Pop Nozzle Assembly Jig

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ABSTRACT

SW Resources, a non-profit organization, was contracted to assemble 20,000 pop nozzle assemblies per day. Most of the workers at SW Resources have mental or physical disabilities which hinders their ability to assemble the parts correctly. The current assembly process can be performed by most individuals but there are problems with over tightening of the nozzles and with worker discomfort. The over tightening of the outer casing caused leaks which led to a recall of nearly 400,000 assemblies. The purpose of this project is to produce a food sanitary assembly jig, make the assembly task more comfortable for the workers, and decrease the reject rate. This report documents the research, design, development, and performance of the assembly jig that is being used by workers with disabilities at SW Resources to assemble hundreds of pop nozzles a day without over tightening and without hurting their hands.

BACKGROUND

The customer for this project is SW Resources located in Parkersburg, West Virginia. SW is a NISH affiliated, non-profit organization that performs work for both large corporations and local businesses but always aims to increase the opportunities for people with disabilities to be valuable to the community and themselves. SW Resources' mission statement is: "Our mission is to provide vocational services, employment and other opportunities for individuals who have disabilities enabling them to achieve their full potential" [1]. The work that is performed is generally the repetition of a physical task including stuffing envelopes, assembling, packaging, counting and bagging small parts, and labeling.

STATEMENT OF PROBLEM

The task that was selected for this project is the assembly of a pop fountain nozzle manufactured by DuPont. SW Resources needs to be able to provide 30,000 finished assemblies per day in 2009. The individuals performing this task, between 25 and 30 people, have a range of disabilities. These disabilities can lead to limited dexterity (problems handling the small parts), inability to determine when to stop turning (the part can fail if not sealed or over tightened), and inability to meet the desired production rate.

The pop nozzle contains four main parts. These parts are the shaft, spring, plug and casing as shown in Figure 1. There are also three pre-assembled o-rings. Figure 1 also shows the current process that the workers perform to assemble the pop nozzles. First the shaft is placed on the assembly base. Next the spring is placed over the shaft, and the plug is pressed down on the shaft. Finally the casing is threaded over the sub assembly to seal the lower o-ring.

Our defined problem statement is:

> SW Resources needs a device to assist with the assembly of the pop nozzle. Assistance can come in the form of added comfort, increased efficiency, or an increase in the number of people who can perform the task. The customer needs to produce 20,000 pop nozzles per day to reach their contracted quota.

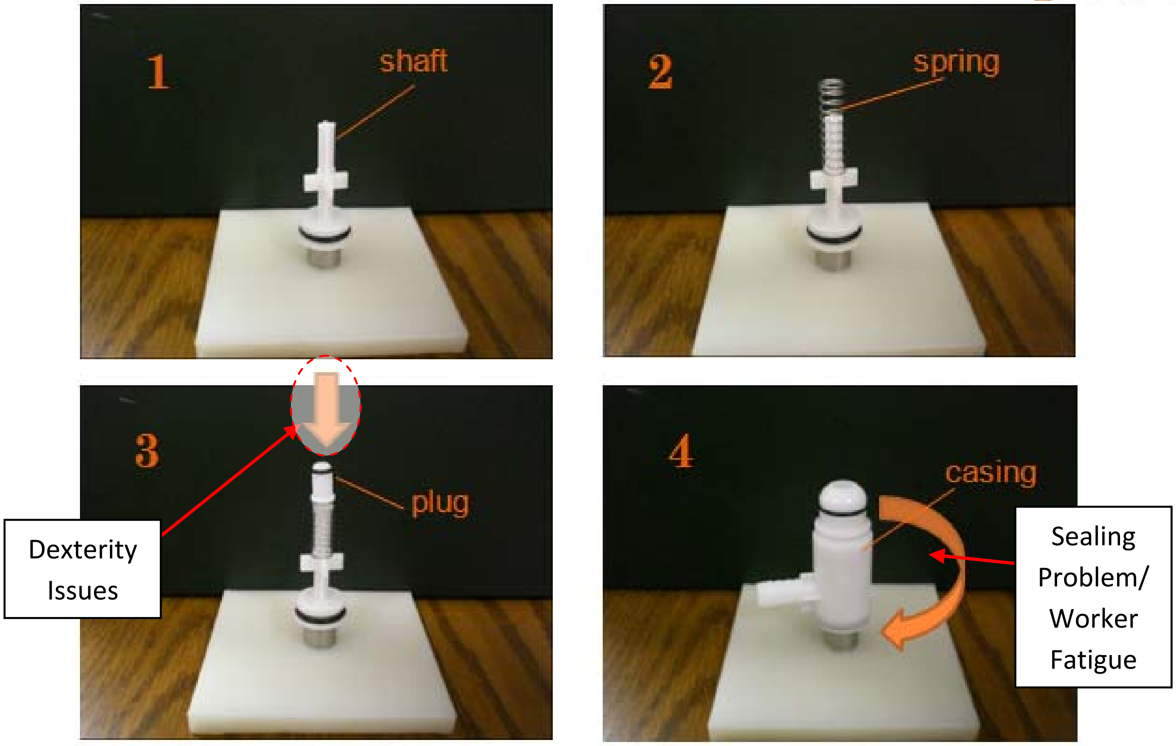


Figure 1 - Assembly of pop nozzle

RATIONALE

The employees at SW Resources have a wide range of disabilities, so the goal was to make a device to help as many of their clients as possible. With the help of SW, we determined some project requirements and specifications. Two requirements that must be met are safety and quality. To meet the safety requirement the jig must have no pinch points, sharp edges, or additional personal protective equipment required. The assembly jig must also uphold the quality of the nozzles to ensure the threaded o-ring is completely sealed, the jig causes no damage to the assembled nozzle, and follows all proper sanitation codes.

Three specifications were set as well; cost, space/size, and productivity. Each jig should cost no more than 200 dollars including materials and manufacturing costs. The jig must be small enough to fit four jigs per 3’ x 8’ work table. Also each person must complete around 1,000 assemblies a day. Therefore we set 25 seconds as a target assembly time.

SW is having a difficult time making sure all of the assemblies are tightened the proper amount. Recently, close to 400,000 pop nozzle assemblies were recalled by DuPont due to over tightening. This shows that the current hand tightening process results in low production quality. Another problem is that many of the clients mentioned having blisters and sore fingers from tightening the assemblies by hand.

With the use of a manufacturing torque wrench in our design both of these problems can be addressed. The torque wrench will ensure that every assembly is tightened to the specified torque every time, leaving no guess work. Also the torque wrench takes a considerable amount of stress off of the clients’ fingers when performing the assembly process.

DESIGN

Our design, shown in Figure 2, is a jig to assist in the assembly of the pop nozzle. The nozzle that is being assembled is shown in Figure 1. Our simple design is easy to use while still providing a quality product under SW Resources' and DuPont's specifications.

The assembly process using our jig is a two step process. Step 1 has the cutout so that you can press the shaft through the spring and attach it to the plug. For this step, we decided to have a guide hole for the plug, and a countersink hole deep enough so the spring would lie on the plug exactly and stand straight up in the hole. A countersink hole was used so the user could just slide the plug into the hole and it would slide down the slope of the countersink and go directly into the guide hole without any complications. The spring goes down into the hole with the same objective. After both are placed into the hole, the shaft is pressed through the spring onto the plug.

Step 2 of the assembly process is where the shaft is torqued into the case of the nozzle. We tested the torque to seal the pop nozzle to meet specifications. The test results showed that the amount of torque needed to seal the nozzle without over or under tightening was 10 in-lbs. A 10 in-lb manufacturing torque wrench was ordered from McMaster Carr. We designed a custom socket to fit on the end of the base so we can torque the nozzle down. The custom socket is shown and labeled in Figure 2.

We designed a t-slot to go through the jig so it can be attached to the table and can be easily removed if a part is dropped in improperly. We designed a T-bar that is bolted down to the table, and the jig will slide onto it and be stabilized.

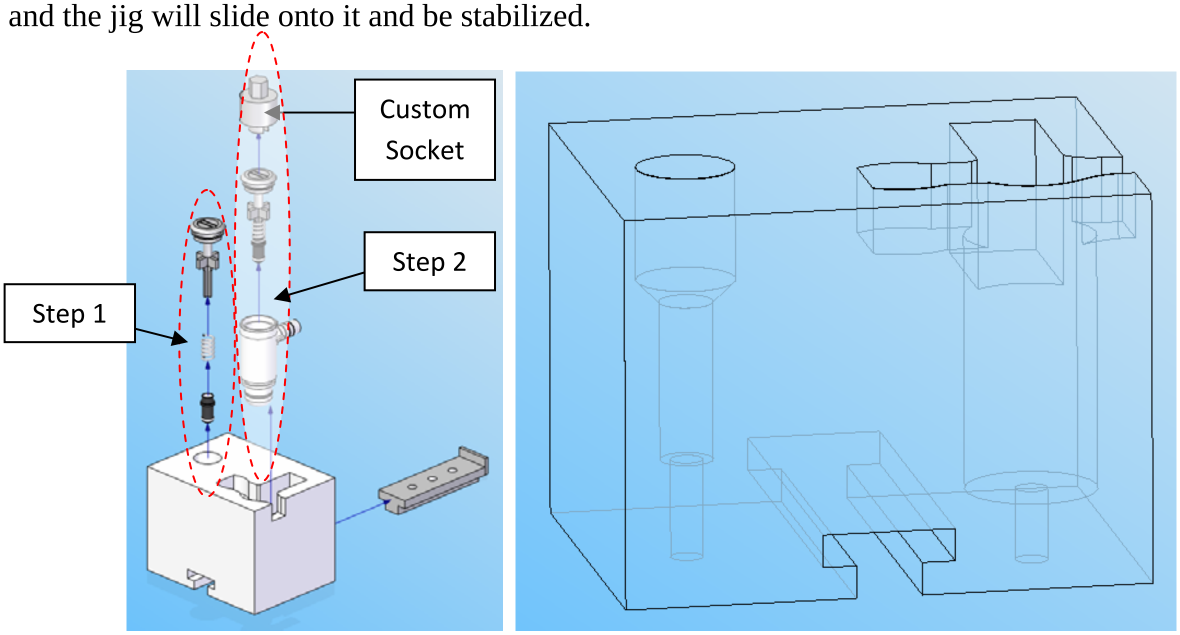
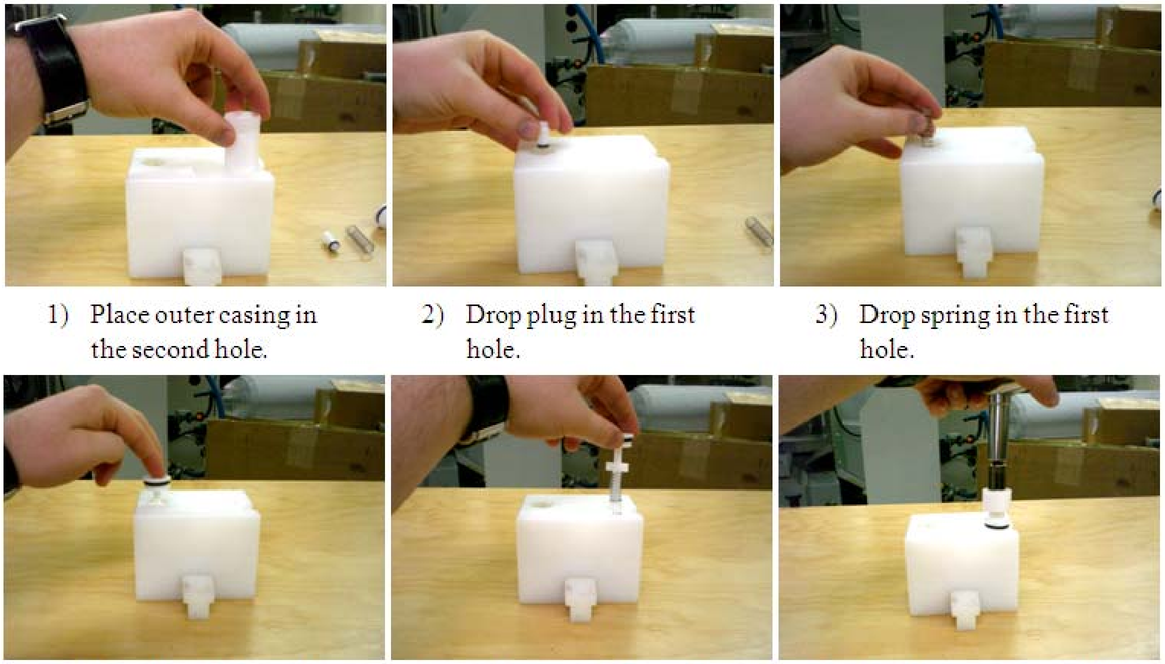


Figure 2 - Team Lean on ME assembly solution

DEVELOPMENT

Team Lean on ME initially designed our device around the specifications established by SW Resources. Our team received a model of the original device that SW Resources uses in their current assembly process. We studied this device and the steps it took to assemble the pop nozzle. Then we brainstormed ideas on how to make an easier but similar process in addition to fresh ideas unrelated to the current device.



1) Place outer casing in the second hole.
2) Drop plug in the first hole.
3) Drop spring in the first hole.
4) Press the shaft into the first hole.
5) Move the subassembly to the second hole.
6) Use the torque wrench to screw subassembly into outer casing.

Figure 3 – Lean on ME Assembly Process

SW Resources initial device was a simple square platform base about 3x3 inches with a nozzle adapter located and protruding from the platform's center. This base can be seen in Figure 1. The problem with this method is that it requires steady accurate placement of the small parts of the assembly in addition to the ability know when to stop tightening.

After analyzing the current assembly steps, we observed that the most difficult steps in the process include connecting the plug, and knowing when the appropriate torque is reached. After identifying these complications, we required that our device had to contain a solution to them.

After reviewing our brainstormed and refined ideas, we selected aspects of each which we agreed would benefit the user the most while also meeting the SW Resources requirements.

These aspects included:

- Recessed Container - for the shaft sub assembly
- Funnel - for easy placement of plug and spring
- Ratcheting Torque Wrench – for consistently tightening the assembly to the specified torque
- T-Slot Mount – for securing the jig to the table and quick removal

We chose to incorporate the ratcheting torque wrench, a pre-existing tool, because we believed it would be the easiest way for the user to know when the assembly is tightened to specification without requiring the ability to count.

Our team then sketched the concept, modeled it using the computer aided design program, SolidEdge, and created preliminary mock ups containing individual design features that would allow us to test their feasibility. Due to test results, we made modifications to some features of the device such as the material, the angle of the funnel, and the pre-set value of torque for the ratcheting torque wrench. We then machined a prototype for full scale testing.

EVALUATION

To validate our assembly design we performed two different tests. The first test was a timed evaluation of the original and new assembly processes. The second test was a comparison of hand tightening versus torque wrench tightening using a gauge repeatability and reproducibility (gauge R&R) statistical analysis.

The procedure for the first test began by measuring the time to assemble one part using the original assembly process. This consisted of taking 40 data points for three different workers. This overall average assembly time was 16.1 seconds. After we completed our assembly jig, it was delivered to SW Resources so that the same test could be performed with our assembly jig. After testing three different workers 40 times each the overall assembly time was 15.2 seconds.

The second test that was performed to validate our assembly design was a torque test using gauge R&R statistical analysis. The first step in this validation was to test the average torque that was being applied to the nozzles by hand. This was accomplished by using a one foot moment arm, a nozzle adaptor, and a data acquisition system with digital force gauge. The persons that were tested followed the same criteria as the workers at SW Resources. Three operators were tested 30 times each. The gauge R&R value for hand tightening is 85%. The test was repeated using the same three operators using the manufacturing torque wrench. This change gave a gauge R&R value of 13%. A gauge R&R value less than 15% shows that the procedure is acceptable, meaning that it is repeatable and reproducible. Any gauge R&R values over 30% are considered not acceptable. With the addition of the torque wrench the gauge R&R value decreases by 72%.

During the time that our jig was at SW Resources there were several other non-quantifiable results identified. The jig met the safety requirements of no pinch points, no sharp edges, and no additional personal protection equipment required. The jig is made of a sanitary material that is easily washed. Also, many users commented that it significantly reduced the stress on their fingers.

DISCUSSION

We were able to design and build a jig that allows for the successful assembly of the pop nozzle. The device is easy to use and can be sanitized with minimal effort. Any of the current workers at SW Resources would be able to use our jig after a small training session. Even though not all of the tested subjects were faster with the new process, we are certain that we have created a device that will increase productivity. The torque wrench greatly decreases misassemblies and hand fatigue.

Our jig is low cost, easy to manufacture, and significantly increases quality. We have supplied SW Resources with a user manual, engineering drawings, and parts list needed to create more jigs.

ACKNOWLEDGEMENTS

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1. Dr. Greg Kremer, our senior design professor, for his guidance through the year.
2. Kellie Conrad, SW Resources operations manager, for all of her help and input with our project.
3. Randy Mulford, machine shop technician, for his help in manufacturing the assembly jig.

REFERENCES

1. SW Resources. Mission Statement. http://www.swresources.com/html/mission.html

Alternate Text for Figures

Figure 1: This figure contains a series of four pictures showing the current process used by SW Resources to assemble to pop nozzle. The first picture shows the shaft being placed on the assembling base. The second picture shows the spring being placed over the shaft. The third picture is the plug being pressed down onto the shaft compressing the spring. The final picture is the casing being threaded over the sub assembly to seal the lower o-ring.

Figure 2: This figure shows Team Lean on ME's jig used to assemble to pop nozzle. The left side of the figure shows an exploded view of the nozzle parts being assembled into the jig. The right side of the figure shows the internal geometry of the jig

Figure 3: This figure shows the step by step process used to assemble the pop nozzle using the Team Lean on ME assembly jig.