Optimizing Inventory Levels in a Medical Device Company

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Abstract *— Having material shortages can be dangerous to production since it can cause lack of product availability for sale therefore making the company unprofitable. Only measuring the weeks of inventory and inventory turns can be misleading since these two ratios can indicate that the inventory is under control when is not. Considering the safety stock coverage as part of the analysis can help identify what percentage of the items have the necessary inventory available to run the manufacturing line effectively. In order to calculate the optimum material quantity to have healthy levels of inventory, the ABC Analysis was used. Also, to make ensure the Enterprise Resource Planning (ERP) System provides the right signals, a kaizen event was implemented to identify all the parameters that needed to be updated, to what quantity and the owner of them. As a result, the variable of Buyer and ERP System Execution decreased its occurrence 28%.*

Key Terms *— DMAIC, Inventory Control, Inventory Optimization, Supply Chain Management.*

PROJECT STATEMENT

The control of inventory affects directly the ability of the company to invest but most importantly the capacity to operate. Stock on hand represents money tied up that cannot be used in other investment opportunities; that is why companies try to have low levels of inventory. Having no stock at all can be dangerous too since it can cause the production line to shut down. Therefore there is no product available for sale and no income in return.

Research Description

The purpose of this project is to analyze and identify what is causing material shortages and explore diverse techniques used in the Medical Device industry to calculate the optimum material quantity in order to have healthy levels of inventory. The project will be developed from the perspective of raw material in the SNSR Business.

Research Objective

The following are the objectives of this research work:

- Weeks of Inventory: 2.5 weeks
- Safety Stock Coverage 80%
- Inventory Turns: 21 turns per month

Research Contributions

With this research, the SNSR Business will meet the desired levels of inventory to support the production plan but most importantly it will maintain the same inventory cost forecasted at the beginning of the year. It will also improve its customer services that consequently will increase sales and gross margin. Another contribution of this research will be reducing waste and optimizing process.

LITERATURE REVIEW

In the manufacturing industry, inventory is the key element in the process of making a product. There are different types of inventory: raw material, work in process (WIP), finish goods, and supplies. This research will be concentrated on raw materials, purchased items that are transformed into WIP or end products through the manufacturing process using labor and equipment. WIP is any material that is on the production line, from raw material that started the manufacturing process up to products waiting final inspection and acceptance as finish goods. Finish goods are completed products ready to be sold. Last but not least we have material, repair, and operating supplies (MRO) which are materials that support the manufacturing process but are not part of the end product. Examples of these are spare parts, consumables, and maintenance supplies.

Inventory is the most expensive asset and it should be controlled wisely since having low levels of inventory can be catastrophic to the production. Having material shortages is considered in Lean a waste, any process or activity that doesn't add value to the customer. So Lean believes that waste comes from unnecessary activities in the process that do not add value to the end product or service. By this way, Lean improves the speed of the process and reduces process waste that adds value for the customer since they receive the product or service more quickly than the competitor. Lean also reduces cycle time, as well as excess inventory and improves response time. The eight wastes that Lean seeks to eliminate are waiting, poor process design, overproduction, transport, inventory, defects, motion, and underutilized personnel resources and creativeness. Overproduction is when the company produces more than what the customer needs. Waiting is any waiting time such as waiting for personnel, material, maintenance, information, etc. Transport is the distance traveled by the employees in order to make the end product or service. Poor process design is when there are too many or few steps in the process, there is no standardization. Inventory is the days of supply that there is of a product that is not converted into finish good. Motion is based on the unnecessary movements the workers have to make because the workstations do not have an efficient layout. Defects are any errors, rework, scrap and non-conformance of the product. Last but not least is the underutilized personnel resources and creativity when the organization is not using their employees to their fullest potential. [1]

The Six Sigma methodology focuses on those variations within the process that is causing inventory waste. Six Sigma is a problem-solving method that improves process performance, measure process quality against customer expectations, and reduces process variation. In this way, they are consistently meeting or superseding customer expectations by decreasing defect rate and increasing process yield. Six Sigma always focus on effectiveness. What makes it a unique philosophy is that is driving by data, so it gets problems solved by analyzing quantitative or numerical data [2]. Six Sigma is accomplished through the use of two methodologies: DMADV and DMAIC, which we will be focusing on the second one that signifies define, measure, analyze, improve, control. In the first phase, Define, is where the problem statement is developed in conjunction with the project objectives, scope, and customer expectations. Here is also identified who will be the champion, process owner, and team member. In this phase is stated the resources to be used, it's evaluated the main administrative support, and a project strategy is develop. The different tools that can be used in the Define phase are project charter, critical to quality diagram, process map, SIPOC diagram, stakeholder analysis, and voice of the customer. In simple words a project charter is the project plan; the SIPOC is a high-level view of the problems and boundaries and the voice of the customer is gathering information through survey and complaints.

In the second phase, the process is measured to determine current status and collect data to quantify the problem. It's also used to define the defect, opportunities, metrics, make a detailed process map, develop a plan to collect the require data, and validate the measurement system. In this phase is where a relationship between the X's (inputs) and your Y's (output) start to develop. Also the process capability and Sigma baseline are determined. After this, all the necessary information is gathered to start analyzing the data to define the root cause. The most common tools used in the measure phase are the fishbone and process diagram. A fishbone diagram is a tool that helps identifies potential causes for a particular problem. A process diagram also known as a flow chart, is a graphical demonstration of a business process flow and the relationship between its activities.

Here on the Analyze phase the source of variation is identified, the objectives are defined, and the process activities that add value and do not add value to the process are differentiated. Some tools that can be used in this phase are Scatter Pot diagram, Histogram, Time Series analysis, Pareto Chart, Regression analysis, Fishbone diagram, and Five Ways. The Analyze phase is the beginning of the statistical analysis of the problem, where the significant contributors to the output are established. The statistical analysis is done with the development of a theory. Pareto Chart is a bar graph where each bar represents frequency or cost. The Vital Few Analysis helps us indicate that many defects come from relatively few causes. The Box Plots are used as graphical summaries illustrating distributions.

After this phase comes the Improve phase, here is where the improvements are implemented to the process by eliminating the defects. In this phase, a lot of experiments are performed to develop potential solutions to the problem. The tools that are used in this phase are brainstorming, mistake proofing, simulation software, design of experiments, and failure modes and effects analysis. Once the solution of the problem has been found it's validated, so the problem does not rise again in the future. Here is where the last phase, Control, takes place. The necessary controls are created so that the process does not fluctuate and if it does the deviations are corrected before they result in defects. In order to do this, a standard procedure is developed, and a statistical process control is implemented. In this phase, it's also determined the new process capability and the benefits and cost savings of the project are verified. The tools that can be used in this phase are control charts and control plan. Control plan is an essential document that adequately describes all the inspections and control points found in the process. In the control phase is confirmed that the process continues to perform as expected producing the projected outputs, and maintaining the desired quality levels. The key components in the control phase are the control, training, document and standardize. [3]

METHODOLOGY

Through the Six Sigma methodology, DMAIC the objectives of this research will be achieved. In the Define phase, a project charter will be used to describe in details the current problem, provide the goal of the project, establish the scope or areas that the investigation will be concentrated, define the roles and responsibilities of each participant, indicate the resources needed in order to achieve the objectives, specify a detailed schedule with all the activities and their completion dates, and provide the benefits that could be expected from this project. Then in the second phase, the source of variation is identified by using a Pareto Chart. A Pareto chart is a bar graph on which each bar represents occurrence and is arranged with the longest bars on the left and the shortest ones to the right. In this way, the chart visually illustrates which situations are more significant than others. The Pareto chart is used when analyzing data about the frequency of problems or when there are many probable causes and need to focus on the most substantial one. Also, a C Chart will be used to define the average quality level at the beginning of the project. This control chart provides the initial process capability and will tell whether any improvement idea is appropriate or not. The control chart it's also used to keep a continuing record of a particular quality characteristic. At the same time, this chart will help distinguish between assignable causes and chance causes. Assignable causes are an unnatural variation that requires corrective action by the operators and a chance causes are a natural variation that needs management involvement to accomplish the quality improvement.

Once all the necessary information is gathered the analyze phase starts. A fishbone diagram will be used in this step to help identify all the possible causes of the stated problem, but most importantly it will also help visually display these potential causes. The fishbone uses five categories that help get the right drivers of the problem: Mother Nature, Method, Man Power, Measurement, Equipment, and Materials. It's very useful for situations in which there is no much quantitative data available for the analysis. Another tool that will be applied in this phase is 5 Whys, which is a simple way to reach quickly the actual cause of the problem.

After this period comes the Improve phase, here is where a lot of experiments are performed to develop potential solutions to the problem. Here is where procedures are changed to include the improvements of the process and making sure everyone follows the new method, parameter settings are adjusted, and standardized work are created. Once the solution of the problem has been found, the control method needs to be validated to ensure that this issue does not rise again. Here is where the last phase of the DMAIC methodology takes place. The necessary controls are created so that the process does not fluctuate and if it does the deviations are corrected before they result in defects. These controls are periodic audits, training, and documenting and standardizing the progress of the project. The tool used in the last phase is the control chart, which will show if the improvements have been successful if the control limits move closer together. This indicates that there is less variation and that the process it's now in control. The following graph (Figure 1) illustrates the schedule of the activities necessary to complete the project and the duration of each activity.

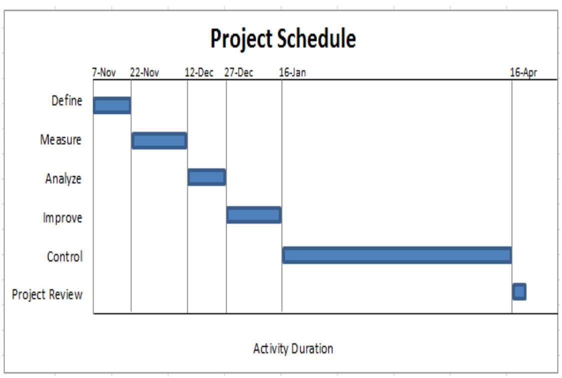

Figure 1
Project Schedule

Results and Discussion

The SNSR Business has an opportunity for achieving optimum levels of Raw Material using the Six Sigma methodology, DMAIC. Throughout the following phases the different problems causing material shortages will be revealed and diverse techniques will be used as improvement methods to healthy levels of inventory.

Define Phase

The SNSR Business is continuously meeting the financial metrics in terms of inventory. As shown in (Table 1) from the months of September to November this business had an average of 2.4 weeks' worth of inventory and an inventory turn of 22.

Table 1
Financial Metrics before Implementation

Month	Raw Material	Usage	12 month Historial Usage	Turns Monthly Actual	Inventory Weeks Actual	SS coverage
September-14	$ 859,416	$ 2,424,617	$ 15,475,152	22	2.4	63%
October-14	$ 707,034	$ 1,535,888	$ 16,179,649	21	2.4	69%
November-14	$ 715,964	$ 1,690,032	$ 16,630,128	22	2.4	58%

$$\textit{Weeks of Inventory} = 52 \,/\, \textit{Inventory Turns} \tag{1}$$

$$\textit{Inventory Turns} = \textit{Historical Usage} \,/\, \textit{Inventory Average} \tag{2}$$

The weeks of inventory (1) and inventory turns (2) are two ratios that can indicate that the inventory is under control when they are on target. But how can this be if the SNSR Business is having a lot of material shortages. Taking only these two ratios in consideration can be misleading. That is why the safety stock coverage was introduced; this is the percentage of items that are within the safety stock target, in this case the target is two weeks. In the months of September to November, the average safety stock coverage indicates that 37% of the items were below target. Consequently, the supply chain department is looking for new ways to manage the inventory and reach the optimum levels. With this project, the SNSR Business should be able to maintain the weeks of inventory and a turnover rate as they are and reduce the material shortages. There are many types of inventory, but this project will be concentrated in Raw Material only.

In order to reach these goals, the following team players: buyer, material handler, inventory analyst, planner, and supplier quality engineer should participate in weekly meetings.

Project Charter	Project Name: Optimizing Inventory Levels in a Medical Device Company
Problem Statement In the months of September to November, the SNSR Business has had in average 2.4 weeks worth of inventory , an inventory turnover rate of 22 and a safety stock coverage of 63%. If no action is taken, the production can be shutdown due to material shortages, making the SNSR Business unprofitable.	**Project Goal** Achieve 2.3 weeks of inventory, an inventory turnover rate of 21, and a safety stock coverage of 80%.
Project Y Safety Stock Coverage **Path Y's** • Inventory Turnover Rate • Weeks of Inventory	**Scope** Scope includes: Raw Material Scope excludes: MRO, WIP, and Finish Good
Resources Project Team • Buyer • Material Handler • Planner • Inventory Analyst • Supplier Quality Engineer Support Team: • Operational Excellence Dept. Stakeholders: • Supply Chain Manager	**Business Impact and Benefits** Schedule: • Project start date: 7-Nov-14 • Estimated project completion date: 21-Apr-15 • Estimated date when benefits will begin: 27-Dic-14 Benefits: • Reduce Material Shortages • Reduce Production shutdown risk • Reduce Obsolescence Risk • Project implementation in other business

Figure 2
Project Charter

Here they will collect and analyze data about material specifications, running changes, production fallout, supplier performance, inventory accuracy, and forecast accuracy. All of these activities must be completed by December 27th so the improvements can be implemented by the begging of January. A project charter (Figure 2) was created, so the team members and management have a clear view of the project goals and commitments.

Measure Phase

In term of financial metrics, the SNSR Business was hitting the numbers but at the same it was constantly having material issues. That means this business has excess inventory for items that they don't need and very low inventory on items that the production line requires in order to operate. After reviewing the percentage of material shortages and excess inventory (Figure 3) through the months of September to November, it was identified that the top offender for material issues was shortages. In average, 37% of items from the SRNS Business had a shortage versus 15% of items that had excess inventory.

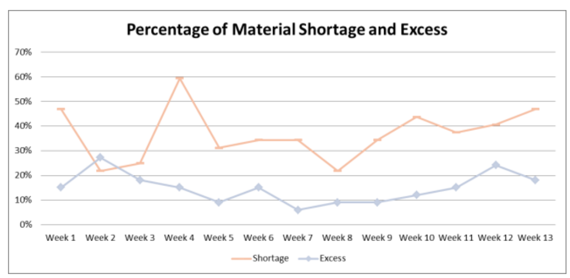

Figure 3
Percentage of Material Shortage and Excess

Even though there are many variables that can create a material shortage, this project will be concentrated only on those drivers that are directly related to Buyer and ERP System Execution. As shown in (Figure 4) this is the variable with the highest frequency and controlling it will make a significant impact since 80% of the material shortages are due to this reason. [4]

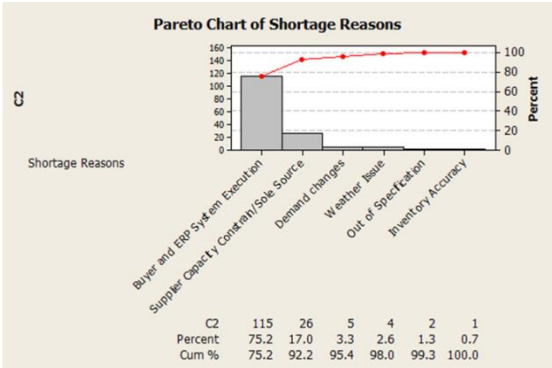

Figure 4
Pareto Chart before Implementation

A C chart was created (Figure 5) by counting weekly shortages for the months of September to November in order to establish a baseline to later compare and see if the improvements executed has been successful or not. Weekly, the SRNS Business is having an average of 12 material shortages. Without material availability, the production line will never run efficiently, impacting directly the profits of the company. That is why is so important to control the inventory levels but most importantly optimizing it.

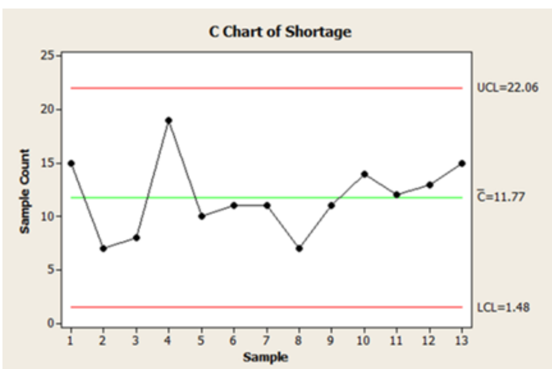

Figure 5
***C* Chart before Implementation**

Analyze Phase

Due to this information, the project will be concentrated on finding those reasons that are causing material shortages. That is why a fishbone diagram (Figure 6) was generated to help identify all the possible causes of the stated problem. These were the drivers found in the different categories. As part of Mother Nature, there have been material shortages caused by shipment delay due to weather issues. Also, changes in demand that were not forecasted causes the inventory to deplete faster than anticipated. In the second category, Method, was found that the procurement procedure did not provide a guideline for the buyers to follow in order to reach the optimum levels of inventory desired. In the Man Power category the following drivers were found for material shortages: the lack of communication between different functional areas with the buyer can cause delay on material acquisition. For example, if the planner changes the production plan and does not notify the buyer of these changes, the buyer will not bring the right material on time to support that plan. Another example can be when the inventory analyst finds a material discrepancy they should notify the buyer as soon as possible so they can expedite or differ any order that will be affected due to the discrepancy. Also, when a material quality issue is raised the buyer should be included immediately so good material can be expedited, and the production is not affected. An additional driver for this category is the usage of Excel instead of the ERP system. To this problem, it can be added the poor maintenance of the ERP system by the buyers. For example, every time there is a change in demand the buyer should update the safety stock, minimum and maximum quantity, and reorder point of each item. In regards to the Measurement category, it was found that no scorecard was created to monitor supplier performance. As well, no forum exists to discuss buyer Metric and performance. The Equipment category includes the supplier capacity constraint that provokes the production to run “hand to mouth” and never having healthy levels of inventory. Also, the variability in the equipment performance can affect directly the consumption of the materials. In the last category, Material, there are two drivers for material shortages. The first one is that most material has only one supplier, and if the vendor encounters a problem there is no one else that can provide that item. The second driver is the material out of specification. If all the stock on hand has this condition then it cannot be used for production, causing a material shortage instantly.

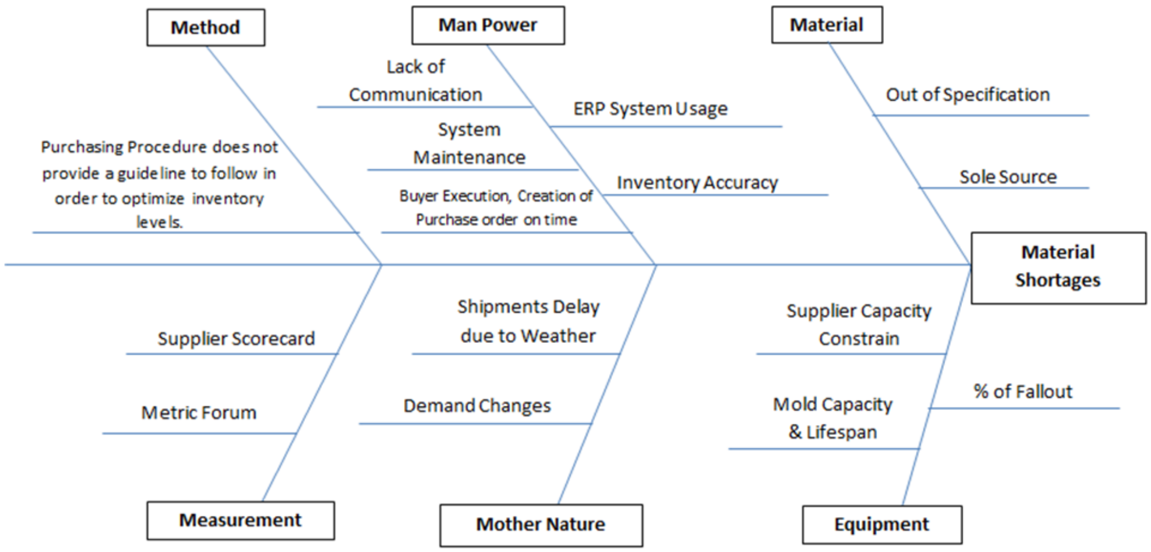

Figure 6
Fishbone Diagram

Through the fishbone was identified a non-value activity that was the use of Excel instead of the ERP System. This creates a burden on the employee since they have to calculate manually the material requirements and create analysis reports that are already provided by the ERP System. A 5-Whys Analysis was prepared to identify the root cause of why the Buyer wasn't using the ERP System as shown on (Figure 7). It was discovered that the Demand Planner didn't have access to the same ERP System as the Buyer and Planner. Therefore, a task was open to the Information and Technology Department to provide access to the Demand Planner so the forecast can be uploaded into the system.

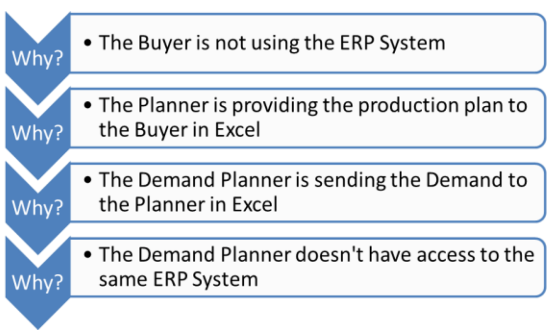

Figure 7
5-Whys Analysis

Improve Phase

In order to control the Buyer and ERP System Execution, the following improvements were executed. To cover the lack of communication, a representative from each functional area will assist the SNSR Tier 2 Meeting. This meeting is held daily in the manufacturing area with supervisor and production group leader. Each representative will provide any information relevant to the business. For example, the planner will present the schedule adherence and any changes in demand will be announced in this forum. The buyer will provide any material shortages and its impact to the production plan. The production engineers will present the production scrap and their reasons. The supplier quality will provide any material issues that are affecting the production line. The engineers will communicate any changes in the manufacturing process or raw materials. In other aspect, a weekly meeting was created to monitor the procurement team performance through the discussion of a scorecard that contains all the buyer metrics. In this forum, any material or supplier problems will be escalated to management for resolution. These types of meetings ensure that the buyer is on top of any situation.

Since the demand and production plan is now uploaded in the ERP System, the buyer has no choice to use the system. To ensure the ERP System provides the right signals, a kaizen event was implemented to identify all the parameters that needed to be updated, to what quantity, and most importantly who will be owner of maintaining them. This event had the participation from receiving, incoming inspection, planning, manufacturing, purchasing, and management. Incoming and receiving had the opportunity to calculate and provided their current lead time. Planning with manufacturing reviewed the machine time, time fence and capacity. Purchasing contacted their suppliers to obtain the material lead time, the minimum order quantity and in transit time. As part of achieving the optimal levels of inventory the management decided to use the ABC Analysis to calculate the minimum quantity, the maximum quantity, and the reorder point of each item. This analysis uses the letters A, B, C for classifying inventory items in descending importance reflecting the difficulty of controlling each material and its impact in terms of costs and revenue. [5] The ABC Analysis was performed to the SNSR raw materials and their parameters were updated in the system accordantly. In order to maintain the systems updated the purchasing work instruction was revised to include the following statement: “The Buyer is responsible for maintaining the ERP System. At least every quarter each parameter must be reviewed taking into consideration the usage and forecast. Also is a good practice to review the targets each time the demand changes. The following parameters must be updated for each item:

- Receiving Lead Time
- Incoming Lead Time
- Supplier Lead Time
- In transit Lead Time
- Minimum Quantity
- Maximum Quantity
- Reorder Point
- Rounding Value/ Package Size
- Unit Cost
- Safety Stock

As a recommendation, the items with classification A must be received weekly, type B two times a month and those classified as C monthly.”

Control Phase

After all the improvements has been made, the count of shortages was measured weekly for almost three months to monitor its performance. The result of these improvements can be shown on the control chart (Figure 8). Some may say that the process is not in control because there is one outlier but since this was due to an assignable cause, it can be disregarded. [6] The unnatural variation was due to a change in demand that was not forecasted. Corrective actions were taken by the buyer who revised the ERP System targets and adjust them based on the new forecast.

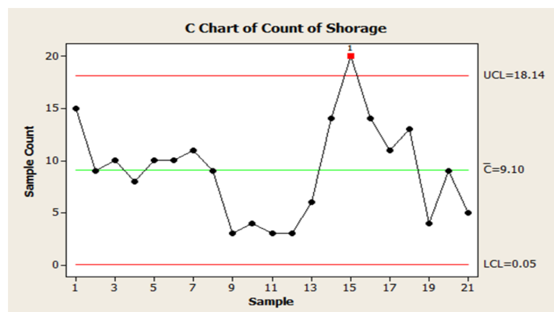

Figure 8
***C* Chart after Implementation**

After this, the control limits were revised to eliminate the point that was outside the control limits since it was due to a special cause of variation as shown in (Figure 9). The new C Chart shows that the improvements implemented were successful by the control limits moving closer together. Before they were from 1.48 to 22.06, and now the boundaries run from zero to 17.32. Also, the average of items been shortage was 11.77, and now it decreased to 8.55.

Even though the process is now in control, the trend doesn’t have a smooth flowing because some common cause variations still exist as shown in (Figure 10). Since this project was focus on the Buyer and ERP System Execution, it’s safe to say that the improvements established were successful as the variation for this diver reduced from a 75.2% to a 47.1%.

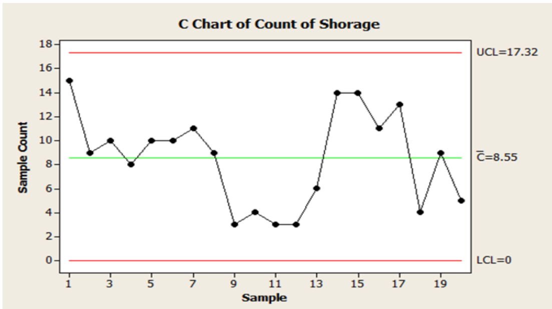

Figure 9
***C* Chart after Implementation Revised**

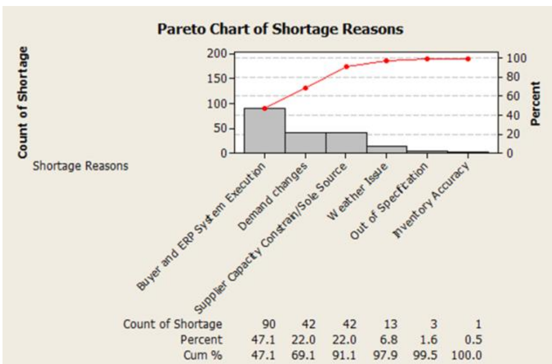

Figure 10
Pareto Chart after Implementation

Also as per (Table 2), the process it's more in control since the weeks of inventory and inventory turns stayed the same but the average of safety stock coverage improved to a 74% instead of a 63%. If the month of March is not taken into consideration due to the assignable cause, then the average of safety stock coverage will be at 77%.

Table 2
Financial Metrics after Implementation

Month	Raw Material	Usage	12 month Historical Usage	Turns Monthly Actual	Inventory Weeks Actual	SS coverage
December-14	$ 1,025,217	$ 1,907,080	$ 17,297,655	21	2.5	71%
January-15	$ 626,479	$ 899,722	$ 16,957,824	21	2.4	79%
February-15	$ 461,808	$ 778,772	$ 16,930,463	24	2.2	80%
March-15	$ 1,200,722	$ 1,970,143	$ 18,003,210	24	2.2	61%
April-15	$ 950,770	$ 1,426,155	$ 18,714,496	21	2.4	80%

Conclusion

The key to success, not only in this project but in the day to day job is the communication between the team players. In this case, good communication will help the Buyer make the right decisions in terms of raw material acquisition and maintaining the best level of inventory necessary to run the SNSR business. For example, the material handler should communicate to the buyer any material irregularities that occur in the production floor, like inventory discrepancies, shortages, and overstock. The planner must advise to the buyer any changes in demand or production plan. The inventory analyst is required to monitor inventory accuracy and advise to the purchasing team any material adjustments. And the supplier quality engineer needs to communicate to the buyer any quality issues regarding raw material. Any issues from these functional areas should be disclosed to the Buyer in the Tier 2 or through email.

It was a challenge to maintain the same inventory weeks and inventory turns when it was needed to purchase more material from those items that had low inventory. But with the right tools and commitment from the team the project made a huge impact in terms of material shortages. One of the benefits of this project is that it can be implemented in other businesses to optimize the inventory levels not only to control the inventory but to maintain the manufacturing line running efficiently.

Even though the SNSR Business didn't achieve the goal of 80% in safety stock coverage during the time fence of the project, there was a good trend of improvement. Probably in two months the SNSR will be capable of reaching the target. The variable of Buyer and ERP System Execution, which this project was focused on, decreased its occurrence from 75% to a 47%. This means that raw material availability is more stable, and the SNSR Business should now focus on the others variables to improve even more the safety stock coverage. During the investigation other types of shortages were discovered that couldn't be part of the scope due to lack of capital and top management decisions. For example in order to increase mold capacity and equipment yield the company needs to invest in a new mold and equipment or pay for repairs. For supplier constraint and sole sourcing, management needs to evaluate and decided if they want to invest in the current supplier or they prefer to search for a second vendor to mitigate the supply constraint. New projects can be implemented to improve these opportunities that were identified but were out of scope.

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