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Sobczyk, Kristine S. ***Understanding Inventory Movements Using an Enterprise Resource Planning Software System***

Abstract

Manufacturing any product requires accurate inventory to maintain on-time delivery and accurate financial records. Understanding the movements of inventory as products are produced is a key step in accuracy. Using an ERP software system creates efficiency if it is used properly and understood. This study will analyze inventory movements of Company XYZ using their ERP software system.

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To my husband Todd who has always shown me I am better than I think I am. To my children Owen and Emma for sacrificing a little mommy time so I could get my degree. To my sister Karen for showing me that nothing is impossible, my past does not own me, and I am more than what was expected. And to Carol, for seeing something in me before I even knew it was there. You are all an inspiration and a part of my success. Thank you for always believing in me.

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Chapter I: Introduction

Company XYZ, whose name has been withheld to protect confidentiality, is one of five wheel and tire manufacturers, part of a large international organization based in Europe. Of the five manufacturers, Company XYZ is one of three that manufactures polyurethane wheels, tires, snowplow blades and spinners, and custom polyurethane products. Company XYZ provides wheel and tire solutions for forklifts and other material handling equipment including: automated guided vehicles (AGVs) and equipment, logistics and transportation services, and storage and organization systems. Company XYZ's goal is developing into a one-stop-shop for original equipment manufacturers (OEMs) and aftermarket dealers by providing wheels, tires, and value-added services such as pressing of hubs, pressing of bearings, and pad printing of customer specified artwork.

For the last eight years, Company XYZ has worked with an enterprise resource planning (ERP) software system, IFS AB (IFS). This system is utilized in the sales, accounting, purchasing, scheduling, and maintenance departments. IFS is the ERP software used in all five of the internationally held companies, making intercompany transfers and orders easier. IFS is maintained at the corporate headquarters in Europe, which can create difficulties in support and training. In 2018, Company XYZ invested in a full-time information technology employee to learn IFS. Having an individual on-site eliminated time zone differences when dealing with corporate, and ERP issues were solved more efficiently. Identification and elimination of processing errors or system issues is an important part to understanding the inventory movements within the ERP software system.

At the strategic planning review meeting in 2017, Company XYZ focused on 100% on-time delivery. Since that time, the company has struggled to maintain percentages above 90%

due to inventory variances. In an effort to improve on-time delivery percentages, cycle count programs and physical inventories were implemented in 2017. However, a review of the data suggested the problem seemed to be worse. In 2017, Company XYZ ended the year 72% on-time with customer orders and wrote off $125,000 of product inventory. Given that physical inventory was completed two days before the end of 2017, Company XYZ decided to move the date of physical inventory to the beginning of December in 2018 to allow more time to verify counts. Cycle count processes were also changed in 2018, only being done in the trim and metal preparation departments as these were where most inventory discrepancies occurred throughout the year. However, in 2018, December on-time delivery was lower than 2017 at 66%. Product inventory adjustments remained somewhat stable compared to 2017, but there were still $30,000 in adjustments. Both years, as the production plan was developed for the upcoming week, the ERP software showed the material on hand, yet when the warehouse attempted to pull the material to make parts, the material did not exist. Per the strategic plan, one of Company XYZ's goals is to be a just-in-time delivery corporation, however not having the inventory on hand when needed is prohibiting the company from achieving this goal.

Given how 2017 and 2018 ended, senior management developed a continuous improvement team to review inventory transactions on a weekly basis. The team focused on understanding how IFS works and identifying patterns regarding inventory discrepancies. Each meeting showed inventory gains or losses exceeding $5,000 per week. In an effort to understand these fluctuations, one of the action items was obtaining help from corporate office. Corporate helped IT and the team identify how IFS reported material being used. The team also reviewed what departments were reporting material usage and the incoming receiving procedures to identify areas where material counts may be incorrect. In 2018, even though inventory movements remained stable compared to 2017, on-time delivery still suffered, ending the year below 90%. With an on-time delivery goal of 100%, work still needed to be completed.

Statement of the Problem

Inventory transactions at Company XYZ were reviewed on a weekly basis with gains or losses exceeding $5,000 per week. The ERP software showed stock available to ship, but the stock did not exist. The inventory transactions were the result of the missing inventory which prevents the company from shipping 100% on-time.

Purpose of the Study

The purpose of this study was to identify the direct and indirect causes for incorrect material in the ERP software, IFS, used at Company XYZ. With the help of the production staff and supervisors, Company XYZ completed two important objectives listed below.

The first objective was to follow raw materials through each stage of manufacturing and track how IFS reported the usage of those materials. Since Company XYZ produces 24 hours a day, the first step of this objective was a process review with all employees. This review identified areas of concern that could lead to inventory discrepancies, and identified potential areas for improvement in the process.

With the process review complete, the team looked at how IFS was reporting usage. As materials were pulled and reported, data was collected from IFS and inventory counts were completed and compared to system counts. This added additional areas of concern that could lead to inventory discrepancies.

Finally, the team completed objective two by reviewing all cycle count transactions. These were the transactions that had been completed prior to the team being established. The goal was to identify patterns that may suggest a process related issue or a bill of material structure issue. The review identified which materials were reported incorrectly.

Assumptions of the Study

The process for this study followed the standard operating procedures developed by Company XYZ. No capital investment was made, and resources used were plant workers performing their normal daily duties.

Definition of Terms

The polyurethane industry has several terms that apply specifically to the industry. Company XYZ also has several terms that only apply to their facility and their production. Understanding these terms was critical to understanding the research that was completed.

Bond. A liquid material applied to metal which, when heated, allows the polyurethane to stick to the metal.

Cast room. The area in production where the polyurethane is poured onto the metals.

Clean room. A room which is dust free and climate controlled, so the bond is not compromised.

Degrease. A process where metals are dunked in a tank of liquid that helps pull any excess oil out of the metal.

Metal preparation. The department which pulls and prepares raw metals by washing and shot blasting.

Model. Paperwork created for the shop floor showing which parts need to be produced, the tooling necessary to make those parts, and the raw materials to be utilized.

Router. Paperwork given to the shop showing the bill of material (BOM), the tooling required, and a print of the product being produced.

Shot blast. Small metal beads that are blown at a metal to remove any rust or oil that may be on the surface.

Trim. CNC department where cast wheels are cut to finished size.

Limitations of the Study

This study was limited to resources available in the plant. Company XYZ is a small company, employing 55 people across three shifts. The team followed employees as they were working to gather data. The team used specific, high-value discrepant parts, which were manufactured on a weekly basis. This limited identification of issues on lower-value discrepant parts. The team concluded that the issues found on high value items would likely be the same on low value and therefore focused on the higher-demand parts. The implementation of solutions was limited to the approval of senior management at Company XYZ.

Methodology

The methodology used to complete this project followed the five phases of project management which are: initiating, planning, executing, controlling, and closing. The initiation phase began when senior management developed the continuous improvement team to review inventory transactions on a weekly basis. The team consisted of plant management, the scheduler, the chief financial officer, and the president. After the team was developed, a plan was put into place to identify areas that could be causing inventory issues. As the team reviewed transactions on a weekly basis, patterns of where inventory issues existed were created. The team went to each department identified as an issue and reviewed the standard operating procedure. During this review, the highest value inventory discrepancy parts were used. Most of the parts were high volume, but some were after-market, low volume parts. This gave a wide range of system and production issues that occurred in the process.

Once all the departments were reviewed, issues were broken down into two groups: ERP system issues and process or training related issues. The continuous improvement team was then broken into two group and each tackled one of the lists of issues.

The subcommittees developed new standard operating procedures that would change how data was being received in the ERP software system and new procedures that would affect how employees performed their daily tasks. The execution of these changes occurred first by a step-by-step training process with each employee that was affected across all three shifts. Training was provided and once each employee tested with 100% accuracy, the new procedures were released to the production floor. The continuous improvement team controlled the processes and inventory movements by monitoring each employee and ensuring the new processes were being followed. The team also monitored the inventory transactions to confirm on hand counts remained accurate.

The team closed the project with a quarterly meeting to review the procedures and inventory transactions of a select group of parts to confirm accuracy of inventory counts. In addition to the meeting, a review of product structures and inventory transactions during new process development was added. This step was to help eliminate any potential of future issues.

Summary

The focus of this project was to understand the inventory movements at Company XYZ within the ERP software system. Company XYZ developed a team to review transactions, identified where inventory issues existed, and evaluated where it could add reporting of raw materials for better tracking of inventory. Company XYZ also found places where human error could be reduced or eliminated, and areas where the ERP software created issues and could be corrected. The next chapter focuses on the history of polyurethane production and the history of

ERP software systems. Both offer an understanding of the problems that occurred when producing polyurethane wheels and tires.

Chapter II: Literature Review

Inventory transactions at Company XYZ were reviewed on a weekly basis with gains or losses exceeding $5,000 per week. The enterprise resource planning (ERP) software showed stock available to ship, but the stock did not exist. The inventory transactions were the result of the missing inventory which prevents the company from shipping 100% on-time. The review of literature includes a history of polyurethane and its multiple uses as well as a brief history and analysis of ERP software systems. The main objective was to provide a background of polyurethane and the basic production requirements to produce polyurethane. Additionally, a background of ERP software systems and the help provided by implementing an ERP software system was included.

Company XYZ is one of three polyurethane manufacturers of wheels and tires under its corporate umbrella. The brief history of polyurethane and the history of ERP software helped provide the potential solutions and corrective actions to eliminate inventory discrepancies, therefore helping improve on time delivery to 100%.

Polyurethane

To solve inventory issues found in producing polyurethane, it was important to understand the history of polyurethane. Polyurethane was discovered at the beginning of World War II (American Chemistry Council, n.d.). According to the American Chemistry Council, the invention of polyurethane was at a time when rubber was hard to find, and polyurethane was versatile enough to use as a replacement. By the end of the war, polyurethane was found to be useful in many industries, and, therefore was in full scale production. The chemistry was a result of Dr. Otto Bayer who invented the diisocyanate polyaddition process. Since then, the American Chemistry Council pointed out that polyurethane is found in virtually everything used today.

Polyurethane offers advantages when compared to other materials (PMA Industrial Solutions, 2018). The Polyurethane Manufacturers Association (PMA) pointed out that when comparing polyurethane to plastic, polyurethane has the following advantages:

- Tooling is 1/5th the cost
- Prototypes are created faster and more accurately
- Durability and wear resistance are greater

These advantages also applied to metal and rubber. According to the PMA, other advantages include: lighter weight, faster turnaround, better wear resistance, and higher load-bearing capacity.

End users and key markets. Due to polyurethane being so versatile, it appeared in most things used daily. It can be used for comfort and in heavy machinery. Some of the end uses for polyurethane can be found in items such as: furniture and bedding, thermal insulation, elastomers, footwear, straps, and coatings (Mark Tool & Rubber, 2017). Polyurethane is also found in manufacturing and warehousing in fork trucks, automated guided vehicles, and pallet jacks. In fact, due to the heavy loads and short distances being driven in a warehouse setting, polyurethane was a better choice than rubber (Estrada, 2017).

With polyurethane being offered in so many different areas, it was not surprising that the polyurethane markets continued to grow. Figure 1 shows that polyurethane use has continued to grow since 2010 and the trend is expected to continue (Grandview Research, 2016).

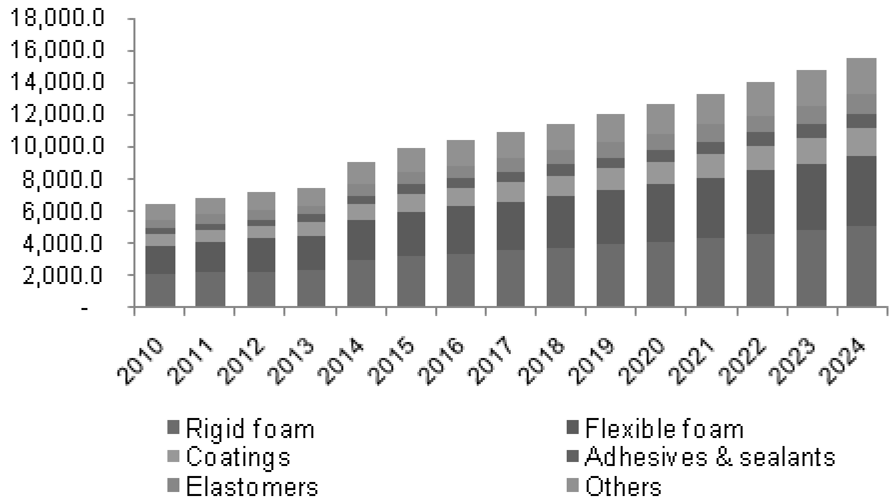


Figure 1. U.S. polyurethane (PU) market revenue by product, 2010 - 2024 (USD million).

The future of polyurethane. The Polyurethane Manufacturers Association (PMA) published a study in 2010 that showed optimism for the future of polyurethane (The Post-Recession State of the Cast Polyurethane Industry, 2010). The PMA highlighted a few key points for the manufacturers and suppliers:

- Cast polyurethane is gaining popularity from engineers and designers in new areas and applications.
- The versatile material is expanding into new markets, giving the potential for new opportunities.
- Suppliers and manufacturers are pushing the limits on polyurethanes. They are working hard to advance the physical limitations of the materials which will make products more durable and last longer.

The PMA encouraged its members to explore new opportunities to keep polyurethane on an upward growth cycle (The Post-Recession State of the Cast Polyurethane Industry, 2010). Advancement in industrial development was a contributing factor to the advancement of polyurethane. (Yanping, 2018). Yanping also mentioned that due to the advancements in polyurethane, growth has been seen at about 7% each year.

Methods of Polyurethane Production

"A variety of raw materials are used to produce polyurethanes. These include monomers, prepolymers, and stabilizers which protect the integrity of the polymer, and colorants," (Polyurethanes, n.d., para. 6). Polyurethanes can be produced in many different forms, depending on the end application. One method to polyurethane production is open-cast molding (Creating Polyurethane Products, n.d.). In this process, liquid polyurethane is poured into a mold which is then placed into an oven or on a heated table to cure. Open-cast uses isocyanates Methylene Diphenyl Diisocyanate (MDI) or Toluene diisocyanate (TDI) (Polyurethanes, n.d.). Either of these are combined with a diol, or curative, making the polyurethane hard. This is the diisocyanate polyaddition process that was invented by Dr. Otto Bayer during World War II (American Chemistry Council, n.d.). MDIs, TDIs, diol and colorants are in liquid form. This is one of the main reasons polyurethane is so versatile; the liquidity allows the polyurethane to take on many different shapes (Drewett, Christopher, & Wimberly, n.d.).

Before production of polyurethane can begin, the MDI or TDI must be melted for use in pouring (Clemitson, 2017). The most common, approved method to melt material is a steam or hot-air environment. Clemitson points out that the requirements are to first make sure the drums are free from dents. Any drums that were previously used need to be flushed with nitrogen gas and all bungs are closed tightly. If the drum is being rolled to mix the material, speeds of 5 rpm or less are suggested. To melt the material, use steam or hot air with a typical time to reach the desired temp of 70 degrees C being 4 to 5 hours. Temperature must be monitored throughout the pouring process. If the temperature rises too quickly, the polyol addition must be slowed down or stopped (Clemitson, 2017).

Following the production of polyurethane, storage of the raw materials is critical to health and safety of employees. The American Chemistry Council suggests the following guidelines for storage (Polyol Resin Blends, 2013). Practice good housekeeping, storing material in an enclosed, well-ventilated area. Segregate containers that are not compatible with polyols and provide secondary containment. Store the material using the temperatures suggested by the supplier of the raw material.

Maintaining proper inventory of liquid inventory can be extremely difficult. Understanding the process of pouring polyurethane is the first step in the process. Monitoring and sustaining correct inventory levels requires the proper software system.

Software Used in Manufacturing

Enterprise Resource Planning (ERP) software systems are systems that allows businesses to encompass modules to support many functions of the company (Rashid, Hossain, & Patrick, 2002). The software was designed to allow information to flow in a consistent manner, generally in real time. A primary misconception many organizations must overcome is that reporting, and data will improve overnight with the use of ERP systems. The improvement of reporting and data is dependent on the system chosen for the corporation, the accuracy of the data put into the system, and the accuracy of reporting throughout the process.

ERP reporting methods. Within the ERP system is a Material Resourcing Planning (MRP) module (MRP and ERP: It's all Relative, 2017). MRP is specifically designed to plan resources used in manufacturing from the sales order to the purchasing of raw materials. The first system was created in 1964 by Black and Decker and has been adopted into thousands of manufacturers over the last 25 years (MRP and ERP: It's all Relative, 2017). With MRP integrated into an ERP software system, correct material in the correct quantities are available for production. This reduces waste, and allows proper planning and scheduling in manufacturing, shipping, and purchasing. Data integrity reduces cash flow and increases profitability. With the use of MRP within the ERP software program, managing liquid inventory can be more accurate if the systems are integrated correctly from the beginning (MRP and ERP: It's all Relative, 2017).

Lean Solutions for the Management of Materials

A lean organization is one that creates value streams comprising all departments to become closer to the customers with a quicker response (The Lean Toolbox, 2016). As with any corporation, the goal is to provide value to the end user, with no waste. The Lean Enterprise Institute stated that eliminating waste along value streams, rather than specific areas, will create processes that eliminate the eight wastes. Figure 2 shows the eight wastes.

Table 1: Lean Enterprise Eight Types of Waste

	Waste	Description
1.	Overproduction	Products being produced in excess quantity and being made before the customer needs them.
2.	Waiting	Periods of inactivity in a downstream process that occurs because an upstream activity does not produce or deliver on time.
3.	Transportation handling	Unnecessary movement of materials or double handling.
4.	Overprocessing	Spending more time than necessary to produce the product or service.
5.	Unnecessary inventory	Any excess inventory that is not directly required for the current customer's order.
6.	Unnecessary motion	Extra steps taken by employees and equipment to accommodate inefficient process layouts.
7.	Defects	Errors produced during a service transaction or while developing a product.
8.	Intellect	Inefficient use of resources based on job level, skill, knowledge, and experience.

Figure 2. Lean waste. (Duffy, G.L, & Wong, A.K., 2016)

Of the eight wastes, unnecessary inventory, which was once considered an asset in a traditional manufacturing environment, is considered a waste in a lean environment (Giarrizzo, M., J.R., 2016). Unnecessary inventory ties up both cash flow and capital and prohibiting the company from making investments into the future. Managing the flow of materials reduces the waste and, in turn, opens the cash flow for capital investments. Another waste shown in Figure 2 is overproduction. If the ERP software system shows an understated inventory value, then overproduction can occur. Each piece of inventory held has a physical cost to it and can be the difference between inventory or something else needed for your business (Giarrizzo, M., J.R., 2016)

The cost of materials within a manufacturing company make up a large portion of the selling cost of the product (Giarrizzo, M., J.R., 2016). The timing between purchasing materials and shipping product out to a customer varies, but in most organizations, this timing ties up cash flow. Lean manufacturing sets out to reduce the amount of inventory held on hand without affecting delivery of product to the customer.

Physical inventory and cycle counting. An effective solution to ensuring accurate inventory would be using physical inventory or creating a cycle count program. Accuracy in the inventory count is important to any corporation (Slater, P., 2013). Without accurate inventory, a company can encounter stock outs when inventory is believed to be on hand. Excess inventory can also be ordered due to understated inventory. The implications can be significant: wasted money, downtime, expedite costs, and inefficient labor.

Physical inventory is an actual count, weight, volume, or measure of items in inventory (Lannon, Amber, 2012). Physical inventory counts everything in stock and requires quite a bit of time and resources. Skipping any of the following steps can affect the accuracy of physical inventory (Bragg, S., 2005). Physical inventory first requires an inventory tracking software system. This system should be implemented and tested for accuracy prior to physical inventory. Once the system is verified, warehouse locations should be established in the system and the warehouse locked down. Consolidation of like parts will help reduce the labor needed to complete inventory and ensure all like inventory is located in similar warehouse locations. Once all the units of measure have been verified and the parts are packed in the appropriate containers, counting can start. Following the count, data is entered into the tracking software system and any errors that are found should be verified by the counting team. Once all verifications are complete, the data can be posted.

Unlike physical inventory, cycle counting is a sampling (Brooks & Wilson, 2007). Cycle counting has been found to yield more accurate results without the high costs that come with physical inventory. All the techniques for cycle counting are the same, however, the type of cycle counting can vary from company to company.

Control group cycle counting is used for proving the design of the inventory process. This process is the only one not used to measure inventory accuracy (Brooks & Wilson, 2007). The process entails counting the exact same inventory in the same place within a short period of time. Any flaws that exist should be found with this process. The five-step process to control group cycle counting is: Identify the control group, count carefully, set inventory counts to the physical count, re-count the same group within one week, and compare the counts to the updated inventory records.

Random sample cycle counting selects the parts to be counted from the population at random (Brooks & Wilson, 2007). This gives every part number equal opportunity to be counted. Random sample cycle counting is generally accepted as the best inventory record for accuracy so long as the samples have stability and are sufficiently large.

ABC cycle counting puts a bias on samples to reflect money invested in inventory (Brooks & Wilson, 2007). The method is designed to count stockroom parts each year, putting a bias on those that generate the greatest amount of annual expenditure. The first step is developing the ABC cost classifications. Following classification, the company needs to determine how many people will be required to complete the cycle count for each category, A, B, and C. The more part numbers the company has, the more people will be required to complete the cycle counts.

The final cycle counting approach is process control cycle counting (Brooks & Wilson, 2007). This process was developed to overcome the flaws found in ABC cycle counting, too many parts requiring too many people, and the bias towards parts with the most amount of expenditure. In process control cycle counting, once the supervisor assigns counters to specific areas, it is up to the counter to decide what to count. Parts to be considered would be low in count inventory or parts that are packaged in an easy to count way. This speeds up the process of counting but does come with flaws. The counter is being given the discretion of what is too difficult to count, and it could be argued that this process could skew the counts being given.

Cycle counting evolved as an alternative method to a full-scale physical inventory (Graff, 1987). The annual physical inventory is required for accounting practices, however, concern for the physical piece count also needs to be considered. Determination of which is used at a company is at the discretion of the corporation and their accounting department.

Summary

This chapter presented a brief overview of the production process of polyurethane and the inventory management of raw materials. The literature reviewed gave a history of polyurethane, and the key markets and end users that consume polyurethane every day. Polyurethane has a strong economic future. The literature also reviewed ERP and MRP software systems and how they can be useful to an organization trying to organize data and inventory. Physical inventories and cycle counting are two methods that can help identify issues in the inventory chain. Both are types of inventory control and key to maintaining accurate records. In turn, inventory control and accurate records enable ERP and MRP software systems to work efficiently. Finally, this chapter reviewed the theory and practice of lean wastes and how, when implemented, waste reduction is cost effective and efficient. All the literature reviewed helps to identify areas where inventory issues could be occurring.

Chapter III: Methodology

Inventory transactions at Company XYZ were reviewed on a weekly basis with gains or losses exceeding $5,000 per week. The enterprise resource planning (ERP) software showed stock available to ship, but the stock did not exist. The inventory transactions were the result of the missing inventory which prevents the company from shipping 100% on-time.

The objective of this chapter was to analyze the procedures for collecting inventory data and how it was reported in the ERP system from all departments at Company XYZ. The methods used in this study showed reduced inventory discrepancies on the analyzed parts. This chapter focused on current procedures used at Company XYZ, data collection procedures, analysis methods, and limitations of the study.

Analysis of Current State

Company XYZ produced over 600 active parts annually. Not all 600 parts had inventory transaction issues. When deciding which parts to focus on, the team decided to concentrate on parts that were consistently changing due to inventory discrepancies. The parts were either high volume, being produced and shipped weekly, or low volume aftermarket parts shipped only a few times a year.

The objective of this study was to follow inventory through every stage of the production floor and verify inventory counts at the completion of each procedure. The process, therefore, began in the receiving department. When a truck arrived with raw product, the raw product was offloaded until the lead supervisor in the metal preparation department could check it in. The check-in procedure involved comparing the part number on the packing list with the contents in the box ensuring they match. There were no counts completed; the supervisor went off what the packing list says. An inventory sheet, shown in Figure 3 was stapled to the box to keep track of inventory, and then the parts were moved to the warehouse to be stored.

QS form #10 Rev 3, 4/19/11

Inventory Form

Date			
Part #			
Quantity		Received by	

Inventory Control

Date	PARTS IN	PARTS OUT	Operator's Initials	Balance

Figure 3. Inventory control form.

Castings were stored with castings, and base bands were stored with base bands. There were no inventory locations set up at the time of this study.

Once in the warehouse, the parts were stored until a model was released to the floor for production. The scheduler brought a model, shown in Figure 4, to the production floor.

Compound: 34161196 Model: 190204B Cycle Time: 23

Supervisor Copy

ITEM DESCRIPTION	INSERT DESCRIPTION	BA qty	LO qty	SL qty	CA qty	V# qty	TOOL QUANTITY	START CYCLE	RUN QUANTITY
9632- UT 2.50 x 1.72 x 1.574 x .472 95A BROWN	34240076	BA 9	LO 37	SL 8	CA 8		8	1	72

Figure 4. Model.

The employee in the metal preparation department staged the model for degrease. Staging material required that the employee pull the castings or bands shown under insert description, off the shelf. The quantity of parts shown in the run quantity were transferred to a degrease basket. The model called for 72 castings, so the production employee pulled and counted 72 individual castings. The employee documented the amount of parts taken on the Inventory Control Form and returned the box to the warehouse. The parts that were pulled and counted were then degreased and moved to a clean room where they remained until they were pulled to be bonded.

The bonding employees took the parts from the clean room to apply a coat of primer and bond. Once the parts were bonded, they were put on a cart and wheeled into a different clean room to dry. The parts remained in this clean room until the cast room staged the model to pour. The cart was pulled from the clean room two hours prior to pouring. This allowed the parts to be put into an oven to heat up. There was no verification of counts during bonding or when the parts were put into the oven in the cast room.

Once the parts were poured, the cast room employee noted the quantity poured on a production report. At the end of the shift, the production team lead verified the count the cast room employee was reporting. If the counts matched, the team lead signed the production report shown in Figure 5.

PRODUCTION REPORT

SAMPLE PARTS MADE ______ ______

MODEL 180828P

FORMULA 1548-98

OPERATOR ______

DATE ______ **SHIFT** ______

CONVEYOR 5

SHOP ORDER	PART NUMBER	DESCRIPTION	TOTAL QUANTITY INCLUDING SCRAP	SCRAP
379578		UT 4.00 X 2.00 X 2.047 X .590 95A CONTROL ORANGE (DNPP)		
379579		UT 2.50 X 2.06 X 1.189 THRU 95A CONTROL ORANGE (DNPP)		

Figure 5. Production report.

The parts were transferred from the cast room to the post cure oven for sixteen hours. After post cure, the trim team lead emptied the oven and verified the counts reported on the production sheet. If there were any discrepancies, the counts were given to the materials manager to investigate. Once the counts were corrected, the parts were shelved until needed for a customer order.

When a customer order came in, the materials manager scheduled the product to be trimmed. A shop router, shown in Figure 6, was produced and given to the trim department.

Shop Order No	Release No	Sequence No	Part No	QTY
418632	*	*	0632-	168

Customer	Customer No	Tool Id	Material	Part Description
			9632-	5.00 x 3.63 x 2.441 x .667

Operation No	Work Center No	Next / Prev	Operation ID
40	903		1522772

TRIM

Op Start Date/Time: 2019-02-19 18:23

Op Finish Date/Time: 2019-02-19 23:59

Operation Materials

Part No	Part	Qty Required	Unit Meas
9632-	5.00 x 3.63 x 2.441 x .667	168.00	pcs

Labor Class	Labor Class Desc	Crew Size	Machine Run Factor
		.5	30

Part characteristics
STUS Cast Op Characteristic 61192
STUS Trim Op Characteristic 5

Op notes

Figure 6. Shop router.

The product listed in the operation materials was pulled from the shelf and trimmed. After trimming, the part number and date code were stamped on the part. The stamper counted the parts as they were loaded into the box, verifying how many additional parts were needed to be trimmed. Once all parts were trimmed, the parts and router were given to the trim supervisor. The supervisor verified the count and details from the print and initialed the router if everything was correct. The parts were moved to shipping to be wrapped and shipped. No additional counts were done before shipment.

Data Collection Procedures

Inventory count transactions were pulled from IFS to identify parts with discrepancies during the previous week. The transactions that were searched were count in or count out transactions. An example of this type of transaction is shown in Figure 7.

Created	Transaction Time	Transaction Code	System Event Description	Transaction Qty	On Hand Qty After Transaction
12/7/2018	12:58:36 PM	COUNT-IN	Positive Counting Difference	662	552

Figure 7. Inventory count transaction.

These parts were flagged to follow the process from receipt of raw materials through the next shipment. Since the products produced go through multiple departments, an inventory sheet shown in Table 1 was used to track the parts through the plant. After each stage of production, a cycle count of the product in that area was completed. The operations manager then verified the total quantity on hand as shown in IFS. The data was collected in real time.

Table 1

Example of Inventory Count Analysis

	Quantity on Hand						
Product Number	Receiving	Metal Preparation	Bond	Cast Room	Trim	Total	Qty Shown in IFS
xxx-xxxx	0	0	0	0	0	0	0
xxx-xxxx	0	0	0	0	0	0	0
xxx-xxxx	0	0	0	0	0	0	0
xxx-xxxx	0	0	0	0	0	0	0
xxx-xxxx	0	0	0	0	0	0	0

Analysis Methods

Each week, the continuous improvement team met and reviewed inventory transactions on the documented parts from the previous week. The data collected from the inventory count analysis was compared to the transactions in IFS. The team first reviewed transactions for data entry errors. By comparing the cycle counts from the inventory count analysis and the physical transaction that occurred in IFS, the team identified that data entry errors included, but were not limited to sales entering the wrong part, receiving the incorrect amount on a shop order or billing the incorrect line item.

The team gave the list of parts to the engineering group who reviewed the bill of materials and how the structure of the part was set up in IFS. The engineering team verified the correct raw materials, in the correct quantities were listed in the bill of material and the correct raw materials and part number information showed up on the shop floor router.

Once these steps were completed, the team met with employees from each department and reviewed the reporting methods. This step verified the correct procedure was being used, and verified all employees understood the procedure and followed it the same way. This step also identified areas where the procedure was not clear and needed to be revised.

Finally, the team reviewed each reporting area. This included metal preparation, the cast room, trim, and shipping. The team analyzed which areas were reporting counts, and areas where counts were redundant. The findings for each discrepancy were grouped by department. This information was recorded into a spreadsheet, shown in Table 2. This gave the team a clear picture of all the problems, that resulted in solutions to the direct and indirect causes for incorrect material in the ERP software.

Table 2

Example of Problem/Solution Spreadsheet

Department	Problem	Solution
Warehouse	Wrong counts received from the vendor and not reported to purchasing	Verify the count upon receipt and notify purchasing of any discrepancy before warehousing the product

Limitations

Some of the parts being reviewed were low volume and the entire production process could not be followed. At the time of the customer order, these parts had already been produced in the cast room and were in the trim department. In these cases, a review of raw material receipts, metal preparation, bond, and cast could not be completed, but the team did a complete review of the transactions that were completed from these departments.

Summary

This Chapter showed the process used at Company XYZ to move parts through production. Data was collected in real time as product moved through the production process. Analysis methods used by the continuous improvement team were also shown in this study. The limitations of the study did not prohibit the team from completing their research.

Chapter IV displays the data collected during this study, as well as solutions for the problems identified in this chapter. The next chapter will also show the additional areas that need data collection, and other areas that were found needing improvement.

Chapter IV: Results

Inventory transactions at Company XYZ were reviewed on a weekly basis with gains or losses exceeding $5,000 per week. The enterprise resource planning (ERP) software showed stock available to ship, but the stock did not exist. The inventory transactions were the result of the missing inventory which prevents the company from shipping 100% on-time.

The objective of this chapter was to review analyzed inventory data and how inventory was reported in the ERP system from all departments at Company XYZ. The methods used in this study showed reduced inventory discrepancies on the analyzed parts. This chapter focused on current procedures used at Company XYZ, data collection procedures, analysis methods, and limitations of the study.

Analysis of Current State

Company XYZ produced over 600 active parts annually. Not all 600 parts had inventory transaction issues. When deciding which parts to focus on, the team decided to concentrate on parts that were consistently changing due to inventory discrepancies. The parts were either high volume, being produced and shipped weekly, or low volume aftermarket parts shipped only a few times a year.

The team began in the receiving department reviewing incoming raw materials. During the review of this process, the team recognized that the only member that was trained to put material away was the lead supervisor in the metal preparation department. While the procedure was not difficult, it was clear the company needed more than one individual to know and understand the process. The team also recognized there was not a physical count of the parts being completed. The company relied solely on the packing slip received from the supplier. Even if the only verification was weight counting product, this procedure needed to be changed.

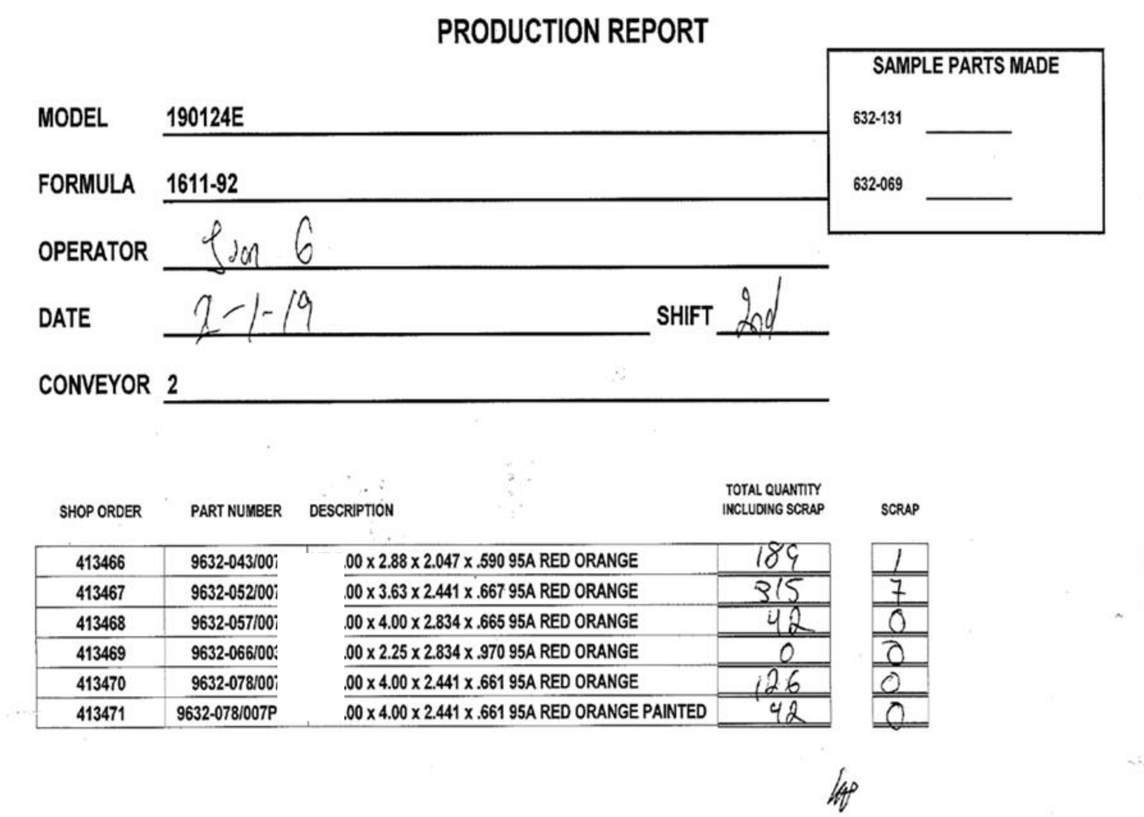
Finally, the team found that the material was not received in IFS immediately upon receipt and warehousing. There was a delay of one to two days in receiving product, because the product was being entered by the purchasing agent, not the lead supervisor in the metal preparation department. The delay happened when packing lists were not brought to the purchasing agent in a timely manner. The team recommended a computer be installed in the warehouse for real time receiving data. With a computer, barcode labels would be printed from IFS as soon as product was received. This eliminated the manual writing of tags and the potential for writing the wrong part number or quantity. The team created an example of what the barcode label should look like, shown in Figure 8.

Date	*12/21/2018*	Quantity Received	*168*
Part Number	*34532052*		

Figure 8. Example of inventory barcode label.

The team moved to the metal preparation department. After a model was released to the floor, the team documented that without a computer in the warehouse, real time data was not being used to pull parts out of the system for processing. When the scheduler created the model, the system showed parts on hand, but the parts had already been allocated to another model. This also created a problem for the buyer who showed inventory on hand. Without real time data, there was a lag in when the system would create a requisition to order more product. The employee pulling the material had no physical location to easily find the parts, therefore creating a longer time to pull parts because the employee had to find them first. The team recommended a computer for the warehouse, so locations could be added. This also allowed parts that were staged for a model to be immediately pulled from the system driving demand quicker.

Once the parts were poured, the employee was manually writing the quantities on the production report shown in Figure 9.



PRODUCTION REPORT

MODEL 190124E

FORMULA 1611-92

OPERATOR [illegible]

DATE 2-1-19 SHIFT 2nd

CONVEYOR 2

SAMPLE PARTS MADE

632-131 ______

632-069 ______

SHOP ORDER	PART NUMBER	DESCRIPTION	TOTAL QUANTITY INCLUDING SCRAP	SCRAP
413466	9632-043/00	.00 x 2.88 x 2.047 x .590 95A RED ORANGE	189	1
413467	9632-052/00	.00 x 3.63 x 2.441 x .667 95A RED ORANGE	315	7
413468	9632-057/00	.00 x 4.00 x 2.834 x .665 95A RED ORANGE	42	0
413469	9632-066/00	.00 x 2.25 x 2.834 x .970 95A RED ORANGE	0	0
413470	9632-078/00	.00 x 4.00 x 2.441 x .661 95A RED ORANGE	126	0
413471	9632-078/007P	.00 x 4.00 x 2.441 x .661 95A RED ORANGE PAINTED	42	0

Figure 9. Completed production report.

The team observed room for human error and wrong inventory counts entered on the wrong lines. A shop router was also being generated for the cast room as part of the model, giving Company XYZ two options to reduce human error. The first option was to have a computer in the cast room to sign into the job and enter produced parts in real time. The second, and more advanced option was to get a barcode scanner which would scan the employee into the job and quantities would be entered as they were produced. Either solution would show data in real time, rather than waiting to pull the parts from post cure before production was entered.

Once the parts were in trim, and a customer order was received, trim received the shop order to produce finished goods. Trim did not have a computer at the stations to report trimmed parts, rather the entry lagged anywhere between a few hours or a few days. The team recommended computers at each station to sign into the job they were trimming and enter the parts produced. Trim could also use barcode scanners for real time data entry.

Data Collection Procedures

The team used the inventory count transactions compiled weekly and shown in Figure 10 to identify which parts they were reviewing process for.

Part No	Part Description	Counted Qty	On Hand Qty	UOM	Difference	Unit Cost	Amount	Confirmation Date/Time
34532052	CASTING 632-052	87	(36)	pcs	123	11.38	1,399.74	1/7/2019 9:54
34202000	MACHINED HUB	5	14	pcs	(9)	14.08	-126.72	1/7/2019 15:16
34202559	06.00 X 10.50 I.D.	60	8	pcs	52	28.83	1,499.16	1/9/2019 9:57
9632-	UT 632-	931	945	pcs	(14)	18.07	-252.98	1/10/2019 14:57
34100048	POLYURETHANE	-	2,203	lb	(2,203)	2.45	-5,398.00	1/11/2019 8:53
							-2,878.80	

Figure 10. Inventory count transactions.

The team followed the process on the parts listed on the report from warehouse to shipping using Table 1, shown in Chapter 3. Many part numbers were reviewed, with some results shown in Table 3.

Table 3

Inventory Count Analysis

	Quantity on Hand						
Product Number	Receiving	Metal Preparation	Bond	Cast Room	Trim	Total	Qty Shown in IFS
34532052	2100	1502	0	0	0	3602	3593
34202000	0	0	180	0	0	180	183
34202559	252	150	35	100	0	537	549
632-	0	0	0	240	3200	3440	3502
34100048	38000	0	0	500	0	38500	42543

Analysis Methods

The parts shown above were ones that continuously showed up on the inventory count transaction reports. Material was consistently counted in or out on a weekly basis. The team reviewed the transactions for each part to identify any data entry errors. None of the parts listed above had data entry errors.

The team then had engineering review the items shown and they found an issue when reviewing part number 34100048. This product is a liquid raw material and was consistently showing more inventory on hand than what was in inventory. Upon further investigation, engineering found that a few of the structures were not calling out the proper weights of material used in pouring. The structure called for a specific amount of material to pour, but less was used. Not only did this cause issues in inventory, but it also had the potential to burn up material which may have been in the oven too long. The structures were corrected, and the part number continued to be monitored for inventory issues.

After the engineering review, the team met with members of each department to review reporting methods. When the team asked about part number 34532052, it was discovered that more parts were on hand than what inventory showed because parts that had been considered scrap were burned off and the castings reused for new orders. However, there was no procedure to enter burned off castings back in the system. While the company could reuse the parts, only claiming the polyurethane as scrap, the castings never made their way back into the ERP system to show as usable inventory. Purchase requisitions would also be generated earlier than needed because inventory was not shown on hand. After the inventory transaction had been completed, new material had already arrived and therefore inflated the amount of inventory in the building.

Lack of procedure was also the issue in the case of 34202000 and 632- , both showing more on hand in IFS than what was found in the departments. The team located these parts in trim, but they needed to be fixed. There is no inventory location for parts requiring fixing, and no way to identify them as unusable until fixed in IFS. Therefore, the parts are considered inventory which is not true until they are fixed. Parts are shown on hand, which will eliminate demand for the scheduler. Therefore, when the trim department attempted to make an order, they were short the amount of parts needed because the parts are not in location.

Finally, in the case of the 34202559, lack of procedure for cutting bands was found to be the issue. The team discussed the process of pulling parts for a model with the warehouse and it was found if a band is not in stock, the warehouse will have a similar size cut down to the proper height, but no procedure exists to take the band that was cut down out of inventory and enter in the correct part. This will over inflate the stock of the bands that were cut down and drive the bands that they were made negative.

The team discovered many other issues and created a problem solution spreadsheet. Issues consisted of technology issues, lack of procedures, lack of training, or incorrect counts moving from department to department. The complete list of problems can be found in Appendix A. The team moved from collecting data on the floor to finding solutions to the problems found in this spreadsheet. As solutions were implemented, the team continued to monitor the inventory count transaction report. The original problem Company XYZ had was gaining or losing more than $5,000 per week on inventory. As solutions were found, the team began to monitor the report as well as on-time delivery and past due line items. January 2019 started the year at 81.38% on time. With new solutions in place, by February that number had risen to 82.77%. On-time delivery increased, and the number of inventory adjustment transactions fell to an average of $1,195.32 per week between January and February 2019. Based on the early results, the objectives required to complete the study would be achieved within three months. The team reviewed the parts still being adjusted and found that over 90% of the parts are liquid raw materials. This gave the team a specific problem to focus on, while continuing to monitor all other materials.

Limitations

Some of the parts that had inventory transactions were low volume products, only being produced once or twice a year. These parts were on the shelf already in trim, and therefore a review of all the procedures could not be completed. The team reviewed the transactions in the system, as well as the production reports from the cast room. Even though the team was not able to follow the parts through every process, it did not prevent them from discovering problems which were added to the problem/solution spreadsheet.

Summary

This Chapter showed the results of the data collected while following the process of moving inventory at Company XYZ. Results of the study were based off the real time data collected and limitations of the study did not prohibit the team from completing the analysis.

Chapter V shows the recommendations and conclusions based on the data collected and analyzed. This chapter also showed justification for any capital expenditures that may be required as a result of this study.

Chapter V: Discussion, Conclusion and Recommendation

Inventory transactions at Company XYZ were reviewed on a weekly basis with gains or losses exceeding $5,000 per week. The enterprise resource planning (ERP) software showed stock available to ship, but the stock did not exist. The inventory transactions were the result of the missing inventory which prevents the company from shipping 100% on-time.

Chapter I detailed how Company XYZ has struggled for the last two years on inventory management. The chapter also gave background into the ERP software system used and how the lack of training and utilization of the system may have contributed to the problem. Company XYZ developed a continuous improvement team based on the objectives determined during the strategic planning meeting.

Chapter II gave the history of polyurethane and the many ways it can be produced. Dealing with liquid raw materials can make maintaining inventory difficult; however, Company XYZ had issues with all raw materials including castings, bands, and finished goods. The chapter transitioned into the history of ERP software systems and how the maintaining the data properly can have a lasting effect on inventory and its accuracy. Finally, Chapter II discussed lean wastes and where Company XYZ needed to focus in order to reduce these wastes.

Chapter III discussed the methodology of the study. The sample for the study was selected based on inventory adjustments done the previous week. The parts selected for the process were those that had appeared in multiple weeks of inventory adjustments. The full production process including receiving of raw material, warehousing, metal preparation, cast, trim, and shipping and were included in the study.

Chapter IV presented the results of the study. The results were not decisively related to one specific issue. The team was able to determine issues in reporting, engineering structures, lack of procedures, and human error.

Chapter V will discuss what should be done with the results of the study. The conclusions drawn will be outlined and recommendations on how to resolve the root causes will be addressed.

Limitations

This study was limited to resources available in the plant. Company XYZ is a small company, employing 55 people across three shifts. The team followed employees as they were working to gather data. The team used specific, high-value discrepant parts, which were manufactured on a weekly basis. This limited identification of issues on lower-value discrepant parts. The team concluded that the issues found on high value items would likely be the same on low value and therefore focused on the higher-demand parts. The implementation of solutions was limited to the approval of senior management at Company XYZ.

Conclusions

Manufacturing using liquid raw materials was shown to be difficult as inventory is never accurate when dealing with liquids. While the bill of materials shows a specific weight of product, waste and scrap can play a factor in accurate inventory. Company XYZ did not have a problem with only liquid materials though, all types of raw materials were found to be adjusted on a weekly basis. Some of the issues were easily found during the study, and others required the entire team to figure out why inventory was being adjusted.

Company XYZ also lacked in technology. Many of the reporting areas were without a computer to enable real time data; departments relied on paper that was updated once per day rather than as changes were made throughout the day. The lack of technology created a mindset that paperwork did not need to be handed in timely and this also contributed to the lack of real time data. The ERP software system required many updates to add more reporting areas, but the addition of computers in the warehouse would allow for product to be received as it was put away. The scheduler would have a better understanding of product available in the warehouse, and the buyer would reduce the buy as inventory would be more accurate.

Finally, mixed parts contributed to many of the inventory adjustments. This issue was visible in all department which led the team to conclude lack of training. With over 600 active parts, understanding which raw material is which required training and time. Some of the employees were new, and the lead in the departments were not monitoring how product was being staged, produced, or stored. This led to the mixed parts and the cycle counts adjusted stock accordingly. The leads in each department needed to spend more time verifying to reduce the number of times this situation occurred.

Recommendations

Reviewing the problem solution table, there are two main themes that stand out. Company XYZ lacks in technology, and there is also a lack of procedures or methods in IFS to track product. Company XYZ should address these two items first using the following recommendations.

Each area of the plant is lacking a computer to report materials being brought in or taken out to produce. This lack of real time data makes it hard to schedule because there is limited understanding of how much product is available. It shows a quantity of bands or castings, but if those are already produced and not reported, the scheduler will create another model and the warehouse will report not having the metals. A computer needs to be added to the warehouse where product can be received upon receipt. This will eliminate the delay of receipts and help the buyer understand what came in and what products need follow up with the vendor. Adding the computer to the warehouse will also allow Company XYZ to explore barcoding and setting up locations. This will create a more efficient workspace and effectively report real time data to the buyer and the scheduler.

A computer in the cast room will allow production to be reported as it is happening. Back flushing of raw materials will create real time demand and a list of products that may require expediting from the vendor. If the cast room is reporting production immediately, scrap produced can also be reported. The scheduler will have a better chance of knowing parts that will be short before the customer order is due. Parts can be rescheduled to be poured if this data is in real time.

Adding computers in trim will reduce the number of set ups since product can be scheduled by size and tooling. Understanding the work load at each cell will also allow the operations manager to determine if overtime is needed to get customer product out the door. This will increase on time delivery and make the cells more efficient.

The second problem that should be addressed immediately is the lack of procedures in certain areas. After producing a scrap piece, some of the metals can be burned off. There is currently not a procedure to put burned off material back in the system. Inventory is on the shelf, but no one is aware it is available for production. Company XYZ needs to create a process for this. There also needs to be a place in IFS to show these parts are being reworked. This is also the case in the trim department. Some products after being trimmed need rework on the bore or require rework to the polyurethane. These products are shown in work in process inventory and need to be segregated to be shown as rework. Segregating materials in separate locations reduces confusion for the metal preparation department and the scheduler.

The other procedure that needs to be created is sample runs. Currently, the engineering department creates a word document that states the tooling to be used, the raw materials to be used and how to pour the parts. However, because this is done outside of IFS, all the raw materials used are not back flushed and a sample pour could create a tooling conflict with another model being produced. A process within IFS should be found that would show the product as a sample run, but allow the cast room to report production, therefore back flushing material.

Company XYZ is a small company producing close to $20M of product each year. This is done with a staff of 55 shop employees and 15 administrative staff. With such a small head count, it is important for Company XYZ to work as efficiently as possible in all processes. Utilizing technology will increase efficiency and remove some of the human error factor, creating an increased confidence of the data in the system.

Improving the processes and procedures also has shown a reduced affect on inventory adjustments and a better understanding of what is moving through the shop. With the solutions already implemented, a reduction in the amount of inventory transactions has already been achieved and on time delivery has already begun to increase. If the improvements suggested above are implemented, the company will become even more efficient which will create additional capacity for new contracts.

References

American Chemistry Council. (n.d.). *Polyurethanes*. Retrieved from https://polyurethane.americanchemistry.com/History/

Bicheno, J., & Holweg, M. (2016). *The lean toolbox*. Buckingham: PICSIE Books.

Bragg, S. (2005). *Inventory accounting: A comprehensive guide*. Hoboken, N.J.: John Wiley & Sons, Incorporated.

Brooks, R., & Wilson, L. W. (2007). *Inventory record accuracy: Unleashing the power of cycle counting* (2nd ed.). Hoboken, N.J.: John Wiley & Sons.

Clemitson, I. R. (2017). *Castable Polyurethane Elastomers*: Boca Raton, FL, CRC PRESS.

Creating Polyurethane Products. (n.d.). Retrieved from http://www.precisionurethane.com/molded-urethane-products.html

Drewett, M. L., Christopher, C., & Wimberly, M. (n.d.). *Different methods of polyurethane molding and casting*. Retrieved from http://www.marineurethane.com/mu-polyurethane-info/polyurethane-molding/molding-and-casting

Duffy, G. L., & Wong, A. K. (2016). Complementary strengths. *The Journal for Quality and Participation, 39*(2), 20-22.

Estrada, D. (2017, February 2). *Forklift tires: What you need to know*. Retrieved from https://www.tmhnc.com/blog/forklift-tires-what-you-need-to-know

Giarrizzo, M. (2016). Create flow by eliminating waste. *Automotive Body Repair Network, 55*(6), 16-16,18,20. Retrieved from https://login.ezproxy.lib.uwstout.edu/login?url=https://search-proquest-com.ezproxy.lib.uwstout.edu/docview/1806551362?accountid=9255

Graff, R. T. (1987). The limitations of cycle counting. *Production and Inventory Management Journal, 28*(4), 39. Retrieved from https://login.ezproxy.lib.uwstout.edu/login?url=https://search-proquest-com.ezproxy.lib.uwstout.edu/docview/199917351?accountid=9255

Grandview Research (2016). *North America polyurethane (PU) market size report, 2024.* Retrieved from: https://www.grandviewresearch.com/industry-analysis/north-america-polyurethane-market.

Lannon, Amber. (2012). Business: The ultimate resource by Jonathan Law. *Journal of Business & Finance Librarianship. 17*. 359-361. 10.1080/08963568.2012.711965.

Mark Tool & Rubber. (2017, November 24). *The 6 most common uses of polyurethane*. Retrieved from https://www.marktool.com/the-6-most-common-uses-of-polyurethane/

MRP and ERP: It's all relative. (2017, January 8). Retrieved from https://www.processproerp.com/blog/mrp-and-erp-its-all-relative

Lannon, Amber. (2012). Business: The ultimate resource by Jonathan Law. *Journal of Business & Finance Librarianship.* 17. 359-361. 10.1080/08963568.2012.711965.

PMA: Industrial Applications. (2018). Retrieved from http://www.pmahome.org/main/polyurethane101/industrial-applications/

Polyol resin blends safety and handling guidelines. (2013, January). Retrieved from https://polyurethane.americanchemistry.com/Resources-and-Document-Library/3859.pdf

Polyurethane. (n.d.). Retrieved from http://www.madehow.com/Volume-6/Polyurethane.html

Rashid, M. A., Hossain, L., & Patrick, J. D. (2002). *The evolution of ERP systems: A historical perspective*. Idea Group Publishing. doi:https://faculty.biu.ac.il/~shnaidh/zooloo/nihul/evolution.pdf

Slater, P. (2013). Why inventory accuracy matters. *National Provisioner, 227*(8), 48-49. Retrieved from https://login.ezproxy.lib.uwstout.edu/login?url=https://search-proquest-com.ezproxy.lib.uwstout.edu/docview/1425423348?accountid=9255

The Post-Recession state of the cast polyurethane industry. (2010). Retrieved from http://www.pmahome.org/main/polyurethane101/state-of-polyurethane/

Yanping, Ye. (2018). The development of polyurethane. *Materials Science: Materials Review. 1.* 10.18063/msmr.v1i1.507.

Appendix A: Problem/Solution Spreadsheet

Department	Problem	Solution	
Warehouse	Wrong Counts received from the vendor and not reported to purchasing		
	Mixed Parts received from the vendor and not reported to purchasing		
	No computer to enter incoming or outgoing material		
	Material that is burned off to be reused is not entered back in the system as useable inventory		
Metal Preparation	Wrong Counts pulled from the warehouse and not verified		
	Mixed Parts pulled from the warehouse and not verified		
	No computer to enter incoming or outgoing material		
Bonding	Wrong Counts		
	Mixed Parts		
	No computer to enter incoming or outgoing material		
Cast Room	Wrong Counts reported to the materials manager and production is entered incorrectly		
	Mixed Parts from the warehouse, wrong parts are produced		
	No computer to enter incoming or outgoing material		
	Using different material than what is listed on the bill of material and not having inventory adjusted		
Trim	Wrong Counts coming out of the cast room which are not corrected before the parts are put on the shelf		
	Mixed Parts which are counted together, and inventory is adjusted		
	No computer to enter incoming or outgoing material		
Shipping	Wrong parts pulled off the shelf		
	Parts are stamped incorrectly, therefore inventoried incorrectly		
	Inventory location is incorrect, wrong parts are pulled		
	Lack of understanding of the parts		
Receiving	Parts are labeled incorrectly and therefore received as something different		
	ID label is missing allowing warehouse to pull the wrong parts		
	Lack of receiving paperwork		
	No computer to enter incoming material		
Sales	Order is hard to read, entered incorrectly		
Engineering	Bill of material or structure issue		
	Copying an existing part to make a new part number without verifying information		
	Running sample parts without notifying the materials manager of which materials are being used to backflush IFS		
	Back flushing of material does not work if the item is purchased, showing inventory in stock that has already been used		
Quality	Scrap is not entered quickly, parts still show in stock		