PROD-TRACK

Production Tracker

ELECOMP Capstone Design Project 2023-2024

Sponsoring Company:

Cambridge Technology
125 Middlesex Turnpike, Bedford, MA 01730
http://www.cambridgetechnology.com/

Company Overview:

Cambridge Technology designs, develops, and manufactures leading-edge laser beam steering solutions including galvanometer and polygon optical scanning components, 2-axis and 3-axis scan heads, scanning subsystems, high power scanning heads, and controlling hardware and software. Our company partners with OEM customers to deliver scanning solutions that support advanced industrial processes, electronics, and laser-based medical applications. As the inventor of galvanometer-based optical scanning technology, we make it our mission to drive innovations in photonics by delivering unprecedented technical capabilities through the critical lens of collaboration, quality, and customer service. We dedicate ourselves to excel at:

- Collaboration with our partners to ensure our goals and pathways align
- Innovative engineering bringing tomorrow's solutions to life today
- Manufacturing excellence through DFMA and continuous process improvements
- Delivery from the largest engineering solution to the smallest component

Technical Director:

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Project Motivation:

High performance galvanometers involve complex assemblies having numerous operations that are required to obtain a quality product meeting all specifications. As the latest products push the limits of performance and become more advanced in their design, so too must their manufacturing methods. Integral to the advancement of these manufacturing methods is the collection of better data about the process itself. This includes pass and fail data at different stages of production, as well as failure modes and cycle times. Currently operators in production might need to manually record some data using spreadsheets through the use of keyboards. Although keyboards might be efficient for data entry in general, it is often not practical or efficient in a manufacturing setting. For example, keyboards are sometimes susceptible to debris or damage during various operations and take up space on workbenches or in the work area. Manual data entry can also result in input errors due to mistyping or forgetting the information that needs to be recorded. More commonly, however, the problem is the consistency with which data is collected. Free-form data entry made my operators often creates inconsistencies in the data that makes it difficult to query. This usually becomes an issue when there is more than one operator collecting data for the same process. Having no standardization for the data format and inputs makes it tedious to sort and aggregate with other data for a complete analysis of the process.

The goal of this project is two-fold: first to take one or more important process steps and implement a barcode scanner to record data without requiring keyboard entry and second, to combine the data from the new barcode process and aggregate with some existing process data into a single standardized database. The database will then be used in a simple software tool developed to query and view the data graphically.

Anticipated Best Outcome:

A barcode scanner implemented for at least two key process steps, including one that tracks a lot number and one that tracks parts. This will enable us to demonstrate feasibility of completely keyboard-free data entry and the ability to monitor the overall process through a scalable database format. The database format will enable convenient querying based on different metadata and the presentation of key production metrics.

Project Details:

Overall system concept:

The system shall include a barcode reader in the form of an industrial handheld scanner that is integrated with a computer. The barcode reader will be placed near one box that represents an oven for the curing of workpieces and another box that represents a test fixture for an inspection operation. Several QR/barcodes will be created and placed near each of the two previously mentioned process steps. The QR/barcodes codes will be broken down as follows:

QR/Barcode Code Summary

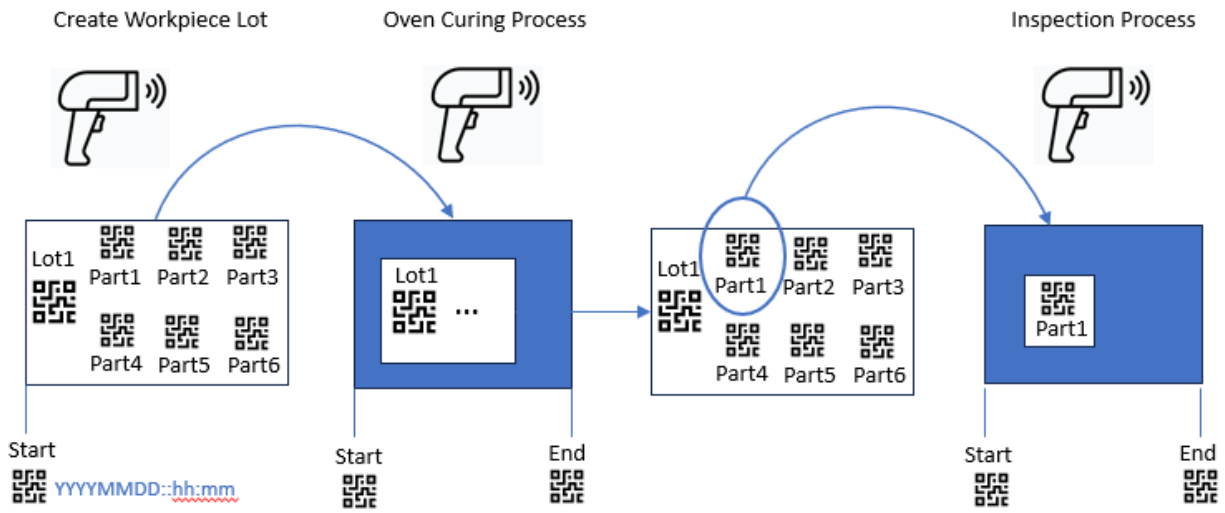
Oven Curing Process

Operator ID	Lot #	Start/End Time	Error Codes
• Operator 1 • Operator 2 • Operator 3	Code on tray	• Start time • End time	• Oven off • Low temp • Other

Inspection Process

Operator ID	Start/End Time	Lot #	Part SN#	Test Type	Test Result	Failure Mode (IF Result = Fail)
• Operator 1 • Operator 2 • Operator 3	• Start time • End time	Code on tray	On part	• Phase • Trim • Cable	• Pass • Fail • Skip	• Short in cable • No signal • Mismatched coil wire • Broken coil

Process Diagram:



Database Requirements:

While the integration of the barcode scanner and QR/barcode code testing is being completed, a sample collection of process data will be reformatted into a database for the purpose of analysis and display in a user interface. The preferred database format for this purpose is SQL however this data may be subsequential reformatted as needed for display purposes in JSON format or otherwise. The main object data shall be the actual part being tracked and be referenced by the part's serial number. In addition to the serial number of the part, it should also be able to be easily referenced to a lot number (Lot #). Additionally, the data for each part being tracked shall include the operations and steps in each operation, if relevant. For example, the "Oven Curing" operation only has one step in the process whereas "Inspection" has three steps. Additionally, each step and or operation should have start and end times and failure mode data types.

Other data tables may also be necessary to automate the scanned input data associated with each QR/barcode. For example, if the user scans a QR code on a tray representing a lot of separate parts, then records for each of the separate parts will be generated automatically in the database.

An example of the SQL database format might look like the following:

Part SN	PN	Lot #	Product Name	Timestamp	Operation Type	Operation Step	Status	Data	Failure Mode	Comments
123	9007	101	Great	20230831:11:22:22	Oven	Load	OK	Null		
124	4347	101	Great	20230831:11:22:23	Oven	Load	Ok	Null		
125	7844	101	Better	20230831:11:22:24	Oven	Load	Ok	Null		
126	2023	101	Better	20230831:11:22:25	Oven	Load	Ok	Null		
127	4555	101	Better	20230831:11:22:26	Oven	Load	Ok	Null		
128	2479	101	Better	20230831:11:22:27	Oven	Load	Ok	Null		
509	8256	500	Awesome	20230831:11:22:28	Inspection	Cable Test	Pass	1		
510	2159	500	Awesome	20230831:11:22:29	Inspection	Cable Test	Pass	1		
511	1652	500	Awesome	20230831:11:22:30	Inspection	Cable Test	Pass	1		
512	9655	500	Awesome	20230831:11:22:31	Inspection	Cable Test	Pass	1		
123	9007	101	Great	20230831:11:22:22	Oven	Unload	Fail	Null	Low temp	Uncured
124	4347	101	Great	20230831:11:22:23	Oven	Unload	Fail	Null	Low temp	Uncured
125	7844	101	Better	20230831:11:22:24	Oven	Unload	Ok	Null		
126	2023	101	Better	20230831:11:22:25	Oven	Unload	Ok	Null		
127	4555	101	Better	20230831:11:22:26	Oven	Unload	Ok	Null		
128	2479	101	Better	20230831:11:22:27	Oven	Unload	Ok	Null		

Look up table

Lot #	Part SN	PN	Product Name
101	123	9007	Great
101	124	4347	Great
101	125	7844	Better
101	126	2023	Better
101	127	4555	Better
101	128	2479	Better

Inserted data when lot is scanned

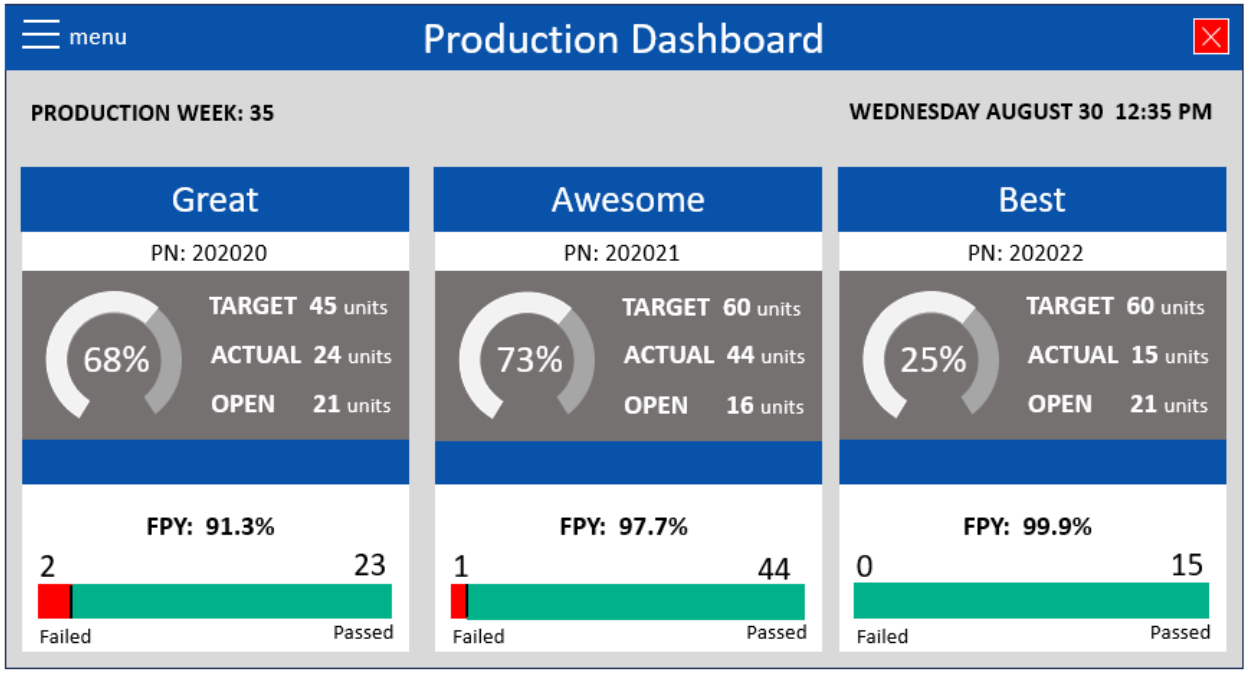
The next step in the design project will be to combine the data collected from the steps using the barcode reader and append it to some existing sample data provided. The purpose of this is to ensure that we can make use of pre-existing process data while incorporating the new data

collection tool using the barcode scanner. An additional benefit of appending to more pre-existing data is that we will have more interesting statistics to use to help generate graphical results while developing the analysis part of the production tracker tool.

Interface Requirements for Production Tracker:

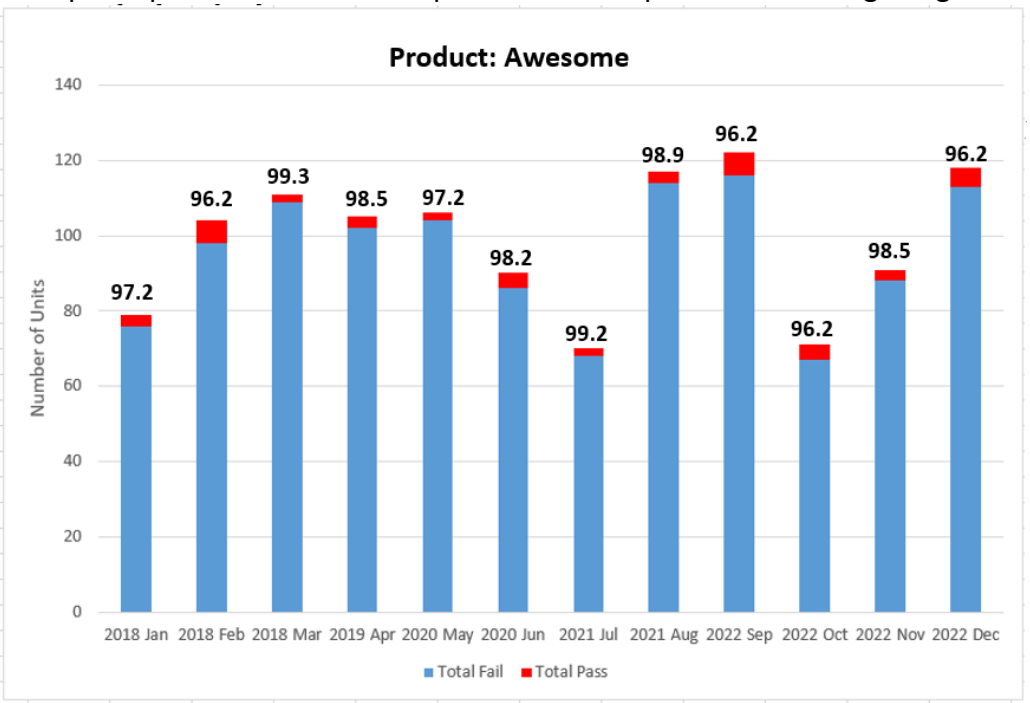
The graphical user interface should have a main dashboard from which to have an overview of key statistics for the different products. For this project there will be three product names, "Great", "Awesome" and "Best". Each product will have a display showing the key metrics for the current week, including quantities built and the average first-pass yield rates.

Example of a main dashboard for production viewing:



In addition to the main dashboard for key production metrics, a basic menu will allow a user to get to a new page and query data based on different metadata in the lookup table/s and specify sample date ranges. The output of these queries can be either a new text file or display graphs for the key metrics over those date ranges. The actual user interface may be implemented any number of ways using input widgets such as text fields, list boxes, radio buttons, etc., as long as the data can be retrieved and displayed. This additional query dialog or window should also have a way to return back to the main dashboard.

Example of production data for a product over a specified date range might look as follows:



Composition of Team:

1-2 Electrical Engineers & 2-3 Computer Engineers; + 1 Double Major ELE/CPE

(Looking for one ELE major to take on the CPE responsibilities in this project)

Skills Required:

Electrical/Computer Engineering Skills Required:

- System integration of a barcode scanner/s with one or more PCs.
- Integration of output devices such as voice, sound or alarms with system software.
- QR/barcode code design, sizing, placement and encoded data.
- Familiar with SQL database structures and manipulation
- Other data portability formats JSON, XML.

Computer Engineering Skills Required:

- Developing GUIs in an IDE using either Python, JS
- Database manipulation in either Python, JS, C++, C#
- Familiar SQL database structures and manipulation.
- Other data portability formats JSON, XML.

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

The developed solution will serve as a proof-of-concept for standardized production data collected using a barcode scanner and basic software monitoring tool. The best outcome would be to implement the developed method in several actual production operations enabling management to better monitor quality and cycle times as a baseline for future manufacturing improvements.

Broader Implications of the Best Outcome on the Company's Industry:

The ability to produce quality galvanometers in higher volumes for a variety of high demand industry applications, including additive manufacturing and via hole drilling for PCBs, will help to ensure that supplies can be met for these high demand markets. The increase in quality enabled through the acquisition of traceable operational data and improved manufacturing controls will enable our customers to also improve their own technologies, finding new applications for high accuracy laser beam steering.