Assisted Packaging Project

for Johnson County Developmental Supports

Final Project Design Report

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Abstract

In order to further the employment value and potential of workers presently employed exclusively at facilities such as Johnson County Developmental Supports (JCDS), a device was developed to assist in the packaging of a common assembly : a syringe and two nitrile gloves inside a urine sample cup. This project was funded by a grant from the National Science Foundation (NSF) for the KU Biomechanical Rehabilitation Engineering Advancement in Kansas (BREAK) program. The final design was built according to initial design plans and preliminary testing was done. Upon preliminary testing, additional parts were purchased and the design was modified as necessary. The Bill of Materials reflects all parts included in the final assembly, but excludes the purchased parts that were not used in the final design. The final design was fully completed on May 6 before the final presentation at JCDS later that day.

Introduction

There are many people in local communities with physical or intellectual disabilities. These disabilities make it difficult to find employment. Organizations such as Johnson County Developmental Supports (JCDS) in Lenexa, KS hire these individuals and offer them employment opportunities, often in the form of packaging various products. Due to their disabilities, these employees tend to function far less efficiently than their non-disabled counterparts. Pay for such workers is on a per-piece basis, meaning that workers whom package few parts may make very little money. Many do not even make minimum wage, depending on the limitations of the worker. Because of this problem, Johnson County Developmental Supports has requested a device to be engineered that will enable workers to package items at a much faster rate, increasing efficiency to a more competitive level, allowing for higher earning potential, and the possibility of community employment.

The assembly chosen involves the packaging of a medical cup filled with a syringe and two vinyl gloves (see Figures1 & 2). A needle was originally part of the assembly, but was excluded in the build stage of the design per customer feedback. This is one of the common assemblies packaged at JCDS and also is one of the more difficult assemblies for the workers due to the difficulty in handling the gloves. The goal of this project is to create a device that will dispense the cups, syringes, and gloves in the correct amounts, and in a much faster manner than could be done manually by the employees with disabilities. The device should be relatively portable and create little noise so as to fit into the quiet workplace environment.

Figure 1: Completed Cup Assembly/Packaging

Figure 2: Nitrile Gloves (upper left), Hubs (lower left), and Cups (right)

Design objectives include ensuring the overall size and weight of the mechanism is minimized. This will allow for easy transportation to future locations. The device should create little noise so as not to negatively affect the quiet workplace environment. All subsystems should require minimal maintenance. Most importantly, all subsystems should pass multiple tests for reliability and repeatability to ensure the final design will function after repeated uses. The design process for this project began by meeting with the customer and learning about the customer requirements as well as other desired aspects to be used in the design of the device. Engineering specifications were created based on these customer requirements.

The main goal of the project is to increase efficiency in packaging cup assemblies. JCDS stated the community average rate of production as 209 cup assemblies/hour. The specific design problem is the matter of percentage production. The project's primary intended recipient currently operates at 4.3% of the stated average. The goal is to develop a design which will raise this percentage to 80% of the community average of 209 cups per hour, or roughly 167 cups per hour. This would make the recipients of the device competitive in the community job market for these cup assemblies.

System Design

There are four main parts to the process: dispensing the cup, placing the syringe in the cup, placing the two gloves in the cup, and placing the completed assembly into the collection tray. Additionally, the cup must be positioned so that these four processes are possible. The cup must also move without tipping. Syringe Agitation The basic design concept is a conveyor belt with simple, movable controls and semiautomated dispensers for each item. At the end of the conveyor a collection bin will be placed to receive the finished cup assemblies. Figure 3 below shows the CAD model of this design. The design will include semi-automation, movable controls, some manner of process feedback for the operator, and minimal oversight.

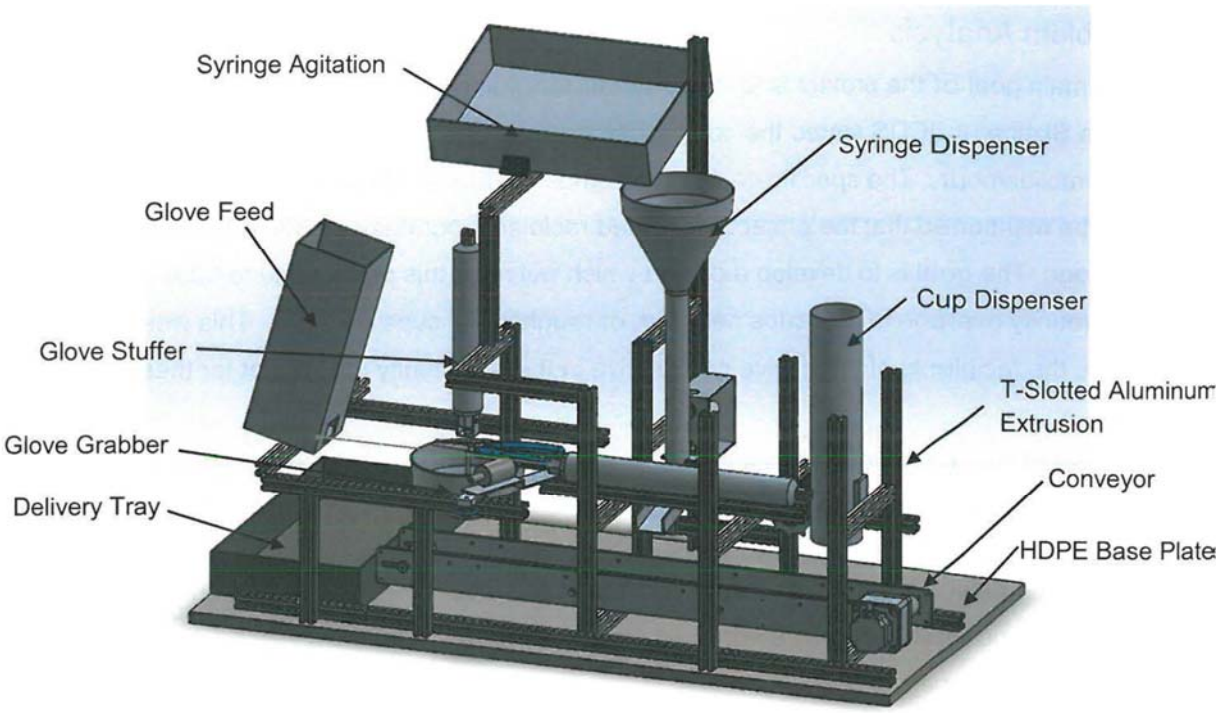

Figure 3: CAD Model of Full Packaging Assembly

The conveyor holds one cup at a time and moves that cup to each unique dispensing station before sending it to the collection tray. The complex program would have three cups on the conveyor belt at a time and would have further improved the efficiency, but it was considered too difficult and problematic to implement. It also may have proved too complex for the individuals operating the machine, as there would have been more places to watch for potential problems or inaccurate dispenses. Ultimately, it was decided that while only filling one cup at a time was less efficient than filling multiple cups on the belt at once, it was still a large enough improvement on the current packaging rate.

Cup Dispenser Sub-system

The cup dispenser consists of a clear vertical tube with a metal gear-gate at the bottom, which ejects one cup each time it rotates the programmed amount. The dispenser holds nearly 40 cups, and can be filled as high as the added white guard. The dispenser is located as close as possible to the conveyor to minimize potential bouncing or tipping. Due to the infrequency of tipping during testing, a guard was deemed unnecessary. The cups dispense near the end of the conveyor farthest from the collection tray (Figures 3 & 4).

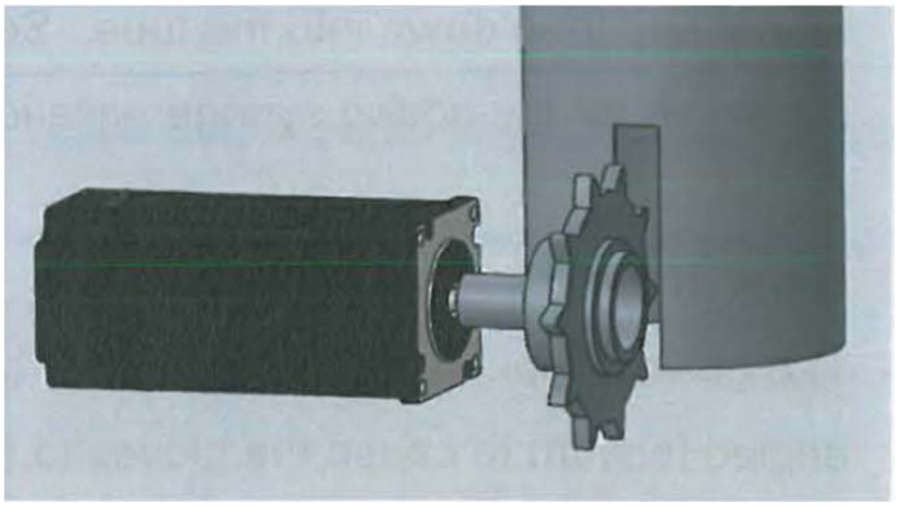

Figure 4: Cup dispenser with stepper motor/sprocket design

Syringe Dispenser Sub-system

The syringe system consists of a funnel mounted on top of a vertical tube. A dual-solenoid system is used for syringe dispensing (see Figure 5). A push solenoid actuates to push and hold the syringe above the bottom one in place. Then, a pull solenoid actuates and pulls a gate backward to allow the bottom syringe to fall. This ensures that only one syringe is dispensed at a time. After being dispensed from the solenoids, the syringe drops onto a chute below and slides into the cup waiting in position on the conveyor. After testing, it was found that an agitation system was necessary as the syringes did not dispense through the funnel. A rectangular hopper was added above the funnel, with a corner cut out to allow for a small amount of syringes to fall into the funnel. Below this hopper is a linear solenoid that is used to agitate the syringes inside the hopper, and to dispense the syringes into the funnel and then down into the dispensing tube.

Figure 5: Syringe bin with agitation system to feed syringes to funnel and dispensing tube.

Glove Dispenser Sub-system

The glove hopper is a tall rectangular box, angled forward to cause the gloves to fall forward towards the opening. The opening is a rectangular hole cut at the bottom center of the box to allow for the grabber mechanism to reach in and grab gloves out. The grabber mechanism consists of an electric linear actuator that moves the rubber-tipped pliers forward and into the box, and a linear solenoid mounted to the linear actuator that closes the pliers tight (Figure 6). The solenoid is attached to the pliers with wire, and the pliers are attached to the linear actuator by a metal bracket. The bracket is secured to the t-slotted aluminum extrusion via a set of wheels. A glove is grabbed by firing the linear actuator forward, then triggering the solenoid to close the pliers once the tips are inside the glove box. Then the linear actuator retracts and the solenoid releases the glove over a funnel. Once a glove is grabbed, it is stuffed by actuating another vertically mounted linear actuator with a stuffer attachment mounted to the end (Figure 7). The current stuffer attachment consists of a dual-spring system, though other options may prove better suited. The spring stuffer actuates downward and through the funnel below to stuff the gloves into the cup. After testing, it was noticed that the gloves did not always fall perfectly centered over the hole in the glove funnel. Because of this, two chutes were added to ensure proper placement for stuffing (Figure 8).

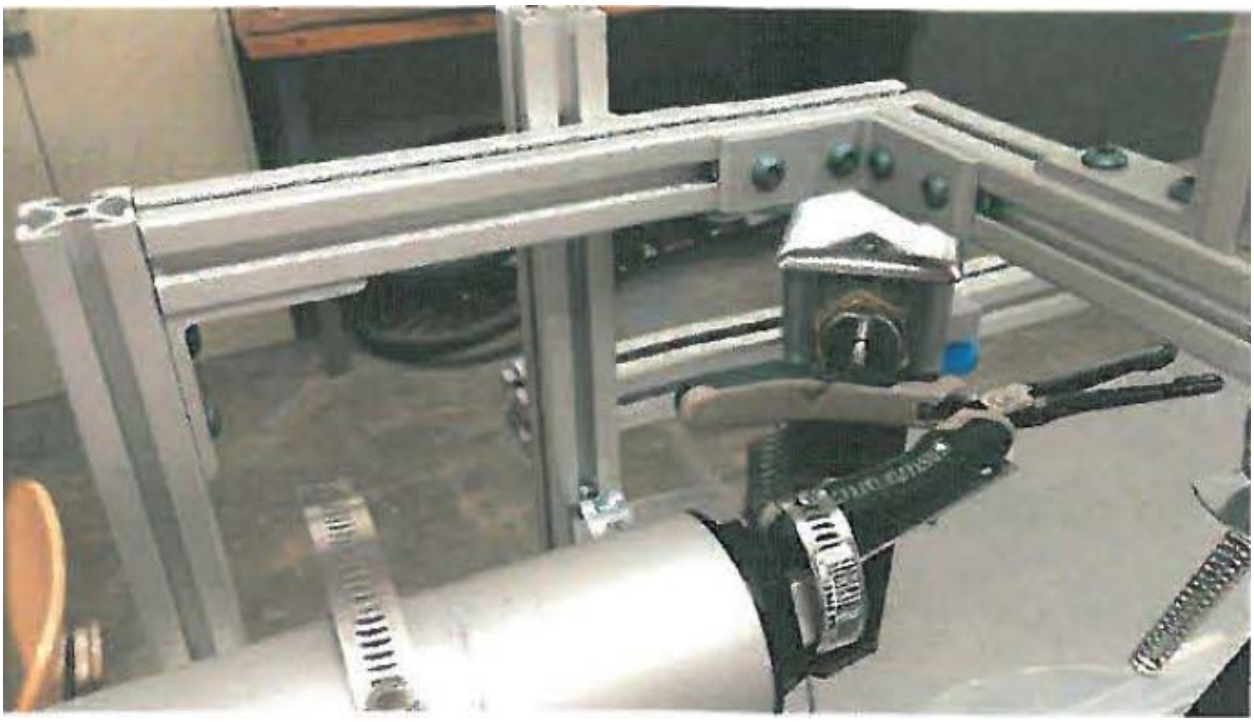

Figure 6: Glove Grabber System

Figure 7: Glove Stuffer

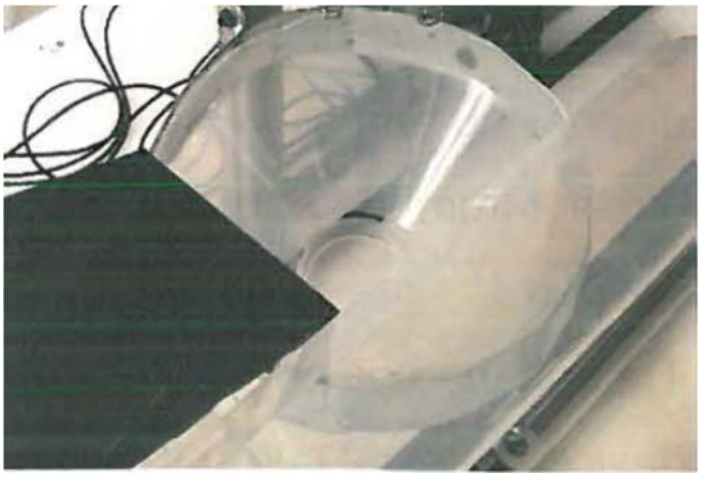

Figure 8: Glove Chutes/Guides

System Frame

The entire device is mounted to a High Density Polyethylene (HOPE) base with dimensions of 24" by 48" by 3/4". The frame consists of T-slotted aluminum extrusions that are used to arrange the systems, attached them to the base, and mount each of the subsystems in the proper position.

Table 1. Component Descriptions and Specifications

Subsystem	Component	Description	Specifications
Cup	Cup Holder	physically holds stacked cups upright	*must hold 50 cups at once *friction must be sufficient so as not to allow cups to fall due to gravity
	Stepper Motor	motor that rotates in increments as defined by the programmer	*high enough torque to offset frictional and gravitational effects
	Gear	notched gear used with stepper motor to drop cups one at a time	*must have teeth that will hold the ridge between 2.20" - 2.15" OD of the cups
Syringe	Funnel	large plastic 6 quart funnel to house syringes until dispensed	*large enough to hold at least 50 syringes at once
	Tube	1' long clear plastic tube to house syringes before dispensing and dropping to the chute	*clear *small thickness for rapid solenoid actuation
	Push Solenoid	small linear actuator that pushes a plunger forward when signaled used to hold syringe above the one being dispensed	*1" stroke length *actuates through hole in the tube
	Pull Solenoid	small linear actuator that pulls a plunger backward when signaled used to hold syringe being dispensed	*1" stroke length *actuates with attached gate at bottom of tube
Glove	Linear Actuator	electric linear actuator to move grabber arm forward used with push solenoid	*10" stroke length *high speed of travel
	Linear Actuator	electric linear actuator to push gloves down into assembled cups	*8" stroke length *high speed of travel *soft/rubberized pad attached on stuffing end to limit glove damage
	Push Solenoid	small linear actuator that pushes a plunger forward when signaled used to push gripper to grasp individual gloves	*1" stroke length *must be able to mount perpendicular to linear actuator
Conveyor	Conveyor	purchased conveyor belt system used to move cup to different dispensing stations	*low torque drive *must be able to increment
	Belt	the physical belt on the conveyor system	*possible need for cleating / raised features to ensure cups remain upright

Human-Machine Interface

The human machine interface was completed as desired. It consists of an LCD touch screen display with clearly labeled instructions, system status and touch buttons for dispensing. The touch screen is mounted on a moveable and adjustable mount that allows for the screen to be accessed by individuals with potentially limited range of motion. Wired in parallel are standard mini audio jacks that can be used for inserting various types of control buttons and switches that could also be used to dispense items and complete the packaging assembly. The programming is done for and control is provided by an Arduino Mega micro-controller.

System Operation and Assessment

The assisted packaging project was brought to Johnson County Developmental Supports on Friday, May 6. During that meeting, the details of using the device were thoroughly explained and demonstrated to the liaison Brian Skibbe and others to aid in their implementation of the device with their workers. A user's manual is attached in Appendix F that also explains details about how to use and modify the device as needed, as well as common issues determined during testing and how to resolve these issues. It was recommended that Skibbe spend time familiarizing himself with the device before trying to implement it with his workers, as he has more knowledge of their physical limitations.

Prior to delivery, the assisted packaging device was tested as individual subsystems. Due to time constraints, there was minimal testing of the device operating as a full assembly line as it will be used in the future. Accordingly, there is no data for the efficiency of the packaging device as a whole. Appendix G shows a spreadsheet of the results from testing syringe agitation, syringe dispensing, and glove grabbing. Cup dispensing and glove stuffing were not fully tested, again due to time constraints. As is evident from the spreadsheet, the repeatability of all tested systems is below what was desired.

Though there is no data for testing the efficiency of the entire device, it is likely that the device does not currently operate at the desired 80% community average of 167 cups/hour. The repeatability of many of the subsystems is low, meaning that the user would need to ask for assistance or re-dispense an item on a fairly regular basis. This would increase the time needed to dispense one full assembly, and decrease the overall efficiency.

Conclusion

This project was a rare and welcome privilege, offering the opportunity to give back to the community and help those who are not only in need but want to be able to do more for the community and themselves. Completing this project will help several parties and make a tremendous difference in the quality of life and personal satisfaction of a group of individuals which have grown accustomed to working hard for much less gain. Satisfying the customer in this instance was not only a professional matter, but a matter of personal pride, and this team was strongly committed to seeing this endeavor through as thoroughly and effectively as possible.