Upper & Lower Shell Assembly Module Productivity & Cost Savings Activities

Carlos R. Ortiz
Advisor: Prof. Héctor J. Cruzado
Graduate School

Abstract

At a manufacturing site in Puerto Rico, compressor failure and upper shell damage were identified as major contributors to yield loss and downtime in the automated assembly line for glucose sensors. The main root causes of these conditions were associated to components dimensions. After evaluating each process, it was found that increasing the dimensions of each component improved compressor retention at the subassembly stage and enhanced the upper shell's resistance to the ultrasonic welding process. These were validated throughout effectiveness runs which enabled a 15% and 20% improvement for yield and downtime metrics, respectively.

Introduction

A seven-module interconnected assembly machine is used to assembly a glucose sensor. The assembly process on each machine module is performed using a linear transport conveyor where product and/or components are loaded into each product transport carrier. As the product transport carrier moves through each module station, tasks such as component loading, processing and inspections are conducted to subassembly. Upon subassembly completion, these are placed on buffer conveyors to feed other modules up to product completion. The glucose sensor is comprised of upper and lower plastic shell subassemblies that are welded using ultrasonic welding technology to complete devices. These subassembly shells are pre-processed in upstream module to install device internal components using several assembly applications.

As part of upper shell module assembly process, installation of compressor components is performed. This is installed through a press fit assembly process where a robot picks the component from a position and installs it under pressure into the shell subassembly. Then, this is loaded into a conveyor to next module.

Figure 1 shows compressors fall out and upper shell damage conditions as mayor offenders for machine downtime per station and machine yield per station metrics accordingly. The compressor fall out was found to produce 3.5 hrs. of downtime per month as the upper shell damage condition produced over 27,000 scrap units per month.

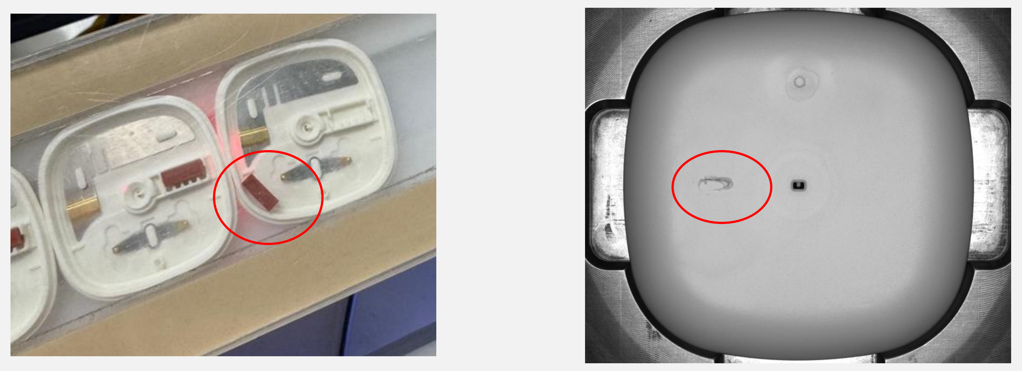

Figure 1: Compressor Fall Out and Upper Shell Damage

The objective of this project was to reduce that occurrence to under 1.5 hrs. downtime per month for the compressor fall out condition, and below 1500 scrap units per month for the upper shell damage condition.

Methodology

The project's methodology ensured thorough consideration of all investigation factors by outlining organized, well-documented steps. Figure 2 illustrates the root cause analysis (fishbone) method used to identify likely causes of compressor fall-out and upper shell damage

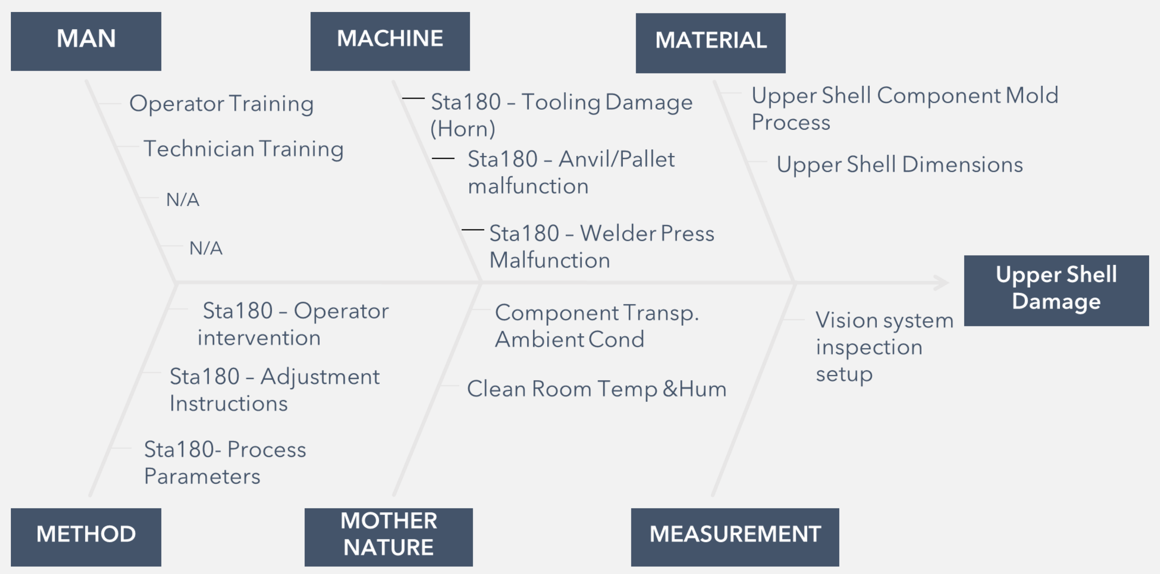

Figure 2:Root Cause Analysis (Fishbone)

Alongside root cause analysis, a structured investigation approach was developed to guide activities. Several solutions were considered, including altering component dimensions, adjusting process parameters, and adding tooling, each aimed at resolving the identified issue. A literature review supported the assessment of component dimensions and tolerances. Changing component dimensions was deemed the most promising and permanent fix, so compressor dimension modification was selected for swift implementation. This solution was subsequently tested to verify its effectiveness.

Literature Review

During ultrasonic welding, amorphous plastics require less energy to melt than semicrystalline plastics due to this structural difference [1]. Joint and part design play a crucial role in ultrasonic applications, as features like triangular energy directors are molded onto the parts to concentrate heat locally during welding [2]. Semicrystalline plastics organized molecular structure contributes to greater hardness and requires more energy to deform than other plastics. However, it tends to be a brittle polymer which makes it susceptible to fractures[3]. Experimental results show that joint strength and potential part damage are influenced by the process parameters used during manufacturing [4]. A critical aspect of press-fit design is accurately determining the interference dimension between parts to ensure proper retention under nominal conditions [5]. Interference is considered as the dimension of the insertion part minus the dimension of the hole or opening [5].

Results

Upper Shell Damage

Solution effectiveness demonstrates that the proposed solutions provided significant improvement at the scope metrics (yield & downtime). Upper Shell damage condition was accessed by increasing component dimension to withstand the ultrasonic process to complete the assembly. This was tested on a three-run configuration:

- Baseline run (before), represents no component change.
- Upgrade 1, which accounts for the dimension increase for the upper shell component wall thickness
- Upgrade 2, which represents additional dimension increased for the component wall thickness to confirm continuous improvement due to the change.

Figure 3 shows results from upper shell runs considering yield values obtained on each run. These results show that the upper shell dimensional change to correct the upper shell damage condition was effective.

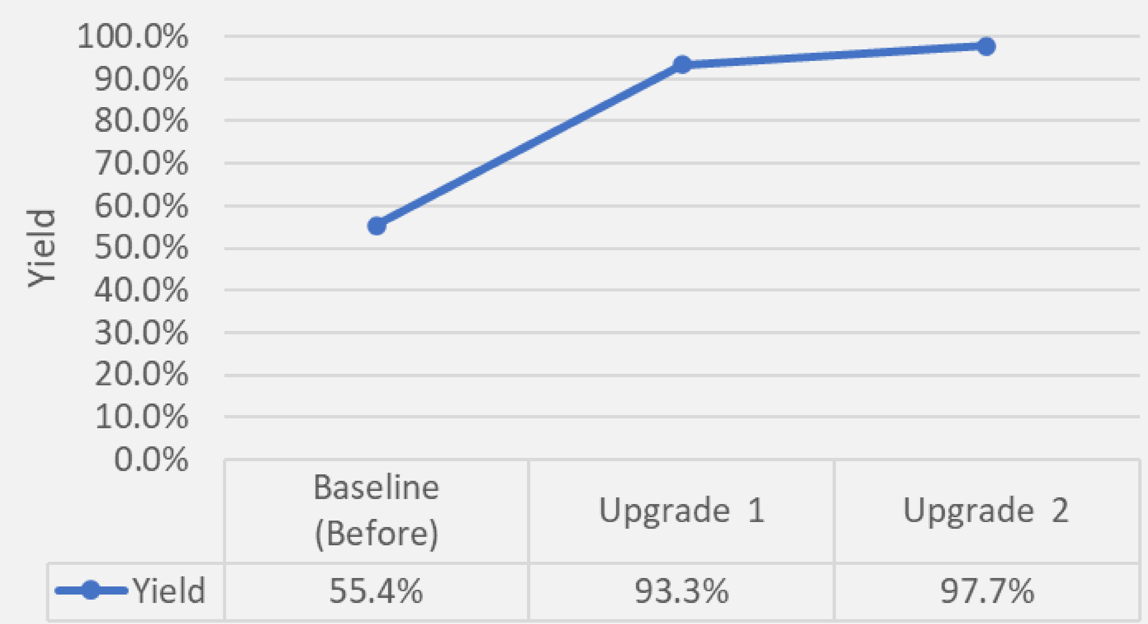

Figure 3: Upper Shell Damage Yield

Compressor Fall Out

Compressors fall out condition was accessed by increasing components thickness to achieve retention at the upper shell subassembly preventing this to fall. This was confirmed through two one-hour runs under the following component configuration:

- Baseline run (before) which represents no component change
- Upgrade (after) which represents dimension thickness increase at the compressor component.

Results showed that there was downtime events at the baseline run compared with upgrade run, where no events were recorded. Figure 4 shows sum of downtime produced by compressor fall out events within an hour run. These results confirmed that the compressor component dimension change to correct compressor fall out condition affecting the performance on the glucose sensor assembly line was effective.

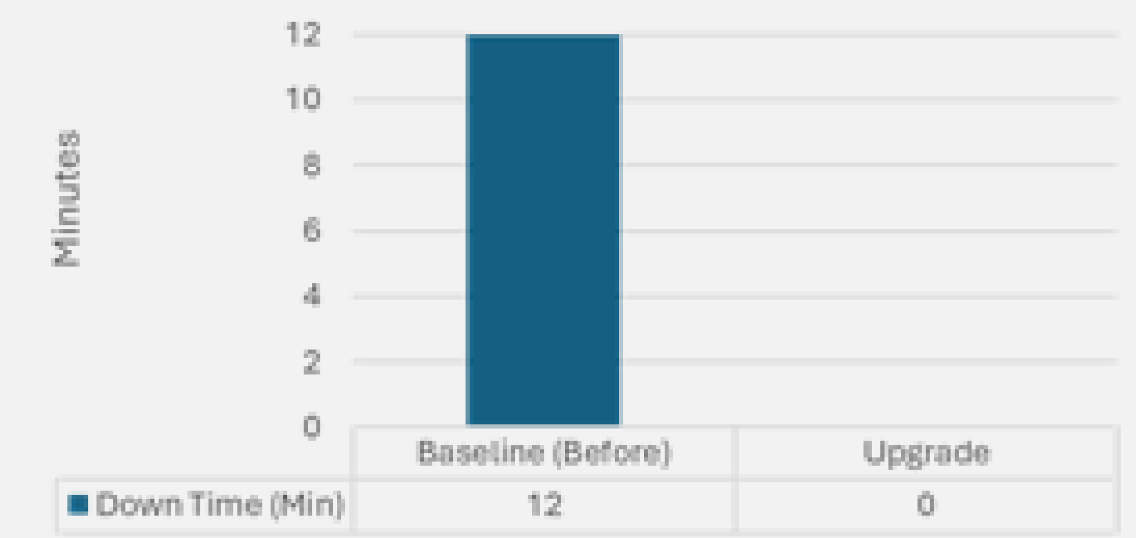

Figure 4:Downtime for Compressor Fall Out

Conclusions

Opportunities to improve yield and reduce downtime were identified in the glucose automated assembly lines, mainly due to upper shell damage and compressor fall-out. Root cause analysis revealed dimensional gaps, prompting changes to component dimensions. Testing confirmed these modifications improved upper shell damage by 15% and machine uptime by 20%. The changes will be implemented after design and validation. The investigation also highlighted the importance of plastic material properties and dimensional tolerances for robust press-fit designs, ensuring components withstand operational forces. Approved changes will proceed following validation.

References

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