DEVELOPMENT OF WAREHOUSE MANAGEMENT IN MICRO COMPANIES
-BICYCLE REPAIR

Jackline Ndungi

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JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

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Tutor(s)
Lohimäki, Tero, Franssila Tommi

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Abstract

Warehouse management is a key concern for all industrial companies. The objectives was to analyze the processes of Polkupyörä Tori's warehouse and find the problems affecting the warehouse and provide the company with alternatives to renting extra warehouse space.

Books, journals and Internet were relied upon for theoretical background. Qualitative research was used and through competitive benchmarking approach companies were selected and recruited to be interviewed. Data collection was done using in-depth interviews and observation methods. A camera and a tape recorder were used for data collection. Thematic analysis was used to analyze the data collected.

Different problems identified from Polkupyörä Tori's warehouse range from inefficient product slotting to high inventory levels. From the empirical research different results were identified such as storage equipment, information management and product slotting. These results were compared to the results found from the theoretical research and recommendations were provided for Polkupyörä Tori. Recommendations included the use of safety stock and service level to control the inventory flow, a different layout, as well as investing in storage equipment.

In the course of the study Polkupyörä Tori has invested in some of the storage equipment recommended and has employed extra work force to deal with inventory control.

Keywords

inventory, storage, equipment, warehouse

Miscellaneous

Contents

FIGURES

1 INTRODUCTION

1.1 Research Background

Most micro companies speculate that the strategic and operational processes applied in large companies are inapplicable to their companies. Large companies may have more resources than the micro companies, but this is not reason enough to ignore the facts of business life. Warehouse management and material flow are attributes that exact similar pressure on both large and micro companies.

Bicycle repair is a business industry that requires proper warehouse management and material flow due to its extensive use of different products in its service provision. Polkupyörä Tori, which is the case study company for this study is a bicycle repair company that provides bicycle services to residents of its area. Polkupyörä Tori wishes to expand its business by buying or renting an extra warehouse space to store its products in order to reduce congestion in the current warehouse. This will reduce misplacement of products in the warehouse, decrease lead time to service and enable customer demand satisfaction. However, warehouse management and inventory control measures are unavailable in the current state of the company.

1.2 Research Objectives and Questions

The main objective of this thesis was to assess the current situation of Polkupyörä Tori's warehouse, study through the problems affecting the warehouse productivity, and provide possible solutions to curb the problem, which will provide the company with alternatives to buying or renting of extra warehouse space. Although warehouse productivity can be accomplished by carefully looking into forecasting, procurement, space optimization and the rate of material flow in the warehouse, this study focused more on space optimization and material movement.

In order to attain the purpose of this thesis there were some supporting goals that were examined that bring overall light to warehouse productivity. These supporting goals included the following:

1. To propose methods for inventory control methods to Polkupyörä Tori
2. To suggest ways to achieve a convenient, safe and comfortable working environment for staff
3. To improve product slotting and provide flexibility for manual inventory calculation, maintenance and cleaning
4. To reduce misplacement of products and reduce lead time to service provision

The goals mentioned above were achieved by investigating how the warehouse productivity would be improved while reducing the operational cost. This led to research questions related to how much stock should be stored, how to regulate the stock and how it should be stored in a warehouse to improve the efficiency and effectiveness.

2 CASE STUDY

2.1 Background

All information and data used in this case study are based on a practical day to day situation. The information found here is from the company Polkupyörä Tori which is a micro company that repairs bicycles in Jyväskylä. The definition of micro companies differs quite often by industry and country. According to Decline and Small (2012), micro companies are defined as firms that have fewer than 10 employees. In addition, Summaries of EU legislation (2003), define a micro company as an enterprise which employs fewer than 10 persons and whose annual turnover and/ or annual balance sheet total does not exceed EUR 2 million.

Polkupyörä Tori was established in August 2003 in Minna Canthinkatu Jyväskylä as a bicycle repair shop. It covers a total area of 140 m2, which represents the total area of the warehouse area and office area. It has a manager and an employee; the two are the engineers in the company. It provides bicycle repair services to the residents of Jyväskylä city. The company originated from the manager of Polkupyörä Tori, Waleed Salih's, and desire to exercise his interest in repairing bicycles.

Polkupyörä Tori is positioned in its market area by price, quality and lead time. This signifies that the company provides customers with a respectable quality of repaired bicycles under a short amount of time within the customers' presentation of the problem with the bicycle and receipt of the repaired bicycle. This also suggests that the customers view the company as of better pricing than most of its competitors.

The company has grown from initially repairing 1 bicycle a day to 16 bicycles a day as of today.

2.2 Company Presentation

Polkupyörä Tori is involved in repairing of all categories of bicycles: mountain, road, flat bar road, utility, military, racing, BMX, cruiser. The company does not produce bicycle parts however; it only repairs bicycles according to customer specification and customer need. The repair process is performed manually and each engineer deals with one bicycle at a time until the repair is completed. The following steps are used in the company when receiving customer bicycles that require repair.

1. Customer presentation of the problem
2. Engineer moves bicycle to need repair section and customer note
3. Engineer decides on lead time
4. Provide the customer with a copy of a note including; fault to be repaired, approximate cost of repair, day and time for collection of the repaired bicycle written on it.

The repair of bicycles is often done on the first in first out basis, but sometimes it depends on how much repair the bicycle needs. Due to the continuous introduction of new designs in the bicycle industry, the engineers in Polkupyörä Tori have to conduct continuous training in order to sustain the new market. In addition to repairing bicycles for its customers, Polkupyörä Tori also acquires used bicycles from customers, then repairs and resells them. The company also sells new bicycles, helmets and spare parts for bicycles as the supporting activities for the business.

2.3 Current Situation in the Company

The Repair process for the bicycles is presented as follows:

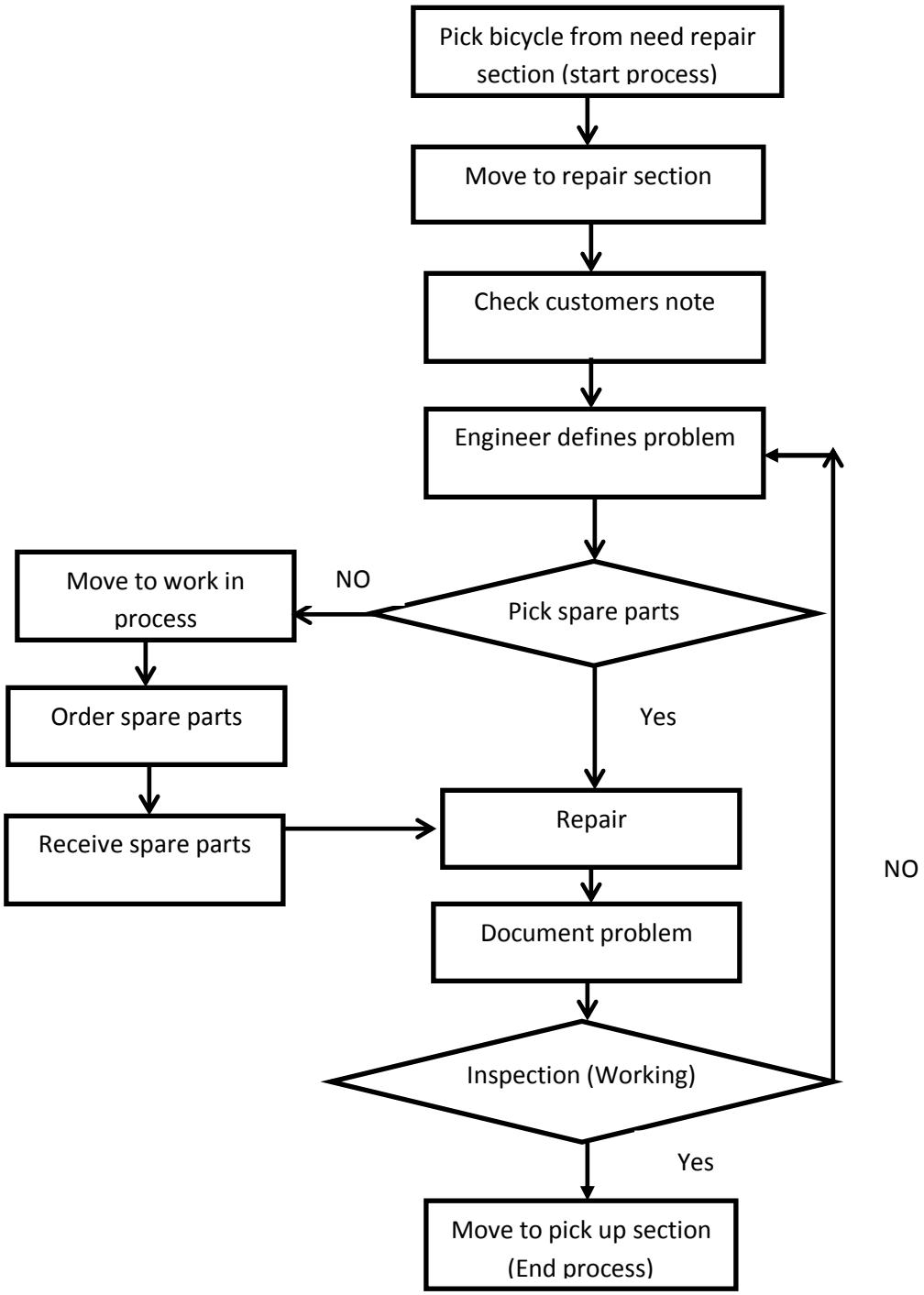


FIGURE 1. Polkupyörä Tori Repair process

In the Figure 1 above, the arrows indicate the flow of the customer's bicycle from the time of receiving it into the warehouse to the time the bicycle is ready for pick up. First, the customer delivers his bicycle in for repair and indicates what kind of service he re-

quires from the company, and then the bicycle is conveyed into the waiting repair section where the bicycle awaits repair. The bicycle is then moved to the service area, where the engineer checks the required service and defines the problem. The engineer picks the spare parts needed for the service if they are available. However, if the spare parts are not in stock, the engineer orders for replenishment and is informed of the arrival of spare parts, and then proceeds to repair the bicycle. The documentation of the services offered by the company to the customer's bicycle is prepared and an inspection of the repaired parts is also conducted by a different engineer. In case the serviced bicycle fails the inspection, the bicycle is taken back to the stage in which the definition of the problem is assessed, and when the bicycle passes the inspection it is then transferred to the pickup section.

Studying the repair process shown above indicates that the space needed for the repair process to be efficient and effective includes: Need repair section, Repair section, Warehouse (storage) and Pick up section. By the use of a flow chat and flow process symbols shown in Figure 2, the layout of the company's warehouse and workshop can be seen in Figure 3.

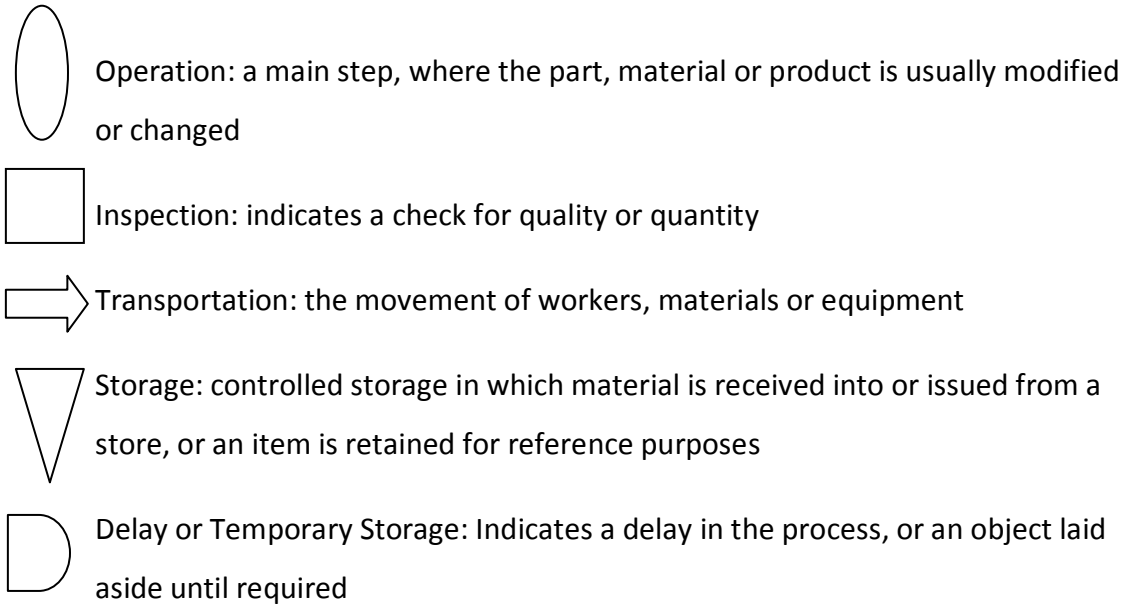


FIGURE 2: ASME flow process symbols, 2011

Using pictures from the company as of 1st November which can be found in Appendix 1 the layout of the company can be illustrated by the symbols as follows.

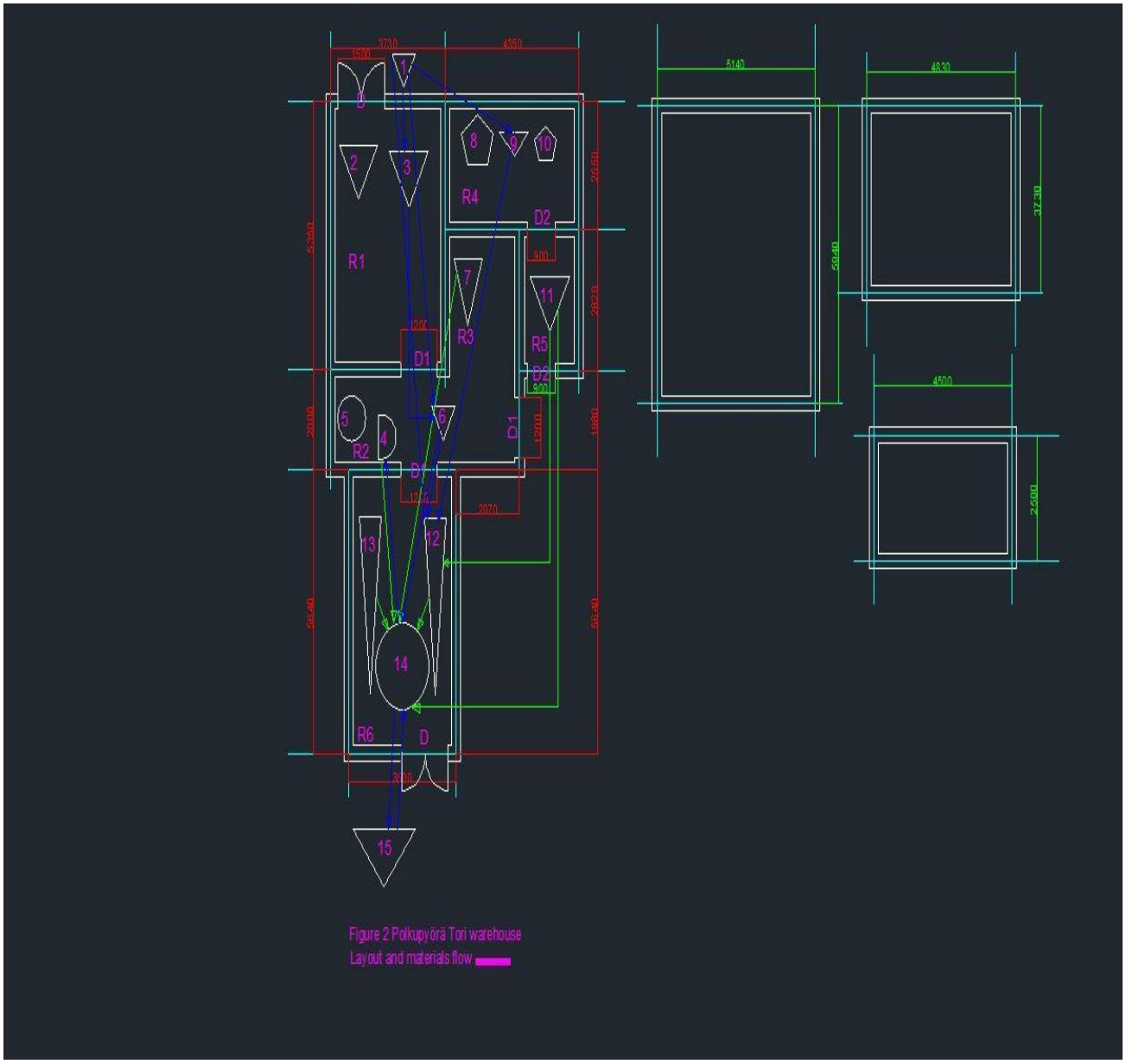


FIGURE 3. Polkupyörä Tori Layout and material flow

The layout above illustrates the design of the workshop and material flow. Polkupyörä Tori has three extra rented warehouse areas which hold used bicycles and new bicycles,

and are located in the basement of the company's building. The numbers 1 through 15, D and R, are denoting as follows and green arrows indicate flow of spare parts while the blue arrows indicate the flow of customer bicycles:

D. Doors

R1-R6 Rooms in the workshop

1. Storage for bicycles after customer problem specification
2. Storage of small spare parts that can also be sold directly to customer e.g. oil, helmets, brakes, brake pads, baskets
3. Storage area for new bicycles, old repaired bicycles for sale
4. Storage for bicycles that have been repaired and are ready for customer pick up, storage for lights sold directly to customer
5. Customer service desk
6. Storage for bicycles that require repair and repair area for one of the staff
7. storage for raw materials such as rims and tires
8. Office area
9. Raw material Storage for e.g. tires, rims and bicycles that require heavy repair
10. Rest room
11. Storage for tires
12. Storage for bicycles going into the repair section and tires, equipment used during repair e.g. bolt holders, screw drivers, oil.
13. Storage for frames, electric pump, working bench for repair of rims
14. Repair section and inspection

15. Storage for repaired bicycles

In the company, inventories include new spare parts for bicycles, old bicycles in need of repair, used spare parts, customer repaired bicycles, new bicycles, helmets etc. The inventory control system employed in the company is referred to as an Eye ball system. The eye ball system is a process in which the manager stands in the warehouse and looks around, on noticing that a product is out of stock he then makes an order for the product (Score 2002, 2). Currently, the company does not store records of sold products, and inventory calculations are conducted once a year. The following diagram shows the item level of inventory for one type of bicycle.

FIGURE 4. Material requirement planning for product, 2012

Purchasing of goods for the company is conducted by the use of emails and the use of spreadsheets. Suppliers provide spreadsheets to the company to fill in details of the parts required by the company. Polkupyörä Tori has 6 main suppliers, and due to time consumption in order processing and limited numbers of people working in the company, the same suppliers have been supplying for the company since the business kicked off until to date. These suppliers were determined under lead time, price, location of supplier and the quality of the product offered.

Buying of goods is conducted in bulk because most parts are small and can only be sold in large amounts: this creates high inventory levels and the storage capacity is overwhelmed. According to the manager, the lead time used when buying spare parts is 2 days, however, when stock outs occur without prior knowledge, the company has to obtain parts from nearby stores to sustain customers' demand until the spare parts ordered arrive in the company. This proves to be more expensive than buying on the long lead time basis and this reduces the company's potential savings.

2.4 Challenges

As mentioned earlier Polkupyörä Tori is situated near the universities and a busy city center where most people work and attend school. In addition to the location being convenient for the business since it is close to potential customers and current customers, the area also has a large park where it is possible for customers to ride their bicycles in order to confirm if they are satisfied with the service rendered. Another great advantage of the location is that it is easy to acquire products for the company from suppliers since the company is located near the train station and road transport is abundant.

Although the company's service operations are easy to plan and control and huge and expensive equipment is not required, the company cannot achieve its full potential

when other departments are being ignored. Warehousing processes, the purchasing process, inventory control and information management are among other departments that are being neglected; this promotes unnecessary time consumption, stock outs, and increase in expenses. The importance of these other departments should be considered in order to maximize savings.

Currently, Polkupyörä Tori is manually operated and information and communication technology has not yet been adopted. This means the company does not have software to detect low levels of inventory, to trigger replenishment and send information internally or externally. Information management is neglected due to lack of enough workforce, hence this causes problems like shortage of material, late repair and deliveries, excess inventory, interrupted schedules, lost items, and inventory inaccuracy.

The company has managed to own a significant amount of space for its services and has rented warehouses near the company in order to reduce material handling time and movement from one area to another. On the other hand, as shown in (the pictures) Appendix 1 slotting in the warehouse is inefficiently organized in that high moving products are stored far from the repair area and slow moving products near the repair area. Inefficient slotting creates long waiting times due to the lack of name tags in the warehouse and long movements for workforce when collecting products.

Another problem that can be identified is the layout and design of the company. Even though the design is inconvenient for space optimization in the company, the pictures taken of the warehouse indicate inefficient allocation of the storage area. Due to this issue, the company experiences shortage of space in one area and empty areas in another; as a result numerous problems leading the company to purchase new or rent extra warehouse space to solve the problem.

3 THEORETICAL FRAME WORK

3.1 Inventory Management

According to Müller (2002, 1) inventory includes raw materials, unfinished goods, finished goods, and supplies used in operations in a company. According to Arnold, Chapman and Clive (2008, 254) Inventories are materials and supplies that a business or institution carries either for sale or to provide inputs or supplies to the production process. Inventory can be categorized as raw materials: semi- finished goods, finished goods stored and maintenance/repair supply. Inventory depends on production; it either evolves from production or is held to support the production processes.

Inventory is important for businesses because it balances supply and demand, but a too large stock does not support operation due to inventory turnover and increase in operating cost, which will reduce profits. On the other hand a too small stock may cause stock outs, meaning there will not be enough products to meet the demand, in this case sales are minimized and there is loss of profits as buyers transfer to other suppliers. (Ellram, Grant, Lambert & Stock 2006, 128-135.) Inventory takes 20%- 60% of the total assets. Inventory can be classified either in aggregate level or item level. Aggregate level deals with handling inventories according to groupings: raw material, work in progress and finished goods, according to functions and not in the single item level while the item level deals not only with the aggregate level but also the single item level. (Arnold et al. 2008, 254-255.)

Emmett (2005, 25) defines inventory management as an approach to manage the product flow in a supply chain, to achieve the required service level at an acceptable cost. Waters (2009, 337) defines inventory management as another term for inventory control and stock control and as a method used in an organization to control levels of inventory but still stock enough to act as buffers between production and satisfaction of customer demand. From the above definitions from Emmett and Waters, it is clear to con-

clude that inventory management is the planning, managing and controlling of inventory in a business, and it is important for a company in order to maximize customer service, minimize inventory investment and reduce the operation cost in the company.

3.1.1 Inventory Cost

Storing of inventory brings about inventory cost. The cost calculated for an item begins when the item is purchased until it is consumed. These costs include space, labor, damage, theft, shipping etc. While dealing with the management of inventory cost, the following categories of costs are employed. (Emmett 2005, 35-41.)

Holding cost

This is the cost associated with storing the item. If production is not leveled, inventory levels tend to vary in the peak periods of production and in periods of slack, which bring about the holding costs. Holding costs can be broken down into capital costs, storage costs and risk costs. Capital cost also known as opportunity cost is the money invested in the inventory items and is not accessible for any other use. It also includes an interest rate and is highly depending on investment opportunity. Storage costs are costs related to the required space, workers and equipment. It also includes costs brought about by overtime, hiring, training, extra shifts and layoffs. Risk costs are associated with the damage that might occur to the items while in stock, costs of goods lost or stolen, costs of obsolescence (product value), and costs related to deterioration or rots on items which have a limited shelf life in storage. (Arnold et al 2008, 261-264.)

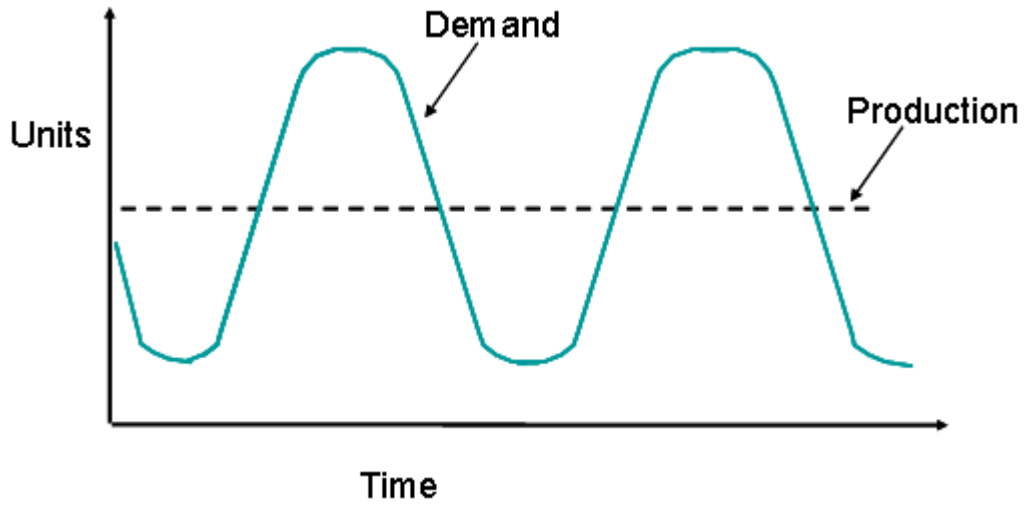


FIGURE 5. Level production by Management& Development Center 1992

Fixed order costs

This is the money related to the procurement of an item. Procurement deals with purchase, transportation, customs duties, insurance and warehousing of an item until it arrives to the company. These are costs related to placing an order and they might arise from the supplier or the company itself if the raw materials are produced in-house. They are called fixed order costs since they do not vary with the quantity of products ordered but the annual orders placed in a year. Fixed order costs include production control costs, setup and teardown costs, lost capacity costs and purchase order costs. (Op. cit p. 261-264)

Production control costs are those related to inventory flow; these are issuing and closing of orders, scheduling, loading, dispatching and expediting. Set up and tear down costs are costs related to work centers when placing an order and lost capacity costs are related to the time, people or space related to placing an order. Purchase order costs are costs related to the purchasing process; order processing, follow up, expediting, delivery and payment. (Müller 2002, 40-41.)

In addition, cost of purchasing an item is also explained by the number of purchasing orders (PO) created early. For example if the PO for 1 order of 20 items is 3 euros, if 50 orders are created the PO cost is 50*3, which makes the cost 150 euros. If the product is produced in-house, the costs include direct labor, factory overhead and direct raw materials.

Shortage and unit costs

These are costs brought about by stock- outs and are hardest to quantify. They include back-order costs, loss of sales, loss of reputations and possible loss of customers. Back-orders costs are orders made to the company which cannot be delivered since the product is not ready to be delivered because of lack of raw materials.

Lost sales can be explained as informing customers that the company is not able to provide at the current situation, these is also related to loss of customers in that due to lost sales, customers find new suppliers to meet their needs (Arnold et al. 2008, 261- 264). Shortage might also disrupt production due to the lack of raw materials needed, which may lead to the disruption of maintenance periods. This is expensive for the company and when the company tries to solve the shortage abruptly it will incur expediting order cost, special delivery cost and most of the time it has to purchase from expensive suppliers.

Another type of cost is unit cost. This is the price charged by a supplier for one unit item; it can also be defined as the cost of production for an item if the item is manufactured in-house. When the item is produced in-house the cost might be difficult to determine, but if the item is bought from an outside supplier, this information can be found on quotations or invoices.

3.1.2 Inventory Control Methods

After discussing the inventory costs above, the big questions that remain are how much a company should order and how often should it be made. Inventory control illustrates how these questions can be dealt with. As mentioned by Waters (2009, 337), inventory management and inventory control are one and the same thing. According to Müller (2002), inventory control is methods used to minimize the cost related with inventory while still keeping the customers satisfied thus lowering operation cost. These control systems are also used in order to release capital held on unnecessary inventory and to optimize space in the warehouse. (pp. 43-47)

According to one article Score (2002, 1-8) reasons for inventory control include:

- Maintaining of business status by providing up to date and fresh products.
- Balancing the stock levels in proportion to demand or sales drift
- Reducing expenses
- Improving stock turnover for each item
- Planning fast moving items as well as slow items

There are a number of approaches used but in this case three ways are discussed.

JIT (Just In Time)

The JIT philosophy was developed by Toyota in Japan and it refers to acquiring products at the very moment they are needed and at the exact quantity required. The idea behind the philosophy is to reduce and eliminate all waste and advocate for continuous improvement in production and customer service. Waste is anything that does not contribute to adding value to the product or process. (Chan, Chan & Yin 2010, 1.)

According to Müller (2002, 137-140), the Just in Time system is not only a purchasing strategy but an inventory control method. Storage of inventory has a large amount of waste e.g. the processes of warehousing do not add value to the inventory; thus the processes are considered as waste. Receiving the inventory needed at the required time of use reduces inventory levels and material handling, since the inventory moves directly to the operation needing it and not into warehousing and brings significant quality improvements since the material handling is reduced. These are among many advantages of the JIT system.

ABC /XYZ Analysis

The ABC analysis is based on the 20/80 rule first discovered by Vilfredo Pareto. This analysis is used in material management and is usually based on analyzing the monetary value of annual consumption. (Gopalakrishnan 1994, 164.) According to the principle there are three groups A, B, C to define the inventory (APICS article, 2010).

Group A: About 20% of items account for 80% dollar usage. These are the most important raw materials to stock and should get more attention. Lack of items in this category might result in large losses.

Group B: About 30% of items account for 15% of the dollar usage. This group consists of the second most important raw material

Group C: About 50% of items account for 5% of the dollar usage. This consists of the least important items.

These percentages vary from company to company. Using this principle will encourage inventory control. According to Arnold et al (2008, 270), the steps for preparing an ABC analysis are as follows.

1) Identify the annual quantity usage of an item
2) Multiply the quantity usage by the cost of the item that will give the annual dollar usage
3) List items according to annual dollar usage
4) Add the annual dollar usage to get the total annual dollar usage.
5) Find the cumulative percentage of items
6) Observe and list the distribution by percentage annual usage and group the items into A, B and C.

The difference between the ABC analysis and the XYZ analysis is that while the ABC analysis concentrates on the annual monetary value consumption, XYZ concentrates on the steadiness of demand for individual items. X parts indicate a relatively constant demand that has a high degree of predictability (more than 20% of items). Y parts indicate items that are irregular but have a patterned demand and a medium degree of predictability (20-10% items). Z parts show items that can have an irregular demand and a low degree of predictability (less than 10%). (Gleißner & Möller, 2011.)

ABC/XYZ analysis can be combined together to generate a matrix classification (AX, BX, CX, AY, BY, CY, AZ, BZ, CZ), which is used for inventory control, production demand and forecasting strategy. According to Franco, Gasquet &Ortiz (2010), the generated matrix from ABC/XYZ can be interpreted in the following format: AX and BX are items that have a high proportional value and are good to forecast, since the two are the most common used, thus they are easy to adjust. AZ and BZ items are not easy to control since they have an irregular consumption. Items in these categories might be stored for a long period of time since having a too small storage of these items might come to affect the production, and this is expensive. (pp. 129-136)

Safety stock and service level

The quantity ordered depends on the economic order quantity and safety stock. Economic Order Quantity (EOQ) is the optimal order quantity that minimizes the annual inventory costs. This model has some assumptions related to it. This model assumes that the demand rate is relatively uniform and known, production is in batches and not continuously, there is a constant lead time, a fixed item cost, a fixed inventory ordering and holding cost. (NC STATE University, 2011.) Due to these assumptions, it is not advisable to rely on the EOQ when the demand rate is uncertain, thus safety stock and service level are introduced in order to cater for the uncertainties.

According to Arnold et al. (2008, 307), safety stock is an extra calculated stock used to protect against stock outs and quantity ambiguity. Safety stock indicates when to place an order but has no effect on the amount ordered. The idea behind this method is to calculate the quantity of an item used in a week and according to the lead time of the procurement of the item carry extra inventory. In an example, if the company consumption for a week in item A is 100 and the lead time is 3 weeks then the safety stock is (100*3) 300 A items.

Service level can be defined as the probability of the held stock in the warehouse to satisfy the demand from customers (Waters 2009, 354-355). For example, if the chosen service level is 95%, it means that the company is ready to conform to 95% of orders made by customers and the company is also ready to forgo the remaining 5% of orders. This decision should be thought about carefully before being implemented.

The relationship between EOQ, safety stock and service level can be expressed by the following figure.

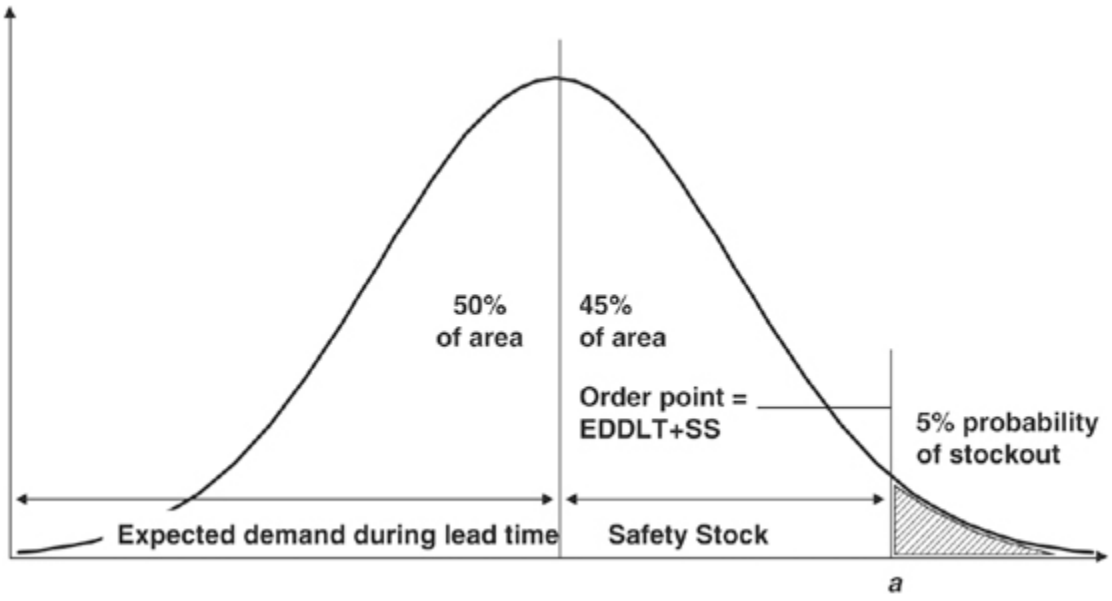


FIGURE 6. Safety stock for 95% service level and a normally distributed demand, 2009

3.2 Warehouse Management

A warehouse is defined as a space used to store goods from the time they arrive, until the time of consumption (Ellram et al. 2006, 229). Warehouse Management is the technique of monitoring the receipt, handling, storage, transport, packaging and distribution of materials in and around the warehouse (Knowledge management articles, 2009). According to Emmett (2005), warehouse management involves deciding on the location of the warehouse with the lowest cost that will provide easy access to its customers and suppliers. In addition, it involves planning of methodologies used for easy material flow in the warehouse, and management of the cycle lead time flow for products in the warehouse. (pp. 5-8.)

Depending on the size and strategies used in a company, a warehouse can be managed in different ways. In addition to the definitions presented above, Emmett (2005, 5-8) and Ellram et al. (2006, 261-262) explain that management of warehouses should be organized in relation to the products being stored, that is, they can either be manually oper-

ated or automated. Another management difference includes paper documentation and the use of electronic documentation as information management systems in warehouses, these documentation processes are used in order to manage inventory and flow. On the other hand, some factors remain similar to effective warehouse management. These factors include SKU (stock keeping unit), space utilization, stock location, material flow process and recording of processes. (Ellram et al. 2006, 242-250.) These factors need to be managed effectively in order to reduce operational costs and maximize customer service.

3.2.1 Warehouse Material Flow

The movement of material in the warehouse from the point of receiving to the point of shipping is what is referred to as material flow. When operating a warehouse, several functions are performed in order to have an effective operation, reduce pilferage and deterioration of products. These activities include receiving goods, identifying and sorting the goods, dispatching the goods to storage, holding the goods, picking the goods, marshaling the shipment, dispatching the shipment and preparing records and information systems. (Mohsen 2002, 432-440.)

Receiving of goods is the acceptance from an outside supplier or inbound supplier; outside goods are inventory produced from another company while inbound means produced in the company. As mentioned above there are different types of inventory raw materials, semi-finished and finished. All these inventories are stored in the warehouse. The responsibility of the receiver is to check whether the goods are in a good condition and according to the order and bill of lading including the quantity and part number. If the goods are not as indicated or the quality is not as required, a report is drafted to be sent to the supplier of the warehouse.

Identifying and sorting of goods means identifying how the goods are stored in the warehouse and in which location in the warehouse. The responsibilities include keying in the part number (stock-keeping unit) and the name of the item into the system used in the warehouse for record keeping and then sorting according the location to be stored. Dispatching of goods to warehouse means moving the goods from the receiving area to the location identified for storage and put away. This movement can be done using manpower, forklifts or conveyors depending on the company's resources. (Ghiani, Laporte & Musmanno, 2004, 158- 160.)

Holding of goods means storage of the items in a good condition until they are needed by the warehouse customers. The warehouse customers may include production, maintenance and direct consumers. Picking of goods and marshaling the shipment happens after an order or orders have been placed to the warehouse; picking is the selection of goods needed against the order made. Goods are then moved to the shipment area where goods making a single order are marshaled together to form a shipment. During these activities orders are updated and errors are documented.

Dispatching of the shipment includes the preparation of orders, bill of lading, shipment documents, and loading of the shipment from the shipment area to the right transport vehicle. After the dispatching of the shipment, the systems and records need to be updated to indicate the action completed and to which customer the shipment has been sent to, with all the details including the quantity issued; this activity is referred to as preparation of records. (Arnold et al. 2008, 336.)

Depending on the material being handled, there are different ways to move the products, most common ways are the use of pallets and forklifts, conveyors, trucks, automated systems etc. The method used in the movement of goods should be cost oriented, safe and reliable. The process should be easy to follow and should have less material handling time. These can be managed by having labels on shelves, bar codes on products, RFIDs system and re-organization of racks according to SKUs. (Garcia 2004.)

3.2.2 Warehouse Storage and Material Handling Equipment

TechTarget (2004) presents the definition of storage utilization as a ration of how well the storage space is used. According to Ross (2005), Warehouse storage utilization is defined by describing the types of storage areas and determining the requirements for storing every product. Storage utilization aims at exhausting the space available in an efficient way while still having an effective material flow. According to Mohsen (2002, 432-440), storage utilization should not be exercised as a single operation, but the design and layout of a warehouse should also be adjusted for easy access and to minimize handling time.

Warehouse layouts vary for each company according to the items being stored, the company's resources and what the company's customers require. However, all warehouse layouts should be divided into areas that support day to day processes and should similarly support the functions related to warehousing and aim to achieve maximum efficiency. (Frazelle 2002, 189-192.) Ellram et al. (2006, 249) state that a good layout can increase output, improve material flow, reduce operation costs, improve customer service, and provide a better working environment for the employees.

Before establishing a layout, the warehouse manager must consider the flow of materials and the inventory levels to be stored. First in First out (FIFO) means the first products received into the warehouse leave the warehouse first regardless of time of use; this mostly applies to products that have a short life cycle. Last in First out (LIFO) means the most recent items in the warehouse are removed first from the warehouse regardless of time of consumption, this method is used on products that have a long life cycle time and is also used to protect companies from inflation. (Tuller 2008.)

There are different methods for inventory slotting in warehousing. As Frazelle (2002, 35) mentions, one of the methods is the use of demand correlation distribution, which states that calculations should be prepared to analyze items that are ordered or picked at the same time for an order, and the items should be allocated the same area to re-

duce picking time on items. This method can also be utilized for items with the same functions.

Grouping physically similar items together is another method discussed by Arnold et al. (2008, 340). In this method items that require the same management are stored together. E.g. frozen foods need a freezer; some chemicals need a dark lighting and cool surrounding etc. Another method discussed by Arnold et al. (2008) is grouping fast moving products together and allocating the products near the marshaling area. This will reduce the handling time of products since the movement of products from receiving area to the shipping area has reduced. In addition, slow moving items can be stored a little far from the shipping area. An example of this is when storing items in a shelve, store the ones that you pick frequently on the low shelves and the items that are seldom used on the upper and top shelves to reduce time and movement up and down. An additional method discussed by Arnold et al. (2008, 340) is the locating of safety stock and working stock at different locations. This is placing a small amount of working stock near the shipping or marshaling area to reduce material handling time, space optimization and provide a fast reaction time to customer order.

With reference to Frazelle (2002, 127-134) storage and handling of items should be prepared in material handling terms. These Stock keeping units (SKUs) include pallets, cases, boxes etc. Taking small items into consideration, if the items stored are less than its SKU, which in this case is a box, the items should be stored in shelves. However, if the items are more than the SKU they should be stored in boxes. Material handling is loading, moving and unloading of materials (Ray 2007, 1). According to Tompkins (2010, 215-218), material handling equipment refers to the gears used to enable movement and storage of materials in the warehouse. These gears can be conveyors, shelves, racks, forklifts, pallets etc. Moreover, Ellram et al. (2006) state that the proper selection of material handling equipment will increase productivity and efficiency. Manual material handling equipment systems are the most common gears in warehouses and are characterized for all the material flow functions of the warehouse (pp. 261-267.)

In reference to the case study used in this thesis, most of the products in the warehouse are small items. Frazelle (2002, 127-134) mentions that bin shelving, racking and drawers are storage systems used for small items. Bin shelving as shown below is affordable which means low investment and provides the user with substantial elasticity. On the other hand bin shelving underutilizes the space in the warehouse. Bardi, Coyle, Gibson, Langley and Novack (2009, 507-509) state that the utilization of space is limited by the reaching height of the picker since the picker needs to be able to pick without any hindrance. Another disadvantage of bin shelving is security, the shelves are accessible to any person who walks past them, this can be visitors, customers, workers etc.

FIGURE 7. Bin shelving, borrowed from Material Flow & Conveyor Systems Inc. 2011

Drawers are similar to shelves and they are affordable and require a low investment. The benefits of drawers include security since the drawers can be closed and locked and the storage capacity is more than that of bin shelving. However, the height level of the drawer is lower than that of bin shelving because the picker needs to see inside the

drawers while picking. (Frazelle 2002, 127-134.) Shown below are racks and hanger systems; these are other forms of storage systems that encourage space utilization by allowing higher stacking Other forms of material handling equipment include 2-wheel hand trucks, multiple wheel hand trucks and platform trucks. This equipment is used to move material from one position to another in a warehouse. The advantages are it makes it easy for the picker to carry because it requires less force and protects the products from damage. (Ray 2007, 2-3).

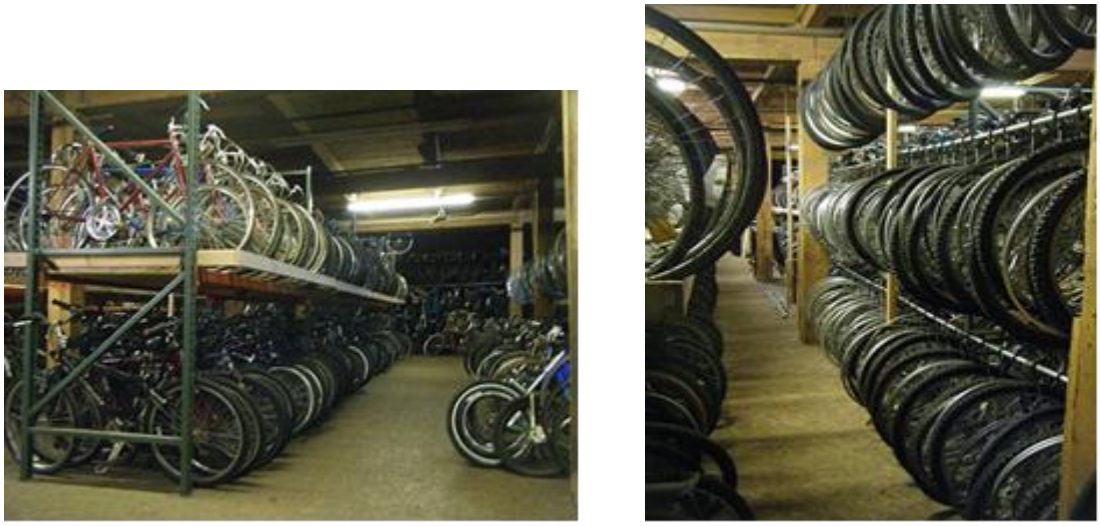


FIGURE 8. Bicycle racks and tire hangers borrowed from working bicycle cooperative, 2010

3.2.3 Information Management in Warehousing

Information management is the conscious process by which information is gathered and used to assist in decision making at all levels of an organization (Hinton 2005, 5). In addition, Emmett mentions that information flow in the warehouse is as important as physical product flow and that Information and communication technology (ICT) enables the flow of information from one point to another (Emmett 2005, 128-129). Most companies continue to move and record information of processes and products on paper how-

ever, this brings about problems that affect the company's expansion. For example: When a paper document becomes lost the information in the document becomes lost with it, when a warehouse worker is calculating inventory it takes a considerable amount of time to count and write down. (Frazelle 2002, 204-205.)

There are different types of systems that can be used for information management in the warehouse in order to avoid these problems (Emmett 2005, 128-129). Deciding on the appropriate information management system in the warehouse depends on the functions required by the warehouse manager from the system. Functions required by the manager should be detailed down and estimates for the system defined and calculated. This is conducted to avoid wastage of resources because depending on the size and functions of the warehouse an expensive and flexible system might not be required. (Nadeem 2005.)

Stock control system (SCS)

Senker (2010, 27) mentions that an SCS is a computerized system that monitors the material flow of stock in and out of the warehouse. This system is used to continuously monitor the stock levels of items in the warehouse by recording reorder levels, reorder quantity and generating a replenishment report when additional items are required in the warehouse. Re order levels can be set differently for each product as mentioned in the previous chapter. According to Heathcote and Richards (2004), the stock levels in the SCS automatically updates from different inputs. Inputs include new items in the warehouse; these are items that have not previously been stored in the warehouse. When the item record details are input into the system, the stock levels automatically adjusts to include the new items. (pp. 102-105.)Another input is customer order, when a customer order is received in to the system, the stock level automatically updates by deducting the ordered items from current stock levels. If the items ordered are not in stock the order is moved to the replenishment report. (Jarvis & Lawson 2004, 108-109.)

Returns are an additional input which is discussed, according to Event Sales Inc., customer returns are items brought back to the warehouse for one reason or another by the customers. When input is received, the system updates the stock levels according to the input condition of the item this means that if the item is in good condition it is added to stock on the other hand if the item cannot be resold the adjustment are made to the stock level. Adjustments are also considered as inputs; in a situation where physical stock is imbalanced to system stock the stock levels on the system are adjusted to meet the physical stock. (Heathcote and Richards 2004, 102-10.5)

Warehouse management system (WMS)

According to Richards, a warehouse management system is not the same as a stock control system in that as discussed an SCS monitors the location and quantity of the stock while a WMS has the functions of an SCS but also monitors the productivity of the warehouse (2011, 102-105). In addition Emmett (2005) mentions, that WMS can be integrated with other systems such as enterprise resource planning and other ordering systems. This integration is important for companies that have numerous functions in their operations which will require a flexible system to manage all at once. WMS are expensive and companies should consult an expert before deciding on acquiring one. (pp. 128-129.) Richards (2011, 102-105) also mentions that the system might prove to be expensive if the system does not utilize its full potential.

Information system Tools

A company should identify a methodology to automatically recognize when an operation has occurred in the company. Since technology growth is exponential and technological devices keep changing it is clear to deduce that a company's operation and the logistics apparatus involved e.g. Location, container, pallet etc. are the only constant elements in a system. This indicates that the constant elements should be used as the methodology

to transfer information in the systems. (Frazelle 2002, 204-212.) WMS and SCS require input tools which will provide the systems with information. These tools include:

1. Bar codes and bar code scanners are technological tools that are used to support the operations of information systems and are also used to keep track on information about goods and inventories. Barcodes are encrypted on products and in order to read the information on the barcode the products are placed on the barcode scanner and the camera in the scanner will process the codes and decode the information and move the information to inventory records in the computer. Barcode scanners can be in the form of a handheld laser camera, light pen bar code scanner etc. and they are commonly used in warehouses, mega mall, shops etc. (Lehpamer 2007, 51-56.)

2. Radio frequency identification tags and antennae (RFID) is an automatic identification method that stores and retrieves data. This technology is similar to barcodes in that the methodology for both technologies is to transmit data, on the other hand RFID are more effective in regard to the distance that RFID can read information from tags and antennae compared to barcodes. RFID systems can read products from a longer distance (max 300feet) compared to barcodes tags and scanner (max 15 feet). Another difference is that Barcodes require a direct line of sight while RFID do not require direct line. (Lehpamer 2007, 51-56.)

3. Stock controller- This is the person that operates the systems used in the warehouse. Functions for stock controller might include 1.) Inputting new products into the system and details related to the products. 2.) Manual transferring details to the systems where RFID and Barcode tools are not available in the company.

4 RESEARCH METHODS

This chapter deals with the research methods employed in understanding how micro bicycle repair companies in Jyväskylä city operate their warehouses. The aim behind the research was to determine and understand how other micro companies related with bicycle repair respond to inventory control, information systems and storage equipment in their companies. The qualitative research method was chosen by the author as the appropriate method for this particular study. This is because qualitative research is a methodology whose purpose is to understand why and how; what the processes are, and what influences the processes in a particular study. Qualitative research is important in this study, since it provides the opportunity to be more flexible with the methods used to attain information such as the use of in-depth interviews, focus groups, observation and visual observations. Qualitative research is used when a clear and deep understanding on a research is needed. (Bailey, Hennink & Hutter 2011.)

Observation is a method used to collect data by observing the events around the research area and the observed group. There are different ways to conduct observation in reference to knowing what you want and not having any previous information about the subject. In this study, observation was a key method and since the author had little information on what requires observation such as storage equipment and slotting of material the study was carried out by the use of a camera. (Kananen 2011, 48-51.)

The steps to follow when conducting a qualitative research are first, to understand the qualitative approach to be used in the study, second, to identify methods to be used in the research, third, to assess the methods and decide on the appropriate methods. The forth step is to collect data from interviewees and the fifth step is to analyze and assess the data received. (Bailey et al. 2011, 30-36)

Competitive benchmarking was the approach and tool used to select the sample of the interviewees in this study. Competitive benchmarking is the assessment of the performance of a company in relation to the company's competitors in the same business industry (Frazelle 2002, 46-50). Three companies located in Jyväskylä were identified that have similar operations to the case study and they were used as the sample group. The sample group deals with selling of new or old bicycles, repairing of bicycles and selling of bicycle spare parts. Since the research requires a better understanding on how processes are conducted and pictures on how space is optimized by the sampled group, semi-structured in- depth face to face interviews and observations were methods selected after identifying the interviewees. Other than companies located in Jyväskylä, benchmarking by the use of observation was conducted on companies in other cities and countries via the internet at www.YouTube.com.

4.1 Research Questions and Data collection

Letters written in English and Finnish were delivered to the sample group of interviewees requesting the owners of the company to join in the development of this research. This letter can be seen in Appendix 2. The group was also provided with an option to answer the questions in Finnish since a Finnish English interpreter and vice versa was available in order to avoid misconceptions of the interview. Interview questions were not sent to the interviewees prior to the interview to ensure that genuine information was received and to avoid exaggerated responses from the interviewees. The owners of the company were eager to assist and the interviews lasted a maximum of 30 minutes, in addition all participants preferred to interact in English, thus ensuring lack of misinterpretation on both parties. A VN-3100PC digital voice recorder was used to record the interviews for further understanding of the conversations and capturing the exact responses of the participants. Where possible, a camera was used to capture images of the storage equipment used by the participant company. According to Kananen (2011, 48-

50) it is advisable to record every event and conversation when collecting data in case of misunderstanding, misread emotions, unclear recalls of event in order to review and verify all information.

The main research questions used in the interviews were similar for interviewees and were as listed below:

1.) What inventory control methods are used in the warehouse and what are the reasons for choosing the methods?

2.) How is product slotting in your warehouse managed and how does it support your warehouse functions?

3.) What kinds of storage equipment are used for space utilization in the warehouse?

4.) How does your warehouse store and retract information for product replenishment and inventory calculations?

4.2 Data Analysis

Data analysis involves describing, comparing, grouping, and developing theory from the data provided. The first step is to listen to the recorded data collected during the interviews and produce a written transcript. This transcript can be in the form of selecting the relevant information for the research from the recorded data or can be a word- for-word replica of the data. (Bailey et al. 2011, 210-214) Subsequently to the production of a written transcript, is categorizing the data into classes and blend the classes into greater subjects (Kananen 2011, 57-58).

Thematic analysis is a method for identifying, analyzing and reporting themes within data (Braun & Clarke 2006, 79). After listening to the tape recording several times, a written transcript of a word- for- word replica of the conversations a total of 20 pages

was generated including photographs collected from individual warehouses. The transcript was then read through and the responses that related to each other were coded with the same color. The information in the transcript that did not relate to the study was deducted. According to the colors, the transcript was read deriving themes from the data. The themes identified from the transcribed data were information management, storage allocation, inventory control, and storage equipment. Photographs taken during the data collection were compiled together and categorized according to storage equipment. The research process was conducted by one person thus avoiding loss of information in transit.

5 RESEARCH RESULTS

This chapter looks at the results provided by the sample group and how the information provided relates to the research problems of this study. The transcript formed from the recorded interview, indicates that all of the companies interviewed had different ways of dealing with their warehousing processes. All the different processes have their advantages and disadvantages, and based on the data analysis conducted, the results are presented in accordance to the subjects identified beforehand. The names of the interviewees are denoted in this study as Participant 1, 2 and 3.

5.1 Information Management

According to the data provided, the participants portrayed that information management was not a key concern for the companies since their companies are micro and inventory calculations are prepared once a year. Another concern was raised when the participants mentioned that shipping lists and outgoing items are not reviewed or documented to be compared to the physical inventory.

P1: "We do physical inventory once a year , we have information sheets where you input the details about the bicycles and the customers, estimated cost, what needs to be repaired and which parts were used and who did the repair and final price. We don't record second hand parts and second hand bicycles. We have order invoices and receipts where if need be we can see what has been ordered in relation to new spare parts."

P2: "We don't list one part that we sell since we have the cash machine so we always hit the spare parts and stuff like that when you sell it and not individual parts. We've had the shipping list that we get with a package and everything is marked there. We keep that (shipping lists) and we always know what we have ordered and how much it cost. Physical inventory is done once a year but it is easy to keep up with what we have."

P3: "Once a year, we make physical inventory but we don't compare to the spreadsheets. We use MS excel spreadsheet and list all the parts that are available and calculate the pricing, but when we charge customers we don't have a program or system that shows the real time amount of stocks."

From the author's observation, the disadvantage of P1's way of handling information in his warehouse is that since some of his products are not recorded but still stored in the warehouse, this creates uncalculated expenses making it unclear to calculate the savings incurred in the business. With regard to P2 and P3, it is worth noting that even though there are shipping lists and Excel spreadsheets available respectively, this information is not enough to assist the company with inventory and space management. As mentioned from the theoretical background of information management, one of its advantages is to improve warehouse processes.

5.2 Storage Allocation

The results from the interview and from observation indicated that compared to the stock held, the storage space is insignificant and some products are stored outside to

relieve space for operations in the warehouse. All participants indicated that they have extra space in the yard near their warehouse, however only one participant paid for the use of the yard.

> *P1: "The yard costs 1260€ per annum, We use it for broken bicycles where we take second hand spare parts and second hand bicycles and the inside room (warehouse) for customer bicycles and new spare parts. We have little amount of spare parts stored in the warehouse (basic parts), we mostly do recycling for bicycles."*

> *P2: "This is kind of not the normal situation since its winter time and the big part of the bicycles are ours that we have repaired to sell but usually the bicycles come to repair are in the front room and on the rack outside and we have a parking lot to store some bicycles. Repaired bicycles are stored in the back room"*

> *P3: "We try to separate, we sell only new bicycles and everything that is used is for us to service. In winter time we store bicycles inside but in summer we have a lot of bicycles we store them outside in the day time but inside in the night. Mainly customer bicycles build up the stock in summer time. "*

Product slotting is among other interesting results that appeared from the interview and observation. It was shown that other than allocating yard space to some products, preparation for product slotting was not clearly done in some warehouses. However, some indicated that product slotting was important and had been clearly outlined. This can be seen from the word for word replica of the interview shown below.

> P1:"*When we receive items we place them where there is empty space. We put price tags on the repaired bicycles that are being sold and for customer bicycles we have a sheet of paper showing it has been repaired. Mainly the repaired bicycles are stored near to the wall in the small warehouse and the ones (bicycles) that need repair are stored in the empty space remaining."*

> *P2: "Receiving of bicycles from the customer is done in the front room while picking of bicycles from the company is done from the inside (back) room. The pay register is located in the inside room. Ski maintenance is done in the winter time and during the spring the space (ski maintenance) is used to store some of the bicycles. It is easiest for the customer to bring the bicycle from the front door and also easy to do the evaluation since we*

keep them on the front side, then it is easier for us to take the bicycle through the small door and do the repair then the customer pays from the inside and takes the bicycle through the backdoor."

P3: "New bicycles are stored on one side of the warehouse, we have bicycle holders on the roof to increase the storage capacity, and the other side is for customer bicycles that need repair and the ones that have been repaired."

The information provided above shows that all the interviewees have different ways of slotting their products in their warehouse however, from in author's opinion only P2 has a clear material flow structure for their products, since products are grouped according to functions, processes and easiness of handling the products for employees and customers.

5.3 Inventory Control

The results related to inventory control were found to be interesting since the results had very defined differences and similarities in relation to each participant. The similarity in all interviewees was that none of the companies use any replenishment calculation methods; the Eye ball system is the method used to decide when products should be ordered. The differences include when to order products for the warehouse and which products should be stored. The reasons for these differences were also noted as lack of enough storage space, ambiguity of products, and availability of products from supplier in a lead time of 2 days. Another difference was in compiling a list of products that have run out of stock; the reason given for this was to reduce the total transportation by ordering a certain amount of products of a certain amount of money and receive free transportation. This can be seen from the transcript below from the recorded data during the interviews.

P1: "We stock basic spare parts which are mostly needed. When a customer brings a bicycle we check what the bicycle needs and order from the needed parts for that time. In Jyväskylä we get (suppliers) from Motonet Oy and Biltema and if we need special parts we order parts from Uimonen Trading Oy. It is a firm which has all the bicycle parts in the catalog. If customer needs one tire we buy one tire. There are so many different types of tires and we don't have so much money that we can keep big amount of (inventory) in the warehouse."

P2: "Since I have been working here for 3 years I have an idea of how spring works usually we order much more products. When a customer brings the bicycle we check what the bicycle needs and we kind of sell it without taking the products from the shelves, then if we don't have the parts on the shelves or it's (the product) going to finish then we add the parts to the order list. Orders (products) come after 2 days to 3 days. Some dealers give free transportation if you order more than some amount of money, usually small amount of money you need to pay for transportation. Order more to get free transportation."

P3: "We just check when we are repairing if something is out then we order more. We store the most common parts in small quantities. We have 2 suppliers who have delivery for free and the rest require us to buy products that have a certain amount of money. The suppliers who deliver for free the products are much more expensive compared to the other suppliers."

5.4 Storage Equipment

Finally from the observation and photographs of the storage equipment, the results indicated that bins, shelves, racks, hangers and hooks are the most commonly used storage equipment. All interviewed companies used bins in their warehouses for the small products. In some warehouses hooks were used to hang tires, bicycle frames and rims while in one warehouse tires were stored in a rack. Bicycles were hanged on a top wooded frame or just stored on the floor. Some of the pictures taken from the different warehouses are as shown below.

FIGURE 9. Schwalbe shelf equipment taken from participant 2

According to participant 2, the tire shelf above indicates that tires of different types and sizes can be stored together with easy access to all tires when needed. This equipment is beneficial since the warehouse deals with many different types of tires and the equipment provides an opportunity for the small sized tires to be stored inside the big tires. The equipment also provides space for storing products that are often used when repairing tires; these products such as bicycle tubes can be stored on the equipment. This saves space and creates a short picking time for servicing a bicycle for tires and tubes. The next picture shows hanging bicycles from the celling using hooks found from videos on www.Youtube.com. The equipment observed from YouTube include siras cycle glide and velo grip. These kinds of equipment are easy to install, easy to use and they free up floor space in the warehouse.

FIGURE 10. Siras cycle glide equipment taken from Bike shop, 2012

The picture below shows bicycles hanging from a wooded bar. Participant 3 mentioned that he built the equipment himself after discovering that the warehouse required extra space to hold enough stock in order to satisfy their customers.

FIGURE 11. Bicycle hanging on wooden bar borrowed from Participant 3.

6 RECOMMENDATIONS

It is important to mention that the following recommendations might be challenging to enforce, since it requires the business to sacrifice its time, workforce and money. In addition to this sacrifice, the company might be required to adjust the departmental operations to synchronize with each other towards achieving its desired goal. This could enable the company to increase on savings, make processes more efficient and influence the company's expansion in the long run. Polkupyörä Tori is a micro business and these resources mentioned above might prove to be overwhelming; with this in mind the author has suggested a couple of recommendations that will not require the use of many resources.

While conducting this research, Polkupyörä Tori has managed to employ some of the recommendations suggested by the author into the warehouse operation system in order to improve the productivity of the warehouse and provide a comfortable environment for its employees and customers. These changes will be discussed in chapter 6.4 below. Chapters 6.1 and 6.3 show the recommendations suggested to the manager of the company.

6.1 Layout Design

As can be seen from the current layout of Polkupyörä Tori's warehouse, the material flow in the warehouse is inefficient and time consuming. From the research above we realize that participant 2 is using a straight thru layout for his warehouse making it easy for customers and employees to access products. In addition, it is noted in the theoretical research that grouping physically similar items together, demand correlation distribution and storing safety stock and working stock at different locations are methods for layout designs. Using these findings it is easier to formulate a new layout that supports the operations of the business and reduces delays in the repair of bicycles, as well as reduces cycle times and buildup of inventory. In consideration to the study above the following layout has been formulated.

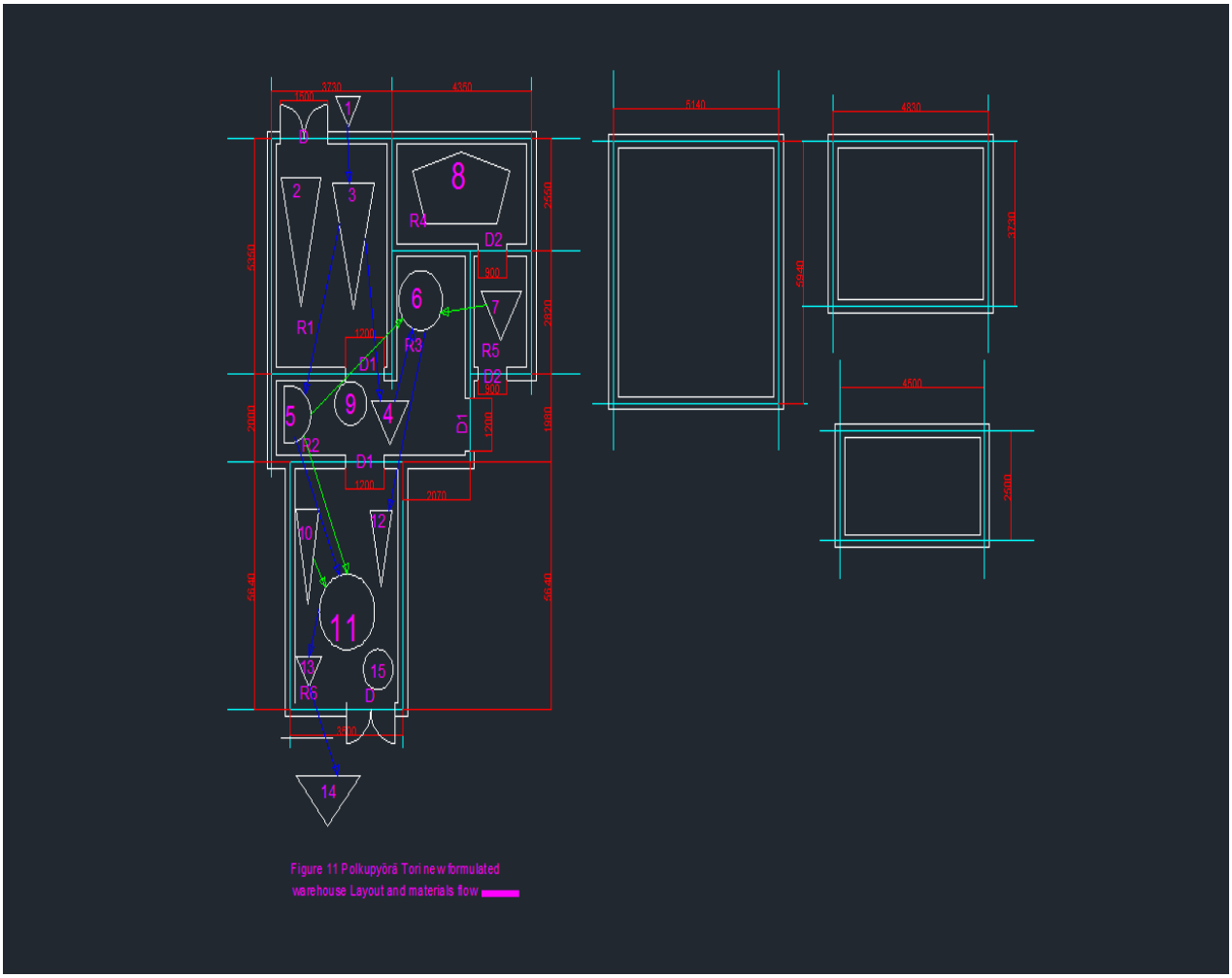


FIGURE 12. New formulated layout for Polkupyrörä Tori's warehouse

The numbers 1 through 15, D and R, are denoting as follows and green arrows indicate flow of spare parts while the blue arrows indicate the flow of customer bicycles:

D. Doors

R1-R6 Rooms in the workshop

1. Storage for bicycles after customer problem specification
2. Storage of small spare parts that can also be sold directly to customer e.g. oil, helmets, brakes, bicycle locks, baskets, pumps, tires

3. Storage area for new bicycles, need repair bicycles (new bicycles are to be stored up by the use of glide equipment)
4. Storage for bicycles that are in line for repair and few spares on shelves (bicycles that need to be repaired that specific day)
5. Storage for bicycles that are in line for repair and few spares on shelves (bicycles that need to be repaired that specific day)
6. Working area for one of the engineers
7. storage for tires in racks
8. Office area and rest room
9. Customer service desk
10. Storage for spare parts such as tires, bicycle frames, and other spare parts used to overhaul a bicycle. Electric pump
11. Repair section and inspection working area
12. Storage for bicycles going for inspection from the previous engineer.
13. Storage for ready to pick up bicycles
14. Storage for ready to pick up bicycles
15. Working bench for inspection engineer

The difference between the new layout and the current layout of Polkupyörä Tori is that fast moving products and working stock have been stored in the workshop while slowly moving products and the safety stock in the warehouse in the basement. Another difference is that storage allocation is defined to accommodate 2 engineers in that products are close to the operational areas in the order of what operation an engineer is in charge of.

6.2 Space Optimization

Although Polkupyörä Tori's warehouse is currently using some of the storage equipment mentioned in the research part of this thesis, more emphasis in space optimization processes should be made. The use of shelves, bins and racks was noted as very important to the warehouse from all participants involved and referenced authors on warehouse equipment. The equipment chosen should be labeled accordingly and used on the products that fully require the equipment.

Racks can be used for bicycles as shown in Figure 8. Since the largest amounts of products in Polkupyörä Tori are bicycles and they occupy a larger space, it is advisable to define the storage allocation for these bicycles and store them in an efficient manner. As shown in Figure 8, the rack provides almost double the storage space for bicycles compared to the current system of storage. This racking system can also be employed on tires as shown in Figure 8; this provides 3 times the storage space compared to the current hook storage system.

Besides racks other suggestions include siras cycle, the wooden holder and the schwalbe shelf. These types of equipment take up less or no space at all on the floor providing an opportunity for other products that require the space. By changing the existing storage system in the warehouse into the one shown in the study not only do the engineers manage to acquire extra space to work and repair with ease but also the manager might avoid purchasing or renting an extra warehouse for the company.

6.3 Information System

Even though the company has limited resources, it is recommendable that the information flow of products within the warehouse be documented. A stock control system is the information system recommended by the author of this research as the best for re-

cording and managing the product flow within the warehouse. This system can be connected to the cashier in order to record outgoing products as well as incoming products and this will help in the future forecasting of customer demand and inventory management.

On the other hand, the company can employ extra workforce to be in charge of the inventory management and procurement of products. Increasing the number of workforce in the warehouse that deals with inventory management will provide the manager with details of which products to stock, when to buy and how much to stock. The duties for the inventory team would include creating an ABC analysis for products, creating formulas for calculating the service level and safety stock for the products, and forecasting on the demand for the next season. The service level and safety can be used as the inventory control methods in the company after creating the limits.

With SCS the manager will require to employ a professional SCS controller or the current employees will require training on SCS, however, SCS is a long term investment, while increasing workforce can be identified as a short term investment. These solutions for information management will also serve as a way to distinguish the problems associated with the buildup of inventory, delays and customer satisfaction.

7 DISCUSSION

Although Polkupyörä Tori has managed to grow and customer retention is high, the departmental operations are inefficiently prepared. This indicates that there can be a potential increase in savings and growth if the operations improve. At the beginning of this study, the initial warehouse operations of the company indicated that there was a need for an extra warehouse to support the operations to run efficiently, but while preparing this study, the company was informed of the recommendations suggested by the author, and some changes have already been enforced. These changes include the use of

racks for tires, product slotting and the use of bin shelving for smaller products. Pictures from the warehouse are shown in Appendix 1.

The layout and product slotting are other changes that have been made. The warehouse manager has arranged products according to their functions and accessibility to the customers and employees. Unrepaired bicycles have been moved closer to the employees' repairing area, while repaired bicycles have been moved closer to the customers' receiving section. The changes so far have provided the company with extra storage space for its products, better working environment and reduced delay and time consumption. Moreover, the company has employed extra workforce for inventory and warehouse management in relation to recording the material flow. The workforce is responsible for documenting the amount of stock stored, the products sold and used, making it easier to calculate how much stock is required. This change has significantly reduced the lead time for repair by having the right products when needed and having the engineers focus on the core function of the business, which is repairing of bicycles. Currently, the company repairs 22 bicycles a day compared to the initial 16.

Although information management has been mentioned in this research, further studies can focus on integrating information systems into micro companies by indicating the return on investment and reliability of each system. Procurement and forecasting are other key departmental operations related to warehouse management that require a great deal of research when increasing the warehouse productivity. These also are focus points that should be studied further.

In conclusion, the warehouse productivity at Polkupyörä Tori can be improved if all changes suggested in the study are followed. This leads to repairing more bicycles than before, which reduces operational costs since the cycle time of the products in the warehouse will be limited, and the manager might avoid buying extra warehouse space. The extra warehouse should be required only when the space in the current warehouse is fully optimized and customer demand is high. This study can also be used by other micro industrial companies in relation to space optimization.

REFERENCES

APICS article. 2010. Redwood Empire chapter of APICS. Accessed on 21 November 2011. http://www.apics-redwood.org

Arnold, T., Chapman, S. & Clive, L. 2008. Introduction to Material Management. Pearson Prentice Hall.

Bailey, A., Hennink, M. & Hutter, I. 2011. Qualitative Research Method. SAGE publications Ltd UK.

Bardi, E., Coyle, J., Langley, J., Gibson, B. & Novack, R. 2009. Supply Chain Management: A logistics perspective. South-Western, Cengage learning USA. Accessed 14 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Bike Shop Liquidators, 2012. Accessed on 26 April 2012. http://www.bikeshopliquidators.com

Braun, V. & Clarke, V 2006. Using thematic analysis in Psychology. Qualitative research in Psychology volume 3 Accessed 22 April 2012. http://eprints.uwe.ac.uk

Chan, H., Chan, F. & Yin, S. 2010. Implementation just in time philosophy to reverse logistics systems. Taylor & Francis Group, UK.

Customer returns. Event sales INC. Accessed 18 February 2012. http://www.eventsale.com

Decline and Small. 2012. The Economist Newspaper Limited 402, 8774, 87-87. Accessed 9 March 2012. http://www.jamk.fi/english/library, Nelli-portaali, EBSCO.

Economic Order Quantity (EOQ) Model: Inventory Management Models. 28.1.2011. NCS State University. Accessed on 21 November 2011. http://scm.ncsu.edu

Ellram,L., Grant, D., Lambert, D. & Stock, J. 2006. Fundamentals of logistics management. McGraw-Hill Education UK.

Emmett, S. 2005. Excellence in Warehouse Management. John Wiley & Sons Ltd.

Garcia, F. 2004. Applying Lean Concepts in a Warehouse Operation. Advent Design Corporation USA. Accessed 28 November 2011. http://www.lean-automation.com

Ghiani, G., Laporte, G.& Musmanno ,R. 2004. Introduction to Logistics systems planning and control. John Wiley & Sons Ltd. England.

Gleißner,H. & Möller, K. 2011. Case studies in Logistics. Gabler Verlag I Springer Fachmedien Wiesbaden GmbH, Germany. Accessed 10 December 2011. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Gopalakrishnan, P. 1994. Handbook of materials management. Prentice-Hall of India Private Limited, New Delhi. Accessed 10 December 2012.

http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Franco, R., Gasquet, P. & Ortiz, A. 2010. Balanced Automation Systems for Future Manufacturing Networks. 9th Edition, IFIP International Federation for Information, Germany. Accessed 14 December 2011. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Frazelle, E. 2002. World-class warehousing and material handling published. McGraw-Hill USA.

Heathcote, P & Richards, R. 2004. AVCE Information and Communications Technology Units 1-3 .W.M. Print, Walsall, West Midlands UK. Accessed 18 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Hinton, M. 2005. Introducing information management: business Approach. Taylor &Francis LTD. Accessed 18 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Dawsonera.

Jarivs, A. & Lawson, J. 2004. BTEC National IT practitioners: software development. Heinemann Educational Publishers UK. Accessed 24 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Kananen J. 2011. Rafting through the thesis process: Step by step guide to thesis research. JAMK University of Applied Sciences. Translator Gates M. Finland.

Knowledge management articles. 2009. Accessed 27 November 2011.

http://knowledgemanagementarticles.wordpress.com

Langley,J 2012. Whats on a Bicycle. Accessed on 26 April 2012. http://www.jimlangley.net

Lehpamer, H. 2007. RFID Design Principles. Artech House USA. Accessed 20 January 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Material flow & Conveyor Systems Inc., 2011. Accessed 15 February 2012. http://www.materialflow.com

Mohsen, H. 2002. A framework for the design of warehouse layout. MCB UP Limited technical journals pp 432-440. Accessed 28 November 2011. http://www.jamk.fi/english/library, Nelli-portaali, Emerald insight.

Müller, M. 2002. Essentials of inventory management. AMACOM USA. Accessed 19 March 2012. http://www.jamk.fi/english/library, Nelli-portaali, Ebrary.

Nadeem, T. 2005. How to start a small business in Canada. Self Help Publishers Canada. Accessed 18 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

NPO, 2011. ASME flow process symbols. Accessed on 26 April 2012 http://www.npo.gov.pk

The peddler bike shop. Accessed on 26 April 2012. http://www.youtube.com

Ray, S.2007. Introduction to material handling. New Age International, India. Accessed 16 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, Ebrary.

Richard, G. 2011. Warehouse management. Kogan Page Limited USA . Accessed 22 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Dawsonera.

Ross, D. 2004. Distribution Planning and Control: Managing in the Era of Supply Chain Management. Second Edition, Kluwer Academic Publishers. Accessed 15 January 2012.

http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Score Inventory control. 2002. Score 471. U.S. Small Business Administration. Accessed 18.2.2012. http://www.sba.gov

Senker,C. 2010. Retail .Evans Brothers Limited UK. Accessed 24 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Storage Utilization. 2004 Tech Target. Accessed 22 February 2012. http://searchstorage.techtarget.com

Strategic purchasing. 1992 The management and development center (M&DC). Accessed 2 November 2011. http://mdcegypt.com

Summaries of EU legislation, Act Recommendation. 8.8.2007. European Union. Accessed 9 March 2012. http://europa.eu

Tompkins, J. 2010. Facilities Planning. John Wiley & Sons,Inc. USA. Accessed 15 February 2012. http://www.jamk.fi/english/library, Nelli-portaali, E-books Google books.

Tuller, L. 2008. The small business valuation book. Adams media, an FW+ Publications Company USA.

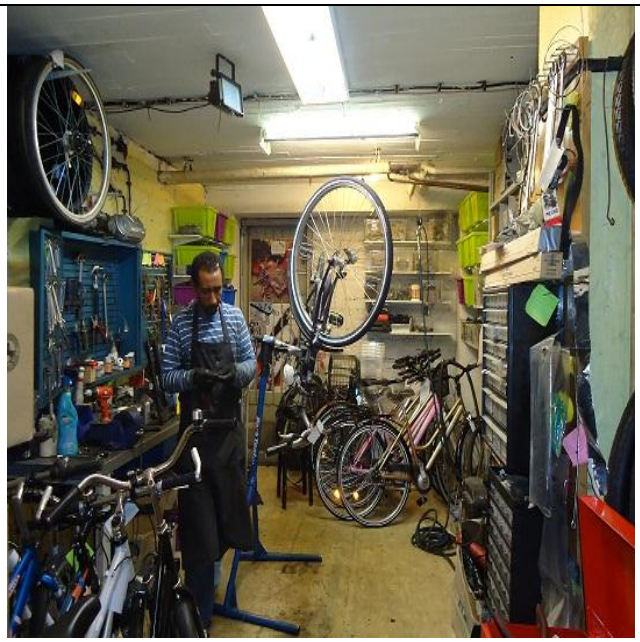
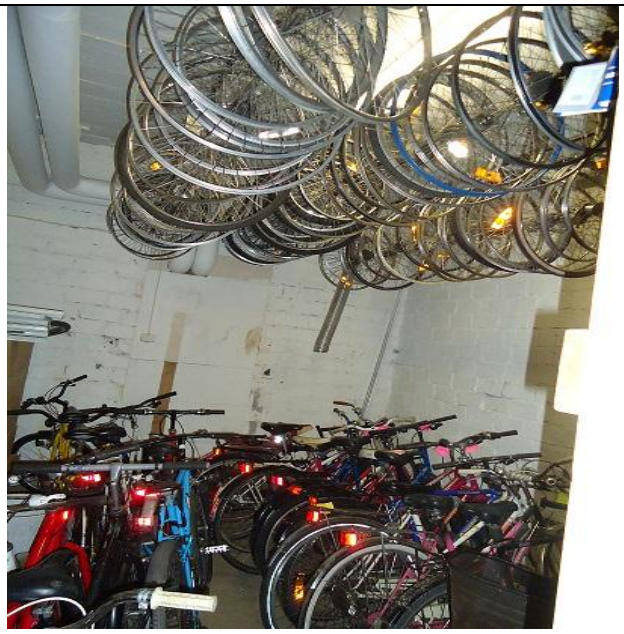
VeloGrip - Bicycle Racks. Accessed on 26 April 2012 on http://www.youtube.com

Waters, D. 2009. Supply chain management, an introduction to Logistics. Second Edition Palgrave Macmillan UK.

Working Bicycle Cooperative, 2010. Accessed 10 December 2012. http://workingbikescoop.blogspot.com

APPENDICES

Appendix 1. Before and after (Warehouse and Workshop)

BEFORE	AFTER
 ROOM NO. 6	
 Warehouse	

ROOM NO. 5

ROOM NO. 3

 Warehouse	Nothing has changed yet

Appendix 2. Letter to interviewed companies

Dear,

My name is Jackline Ndungi and I am a Logistics Engineering student in JAMK University of Applied Sciences.

I am currently writing my bachelor thesis under (DEVELOPMENT OF SPACE MANAGEMENT AND MATERIAL FLOW in micro and mini companies). I kindly ask for 15 minutes of your time to interview you on warehouse management.

I would be grateful if we can meet and talk.

Thank you,

Terve,

Minä olen Jackline Ndungi. Minä opiskelen Logistikka Insinööri Jyväskylän Ammattikorkeakoulussa.

Minä kirjoitan nyt minun opinnäytetyöni (Varsto Kehitys pieneen yritykseen). Minä pyydämme 15minnutia aikasta haastattelumaan varasto Kehitys.

Toivon että voimme tavata ja keskustellaan enemmän.

Kiitos.

Terveisin,

Appendix 3. Interview questions

1. How many employees work in your warehouse?
2. What are the functions of your warehouse?
3. What kind of information systems do you use?
4. What kind of storage equipment do you use?
5. What kind of movement equipment do you use?
6. What kind of inventory control methods do you use?
7. How do you allocate storage room for products in the warehouse?
8. Would you mind if I take a look at your warehouse layout?