Wiscraft Briggs and Stratton Shroud Sticker Application Device

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Abstract

The goal of this semester was to improve the productivity and ease of Wiscraft's assembly lines by evaluating their current system and providing suggestions as well as hardware prototypes. As the semester progressed our goal was refined to designing and fabricating a device that would allow a completely blind employee to easily and accurately apply stickers to an engine shroud. Currently, the existing method doesn't allow completely blind employees to achieve an acceptable success rate. To improve the process, we designed and fabricated a push down system that applies the stickers in a precise location. By incorporating Wiscraft's current shroud mold and a vacuum system, the user must only lay stickers into their designated cavities (sticky-side up) and push a guided shroud into the stickers. The final design not only increases productivity, but also allows for a wider range of Wiscraft's employees to operate the line. Future work entails refining the design to increase speed and productivity for all users, effectively eliminating the need or use of the old method.

Client Introduction

Wiscraft is a non-profit company that provides assembly, packaging, and machining services to a variety of companies, such as Harley Davidson, Briggs and Stratton, and Pentair. An aspect of Wiscraft that makes them unique, is they provide employment, job stability, and ultimately a sense of independence and self-worth for those who have visual disabilities. Nearly all of their employees have some type of visual impairment, with many employees declared legally blind. Besides providing services for the mentioned companies Wiscraft also works under the AbilityOne program (formally known as JWOD), selling products to the Federal Government. The AbilityOne act states the government must purchase products produced by non-profit companies that employ people with disabilities at market price as long as at least 75% of the product has been produced by a person with a disability (Office and Management, 2010). Wiscraft not only satisfies this requirement, but takes pride in having more than 90% of the products they manufacture and assemble produced by an employee with visual impairment.

While Wiscraft is a non-profit company, they are also a “not-for-loss” company. Therefore, they continually look for ways to help themselves save money and to increase efficiency. Thus, they declared the month of December 2010 their Lean Kaizen month and want to use this month to look for ways in which their manufacturing processes can be improved. In order to prepare for this month they received the help of an industrial engineering (ISyE) team as well as our biomedical engineering (BME) team, both from the University of Wisconsin-Madison.

Defining Project Scope

Wiscraft has a variety of products that it assembles and produces. Mike Girard, Wiscraft’s assembly and packaging manager, introduced the lines that could use improvement, prioritizing the lines was left up to both UW-Madison engineering teams. After considering Wiscraft’s values as well as our own strengths and weaknesses it was decided to focus on the Briggs and Stratton engine shroud line. This line involves placing either three or five stickers (depending on the shroud) on a lawnmower shroud with precision and accuracy.

Current Method

The current method for the engine shroud line is to first mount the shroud along with a template (shown in Figure 1) of the shroud to a movable fixture. The template contains cutouts that guide the placement of the stickers. The next step involves removing a sticker from a nearby sticker role and placing it on the shroud. Once all necessary stickers are applied, the shroud is removed from the mount and the shroud is placed inside a clear plastic bag after two more pieces are connected to the shroud.

The main problem with this current process is that it is very difficult for a person without vision to accurately apply the stickers, even with the assistance of the template. All of the products developed by such employees must go through a quality inspection, and most (78%) of the products require rework. As a result, employees who are completely blind are used less often on this line as most become very frustrated with the task and others just can't complete the job efficiently enough. Therefore, it became our goal to first improve this line in order to make it more blind-friendly. Coinciding with this goal, it was important to design a method to apply stickers with more accuracy as well as decrease the time it takes to finish a product.

Figure 1: Current Device
The template for used for a completely blind worker is actually cut out more to allow the user to feel the cutouts better.

Problem Statement

Employees at Wiscraft apply stickers to a lawn mower engine shroud that indicate the location of buttons. The majority of Wiscraft employees are legally blind with different types of visual impairments, including people that are completely blind. The current system incorporates a cover put over the device that guides the operator to apply the stickers in the proper location and orientation. This current system is not conducive to employees that are completely blind and is prone to error (incorrect orientation and wrinkles in stickers) that result in rework. We wish to create a process/design intended to decrease the error rate, improve efficiency, and allow all employees at Wiscraft to use.

Design Criteria

After talking with Mike Girard and observing the shroud line during , it was concluded that a new device would need to be safe to operate, lightweight, easily transported and stored, made of material conducive to factory surroundings, and most importantly ergonomically friendly; it must be usable without sight. First, in terms of safety, the device must not have any sharp edges or any other features that could potentially harm the operator, such as the possibility to pinch or burn the operator's hands. Second, for easy transportation and storage, the device should not weigh more than 10 pounds, have a footprint less than 12” X 12”, and a height of less than 12”. Third, to ensure that the device will have a long life, all parts of the device should be replaceable, with the overall device able to withstand at least 500 uses per day. As the device will be used in a factory setting, the material used should be resistant to the buildup of any dirt or dust. The device should also be able to be easily cleaned. Furthermore, high traffic areas of the device should be decipherable with varying textures or some type of touch-sensitive stimulus.

Preliminary Research

As the process of applying stickers and labels to products on a mass scale is not a novel idea, there are several devices on the market capable of quickly and accurately applying stickers to Briggs and Stratton’s engine shroud. These devices can be broken down into two main categories, automatic and semi-automatic label applicators. Automatic label applicators, such as the Primera AP Series AP362 Label Applicator, apply stickers directly to a product moving along a conveyor belt (Primera Tech In., 2010). While these devices are much more efficient and convenient, they are not suitable for our client for a couple reasons. First, these devices cost no less than $1,200; this triples our client’s desired budget. Furthermore, such devices eliminate the human factor completely. This defeats our goal of making the line blind employee friendly, as no employee would need to be on the line.

Semi-automatic label applicators, such as the ST400 Semi-Automatic, require the user to load the product into the device, and then use a foot pedal or button to trigger the applicator to apply the sticker (South Cali., 2010). This type of device is preferential to the automatic applicator as it keeps the human factor involved. However, they cost just as much as automatic applicators. Furthermore, most devices are only capable of applying one type of label at a time.

Thus, for engine shrouds that need three to five stickers applied semi-automatic applicators are not a very efficient means to solve the problem.

Finally, many industrial processes for handling, developing, and producing products implement the use of vacuums in order to make the processes more automated and efficient. Incorporated into automatic and semi-automatic labelers, vacuums are used to hold stickers in place while the stickers are applied to the product. Piab, a company specializing in automated machines for product handling, has several vacuums that are designed for label application. Piab describes this process as tamp-on labeling as the device pushes or tamps the sticker to the product (Figure 2). While Piab's processes are designed for very large production, their concepts and smaller products could be implemented into a design suitable for our client's needs.

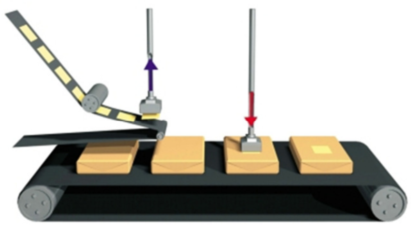

Figure 2: Automated Application Using Vacuum
Process shown is of the tamp-on labeling process in which a vacuum grabs a sticker off a sticker dispenser and then applies it to the product.
PIAB.com

Design Alternatives

Each of the design alternatives, developed by our design team at the beginning of the semester, addressed various means of sticker placement automation utilizing a vacuum. In each case, the design alternatives expanded upon the current template method currently being implemented by Wiscraft employees. The goal of each design alternative was to ensure proper sticker alignment prior to permanent placement, since quality control for each shroud is dependent on the correct orientation of the various stickers and seemed to be the limiting factor preventing the company's completely blind employees from working on the shroud line.

Box Method

The first design alternative, namely the box method, implements a silicone mold of the engine shroud itself, rather than using the existing rapid prototyped template, as a means of interfacing with the engine shroud. In order to create the silicone template of the engine shroud, silicone would be poured into a constructed box and then the shroud would be pressed fit into place. Once completed, holes would be cut into the silicone so as to accommodate individual hollow arrow pedestals protruding from a separate base piece. The separate base piece also supports the silicone mold box with springs and allows for vertical movement to enable the arrow pedestals to move up and down through the holes within the reverse silicone mold (Figure 3). The springs would be adjusted in an attempt to stagger the height of the pedestals just below the height of the template, creating a depression in which the arrow stickers can be placed. The depression will help the employees determine where each sticker should fit. Once each sticker is peeled off and oriented within each arrow depression, created by the interface between the arrow pedestal and silicone mold, a vacuum pull will remove the sticker off of the workers finger and the sticky side of the sticker will be facing up, ready for placement onto the shroud. When all of the stickers are in place the engine shroud is inverted, placed within the template, and pressure is applied downward onto the shroud attaching the stickers onto the shroud surface.

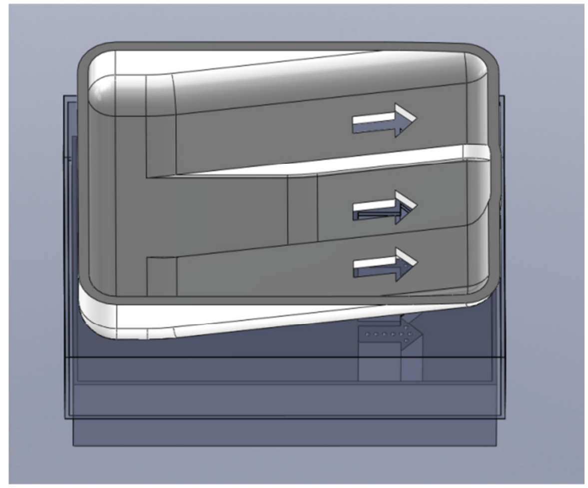

Figure 3: Right side view of box method
The box method prototype displaying the silicone mold directly above the base piece with arrow pedestals.

Dump Truck Model

In contrast with the box method, the dump truck model utilizes the existing template already in use by the company. The template is mounted via lateral bars, allowing the template to be pivoted forward and backward, pinned to the template itself as well as a box apparatus similar to that found in the box method (Figure 4). The base platform of the dump truck model is comprised of two main parts, a bottom and lid of a box, with the top suspended from the bottom by spring loaded legs. Within the base platform are arrow cutouts interfaced with arrow shaped pedestals, just as in the box method, creating the desired arrow depressions for easing sticker placement. Spring loaded legs then allow the movement of the lid with respect to the bottom of the base platform enabling the pedestals to move through the cutouts and press the stickers onto the shroud. In contrast to the box method, the template is initially rotated backward out of the way of the base platform in order to remove it as an obstacle for sticker placement. The stickers are placed into the dump truck model identically to the box method, taking advantage of the vacuum pull, and once all three arrows are positioned, the template is rotated directly above the pedestals. The shroud is then placed into the template and downward pressure applies the stickers onto the shroud's surface.

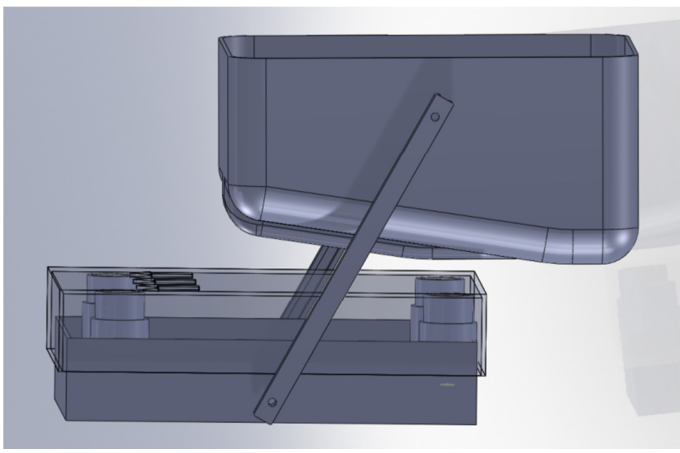

Figure 4: Left side view of the dump truck model prototype

The template is rotated back out of the way of the arrow shaped depressions. Exposed within the base platform are the four spring loaded legs enabling vertical movement of the lid of the base box with respect to the bottom of the base box.

Peg Model

Just as in the dump truck model, the existing template is utilized to aid in sticker placement. Hollow arrow pedestals are externally mounted onto a platform and spring loaded peg legs are used to support the template as well as interface the pedestals with cutouts within the template, creating the desired depression for sticker placement found in all of the design alternatives (Figure 5). The spring loaded peg legs only allow for vertical motion, ideally reducing the degrees of freedom within the system. The application of the stickers once again uses a vacuum pull to remove the stickers from the person's finger and holds them in place within each arrow depression. When all the stickers are in place, the engine shroud is positioned within the template and pressure is applied downward. This causes the arrow pedestals to move up through the cutouts within the template and press the stickers onto the engine shroud.

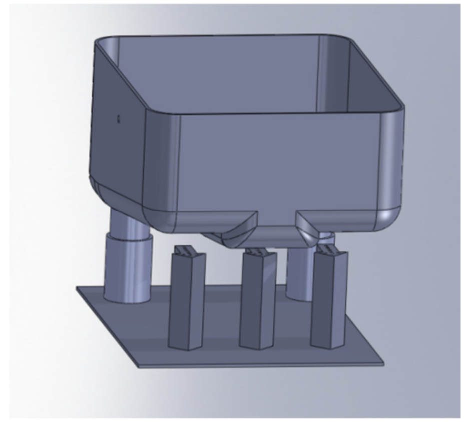

Figure 5: Front view of the peg model prototype
The peg model with the template mounted on the spring loaded legs. The arrow pedestals are shown not interfacing with the template, displaying the holes through which the vacuum pulls.

Design Matrix

The design matrix used to evaluate each of the design alternatives was broken into groups and weighted based on importance. In order to eliminate their high rejection rate for the engine shrouds put together by completely blind employees, Accuracy, determined by quality control evaluation, and Ergonomics, determined by ease of use for completely blind individuals, were considered equally important and weighted the most. Feasibility, or the ease in which the design team could construct the final design, was also considered important since depending on the complexity of the design, production could prove to be too difficult to complete in the allotted time. Another factor considered by the design team is durability. Depending on the week, the final design could be used up to eight hours a day five days a week. If the prototype cannot stand up to the excessive use it will prove to be unhelpful to the client. Wiscraft, being a non-profit organization, has to make up any expenses in a reasonable amount of time. For this reason the team included cost as a design constraint and aimed to keep costs low.

Criteria	Box	Dump Truck	Peg
Accuracy (35)	33	24	**35**
Ergonomics (35)	30	28	**32**
Durability (10)	4	5	**7**
Feasibility (15)	7	9	**10**
Cost (5)	2	3	**3**
Total (100)	76	69	**87**

Table 1: Design Matrix
The peg model was the winning design, mostly due to its high score s in accuracy and ergonomics

Both the box method and the peg model scored highly on accuracy and ergonomics because they only allow for vertical movement, greatly reducing the chance of pedestal misalignment and employee confusion about orientation of the prototype. The dump truck model scored the least in accuracy, ergonomics, as well as durability, because of the hinged mechanism that rotates the reverse mold forward and backward. The hinge mechanism is vulnerable to twisting and has a greater chance of wearing out than the elements within the other two design alternatives. The box method scored rather low in the feasibility category due to the use of silicone. Although a familiar material, none of the team members have worked with it previously to generate reverse molds. The elements within the dump truck and peg models are much more familiar and should be easy to manufacture. The cost for each design alternative is highly dependent on the price of the vacuum needed to generate the necessary pull, but once again the box method is less favored because of the cost of silicone material and manufacturing. Totaling the scores in each column, the peg model proves to be the best design overall and will be the basis for our final design.

Final Design

Concept

The concept for the final design was to eliminate the need for the user to apply the sticker with the sticky side down. This caused several problems for the workers at Wiscraft. The users got one chance and if the sticker was not pressed down properly it stuck to the shroud in the wrong orientation. Also, in feedback from workers as well as experience with obstructed vision, our team found that it would be easier to be able to slide the sticker from the raised template into the cavity formed by the template, which is not possible with the current system. As previously explained, the accuracy was a major target for this design, so it was imperative that our design allowed for a much easier placement of the stickers for those with limited vision. This was accomplished by eliminating the application of the sticker by the user.

Overall Design

The final design uses a prefabricated plastic template that is used in the existing process for sticker application. The template is inverted and attached to a spring system shown in

Figure 6: Template and Spring System
The template is fastened to the spring support system. The spring allow for the template to move up and down.

Figure 6. The figure shows the template fixed to an aluminum plate which is supported solely by the two spring columns. The columns are composed of polyvinyl chloride tubes, chosen such that the inner diameter of the bigger tube is just larger than the outer diameter of the smaller tube. This allows for the smaller tube to slide freely into the larger tube. Together the tubes make a column that supports bending stress, while allowing the column to change height with minimal restraint. The support for the compression of the column is provided by one spring in each column, which allows for resistance for compression, but allows the user to change the height of the template when desired.

Figure 7: Template with Pedestals
The pedestals sit directly below the template, and protrude into the arrow cutouts.

Pedestals were fabricated that protruded into the arrow cutouts on the template in a manner such that the top of each pedestal is just below the top surface of the template. Figure 7 shows the pedestals protruding into the arrow cutouts on the template. This allows for minimal horizontal translation of the sticker once applied in the template cutouts, but still creates a cavity with walls that effectively “hold” the sticker in place.

The final design incorporates ideas that have been previously used in sticker application production lines such as the use of a vacuum system for handling stickers (Piab, 2010). The vacuum used for the prototype is a Gast 115V vacuum/compressor (model DOA-P704-AA) capable of generating almost -25 mmHg pressure. This vacuum was selected because it was readily available for use and was well under the (80 dB) limit for prolonged exposure. This particular vacuum is actually a bit undersized for this application, and because of this we had to incorporate a valve for each of the pedestals. The valves isolate the vacuum pull to each pedestal which allow adequate suction in the pedestals by isolating each pedestal allowing for all of the suction power to be allocated to each pedestal individually.

The final prototype has a footprint of 12" x 8" and can easily fit on a typical table in the Wiscraft warehouse. It weights under 10 pounds and can easily be moved to wherever the user needs to take it. However, the airlines attached to the vacuum require disassembly before transport.

The Process

In order to use the device the user should be seated directly in front of it, with the template cavity and air hoses facing the user. The vacuum should be turned on, and two of the three valves should be closed, such that the vacuum is only pulling a vacuum on one of the pedestals. The user should then remove the desired sticker, with a conscious effort to touch the sticky side of the sticker just hard enough to stick, but not hard enough that the pull of the vacuum will not remove the sticker from the user's hand (this comes with a few minutes of practice). The user should then use their free hand to identify the boundary of the desired arrow cutout and slide the sticker onto the pedestal, allowing the vacuum to pull the sticker flush with the pedestal surface. The user will hear an audible change in the vacuum as it begins to establish

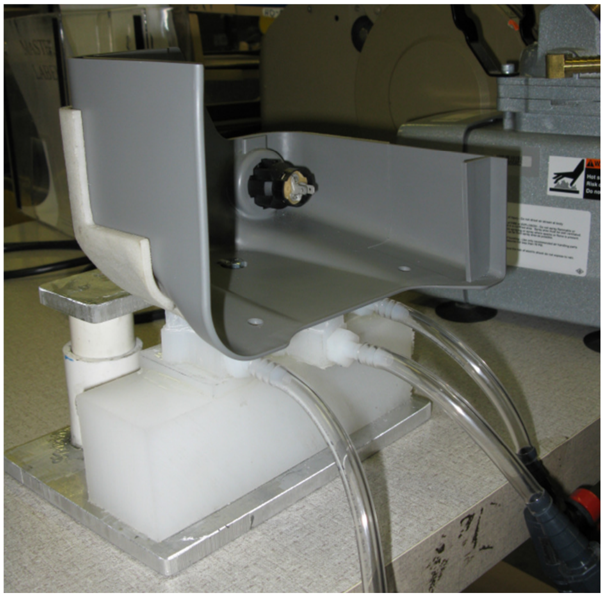

Figure 8: Shroud in Template
The shroud is placed upside down into the template cavity awaiting the user to depress it into the stickers.

a negative pressure with the holes in the pedestal blocked by the sticker. The user should then open valve to one of the remaining pedestals and repeat the previous steps.

Once all of the stickers have been placed in their respective pedestals, the engine shroud should be place upside down into the template. Figure 8 shows a shroud placed the template ready to be pressed into the pedestals. The user should then push down on the shroud, with one hand placed on the left and right edge of the shroud. After the shroud cannot be depressed any further, the user should push one thumb or hand on the middle of the shroud to ensure the sticker on the middle pedestal makes contact with the shroud (the shroud tends to bow upwards in the middle when force is just applied on the sides). Pressure should be released and the shroud removed. The user should then run their fingers over the sticker to ensure smooth sticker application.

Testing

The testing associated with this prototype was off of the problem statement and overall design goal of: designing a sticker applying device that completely blind people can easily use and have a minimal reject rate. The testing trials consisted of a before and after study was conducted by an ISyE student team and the engineering Wiscraft staff. Each study consisted of a completely blind Wiscraft employee working through each sticker applying procedure. The employee was monitored by the test conducting staff, and the following measurements were taken: success/reject rate, shroud rate per hour, and time per shroud. Visual observations were also taken as each employee completed the process.

Using the old method, the employee was able to complete 12 shrouds per hour, with an average completion time of time of 4 minutes and 46 seconds per shroud. The success rate was not measured, but data conducted from a previous study indicated a scrap rate of 78%. Qualitatively, the employee spent the majority of the time trying to find the proper location/orientation for each sticker. Even with the extended time, this led to the majority of fails as the sticker was either crooked or had wrinkles and bubbles.

While using this prototype, the employee completed an average of 23.5 parts per hour, with an average completion time of 2 minutes and 31 seconds. The success rate was 100% with no rejected shrouds. The employee was able to identify the pedestals much easier than the template slots from the previous method. A summary of both tests is listed below in Table 2.

Type of Measurement	Old Method	New Method with Prototype
Shrouds per Hour	12	23.5
Time per Shroud (minutes:seconds)	4:46	2:31
Success Rate	22%	100%

Table 2: Testing Data Summary
Comparison in various production performance numbers from the old method to the new device.

This data proves that the new prototype and method for applying stickers does not only produce a higher quality product (increased success rate) but also reduced process cycle time nearly in half, allowing twice as much output. Beyond the numbers, the employee was at ease while working with the new prototype compared to the frustration felt while processing parts using the old method. The overall cost of the prototype was under $225, which is well within our client's budget constraints (Appendix C). In conclusion, the qualitative and quantitative observations both prove that this prototype is a successful upgrade from the previous method, providing Wiscraft with a more efficient system and a method that is more ergonomic to completely blind employees.

Ergonomics

One of the main focuses of this project was designing a device that was more ergonomic for completely blind employees at Wiscraft. On the previous design, employees struggled with finding the proper location for each sticker and orientating it appropriately. Our system not only guides the user using physical slots, but also the vacuum can be felt through the top of each pedestal. These features and using a tighter tolerance for each arrow, allow the employee to easily find each location apply the sticker in the correct orientation. This prototype is also on a fixed mount, allowing the employee to become familiar with the location of all items used in the process after only a few cycles.

Future Work

Our prototype for the first semester succeeded in increasing the accuracy of the sticker application process. The design also allowed completely blind workers at Wiscraft to be efficiently incorporated into the Briggs and Stratton shroud line. The main improvement we would like to see in our design is the output. We would like to create a system that not only improves upon the accuracy of the existing process for completely blind workers, but is also faster for sighted workers as well. The final product will ideally meet the company goals of 30 shrouds per hour.

The current vacuum used is undersized and struggles to effectively pull stickers off if any of the other pedestal holes are open. By incorporating a much stronger vacuum into the design, it would eliminate the need for any valves. In eliminating the valves, it would simplify the process for someone who is visually impaired, while also reducing the time for the overall process.

The current prototype has several airlines that protrude from the front of the template and pedestals. This takes up excess space and makes it difficult to rotate the whole device. Wiscraft assembles some shrouds that require the application of side stickers as well as the arrow stickers. A rotating device would allow for simple side sticker application. This would be accomplished by using a manifold under the arrows that leads to a hose that would exit the device through the table and to the vacuum. Centering the vacuum tube under the device would allow for easy rotation and eliminate cluttered tubing.

The interface between the pedestals and the template requires the pedestals to penetrate the width of the template, but remain under the top surface of the thickness. This essentially creates “walls” to keep the sticker from shifting horizontally on the pedestal and is vital to the accuracy of the device. By increasing the thickness of the shroud, we could ensure that the pedestal is always within the thickness of the template, and the sticker will always be held in place sufficiently. By incorporating these changes, we could greatly improve the speed, efficiency and ergonomics of our device.

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Appendix A: PDS

Product Design Specifications:
Engine Shroud Sticker Applicator

Team Roles:
Team Leader: Jamon Opgenorth
Communications: Catilyn Collins
BSAC: Justin Gearing
BWIG: Dan Miller

Last Updated: December, 2010

Function: Employees at Wiscraft apply stickers to a lawn mower engine shroud that indicate the location of buttons. The majority of Wiscraft employees are legally blind with different types of visual impairments, including people that are completely blind. The current system incorporates a cover put over the device that guides the operator to apply the stickers in the proper location and orientation. This current system is not conducive to employees that are completely blind and is prone to error (incorrect orientation and wrinkles in stickers) that result in rework. The proposed specifications are intended for a design to decrease the error rate, improve efficiency, and allow all employees at Wiscraft to use.

Client Requirements:
- Improve process time
- Allows all employees access to process
- Reduces error rate

Design Requirements:
- Safe to operate
- Ergonomically friendly, intended use for completely blind employees
- Light weight
- Transports easily
- Material conducive to factory surroundings

1. **Physical and Operational Characteristics**
    a. **Performance Requirements:** Device must provide the operator an easier and more accurate process to apply stickers on a plastic engine shroud. The device has the potential to be used by all employees at Wiscraft, including sighted and completely blind.

    b. **Safety:** The device should have neither sharp edges nor other features that could potentially harm the operator.

    c. **Accuracy and Reliability:** The product needs to ensure the stickers are properly placed in the correct location and orientation. The current success rate is 22%, which is unacceptable by Wiscraft. We would like to improve the application method to increase the success rate to greater than 80%.

d. **Life in Service:** Device should be made out of replaceable parts, increasing the service life indefinitely. The product should be able to withstand 500+ uses daily.

e. **Shelf Life:** Storing the product should have no effect on its function.

f. **Operating Environment:** The device will be used in a factory. Dust, dirt, dog hair, etc. should not affect the function of the product.

g. **Ergonomics:** The product will be designed for people with visual impairments including people who are entirely blind.

h. **Size:** The product will have a footprint less than 12” x 8”, and a height of less than 8”.

i. **Weight:** The product should weigh less than 10 pounds.

j. **Materials:** The device should be made out of light weight material that still retains structural stability.

k. **Aesthetics, Appearance, and Finish:** The device should appear safe and operable in order to not scare the operator.

2. **Product Characteristics**
   a. **Quantity:** One unit will initially built, with the possibility of expanding to four units.

   b. **Production Cost:** A preliminary budget of $400 has been established, with the option to expand if necessary.

3. **Miscellaneous**
   a. **Standards and Specifications:** No standards and specifications are required.

   b. **Customer:** The customer would like a device that allows completely blind people to perform this task more accurately and faster.

   c. **User-related Concerns:** The product should be safe and not harm the person using it.

   d. **Competition**: Currently no product exists that meets all of the requirements of our client.

Appendix B- Time Management

Gantt Chart

Month	September				October						November				December		
Date	3	10	17	24	1	8	15	20	22	29	5	12	19	26	3	8	10
Product Development																	
Initial Client Meeting																	
Background research																	
Site Visits																	
Brainstorming																	
Decision on Hardware prototype (if any)																	
Fabrication																	
Testing																	
Presentations																	
Midsemester																	
Final																	
Deliverables																	
Progress Reports																	
Final Report																	
Notebook																	
Meetings																	
Advisor																	
Client																	
Website																	

Time Allotment

	Cumulative (Hr)
Caitlyn Collins	36.75 Hr
Justin Gearing	36.00 Hr
Dan Miller	41.00 Hr
Jamon Opgenorth	37.00 Hr
Team	28.50 Hr
Total	**264.75 Hr**

Appendix C- Cost Table

Item	Cost ($)
Plastic	15.00
Valves	80.00
Tubing	20.00
Epoxy	5.00
Springs	8.00
Transportation	42.00
Poster	45.00
Vacuum*	-
Total	**$215.00**

*Temporarily donated by the BME department.