank all of the clients at SW Resources who used our prototype and gave us valuable feedback.

REFERENCES


FIGURE DESCRIPTIONS

**Figure 1:** This is an image of the shaft part of the syrup dispenser. This device is used to install the o-ring into the groove on the head of the shaft.

**Figure 2:** This is a Solid Edge CAD model of the design, showing all the parts.

**Figure 3:** A photograph of a loaded O-ring. The O-ring is slid from the tray, down the incline, between the guides. The O-ring is loaded when the bottom of it falls into a groove marked with red, for easy identification.

**Figure 4:** The shaft is loaded into the holder. Achieved by sliding the shaft into the slot.

**Figure 5:** The user pushes straight down on the shaft holder. The force from the rods slide the O-ring onto the shaft, as it translates down.

**Figure 6:** A list of parts and materials used in the design. Also includes the total cost of materials for one Large O-Ring Fixture.

**Figure 7:** SW Resources evaluation of device, 1-5 rating scale.

1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree

**Figure 8:** New design for a smaller tray. Half the size of the existing tray will replace the larger tray, as a request from SW supervisors.

**Figure 9:** A Solid Edge CAD model of a design for automatic part ejection. This will be manufactured and placed within the device, to further increase ease of use and productivity.
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APPENDIX: ADDITIONAL FIGURES

Figure 8: Device with smaller tray.

Figure 9: Lever arm used for automatic ejection.