PLC Modification For Fill & Close Stopping Sequence Improvement

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Abstract

From November 2020 to January 2021 an analysis was made in relation looking for the best way to increase the yield of the machines in charge of the dry process when making a contact lens. In this analysis it was discovered that there was overwhelming evidence that the biggest offender was curing losses. Curing losses were defined as all molds out of the curing ovens divided by the amount picked up by the CUA (Control Unit Acquisition). An analysis of the PLC code that corresponded to the affected areas determined that best course of action to save the greatest number of molds possible and reduce or possibly eliminate curing losses. After implementation of only a plc code modification an expected improvement on the curing losses should be between 1-2%.

Introduction

Contact lenses have been a very popular choice to treat eyes disease since the launch of the disposable contact lenses in 1987 by Vistakon Division of Johnson & Johnson who launched the first seven-day extended wear disposable contact lenses. All contact lenses are approved by the FDA, even for cosmetic purposes showing a different use for contact lenses. Today we have achieved multiple success in the use for these lenses and the name of the game in manufacturing is profitability. We not only want to meet market demands but achieve them with the lowest possible cost while maintaining the highest possible quality.

One of the ways to improve the profitability of a product is to have the best possible yield and over the years many fixed have been done through mechanical advancements and adjustments. Today, Ill be discussing how we were able to reduce a

Objectives

1. Identify opportunities with the help of a pareto which would be the area that we could obtain the most improvement.
2. Understand the machine process and areas of the machine to be translate into the PLC code and how they are impacted.
3. Study and testing of the PLC code and which modifications would be possible based on physical limitations.
4. Apply the modifications and estimate and have trial runs to estimate how much would be the reduction in curing losses.

Background

I have been an automation / controls engineer for 7 years in the implementation of code and fixes in project like Repatha in Amgen and now as a Process Improver in CooperVision. My job is to help and identify projects that would help the business unit achieves its goals.

Background (cont.)

The first step was to identify which was our goal. It was defined that the improvement of the yield was the best alternative since the pandemic have affected the demand for the contact lenses specially as a daily disposable alternative.

After understanding that we wanted to work with the yield we analyzed which were the highest offenders using a pareto. After understanding that the curing losses were the highest offenders by a big margin, we went on to analyze how could we improve it.

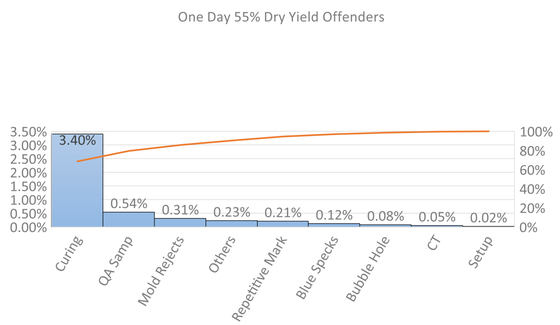
In the analysis we found that mechanically the machine was sound an any improvement on it would be a high-end cost one specially when it would have to be implemented in more than 15 similar machines. Since we understood where the curing losses were happening. We shifted into look opportunities in the PLC code and how we could prevent from the molds being discarded into the waste bins.

The machine constantly wasted molds in the bins and adjustments were made in the PLC (Programmable Logic Controller) to prevent molds being lost in areas when the machine was stopped or faulted. This will save daily thousands of molds in a single machine and the results would be even greater when a deployment of this code adjustments is applied to the rest of the dry machines.

For the control phase the machine yield will continued to be monitor and confirm that the curing losses are reduced by an approximate of 1% - 2%. This fix won't eliminate all curing losses because there are cases like when a fault occurs in the Oven Loading of Oven 1 & 2 when it would be impossible to load the good molds into the oven and the machine will discard them once it reference / home the position of its components.

Methodology

When trying to improve a process usually a pareto of the biggest offenders is produced to understand where we had the biggest opportunities to improve. In the case of CooperVision – Hydrogels it was determined that the biggest area of opportunity was found in what is determined as curing losses.



After understanding that curing was the biggest offender, we focused on what is curing losses. It defined as all the molds that arrived in the bags as final products after the curing oven, divided by all the molds picked up by the CUA (Control Unit Acquisition).

Results and Discussion

The process starts with 2 injection molding machines from the brand Netstal. In the injection molding process polymer balls are loaded, heated, and then pushed through pressure into what is known as the inserts (male and female). These two molds are then brought together one on top of the other with minimal pressure. Since they do come out hot out of the injection molding process, they are placed horizontally in what is called the steel conveyor.

On top of the steel conveyor, we have the CUA (Control Unit Acquisition). This is the one in charge pciking up the molds from the steel conveyor and delivering them into the walking beam. This is where the machine start to consider molds as good and if discarded after it would impact the yield as curing losses.

Once in the walking beam the molds would be open through vacuum pressure. Monomer which is the liquid that would form the contact lens would be inserted through needles and then closed to a specific pressure. If for some reason the monomer couldn't be dispensed or an error occurred during the mold lift or sealing, the mold would be discarded.

If the molds was good, it would then be transferred to the loading conveyors, each oven have its own loading conveyor. The loading robots are servo controlled and pick up the molds in the walking beam and loads them into the conveyor.

Results and Discussion (cont.)

Having understood all the parts of the machine, the main problem is that once the machine start button is pressed the first thing the CUA, Walking Beam, Loading Robots and Loading Conveyors do are reference all the conveyors and home the robots. This is done because once the machine is stopped it does not save the positions of all its components. After reviewing the reference / homing section of the PLC I understood that the original programmers wanted to make sure that all the parts of the machine would return to a specific home position.

The main problem found to modify the reference position was that the machine only had 1 physical point of reference for the conveyors. Meaning that once the machine does not store position of its conveyor but moves in specific distance and when stopped it would not know where it was and would need to reference to understand the position it was in. Another big problem founded was that some of the parts of the machine ran on compressed air, this is not ideal for position storage because once the machine stops it stops sending compressed air to multiple areas and they move from the position they were in.

Once is understood that could not modify the PLC programming to start the machine without homing / referencing, the approach would be to delay the stopping time and segregate the areas faulted as much as it could allow the machine to process as many molds possible. Having successfully saved molds and segregated the part of the machine to stop correctly when a stop button or fault occurs, now we have implemented a fix that will save molds that wouldn't be discard in any of the 4 waste bins.

Conclusions

This project will have a huge impact on not good performing machines which have continuous faults and / or are intervened consistently for some reason by the operators. This curing losses vary from machines from 1% up to 3.28% depending on the day. It is estimated that this project will have an impact of more than 2% reduction in this overall metric and will increase machine yield, increase machine line rate, and reduce waste in the form of polymer and monomer.

Future Work

Futher improvement have been proposed in relation to alarms in the injection molding that stop the machine and should be warnings, also alarms which can be adjusted. This will prevent unwanted machine stops.

References

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