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DMAIC CONCEPT FOR SUSTAINABLE DEAD STOCK REDUCTION: A CASE OF A TEXTILE COMPANY

By

NITI SAMPAT

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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September 2012

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Master of Science in Supply Chain Management

Declaration of Authorship Form

Niti Sampat declare that this project and the work presented in it are my own and have been generated by me as the result of my own original research.

DMAIC CONCEPT FOR SUSTAINABLE DEAD STOCK REDUCTION: A CASE OF A TEXTILE COMPANY

I confirm that:

1. This work was done wholly or mainly while in candidature for the M.Sc. degree at this University;

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Date September 20, 2012

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1D: 5319570

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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

Signed ____________________

(A. Thanapat Panthanapratez)

Date September 20, 2012

ACKNOWLEDGEMENTS

My deepest gratitude is to my advisor, A. Thanapat Panthanapratez. I have been fortunate to have an advisor who gave me the freedom to explore on my own and yet who was always there to guide me. He taught me how to question thoughts and express ideas. His patience and support have helped me to complete a project in an area I was unfamiliar with.

I would like to thank the management and staff of S&P Company, for providing me with data and information as well as valued time to collect information and seek knowledge in their specialized field.

Most importantly, none of this would have been possible without the support and guidance from my husband, who has patiently helped me in collecting all the data and information required from this company as well as morally supporting me to achieve my goal.

Last but not least, I would like to express my deepest gratitude to my family in understanding and supporting me during my entire study, especially my two sons for always encouraging me.

Niti Sampat
Assumption University
September, 2012

ABSTRACT

This case study is about a textile weaving company whose warehouse is bulging with inventory, active as well as dead stock inventory. There is a tendency for these dead stocks of raw material to increase. Applying the DMAIC concept, based on data and facts for sustainable dead stock reduction, would be the ideal solution.

The DMAIC concept systematically helps to pinpoint the problem and the extent of the problem, and then to an understanding of the root cause of the problem. In this research, data used is from the year 2010. Initially it was known that there is high accumulation of raw material inventory of which 8 million THB was dead stock raw material inventory. To narrow the focus, a Pareto analysis is applied and the top 80% value of items is selected. The result is that 65 items lock up 6.75 million THB. To understand the root cause, a Fishbone analysis is applied and the result showed there are four reasons causing accumulation of dead stock. However, only the high impact reasons are selected by using the Pareto analysis, and the top two reasons selected were excess order of raw material and material leftover after production. After interviewing and observing, two separate as-is processes are drawn. These as-is processes identify the areas causing the flaws in each process which need to be corrected. Finally, improved processes are recommended which eliminate the flaws and correct each process, thereby ensuring that accumulation of dead stock does not occur. Measures to control the new system to sustain the improvement and reduce the dead stock are also recommended. Implementing the two new processes will reduce 76% of the dead stock, while the control measures will ensure there is a sustained improvement in those areas.

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I, Asst. Prof. Brian Lawrence ____________, have proofread this Graduate Project entitled DMAIC Concept for Sustainable Dead Stock Reduction: A Case of a Textile Company ______.

Mrs. Niti Sampat ______________________________.

and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

Signed ____________

Asst, Prof. Brian Lawrence

Contact Number / Email address blawrence@au.edu

Date: 26/11/20

CHAPTER I

GENERALITIES OF THE STUDY

Supply Chain Management systematically coordinates and integrates all activities, materials, information and finance as they move along the process and across the supply chain and form an integrated system (Huang, Uppal, & Shi, 2002). To fulfill customers' demand, an organization requires inventory to process and deliver goods and ultimately to attain profit. Therefore, inventory is a key issue to the success of supply chain management.

Inventory is essential for every manufacturing organization to function. Inventory is dynamic and should constantly and carefully be monitored, evaluating internal and external factors and controlling through planning and review. Inventory is held in various forms: Raw material, Work-in-Process, Finished Goods, and Goods in Transit etc.

While inventory is essential, dead stock inventory is absolutely inessential. Dead stock inventory is stock that has not moved from its present state in the past twelve months, killing the cash flow, blocking valuable warehouse space, and freezing earnings that otherwise would be possible if revenue-generating products had been purchased (Bragg, 2010). Formerly, inventory was considered to be a mode of measuring wealth but today inventory is considered to be a current asset that should earn a profit. If the burden of having inventory is more than gaining benefit, such inventory would be a negative asset or a liability, especially if it is idle, and therefore should be a target for reduction (Tersine & Tersine, 1990).

According to Sanchez and Butler (2009), textile companies undergo various processes before delivering the final fabric, such as Spinning, Weaving, and Dyeing. The tendency to accumulate inventory at every stage, to avoid shortages or provide buffer for rejects, is a major cause of high inventory leading to various associated costs that go unnoticed. Consequently, this case study is about a textile weaving company whose warehouse is bulging with inventory - active as well as dead stock inventory. Dealing with the present dead stock alone does not resolve the problem, and the appropriate way would be to prevent future dead stock inventory recurring.

Snee (2010) surmises that businesses today seek to improve their bottom line, particularly in times of financial crisis. Various approaches for improvement have been embraced but the new generation improvement approach is Lean Six Sigma. This approach is not a fad but a step by step evolution improvement method. This research is based on the Lean Six Sigma methodology using the DMAIC tool to understand the current state; select the critical drivers, focus on items that need prior attention; and develop solutions by getting to the root cause.

1.1 Background of the Study

Tersine and Tersine (1990) state that although it is a known fact that negligent stock piling is a burden to an organization, both financially and operationally. Surely organizations would like to hold the optimum levels of stock ensuring quick response to customer demand. However, there are constraints and uncertain factors such as lead times, capacity, desired customer service, minimum order sizes, price discounts, quantity discounts, equipment down time, variation in production yields and transportation availability of organizations, which compel them to hold inventory leading to accumulation which may end up as dead stock. Since inventory accumulation is a result of variable operational procedures, logically the reduction of variation and improvement in efficiency of operations can reduce uncertainties that will curb accumulation and prevent future dead stocks.

An appropriate level of inventory varies with changing conditions and strategies, and it is important for management to monitor and control these. Failure of inventory control or planning mechanisms to maintain stock levels, leads to unexpected shortages or excesses. According to Ballard (1996), regular stock monitoring and measurement by supervisors can assist in providing information to the management to improve operations and reduce errors.

Tersine and Tersine (1990) further state that to initiate inventory reduction it is necessary to break down the inventory's current composition and disaggregate the data to analyze inventory imbalances. This research builds its foundation for the improvement procedure by breaking down and analyzing in depth the current constitution of inventory specifically the raw material (yarn), and by systematically finding the root cause of dead stock inventory accumulation, and finally concludes with recommendations for prevention of future dead stock recurrence.

1.1.1 Background of the Company

The S&P Group of Companies is a vertically integrated textile manufacturing group of companies, with the capability of converting raw fiber into finished products. It is based in Bangkok, Thailand. It is comprised of four main companies, all involved in various stages of the textile manufacturing process, from yarn spinning, through fabric manufacturing and processing, to finished products.

Figure 1.1: Company Overview

Source: author

Figure 1.1 shows the Company Overview of the S&P Group of companies, which prides itself on its ability to create and innovate. Over the years it has developed a multitude of unique, trendy, luxurious and functional fabrics. Over 70% of its production is exported to customers in Europe, The United States, Australia, New Zealand, Africa and Latin America. The company has won Best Energy and Environmental Awards and Best Corporate Award. The value chain of this textile company comprises four stages.

The S& P Spinning Company: is equipped with modern machinery spinning various kinds of yarn such as polyester, viscose, cotton, nylon, linen, recycled polyester, flame retardant polyester, and other kinds of blends.

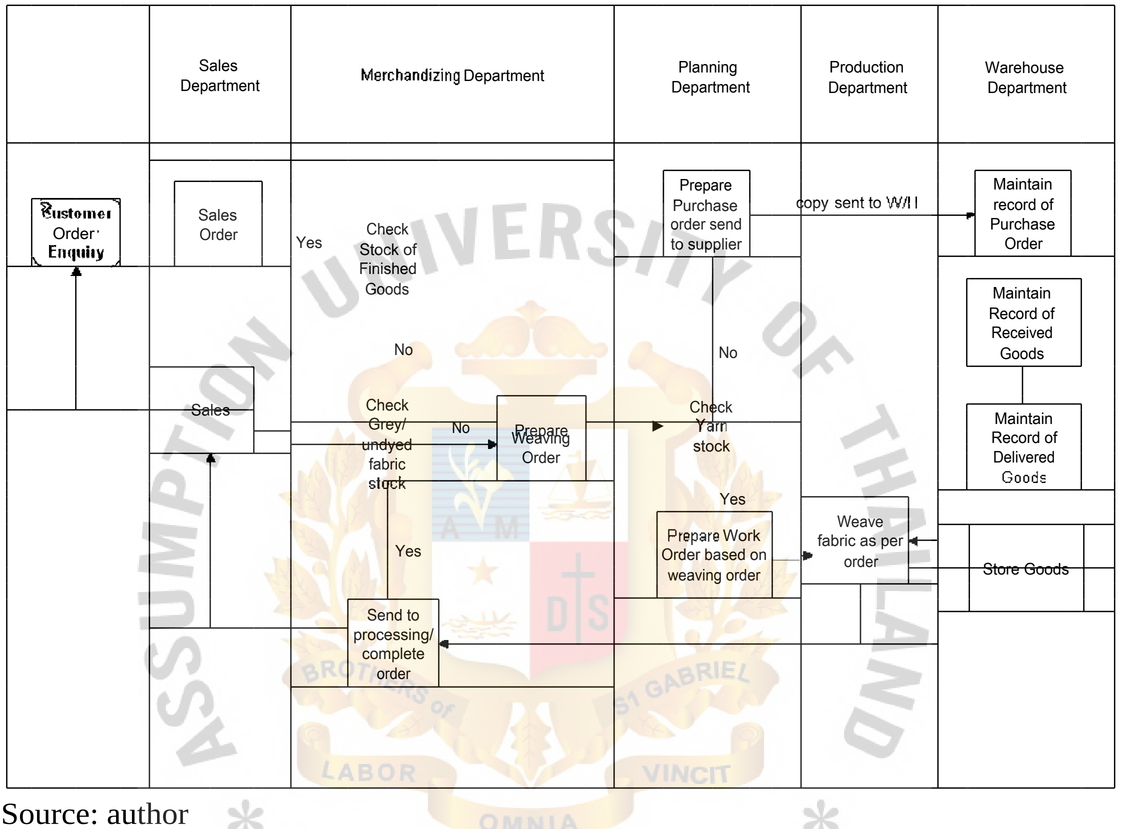
The S&P Weaving Company was created in 1980. Then, most textile plants did not have an adequate understanding of multi-fiber fabrics. The revolutionary treatment of multi-fibers has created market demands. They are well-known for their durable, beautiful high tolerant multi-fiber fabrics. This company started on a small scale, but over the years it has expanded enormously using the most modern equipment and sophisticated techniques. It invests in research development and tries to introduce new products to the market to gain an edge over its competitors. Recently it has introduced the fire retardant fabric which has become very popular in the automotive industry, for hospitals, auditoriums, etc. It also houses an on-site testing laboratory fully equipped to handle fabric testing and quality comparisons.

The S&P Dyeing Company: contributes to processing and finishing the fabric, such as bleaching, dyeing, calendaring, sueding, sanforizing, coating, fabrics for wall covering and other applications.

The S&P Apparel Company undertakes sewing. Its products are chiefly curtains, bedcovers, upholstery, drapery, automotive fabrics and garments, mostly for export.

This study is concerned specifically with the weaving company, which has a potential for competitiveness and growth but has been subject to neglected inventory management. The analysis is performed on the raw material inventory (yarn) in the S&P weaving company for a twelve month period in 2010. Delving deeper into analysis, the dead stock inventory is extracted and further diagnosed to understand the cause of accumulation, in order to correct the process to prevent further accumulation.

Figure 1.2: Order Fulfillment Process Mapping



Source: author

Figure 1.2 illustrates the general procedure of order fulfillment of customer orders for fabrics. When the sales / marketing department at S&P Weaving Co. receives an order from their customer they check their finished fabric stocks. If stock is available it is promptly delivered; however, if the requirement is not in ready stock, it needs to be produced. The merchandizing department acts as the coordinator between sales and internal departments. It checks the stock of un-dyed fabric (grey fabric), which, if available is sent for processing to the S&P dyeing company, or else it sends a request to the planning department for further procedure. The planning department checks the yarn stocks in the information data system. If yarn stocks are available, a weaving order is sent to production department. After weaving, the fabric is sent for processing and later delivered. If specific yarn is not available, the planning department places an order to the S&P spinning company. The purchase order (P.O.) copy is sent to the warehouse department. For every P.O. issued, yarn is received in lots. The warehouse inputs data of goods received from S&P spinning and data of goods delivered to production department.

1.2 Statement of the Problem

Most manufacturing companies tend to have dead or dying inventory, perhaps a consequence of running the business over years. Products which may have been successful once may not be in demand anymore. It would be disastrous for a business to ignore dead stock. Preventing dead stock further building up, and dealing with present dead inventory would avoid future business catastrophe (Harris, 2011).

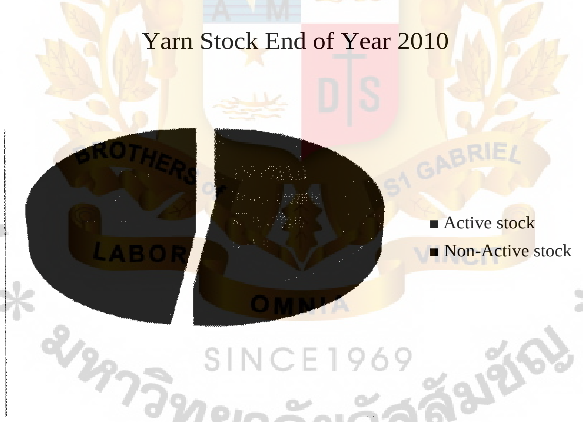
Besides, organizations need to bear the associated costs of holding inventory. Some companies consider the cost of holding inventory merely by estimation. In fact, many companies do not consider these costs while making decisions. However, these costs range from 12% to 35% of the value, which can be a substantial amount, and if these expenses go unnoticed they can silently eat away profits. These costs chiefly comprise of Cost of Capital (inventory investment); Inventory Service Costs (Insurance, Physical Handling & Taxes); Storage Space Costs (Plant, Public, Rented & Company Owned Warehouses) and Inventory Risk Costs (Obsolescence, Damage, Shrinkage and Relocation Costs) (La Londe & Lambert, 2007).

Like people having regular medical check-ups, inventory too needs regular check-ups. To maintain high performance and low capital investment, the health of inventory is essential. Companies ought to have a proactive approach towards inventory rather than neglecting inventory management. Regular valuation can prevent high costs and at times fatality of a company (Tersine & Tersine, 1990).

The S&P Weaving Company like any other manufacturer aims to provide good, timely service, and attempts to introduce innovative products into the market. The company adds new varieties to increase their market share. Each time new items arrive, the previous stock remains untouched. The inventory piles up, filling the warehouse. This compilation of material practically goes unnoticed as the company seems to be making an overall profit on goods sold. However, it has been noticed recently that they need to add warehouse space to store their growing inventory stocks. This revealed cause of concern and the need to identify why the inventory is piling up, and the need to take appropriate steps to prevent recurrence.

The inventory data for twelve months of 2010 was collected, identifying that raw material inventory (yarn) occupied 55% of stocks (details are shown in Chapter 3). This provoked the researcher's curiosity as this company's sole supplier of yarn is its sister concern S&P Spinning Company. Further probing of the data revealed interesting facts which led to deeper research.

Figure 1.3: Yarn Stock at S&P Weaving Co. Year 2010



Source: author

Figure 1.3 above shows the extent of dead stock of raw material inventory found in the warehouses at S&P Weaving Company. The company started with one warehouse for storing their raw material in 1980; today it has five warehouses holding yarn. There is over one hundred thousand pounds of yarn consisting up to 48% items, worth 13% of raw material value (eight million THB) blocked in dead stock inventory having no movement over a period of twelve months. This study aims to answer the research question: "Can the Define- Measure- Analyze- Improve- Control (DMAIC) model prevent future dead stock of raw material recurrence?"

1.3 Research Objectives

The focus of this project is on the dead stock of raw material (yarn) inventory of S&P Weaving Co. Ltd. The yarn used by the company is produced by their sister concern, S&P Spinning Co. Ltd. Although their supplier is at close proximity there is an astonishingly high amount of raw material stocked in their warehouse. The study will concentrate on the dead stock inventory for twelve months of 2010. The objectives of this research are:

1.3.1 To identify the causes of dead inventory compiling and recommend solutions to eliminate defects based on data and facts.

1.3.2 To enhance knowledge of, and propose, the Define- Measure- Analyze- Improve- Control (DMAIC) model in order to make process improvements that last for the organization.

1.4 Scope of the Research

This case study is about prevention of dead stock inventory and further increment, focusing on the top 80% value of present dead stock inventory of raw material at the company. The historical data collected is for a span of twelve months of 2010. Interviews will be held with relevant department heads to collect information regarding reasons for present dead stock occurring, and for further understanding the as-is process causing this occurrence is explored. Finally, an improved process is recommended to prevent future dead stock piling up.

This research is based on Lean Six Sigma principles, proposing the Define- Measure- Analyze- Improve- Control (DMAIC) tools to prevent future dead stock inventory problem recurring. Literature reviews supporting this study provide evidence that this tool is a structured, data and facts based, problem- solving process that can get to the root of the problem It will be best suited to solve the dead stock inventory problem and prevent future recurrence.

1.5 Limitations of this Research

This research focuses on prevention of future dead stock of raw material piling up at S&P weaving company, using the DMAIC concept. The result of the data analysis shows that inventory management systems require improvement. There are several limitations to this case study, as mentioned below:

1.5.1 The paper analyzes raw material inventory and will focus only on the top 80% value of dead stock inventory to understand the causes of this piling up, and recommend improvement of the process in order to prevent recurrence.

1.5.2 The study is based on historical data of twelve months of 2010.

1.5.3 This study focuses only on raw material dead stock inventory. There is a possibility of dead stock in other categories (work-in-process and finished goods) too.

1.5.4 This research is conducted in the context of only a single industry, the textile industry.

1.6 Significance of the Study

This section provides a brief description of the significance this research will bring to those who benefit from this study. The study distinguishes between active and dead stock inventory, focusing on the dead stock inventory, which gives a better understanding of the hidden costs involved in storing it, awareness of the disadvantages in compiling these wastes, resulting in developing steps for prevention of further accumulation.

1.6.1 Theoretical Implications

Using the Define-Measure-Analyze-Improve-Control (DMAIC) tool, will structurally define the problem and measure the extent of the problem, based on data and facts. Analyzing the data will lead to understanding of the root cause. Once the root cause is known improvements can be specifically designed and controls can be set to prevent future recurrence.

This method improves organization profitability and revenue growth, cuts cost, reduces inventory and lead time, and increase customer satisfaction. The users develop valuable job skills such as problem-solving, teamwork and decision making. Most importantly, there is increase of work efficiency as gets rid off wastes by working on as-is data reports rather than gut feeling.

1.6.2 Managerial Implications

The paper aims to recommend actions to prevent future accumulation of dead inventory, since prevention is better and cheaper than cure (Tersine & Tersine, 1990). On implementing recommendations the organization will become more profitable, obtaining increased revenue, cost-cuts; improved delivery time; reduction of inventory, vacate valuable warehouse space, and improve its operations. Along with that it will improve decision making and problem solving skills with stronger team work, making it a better work place by terminating the problem of dead stock piling in raw material inventory.

This project may be used as a guideline for management to implement similar projects in other areas of the organization in order to bring fundamental improvement in the process and increase profitability without compromising on customer service.

1.7 Definition of Terms

DMAIC: Stands for define; measure; analyze; improve and control. It is a tool used by most Lean Six Sigma practitioners as it is a structured data-based problem solving tool which solves real problems in a sequential manner.

Fishbone Analysis: Is a type of root cause analysis. It systematically sorts ideas into categories to identify potential causes of a problem in the form of a diagram resembling the skeleton of a fish. It is an effective tool for continuous improvement.

Pareto Analysis: Is a statistical tool, also known as the '80-20 Rule'. This concept suggests that within a given population of items, approximately 20 percent of items represent 80 percent of the total 'value,' while the other 80 percent of items are only 20 percent of the total 'value.'

CHAPTER II

SUMMARY OF SELECTED LITERATURE

This chapter reviews selected literature, primarily understanding what is supply chain management and inventory management and their interrelationship. Then, a brief description about lean and six sigma concepts, followed by a deeper study of the two methods merged together to form a powerful methodology called Lean Six Sigma, which has been accepted and used by several organizations supported by a framework of the DMAIC tool adopted in this research. Relevant literature on Pareto Analysis and Fishbone Analysis is provided. Lastly is selected literature reviews of other manufacturing organizations who adopted the DMAIC concepts from Lean Six Sigma methodology and the results thereof

2.1 Supply Chain Management

According to Meng (2006), supply chain management addresses activities, materials, information and finance management across the entire chain which consists of several tiers of suppliers to producers, distributors, retailers and finally to the end user (the customer). Traditionally, companies performed activities such as purchasing, production and marketing independently, which made it difficult for the whole supply chain to make an optimal plan. In these present times of high competition aided by advanced technological and information systems and changes in global economies, there is change in the way organizations function. Actions taken by one member of the supply chain affects the entire chain. Companies today synchronize and coordinate with their chain members to optimize their performance. Supply chain management research mainly focuses on three issues, namely the behavior of information flow, inventory management, and planning and operations management.

This research focuses on inventory management. While most researches examine optimum levels of inventory, this study is about preventing inventory build-up whichv turnins into dead stock.

2.2 Inventory Management

Every organization needs inventory or stock of items; and will have a system that monitors and maintains the level of inventory. Inventory is kept for various reasons: to maintain independence in operations buffer stocks help as a cushion between workstations; and to absorb variations in product demand as demand is never completely predictable. Safety stocks are also kept due to variation of supplies: inventories are purchased in bulk to take advantage of economical purchase order size (Meng, 2006).

While holding inventory may facilitate easy accessibility of material, it comes attached with multiple costs which may not seem apparent. La Londe & Lambert (2007) recommend that inventory carrying costs must be taken into account by inventory management personnel. Elements of these costs have been mentioned in Chapter 1, in Statement of the Problem.

Inventory management involves anticipating material requirements; sourcing and obtaining materials; introducing materials into the organization, and monitoring the status of materials as a current asset. The chief functions would be purchasing or procurement, inventory control of raw material, receiving, stocktaking, production scheduling and transporting, These functions need interactive subsystems. The management's objective should be low costs, high level of quality and service, high inventory turnover ratio, and supporting other functions such as sales and research and development (Tersine & Tersine, 1990).

2.3 Lean Concepts

According to Goldsby and Martichenko (2005), "Lean" concepts provide dual benefits: they eliminate waste and they increase the velocity and flow of goods or services. The lean theory considers excess inventory as the most common form of waste, along with waste of transportation, space and facilities, packaging, time, administration, and knowledge. Resources are necessary for planning, processing, and manufacturing. However, if these resources are not utilized effectively, that is if they do not fulfill customer demand nor support operations, they would become a waste. Organizations mostly focus on visible cost drivers such as transportation, packing, and warehousing costs for inventory, neglecting inventory carrying costs, which represent 12 to 35 percent of 'Total Cost.' Considering all cost factors is crucial for improvement in lean system thinking.

Sutherland and Bennett (2007) explain that the business value chain is an end to end set of activities; some activities add value while some do not. Those activities that do not add value tend to add cost. Based on the Toyota Production system or Lean concept, all non-value added activities should be eliminated. The non-value added activities, or the seven deadly wastes, are identified as overproduction, delay/waiting, transportation/conveyance, motion, inventory, over processing, and defects/correction.

2.4 Six Sigma

Goldsby and Martichenko (2005) state that the Six Sigma methodology is a problem solving model equipped with process control tools such as the Define- Measure- Analyze- Improve- Control (DMAIC) tool which is an action based, step-by-step approach which deals with understanding and improving various organizational challenges. The core principle of Six Sigma is variation reduction. The DMAIC model creates understanding of process variation that causes the problem, after analysis improvement strategies can be derived and implemented ensuring higher accuracy and work efficiency which will increase business profitability and reduce variation (such as inventory buildup).

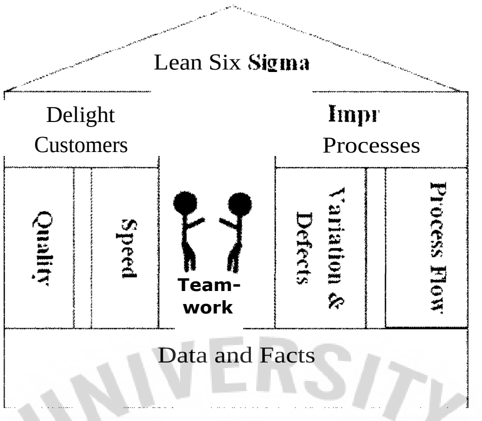
Organizations maintain safety stock due to variation in supplier quality, manufacturing process capability, transportation reliability, and customer demand patterns. Therefore, to reduce variation and reduce buffers we must understand the process both upstream and downstream. To illustrate the problem of inventory variation with a typical example: Why would a manufacturer, who is supported by a reliable supplier at close proximity from the plant, continue to hold excess inventory? Most likely they have not understood their own demand or they are addicted to inventory.

2.5 The Concept of Lean Six Sigma

Based on the elements mentioned above Lean Six Sigma is about managing inventory efficiently by eliminating wastes in a systematic manner, understanding and reducing variation concurrently, and increasing speed and flow within the supply chain. For Lean Six Sigma to work in inventory management, 'total logistics costs' need to be considered not individual cost factors, as well as eliminating wastes of various nature (Goldsby & Martichenko, 2005).

According to George, Rowlands, and Kastle (2004), Lean Six Sigma has enormous advantages as it improves organization profitability. Lean Six Sigma users experience revenue growth, cost cuts, improvement in delivery time, reduction of inventory and increase in customer satisfaction. The users develop valuable job skills such as problem solving, teamwork and decision making.

Figure 2.1: Four Keys to Lean Six Sigma



Source: George et al. 2004)) p. 10

George et al. (2004) explain that the elements shown in the figure 2.1 are keys to lean six sigma, which when combined together can create real solutions; however, applying them individually they cannot succeed. The people working on the process can jointly improve the process by understanding the customers and processes based on data and facts.

Delight-the-customer indicates not only meeting the needs of customers (internal and external customers) but aims to exceed their needs thereby creating delight. The goal is to eliminate defects: for this element, anything the customer does not need is a defect. A process that has a lot of errors is low in speed (the overall processes speed) causing a lot of waiting time. Compiling buffer stocks between processes, in time deteriorate, get outdated or add up as dead stock. Eliminating delays will improve the speed and quality and lower the cost.

Improving the process in Lean Six Sigma emphasizes documenting how the work is done (steps of the overall process), the work flow between people or workstations, and training employees. Variations occur in the form of delivery times, weights, size, customer satisfaction scores, quality difference, lot variation etc.. If the product or service does not meet the customer specification it is a defect. Improving the work process makes it more reliable, predictable, achieving better quality and ultimately eliminating variation. To improve process flow and speed, the work layout should be planned to reduce wastes such as waste of movement, therefore improving speed and efficiency. Rather than blaming people, observing and improving the process along with training the people will reduce defects.

Team work inculcates team spirit, if employees are involved in process improvement, they are proactive as well as there is lower resistance to change reducing information distortion, unnecessary delays and variation. Collaboration improves worker skills such as listening skills, brainstorming, discussion, organizing ideas, and better decision making. To avoid the pitfalls of team work it is important to train employees, set project goals, assign responsibility, and handle conflict, making sound decisions based on facts with team approval and fostering continuous improvement.

Decisions based on data and facts are the foundation of lean six sigma methodology. Traditionally data was collected to monitor employee performance, but in lean six sigma data collected is measured and analyzed to bring improvements in the process. After improvements are made, data is further collected to recheck a new process and track defects in the early stages. There are two kinds of data. Result data consists of the final outcome, whereas process data reflects what happens during the process; both types of data are required for decision making. Basic types of data measured are customer satisfaction, financial outcomes, speed/lead time, and quality/defects. Measuring the data reveals what the problem is, which will contribute in deriving the most appropriate solution. Collecting the right data is critical as it will lead to sound decisions.

Lean Six Sigma used by manufacturers can reduce and eliminate waste in inventory and streamline the entire operation of the company. Hariharan (2006) suggests guidelines for successful Six Sigma projects: the projects should be regularly assessed and reviewed by the senior management and quality leaders to ensure effectiveness, focus and progress. Primarily, the project charter, the problem and goal statement, and the defect have to be clearly defined. The problem statement should be based on data collected and analyzed not merely on gut feeling or brainstorming. Next is focusing on the top four or five categories or main causes that account for approximately 80%

of the problem, analyzing the as-is process and understanding the root causes. These aid in providing recommendations for corrective action. To confirm that the project reaches completion, a date for implementation may be set for each corrective action. Actual results must be assessed to confirm improvement (financial benefit/ customer satisfaction etc.) after every quarter once the corrective action is implemented. Regular monitoring and measuring will control the system.

2.6 Define-Measure-Analyze-Improve-Control **(DMAIC)** Tools

George et al. (2004) explain that Define-Measure-Analyze-Improve-Control (DMAIC) is the most effective tool kit used by lean six sigma practitioners. It is a structured data-based problem solving tool which solves real problems. Solving problems using the DMAIC tool ensures nipping the problem in the bud. This tool has a structured approach of doing specific activities in a sequential manner, gathering data in every phase which guides making decisions. The solutions are based on specific problems.

Table 2.1: **DMAIC** Process Sequence

Process	Steps Taken	Reasons	Tools
Define	Selecting the product or process that requires improvement. Collect relevant data. Sort the data. Creating the as-is map to understand the situation.	Develop team work and shared ideas. Confirm Opportunity. Management/team agreement on the scope. Agree on the goal of the project. Improve process.	Financial Analysis Project Charter Process improvement plans.

Process	Steps Taken	Reasons	Tools
Measure	Identifying the key factors that have the maximum effect on the process. Collect further data, measure the extent of the effect.	Confirming the data is reliable and trust worthy. Decisions are based on facts and reality. Documentation. Selecting key tasks to improve.	Data Collection Plan Process observation Pareto charts Time series plot Histograms
Analyze	Looking for patterns in data. Target areas	Real causes surface Improve process speed without negotiating on quality Identify critical factors to control	Fishbone Analysis Scatter Plots Pareto Analysis
Improve	Identify solution range Review existing best practice Criteria for selecting solution Piloting the project solution Planning implementation	Achieving long lasting solutions. Solutions linked to real cause. Justify the reason the solution is selected. Reality based.	Pick Chart; Kaizen; Four step rapid setup; 5s; Brainstorming Benchmarking
Control	Documentation Training Tracking device Hand- off responsibility	Prevent back sliding Alert for future problems Sharing experience Verifying success and sustenance.	Control charts. Standard Operating Procedures. PDCA cycle

Source: George et al. (2004) p. 58-77

The gist of the tool is shown in Figure 2.2. In the first phase Define, Excel or similar software based inventory data of a period of time enables the determination of the product, process or function that requires improvement. Defining the scope of the problem and goal provides guidelines for improvement. In the measure phase, the key factors that have the maximum effect on the process are identified. Data collection is made, measuring the extent of the problem such as which items or which locations have excess or scarce inventory, which helps to get to the root of the problem. In the Analyze phase, the data collected is analyzed and the problem is further diagnosed, and patterns in data reveal areas to be improved. Since it is impossible to correct all causes simultaneously, advanced tools such as Pareto analysis are used to pick out the high value items. Correcting the process causing the problem to these selected items will improve a most of the problem. In the improve phase, problems that are causing the most impact are selected by various advanced tools; in this case it is the Pareto analysis by reason. Next, by using tools such as Fishbone analysis, real causes surface. On identifying the root causes, an improvement plan can be developed and recommended. In the final Control phase, steps are taken for sustaining the improvement over a span of time.

2.7 **Pareto** Analysis

Pareto analysis is a statistical tool also known as the '80-20 Rule' this concept suggests that within a given population of items, approximately 20 percent of items represent 80 percent of the total 'value,' while the other 80 percent of items are only 20 percent of the total 'value.' The term 'value' may be defined in several ways such as money, usage, popularity (Muller, 2003).

Williams (2009) states that it is impossible for inventory management personnel to focus on and monitor all items in stock on a daily basis, therefore, data needs to be sorted and stratified. Focusing on items that occupy the top 80 percent of the value will make a significant impact and solve major issues.

Pareto analysis is prepared in a systematic manner, by Excel or similar database software to form a table listing items and relevant amounts/causes, and their frequency as a percentage of the total. The data is sorted and items are rearranged in descending order, placing the highest amount or most important items first. Besides the percentage column a cumulative percentage column is added to the table. The cumulative percentage reveals the impact the items have. Selecting items accumulating to nearly 80% value and improving the process of those items significantly solves the majority of problems. The Pareto analysis gives direction to the project manager on what items to focus on.

2.8 Fishbone Analysis

The fishbone analysis systematically sorts ideas into categories to identify potential causes of a problem in the form of a diagram resembling the skeleton of a fish; it is an effective tool for continuous improvement. This type of root cause analysis is also known as Ishikawa Fishbone analysis or Cause-and-Effect analysis. At the head of the diagram is the problem, and the bones stand for the various causes. There is logical categorization of causes, and generally the categories used are Manpower; Methods; Machine; Material; and Environment, there are however variations adapted in selecting these categories. Within these categories there are causal factors. This tool helps to methodologically reach to the root cause of the problem (Gano, 2007).

Figure 2.2: Fishbone Analysis Diagram

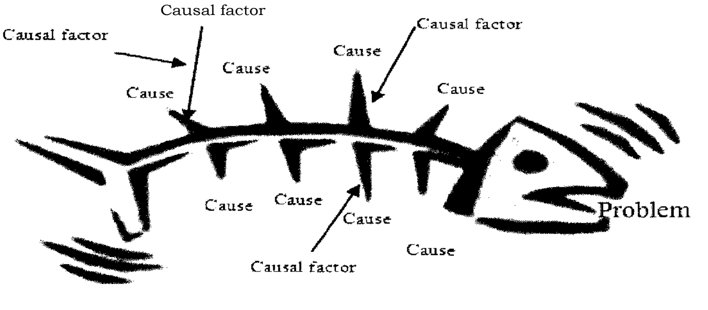


Figure 2.3 displays a sample of how the analysis is formed. The visual effect of analysis aids in mapping the root causes of the problems and their causal factors, if any, which contribute to the aggravation of the problem.

2.9 Review of Selected Literature

This case study focuses on using DMAIC concepts in order to reduce waste piling and improving those processes which cause this occurrence. Various research papers and case studies reveal solutions to improve operations in the manufacturing sector by reducing waste and increase profitability by adopting the lean Six Sigma's DMAIC concept. Past success stories have been summarized in the Table below:

Table 2.2: Summary of Selected Literature

Study	Objective	Originality/ Value	Result/Finding
Kumar & Sosnoski (2009). "Using DMAIC Six Sigma to Systematically improve shop floor production quality and costs."	How a leading tool manufacturer with its drive for continuous improvement used DMAIC Six Sigma to leverage its potential to realize cost savings and quality improvement on their shop floor.	The case study states DMAIC Six Sigma process is an effective and novel approach for industries to improve their process, products and profitability driving down manufacturing costs.	Expects nearly $12,500 p.a. savings by eliminating faulty operation, and approximately $ 1,600 p.a. reducing scrapped parts. Ultimately better performance and quality.
Chirop (2008). "Six Sigma Green, Black Belts	To improve processes, reduce scrap and gas usage, and to fine	The results indicate Lean Six Sigma is the strongest	Received numerous awards – outstanding achievement in waste minimization and

Study	Objective	Originality/ Value	Result/Finding
help Manufacturer Save Nearly $1.5 Million."	tune the operations system.	improvement tool. Six Sigma and Lean programs together lead to quality improvement.	pollution prevention. Their green belt efforts saved $ 1.2 million and black belt efforts save nearly $285 thousand.
Jacobsen (2010). "Quality Revolution Reduces Defects, Drives sales Growth at 3M."	To achieve growth goals by significantly improving quality. To reduce defects in parts per million by 25% p.a. To trim total complaint resolution time by 15% p.a.	Data and data analysis was the key in improvement process to help determine the root cause and its relationship.	3M reduced its defects from 12,000 parts per million to 475. Customer's complaints dropped by 90%. Sales growth by 54% in 7 years.
Jacobsen (2009). "Optimizing Purchasing Process Saves $1 Million."	To reduce waste by focusing on purchasing activities. To improve supplier selection, reduce variability, streamline processes and increase efficiency.	Often simple steps create the biggest impact, adopting the Six Sigma concept and using the DMAIC tools helped determine the root cause of the problem.	There was a cost reduction of more that 13% on purchases. Almost 90% reduction of process variability. Reduced waste costs, lead time and elimination of non-value added procedures.
Corbett (2011). Lean Six Sigma: the	To improve operations,	Organizations world over seek to	The results show there is a strong

Study	Objective	Originality/ Value	Result/Finding
contribution to business excellence	performance and scores to win business excellence awards.	win business excellence awards. Two award winning companies have been studied here.	contribution of lean Six Sigma in each category of business criteria for performance excellence. The study also shows that both lean and Six Sigma are compatible.
Smith (2003). "Lean and Six Sigma- A One-Two Punch."	This article covers two case studies both manufacturers, who initially used Lean techniques. Later combined Six Sigma- To reduce waste and eliminate flaws in process which lead to scrap reduction.	Lean and Six Sigma combined together help achieve more superior, precise results rather than either system individually.	Case 1: reduction in lead time-92%; improvement in productivity- 20%; scrap reduction- from 0.8 to 0.2%; creation of standard operating procedure, training employees and involvement of management. Case 2: reduction of quality defects by 75% and 40% overall leaks rates. Employee participation led to 20% increase in their positive attitude.

Source: author

As observed above, it is apparent that Lean Six Sigma methodology is used by various manufacturers to precisely get to the root of the problem and then correcting it to improve the process and prevent future recurrence. Kumar & Sosnoski (2009) state improvement in operations results in reduction in amount of inventory held within a company. On improving their process, the warping defect was eliminated, reducing the scrap. This in turn reduced inventory and increased cash flow.

According to Chirop (2008) Crown Equipment Corporation, a multinational manufacturer of electric lift trucks, invests in its employees to be trained by certified trainers. The company has integrated the lean system in every manufacturing process. However, they apply Six Sigma to some of their projects (the projects are suggested by the trainees themselves). Combining both Lean and Six Sigma enables the company to address specific problems, identify the root cause in a structured manner and achieve desired outcomes by reducing variation and waste. The data-driven strategies focus on defect prevention in future. The effort of training resulted in hard savings for the company, quality improvement, improved morale, increased loyalty and self-esteem of employees, and enhanced customer satisfaction.

As Jacobsen (2010) writes, the quality revolution reduces defects, as in the case study of the multinational 3M Company which faced customer complaints for nearly seven years due to defects. They adopted the Lean Six Sigma Method and followed the DMAIC approach for a problem they faced with the belts they produced. They identified the root causes, developed solutions by employing process mapping, cause and effect diagrams and failure mode and effects analysis. The project ultimately resulted in reduction of defects from 12,000 defects in parts per million to just 475 defects in parts per million. This also led to reduction in waste, increased productivity, and fewer emergencies. All this increased customer value and loyalty, brand value, and image enhancement.

Jacobsen (2009) says optimizing purchasing processes can save $ 1 million, as in the case of MWM International motors, a worldwide diesel engine manufacturer in Latin America/ The leaders initiated the Lean Six Sigma project to optimize their purchasing process for engine bolts in order to lower costs and reduce waste. They focused on their purchasing activities to reduce waste, by analyzing data, identifying the root cause, developing a solution, addressing resistance from employees, involving stakeholders, and a trial implementation. The project resulted in a cost reduction of 13.6 percent of the annual purchase price, and savings worth $ 1 million. Their quality metrics showed a reduction of nearly 90 percent process variability. There was an overall culture of continuous improvement within the organization as they have further pursued the DMAIC method to develop new projects.

The study by Corbett (2011) shows that two companies which have harnessed Lean Six Sigma have improved their operations and performance and improved their scores to win business excellence awards in their field. Both companies are manufacturers, namely Company A (in New Zealand) emphasizing R&D and Company F (in U.S.A.) having high-volume flow process, who, after trying several improvement programs which failed, they finally adopted the Lean Six Sigma approach. Both companies benefited financially by focusing on wastes and involvement of employees in improvement efforts. Company A started using Lean Six Sigma in 2001. By 2007 it estimated several benefits from this approach: In terms of quality there was 91% improvement; in terms of cost due to wastes, a 70% reduction; promptness in delivery improved by 67%. The overall cost benefit was approximately $ 3 billion from 2001 to 2007. Company F started using Lean Six Sigma from 2005; by 2007. They had maximized the ability to solve critical, high valued complex projects and simultaneously involved employees to make small continuous improvements. Their annual cumulative saving was approximately $ 28 million.

Smith (2003) stated in an article that companies across the spectrum have found the most effective method to eliminate defects that lead to waste, by combining Lean and Six Sigma; together they deliver greater results than they would if implemented individually. This method helps to precisely locate the real problem rather than use guess-work. In the case I in this article, the team expected a problem in priming PVC, but on observing the process they found the problem to be in the welding process. Finding the real problem and correcting the process prevented further wastes occurring. While in case II, a commercial refrigeration equipment manufacturer faced problems of leakage in coils, leading to costly rework process, warranty claims and complaints from customers. Pareto analysis identified the critical areas to focus on. Data analysis revealed the true cause. Learning the root problem gave direction to solving the problem. Various tools were implemented, to systematically remove the problem from its roots, bring improvement in the process, reducing wastes and increasing efficiency.

2.10 Summary

Based on the past research which showed tremendous improvement after applying this systematic approach, the researcher is confident that this case study will benefit too, as Lean seeks to reduce or eliminate waste, while Six Sigma reduces variation. By combining the two, "waste gets spotted and removed, which then allows variations to be spotted easily." The DMAIC concept will systematically spot the problem, and recognize the areas that need improvement, which will help towards the design of a better system to eliminate the accumulation that is being caused and prevent future recurrence.

CHAPTER III

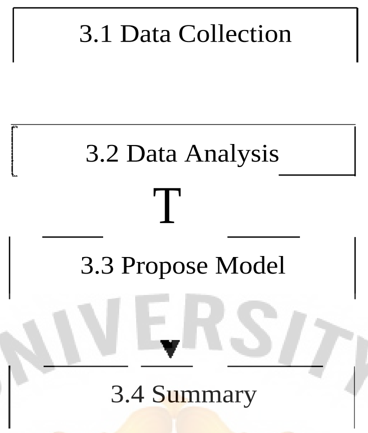
RESEARCH METHODOLOGY

Research enables us to systematically seek knowledge and awareness in a purposive investigation, finding new ways of looking at familiar processes in order to explore possibilities of bringing efficiency and reducing wastes.

This research is a case study of S&P Weaving Co. Ltd., which is a textile weaving company within the S&P Group of Companies. Its sole source of raw materials is from its sister concern, the S&P Spinning Company which provides all the needs of yarn required for weaving. The study focuses on the yarn stock at the S&P Weaving Co. Ltd.. The research is conducted to prevent future dead stock inventory occurring, based on Lean Six Sigma concepts using the DMAIC approach. This action based research method focuses on the 'Dead Stock' in the raw material inventory by studying the dead stocks stashed in the warehouse over a twelve month period January to December 2010.

This chapter comprises four sections, as seen in Figure 3.1. Section 3.1 consists of Data Collection process of this research. Twelve months inventory stocks for the year 2010 have been collected in order to analyze the situation and define the problem. Section 3.2 Data Analysis, firstly evaluates the data collected to reveal the value of the stock in each category - raw material; work-in-process and finished goods inventory, then identifies the trend of the inventory stock through the year 2010 for each category. Secondly, the researcher sorts the raw material inventory through the year to isolate the value of those items that have had no movement over the span of one year. Next, a Pareto Analysis is performed on these dead stock items to extract the key items which need prior attention. Section 3.3 Proposed Model, describes how the DMAIC (Define-Measure-Analyze-Improve-Control) methodology has been spun into a plan to chart the process of improvement. The last Section 3.4 Summary, concludes the chapter.

Figure 3.1: Research Process



3.1 Data Collection

This section provides step by step explanation of the data collection process for this research. As the data has been directly imported in the spread sheet format from the company inventory database, it is reliable. These databases are updated in real time at the source and are stored at the centralized location in the IT department of the company. Since the research is based on the DMAIC approach which is a data and facts based problem solving method, gathering and reviewing existing data will assist in defining the problem.

Initial data collected was from the panoramic view, consisting of monthly stock of raw material; work-in-process and finished goods. The item quantity and value is specified giving an overall picture of the inventory. After analyzing the total inventory for the year 2010, the raw material stock is selected and studied in greater detail. The data of each item received and issued through the months was collected to understand movement of raw material through the year.

3.1.1 Year 2010 inventory data reports:

Monthly reports of the inventories were collected for twelve months of 2010 for raw material (yarn); work-in process (un-dyed fabric/ partly processed fabric) and finished fabric. An overview of the inventory can be observed in Table 3.1 below.

3.1.2 Year 2010 raw material in depth data reports:

Furthermore, Raw material (yarn) monthly reports were extracted from the company database, with details of quantity received and quantity issued with their relevant values for each item for twelve months of 2010. This provides an awareness of the movement and the contribution which each item makes through the year.

3.2 Data Analysis

In order to characterize the nature and extent of the problem, the data collected at various levels has been analyzed to get visual clarity.

3.2.1 Overall Inventory Analysis

Initially monthly data of inventory for the twelve months of 2010 was collected. Inventory consists of several categories: Raw Materials (yarn), Work in Process (Un-Dyed Fabric, Partly-Processed Fabric), and Finished Fabrics. The following Table charts monthly stocks.

Table 3.1: Overview of Inventory Value Year 2010

Unit: in millions TIM

Inventory Category	J								S			D	**End of Year**
Raw Material	43	43	45	49	52	49	51	54	53	52	59	65	*55%*
Un-Dyed Fabric		11	13	14	11	11		10	14	14	10	10	9%
Partly Processed Fabric	11	11	19	19	16	14	14	16	14	18	17	16	13%
Finished Goods	25	27	27	32	33	33	30	29	31	28	30	28	24%
Total Inventory	89	92	103	114	112	106	103	109	112	112	116	119	100%

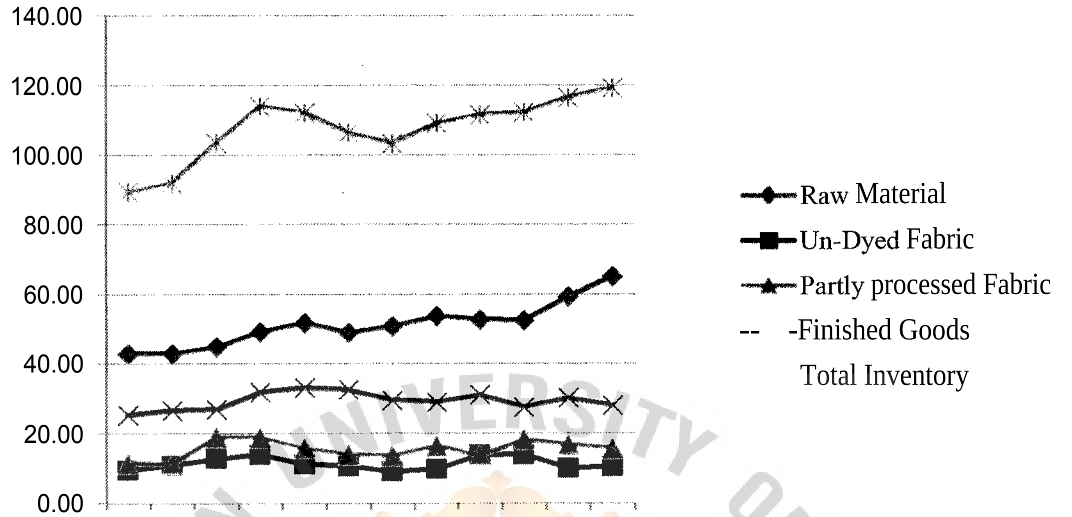
Source: author

Inventory data from the panoramic view shows an alarming amount of inventory at hand over the span of 12 months. Observing the total inventory in Table 3.1, raw material at end of year is around 55% of the total inventory. The categories work-in-process (un-dyed fabric and partly processed fabric) and finished goods, each consist of approximately 25% of the total inventory. Although these two categories also hold substantial inventory, the raw material stocks need prior attention as not only are the stocks highest among all categories, but further analyzing the raw material data, as shown below, confirmed an increase which indicates conditions worsening in the future. This gives a substantial reason to focus on raw material in this study.

3.2.2 Raw Material Analysis

Based on the data derived from Table 3.1, a graph is derived as shown in Figure 3.1 to further understand the pattern of movement of stocks for each category as compared to the total stock.

Figure 3.2: Trend Analysis of Inventory 2010



Source: author

It is observed that the raw material inventory is approximately 55% of the total inventory, with a tendency to increase as observed above which showed that the raw material pattern is on the increase. This pattern causes concern, that not only is the raw material inventory high but there seem to be possibilities of the situation worsening leading to higher dead stock piling up. This pattern led to the interest of the researcher to do further analysis of raw material inventory since this area needs prior attention: if the process is not improved and preventive measures are not taken the situation will worsen.

Comparatively, the work-in-process and the finished goods inventory seem to have a level pattern through the year, and there is no immediate threat of these two categories going out of proportion. Therefore, this analysis proves that raw material inventory needs prior attention.

3.2.3 Data Analysis for Segregating Active and Dead Stock Raw Material Items

To further understand the movement of each item of the raw material inventory through the year, and separate the active items and dead stock items, an in-depth monthly stock report was generated with details. There are three steps involved to derive the report.

a) As Muller (2003) suggests evaluating goods that are not sold, we calculate the ending inventory amount. Calculation is performed through each month (January to December) for each item, which identifies items having movement and non-movement.

b) After deriving records of each item, the monthly difference is totaled to conclude the total movement/ non-movement of each item through the year.

c) The data is sorted based on these figures to segregate active items and dead stock items.

Table 3.2: Inventory Status

No. of Items	Status	Value THB in millions	% by value I	% by Item	Quantity pounds thousand)
438	Active Stock	57	87%	52%	748
405	Dead Stock		13%	48%	109
843	Total	65	100%	100%	857

Source: author

Table 3.2 Inventory Status records show that some items had decreased in stock, while some raw material items actually increased in stock by the end of the year. The rest of the items had no movement. Items that had increased or decreased in stocks have been grouped together as active stock, resulting in 438 or 52% items, worth nearly 57 million THB or 87% value of total 65 million THB of raw material inventory. While nearly 405 or 48% of the items showed no indication of movement over a span of twelve months, these stocks are worth 13% of the raw materials value equivalent to 8 million THB; by quantity it is over one hundred thousand pounds of yarn. These items are considered as dead stock. Over 8 million THB of capital is blocked in items that have not been used through the year as well as occupying valuable space and have probably deteriorated which further reduces its value.

3.2.4 Data Cleaning Phase

The 405 items in the dead stock were further scrutinized. Some items showed zero stock in the beginning and at the end of the year; in fact they had received and issued stock within a short period, so those items were considered as fast moving and were sorted out from the inactive stock items. Filtering out these quick movement items finally reveals the actual dead stock inventory. After cleaning the data, there are 386 items in the dead stock inventory; these items had no movement through the months - the quantity each month was constant right through from January to December 2010.

From the study so far, there are 386 dead stock items; however, making general changes will not fix the problem. Therefore, selecting items that have the highest value, understanding the reasons that are causing the most problem, and fixing those problems will be beneficial. Hence, a Pareto Analysis would distinctly help select the key items.

3.2.5 Pareto Analysis on dead stock yarn

George et al. (2004) stated that it is important to understand what to improve. Targeting the key items that are making the most impact, and pinpointing to the specific cause of their problem, and then further developing solutions for that cause, will achieve in getting to the root of the defect and eliminating it totally.

In order to focus on top 80% value of dead stock yarn a Pareto Analysis is performed on the 386 dead stock items based on their value at the end of year. This concept aids in stratification of items, giving priority and primary attention to items of highest value, as Williams (2009) suggests.

Table 3.3: Pareto Analysis Result on Dead Stock Items

Total Dead Stock		Pareto		80% of Total Dead Stock	
Total Dead Stock Items	Value THB. in millions			Value THB. in millions	Top 80% items
386	8	**80%**	>>>	6.75	65

Source: author

The 386 items are sorted by value. Furthermore, the percentage of each item is calculated in terms of total value of dead stocks. Besides the percentage, their cumulative percentage is also calculated. Based on the cumulative percentage, the top 80% value of items is selected as these are the biggest contributors to the problem blocking a chunk of capital. Improving processes to prevent similar errors recurring will resolve a majority of the problem. As seen in Table 3.3, there are 65 items falling in the top 80% value of dead stock items which will be the focus of further study. These items are blocking capital worth 6.75 million THB.

In conclusion, data is analyzed at several levels. From the over all inventory analysis, it is noticed that raw material inventory is 55% of the total stock inventory, whereas, work-in-process and finished goods levels are comparatively lower. Scrutinizing the raw material minutely through raw material trend analysis, it is gathered that the raw material inventory is not only high but has a tendency to increase, which can lead to further dead stock piling. Next, segregating active and dead stock raw material inventory by sorting and cleaning the data, enabled the researcher to isolate the true value of the dead stock. Finally, use Pareto Analysis to target the key items that are blocking the highest amount of capital. This analysis ultimately gives the area of focus. The next step would be to understand the reasons that cause this dead stock to pile up. Stock does not die overnight; understanding why it occurs and fixing the cause will prevent future recurrence. The proposed model will support improvement.

3.3 **Proposed Model**

George et al. (2004) state that every organization faces problems which get solved but reappear again. However, the Lean Six Sigma approach is a modern problem solving method which is designed to avoid recurrences and bring agility in the process. The DMAIC (Define, Measure, Analyze, Improve, and Control) model systematically and effectively solves the problem as it compels the user to use the actual data to confirm the type and degree of the problem; identify the reasons of the problem; find solutions linking to the evidence of the problem; establish improvement procedures for maintaining solutions and preventing problems from recurring again. The DMAIC model will be used in this study as portrayed in the steps below.

3.3.1 Define: The researcher will collect the inventory stock data in Excel format for twelve months of 2010, prepare an overview of the inventory stocks, and create a trend analysis graph to understand the pattern of the inventory through the twelve months, then select the category that needs prior attention as not all areas can be corrected simultaneously. In this case the raw material inventory needs prior attention as justified above in 3.2.2. This defines the area of the project.

3.3.2 Measure: To measure the extent of the problem, further detailed data of raw material inventory is to be collected for twelve months of 2010, for the amount received and issued of each item, to measure the movement and segregate the active and dead stock. After isolating the dead stock by sorting and cleaning, the Pareto analysis will be applied to the dead stock inventory to narrow down the focus of the project. The items having the highest impact occupying 80% value of dead stock items will emerge as the focus of the study. This unproductive stock should not only be disposed of, but prevention of recurrence is necessary. Therefore the items that have the highest problem should be analyzed further to get to the root cause. When the root cause is known the improvement can be suggested.

3.3.3 Analyze: To understand the root cause and prevent future recurrence the following steps will be taken.

a. The researcher proposes to seek information from the production and planning department heads of the organization to understand the reasons that cause piling of the selected dead stock items, understanding the as-is process which is causing this problem.

b. The historical data of each item will be studied to collect information based on facts. A fishbone analysis will then be made to clearly portray the reasons causing the accumulation.

c. Next, a Pareto analysis based on reasons will then be made to select the top 80% reasons that are causing raw material dead stock inventory, revealing the biggest causes to the problem. The Pareto Analysis will display the problems in descending order along with cumulative importance beside it. The most common reason for failure, defect, complaint will surface.

d. Selecting the vital reasons (i.e. roughly 80% effects caused by 20% reasons) will be studied in-depth, by understanding the as is process and revealing the critical areas, then taking steps to decrease or if possibly eliminate these root causes by improving the process.

3.3.4 Improve: Solutions to correct the process errors will be developed by getting information from the relevant staff which will lead to accuracy in solving the problem. These solutions will be recommended to the management.

3.3.5 Control: The researcher will propose recommendations for solutions to correct the present procedure, measures to sustain the process changes, ensuring new improved procedures are continued and documented, training the employees to bring awareness and a sense of commitment and instill a culture of continuous improvement so as to be able to quickly react to future problems, and therefore prevent backsliding. Share learning experience with other departments and sister companies to cultivate the improvement habit.

Table 3.4: Framework for Action Research Approach: DMAIC MODEL

Model	Action	Plan	Result	Tools
D E F I N E	Collect /review past 12 months data of inventory stock: Raw Material (yarn); Work in Process; Finished Fabric, the quantity as well as value for each item. Understand the trend of the stocks through the year.	Get an overall picture of the as-is situation. To confirm there is a problem existing and select the category of stocks that needs prior attention	Identify area to launch the project.	Sort data.
M E A S U R E	Collect detailed monthly reports of raw material, including the received and issued quantity of each item revealing movement and non movement items	Extract all dead stock items from the raw material inventory, analyze available data, and narrow down the focus of the project.	Demarcate the top 80% value of the inactive raw material of the inventory. Focus on high impact area.	Pareto Analysis 80%-20% rule
A N A L Y Z E	Seek information from department head. To confirm reasons that causes the dead stock compiling of the high impact items. Walk through their as-is process.	Utilizing the ideas and allocating to each of the items. Performing the Pareto – further sorting by possible cause.	Get a more accurate picture of the root cause of the problem. This will direct to the process improvement area.	Fishbone diagram : a thinking tool

Model	Action	Plan	Result	Tools
I M P R O V E	Select those processes which need most attention, Make changes in the process to prevent future dead stock from piling up.	Developing criteria and selecting solutions that best fit the cause.	It ensures the same problem does not recur. Develop solutions linked to real causes. Based on reality.	Pareto Analysis 80%-20% rule to be performed on the reasons to be able to focus on the top causes.
C O N T R O L	Ensuring new improved procedures are continued and documented. Training the employees	Bring awareness among all related personnel, to ensure commitment to the new process and instill a culture of continuous improvement.	Prevent backsliding Quick reaction to future problems. Share learning experience.	

Source: adopted from DMAIC Model

The framework of this research is shown in Figure 3.4. In the first phase, Define, Excel based inventory data for a twelve month period enables us to determine that the raw material inventory management process requires improvement as there is huge stock piling. The goal is to prevent future recurrence. In the Measure phase, the extent of the problem is measured. Further data collection enables us to identify the piling of dead stock raw material inventory. In the Analyze phase, the data collected is analyzed and the problem is further diagnosed, and the Pareto analysis is used to pick out the items that cause the highest impact. The gaps between the as-is state and the goal will be identified and utilized to improve the system. It is impossible to correct all causes simultaneously. Therefore to make a significant impact, in the Improve phase, problems that are causing the most impact are selected using Pareto analysis by reason, after which improvement systems will be developed. In the final Control phase, steps to improve and to sustain the improvement over a span of time will be recommended to the organization.

3.4 Summary

This chapter gives a detailed explanation of the research methodology proposed to define the problem, measure the extent of the problem, analyze the data, and understand the root cause before determining solutions. This data and facts based method will resolve a majority of the problems, and prevent future accumulation of dead stock inventory ensuring that the same problem does not recur. This research will have theoretical as well as managerial benefits.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter is a presentation and a critical discussion of results from the current processes causing accumulation of dead stock inventory and the recommended new improved processes to eliminate dead stock by nearly 80%. Following the DMAIC approach, the two steps Define and Measure have already been completed in the previous chapter, the result of the Measure step helped to identify the critical items that need to be further studied. This chapter shows an analysis of those critical items; with an in depth study of each of the 65 items selected. To identify the reasons of accumulation systematically, a Fishbone analysis is used, followed by a Pareto analysis to select the major reasons causing the accumulation. Furthermore, a study of the as-is process is done to understand the critical areas in the process that need improvement. Next, is the Improve step which recommends a new process to eliminate future accumulation of dead stock in a sustainable manner. Finally, there is a Control system to monitor operations on a regular basis to sustain reduced dead stock inventory.

4.1 Define: the researcher collected and reviewed inventory stock data for twelve months of the year 2010: raw material (yarn); work in process; and finished fabric, studying the quantity as well as value for each item to understand the trend of the stocks through the year, thereby getting an overall picture of the as-is situation. This step confirmed there is a problem existing, and identified the category that needs prior attention, which is the raw material inventory (yarn).

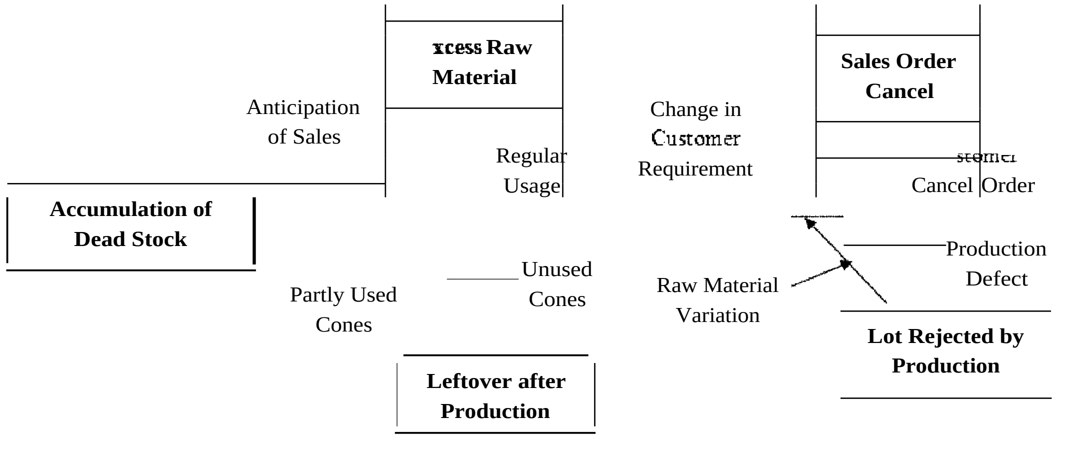
4.2 Measure: to measure the extent of the problem detailed monthly reports for the year 2010 of raw material are collected, including the received and issued quantity of each item, revealing movement and non-movement items. Extracting all dead stock items from the raw material inventory, and then using the Pareto analysis tool to demarcate the top 80% value of the dead stock raw material inventory, the result showed there are 65 items falling in the top 80% value of dead stock worth 6.75 million THB which were the focus of further study. To prevent future recurrence and further compilation of dead stock, the best solution would be to get to the root of the problem and then improve the system would. The next stage is the *Analyze stage,* which is explained in this chapter.

4.3 Analyze: To understand the root cause of accumulation, analyzing the data by studying each of the 65 items selected in depth and understanding the as-is process is essential. Therefore, detailed historical data information is sought for each item and several personal visits to the company are made by the researcher to gather information about their as-is process. It is observed that each department is interrelated and affects the purchase of raw materials. Visiting and interviewing the following departments brought an understanding of their as-is process.

	Department	Designation
1.	Fabric Sales & Marketing	Sales Manager
2.	Merchandizing	Head of Department
3.	Planning	Head of Department
4.	Production	Production Manager
5.	Raw Material Warehouse	Supervisor
6.	Research and Development	R&D Department Head

The historical data revealed the reasons for accumulation, and these are shown in the following Figure 4.1

Figure 4.1: Fishbone Analysis



The fishbone analysis shows the four reasons causing accumulation of dead stock raw material inventory, and the causal effects of each reason. This analysis is based on the 65 dead stock items studied. To make a substantial improvement by selecting reasons that have the most impact and studying their as-is process would be beneficial. Therefore, these reasons are further analyzed using the Pareto Analysis tool to select the top 80% value of reasons.

Table 4.1: Pareto Analysis by Reason Result

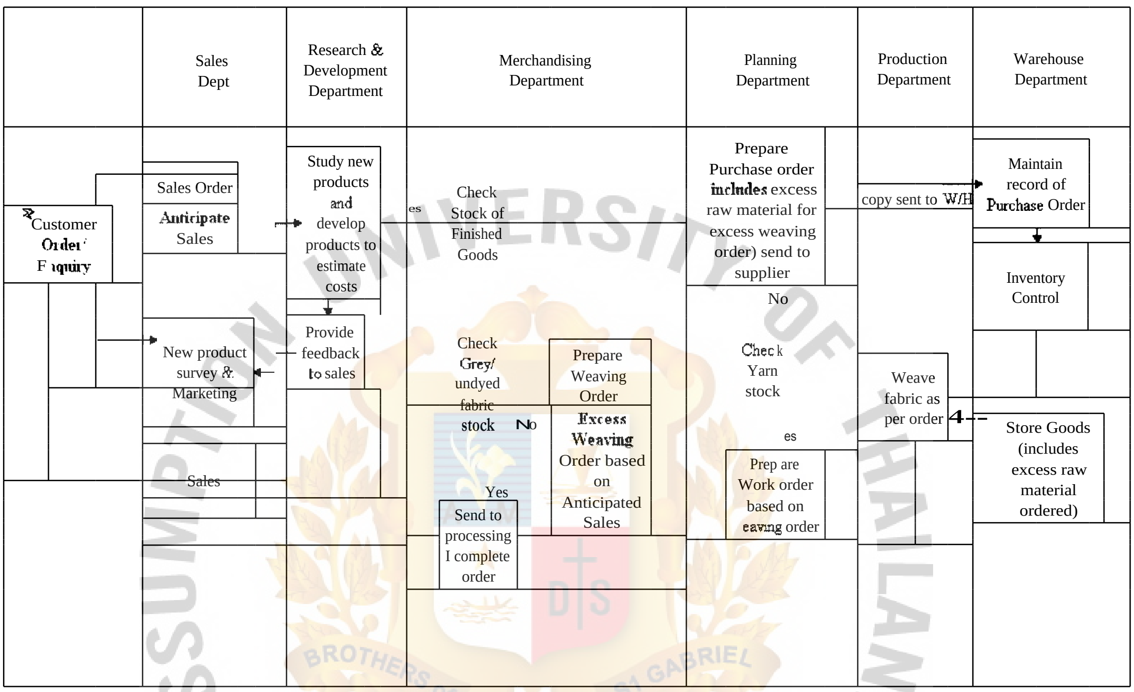
Number of items	**Reasons**	**Value (in millions)**	**Percentage of Reasons by value**
13	Excess Raw Material Order	**2.64**	**39%**
38	Leftover after Production	**2.48**	37%
6	Sales- order Cancel	**1.11**	16%
8	Lot Rejected by Production	0.52	8%
65	**TOTAL**	**6.75**	**100%**

Source: author

Table 4.1 is derived after studying each of the 65 items selected from the dead stock (Appendix B and Appendix C). Based on the historical data, the reason causing the most problem is Excess Raw Material Order, that is purchasing raw material in anticipation of future sales orders. That contributed to 39% value of the items, that is 2,643,717.54 THB worth yarn piled up as dead stock. The second most prominent reason of dead stock compiling is leftover yarn after production. The leftover yarn is not utilized but sent to the warehouse, and data shows this yarn is worth 2,481,354.57 THB. Evaluation of leftover yarn stock is never done, as it is considered to be a small percentage of the actual stock purchased. Since these two items contribute to 76% of the value of the selected dead stock items, understanding their as-is process and recommending a to-be process will provide a sustainable solution to a major extent. The as-is process is prepared after interviews with all departments.

4.3.1 Excess Raw Material Order: The process studied shows when the excess orders for raw material are placed without confirmed sale orders they may not necessarily be used, leading to accumulation of stocks which finally pile up as dead stock.

Figure 4.2: AS-IS Process Shows Excess Raw Material Order



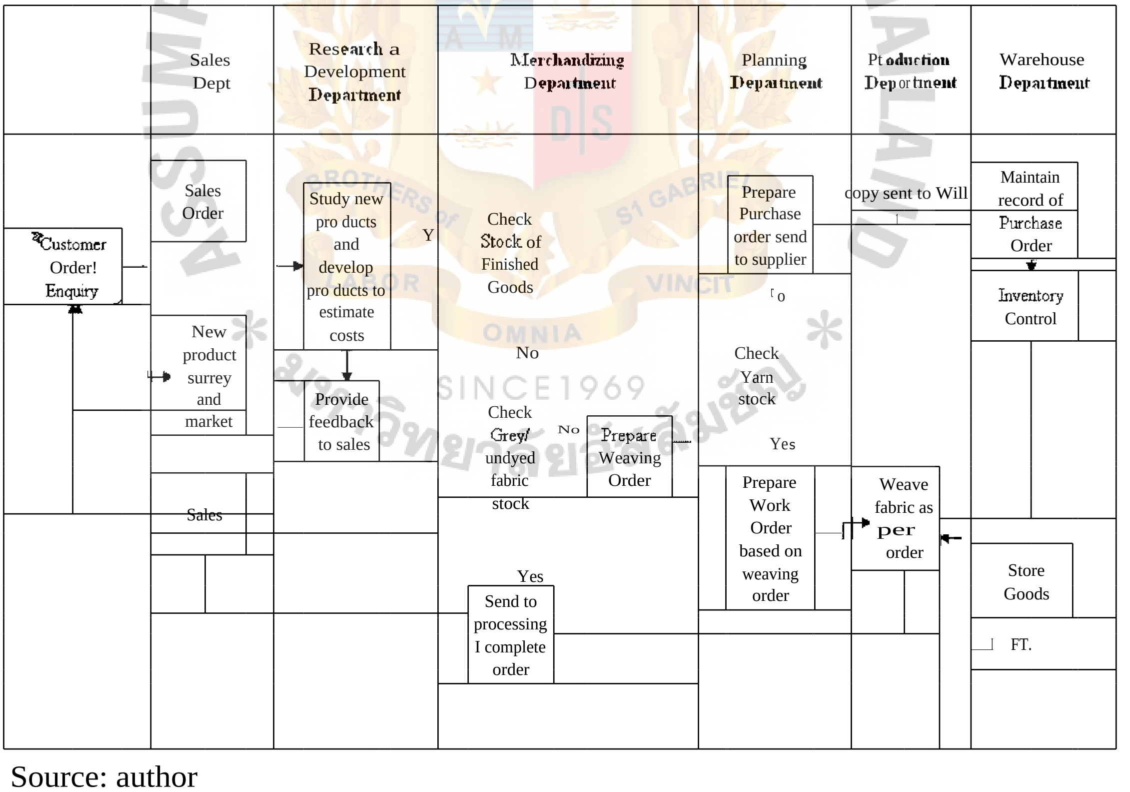
Source: author

In figure 4.2 the AS-IS Process Shows Excess Raw Material Order. In the normal order process, the customer places an order, against which a sales note is prepared by the sales department and sent to the merchandizing department. There, they check stocks of finished and partly finished goods to process the order. If stocks are unavailable they prepare a weaving order and send it to the planning department which checks stock of yarn, if yarn is available a work order is prepared and sent to production, but if yarn is not in stock a purchase order is prepared to place an order to the supplier. Once the stock arrives at the warehouse the production takes place.

However, after interviewing each department and studying their historical data it was learnt that there is a tendency to place orders for raw material based on gut feeling as there has been continuous orders using certain types of yarn. These raw materials are ordered in anticipation of sales. The sales department informs the internal departments to be prepared, which causes a bullwhip effect. The merchandizing department prepares excess weaving orders based on the anticipation of sales, and these are sent to the planning department. Stocks are checked and raw material is ordered. This arrives before the actual sale note is made, and at times it may get used but as seen from the data in Appendix B the items were ordered but not used. At present, there is no process for regular auditing of stocks to check for unused raw material.

4.3.2 Leftover: The second reason for accumulation of dead stock is observed by understanding the process after the fabric is woven. The leftover is assumed to be unusable and considered as a negligible amount and sent to the warehouse. Several lots accumulate, which if evaluated reveal a substantial amount.

Figure 4.3: AS-IS Process Shows Leftover after Production



Source: author

In Figure 4.3, after the production department completes the work order, there is certain amount of leftover yarn. This leftover is generally of two kinds, unused cones leftover and partly used cones leftover which are usually a small percentage of the raw material purchased. Leftover compiles after the weaving order is comp stored in the warehouse. This yarn may be a negligible part of each over time, several lots pile up and accumulate in the warehouse. At present, there is no process to either audit the stock or use the left over.

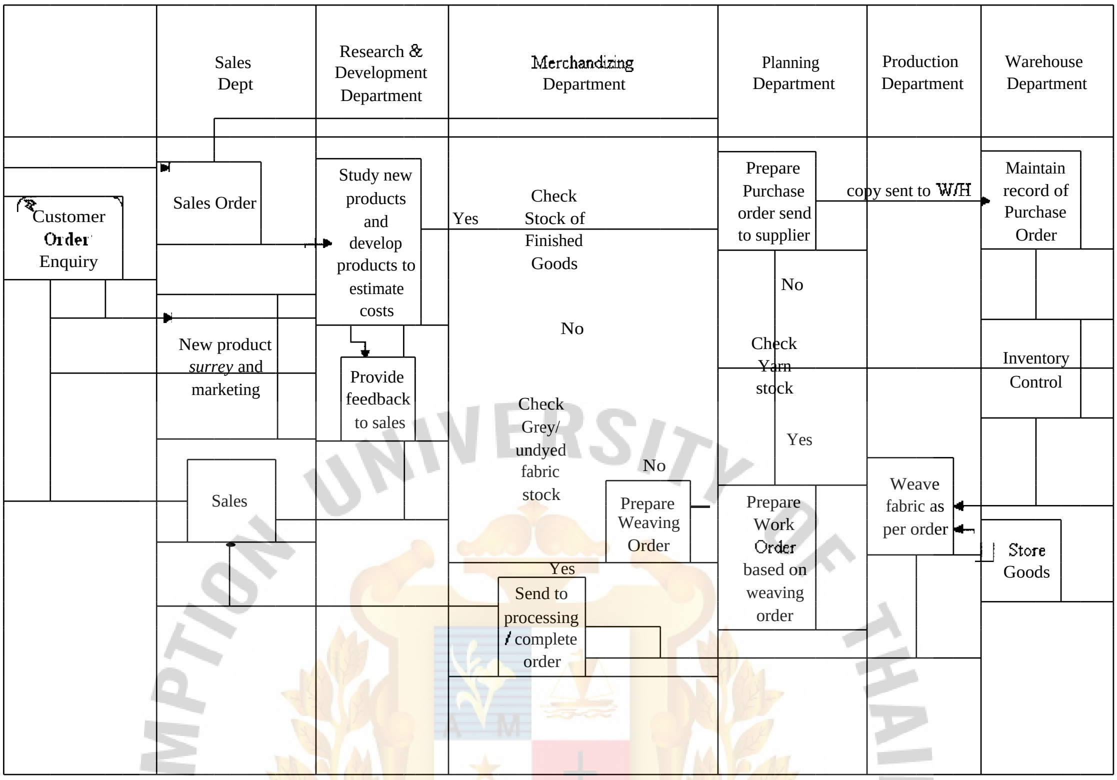
The company estimates a small percentage of leftover but the amount varies with each order depending on the shrinkage, damage, or staining, caused during weaving.

Therefore, after analyzing the data and understanding the as-is process it is concluded that ordering raw material in anticipation of orders and neglecting leftovers after production are the major cause of accumulation of dead stock. The next phase of the DMAIC approach would be to improve the above as-is process in order to prevent accumulation of dead stock.

4.4 Improve: Based on the DMAIC process the next step after analyzing the root cause is to improve the process to enable a sustainable dead stock reduction. As two reasons have been studied in depth, recommendations to improve their as-is process will be made.

4.4.1 *Excess Raw Material Order:* To improve the process and prevent future compilation of yarn which may not get used and turn into dead stock, it is recommended that made to hold stock should not be carried anymore. The supplier of yarn required is the sister company which is located 5 km away from them. Delivery time is short so there is no reason to hold stocks.

Figure 4.4: To-Be Process Shows Prevention of Excess Raw Material Order

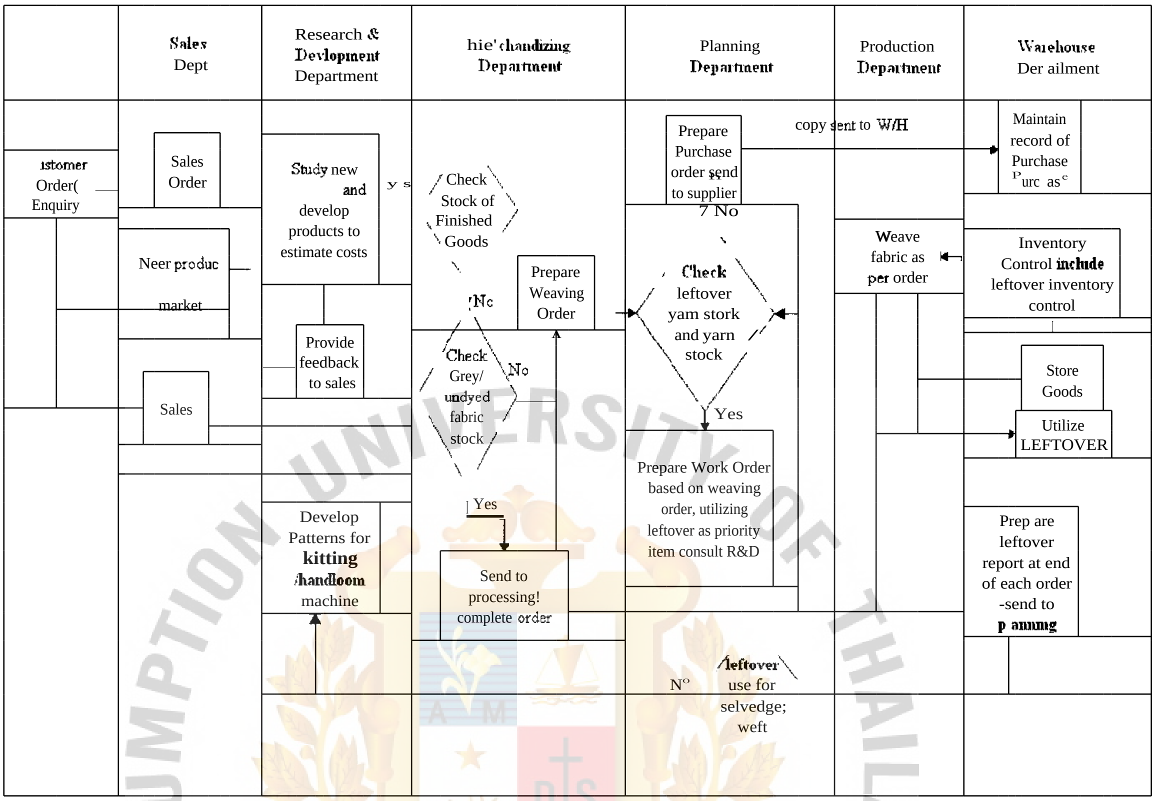


Source: author

Figure 4.4 shows the prevention of excess order. It is natural to anticipate sales orders, but by elimination of preparing buffer orders from the as-is process, raw material ordered is as per requirement, since the delivery of raw material from the supplier is only 2 to 10 days, therefore there is no reason to stock goods in advance. In this scenario, there is no excess raw material ordered as there are no buffer weaving orders to follow, ensuring no excess inventory. The weaving orders are made based on actual sale orders. This process can reduce nearly 39% of dead stock accumulation.

4.4.2 Leftover yarn occurs due to multiple reasons. Although ideally the researcher would like to prevent future occurrence and ensure zero leftover, after interviewing the production and planning departments it was not possible to have a perfect match each time as they have many conditions to meet. However, awareness of the value of leftovers is needed so as to utilize them.

Figure 4.5: To-Be Process Shows Utilization of Leftover



Source: author

Figure 4.5 recommends utilization of leftover yarn, once the leftover yarn is received by the warehouse from the production department after each work order. The leftover must be segregated by the warehouse department into unused cones leftover and partly used cones leftover, and the relevant data must be input into the information system. Unused cones can be used in normal production, however partly used cones cannot be used on the large scale machines, but handloom machines can weave such yarn. At the end of each customer order, the warehouse must generate an order wise leftover report and hand it to the planning department. The planning department decides if the items can be used for regular weaving (this stock can be absorbed into current stock), or else the report can be sent to the research and development department to consult on using the leftover on handloom machines. Utilizing the leftover will prevent accumulation.

After implementing the improved process, control measures must be implemented to prevent slack and continue the new process, as in the next step.

4.5 Control: The last most important step for DMAIC is the control phase, after improving the as-is process. Controlling the new system is essential to ensure a sustainable dead stock reduction. S&P Company must modify their software. The updated data system should accommodate the warehouse for inputting information of leftover received from the production department after weaving.

Figure 4.6: Order wise Leftover Report

Period : DD/MM/YY • to DD/MM/YY							Leftover					
Weaving Order Ref.	Yarn code	Warp Length	Total no. of Warp Sets	Total Yarn. Ordered	Total Yarn Recd.	Total Yarn Issued	Unused Cones	Unused Qty	Partially used Cones	Partially used Qty	Total left over Qty	Left Over %
Page No									Printed on			

Source: author

From Figure 4.6, an order wise left over report must be generated by the warehouse and sent in duplicate to the planning department. The planning department can analyze the leftover stock and use the copy of the report for further instruction. They allocate the leftover either for regular production or production of handloom/knitted material. The unused cones can be mounted on the creel and can be used in regular production, and therefore can be added to current stock. Instructions can be sent to warehouse. Partly used cones report should be sent by the planning department to the research and development department, which can decide the best options to utilize this leftover in knitting or handloom products.

Another report which requires to be generated by the warehouse, with the same information input earlier, is the stock ageing report.

Figure 4.7: Stock Ageing Report of Leftover Stock

Period : DD/MM/YYYY to DD/MM/YYYY (quaterly)													
Yarn code	Total Yarn Ordered	Total Yarn Recd.	Last Recd. On Date	Total Yarn Issued	Last Issued on Date	Unused Cones	Unused Qty	Partially used Cones	Partially used Qty	Leftover Balance C/F	Total leftover Qty	Leftover %	Days since issued
Page No :											Printed on :		

Source: author

This stock ageing report of leftover stock will give a consolidated report on a quarterly basis. This report must be generated by the warehouse and sent to the planning department. The planning department must be responsible for utilizing the leftover yarn before 365 days since last issued, to ensure dead stock does not accumulate.

Apart from documentation and preparing reports, training the staff on a regular basis is essential to increase their efficiency and job satisfaction. The accounting department must analyze stock reports to verify the success of the improved process. Handing responsibilities to relevant departments increases development and growth. Lastly, increase financial and human resources to support the new system in order to sustain improvement.

Summary

In conclusion, the DMAIC concept systematically helps to locate the problem and the extent of the problem, and then understand the root cause of the problem. Since it is impossible to correct all areas of the problem, the high impact areas are selected. In this research, data used is of the year 2010. Initially it was known that there is a high accumulation of raw material inventory of which 8 million THB was dead stock raw material inventory. To narrow down the focus a Pareto analysis is applied and the top 80% value of items is selected, rtesulting in 65 items blocking 6.75 million THB. To understand the root causes a Fishbone analysis is applied, analyzing the historical data of each of these items and finding the root cause of accumulation of dead stock. There are four reasons causing accumulation of dead stock, however, correcting all reasons would not be possible in this project, therefore a Pareto analysis is applied to select the high impact reasons. The top two reasons are selected. Excess order of raw material and leftover after production were the major reasons as these contribute to 76% of the reasons. Further by interviewing the heads of departments and observing on site, two separate as-is processes showing the reasons causing accumulation are drawn. These as-is processes identify the areas causing the flaw in each process, which need to be corrected. Based on the as-is process the improved processes are recommended. These processes eliminate the flaws and correct each process thereby ensuring accumulation of dead stock does not recur. To ensure the new system is sustained, control measures are also recommended. Implementing the two new processes will reduce 76% of the dead stock, while the control measures will ensure there is a sustained improvement in those areas.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The research conducted was based on a textile company which faced a problem of accumulation of dead stock raw material inventory. Using the DMAIC concept the area of the problem was defined, the extent of the problem was measured, historical data was analyzed, and personal visits to the site combined with interview of department heads revealed the root causes of accumulation. Understanding the as-is process showed the critical areas which if improved could reduce the problem of accumulation of dead stock by nearly 80%. Next, an improved process has been recommended and control measures have been stated. This chapter presents the summary findings, conclusions, theoretical and managerial implications, limitations, and recommendations for future research.

5.1 Summary of the Findings

Early findings showed the S&P weaving company holds large quantities of inventory, analyzing the inventory stocks for the year 2010 showed the company holds raw material, un-dyed fabric, partly processed fabric and finished fabric. Further study showed raw material inventory had the highest stocks with a tendency to increase, which meant that if inventory management is neglected there would be further accumulation.

Therefore, the focus of the study was raw material inventory. Scrutinizing the raw material inventory for the year 2010 showed 48% items consisted of dead stock inventory, blocking nearly 8 million THB. These items had no movement over a span of twelve months. To narrow down the focus of the project and study the high impact areas the Pareto analysis tool is used to select 80% value of the items. This resulted in 65 items being selected for further study.

Historical data of each of the 65 items was retrieved from the company database and interviews with relevant heads of departments revealed the reasons for accumulation of dead stock, which are displayed in a fishbone analysis. Next, the Pareto analysis is used to select the reasons having the highest impact (excess order of raw material based on anticipation of sales and leftover after production). The final step in the analysis process was to understand the as-is process. This shows the areas currently causing the accumulation. Improving these areas would improve the process and prevent future accumulation of dead stock of raw material.

The improved processes are recommended. These will result in sustainable dead stock reduction, performance improvement, work efficiency and higher profitability. The findings in each step define, measure, analyze as well as the new processes recommended in the improve step and finally the control phase are all based on real data and direct interview with the company personnel. The key benefit is summarized below:

5.1.1 A reduction of 39% of dead stock inventory by implementing an improved process of ordering raw material as required. Made to hold stock should not be carried out as the supplier is their sister concern.

5.1.2 A reduction of 37% of dead stock inventory can further be achieved by implementing the improved process of utilizing leftover stock, this can be done by generating regular reports, analyzing stocks and allocating responsibility to heads of department to ensure the leftover raw material has been utilized after production.

5.1.3 The control process ensures the new procedure continues which instills a culture of sustained improvement as the employees are trained and the efficiency increases.

5.2 Conclusions

International Trade Centre (2000) recommends improvement and performance evaluation must be continuous and become a routine. It also suggests remembering that what gets attention often gets improved.

Although S&P Company is making an overall profit, neglecting stock evaluation means that the accumulating raw material eats away the company's profits. By improving their process and paying attention to stock management will further increase the profitability margin.

In this case study, the DMAIC concept systematically revealed the problem and the extent of the problem. It helped to understand the root cause and then get to the critical areas which need improvement and create new processes to improve the as-is process. The improvements have been designed specifically to reduce the flaw that is occurring in the as-is process. This method enables the achievement of a long lasting improvement. The control measures will ensure the new system sustains itself.

5.3 Theoretical Implications

Using the Lean Six Sigma Methodology by adopting Define-Measure-Analyze-Improve-Control (DMAIC) tool, structurally defined the problem, measured the extent of the problem based on data and facts. Analyzing the data led to understanding of the root cause. Once the root cause was known improvements were specifically designed and controls set to prevent future recurrence.

This method will improve the organization's profitability and revenue growth, cut costs, reduce inventory and lead time and increase customer satisfaction. It will develop valuable job skills such as problem solving, teamwork and decision making. Most importantly, it increases work efficiency as it eliminates wastes by working on as-is data reports rather than gut feeling.

5.4 Managerial Implications

The benefit of this research aims that it recommends actions to prevent future piling of dead inventory, since prevention is better and cheaper than cure (Tersine & Tersine, 1990). On implementing these recommendations, the organization will become more profitable by obtaining increased revenue, cost-cuts, improved delivery time, reduction of inventory, vacation of valuable warehouse space and improvement in its operations. Along with that, it will improve decision making and problem solving skills with stronger team work and a better work place by terminating the problem of dead stock piling in raw material inventory.

This project may be used as a guideline for the management to implement similar projects in other areas of the organization in order to bring fundamental improvement in the process and increase profitability without compromising on customer service.

5.5 Limitations and Recommendations for Future Research

This research focuses on prevention of future dead stock of raw material compiling at S&P weaving company using the DMAIC concept. The result of the data analysis shows that inventory management systems require improvement. There are several limitations to this case study as mentioned below:

5.5.1 The paper analyzes raw material inventory and has focused only on the top 80% value of dead stock inventory to understand the causes of this compilation and recommended improvement of the process in order to prevent recurrence in future.

5.5.2 The study is based on historical data of twelve months of 2010.

5.5.3 This study focuses only on raw material dead stock inventory.

5.5.4 This research is conducted in the context of only a single industry, the textile industry.

The recommendation for future research would be to check inventory stock of work-in-process and finished fabric as there is the possibility of accumulation of dead stock inventory in these areas as there is no evaluation of stocks. By reducing unwanted stocks and trimming wastes the system will be lean and efficient resulting in higher profits and better performance.

This case study focused only on accumulation of dead stock inventory. It is recommended to study total inventory, stock ageing reports, and evaluation, to ensure that the inventory system is in good shape.

The DMAIC concept can be applied in other areas of the organization as well as other types of organization. Adopting this concept, the problems are understood from the root and the solution recommended is designed to solve the specific problem.

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APPENDICES

APPENDIX A

Warehouses stacked with yarn

APPENDIX B

Excess Orders of Raw Material without confirmed Sales

	YARN ID	ITEM NAME	FABRIC CODE			WEAVING ORDER NO.	WO DATE	YARN QTY	YARN RATE	AMOUNT
1	1	TR30NEP/LYCRA40D	TR	6302	C	12591	29/Oct/09	7518	141	1,060,015.95
	1	TR30NEP/LYCRA40D	VP	6463	A	12591	25/Nov/09	8,671	141	1,222,631.83
2	20	C10RK70D	TF	5550	J	8508	29/Dec/04	1,172	48	56,277.00
3	32	CC/TR2120-SL	TF	6078	A	12485	7/Oct/09	1,544	23	35,512.41
4	37	T18SL	TF	6077	A	12597	21/Sep/09	622	49	30,072.04
5	39	FCD18SL	TF	6150	H	12669	30/Jan/08	412	73	28,257.19
6	46	TF150/144/2/IL	L	6494	A	12675	25/Feb/09	628	45	27.938.22
7	47	CD150/48/IL/280-Z	PV	5514	C	7014	20/Dec/09	755	37	27,781.42
8	48	CC/TRCD900(HS)	TF	6032	G	12330	11/Jan/09	1,323	21	27,703.19
9	49	PK12OE	TF	6028	A	12184	12/Jan/09	729	38	25,670.05
10	52	TF300/96-RK70	TR	5059	A	5622	1/Oct/09	292	88	25,368.18
11	54	T28SL-VHF	TR	5068	A	5999	9/Jan/05	461	55	21,743.86
12	59	VCD24OE	TR	5933	A	12632	19/Jan/09	452	53	23,932.15
13	63	LP/FRC D940	TF	6022	H	12523	5/May/09	100	218	21,876.30

APPENDIX C: Leftover Yarn after Production

	Yarn Id.	Yarn	Recd Qty	Issued Qty	Leftover Qty	Leftover %	No. of lots	Value
1	3	CC/TCDR-SL-735 Total	154,925.30	151,067.66	3,857.64	2.49%	9	667,371.72
2	4	FCDV28N-SL Total	117,849.79	115,103.89	2,745.90	2.33%	4	189,467.10
3	5	TRS40/2HS Total	126,972.48	125,080.59	1,891.89	1.49%	7	147,567.42
4	6	TF150/34/IL/3 Total	66,230.22	64,740.04	1490.18	2.25%	5	120704.58
5	7	TF150/34/IL/280-Z Total	52,978.26	51,637.91	1340.35	2.53%	6	111249.05
6	9	CD150/48/3/IL Total	58,379.29	57,561.98	817.31	1.40%	5	92,356.03
7	10	AP/TR270 Total	52,466.67	51,884.29	582.38	1.11%	9	87,357.00
8	15	TF150/288/IL Total	36,880.38	36,297.67	582.71	1.58%	4	71,673.33
9	16	CC/TR-3185SL-ET Total	21,873.19	21,359.17	514.02	2.35%	5	67,850.64
10	**18**	CC/FRTCD-SL-440 Total	14,187.70	13,841.52	346.18	2.44%	4	66,466.56
11	19	CC/FRPCD1190 Total	13,070.43	12,734.52	335.91	2.57%	2	62,815.17
12	24	FRT75/72/[illegible]/IL Total	15,001.60	14,721.07	280.53	1.87%	3	50,495.40
13	27	AC/FRTCDX450(BL-SIL) Total	7,756.90	7,531.95	224.95	2.90%	2	42,740.50
14	29	CC/FRTCD-SL400 Total	9,059.24	8,843.63	215.61	2.38%	2	38,809.80
15	31	BK/TR1040 Total	11,750.88	11,549.94	200.94	1.71%	2	35,767.32
16	33	CD28SL Total	26,141.12	25,626.14	514.98	1.97%	4	35,018.64
17	34	BB150/48/3/120-Z Total	14,233.33	13,981.40	251.93	1.77%	2	34,514.41
18	35	CDT10-NEP Total	33,192.36	32,671.24	521.12	1.57%	5	31,788.32
19	36	CC/TR-3190SL-ET Total	18,590.98	18,364.17	226.81	1.22%	3	31,753.40
20	38	TKR14-OE-SLMC Total	40,668.75	40,083.12	585.63	1.44%	4	30,452.76
21	40	RM36/SD30 Total	22,739.44	22,330.13	409.31	1.80%	3	29,879.63
22	41	CC/TRCD-SL-735 Total	11,845.89	11,672.94	172.95	1.46%	3	29,747.40
23	42	TKR14OE/2 Total	27,932.06	27,348.28	583.78	2.09%	3	28,605.22
24	43	TF300/96/2/IL Total	21,116.56	20,785.03	331.53	1.57%	5	28,511.58
25	44	T27-LSL Total	19,384.19	18,856.94	527.25	2.72%	4	28,471.50
26	45	BKT-1010 Total	6,159.00	5,974.23	184.77	3.00%	2	28,269.81
27	50	VP19SL-HF Total	18,793.98	18,232.04	561.94	2.99%	4	27,535.06
28	51	TF150/96/3/IL Total	26,431.37	26,161.77	269.60	1.02%	4	27,229.60
29	53	TF150/48/3/IL(BL) Total	15,375.47	15,131.00	244.47	1.59%	3	25,424.88
30	55	TR28OE Total	35,748.62	35,101.57	647.05	1.81%	9	25,234.95
31	56	TRS30/TRS30RK40D-ET Total	30,440.77	30,045.04	395.73	1.30%	3	24,930.99
32	57	CC/FRTCD-SL-695 Total	8,846.63	8,702.43	144.20	1.63%	2	24,514.00
33	58	FRP11LSL/3 Total	11,179.36	10,865.22	314.14	2.81%	4	24,188.78
34	60	AP/TCDX300 Total	5,504.50	5,345.42	159.08	2.89%	2	23,862.00
35	61	TRS40/2 ET-HS Total	16,179.18	15,782.79	396.39	2.45%	3	23,783.40
36	62	VP12OE Total	18,743.75	18,263.91	479.84	2.56%	5	22,072.64
37	64	AC/T270 Total	9,115.38	8,878.38	237.00	2.60%	5	21,567.00
38	65	TR20OE Total	18,690.33	18,129.62	560.71	3.00%	3	21,306.98
								2,481,354.57