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SWE UPRM Team Tech Project: *Spinal Cord Stimulation Therapy Lead Assembly*

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The SWE UPRM Team Tech, from the University of Puerto Rico in Mayagüez, implemented a design project in partnership with Boston Scientific at Dorado, PR. The main purpose of this design project was to semi-automate the assembly process of a high-demand Boston Scientific product as part of the National Team Tech Student Competition, sponsored by The Boeing Company. The competition evaluated teamwork and collaboration with the industry partner, as well as the successful implementation of engineering processes to solve a design challenge. After agreeing upon a conceptual design, simulations were conducted that resulted in significant improvements in terms of manufacturing errors, ergonomics, cycle time, and output production for the product assembly line. The team presented their design project at the National Boeing Team Tech competition and were awarded second place, a feat never before achieved by the SWE UPRM Team Tech since its inception.

Introduction

The National Team Tech Student Competition, a Society of Women Engineers (SWE) national design competition established in 1992, is sponsored by The Boeing Company. The goal of this competition is to emphasize the key role of teamwork across engineering disciplines and to promote interaction with industry members through the engineering education process. The criteria evaluated by the judges included teamwork, successful collaboration with the partner industry, problem solving through engineering processes, the final project deliverables, and the quality of the results.

Every year, universities throughout the United States develop projects to compete and present their findings at the SWE's National Conference. Since August 2017, the SWE Team Tech from the University of Puerto Rico in Mayagüez, with members from five different engineering fields, had been implementing the project "Spinal Cord Stimulation Therapy Lead: Distal and Proximal Assembly", in partnership with Boston Scientific in Dorado, Puerto Rico, which was awarded second place at the SWE's National Conference.The chosen project, related to the medical device industry, was proposed by Boston Scientific Corporation (BSC). Boston Scientific's manufacturing facility in Puerto Rico produces drug-eluting collars, drug-eluting stents, and leads that treat cardiac arrhythmias and heart failures. In 2017, the Neuromodulation Division was integrated into the Puerto Rico facilities to mass-produce the Spinal Cord Stimulator (SCS) therapy device. This therapy device contains a battery and a surgical lead system designed to help treat chronic pain caused by neurological disorders. The assembly process for this product is done manually, and thus, presents a challenge for the manufacturing process.

Team selection began in August 2017 by interviewing 46 students from all engineering disciplines. After examining their relevant experiences, careful deliberation led to the selection of eleven members, seen in Figure 1, from across five engineering disciplines offered at UPRM:

- *Industrial engineering:* Johana Mercado, the SWE Team captain, Camille Marrero, Normarie Román and Zairelys Reyes
- *Mechanical engineering:* Christian Varela, Armani Cabán, Jorge Rosado, and Jesús Adorno
- *Computer engineering:* Nashali Rivera
- *Electrical engineering:* Ricardo Santoní
- *Chemical engineering:* Adria Cotto

A crucial aspect of this design competition was to foster communication, networking, and teamwork between Team Tech members and the industry partner. Once the SWE UPRM Team Tech was officially constituted, the mentors from Boston Scientific informed the team about their project design idea. Team members, in an extraordinary effort, while attending regular classes and extracurricular activities, visited Boston Scientific's site at Dorado frequently to train, conduct studies, perform time and ergonomic analyses and participate in meetings with their mentors to report on the project's progress. The group of industry mentors, seen in Figure 2, included industrial, manufacturing, and electrical engineers, as well as environment, health, and safety (EHS) specialists. Among the group of mentors was Melanie Sifuentes, former UPRM student and SWE UPRM Team Tech member. Melanie is currently working as the industrial engineer at the neuromodulation line and was vital in maintaining close and effective communication between the team and BSC during the project.

Figure 1: 2017-2018 SWE UPRM Team Tech.

Materials and Methods

The primary purpose of the project was to semi-automate the assembly process of a high-demand Boston Scientific product: the 1x16 Spinal Cord Stimulation (SCS) therapy lead, depicted in Figure 3. Since the manufacturing process of this lead is very rigorous and currently done manually, the project looked to improve ergonomics, cycle time and output production, among other aspects, while reducing manufacturing errors.

Figure 2: Boston Scientific mentors at the BSC plant in Dorado, PR.

To target this problem and after an extensive brainstorming process, the team achieved a final conceptual design, which is illustrated in Figure 4. The model consists of different systems: a bowl feeder system, a dispensing system, a gripper system, and a feeder door system. Each has a specific function and operates as follows:

Bowl Feeder System

There are four bowl feeders, one for each assembly component. Bowl feeders use vibration to orient the elements in a specific direction and transport them to the desired location. The operator places the parts inside the bowl feeder so they can be transported to the dispensing system via tube rails.

Figure 3: Spinal Cord Simulator (SCS) 1X16 surgical lead.

Dispensing System

The dispensing system is critical in the design and is composed of two moving plates, two actuators, a static plate, and a component dispenser. The two moving plates employ actuators to transport the components and dispense them inside the fixture where the tubing is located.

Gripper System

The gripper system has a slider and a gripper for each side. The idea is for the operator to place the unassembled tubing inside the dispensing fixture. Each side is placed in its corresponding fixture. Then, the gripper grabs the tubing and, when the machine finishes the assembling process, slides down so that the operator can remove the assembled product.

Feeding Doors Lock System

The lock system avoids placing the wrong components in the bowl feeder. This system, along with its human-machine interface (HMI), locks and unlocks the corresponding bowl feeder's sliding door so the operator can insert the components inside the bowl and prepare the machine.

Results

The four main systems explained above make up the team's conceptual design, which was modeled in Solidworks. After completing the development process, the design improved the following:

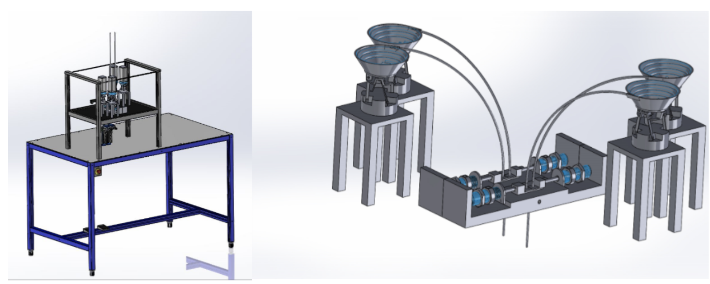

Figure 4: Proposed concept design.

Error Reduction

The proposed electric door lock system and the double gate dispensing system reduced common errors in the current assembly process. The electronic door lock system ensured the use of the correct components. Through a semi-automated process, possible errors caused by misplacing the elements out of sequence were eliminated.

Ergonomic Risk Reduction

The selected concept reduced the strain on high ergonomic risk areas like the neck, wrists, and shoulders. By implementing a semi-automated process, the repetitive wrist movements were eliminated, therefore reducing the strain. The component dispensing system eliminated the need of the product builder to be hunched over the workstation fetching the components, hence, reducing the tension in the neck and shoulders.

Time Per Unit Reduction and Production Increase
Simulations performed in Solidworks revealed a significant time reduction in the assembly process. The simulation also showed that the dispensing system (depicted in Figure 5) takes approximately 48 seconds per side, or 3 seconds per component during assembly. Compared to the current process, a 78 percent time reduction was obtained, an improvement in assembly time from 213 to 48 seconds. This time, reduction represents a drastic increase in the number of leads that can be produced daily, from 11 to 55 kits per shift, if implemented.

Budget Goals Met
The proposed concept had an estimated total cost of $98,776.79, which did not exceed the $100,000 budget assigned by BSC. The beakdown of estimated costs is summarized in Figure 6.

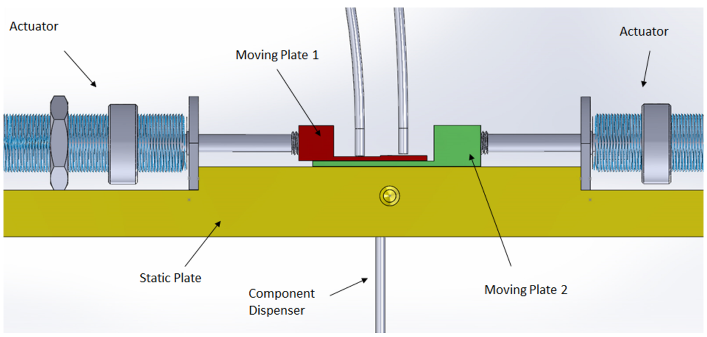

Figure 5: Dispensing system for the proposed concept design.

Conclusion

The objective of this project was to semi-automate the assembly process of a high-demand Boston Scientific product, as part of the National Team Tech Student Competition sponsored by The Boeing Company. The competition evaluated teamwork and collaboration with the industry, as well as the successful implementation of engineering processes to solve a design challenge. After agreeing upon a conceptual design, simulations were conducted, which improved ergonomics, cycle time, and output production for the product assembly line, as well as reduced manufacturing errors.

The proposed system reduced common errors, such as misplaced components, in the current assembly process. It also reduced the strain on high ergonomic risk areas like the neck, wrists, and shoulders. In terms of cycle time, when compared to the current assembly process, a 78 percent time reduction was obtained, revealing an improvement from 213 to 48 seconds. This, in turn, represents a drastic increase in the number of leads that can be produced daily, from 11 to 55 kits per shift, if implemented.

In terms of the National Team Tech Student Competition goals, team members successfully developed their ability to work as part of a diverse team of engineers, learned how to meet requirements based on industry standards and implemented engineering processes, such as the DMAIC (define, measure, analyze, improve and control) cycle to solve real-world industry challenges. Members also learned that, in order to succeed, they had to support each other in order to meet the projected deadlines. Teamwork was vital for the successful completion of the project.

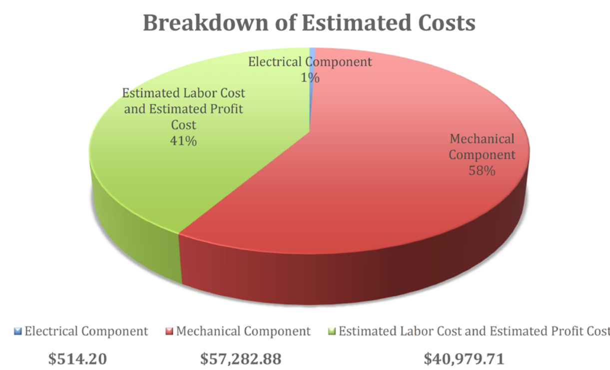

Figure 6: Breakdown of estimated system costs.

Boston Scientific's mission is "to improve the quality of patient care and the productivity of health care delivery through the development and advocacy of less-invasive medical devices and procedures. This is accomplished through the continuing refinement of existing products and procedures and the investigation and development of new technologies that can reduce risk, trauma, cost, procedure time and the need for aftercare". This project allowed team members to be an integral part of this mission. They gained practical experience in the field while being full-time students. In addition, since the Neuromodulation Division is new at the Boston Scientific-Dorado PR plant, the work carried out by the team will allow Boston Scientific engineers to have precise data regarding new designs that will help standardize the manufacturing line. As a result, the engineers and everyone involved in the project were satisfied not only by the team's achievements but of all the work, dedication, and professionalism showed throughout the project's development.

This experience demonstrates that even though Puerto Rico is facing difficulties, the motivation and engagement of its students to achieve their goals and to contribute to society, along with solid industry partnerships will ultimately play a vital role in the economic recovery of the island.

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