Process Improvement at Sjogren Industries

A Major Qualifying Project Report submitted to the faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the degree of Bachelor of Science

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Date Submitted:
March 23, 2023

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Abstract

Our aim was to improve the manufacturing of custom wire-making tooling at Sjogren Industries by identifying and improving process inefficiencies. Our 5-step approach included mapping processes, identifying areas for improvement, prioritizing focus areas, developing solutions, and creating implementation plans. We focused on automating the handwritten tags that are placed on parts before they are stored. The tags contain information regarding specific heat treatments and coating. We also worked to establish average lead times for Sjogren's raw materials to calculate reorder points.

Acknowledgements

We would like to thank the following individuals for their contributions and involvement with this project:

Carl Sjogren
Dylan Sjogren
Gary Collette
Professor Sharon Johnson
All Employees of Sjogren Industries

Leadership Statement

Deliverables	**Primary Leader(s)**
1. Value Stream Map	Gabriel Comenzo

2.	Tagging System	Michael Souza
3.	Prioritization Matrix	Gabriel Comenzo
4.	Lead Time Deliverable	Both
5.	Final Report	Both

Table of Contents

Contents

Table of Figures

Introduction

Sjogren Industries is a niche manufacturing company that provides customizable solutions to the global wire tooling industry. They specialize in wire straighteners, replacement rolls, wire pullers, replacement jaws, magnetic brakes and clutches, contract manufacturing of wear components in aerospace and chemical industries, and specialized machinery. The company has invested heavily in advanced equipment capable of lights-out manufacturing, which allows them to offer their customers custom solutions with rapid delivery for a premium. The company's strategic plan focuses on profitable growth, lean operations, and building a strong and dedicated team through strong leadership and empowerment (Sjogren, 2023). Sjogren aims to achieve global brand recognition, sustainable EBITDA, and a free-standing organizational structure.

As a student group from Worcester Polytechnic Institute, our project goal was to identify opportunities for improvement within the processes of Sjogren Industries and offer solutions for addressing these issues. Sjogren seeks to use lean methods throughout their processes to try and minimize waste and increase output. This was exciting to hear as industrial engineering students, we were able to connect our project into terms that were easy to understand.

To complete our goal, we followed a 5-step process using a lean improvement approach. The first step in completing the goal was to create a value stream map that helps to visualize the entire process. During the project's early phase, a considerable amount of effort was spent on gaining a thorough understanding of the entire manufacturing process, from receiving customer orders to delivering the final product. This involved examining various aspects such as customer order fulfillment, CAD (Computer Aided Design) model customization by the engineering department, implementation of the designs by the manufacturing team, and the machinery used for production. The second step was to identify opportunities for improvement, seeking to identify waste and inefficiency. We asked employees in each department (marketing, engineering, and production) what they believe is an opportunity for improvement. This step can provide insights that may not have been considered otherwise. The third step was to use a prioritization matrix to decide what opportunities have the most potential. This step helps to narrow down the focus to the most significant areas for improvement. The fourth step was to create a solution that addresses the identified opportunity. Finally, the fifth step was to work to implement the solution, which requires collaboration and cooperation from everyone involved in the process. By following these five steps, the project team sought to accomplish the project goal more effectively and efficiently.

After identifying opportunities and creating a prioritization matrix, one opportunity the team focused on was improving the tagging system. Automating the tagging system is an improvement that requires less effort than most but would reduce waste within the processes.

Another opportunity the team pursued was to create a process to better account for lead times for ordering raw materials. Finding lead times, along with finding the demand for the products, allows Sjogren to determine the reorder points for the raw materials. Sjogren can refer to this process when adjusting reorder points for their raw materials. This is a task that requires substantial work; fully implementing the approach would support improving the company's efficiency.

The report is organized as follows. The Background includes information about Sjogren Industries along with their processes. A Literature Review provides insights and general knowledge about items discussed throughout the report. An in-depth discussion of the 5-step process that we followed throughout this project is presented in the Methodology. The Results and Findings of our project are presented next. Finally, the report concludes with recommendations and reflections of our project and experience.

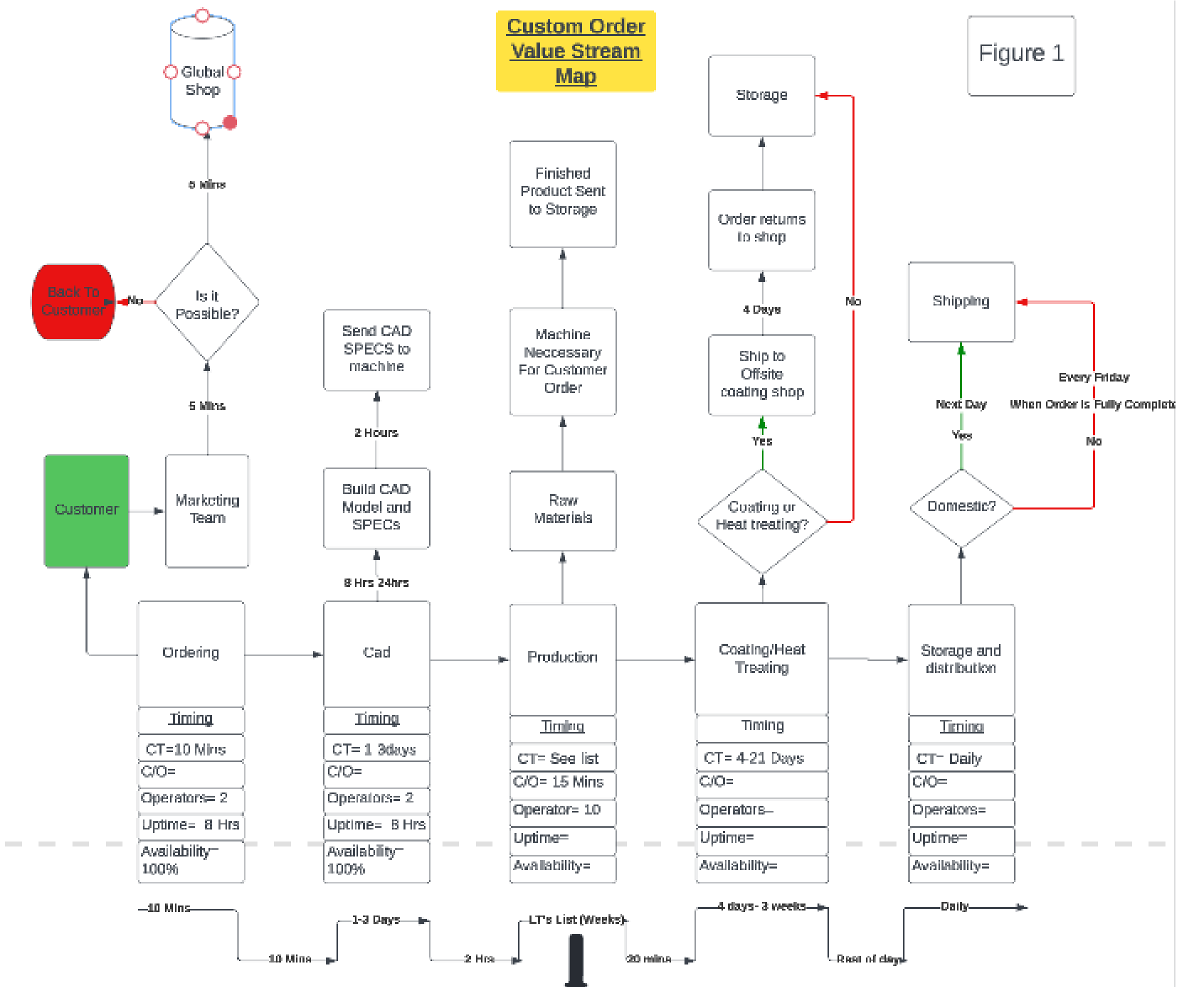
Background

This chapter presents the information necessary for understanding how the project actions were carried out. This information includes a discussion about the processes at Sjogren, the raw materials used, the company's Enterprise Resource Planning (ERP) System, and the current approach for calculating reorder points.

Order and Delivery Process

Sjogren Industries manufactures tooling which is used to make wire. Sjogren Industries offers a variety of products that can be tailored to the dimensions requested by the customer. With this comes an intricate order and delivery process that was mapped out in a value stream map by the project team, as shown in Figure 1.

At the beginning of Sjogren’s working process, the marketing team receives an order request from the customer. At this point, the marketing team decides if the order request is something that Sjogren can complete. The marketing team then categorizes the request into a custom or non-custom order. A non-custom order is an order that does not require CAD modifications since it has already been ordered and is in Sjogren’s system. The production team can pull the CAD specifications (specs) that have already been completed and send them directly to the required machine. The order is classified as “custom” if the engineering team is required to create or modify CAD specs to complete the order. This can range from a slight tweak from a previous order that might take 15 minutes for the engineers to do, to an entirely new design that usually takes between 1-3 days for engineering to complete. In the case of a custom order, the marketing team will input the order into Global Shop, which is an online platform used for all



Product	2020	2021	Target (2022)
Cabot Tips	4.54	5.59	4
Tensile Testing	5.16	5.39	2
Machines	3.13	5.05	6
Subcontract	2.96	4.74	4
Static Dancer Roll	0.71	3.29	4
Straightener	2.34	3.2	2
Brakes and Clutches	2.02	2.92	2
Swaging		2.71	4
Other	1.3	2.1	4
Rolls	1.52	2.01	2
Jaws	2.27	2	1
Pullers	1.2	1.61	2
Wire Guides	1.23	1.56	2
Avg	2.18	3.25	3

Figure 1: Value Stream Map of Sjogren Industries Order and Delivery Process

orders that help the company track orders, materials, and the timeline of it all, and drop all required information into a folder for the engineering team to do the CAD design. Once the engineering team is finished, they will put the CAD design in a different folder where it is taken by production manager. The production manager programs the CAD specs so they can be put into the machine and the parts can be made. After the parts are made and checked for defects, the next step is to coat and/or heat treat the product if necessary. Coating and heat treating are value-added processes that increase the lifespan and quality of their products. Sjogren’s heat-treating strategy includes holding products until they have a large batch and then heat-treating all the batches simultaneously. This saves the company money because they pay a fixed rate for heat treatment, the price will be the same if they heat treat a single part or a large batch of parts. This leads to delays as products requiring heat treatment are stalled to save money.

Raw Materials

Sjogren purchases four distinct categories of raw materials. This includes bearing supplies, round bar material, flat ground material, and A 36 Materials. These are stored on the first floor of their facility. Of these materials, the A 36 material and Bearing supply are purchased with blanket orders while the flat ground and round bar are not. For a blanket order, Sjogren orders a year's supply of material from a distributor. The distributor prepares the material and then stores it in their warehouse. From there, Sjogren can request their material as needed and will receive it extremely fast since it is already manufactured and just needs to be shipped. The lead time for a blanket order is usually between 1-3 days. Finally, the material is cut and shaped per the request of the customer and sold as raw material for them to use.

Production Planning System

Sjogren Industries uses an ERP program called Global Shop that acts as a database to keep track of customer orders at Sjogren and data entries. Global Shop is anchored to a Microsoft Access program which allows employees at Sjogren to obtain data on products and orders. Microsoft Access allows employees to cross-reference different variables such as time, money, material, order, and part number to create reports.

Current Approach for Calculating Reorder Points

Sjogren calculates reorder points for their raw material, including bearing supplies, round bar, flat ground, and A 36 Materials. A reorder point is the level of inventory at which a company should reorder a particular item to avoid stockouts and shortages. It is usually calculated by multiplying the demand by the lead time of the material and adding safety stock which is a buffer to ensure there will be stock if the demand or lead time is significantly greater than expected. Sjogren follows a specific process to analyze their inventory usage, lead time, and reorder points for their inventory. First, they access Global Shop and run a report by navigating to Inventory>Reports>Usage>By Part. Then, they export the report to Excel. In excel, they calculate the average monthly usage and standard deviation for their raw material. These two columns of data are saved as values, and the report is imported into their Microsoft Access program.

Sjogren uses the average monthly usage and standard deviation to forecast demand. From there, Sjogren uses forecasted demand and lead time to calculate the reorder point and reorder quantity. Next, Sjogren runs a report on Global Shop and exports the following data into Microsoft Access: Raw materials>Date Ordered>Date received. On their Access program, they use an equation to calculate the average lead time for each raw material. Once they have the lead time, they can calculate the reorder point with the following equation:

Reorder point = Average usage per day * Average lead time (In days)

Finally, Sjogren has values for demand forecast, lead time, reorder point, and reorder quantity. This information is then used to schedule their purchases and delivery expectations to meet the expected demand. However, these values were not recalculated. As demand and lead time can shift over time, this is a problem. These calculations became outdated as the lead time and reorder point have changed for many of their raw materials. This has resulted in late orders due to incorrect lead times and reorder points.

Literature Review

Introduction

The literature review covers topics within the report such as Enterprise Resource Planning systems, value stream mapping, LEAN manufacturing, and inventory models. The literature review covers these topics with general information rather than information regarding how they relate to Sjogren.

Enterprise Resource Planning

Enterprise Resource Planning (ERP) is a software program used in many manufacturing industries. ERP systems coordinate and amalgamate information from every aspect of a business's production process (McCue, n.d.). The software is shared between departments within a company to remain on point during production. Sales, marketing, production, logistics, accounting, and staffing are just a few departments required for a customer's order to go through the manufacturing process, and for the process to be successful, these departments need to be in concordance (Monk & Wagner, 2013).

Evolution of ERPs:

Before ERPs, companies had individual software systems that were integrated into each specific department, rather than shared between departments. Each software system had its way of interpreting data. Thus, departments developed “Silos” which are stacks of information that are not shared between departments. To be competitive, companies must share information among all functional areas of a business. Companies that do not have integrated systems between departments are at risk of costly inefficiencies and lowered quality of the product for the customer.

The first and most popular ERP software is Systems, Applications, and Products in Data Processing (SAP) developed by former employees of IBM in 1972. Many ERP systems have been developed and implemented in companies since then. Oracle Cloud, Odoo, and Global Shop are just a few ERP systems that have been developed after SAP.

Materials Requirement Planning:

A byproduct of ERP systems is Materials Requirement Planning Systems (MRP). MRP systems are used by supply chain analysts to assist with production scheduling. MRPs determine the timing and quantity of every aspect of production (Jenkins, n.d.). These facets include ordering raw materials to fulfill an order, labor required to fulfill an order, and sales forecasting for future orders. Before MRPs, companies with many different products were required to do the tasks of MRPs manually. Keeping track of raw materials, necessary labor, and projections for future orders was a near-impossible task to do efficiently. Paper purchase orders and invoice systems were highly inefficient as they took many days to process between companies and were extra costly. MRP systems revolutionized the manufacturing processes of many companies and allowed them to expand the horizons of their products.

Value Stream Mapping

Value stream mapping is a tool industrial engineers use to establish where there is non-value-added time in a process (Disciplined Agile, n.d.). Using this information, a person can adjust accordingly to make the process more efficient.

How it is Done:

There are three steps to complete a value stream map, as outlined below (Rother & Shook, 2018):

Step 1: Map out the production flow from raw materials to when the product ends up in the customer's possession.

This step requires a ton of time and attention to detail. Depending on the intricacies of the process, this process could serve many purposes to help employees understand the complete process over all different departments. Having a visual representation of the flow of process and flow of information can reveal opportunities for improvement.

Step 2: Record the timings of each step within the process.

This step of the process requires an individual to record the cycle times, lead times, changeover time, the number of employees, availability %, uptime, downtime, etc.… Any measurement that is a factor in adding potential waste (such as time, and money) should be measured and added to a visual chart.

Step 3: Identifying wastes in processes

To improve the process mapped out and measured, it is important to identify where there is waste. Using a lean approach to identify and reduce waste is the most fruitful way to improve the process.

LEAN Manufacturing

Lean manufacturing is a methodology that focuses on minimizing waste within manufacturing processes while simultaneously maximizing productivity (TWI). In lean manufacturing, seven wastes are worth noting within a process (Gupta, 2013). These seven wastes include overproduction, inventory, motion, defects, over-processing, waiting, and transport.

Overproduction:

Overproduction is seen as the most serious type of waste as it can cause all other types. The costs associated with overproduction are detrimental but avoidable. If proper precautionary measures are taken, overproduction can be reduced to almost 0.

Inventory:

Inventory waste refers to the waste produced by unprocessed inventory. This includes the waste of storage, the waste of transporting the inventory, the containers used to hold inventory, the lighting of the storage space, etc. Having an excess inventory can hide the original waste of producing said inventory and cause major cost issues for the business.

Motion:

Wasteful motion is all the motion, whether by a person or a machine, that could be minimized. Typically, motion waste adds to lead time and cycle time for the process. Motion waste can be reduced by layout optimization. Layout optimization can be reached by charting flow analysis. Using flow analysis, an individual may be able to spot places where motion waste is obvious and avoidable.

Defects:

Defects refer to a product outside the standards of its design or quality. Defective products must be replaced and human labor to process them. Also, the company may lose customers if the product does not live up to their wants and needs. The resources put into the defective product are wasted and considered a sunk cost. Making a more efficient production system reduces defects.

Overprocessing:

Over-processing refers to any component of the process of manufacture that is unnecessary to complete. Painting an area that will never be seen or adding features that will not be used are examples of over-processing. Overall, overprocessing refers to adding more value to a product for a customer than is necessary.

Waiting:

Waiting can be described as wasted time because of halted production in one step of the production chain while a previous step has been completed. For example, the production line. If one task along the process takes longer than the task, then any time the employee or machine in charge of the next task spends waiting is wasted. The task that takes more time must be made more efficient, other employees must be hired for that task, a new machine must be purchased to complete the task at the most efficient rate, or the workflow must be better coordinated to make up for the wasted time.

Transport:

Transport is moving materials from one position to another. Transport waste can be reduced by constructing algorithms and using computer-aided programs. Using these strategies, a person can figure out where to place departments and certain machines to minimize waste and save the most amount of money.

Inventory Models

Inventory modeling is a concept in supply chain management that involves the optimization of inventory levels to minimize cost while maintaining quality (Nacht, n.d) various mathematical models have been developed to provide insights into inventory management strategies. Inventory models can be categorized into continuous review systems, depending on how often inventory levels are reviewed. Continuous review models provide real-time inventory control, while periodic review models offer a more cost-effective option for items of lower demand. Literature on inventory modeling has expanded significantly in recent years, with researchers exploring new models that consider numerous factors such as product perishability, inventory holding costs, and demand variability.

There are several diverse types of inventory models, each with its characteristics. The Economic Order Quantity (EOQ) model is a well-known deterministic model that assumes demand and lead time are known with certainty, and ordering costs and holding costs are constant. The Periodic Review Model (PRM) is another widely used model that allows for the review of inventory levels at predetermined intervals. In contrast, the Continuous Review Model (CRM) tracks inventory levels in real time and triggers an order when the inventory level reaches a reorder point. The Newsboy Model is a probabilistic model that considers uncertain demand and is often used for perishable items with a limited shelf life. Finally, the Multi-Echelon Inventory Model considers inventory management across multiple tiers of the supply chain to optimize inventory levels and reduce costs (Baker & Urban, 1988). Overall, the choice of an inventory model depends on the business's specific needs and constraints.

As part of inventory planning, a company may consider holding safety stock. Safety stock refers to the inventory that a company or organization maintains to mitigate the risk of stockouts. In other words, it is the extra stock that a company keeps on hand to ensure that it can fulfill customer demand even in situations where there are unexpected increases in demand or delays in the supply chain. There are various methods and models that companies can use to calculate the optimal level of safety stock based on factors such as lead times, demand variability, and service level targets.

Methodology

The goal of our project was "Process Improvement at Sjogren Industries". This goal is open-ended, and it gave us the freedom to complete the project using an approach we believed would be most effective. Thus, we created a five-step plan to complete this process efficiently, and effectively, based on lean improvement ideas. Following this five-step plan brought structure and generated smaller objectives. Having smaller objectives was beneficial because it made it easier to understand the full impact that our completed project would have. It also allowed us to discover what worked well with our project and what did not work well without having to restart the entire project.

Step One: Value Stream Mapping

We began our project at Sjogren Industries with a tour of the facility. We were taken through the production process and received a rundown of how the production process worked. We asked questions and took notes on the process. Then, we used our understanding to create a value stream map. Once this was completed, we showed it to multiple Sjogren employees to confirm it was correct and make the necessary changes. We then used the value stream map to identify areas of inefficiencies within the company's operations.

Step Two: Identifying Opportunities for Improvement

Next, we went to each department at Sjogren and asked what they believed would be a useful subproject for us to complete. Each department offered suggestions on where to have us focus to improve the processes.

Step Three: Prioritization Matrix

This step of our process allowed us to distinguish the priority of each subproject. A prioritization matrix is a graph that shows the benefits of resolving an issue vs the effort it would take to solve it. Typically, a task that takes a lot of effort should yield a higher benefit. An issue that has a high benefit and low effort is preferred compared to a low benefit and high effort. After identifying potential improvement areas by talking with employees, we presented these opportunities in a prioritization matrix that was shared with marketing, engineering, and production staff. Based on their feedback, the issues that we decided to focus on were automating the tagging system and establishing the lead times for ordering raw materials.

Step Four: Creating Solutions

The first area we focused on was the company's tagging system. We interviewed employees and learned that the current tagging system was flawed, as tags were hand-written and were subject to human error. When a code was incorrectly written, this caused defects as the codes on the tags correlate to types of coating and heat treatment. We observed that Sjogren's products were linked to their work orders and blueprints through Global Shop. The work order and blueprints are automatically printed when the part flows through the system. We proposed that the tag be linked to the part in Global Shop to eliminate human error. We designed a template for the tag that adds more detail than the current tag. We added a description and a picture to the tag. This eliminates another error we observed where a tag is placed on the wrong part. A description and picture of the correct part on each tag make it less likely to mix up tags.

The next area we focused on was inventory management, in terms of how Sjogren purchases its raw materials. We interviewed the CEO of Sjogren and discovered that the lead time and reorder point values Sjogren was using were outdated as Sjogren did not recalculate these values frequently enough. We learned how Sjogren calculated these values and agreed with the CEO that they should calculate lead time and reorder points at the beginning of every quarter to avoid them becoming outdated. We also learned that the current formulas being used to calculate lead time were flawed and needed to be adjusted, as they did not work correctly for blanket orders. A blanket order is a bulk purchase of materials stored until needed. The Access program's lead time calculation based on the delivery time of a year's supply is inaccurate as it calculates the time it takes for Sjogren to receive the entire year's supply instead of the time it takes to receive the small shipments when requested. Sjogren has enlisted our help to find a solution to either filter out the blanket order calculations or find a new method to accurately calculate the lead time for blanket orders. Once the lead time is calculated, the following formula can be used to calculate the reorder point:

Reorder point = (Average Demand * Average Lead time) + Safety stock

Whenever the number of units in the inventory drops to the reorder point, a new order will be placed.

We proposed that Sjogren should incorporate safety stock into its inventory calculations. Although we could not access Sjogren's production data directly, we set the process of finding the lead times of raw material ordering and used hypothetical data to set reorder points based on this information. Using the information obtained from our research combined with the outsourced information from another WPI student team working on the demand component, Sjogren can pool our knowledge to finalize the process for setting reorder points.

Step Five: Recommendations for Implementation

To implement the tagging system, the proposed template needs to be implemented into Sjogren's ERP system for each part. Since we did not have access, we recommended the production manager begin by linking the 10 most frequently ordered products.

For the reorder points, we were only responsible for finding the lead times. To calculate reorder points, both lead time and demand are needed. Since the demand component of the reorder points was outsourced to a separate group, we shared our conclusions with them which allowed them to determine the reorder points.

Findings and Results

The results of our reports provided valuable insights into three key areas of Sjogren's business: identifying several opportunities for improvement, discovering lead times for raw materials and improving the tagging system. While we focused on two sub-projects to explore improvements, our initial value stream work identified additional opportunities that Sjogren might explore. Through our research, we also determined the negative effects of outdated lead times and an ineffective tagging system, which can include delays in production, inefficient use of resources, and difficulty in locating important data. The first sub-project focused on determining accurate lead times for raw materials, which can help to identify optimal reorder points and prevent stockouts through the use of safety stock. The second sub-project aimed to improve the tagging system, making it easier to categorize and locate data. Our findings show that both areas are critical for the success of our business, and we recommend implementing the strategies outlined in this report to improve our efficiency and productivity.

Prioritizing Opportunities for Improvement

The value stream map proved to be an asset in pinpointing areas of operations that produced negative effects, known as undesirable effects, which hinder the performance or achievement of a system's goal, process, or its stakeholders and clients. They are obstacles that limit throughput or performance and are often symptoms of underlying root causes (Hohmann, 2021). By analyzing each process with input from relevant department workers, we were able to identify five significant undesirable effects. Out of these five, we chose to concentrate our efforts on the tagging system and inventory management. This includes automating hand-written tags for parts and establishing reorder points for Sjogren's raw material. These will be discussed in more detail later.

Other Undesirable Effects:

Heat treating process:

Sjogren's current practice of delaying heat treatment until a significant quantity of products is ready is a cost-saving measure. However, this approach results in the unintended consequence of delaying the heat treatment of products that are ready, leading to a slowdown in production and causing an increase in lead time for customers.

Communication Process between Marketing and Engineering

Upon receiving an order, Sjogren's marketing team records the product specifications and related information in a designated email folder, which is subsequently reviewed by the engineering team responsible for designing the product using Solid works software. However, an unintended consequence of this is the occurrence of transfer errors that may prevent the information from being correctly received in the folder. This, in turn, may lead to a lack of awareness on the part of the engineering team regarding pending product designs. This can result in delayed processing of product information for days or weeks, causing potential setbacks in production and delivery timelines.

Storage System:

Sjogren employs an organizational system for its parts that involves storing them on unlabeled boxes on shelves. One unintended consequence of this approach is the potential for parts to become misplaced or lost, leading to difficulties in keeping track of them. Consequently, workers may need to invest a significant amount of time and effort to locate the required parts, leading to a delay in the production process.

Prioritization Matrix

Deciding on which subprojects are worth completing is an important decision. Given this, we decided to create a prioritization matrix to help us make this decision. We had identified 5 potential subprojects, but only enough time to complete two of them.

Typically, a task that takes a lot of effort should yield a higher benefit. The prioritization matrix shown in Figure 2 shows the linear line with points showing where each project lies. The red dot illustrates the tagging system improvements and where it lies on the prioritization matrix. The blue dot represents the lead times for raw materials purchasing. The yellow dot shows the marketing-engineering communication subproject, which we omitted after discussing with company employees the cost, complexity, and likelihood of it being completed in the timeframe of the project. This subproject would require a lot of effort and resources for less benefit. One solution required creating a GAB script in Global Shop which could cost hundreds or potentially thousands of dollars. The green dot represents the storage system. This project is a good option because it has relatively low effort and a high benefit. Another WPI team is currently working on this project. The purple dot represents the heat treatment process. This project has a high effort to benefit ratio due to the complexity of finding a better way to heat treat parts without sacrificing the money saved in the current process.

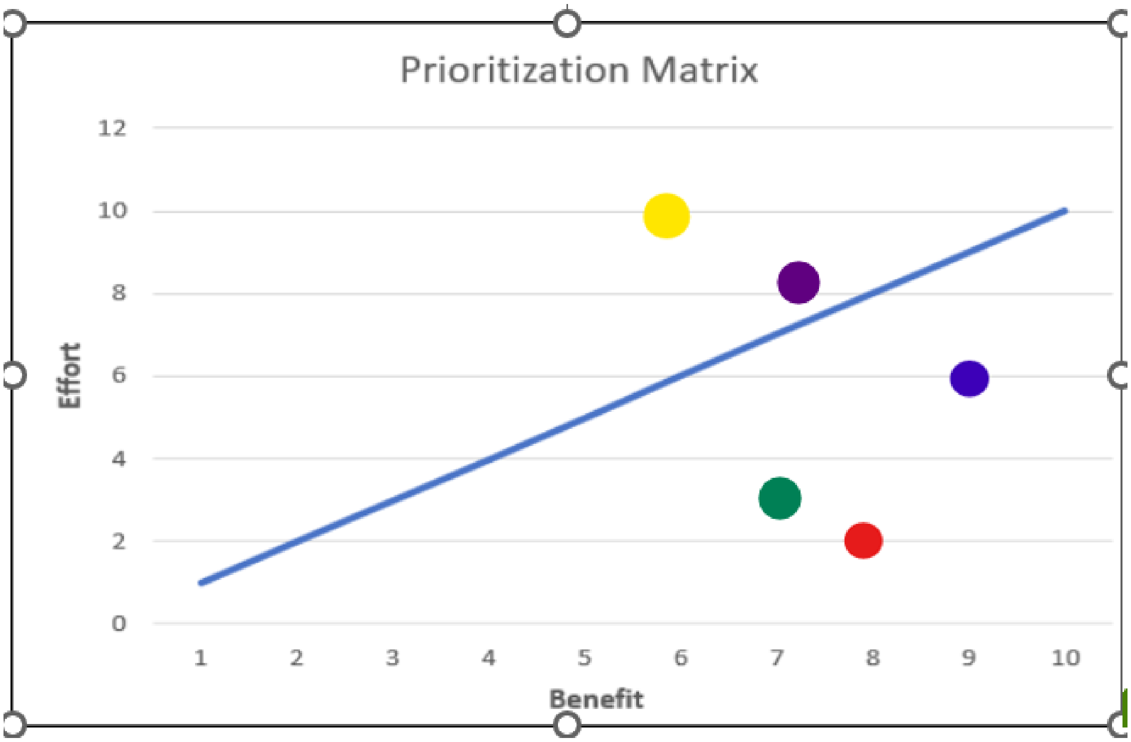


Figure 2: Prioritization Matrix.

Lead Times for Reorder Points

To improve the efficiency of the supply chain process, it is essential to accurately estimate lead times for raw material ordering. To achieve this, we utilized Microsoft Excel and mock data to develop formulas that can help determine lead times based on several factors such as order quantity, price, and lead time. In this paragraph, we discuss the findings and results of our analysis, including the formulas we developed and the insights we gained into the factors that impact lead times.

We separated each raw material into 4 separate categories: A36, Bearings, Round Bar, and Flat Ground. Separating these materials allowed for more organization. After we separated our categories, we determined what criteria to consider when keeping track of this data. We decided on: Order quantity, price paid, unit price, date ordered, date received, and lead time.

A spreadsheet was developed for each of the 5. The spreadsheet for A36 materials is shown in Figure 3.

	A	B	C	D	E	F	G	H
1	A36 Part #	DESCRIPTION	Quanity (Bars)	Price Paid	Price Per Bar	Order Date	Date Received	Lead Time(Days)
2	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	6	720	120	1/10/2022	1/11/2022	1
3	A36F1.000X2.000 (REV:) ANL	A36 1 X 2, ANNEALED	12	1620	135	1/10/2022	1/13/2022	3
4	A36F1.000X3.000 (REV:) ANL	A36 1 X 3, ANNEALED	16	1776	111	1/10/2022	1/14/2022	4
5	A36F1.250X1.250 (REV:) ANL	A36 1-1/4 X 1-1/4, ANNEALED	4	536	134	2/15/2022	2/18/2022	3
6	A36F1.500X3.000 (REV:) ANL	A36 1-1/2 X 3, ANNEALED	6	1404	234	2/15/2022	2/16/2022	1
7	A36F1.500X4.000 (REV:) ANL	A36 1-1/2 X 4, ANNEALED	6	1926	321	2/15/2022	2/18/2022	3
8	A36F1.500X6.000 (REV:) ANL	A36 1-1/2 X 6, ANNEALED	11	1353	123	3/5/2022	3/6/2022	-1
9	A36F2.000X2.000 (REV:) ANL	A36 2 X 2, ANNEALED	4	932	233	3/5/2022	3/8/2022	1
10	A36F2.000X3.000 (REV:) ANL	A36 2 X 3, ANNEALED	2	424	212	3/5/2022	3/9/2022	2
11	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	4	480	120	4/10/2022	4/13/2022	2
12	A36F1.000X2.000 (REV:) ANL	A36 1 X 2, ANNEALED	12	1620	135	4/10/2022	4/15/2022	4
13	A36F1.000X3.000 (REV:) ANL	A36 1 X 3, ANNEALED	16	1776	111	4/10/2022	4/14/2022	3
14	A36F1.250X1.250 (REV:) ANL	A36 1-1/4 X 1-1/4, ANNEALED	4	536	134	5/15/2022	5/19/2022	3
15	A36F1.500X3.000 (REV:) ANL	A36 1-1/2 X 3, ANNEALED	6	1404	234	5/10/2022	5/15/2022	3
16	A36F1.500X4.000 (REV:) ANL	A36 1-1/2 X 4, ANNEALED	6	1926	321	5/10/2022	5/11/2022	1

Figure 3: A36 Material Spreadsheet

The table can be filtered by material to determine lead times for specific raw materials further evaluation. Below is the A36 3/4 X 1-1/4, ANNEALED, as shown in Figure 4.

	A	B	C	D	E	F	G	H
1	A36 Part #	DESCRIPTION	Quanity (Bars)	Price Paid	Price Per Bar	Order Date	Date Received	Lead Time(Days)
2	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	6	720	120	1/10/2022	1/11/2022	1
11	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	4	480	120	4/10/2022	4/13/2022	2
20	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	8	960	120	6/15/2022	6/16/2022	1
21	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	2	240	120	6/10/2022	6/11/2022	0
24	A36F0.750X1.250 (REV:) ANL	A36 3/4 X 1-1/4, ANNEALED	6	720	120	7/11/2022	7/12/2022	1

Figure 4: A36 Material Spreadsheet Filtered

Using excel functions, we can determine output for each of these categories. For a lead time, it is as simple as subtracting the date received from the order date to discover the lead time. Since suppliers do not ship on weekends, an equation was used to only count weekdays for the lead time. The following equation was used: =NETWORKDAYS.INTL([Order Date],[Date Received],1). This equation simply counts the days in-between two dates without counting Saturday or Sunday.

Overall, being able to keep track of lead time for individual raw materials will help tremendously when figuring out the reorder points. For the implementation of this deliverable, it is important that the employee who oversees raw material ordering downloads the necessary data from Global Shop. Sjogren has suggested recalculating these values at the beginning of each quarter.

Safety Stock Calculations

Safety stock calculations are necessary for calculating reorder points, especially in today's volatile global supply chain. Safety stock calculations consider average daily use, maximum daily use, average lead time, and maximum lead time. Using hypothetical data, we demonstrate how to calculate how much safety stock is necessary to be at a service level of 99%. All hypothetical data such as lead time and demand is based on a quarterly schedule (65 workdays, n.d.). This means that we are 99% confident of preventing a stock out. The results of these calculations are found in Figure 4.

The equation that was used to calculate safety stock is:

SS = [Average Daily Usage in inches] * 2.67 * [Standard Deviation of Lead Time].

This equation is an efficient way to calculate safety stock (Indeed, n.d). It considers average daily usage as well as lead time. This equation also portrays the safety stock value at 99% confidence of not having a stockout. The value 2.67 is simply the Z score of a 99% confidence interval, which assumes a normal distribution. If a lower service level is appropriate, the Z Value will be smaller which will require less safety stock. When multiplied by average daily usage and lead time, the safety stock is determined. The average daily usage is a calculation to determine the rate in which Sjogren can go through material. For this equation, we multiplied the number of bars used by 48 (the number of inches in one bar) and divided that number by 65 (the number of days in a quarter).

Each row in figure 5 represents a different product. Taking row 1 as an example, we were able to calculate that the safety stock for this material is 11 inches (Peterson & Pyke, 1998) . The equation looked like:

$$SS = [5.76] * 2.67 * [0.7] = 11$$

Given there is 48 inches in each bar, this means that this material does not require safety stock.

Row Labels	Average Daily Usage	StdDev of Lead Time(Days)	Safety Stock in inches	Safety Stock in Bars	Average Reorder Point
A36F0.750X1.250 (REV:) ANL	5.76	0.7	11	0	0
A36F1.000X2.000 (REV:) ANL	13.29	1.3	46	1	2
A36F1.000X3.000 (REV:) ANL	17.72	0.8	39	1	4
A36F1.250X1.250 (REV:) ANL	4.43	0.0	0	0	1
A36F1.500X3.000 (REV:) ANL	6.65	1.4	25	1	1
A36F1.500X4.000 (REV:) ANL	6.65	1.4	25	1	1
A36F1.500X6.000 (REV:) ANL	12.18	1.4	46	1	2
A36F2.000X2.000 (REV:) ANL	4.43	0.7	8	0	0
A36F2.000X3.000 (REV:) ANL	2.22	0.7	4	0	0

Figure 5: Safety Stock Excel Spreadsheet

Reorder Point Calculations

With all of this considered, we now demonstrate how to calculate the reorder point. Reorder point is a calculation that can determine when materials should be ordered to prevent a stock out. The unit of reorder point is in bars. This means that once the stock of this certain material gets down to certain number of bars, then Sjogren must reorder this material. This calculation requires the average daily usage, lead time, and the safety stock. The equation we used is:

Reorder Point = [Safety Stock in Bars]+[Average Daily usage in Bars]*[Lead Time(Days)]

The results of adding this equation into the spreadsheet can be found in Figure 6.

Row Labels	Average of Reorder Point
A36F0.750X1.250 (REV:) ANL	0
A36F1.000X2.000 (REV:) ANL	2
A36F1.000X3.000 (REV:) ANL	4
A36F1.250X1.250 (REV:) ANL	1
A36F1.500X3.000 (REV:) ANL	1
A36F1.500X4.000 (REV:) ANL	1
A36F1.500X6.000 (REV:) ANL	2
A36F2.000X2.000 (REV:) ANL	0
A36F2.000X3.000 (REV:) ANL	0

Figure 6: Reorder Point Excel Spreadsheet

Blanket Orders When Calculating Reorder Point

Blanket orders should be monitored to see how they affect lead times and safety stocks. It is important to distinguish between two types of orders. The first type is the "payment order" where Sjogren will buy a larger number of units to cover a longer period of time, such as a year. The second type of order that comes with blanket orders is the "suborder." Suborders refers to the type of orders that Sjogren makes when requesting their materials. Suborders should be treated the same as non-blanket orders when calculating safety stock and reorder points. Safety stocks may not be required because lead times are typically short, 1-3 days.

Automated Tagging System

To minimize human error and improve the efficiency of Sjogren's process, we propose automating the tagging system. An example of the current tag is shown in Figure 7.

Figure 7: Tagging Picture

The suggested format for the automated tagging system is shown in Figure 8. The added categories of quantity, weight, and a picture of the part work to increase the accuracy and efficiency of part storage and organization. With the added tag features, parts will be more distinguished and easier to identify when checking for errors.

Part Number	Description
Quantity	Weight
Heat Treatment Code	Picture of the Part

Figure 8: Suggested Tagging Format

Automatic tagging can be achieved by manually linking tags to parts in Global Shop. Once the link is established, it will remain. Therefore, each part will only need to be linked once. However, as there are thousands of parts that require linking, the process can be time-consuming. To address this, we suggest employing interns to carry out this task, as it is simple to execute and does not require technical expertise. Once implemented, automating the tagging system will decrease defects and increase the efficiency of Sjogren's production process.

Conclusions, Recommendations, and Reflections

Conclusions

In conclusion, our project aimed to identify and improve process inefficiencies at Sjogren Industries by following a structured 5 step process using a lean improvement approach. Through the creation of a value stream map, discussions with employees in various departments, and the use of a prioritization matrix, we were able to identify opportunities for improvement and prioritize among them to develop solutions to address them. We developed an automated tagging format that will decrease defects and speed up production and we provided formulas and instructions on how to calculate lead time, reorder point, and safety stock for all raw materials. By implementing these solutions, we hope to enhance efficiency, reduce costs, and increase customer satisfaction. Our project provided a valuable opportunity for us as industrial engineering students to apply our knowledge and skills to a real-world situation. We are confident that the improvements we have suggested will have a significant impact on Sjogren Industries' operations and success in the future.

Recommendations

Based on the results of our project, we have several recommendations for improving our overall efficiency and productivity. First, we recommend that Sjogren implements the proposed tagging system. This will remove human error from the tagging codes and decrease the likelihood of a tag being placed on the wrong part. Additionally, we suggest implementing the findings from the second sub-project, which focused on updating reorder points for raw materials purchasing. As a first step, we recommend that Sjogren review historical data on lead times, so safety stock can be included in calculations. By understanding the lead times, Sjogren can better plan our production and procurement schedules to avoid potential bottlenecks and delays.

Overall, we believe that implementing these recommendations will help Sjogren to streamline our operations and achieve greater success in the long term.

Reflections

While the main topic of our project was to improve processes at Sjogren Industries, the goals of a Major Qualifying Project go beyond the project. We were tasked with creating an engineering design process while working efficiently and effectively as a team. This section of the report outlines our reflections on what we learned throughout this project.

Design Process

In this project, using a design process, we were able to create a process improvement approach that Sjogren can use in the future to assure process competitiveness. The scope of our project was very broad, and with this, we were able to choose what we wanted to pursue. We wanted to choose subprojects that would be of value to Sjogren Industries, so we started our design process by gathering background about the processes at Sjogren. Then, we gathered background on where employees of each department believed the most opportunity for improvement was present. After deciding on subprojects, we started to brainstorm solutions and started the process of creating solutions. Then, after the solutions were created, we added recommendations on how to hand off our project to Sjogren and have them implement our project in their processes.

Constraints in Design

When completing a project, there are often a variety of constraints that can impact the process and outcomes. One constraint we encountered was limited access to certain resources or information, such as the case of not having access to a company's servers or data. A major constraint that we faced is that we were not able to access to Global Shop. As non-employees, we simply were not allowed to access certain data or systems for security reasons. This limitation can significantly impact the project's scope and objectives, requiring alternative approaches to achieve the desired outcome. For example, we had to use theorical data in our recommendations. This also made it difficult to fully understand the data available in Global Shop. It also put a greater emphasis on data analysis and interpretation based on available information, rather than relying on direct access to data sources.

Another constraint that we had to be considerate of was that we sought to develop solutions that the employees at Sjogren can find useful. Thus, we had to run our ideas by multiple employees and get approval before we began working.

Another constraint is time, we were given twenty-one weeks to complete our entire project. During this time, we were still working as full-time students so we could only focus 1/3 of our efforts on our project.

Acquiring and Applying New Knowledge

Throughout the project, we learned more about real-world applications than we normally do during coursework. One of the moments where we realized this was when we presented our subproject ideas to some employees at Sjogren. Typically, when we present during class, it is to professors who assign us research topics where the professor knows less than the student about the project. But, when we presented our subproject ideas to the employees at Sjogren, we knew that each employee knew more about our subprojects than we did. Thus, we had to switch our typical presentation style of trying to show off everything we know and change to being more curious. This is something we believe will carry onto real-world applications once we graduate college and have a job.

Teamwork

As a team, we have different strengths, weaknesses, experiences, and goals. Working on a long-term project required us to be more communicative, direct, and understanding of each other. Both Michael and Gabriel took on leadership roles in their respects. Michael was the leader in the tagging subproject while Gabriel took leadership of the lead time subproject. Although each project was discussed separately from the other, this does not mean that one student worked on each subproject independently. Both Michael and Gabriel provided helpful insights into each subproject and displayed individual talents.

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