IMPROVING WAREHOUSE EFFICIENCY THROUGH
WAREHOUSE MANAGEMENT TECHNOLOGY AND
INVENTORY CLASSIFICATION: A CASE STUDY OF
GRINDING BALL MANUFACTURER

By
SURAWIT NAKBUA

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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November 2014
Declaration of Authorship Form

I, Surawit Nakbua declare that this thesis/project and the work presented in it are my own and have been generated by me as the result of my own original research.

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Date November 8, 2014
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(Assoc. Prof. Dr. Sompong Sirtsoponslip)

Date November 8, 2014
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Surawit Nakbua
Assumption University
ABSTRACT

This study is a case study of a grinding ball manufacturer. The company is facing the problem of increasing aging inventory (the batch item that stays in inventory for more than six month as aging stock that requires quality assurance attention) and non-production related delay shipment at the end of year 2013. The paper observes and tries to find the root causes of this problem by using fishbone analysis. Once the root causes is identified, the study then recommends the new approach by applying a concept of inventory classification by nature of demand and automated warehouse management system to solve the problem found and improve warehouse efficiency.

Using a computerized warehouse management system has great benefit toward warehouse operation process. It is proved in many studies that technology is able to improve utilization of space, eliminate or reduce paper work; reduce clerical overhead, provide stock location control and greater stock accuracy. At the same time, improve warehouse service levels and provide more management information. With the help of inventory classification, a new to-be process is studied and proposed. The methods help the worker to eliminate extra handling, reduce time, and First-In, First-Out can be maintained.
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Assumption University
Martin de Tours School of Management and Economics
Master of Science in Supply Chain Management

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I,  [Dr. Scott Roach], have proofread this thesis/project entitled
IMPROVING WAREHOUSE EFFICIENCY THROUGH WAREHOUSE
MANAGEMENT TECHNOLOGY AND INVENTORY CLASSIFICATION: A CASE
STUDY OF GRINDING BALL MANUFACTURER

[Mr. Surawit Nakbua]

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

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Date:  February 16, 2015
CHAPTER I

GENERALITIES OF THE STUDY

Warehouse management today is playing a more important role and even causing the failure of businesses. Warehouse performance can be represented as a critical intermediate role between supply chain pipeline, affecting both supply chain costs and service level. Thus, warehouse operation is something that an organization has to consider as another critical factor to be successful. There are many firms that consider the warehouse as a storehouse where they can keep products or other equipment unorganized. This kind of perspective led many firms to a big problem afterward. This can cause inefficient operation in warehouse. A poor control system in warehouse will affect the time required to locate items the warehouse staff may spend more time looking for products in the storage area because they have no idea of the location of the required product, or the product is located in other location that was not supposed to be. Then, another common problem is the older product stays in warehouse for too long. This causes the firm to bare extra material handling in the warehouse which leads to higher cost eventually. In order to avoid unnecessary expenses, optimize material flow, and eliminate waste, a suitable warehouse layout design needs to be developed.

A good warehouse should have certain characteristics such as modularity, adaptability, compactness, accessibility, flexibility, and distribution of movement to enable it to respond to changing conditions, improve space utilization, and reduce congestion and movement. The study therefore attempts to adapt and deploy a holistic view of warehouse management technique to improve performance of the traditional warehouse in ABC Company.
1.1 Background of the Research

“ABC” company is the manufacturer of a grinding media used in mining, cement, and recycling industries. It serves over 84,000 tons of grinding balls each year domestically and throughout the world. It was first established in Thailand in 1990, currently has two plants and over 400 employees supplying different types of grinding balls categorized by sizes and material aspects (alloy or chemical composition which reflect hardness of the ball). Over 100 sizes and alloys are now available for customer selection. Options of package are also available for the customers choosing to fulfill their requirement. There are three main types of packaging as follows (Figure 1.1):

a) Drum: grinding balls packed 900 kilograms per oil drum
b) Jumbo Bag: grinding balls packed in 1000 kilograms per bag
c) Container Bulk: no packaging, the goods will be put in container in bulk of 21 to 23 tons

Figure 1.1: Samples of ABC’s Products
The product is normally stored in drums or sometimes in bags and then placed in a plain outdoor area with no roof. Thus, most of the time bag will be packed just before loading due to durability issues; a bag can only last for three or four months outdoors. In the storage area, drums and bags are placed on pallet. Three drums or two point seven tons can be placed on one pallet. With two pallets, five point four tons can be double stacked in one location. On the other hand, only one bag or one ton can be placed in a slot. As for delivery, around 70 percent of the balls are shipped in drum and bag. Approximately 80 percent of customers are overseas customers. The export shipment is then usually shipped by sea container, or sometimes trailer (border delivery) or air freight (hurry and small shipment). As for the rest, 20 percent of domestic shipment is mostly delivered by trailer or ten wheel truck.

With an increasing demand as shown in figure 1.2, the company is currently preparing to open a new plant, in order to increase its capacity. The target of full capacity of the new plant alone is 55,000 tons. The firm is planning to achieve full capacity in three years. Hence, the total capacity of the company after three years is going to be approximately 139,000 tons yearly.
1.2 Statement of the Problems

The ABC Company has been managing its warehouse in a traditional way with no design of layout to support its function. The researcher found that its poor organization has led to two problems. Firstly, warehouse operation inefficiency which is unable to complete cargo operation within deadlines due to slow retrieving or picking process. As a result there is a present of non-production related delay shipment. The logistics department always tries to keep zero delays unless there is a problem in production which is understandable. The overtime working hours are also increasing and exceed the limit of ten percent allowance according to the organization’s rule. Secondly, an accumulation of
aging inventory keeps increasing. This is normally unacceptable because it requires extra quality assurance attention.

Table 1.1: Number of Non-production Related Delay Case and Overtime

Percentage Year 2013

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tr>
<td>Number of Non-production Related Delay Case (Case)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Over time Percentage</td>
<td>3%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
<td>7%</td>
<td>9%</td>
<td>6%</td>
<td>4%</td>
<td>8%</td>
<td>4%</td>
<td>12%</td>
<td>13%</td>
</tr>
</tbody>
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Source: ABC Company Records

Lack of inventory visibility has resulted in aging inventory (the firm determines the batch item that stays in inventory for more than six months as aging stock that requires quality assurance attention) piling up. This requires extra material handling in the warehouse. These factors create lots of waste in the warehouse that is excessively consuming the company's resources more than it is supposed to be. With an increasing potential sales volume, it would be very difficult for the company to handle a larger amount of stock with current warehouse management methods. According to the dispatch volume record of Year 2013 and the current year 2014 target, the company has to produce and ship 84,000 tons per year (or 7,000 tons per month) to achieve the target.
After the grinding balls are produced, non-pre-allocated products will be stored in the storage area. Those pre-allocated ones will be staged and prepared for loading instantly. After the production has finished, the logistics department takes responsibility to handle
those finished goods (FG) until they are shipped out from the factory. The reasons why the firm needs stock are because it can act as a buffer to satisfy the customers. Another reason is when the machine starts to produce any specific item; it cannot produce an exact quantity. It is a constraint in the company’s production line that can only be solved by a new technology. The machine usually produces an extra five to ten percent depending on the size of the grinding ball. These over produced goods are then going to be stored in warehouse. The stored items are usually put away in the storage area with no location specified.

Once there is an order, the staff will check the stock availability and then look for the product that can be found in the storage area. Since the goods are stored randomly (no location for specific items or specifies categories) the staff then requires extra time to find where those products are stored. Additionally, the firm has no roofed warehouse to store the goods; the products are stored in a plain outdoor area with a Last-In, First-Out (LIFO) basis. If the required product is inside, the staff will need to take the entire blocking items out and then return them to the same place afterward which is considered as extra material handling. Besides that, the old items sometime will not be retrieved and left at the bottom.

This year the department has set the target to reduce the aging inventory to five percent and any non-production related delay case is unacceptable. Since the current warehouse operation creates lots of aging inventory, obviously it brought more difficulty toward the warehouse operation. More and more old stock keeps piling up and continues to increase as shown in Figure 1.4.
Thus, the research is then attempting to study warehouse management techniques and the use of an information technology assignment aiming to answer the research question “How does information technology and warehouse management techniques support the warehouse operation and reduce the aging inventory to five percent and non-production related delay cases to zero”.

1.3 Research Objectives

The objective of the study is proposed as follows: First, the research attempts to use a data analysis tool to find the root cause of the problem that has occurred. Then the study
applies the concept of warehouse management and the use of information technology to better control and improves ABC Company’s warehouse operation by reducing aging inventory and non-production related delay cases. To find the best combination of warehouse management technique with an information technology that can solve the problems that ABC Company is facing.

1.4 Scope of the Research

The research was conducted to examine the existing warehouse current process of ABC Company. Warehouse management concepts and information technology will be applied to improve the control process of warehouse operation and reduce unnecessary movement, handling time, and excess of aging inventory. Then this study will introduce a tool for improving the order cycle time. Class-based storage layout is one tool that has appeared in many academic and professional papers and is shown to help reduce picking time. Time measurement of order cycle time was used to determine the performance of the existing and the improved process. Data was collected by time measurement, review of the company’s records, and an interview with the key man.

1.5 Limitations of the Research

The study did not seek to involve with other departments that cause dynamic workload during the month, for example, the Sales Department or Planning Department who are responsible for the demand management. However, it aims to increase warehouse process efficiency with existing resources.

1.6 Significance of the Research

The research studies academic and professional papers regarding warehouse management techniques. Then applies them in the real business in order to find out whether these
warehouse operation frameworks can actually improve the process of receiving, storing, picking and allow the firm to better control its warehouse operation flow, reduce extra handling time, and decrease aging stock and the cost incurred. The paper can be useful for any person who seeks to study those mentioned issues for academicals or professionals proposes.

1.7 Definition of Terms

Class-Based Storage (CBS)  The warehouse management technique that divides stock-keeping units (SKUs) into storage classes by demand and randomly assigns storage locations within each storage class area (Petersen, Aase, & Heiser, 2004).

Efficiency  The stage that resources and relationship between resources are coordinated in a timely, complete, and reliable manner (Faber, Koster, & Smidts, 2013).

Inventory  One or more items of a physical nature moved and held from the primary source to the final customer and not undergoing any form of transformation (Howard, 1974).

Inventory management  A way to minimize the cost associated with inventory decisions (Howard, 1974).

Order Picking  The process of retrieving items from warehouse storage locations in order to satisfy customers’ orders (Petersen et al., 2004).
Warehouse

A planned space for accommodating and handling of materials and goods (McKibbin, 1976).

Warehouse Management

The method to efficiently and effectively coordinate all warehouse processes and activities including all the planning and control procedures operating and managing the operations to satisfy the customer (Faber et al., 2013).

Warehouse Performance

The measurement means to identify and solve warehouse problems, and to reduce cost by improving operation (Gunasekaran, Marri, & Menci, 1999).
CHAPTER II

LITERATURE REVIEW

This chapter reviews the related literatures which are composed of main interest sections that can be helpful for improving the warehouse operation performance. This starts with the basic function of warehouse and warehouse management to gain the understanding of basic management method. In addition, warehouse planning and layout were also studied. Inventory and inventory management were also explored in order to understand the nature of each type of inventory which can be used to help the researcher to find the way to improve space utilization. Then the researcher studied the nature and benefit of ABC or Pareto approaches toward warehouse management such as reducing inventory and designing the warehouse layout supporting warehouse operation.

2.1 Role of Warehouse

According to McKibbin (1976), the warehouse is a planned space for accommodating and handling of materials and goods. The warehouse roles are:

1. Allowing the unbalanced flow of materials from production or external sources.
2. Providing enough buffers against production failure or unstable order lead time.
3. Absorbing standard costs of production runs.
4. Holding buffer stock against seasonal, peak and unknown demand.
5. Providing physical resources to support economic order quantity buying or producing.
An efficient warehousing should provide a greater volume of throughput at a lower cost. It can be achieved by the best combination of operating cost, material handling equipment, labor utilization and space utilization.

2.2 Warehouse Management

Gunasekaran, Marri, & Menci (1999) stated that warehouse operations and activities concern the physical handling of materials including storage and retrieval of them. This includes the processing of the goods’ information such as the goods’ origin, identification, dimensions and packaging. The management must ensure that the right stock level is maintained, no unnecessary capital is sunk in inventory, and warehouse capacity is efficiently utilized.

The operations should be economical, and the products are kept properly. They also conclude that there are six major activities as follows:

1. Receiving
2. Transfer
3. Handling
4. Storage
5. Picking
6. Expediting

The researchers suggested that it is quite important to ensure that there is a good methodology is put in operation to distribute the goods from the production line to the customer economically and punctually, using a shortest-path strategy, and avoiding unnecessary waiting time. Moreover, the organization might as well consider make-to-order system, pull system electronic data interchange (EDI), reducing incoming product
inspection, improving accuracy of the forecasting and minimizing the number of personnel in the system.

Warehouse performance is measurement as a means to identify and solve warehouse problems, and to reduce costs by improving operation. Faber et al. (2013) stated that the warehouse management is a method to efficiently and effectively coordinate all warehouse processes and activities including all the planning and control procedures, in order to increase warehouse performance. Operating and managing the operations to satisfy the customer consists of three aspects as follows:

1. Planning systems include stock planning that decides what quantities of which product should be kept in storage, and storage location planning that helps by assigning the location types and zones where the goods will be stored. Good planning systems may help the organization to reduce warehouse cost; space needed and travel time during storage/retrieval and order picking. Finally, capacity planning determines the required resources such as personnel, handling equipment and transport capacities.

2. Control systems include monitoring, analyzing, and reporting. The information should be recorded and presented for physical stock in a timely manner and accurately, in order to ensure what happens and then make necessary adjustments.

3. Inbound, storage, and outbound flows are dealing with sequencing, scheduling, and routing of storage/retrieval and order picking operations.

The more competitive environment is forcing organizations to lower costs and improves customer service by faster response and is leading many firms to seek new ideas to implement in their warehouse facilities. At the operational level, existing warehouse operation improvement research focused on the main operation to improve the performance of picking, routing and storage time. Moreover, according to their study, warehouse management is driven by two important factors which are task complexity and
market dynamic. These two factors have to be reviewed to improve the warehouse management (Faber et al., 2013).

Ballard (1996) suggested in his study that a good warehouse management system does not necessarily mean fully computerized in real time. It is important that the solution is suitable to solve the problem of each organization. However, the best way to provide easy monitoring is certainly with some computerization. Most organizations seeking to make improvements in this area would be well advised to implement a warehouse management system, but not necessarily to be a radio frequency communication. The following list contains some characteristics of good system:

1. Job sequencing: either through the controlled use of paper lists or through the use of radio frequency communications. Good systems will allow upgrade from one to the other.
2. Control of picking: to determine pick sequence by location and manage pick sequence for FIFO or other requirements.
3. Job verification: ability to check that each activity has been completed.
4. Location control: sometimes managed by the inventory control system but much better managed by the warehouse management system. Random location control allows the system to optimize the use of the warehouse space, subject to user-defined constraints on use of product zones.
5. Automatic replenishment: where appropriate the system should automatically issue movement instructions to move stock from back up locations to picking locations.
6. Performance monitoring: provision of derived information such as picking rates and error rates from analysis of picking, discrepancies etc.
7. Supervisory functions: Quarantine, QC hold, area flushing, perpetual inventory counting.
8. Reporting: ability to provide comprehensive user-defined reports based on any of the fixed, variable or derived information.

9. Interface with other management information systems: ability to receive and send data from and to other business systems including inventory control, purchasing and sales processing. Inventory control and warehouse management working together

2.3 Warehouse Planning and Layout

Planning and layout are essential. In essence, layout is the planning and integration of overall material movement, designed to achieve the effective and efficient relationship between men, equipment and the use of space (McKibbin, 1976)

Gunasekaran et al. (1999) stated that warehouse layouts are the perfect examples of fundamentals often neglected. Most organizations simply treat the warehouse as a place where product is stored until it needs to be shipped to the customer. This often results in the shutdown of warehouses. A properly installed Warehouse Management System (WMS) can change the way a company does business. Any changes in WMS should be communicated and coordinated throughout the organization.

According to McKibbin (1976), during layout planning, the inventory analysis and a summary of sales volume by product, class or line item must also be considered in developing an efficient warehouse planning and layout.

2.4 Inventory and Inventory Management

According to Howard (1974), inventory is one or more items of a physical nature moved from the primary source to the final customer and not undergoing any form of transformation. It can be categorized in three classes as follows:
1. Fluctuation inventory
2. Lot-size inventory
3. Speculative inventory

Fluctuation inventory is there to meet an uncertainty of demand such as seasonal demand. Lot-size inventory occurs when batch size from production or transportation is much greater than demand; the inventory will suddenly increase after production is finished or the transportation has reached the warehouse. Finally, the speculative inventory is an extra inventory that be held as a contingency against a major break in the supply chain.

Inventory management can be a way to minimize the cost associated with inventory decisions. However, the objective of inventory management is not always reducing inventory level. According to Howard (1974) an effective inventory management must rely on stock recording and stock control. Stock recording is an accurate record of receipt, issue, balance, order allocation, return and adjustment. Stock control focuses on the order timing and order size. The control system should alert the user when the stock is too low and the order quantity should be changed accordingly. Once timing and size of order is determined the control system process can be performed as routine unless there is a significant change in demand pattern.

2.5 Improvement of Efficiency in Warehouse Operation

According to Gunasekaran et al. (1999), improvement of warehouse operations can be realized using software and automatic data collection. Software is an important control and scheduling tool suited for enhancement of warehouse operations. It supports a better handling of goods, keeping track of inventory and serving customers. Order picking in the warehouse involves determining a sequence of locations where the parts of each order are stored. With the computer tracking of inventories, parts may now be stored in
multiple locations, eliminating the need to reserve an extra space for each item. Gunasekaran et al. (1999) have developed two conceptual frameworks for improving the effectiveness of warehouse operations: JIT (Just-In-Time) application and TQM (Total Quality Management). They found that the processing of information plays an important role in warehouse activities. Since each individual order batch has specific detail, an efficient and reliable data handling system is needed to store more accurately. There is a tradeoff between transportation and inventory level when JIT application is applied. Barcoding and EDI (Electronic Data Interchange) prove useful. The introduction of ERP or Enterprise Resource Planning system, a business management software usually a suite of integrated applications that a company can use to collect, store, manage and interpret data from many business activities, normally including; product planning, cost, manufacturing or service delivery, marketing and sales, inventory management, and shipping and payment can greatly expand the level of improvement.

2.6 Fishbone Analysis

Cause-and-effect diagrams are called Fishbone diagrams since the design looks like a fish skeleton. It is a tool for problem solving and analyzing the process dispersion, to help the cross-functional team identify the potential root causes to effect by brainstorming until the root causes are identified. The analysis will begin by clearly defining the problem, identifying possible root causes, drawing the diagram as displayed in Figure 2.2, brainstorming the idea to find where the problems begin and discussing how to eliminate the root causes (Garnes & Vikhagen, 2011).
Figure 2.1: Fishbone Diagram

Source: Garnes and Vikhagen (2011)

Figure 2.2 shows a fishbone diagram template. The effect of the problem is on the fish head and the main causes of the problem are along the fish bone in each classification. The causal factors are laid out alongside the main causes.

2.7 ABC Classification

According to Sander (1987), the ABC classification was proposed by an economist/sociologist named Vilfredo Pareto. By his observation he concluded that about 80 percent of wealth was concentrated in about 20 percent of population. The rule was popular and had been applied to many professions. For example, it is used in identifying the major problem in quality control processes, the major contributing customer accounts or sales force in sales and marketing, and even product classification in inventory management and warehouse management.
2.7.1 Classification of Item by the Nature of Demand

Based on Howard (1974), the practice of the level of importance ranking by some criterion is well known. The most usable is annual sales and level of contribution. This gives rise to the well-known “ABC” or “80-20” classification, also known as Pareto principle. It suggests categorizing the inventory into three classes due to their sales volume in order to more easily control inventory. There are some studies that have proven that it can be useful to operations in a warehouse as well.

2.7.2 Sample of Implementing ABC Classification in Warehouse Management

One study by Petersen (1999) was conducted in order to find out the impact of routing and storage policy on warehouse efficiency. The study was carried out focusing on two main policies, routing and storage. The use of several routing and storage strategies was examined by experimenting using a random pick list. With those strategies given, the travel speed and picking rate of the warehouse seemed to be reduced significantly. Therefore, in order to develop efficiency in warehouse, picking/routing and storage policies should be determined. The storage location assignment problem has been a critical issue in warehouse operations management for a long time (Battista et al., 2014). Literature is now providing more and more of scientific contribution to the study of optimization of the management of a warehouse. Additionally, some authors have proposed the modeling of effective approaches in order to improve the efficiency of warehouse space utilization and operational activities or handling times in terms of inventory management. In summary, they all agree that there are two main criteria for organizing the warehouses; one is to permanently assign storage locations, and the randomized policy that randomly put each SKU in the location, in order to minimize the required storage space.
According to Petersen et al. (2004), a Class-Based Storage (CBS) is the warehouse management technique that divides SKUs into storage classes by demand and randomly assigns storage locations within each storage class area. They have proposed the CBS approach specifically for use in a manual picking environment. Order picking size, number of storage classes, size of storage classes, and routing heuristics were examined. The researcher conducted a warehouse simulation model of current, random storage warehouse process and observed in order to determine existing performance. After that the warehouse operation was performed using the CBS policy. The SKUs were ranked by total volume and categorized into several classes; high volume SKUs were determined as one class and other lower SKUs were determined as additional classes. The research found that the number of classes and number of SKUs picked are two key factors of the experiment that affect the performance of the picking and routing process. In the end, the researcher learned that the number of classes should be three or four which provide a 90 to 94 percent of total saving respectively.

The strategy also appeared in Eynan and Rosenblatt's (1994) work where they studied the CBS in an automated warehouse. The result showed that CBS offers significant cost saving over traditional storage. This CBS approach was also proposed in the manual warehouse as well. Jarvis and McDowell (1991) concluded that the best strategy for CBS in a manual warehouse is to place the most frequently pick SKUs at front, near the staging and loading area. Additionally, Warehouse layout also plays an important role in order to maximize the warehouse space and reduce handling time. According to Larson et al. (1997), improving the warehouse layout with CBS helps to increase floor space utilization and decrease material handling.

In conclusion, most of the studies focused on improving picking time and space utilization, in order to increase warehouse performance. The CBS concept has been used and provided positive results for organizations. It was proposed in many studies as a useful warehouse operations improvement tool. The CBS concept where those SKUs are
divided into storage classes by demand and randomly assigned storage locations within each storage class area has been introduced in several studies in both manual and automated warehouse improvement projects. With a suitable layout CBS zoning following the study of Larson et al. (1997), it can create benefit with both handling time and floor utilization in the warehouse. Thus this research is aiming to study applying the concepts in the manual warehouse of ABC Company.

2.8 Technologies Used in Warehouse

According to Ballard (1996), it is indicated that there is a local solution to efficiently monitoring and exercising control over warehouses where no other special warehouse computerization exists. Databases can be easily used to hold the fixed information about each SKU and both spreadsheets and databases are very good for analysis to develop the needed information. However, the use of these tools for recording the variable information such as location control requires significant effort and a strict adherence to the disciplines of data entry. Even if the worker discipline can be maintained, error from human carelessness especially during peak periods can cause data discrepancies. However, the only way to ensure that the monitoring is effective is to propose a proper warehouse management system that can be tailored to meet the specific requirements of an organization. Two management systems were discussed for use in filling sales orders and picking products from warehouses:

1. Batch with paper list. A system provides instruction for putting away, picking and replenishment in paper list. This has to be carried out and updated manually so discipline is critical.

2. Real time with radio frequency or optical barcode communication. It provides a full real time data update and minimizes human error. With this system inventory is now monitored and measured continually by handheld devices used by workers in the warehouse.
Connolly (2008) has studied technologies that can help support and improve the warehouse operation and management. Since, in order to efficiently manage the warehouse, one must know the exact location where each item is stored. This is especially important for the picking activity. The data labeling and reading are key to this implementation. Here is a summary of the use of technologies for efficient warehouse management.

1. Labeling technology

The digital optical barcode and Radio Frequency IDentification (RFID) allow faster and more reliable product identification while the barcode provides a simpler and cheaper scanning process. However, barcoding accommodates smaller amount of data, typically a dozen digits. On the other hand, RFID tags can store a thousand digits and can be read without sight access. The tag has microchip data storing label, and can be attached onto the goods for communicating with the reader. Another superior feature is that the RFID reader can read all nearby tags, even though the packaging, at the same time. This gives an advantage over optical reading when dealing with crates and pallets.

2. Label-reading systems

It consists of barcode scanner, RFID reader, and stock taking and order picking software. The scanner can be handheld accommodating the warehouse staff to physical handling the pick operation with real time inventory update. On the other hand the RFID reader can be installed near the entrance and exits where it will automatically detect the goods moving in and out, and then update onto the inventory database.

3. Location finding
The worker can easily find the allocated goods throughout the warehouse using handheld computer. This consumes much less time than manually finding and retrieving the goods by remembering or looking at a record of the item and where it is located.

4. Automated handling

Robotic handling equipment and conveyors with navigation systems have been in use for many years. However, there is a huge start-up investment and some limitation regarding the goods’ physical characteristics. Automated handling is used in some industries.

These technologies help the firm to efficiently pick goods to fulfill the customer’s orders, check goods in and out of the warehouse, and keep inventory up-to-date. Speed, more accuracy, and more reliability are the benefits of using the technology helping workers in the warehouse.

According to Frosdick (1989), automation of warehouses was introduced and implemented by many organizations as the trend of logistics concept. The emphasis is the creation of more and more stock efficiency. The concern is not only how well the firm stores its product, but focusing more on how effectively the firm moves its product along the supply chain. The stock has to be handled accurately and fast to meet requirements. This is where the technology comes in. In order to gain efficiency in warehouse operation, the information of each activity in warehouse operation needs to be recorded accurately and fast. Controlling the warehouse manually seems not enough for today’s requirements anymore. Below is a list of benefits the firm would gain by conducting the automated warehouse:

1. Improved utilization of space
2. Elimination/reduction of paper work
3. Reduction of clerical overhead
4. Stock location control
5. Greater stock accuracy
6. Improved warehouse service levels
7. More management of information

From the view of Frosdick (1989), transforming an old warehouse into the automated one seems challenging and beneficial. The seven probable benefits mentioned above are obviously an ultimate goal for every warehouse operation improvement project. According to Osyk et al. (2012), researched about RFID implementation in many organizations, the paper concludes that the reason for implementing this kind of technology is “to meet customer requirements,” “better inventory visibility,” and “better supply chain visibility.” While the top reason why many firms decide not to use the automate technology is “lack of foreseeable benefit and cost.”

2.9 Summary

The literature review of this chapter shows the key elements of warehouse management, and its limitations and benefits. From the literature’s point of view concerning the benefits, an organization with a manual warehouse should consider the technology and ABC principle to improve its operation.

The ABC principle allows the worker to focus the priority of the inventory by its level of importance and also help them to determine an efficient warehouse layout. Technology such as labeling, location finding, and automated handling systems allow faster and more efficient order retrieving, and inventory visibility which can significantly reduce operating time in warehouses. Since the goal of the case study is to improve the manual warehouse operation with two major problems to be tackled, lack of inventory visibility and delay cargo loading, the researcher believes that these reviewed methods will be able to solve the problems of ABC Company as well.
CHAPTER III

RESEARCH METHODOLOGY

The purpose of this chapter is to describe the methods which are used in this case study. A case study of ABC Company is conducted analyzing the current performance and then an improved operation is proposed in order to reduce warehouse process time, cost and aging stock in the future. The researcher determined the current situation of the ABC Company’s warehouse first by gathering all the data from historical records, physical measurement, and in-depth interviews. The warehouse management techniques were determined and adapted to improve the efficiency of the warehouse operation. Following the lead of several researchers, the study used the ABC principle to categorize the inventory in a class based on volume in order to focus more on those more popular SKUs in the storage area for better layout planning of the warehouse area. The information technology was also integrated and implemented in the warehouse for inventory visibility. It allowed the workers to know the exact location that they needed to go to retrieve the product. According to Connolly (2008), the worker can better control the inventory such as FIFO, and reduce handling time significantly. With the help of the ABC principle, the high volume SKUs can be placed near the staging area. That was a shorter route for the picker.

The study was divided into four stages as shown in Figure 3.1. The first stage was the data collection representing what data was collected and from which data sources. Secondly, the data analysis stage was conducted to expose the value and quantity of aging inventory in 2013, and the trend of the inventory was observed. The result was that aging inventory was increasing drastically in the middle of the year. The number of non-production related shipment delays was also determined. The researcher found that at the end of year 2013, 23 percent of inventory was aging. To retrieve one unit (one pallet or...
2,700 kilogram) the worker used approximately thirteen minutes. Thirdly, for the proposed model stage, the ABC principle and use of technology in warehouse were the two main approaches, and the paper explained how those two methods can be applied and used to solve problems in this study. The last stage was the whole summary of this chapter.
Figure 3.1: Research Procedure

<table>
<thead>
<tr>
<th>Stages</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collection</td>
<td>Step 1: Gathering of the relevant data from Jan 2013 – Dec 2013 and In-depth interviewing with the relevant personnel.</td>
<td>Data for analyzing</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>Step 2: Overview inventory data and non-production related delay case analysis year 2013 and the number of non-production related</td>
<td>Aging inventory keep increasing throughout the year and the number of non-production related delay cases appeared from time to time</td>
</tr>
<tr>
<td></td>
<td>Root Causes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Unsupported facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Inefficient warehouse operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Undisciplined manpower</td>
<td></td>
</tr>
<tr>
<td>Proposed Model</td>
<td>Step 3: Use fishbone analysis to determine the causes of increasing aging inventory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Step 4: Use fishbone analysis to determine the causes of non-production related delay case</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>Step 6: Discussion of the method of problem solving</td>
<td>Propose ABC classification and use of technology in warehouse</td>
</tr>
<tr>
<td></td>
<td>Step 7: Conclusion and Recommendations</td>
<td>The whole summary is reviewed.</td>
</tr>
</tbody>
</table>

Source: Author
3.1 Data Collection

This section presents the method of gathering necessary information to carry out the study. This started with an historical data review to give the researcher data on the result of the problem and to find what the root cause of the problem is. In-depth interviews with the workers gave a clearer view and allowed for visualization of the current process. Finally, the amount of time of each warehouse activity was captured to determine the largest portion of time consuming activity for material handling in the warehouse.

3.1.1 Historical Data

The first document reviewed was the monthly Fished Goods (FG) inventory report for the year 2013. This comes from the production planning department and shows the quantity in tons of the goods in drums and bags in storage area each month. Secondly, the grinding media dispatched volume report year for 2013 was reviewed in order to understand the volume and movement of the 94 SKUs that are now still active. However, there are only nine SKUs that are contributing to more than 90 percent of the whole volume. Finally, the FG stock report for the year 2013 created by logistics department was reviewed. The data consists of the quantity in tons of FG whose status is in receiving, retrieving and balance quantity in drum and bag along with a length of time in each status. The study focused on the period of time the FG stayed in the storage area and found that over 1,000 tons of goods stayed in the warehouse more than eight months. The number of non-production related delay cases and the overtime of the logistics department’s workers were also reviewed to determine the effect of warehouse operation performance.

After observation and review of the documents, it was found that most of the inventory stored is kept in drums on wooden pallets; mostly three drums on each one pallet. The department avoids keeping goods in bags due to their durability. The bag is packed after an order is received and is shipped as soon as possible. Thus, the inventory the study
focuses upon is balls in drum packaging. Last year, the total shipment volume was 85,390.546 tons while shipment in drums was 33,265.846 tons which was 40 percent of total volume shipped. Since it is easy to count and quite a durable package, the firm tended to store the FG in drums. The aging inventory of year 2013 is shown in Figure 1.4. The aging inventory level was increasing slightly since in January and significantly increasing in July. More and more inventory piled up in the warehouse without anyone noticing the area used in warehouse had become larger. This made the products become harder to retrieve.

3.1.2 In-Depth Interview with Logistics Staff

Face-to-face interviews with the warehouse staff, logistics team leader and supervisor were conducted to fully understand the warehouse operation, goods receiving and retrieving procedure, and the warehouse layout and the warehouse flow. The finding was quite unexpected. The warehouse was managed in a traditional way. The picking process concerned only the correctness of SKU and quantity but receiving date or age of the goods was not determined. Additionally, the location for each SKU was not determined. Therefore, each time after receiving an order the staff needed to check the required SKU location manually before retrieving it.

3.1.3 Warehouse Operational Activities Time Capture

Physical time measurement was conducted in this research in order to determine the responsive time or warehouse operational time; especially critical activities like routing and picking. Six activity times were captured using a stop watch during a one month period, averages of searching, routing, and picking time were used as a base to determine the current operation performance which the researcher set as a benchmark.
According to Gunasekaran et al. (1999) study, there are five main activities of warehouse operation: receiving, transferring, storing, packing and expediting. In order to match with the actual operation performed in ABC Company warehouse, the researcher captured the time of each activity except expediting and put re-palletizing instead. Stagging and final preparation were also added as shown in Table 3.1.

Table 3.1: Handling Activities Time Table

<table>
<thead>
<tr>
<th>Activities</th>
<th>Time Consumed (Minute/Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive and register FG in the spreadsheet</td>
<td>1</td>
</tr>
<tr>
<td>Store FG in storage area</td>
<td>2.5</td>
</tr>
<tr>
<td>Search and pick allocated SKUs</td>
<td>5</td>
</tr>
<tr>
<td>Re-Palletizing</td>
<td>2</td>
</tr>
<tr>
<td>Stagging and Preparation</td>
<td>1</td>
</tr>
<tr>
<td>Note item code to unregister loaded FG from spreadsheet</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Author

According to Table 3.1, the accumulated amount of time consumed for the warehouse operation was approximately 12.5 minutes per unit (one pallet with three drums each per unit). The researcher also learned that picking time and storing time were around five and two and a half minutes respectively which was considered a major portion of time in the whole process.
3.2 Data Analysis

The analysis of the collected data was conducted step by step to determine the problem as follows. The overview inventory and delay case is shown in Table 3.2. The overall inventory is increasing. It seems to be as a result of the firm’s strategy that the organization would like to expand the market and increase production capacity as mentioned earlier in chapter one. However, the researcher separated the inventory items that had been stored in the warehouse for more than six months. The portions of these long staying products were increasing significantly, especially since in October.

Table 3.2: Inventory Quantity Year 2013

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Quantity (Ton)</td>
<td>2,285</td>
<td>2,316</td>
<td>2,321</td>
<td>2,315</td>
<td>2,335</td>
<td>2,341</td>
<td>2,569</td>
<td>3,157</td>
<td>3,535</td>
<td>3,860</td>
<td>4,036</td>
<td>4,257</td>
</tr>
<tr>
<td>Aging Inventories (Ton)</td>
<td>348</td>
<td>231</td>
<td>278</td>
<td>222</td>
<td>266</td>
<td>201</td>
<td>349</td>
<td>390</td>
<td>437</td>
<td>658</td>
<td>782</td>
<td>981</td>
</tr>
<tr>
<td>Aging Inventories (Percentage)</td>
<td>15%</td>
<td>10%</td>
<td>12%</td>
<td>10%</td>
<td>11%</td>
<td>9%</td>
<td>14%</td>
<td>12%</td>
<td>12%</td>
<td>17%</td>
<td>19%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Source: ABC Company Records

According to the Table 1.1, the delay cases were also found in October and December of year 2013. These delay cases were non-production delay related but were logistics related. The main factor for this delay was more workload. Since the company increased its capacity and sales volume throughout the year according to Figure 1.2, the volume of year 2013 was around six or seven percent more than the previous year. Additionally, overtime working hour percentage had also increased and exceeds ten percent in
November and December of 2013 according to Table 1.1; the level expected at the end of the year.

3.3 Current Process Mapping

After the data was gathered and analyzed, the current process was mapped to visualize the workflow, in order to better understand how current work flow was done and to analyze the root cause simultaneously. This stage shows the current process of order fulfillment and warehouse operation process of ABC Company to be able to understand the process as a whole. Order fulfillment involved three different departments in the firm. These included warehouse, sales and production planning as shown below in Figure 3.2. The current process flow chart shows the current operation before improvement.
Figure 3.2: Current Operation Flow Chart

<table>
<thead>
<tr>
<th>Customer</th>
<th>Sales Department</th>
<th>Production Planning Department</th>
<th>Warehouse and Logistics Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue purchase order</td>
<td>Receive and anticipate prospect</td>
<td>gather data, forecast demand and plan production schedule</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input prospect data in system</td>
<td>Anticipate FG ex-work date</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Confirm order</td>
<td>FG ex-work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Issue sale order</td>
<td>Check stock availability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warehouse</td>
<td>Receive FG</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Register new FG in spreadsheet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Store FG in warehouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre-sold?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Register for required SKU in warehouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pick required SKU in warehouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-palletize, sort, stage and prepare loading</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work note batch number of picked item</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Un-register loaded FG from spreadsheet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perform monthly stocktake and report to production planning department</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AVAILABLE?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Search for required SKU in warehouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pick required SKU in warehouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-palletize, sort, stage and prepare loading</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work note batch number of picked item</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Un-register loaded FG from spreadsheet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perform monthly stocktake and report to production planning department</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author
The operations in the warehouse can be divided into steps. Beginning with step one (the order receiving step) the sales department receives a potential order and this triggers production process by sharing this data with the production planning department via the integrated sales and operation planning (S&OP) spreadsheet. The planning department gathers data from both the sales and logistics departments and plans the production schedule with the production department afterward. Once the confirmed order has been placed, a sales person issues a sales order and passes it to the logistics and warehouse department for order preparation.

Next is step two: goods receiving and retrieving in the warehouse. After receiving the sales order (SO), the stock clerk will check the availability of the SKU in the updated spreadsheet. If the SKU is available, a work order will be issued to the warehouse worker who is responsible for finding and picking the correct SKU to pick and bring it to the sorting and staging area. On the other hand, if it is not available, the clerk will check with planning department to see if the SKU is finished or not. However, the stock clerk and warehouse workers receive new FG from production on a daily basis and store where they can find space in storage area before recording this information in the spreadsheet manually.

The last step is order sorting, final preparation and loading. After picking, the goods will be transferred to the staging area where all the goods are sorted and prepared according to the requirements of each customer. After sorting and preparation is completed, the warehouse worker will need to record the batch number of those staged items in order to manually take those goods out of the inventory sheet manually. The updated FG inventory spreadsheet is used by the production planning department afterward for planning and scheduling production.

The process is operated solely based on the workers manual input. Every step of the operation is done manually. Lots of error is presented, and an aging inventory is
increasing as well. The result is inventory inaccuracy, extra handling time, and the workers require extra stock counts to adjust the stock quantity. Refer to Table 3.1, current process takes approximately 12.5 minutes for handling one pallet. Receiving and register those FG into system take one minute, storing FG takes two and a half minutes, Search and pick the allocated SKUs take five minutes, and re-palletize, sort, stage and loading preparation take three minutes. Additionally, worker note batch numbers to unregister the staged FG from the spread sheet take another one minute.

3.4 Finding Root Causes

In order to identify and define the root cause of the problems of increasing aging inventory and extra handling time of the current process as shown in Figure 3.2 Fishbone analysis was utilized. Possible root causes were listed in the fishbone diagram, see Figure 3.3 and 3.4, for easily visualization of the related causes for each of the two identified problems.
Figure 3.3: Fishbone Diagram of Aging Inventory Problem

Facilities
- Over production
- No reliable technology
- Unsuitable layout

Method
- No FIFO based picking
- No inventory visibility
- Random-based storage
- Lack of knowledge
- No discipline during picking and receiving
- No idea about the goods age and location

Manpower

Aging stock keep increasing

Source: Author
Source: Author

After analysis of the delay problem, the lists of main factors identified are as follows:

1. **Warehouse** has an inefficient storage layout. The high demand volume SKU is kept randomly mixed with lower demand volume SKUs. High demand SKUs are being kept far from the staging area, so the worker tends to travel longer distances more often to retrieve high demand volume items. The activity time tends to be longer this way.

2. There is no control over inventory and no inventory visibility. The location of goods is not assigned. The staff does not retrieve the finished goods from warehouse based on a FIFO basis and are unable to find the item easily. Incorrect data is entered due to carelessness and ignorance of the workers and results in extra handling time being incurred. Additionally, it can result in over production due to incorrect finished goods inventory data.
3. The staff lack discipline and warehouse management knowledge. Even a trained employee who is aware of warehouse management principles can be wrong by mistake or by ignorance. Receiving, picking, and data entry all depend on manual labor discipline and high levels of supervision. Any error or lack of discipline can result in more time consumption.

3.5 Proposed Model

The improved model shown in this paper was created by the integration of warehouse management technology, layout planning and class based inventory management to improve efficiency in warehouse.

3.5.1 Classification of Item by the Nature of Demand

The improvement was in the stage where the warehouse operator designates what quantity of which products should be stored in what location. This paper tended to use the ABC method to categorise those SKUs in storage into classes and then decide which of them should go into which location. The storage areas were divided into classes based on a historical sales volume of the SKUs. The Pareto principle was deployed to divide the inventory into a groups of SKUs based on their sales volume. Class A, only 17 percent of 78 SKUs contributed 78 percent of the whole sales volume; class B, 23 percent of 78 SKUs contributed only 18 percent of the whole sales volume; and finally class C, 60 percent of 78 SKUs contributed only five percent of the whole sales volume as shown in Figure 3.5.
Figure 3.5: Volume Based Pareto Chart for ABC Classification by Demand

Source: ABC Company records

In order to reduce aging inventory and as well as dead stock, the SKUs in class B and C that have low volume will be recommended for make-to-order (MTO) and the one with large volume will be made-to-stock (MTS). This is following the paper of Gunasekaran et al. (2013) that stated it is a good methodology in operation and helps reduce capital sunk in inventory.

According to Faber et al. (2013), there are factors that can be beneficial toward warehouse management. First of all, planning where the quantities and storage location of each SKU should be kept in storage was decided. Each SKU was assigned to each specific class based on its volume. Class A, B, and C were representing the high, medium, and low volume respectively. Since class A has much more volume than the others, the quantity and area of the SKUs in class A was the largest. These SKUs were to be stored in the area easiest to access, nearest the staging and loading area. As for those in class B, the goods were stored in the second largest, easiest to access area near the
staging and loading area. The rest were placed in the class C SKUs. In the improved operation model, some SKUs in class C were aging or dead stock. Those goods were reported to the production department monthly.

From classification of items by its demand, the class is set up and the storage layout is reviewed to adapt accordingly in order to reduce handling time as shown in Figure 3.6. The idea is to give priority to those high demand SKUs, make them more accessible, easy to retrieve and move them closer to the staging area. Since the higher volume SKUs are now located near the sorting and staging area, the overall travel distance of the workers should be reduced significantly.

**Figure 3.6: Proposed New Warehouse Storage Area Design**

Source: Author
3.5.2 Warehouse Database System and Information Technology

According to Connolly (2008), four aspects of information technology commonly used in warehouses that help increase inventory visibility are: labeling technology, label-reading system, location finding and automated handling. The new approach introduces a barcode into the warehouse database system in order to help workers to track the status of each product in the warehouse from receiving, through storing, allocating and selling. Each activity performed by workers will be recorded by a handheld barcode reader and automatically updated into the warehouse inventory database.

3.5.3 Proposed Warehouse Operations Process

The process is improved and changed to support the new operation using technology and inventory classification by nature of demand as shown in Figure 3.7. After the goods are finished the worker who packs the product in the drums and bags will print out the barcode containing batch and SKU information, and then affix it on the packaging. While the FG is physically received, the warehouse worker will register the product into the inventory database by handheld barcode reader. If the SKU is now required by sales department, the warehouse worker will transfer the product directly to staging area. If the new product is not pre-allocated or currently needed, the staff will transfer the goods to storage area. In the storage area, the barcode containing location information is also installed at the specific location in storage area following the class of each SKU. The worker will update the product location and store it afterward. Now the inventory is in place available for sales allocation.

After the selective list of product is sold, the sales department will allocate the product in this new inventory system. If the product is available, a pick note will be generated using FIFO. The warehouse worker will pick the product following the pick note instruction unlike the current process where the worker had to find the product and then look at the
mark on packaging and write it down to be unregistered after the product is sold. The aging inventory will be the first to be taken out using this new system.

**Figure 3.7: Proposed Warehouse Operation Improvement Model Flowchart**

Source: Author
A summary of the root causes and the methods for solving these problems and improving the procedure is shown in Table 3.3 and described below.

**Table 3.3: A Summary of Root Causes and Solving Methods**

<table>
<thead>
<tr>
<th>Root causes</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse has Inefficiency</td>
<td>Inventory classification for a new layout design</td>
</tr>
<tr>
<td>storage layout</td>
<td></td>
</tr>
<tr>
<td>No control over inventory and no inventory</td>
<td>Automated warehouse management system that can update a close-to real-time data update, reduce manual work load and improve inventory data accuracy</td>
</tr>
<tr>
<td>visibility</td>
<td></td>
</tr>
<tr>
<td>Staff lack of discipline and warehouse management</td>
<td>Automated warehouse management system to control and supervise worker instead of solely rely on manual input</td>
</tr>
<tr>
<td>knowledge</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author

1. **Warehouse has an inefficient storage layout**

   Classification of inventory based on the nature of demand is introduced to solve this problem. A new inventory management and warehouse layout design is proposed using an ABC classification.

2. **No control over inventory and no inventory visibility**

   An automated warehouse management system is introduced to solve this issue. Automatic and real time inventory updates and data entries will be performed under the warehouse management system.

3. **Staff lack of discipline and warehouse management knowledge**

   The warehouse control management system is deployed to eliminate and reduce manual activities and associated supervision. The control process itself will check the
correctness of inventory movement, since it is able to track the status of the goods and update immediately. However, some manual activities are still inevitable. Thus the knowledge and discipline of employees is still important to the operation. Training and coaching during or before warehouse operation improvement might be required. The paper will discuss more about this in the managerial implication section.

3.7 Summary

The paper gathered the historical data for analysis step by step, and the result showed that the warehouse of ABC Company should consider improving its layout, storage/retrieval process, and implement some automated warehouse systems to gain inventory visibility. This will prevent unnecessary accumulation of stock and reduce operation handling time.

Theoretically, using warehouse management technology helps the firm to achieve improvements in utilization of space, eliminate/reduce paper work, reduce clerical overhead, provides stock location control, provides greater stock accuracy, improves warehouse service levels, and provides more management information for decision making (Frosdick, 1989). According to Howard (1974), an effective inventory management must rely on stock recording and stock control. Additionally, the ABC classification would help the firm to focus on those inventories that are more important and assist in planning how to store them (Sander, 1987). In the next chapter, the improvement process is to be implemented and the result observed.
CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter presents the improved process that is recommended to reduce the aging inventory and improve warehouse operational efficiency. After the root causes were identified using fishbone analysis, the researcher further studied the current process with relevant staff of the cross-functional team to understand the problem, the process and the solution that is generated by the proposed process.

4.1 Proposed Process Mapping

After studying the information technology used in the warehouse, the proposed information update flow was introduced as described in chapter three. The computer software helped the process to rely less on human input and prevented error that might occur due to carelessness of each worker. The main benefit is that the software will put the entire inventory in picking sequence and instruct the warehouse worker through a pick note. The proposed process map is shown in Figure 4.1.
Figure 4.1: Proposed Process Flow Chart

<table>
<thead>
<tr>
<th>Customer</th>
<th>Sales Department</th>
<th>Production Planning Department</th>
<th>Warehouse and Logistics Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Receive and anticipate prospect</td>
<td>Gather data, forecast demand and plan production schedule</td>
<td>Receive FG</td>
</tr>
<tr>
<td></td>
<td>Input prospect data in system</td>
<td>Anticipate FG ex-work date</td>
<td>Register new FG in database by barcode system</td>
</tr>
<tr>
<td></td>
<td>Confirm order</td>
<td>FG ex-work</td>
<td></td>
</tr>
<tr>
<td>Issue purchase order</td>
<td></td>
<td>Available?</td>
<td>Available stock is automatically allocated</td>
</tr>
<tr>
<td>Issue sale order</td>
<td></td>
<td>Yes</td>
<td>Print out pick note from system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Pre-sold?</td>
<td>Pick required SKU in warehouse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>Store FG following instruction from the system based on class in warehouse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Re-palletize, sort, stage and prepare loading</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Perform stock take, reconcile if necessary and update in the database</td>
</tr>
</tbody>
</table>

Source: Author
4.2 Proposed Process Implementation Detail

There are three aspects to be considered before executing the proposed plan: work process, technology and cost of implementation. This section presents how the work process outlined in the proposed model is carried out by the workers. The next section presents a discussion of technology and software with its cost.

4.2.1. Work Process

There are three steps to the proposed model: the order receiving step, the FG receiving and retrieving in warehouse step, and the sorting, final preparation and loading step. First, after the sales department receives a confirmed order, (S&OP takes place just the same as before), a sales order is issued in the system. If the product is available in stock, the oldest one will be automatically allocated by the system to maintain FIFO and reduce amount of aging inventory.

Second, in the finished goods receiving and retrieving from the warehouse step, after finishing from the production line workers will attach a barcode that contains the production batch number and product SKU to the inside of the packaging. The stock clerk with a hand-held device who receives these goods will register them into the database of the system. The system will tell exactly where these items should be stored since each item is designated to a specific category. Those with more volume, (thirteen SKU from class A) will be stocked in larger volume, have larger storage area, and be located near sorting and preparation area for faster handling. After the FGs are stored, the worker updates the location information and confirms storing by reading the location barcode in the storage area with a hand-held device. After the sale order is issued and the pick noted is printed, the worker will start picking at the location according to the pick
note. The barcode on the location and on product’s packaging are required to be read by a handheld device in order to confirm that correct item and location is picked and to update the stock availability status at the same time.

Finally, the retrieved product is transferred to the sorting and preparation area for performance of the final inspection and preparation according to the customer’s requirement. As soon as the truck, container or trailer comes, the worker is able to load the cargo right away without the need to record the batch number and unregister the cargo manually from spreadsheet as in the current process.

This real-time shared database can be useful for both the production planning department and the sales department. The ABC classification also needs to be adjusted from time to time according to a real demand of each SKU to maintain the least handling time as much as possible. The items that stay in storage area for more than six months are considered as aging inventory and will be highlighted in the database and the production planning department and sales department will decide whether to sell them out or recycle them into another more frequently dispatched SKU.

4.2.2. Database Systems and Technology

There is plenty of warehouse management software and hardware in the market. Some companies can hire an information technology consultancy firm to do the job for them or they can select the software and equipment themselves depending on cost and investment of the project. This section presents things that are required to be procured following the proposed process requirement.

First of all, a warehouse management system, the software needed to support the barcoding system, handheld devices, real time data updates, and support for future expansion, FIFO and tracking of aged product or overdue date must be purchased. This
system will also have ability to generate a report of all activities in the warehouse operation that is easily converted to basic office spreadsheet. The report shall include receiving, storing, transferring, unit breaking, counting, and retrieving information.

Next, barcode scanner, barcode printer, and label control software must be purchased. Good software allows the user to freely design and prints out a label and can be connected to every barcode printer brand available in market. More importantly, the program should support a connection to the warehouse software.

4.2.3. Cost of implementation

The major cost of this proposed model implementation is the purchase of the warehouse management software and barcode scanner/printer. However, purchasing of software is considered too expensive. The researcher therefore recommends purchase of online software with a very inexpensive fee as it is pay per use based application.

Currently, there is software available on cloud and online where the company can easily access it through a mobile device. The investment in this kind of software tends to be very inexpensive. It is pay per use software with less than a THB 4,975 per month and around than a THB 300 monthly fee per additional user. Since it is cloud application, the scanner is available by mobile application. Every smart phone can be a barcode scanner with only a THB 8,000-10,000 per unit. Hardware should be mentioned is barcode printer which can be found in market with only THB 5,000 to THB 30,000 or even higher depend on its performance. Plus a consultancy for a first set up cost around THB 10,000 which requires as least ten day mapping the operation process into the warehouse management module. Thus, the total cost for the purchase of these hardware and software would be around THB 174,075 as a startup and THB 5,575 per month as shown in Table 4.1. Lastly, the printing cost for each barcode of four x three centimeters is approximately one bath per piece.
Table 4.1: A Summary of Warehouse Management Software and Devices Cost

<table>
<thead>
<tr>
<th>Required Items</th>
<th>Price (THB)</th>
<th>Required Quantity</th>
<th>Total Cost (THB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Handheld Devices</td>
<td>10,000</td>
<td>6</td>
<td>60,000</td>
</tr>
<tr>
<td>2. Barcode Printer</td>
<td>8,500</td>
<td>1</td>
<td>8,500</td>
</tr>
<tr>
<td>3. System Setup Consultancy (Job)</td>
<td>30,000</td>
<td>1</td>
<td>30,000</td>
</tr>
<tr>
<td>4. Warehouse Management and Labeling Software</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Application Fee 1 User (First month)</td>
<td>4,975</td>
<td>1</td>
<td>4,975</td>
</tr>
<tr>
<td>- Additional User Fee (First month)</td>
<td>300</td>
<td>2</td>
<td>600</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>104,075</strong></td>
</tr>
</tbody>
</table>

Source: Eflowsys and Thai POS quotation

4.3 Discussion of Results

Theoretically, using warehouse managing software help the firm preventing mistakes from human error, reduce the amount of aging stock by maintaining FIFO, and reduce handling time of manual operations. Connolly (2008) has stated that in order to efficiently manage the warehouse, one must know the exact location of where each item is stored. This is especially important for the picking activity. The data labeling and reading are key to this implementation. Frosdick (1989) also stated that improvements in warehouse technology help the firm to have better control over inventory while improving inventory visibility as well. Howard (1974) also suggested categorizing the inventory into classes according to their sales volume in order to have easier control of inventory.

The first step in the whole operation (order receiving in current process) creates some mistakes like allocating wrong SKUs or most of the time the warehouse worker selects
the more recently produced FGs over the older ones. The proposed process will prevent this by allowing the system to automatically allocate the items on a FIFO basis. The system will always select the oldest items first. The rest of the unsold aging items will also be highlighted. Thus, other departments such as sales or production can look through and try to sell them or re-melt them into other saleable SKUs.

The second step (receiving and retrieval in warehouse) involves lots of material handling. The current process shows that the worker requires extra time to find each item which was stored randomly without a specific location. The warehouse worker may pick the recently produced item, wrong item, or be unable to find the required item at all. After picking, the worker also needs to record the picked item batch number by hand and give it to stock clerk for unregistering those goods afterward. The improved proposed process suggests a barcoding system with software to control inventory in and out based on FIFO, tracking the status and location of the required SKU for easy finding and picking. More importantly it eliminates the manual recording of the batch number, since the system will automatically unregister those items once they are picked. Item classification is involved in this solution. As mentioned, the 78 percent of the inventory kept belongs to class A which has more storage space and is located near the sorting and staging area. Thus the overall picking time is reduced because most of the items to be picked are next to the area where the next step in the process is performed. By this proposed model, the worker can save lots of time operate this step. The result will reduce overtime working hours and non-production delay cases to meet the maximum allowance of the company.

The final step (the sorting and preparation step) is relatively the same as in current model. However, the new proposed storage area lay out design that uses the ABC classification of inventory will allow the picker to retrieve most products from a closer area. The overall route and travel time is reduced. Class based zoning also allows easier cycle stock count and housekeeping inside the warehouse, making it easy to keep the storage area tidy.
Table 4.2: Handling Activities Time Table After Implementation of Proposed Process

<table>
<thead>
<tr>
<th>Activities</th>
<th>Current Process Time (Minute/Unit)</th>
<th>Proposed Process Time (Minute/Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive and register FG</td>
<td>1</td>
<td>0.17</td>
</tr>
<tr>
<td>Store FG in storage area</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td>Pick allocated SKUs</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td>Re-Palletizing</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Staging and Preparation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Note item code to unregister loaded FG from spreadsheet</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Author

Activities time was also capture in order to determine the improvement level of the proposed process. Refer to Table 3.1, accumulate time for the current process was around 12.5 minutes. After improved process is proposed, the estimate time of the whole operation process will be around six a half minutes or 47 percent reduction of handling time for each pallet as shown in Table 4.2. Receive and register FG, and Picking activities seem to be benefited from the implementation of warehouse management technology and SKUs classification the most. Using hand-held barcode scanners to check and register reduce error and activity time significantly. The location finding system is also beneficial toward the picking process. The worker is not required to manually find the allocated items by remembering or looking at the record anymore. The worker will be able to drive to the location directly. Finally, the activity of “Note item code to unregister
FG” will be eliminated. The worker only need to read the barcode of the allocate product for checking if it is correct and then unregister from the database simultaneously.

Additionally, the inventory data base with more accurate and up to date inventory data allows the production planning department to review anytime and can prevent overproduction of goods. The inventory status update in the database is the key for every department to make this operation better. The information of inventory will be more accurate and real-time. However, warehouse management implementation requires control system including monitoring, analyzing, and reporting to ensure sustainability of the process and continue improvement (Faber et al., 2013).

4.4 Summary

The chapter presents the current and proposed process model describing how technology and ABC classification can be applied and adapted in ABC Company’s warehouse. Frankly, applying both tools proved beneficial to the warehouse. It can operate faster, with more information accuracy, and eliminate unnecessary activity along the way. In chapter five the paper will discuss more about applying the method in a real business and other important findings.
CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter explains the summary of the findings, conclusions, managerial implications, and recommendations for future research based on the analysis of historical data. The accumulated overdue stock, exceeding overtime working limits and delay complaints from clients has continued to grow in ABC's Company. This led to a loss of capital with an amount of sunk cost in aging inventory affecting their cash flow. The delay issue can cause the firm to lose its reputation which is considered very critical. It requires the company to make a quick response to find the root cause of the accumulation and eliminate it.

5.1 Summary of the Findings

The ABC’s warehouse has been managed in a traditional way. Each activity, especially inventory information tracking and updating is done manually. These cause the firm to face warehouse problems. Lack of inventory visibility results in an aging inventory that keeps piling up. Manual tracking and lack of inventory visibility also result in extra material handling in the warehouse. The aging inventory and extra handling are both increasing which results in extra costs. The current situation and problem of the warehouse was observed. Review of historical data, in-depth interviews with related staff and warehouse activity time tracking was done. The data gathered was then analyzed using a tool, fishbone analysis, which classifies and visualizes each cause and its root, in order to fully identify and understand the root cause of the problems in the warehouse, in warehouse operational performance, and to fully understand the SKUs movement.
After the information had been analyzed, it was concluded that there were two main issues in the warehouse operations that needed attention, the aging stocks accumulating and improvement of handling time. The fishbone analysis was deployed to identify the root causes of this inefficiency in the warehouse. Three main causes were determined: 1) no control over inventory and no inventory visibility. 2) Inefficiency in warehouse storage layout. 3) Staff lack of discipline and warehouse management knowledge.

The new model of warehouse operation was introduced to remove these causes of the problem. Barcode and warehouse database technology was recommended to improve warehouse operation activities time, reduce manual activities and errors, and maintain inventory data accuracy. The firm can now gain control and increase their inventory visibility.

Inventory classification and zoning help warehouse workers, planning staff and even the sales team to manage inventory easily. It can reduce travel distance and time by moving the high demand products near the sorting and staging area since the high demand product has a higher picking rate.

Worker lack of discipline and warehouse management knowledge is solved using technology as well. In the current process, the staff controls the process. After receiving an order, the worker will search for the product in warehouse. Some workers may pick goods on FIFO basis. Some of them may not, because no specific item and location is assigned. In the proposed model, the required product is allocated by the system at the beginning. The worker is required to go to a specific location and pick a specific product following instructions from a pick note instead. The system will help the worker checking the correct item at the time of picking to ensure that the worker is picking a 100 percent correct item.
5.2 Conclusion

This study explored the benefits that one will get from using technology to perform inventory monitoring and warehouse information management by examining and applying it to a real problem in the case study warehouse. The tools of data labeling technology were reviewed including RFID that can contain a large and complex data and barcodes that can provide a cheaper and simpler data and scanning process. The research recommends barcode in this case study based on its characteristics and acceptable investment cost. Barcoding is appropriate because the warehouse only requires basic information to be labeled for solving its problem. However, this is not to imply that using barcoding is better than RFID. In some industries, especially the one with more diversity of product, RFID might be more suitable to implement.

The study indicates that the use of product classification by nature of demand can be helpful in warehouse layout planning. The partition of SKU classes and storage area allowed a smooth control process in warehouse. Each class has its own picking frequency and is handled a different way such as the higher demand volume SKU required more buffers and that means it requires more space and accessibility. Those low demand volume goods that tend to stay longer in the storage area require better shelter and an easier way to be transferred back for quality assessment and repacking/re-production. Thus, storing all SKUs together is certainly a bad idea for efficient warehouse operation. The research classifies the inventory into three classes based on demand of the past year which should be reviewed from time to time since the demand volume of the same SKU can be dynamic. However, it does not imply that classification by demand nature into three classes is always the best option to classify the inventory. It is the simplest and was able to improve warehouse operation efficiency to a higher level. The study of Petersen et al. (2004) indicates that a simple two-class system attained nearly 80 percent of benefits over random storage.
Additionally, it is not mentioned in this study but product classification using Pareto principle also benefits other department. For example, the sales department can easily choose to focus on each SKU class based on their current strategy. They might find the way to clearing the slow moving items before those items need quality attention which result in incurring cost.

5.3 Managerial Implications

ABC Company is able to prevent an increasing aging inventory and reduce overall handling time in the warehouse using the proposed warehouse management system and a classification of inventory by nature of demand and a class based storage layout design. Actually, the study indicated that there is a more simple solution to efficient monitoring and control over the warehouse where no special warehouse computerization is required. A spreadsheet can basically contain the entire warehouse information. It can be used easily to hold the fixed information about each SKU and both spreadsheets and databases are very good for analysis to develop the information report. However, the use of these tools for recording the variable information such as location control requires significant effort and strict determination of the worker, supervisor and manager to the disciplines of maintaining data entry. Even if the worker discipline can be maintained, the error from human carelessness, especially during peak periods can cause data discrepancy and lead to more time consumption. The database system is helpful for this matter. Nevertheless, the discipline of workers to perform each step is still important, even though, the systems will help workers perform data entry during the operation. It is the workers’ job to ensure the completion of their action. It is quite critical to review the workers discipline and knowledge from time to time.
5.4 Recommendation for future research

It is worth mentioning full automation in warehouse in a further study, if for no other reason than that it is the extension to real time warehouse management system for process monitoring. For automated systems to work well staff discipline must be imposed and monitoring of inventory and many other aspects of the warehouse operation must take place continuously. Information is updated in real time and the computerized system enables management information to be readily available.

Compared to an automated system, the conventional periodic stock checks are quite impractical and rely much more on the worker’s ability to monitor the process rather than the system’s ability to monitor the stock. It is not suggested that automation should always be considered as a means of monitoring and measuring inventory but financial and cost-analysis can be further considered in the next study as well.
BIBLIOGRAPHY


