IMPROVING THE CONTROL OF WORK-IN-PROCESS AT VSM GROUP AB

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Abstract

Today many companies face problems with inventory management. The importance of adequate inventory management has become more evident, while organizations try to reduce their costs and increase their service level.

This master thesis was conducted at VSM Group AB in Huskvarna, which is a manufacturer that produces and delivers sewing machines to a worldwide market. VSM Group AB has problems with the management and the refilling of the work-in-process (WIP) inventories and also with lack of information about component balance and location in the production and material planning system.

Therefore, the purpose of the thesis was to improve the control of the WIP inventories and the information about the components in the production and material planning system. In order to achieve the purpose, interviews and observations were performed, theories in inventory management were reviewed and the production process was studied.

Afterwards solutions for improvements were proposed. To solve the management and refilling problem, a kanban ordering system was proposed, which would use kanban cards to order components from the storages to the WIP inventories. To develop the component information displayed in the production and material planning system, an additional feature was proposed to the system. So instead of showing one inventory balance for each component, the system would display balances for three different places in the factory: the goods arrival and quality control area, the storage and the production.

The proposed solutions can provide several benefits to the company. The kanban ordering system can increase the material handlers' efficiency, set a standard refilling quantity and be a tool for reducing the WIP inventory levels. The more detailed information in the production and material planning system can improve the decision making for the purchasers and planners and give the ability to measure the flow and level of material inside the factory.

These solutions will provide a more appropriate inventory management to the company, with better control of the components and improved information quality.

Key Words

Inventory management, WIP inventory, production and material planning system, kanban, inventory balance information
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I Introduction

In this chapter a description of the topic of inventory management is presented followed by a brief description of the company, where the thesis is performed. Furthermore the two problem areas faced by the company are described and the purpose, goal and limitations of the thesis are presented. The problem areas are considering work-in-process inventories and inventory information, which both belong to the topic of inventory management.

This master thesis is a part of the Master of Science program with a major in Industrial Engineering and Management, specialization Manufacturing Systems, at the School of Engineering in Jönköping. The thesis is performed at Viking Sewing Machines (VSM) Group AB in Huskvarna, which is a company that produces sewing machines for a worldwide market.

Today, VSM Group AB faces problems related to their inventory management and wants the researchers to find solutions that provide them with more adequate inventory management.

1.1 Background

1.1.1 Topic Background

Inventories of different kinds are found in most organizations today, but they vary a lot in number and nature of the material held. Inventories in a manufacturing firm take many forms, such as: raw materials or components, intermediate work-in-process, finished goods and distribution inventories at distribution centers or wholesalers (Tersine, 1998).

Inventory management or inventory control is an attempt to balance inventory needs and requirements with the need to minimize costs resulting from obtaining and holding inventory (Helms, 2006).

The importance of inventory management, for the coordination of inventory decisions and transportation policies, has been evident for a long time. Managing inventory in supply chains is not an easy task, and may have large impact on the customer service level and the total supply chain cost (Simchi-Levi et al., 2003).

A requisite for successful production and inventory management is an enterprise system that provides the right information needed for decision making without overwhelming the manager with wrong data and with data of minor interest (Fogarty et al., 1991).
1.1.2 Company Background

VSM Group AB develops, produces, markets and sells sewing machines and sewing accessories. VSM Group AB is a company in the SVP Group, which is one of the world’s leaders in manufacturing of sewing machines and sewing accessories for the consumer market. The products are marketed by the brand names of Singer, Husqvarna Viking and Pfaff. The group has around 3600 employees over the world, where 400 are situated in Sweden, mostly in Huskvarna, and have retailers in about 190 countries.

During the year 2008, the Huskvarna factory is producing 17 different sewing machine models, which all have the Husqvarna Viking or the Pfaff brand. However, at the end of the year there will be only six models produced, since new models are being introduced and old ones are phased out.

1.2 Problem Areas

At VSM Group AB, two major problems related to inventory management appear in the production of the sewing machines:

- The work-in-process (WIP) inventories are not well managed. There are no criteria for how and when to refill them with components and the maximum quantity of each component is not specified. The company feels a lack of control over the WIP inventories, therefore these often have higher levels of components than necessary.

- The information displayed in the company’s production and material planning system is not enough for supporting the purchasers and planners’ decision making. The balance displayed for each component does not always provide a realistic picture of the component status, such as quantity and location, which increase the risk of wrong decisions.

1.3 Purpose and Goal

The purpose of this thesis is to improve the control of the WIP inventories and the information about the components in the production and material planning system.

To achieve this purpose, five research questions are posed:

- How is the refilling of the WIP inventories performed today?

- How is information about the component status updated in the company’s computer systems?

- How could the refilling of the WIP inventories be improved?

- How to improve the information handling within the computer systems?
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• Which benefits and drawbacks will these improvements give to the company?

The goal is to provide a useful solution for the company, by answering the research questions with support from theories in the topic. By listing benefits and drawbacks of the improvements, VSM Group AB can see the advantages and disadvantages they might have with the proposed solutions.

1.4 Limitations

• Since each sewing machine contains about 400-500 components and the Huskvarna factory is producing 17 different models, the researchers limit the data collection process to just one model, the Pfaff Creative Vision. The decision of focusing on this model was made by the company, since it is the newest model, introduced to the production in March 2007, and it is designed according to a new strategy of sharing more components both between the different models and among the two brands, Husqvarna Viking and Pfaff.

• The WIP components, which are not kept in the WIP inventories, but used in the pre-assembly areas and the final assembly line are not considered.

1.5 Disposition

The outline of each chapter in the thesis is as follows:

Chapter 2 – Methodology

The chosen research methods and techniques, the research process and the quality of the research are presented.

Chapter 3 – Theoretical Framework

A theoretical framework is presented with aspects on the topic of inventory management.

Chapter 4 – General Description of VSM Group AB

VSM Group AB products, suppliers and markets are described. The material flow in the factory and the different enterprise systems used in the company are also presented.

Chapter 5 – Sewing Machine Production

The different stages of the sewing machine production at VSM Group AB in Huskvarna are described.
Chapter 6 – Work-in-Process Inventories

The different WIP inventories in the production are presented, followed by a description of the working procedures.

Chapter 7 – Information in the Enterprise Systems

A description of how the information about the components flows within the company and in the computer systems is presented.

Chapter 8 – Analysis and Proposed Solutions

The problems faced by the company today are presented and analyzed, and then solutions for how to solve these problems are described.

Chapter 9 – Conclusion and Discussion

The thesis is concluded and the accomplishment of the thesis, chosen methodology, proposed solutions and future improvements for VSM Group AB are discussed.
2 Methodology

In this chapter the chosen research methods and techniques are presented followed by an explanation for the reasons of why they were chosen with support from theory. A description of how the research was carried out and how the quality of the research was ensured is presented afterwards.

2.1 Research Method

In order to carry out this research, the data needed for the thorough understanding of the situation was mainly gathered from the personnel’s knowledge and experience about the situation. Jacobsen (2002) states that to get rich and nuanced information from the respondents, a qualitative approach is preferred to be used.

The qualitative approach is also connected to the flexible design, which means that the research process is reversible; in other words, the researcher can go forwards and backwards in the different stages of the research process. Furthermore, the flexible design is suitable when the researchers have no or little knowledge about the situation studied (Jacobsen, 2002).

According to Yin (2003), case study allows the researchers to keep the holistic view and meaningful characteristics of real-life events, for example organizational and managerial processes. Besides, Williamson (2002) claims that the use of case study is appropriate for areas with no or little understanding of how and why process or phenomena occur.

Yin (2003) states that a single-case design is appropriate when an extreme or unique case is being studied. And for Williamson (2002) single-case study allows researchers to investigate phenomena in-depth and provide rich description and understanding.

Since the researchers lacked previous knowledge of the current situation at VSM Group AB, and the research was aiming at getting a deep and thorough understanding of the situation, the qualitative approach with a flexible design was chosen, as the most appropriate for this research. Among the different research methods suitable for the flexible design, single-case study fit the research’s purpose.

2.2 Research Techniques

According to Jacobsen (2002), there are two different types of data: primary and secondary data. Primary data is collected for the first time by the researchers, by studying the primary information source. On the other hand, with secondary data, the researchers base their information on data collected by others. Primary data is often collected through interview, observation or questionnaire. Documents and literature studies are the most common ways of getting secondary data.
In this research, primary data was collected by performing interviews and observations and the secondary data by consulting theories and the company’s computer systems and internal documents.

Yin (2003) states that one of the most important sources of case study information is the interview, and in a case study this will often be guided conversations rather than structured queries. According to Williamson (2002) there are different types of interviews: structured, unstructured and semi-structured. Since the researchers had limited knowledge in the company’s way of working, the most appropriate types of interviews for this research were semi-structured and unstructured interviews. Unstructured interview, as described by Williamson (2002), is used to explore a subject and to collect extensive data from key people. With this type of interview the answer for a question basically generates the next question. The semi-structured interview has a standard list of questions, but allows the interviewers to follow up on leads given by the interviewee and pose additional questions (Williamson, 2002).

The information given by the interviewees was written down by both interviewers, to make sure that as little information as possible was missed. Afterwards, when the information from the interviews was compiled, the findings were presented to the interviewees for review, to make sure that they were correct.

To collect information by observation is a good way of seeing how people behave and to check if people behave the way they say they do (Jacobsen, 2002). The observation helped the researchers to understand the way of working at the company by observing the workers daily activities.

Jacobsen (2002) claims, it is important to criticize the sources of secondary data, especially the trustworthiness and possible faults in the data. By searching in the company’s computer systems and internal documents, information about the different components was gathered. A literature review on the topic of inventory management was created using suitable books and articles within the area. The books and articles were searched for at the Jönköping University Library and also at different databases on the internet. In order to criticize the secondary data gathered, theories from different authors were compared and the information collected through the computer systems and documents was judged against the reality on the shop floor.

2.3 Research Process

The research was conducted at VSM Group AB in Huskvarna from January until May 2008. The researchers contacted the company in the beginning of December 2007 for an opportunity to perform the master thesis’ work there. The company was positive and inventory management was decided as the area for the research.
In order to establish a common view of the problem and purpose of this thesis between the company’s supervisors and the researchers, a meeting was held in the beginning of the thesis work, in the middle of January. Afterwards, the purpose of the research was defined, and since the researchers lacked knowledge about the situation at VSM Group AB, a general overview was needed.

To get this overview, nine semi-structured interviews were performed, during two weeks, with personnel responsible for production planning, purchasing, goods arrival and quality control, storages, in-house plastic production, production engineering and enterprise computer systems. During the interviews a general question about how the interviewees performed their work tasks was addressed and the interviewees described and explained their work situation.

With a clearer overview of the situation, the researchers could realize and define the problems that the company was facing. With problem areas, purpose and goal well defined, the searching for suitable books and articles within the area was started, and at the same time the data collection process. The theoretical framework was written in February and the data collection was performed during February and March.

At the start of the data collection, the researchers had to acquire deeper knowledge about the components used in the sewing machine and how they are assembled. This was done by choosing one sewing machine model, the Pfaff Creative Vision model, and collecting information about the 400-500 components used in that machine. The different types of information were collected through the company’s computer systems, the production and material planning system and the inventory system, in the company’s internal documents and by observations on the shop floor. The internal documents used were bill of material, component list and assembly instructions. The data and the source of the data are presented in the table 1.
Table 1. **Data collected and the source of the data**

<table>
<thead>
<tr>
<th>Data Collected</th>
<th>Source of the Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component name and number</td>
<td>Bill of material and Component list</td>
</tr>
<tr>
<td>Assembly station for the components</td>
<td>Observation and Assembly instructions</td>
</tr>
<tr>
<td>WIP inventory position</td>
<td>Observation</td>
</tr>
<tr>
<td>WIP inventory box type</td>
<td>Observation</td>
</tr>
<tr>
<td>Estimated use in 2008</td>
<td>Production and material planning system</td>
</tr>
<tr>
<td>Component sharing between models</td>
<td>Production and material planning system</td>
</tr>
<tr>
<td>Average inventory</td>
<td>Production and material planning system</td>
</tr>
<tr>
<td>Supplier lead time and order quantity</td>
<td>Production and material planning system</td>
</tr>
<tr>
<td>Number of boxes in WIP inventory</td>
<td>Observation</td>
</tr>
<tr>
<td>Quantity in each box in WIP inventory</td>
<td>Observation and Inventory system</td>
</tr>
</tbody>
</table>

The data collection gave an initial overview of how the refilling of the WIP inventories was done. To get a thorough understanding of the refilling, two additional semi-structured interviews were performed with the two material handlers. The interview questions are presented in appendix A. Observations were carried out by looking at the WIP inventories and the assembly stations at different occasions, and by observing how the refilling and assembly work were performed.

By performing the data collection, the researchers acquired knowledge in how the company’s computer systems work and what information they display. This knowledge was valuable in order to better understand the problem with the information displayed in the company’s production and material planning system. A semi-structured interview was performed with the IT-manager, in order to completely understand the system’s transactions and integration, and the component information flow. The appendix B presents the interview questions.

Afterwards, when the data collection was finished, the analysis of the data started. By doing so, it was possible to understand and describe the current work situation in the problem areas, and then compare this reality with suitable theories. The aim for the analysis was to propose solutions for the problems faced today and also provide the benefits that these solutions could give to the company.

At the end of the research process the results achieved were concluded and discussed in order to summarize the work, criticize the methods chosen and proposed solutions, and discuss further work.
2.4 Research Quality

In order to secure the quality of this research, the reliability and the validity of the chosen method and techniques were considered. Williamson (2002) refers to reliability as the consistency of the results, in other words, if the same results will be achieved if the study is performed again. For her, there are two kinds of validity, such as: internal validity, which refers to the accuracy of the results, that is, if what is intended to be measured is actually being measured; and external validity, which refers to the possibility of generalization, that is, if the results are valid in other situations than the one studied.

To ensure more reliable results, Williamson (2002) suggests the use of method and source triangulation. According to her, the idea is that the data should be more reliable if several methods are used to collect the data and if a number of sources are used instead of just one. To increase the reliability of this research, the ideas of triangulation were considered during the choice of techniques and how to perform them. The use of interviews, observation and the company’s computer systems and internal documents for data collection provided a way of method triangulation. Source triangulation was mainly used by conducting interviews with people at different positions in the company, to get several opinions about the situation studied. Both the method and the source triangulation provided higher reliability to the data collected.

The internal validity of the interviews was increased by letting the interviewees review the compiled information from the interviews. By doing so, the data from the interviews was more trustworthy and gave a truer picture of the situation. The external validity of the research is discussed in section 9.2.1. Since the questions to the interviewees were about their work, of which they have a good knowledge and experience, the reliability of the interviews was increased.
3 Theoretical Framework

In this chapter a theoretical framework is presented in the areas of enterprise system, lean production, inventory control systems, inventory reliability and component registration and tracking. Theories in these areas were chosen to support the understanding, analysis and proposed solution of the problems faced by the company.

3.1 Enterprise System

An enterprise system is generally a system composed of people, processes, and information technology built around packaged enterprise systems software (Watson et al, 2004).

According to O’Leary (2000), enterprise systems provide a technology platform that enable organizations to integrate and coordinate their business processes. They provide a single system that is central to the organization and ensure that information can be shared across all functional levels and management hierarchies. Enterprise systems are very useful in eliminating the problem of information fragmentation caused by multiple information systems in an organization, by creating a standard data structure.

Fogarty et al. (1991) claim that a requisite for successful production and inventory management is an enterprise system that provides the right information needed for decision making without overwhelming the manager with wrong data and with data of minor interest.

3.1.1 Enterprise Resource Planning

According to O’Leary (2000), Enterprise Resource Planning (ERP) systems are computer-based systems that process an organization’s transactions and facilitate integrated and real-time planning, production and customer response. O’Leary (2000) describes the following characteristics of ERP systems:

- Packaged software designed for a client server environment, whether traditional or web-based.
- Integrate the majority of a business’ processes.
- Process a large majority of an organization’s transactions.
- Allow access to the data in real time.
- Ability to customize without programming.
- Support for specific industries.
Theoretical Framework

• Support for multiple currencies and languages (critical for multinational companies).

For Norris et al. (2000), what ERP really does is organize, codify, and standardize an enterprise’s business processes and data. For them, an integrated ERP system is the core of an organization and is used to support existing business strategies. ERP offers the company the flexibility required to improve customer responsiveness and to manage production needs and inventory in a better way. Also, senior management can gain control over the information and improve decision support.

Norris et al. (2000) also state that ERP provides a uniformity of information across a global enterprise and integrates the following:

• Resource Planning, which includes forecasting and planning, purchasing and material management, warehouse and distribution management, product distribution, and accounting and finance. By providing timely, accurate, and complete data about these areas, ERP software helps a company to assess, report on, and arrange its resources quickly and to focus on organizational priorities.

• Supply Chain Management, which includes understanding demand and capacity and scheduling capacity to meet demand. By linking distinct parts of an organization with ERP, more efficient schedules can be established that satisfy, in an optimal way, the organization’s needs. This reduces cycle time and inventory levels, besides improving the company’s cash position.

• Demand Chain Management, which includes handling product configuration, pricing and contracts, promotions, and commissions. By consolidating information with ERP, contracts can be better negotiate; pricing can be established to consider the total enterprise-position; and sales offices can be better assessed, rewarded and managed.

ERP Software

ERP software is not fundamentally strategic; rather, it is an enabling technology, a set of integrated software modules that make up the core engine of internal transaction processing (Norris et al., 2000).

Still according to them, the software transforms transactional data into useful information and brings the data together so it can be analyzed. In this way, all of the collected transactional data becomes information that companies can use to support business decisions.
ERP Systems Implementation

Norris et al. (2000) argue that implementing ERP requires major changes to organizational, cultural and business processes. Consequently, for Fogarty et al. (1991), implementation involves more than conversions and adequate documentation is a prerequisite, such as education, testing and installation, which are described, according to Fogarty et al. (1991), as follows:

- **Education** – the transition from one method of operation to another requires the education and training of people in many different positions. Top management, managers and staff personnel all require training. Production planning and inventory management techniques may change; therefore, all involved personnel need to understand the objectives of these techniques and how they work.

- **Testing** – the computerized information systems, programs and systems modules all require testing to verify that they interface properly.

- **Installation** – new systems may require changes in data processing equipment, functional systems, forms, data processing, information provided and the organization structure and the way the organization does business. Therefore, orientation, training and testing are essential. The result of a successful implementation belongs to the users; they are the crucial factor in a system’s operation, thus they should participate in its development.

3.1.2 Material Requirements Planning

Reid and Sanders (2002) have mentioned that with computers, data processing was made easier, with important effects in areas such as forecasting, scheduling and inventory management. A particularly important computerized system, material requirements planning (MRP), was developed for inventory control and scheduling.

According to Reid and Sanders (2002), MRP is an information system that uses the concept of backward scheduling, which means, that it starts with the due date for an order and works backward to determine the start date for each activity. Besides, MRP enables companies that produce items in batches to have the right materials in the right quantities available at the right time.

They have stated that the objectives of an MRP are:

- **Determine the quantity and timing of material requirements** – the company uses MRP to determine what to order, how much to order, when to place the order, and when to schedule delivery.
• *Maintain priorities* – the company uses MRP to keep priorities updated and valid. Requirements change and customers change order quantities and timing; suppliers sometimes deliver late or the wrong quantities; equipment breaks down and production is delayed. In an ever-changing environment, the MRP is used in order to respond to the changes, to recognize priorities and to keep plans current and viable.

**The Demand Pattern**

According to Fogarty et al. (1991), the nature of the demand pattern has an effect greater than any other possible factor on the appropriateness of the when-to-order decision rules.

*Independent Demand*

The independent demand is the demand for finished products; it does not depend on the demand for other products (Reid and Sanders, 2002). The independent demand may be affected by trends and seasonal patterns (Fogarty et al., 1991).

*Dependent Demand*

The dependent demand is derived from finished products. The company does not forecast dependent demand but, rather, calculates the material needs based on the final products to be produced. MRP is designed to manage dependent inventory and to schedule necessary item replenishment orders (Reid and Sanders, 2002).

For Fogarty et al. (1991), sub-assemblies, component parts and raw materials have a demand that is primarily dependent on the demand for the final products in which they are used.

**3.1.3 Backflushing**

According to Costanza et al. (2005) a method to relieve the components in a finished product from the component inventory record is called backflushing. The backflushing transaction, in the computer systems, takes place when the final product is completed. Then the product’s bill of material deducts the components used in the product from the component inventory records.

Fogarty et al. (1991) states that backflushing reduces the amount of data capturing and processing but requires system integrity, accurate reporting of completed items, accurate measures of yield, and special reporting of unusual situations such as batch that must be scrapped. Backflushing also results in inventory records for components and materials showing larger quantities of inventory on hand than actually is the case, for at least a short time.
3.2 Lean Production

Liker (2004) has cited the TPS – Toyota Production System as the basis of the ‘lean production’ movement which has dominated the manufacturing trends. According to him, to be a lean manufacturer requires a way of thinking that focuses on the product flow as a one-piece flow, which means without interruptions, and can be reached by the reduction on the set-up time, attention on the tools maintenance and on the work space.

According Monden (1998), the lean production gives much importance to the continuous improvement and to people’s respect. The workers are encouraged to create, to have a long-term vision and to make decisions well evaluated. For him, there is a belief that nothing is perfect and the improvement is infinite, in other words, if the results look perfect, it can still be improved.

Liker (2004) states that in a lean manufacturer, the process starts with the customer demand and its order is processed. It is a one-piece flow and there are no loops in the process flow. He explains that if some problems are detected, signs of help are immediately generated and the operator immediately calls for help. The operators use a standard method to solve problems and they have support from the experts. According to him, the problem can never be transferred to the next step, so the quality of the product can be affected, thus the problem is solved as soon as detected.

Dennis (2002) states that lean production means doing more with less – less time, less space, less human effort, less machinery, less material – while giving customers what they want.

Accordingly, Shingo (1989) summarizes lean production as a system for the absolute elimination of waste, and there are seven kinds of waste that should be eliminated:

- Overproduction
- Delay
- Transport
- Processing
- Inventory
- Wasted motions
- Waste of making defective products

From Monden’s (1998) point of view, by eliminating those wastes, quality and production time are improved and cost are reduced.
Liker (2004) has affirmed that the TPS was established on two concepts:

- The first is called *jidoka*, which can be translated as ‘automation with a human touch’ and it means that when a problem occurs, the equipment stops immediately, preventing defective products from being produced.

- The second is the concept of *Just-in-Time* (JIT), in which each process produces only what is needed by the next process in a continuous flow.

According to Monden (1998), *jidoka* supports JIT by never allowing defective units from a preceding process to proceed and disturb a subsequent process. It is not just *jidoka*, but many other philosophies support JIT, such as: kanban, pull system and Single Minute Exchange of Die (SMED).

### 3.2.1 Just-In-Time

Liker (2004, 23) has defined JIT as “a set of principles, tools and techniques that allows a company to produce and deliver products in small quantities, with short lead times, to meet specific customer needs. Simply put, JIT delivers the right items at the right time in the right amounts”. He has also cited that the power of just in time is that it allows the company to be receptive to day-by-day shifts in customer demand.

For Reid and Sanders (2002), the central belief of the JIT philosophy is elimination of waste, but there are other beliefs that help defining this philosophy. These include, according to them, a broad view of operations, simplicity, continuous improvement, visibility and flexibility.

According to Fogarty et al. (1991), JIT is a philosophy which involves various concepts that result in a different way of doing business for most organizations. For them, the basic principles of this philosophy include:

- All waste, anything that does not add value to the product or service, should be eliminated. Value is anything that increases the usefulness of the product or service to the customer or reduces the cost to the customer.

- Inventory is a waste. It covers up problems that should be solved rather than covered. Waste can gradually be eliminated by removing small amounts of inventory from the system, correcting the problems that result, and removing more inventories.

- Manufacturing flexibility, including quick response to delivery requests, design changes, and quantity changes, is essential to maintain high quality and low cost with an increasingly differentiated product line.
• Mutual respect and support based on openness and trust should exist among the organization, its employees, its suppliers and its customers. The employee who performs a task often is the best source of suggested improvements in the operation.

Fogarty et al. (1991) state that the view of the Just-in-Time is that inventory does not add value but instead incurs cost, thus is a waste. For them, JIT views inventory as a sign of inadequate management, a method of hiding inefficiencies and problems. They have cited some examples of inefficiencies that cause inventory: scrap, lengthy and widely varying manufacturing lead times, inadequate capacity, lack of worker and equipment flexibility, long supplier lead times, and unreliable supplier quality.

JIT emphasizes that solving each of these problems will reduce the need for inventory and improve productivity (Fogarty et al., 1991).

Dennis (2002) states that JIT production follows few rules, such as:

• Don’t produce something unless the customer has ordered it.
• Level demand so that work may proceed smoothly throughout the plant.
• Link the processes to customer demand through simple visual tools (e.g. kanban).
• Maximize the flexibility of people and machinery.

According to Reid and Sanders (2002, 180), JIT relies on “a coordination system that withdraws parts from a previous work center and moves them to the next. The system typically relies on cards, called kanban, to pull the needed products through the production system. For this reason, JIT is often referred to as a pull system”. They have mentioned that the kanban specifies what is needed; there is no excess production because the only products and quantities produced are those specified by the kanban.

**Benefits of JIT**

Reid and Sanders (2002) cite that the benefits of JIT are very impressive and one of the greatest benefits of JIT is that it has changed the attitude of many firms toward the elimination of waste; improvements of responsiveness, and competition based on time. The have also stated: “time-based competition is one of the primary ways in which companies compete today, and JIT is what makes it possible.”

Even for companies that do not achieve the remarkable benefits of a full JIT implementation, JIT provides many benefits, such as (Reid and Sanders, 2002):

• Reduction in inventory
• Improved quality
• Reduced space requirements
• Shorter lead times
• Lower production costs
• Increased productivity
• Increased machine utilization
• Greater flexibility

**Push and Pull Systems**

Reid and Sanders (2002) state that traditional manufacturing systems use ‘push’ production, whereas JIT uses ‘pull’ production. According to them, push systems anticipate future demand and produce in advance in order to have products in place when demand occurs. Products are pushed through the system and are stored in anticipation of demand, which often results in overproduction because anticipated demand may not materialize, thus excess inventory. There are also costs related with having inventories of products kept in storage and waiting for consumption.

On the other hand, still according to Reid and Sanders (2002), pull systems are systems that work backwards, in other words, each station requests the exact amount of products that is needed from the previous workstation. If products are not requested, they are not produced. In this way, no excess inventory is generated.

**3.2.2 Kanban Systems**

According to Monden (1998), the kanban system is an information system that harmoniously controls the production quantities in every process, by using a kanban, which is a card usually placed in a rectangular vinyl envelope.

Shingo (1989) states that the kanban and kanban systems have considerable value, such as: setting the number of kanban to regulate the flow of items overall and hold stock to a minimum, and providing visual control to carry out these functions accurately.

Reid and Sanders (2002) have cited that for the pull system to work there must be good communication between the work centers. This communication is made possible by the use of this kanban card. A kanban card is an authorization to produce or withdraw and may also contain related information, such as:
Theoretical Framework

- Product name
- Part number
- Quantity that needs to be produced
- Where to store it

According to Reid and Sanders (2002), the kanban is attached to a container and when workers need products from the previous workstation, they pass the kanban and the empty container to that station. The kanban authorizes the worker at the preceding station to produce the amount of products specified on the kanban.

Dennis (2002) states that to make the system work smoothly and control the movement of empty and full containers, there are two kinds of kanban that are mainly used: the ‘production kanban’, which specifies the kind and quantity of product that the upstream process must produce; and the ‘withdrawal kanban’, which specifies the kind and quantity of product that the downstream process may withdraw.

**How Kanban is Circulated**

According to Shingo (1989), in order to minimize stocks of finished goods, the basic orientation of the lean production concept is toward order-based production. That is the reason why a pull system is used, in which the later processes go in succession to earlier ones to take the items they need.

Thus, based on Reid and Sanders (2002), figure 1 shows a diagram of how a pull system with two kanban cards works, followed by a description:

![Diagram of how a pull system with two kanban cards works](image)

**Figure 1. The pull system with two kanban cards (Reid and Sanders, 2002, 184)**
When a container becomes empty at the work center B and a worker needs more parts, the worker takes the empty container and a withdrawal kanban to the preceding work center A. The worker then removes a production card from a full container of parts and replaces it with the withdrawal kanban authorizing the withdrawal of parts. The production kanban is then placed on a kanban receiving post at work center A, signaling an authorization for production of another container of parts. The empty container is also left at work center A to be filled.

Now that the worker has left the empty container and the production kanban at work center A, he takes the full container of parts and the withdrawal kanban and goes back to work center B. When this container becomes empty, the withdrawal kanban and the empty container go back to work center A and the cycle is repeated.

**How Many Kanban?**

According to Reid and Sanders (2002), there are as many kanban cards in the system as there are containers and when there are too many kanbans in the production system, it results in too much inventory and production. Conversely, if there is not enough kanban, the system may not be producing quickly enough.

They have cited that the goal is to continually improve the efficiency of the system, which means striving to reduce the number of kanbans and the amount of inventory in the system. Therefore, the number of kanbans and the number of containers in the system is a very important decision.

For Shingo (1989), the question of how many kanban to use is a basic issue in running a kanban system. The number of kanban can be calculated as follows (Reid and Sanders, 2002):

$$N = \frac{D \times T}{C}$$

Where:
- $N$ = total number of kanbans or containers (one card per container)
- $D$ = demand rate at a using workstation
- $T$ = the time it takes to receive an order from the previous workstation (also called the lead time)
- $C$ = size of container

Shingo (1989) states that by using a kanban, the main goal is how to improve the production system to minimize the number of kanban ($N$), in other words:

- Carry out production in extremely small lots and minimize the size of each production lot by through reduction of setup times.
- Use these measures to cut lead times to the minimum.
- Eliminate the minimum stocks that are kept as insurance against production instability.
Shingo (1989) also presents the following questions that must be answered when it comes to determine the number of kanban to be used:

- How many products can be carried on a pallet?
- How many transport lots are needed given the relative frequency of transport?
- Will transport be dedicated to a single product or will mixed transport be used?

According to Shingo (1989), the movement of kanban regulates the movement of products. When processing several different types of parts, it is extremely important for maintaining stock at a minimum to start processing with parts whose kanban have circulated rapidly and then to proceed in order.

Still according to him, kanban systems are very effective in simplifying work and giving autonomy to the production floor which makes it possible to handle changes with greater flexibility. He has mentioned that one of the advantages of kanban systems is that, by giving instructions at the final process, they allow information to be transmitted physically and rapidly. The type of production most likely to benefit from kanban is one that deals with parts using common processes.

Another advantage of the kanban is that it is visual. Kanban cards and containers are all placed in clearly visible areas for everyone to see (Reid and Sanders, 2002).

**3.3 Inventory Control Systems**

According to Tersine (1998), a working inventory control system should show how routine and non-routine situations should be treated via predetermined rules and procedures. For him, a good system can be self-controlled and requires only attention to exceptions. When the system operates, adjustments are made to ensure that materials are available, to identify excess and fast- and slow-moving items, to provide accurate and timely reports to management and to spend the least amount of resources in accomplishing the above.

Different types of inventory control systems, such as, perpetual, two-bin, periodic, optional replenishment, material requirement planning and just-in-time inventory systems are described in the sections 3.3.1 to 3.3.6, based on theories proposed by Tersine (1998).

**3.3.1 Perpetual Inventory System**

The perpetual system keeps a running record of the amount in stock. Every time when a unit is taken out of the stock, it is also withdrawn from the stock record and the new amount is compared to the reorder point. If the amount is equal or less than the order point, an order is prepared for a fixed number of units. If the amount exceeds the reorder point, no action is taken.
The only numbers you need to decide, when running a perpetual system, are the reorder point and the order size. The order size is usually based on the economic order quantity for the item, while the reorder point often is decided so that there would not be lack of material during the order lead time. The time between the orders is variable, since the demand in the system can differ a lot.

The advantages of a perpetual system are that it is excellent for independent demand items needing close control, an efficient order size can be used, safety stock is only needed for the lead time period and that the system is relatively insensitive to forecast and parameter changes. The weaknesses are that the system needs continuous auditing of the inventory levels to know when a reorder point is reached, the order quantities and reorder points may not be reviewed or changed for a long time and if the orders for different products from the same supplier are not coordinated it usually gives higher freight costs.

3.3.2 Two-Bin Inventory System

The two-bin system is a fixed order size system which operates without perpetual record keeping. Usually, the inventory for one item is stored in two bins; one containing the amount of the item which should be used before an order is triggered; and the other containing the amount that should be used during the order lead time plus a safety stock. When the first box is empty, an order is sent for the item. The order quantity is fixed and contains the amount of items in the empty box plus the items expected to be used in the second box during the order lead time. The system could also be used with only one bin, where the bin has some kind of marking when the reorder level is reached.

The advantage of the two-bin system is that no continuous record needs to be kept to know when the reorder point is reached. This is clearly visualized when the first box runs out of items or a clear marked level in the bin is reached. But the system is not suited for all types of inventory items, best suited are fairly consistent used, low-value items that have short lead times from suppliers, such as bolts, nuts and office supplies.

3.3.3 Periodic Inventory System

In a periodic inventory system the amount of items in inventory is reviewed at a fixed time interval. A count or check is made on the review date and the order size depends on the amount in stock at that time. Because of this, the order quantity varies from time to time due to the demand rate for the last fixed review period.

The benefits of a periodic system are that it can provide a reduction in ordering cost because many items are handled in a single inventory order, discounts might be bigger and the shipping costs might be lower if many items are ordered at the same time.
3.3.4 Optional Replenishment Inventory System

The optional replenishment inventory system is a combination of the perpetual and periodic systems. The amount in inventory is reviewed at regular intervals, as a periodic system, but the order is not placed until a certain reorder point is reached, as in a perpetual system. The order quantity is established with a maximum inventory level, where the amount minus the amount in inventory at the review, if lower than the reorder point, is the order quantity.

The difference from a periodic system is that small orders are not placed at every inventory review when the demand is low.

3.3.5 Material Requirement Planning Inventory System

For items that have a dependent demand, classical inventory systems are less desired. These items are more appropriately controlled by an MRP system. The goal of the MRP system is to have the items available when needed, not before not after. To have a working MRP system the future requirement need to be known as well as the lead time for acquiring the item and for the assemblies and sub-assemblies made in-house. If a sufficient time-horizon exists, it is possible to start without any inventory for end items, purchase exactly the material needed and produce the end items without surpluses or shortages.

3.3.6 Just-in-Time Inventory System

The Just-in-Time (JIT) inventory system is used for repetitive manufacturing. The system controls raw material and in-process inventory for dependent demand items. The goal is to have no queues between different work centers and to have a lot size of one unit in the factory’s flow. The philosophy of JIT is that inventories are undesired and should be minimized as much as possible. To have a running JIT inventory system prerequisite that there are a uniform plant loading (on monthly basis), quality control at the source (zero defects), minimized set up times, a type of kanban controlled production system and suppliers nearby.

3.4 Inventory Reliability

According to Toomey (2000), inventory reliability problems are often caused by inaccurate inventory records rather than supply and demand errors. He has mentioned that to protect against supply and demand errors, the usage of safety stock and safety lead time are common, while, to protect the company from inaccurate inventory records counting can be used. He states that the basic functions for counting are to correct inaccurate inventory records and to identify and correct the causes of record errors. To maintain the accurate inventory records a company needs a proper system of receipts and orders, qualified personnel, an effective auditing system and error and cause correction.
The annual physical inventory and cycle counting described in this section are based on theories proposed by Toomey (2000).

### 3.4.1 Annual Physical Inventory

One method of inventory record correction is the annual physical inventory. The idea is to, once in a year, clean up and count every part in the inventory. Afterwards, the records should be updated with the accurate numbers for every part. The problem with this method is that since it is only done once a year the personnel are not familiar with the work, it is hard to trace the cause of inaccuracies and when the faulty number occurred and often all operations must stop at the day of the count.

### 3.4.2 Cycle Counting

The more effective method for error correction is cycle counting. Cycle counting is a routine of counting selected parts frequently and testing their accuracy against the records. The frequent counting continuously updates the inventory records and allows for identification and elimination of causes and inaccuracies. People who are assigned to cycle counting get familiar with the work and the inventory system, and become more efficient than the ones who only do it once a year. With effective cycle counting there are no needs to shut down operations and the annual physical inventory is usually eliminated. The result compared to annual physical inventory will be a higher degree of inventory accuracy at the same or less cost.

When using cycle counting a part classification is useful. An example could be to split the parts into A, B and C classes, where A are significant due to cost, transaction frequency, or are critical in other ways for the company. These parts will be counted more frequently than the others and will also have smaller margins for error. The B-class parts will be counted less frequent and have higher margins for error than the A-class parts, and the same relationship are between the C and B-class parts.

The personnel working with cycle counting can, with proper experience and training, have the role of inventory analysts as well. Their responsibilities will be to make the physical count, compare the count against the record, recount if necessary, and analyze the transactions to determine the cause of error, adjust the inventory record if necessary, and implement corrective actions. Bar coding and barcode scanning equipment can help to eliminate cycle counting errors when reading, writing, and transcribing part numbers.

### 3.5 Registration and Tracking of Components

The theories related to bar coding, tracking of the component and component inventory systems mentioned in this section are based on theories proposed by Wild (2004).
The theoretical framework for the stock-recording system can be manual, spreadsheet-based or software system-based. Manual systems are more prone to error. Spreadsheets are easy to set up, but the systems can be unreliable because the data can be overwritten by accident. There are very few situations where manual systems are recommended over a computer solution. Efficient computer systems will enable wide use of the data throughout the business, and exception reporting at minimal extra effort.

The system must include a record of what is in stock, and also includes a good location system so that the items can be found. The location record should enable an individual to find items without hunting, and a good recording system will identify the quantity of a stock line in each location.

3.5.1 Bar Coding

Barcodes can process a large number of transactions very fast and stock control and management information are produced accurately, automatically and immediately. Bar coding can be the complete solution to achieve stock accuracy, because the input and output of data is more precise. Also, bar coding can add a new dimension for tracking and controlling items within stores and, in all situations, including distributed inventory and in the process through a production plant.

The barcode should be suitable for use throughout the company and provide correct information for all departments. To record items without barcodes all that is required is a barcode label which is applied to the item as it is received.

A starting point for using barcodes is to copy what is currently already bar coded when it arrives. The barcode can contain all the information for physical stock control. Since the barcode should be useful throughout all the company, the data can be considered as fixed or variable. The fixed information should be on the item (or its packaging) as a barcode, while the variable should be separate.

There are several barcode languages available, some being numerical and others including letters as well. They are often industry standards, and the appropriate code should match with those of customers or suppliers. In many cases, barcode readers will automatically identify which code is being used and read it at the same time. Codes can normally be read through clear plastic, and it is usually put on the item or container of items, but sometimes codes can be put onto the paperwork that moves with the item. If the item is large, then it is always functional to put barcode labels on different parts of it - this is particularly useful for palletized goods.
Bar coding can be a cheap solution, depending on the size, quality and sophistication of the system. Costs can vary from a few hundred pounds for a single barcode and software, to hundreds of thousands for a full installation with communication and high-power remote readers. However, the investment is normally worthwhile because of the improvement in accuracy and speed of transactions.
4 General Description of VSM Group AB

In this chapter a general description of the company is presented as follows. In section 4.1, VSM Group AB products, suppliers and markets are described. The different enterprise systems used in the company is presented in section 4.2. In the section 4.3, the material flow is described in text and summarized in a flowchart. In order to provide a better understanding and visualization of the situation, some pictures and two layouts of the factory are also presented. The layouts were made by the researchers and do not contain all the details and the exact proportions of the areas in the factory.

4.1 Models, Suppliers and Markets

According to the 2008 production plan, 17 different sewing machine models are being produced in the Huskvarna plant. The number is larger than usual since some models are phased out in the beginning of the year and a couple of new ones are introduced in the production during the year. The planned annual volume is about 45000 sewing machines. Since VSM Group AB intends to even out the production over the year, approximately 1000 sewing machines need to be produced each week.

The sewing machines produced in the Huskvarna factory are the most expensive and advanced models of the Husqvarna Viking and Pfaff brands. The less complex machines are produced in Shanghai, China, in a factory owned by VSM Group AB. Nowadays the company is moving the production of some of the mid-range sewing machines, which have been produced in Huskvarna, to Shanghai. The future plan of VSM Group AB is to have the Huskvarna factory producing high-end machines and acting as a ramp-up plant for the introduction of new models, which later will be moved to Shanghai.

On the shop floor there are four different assembly lines, where the models are produced. The models are designated to one assembly line and are produced only there. The new models share a lot of components among each other, which are bought from suppliers or made and pre-assembled in-house. Most of the bought components come from Europe or south-east Asia. The supplier lead-time is around 20 days for Europe, about 80-120 days for the components coming from south-east Asia and 3-5 days for components produced in-house.

The biggest markets for VSM Group AB are the North American and the European, which had about 50% each of the units sold in 2007, but the North American market has a bigger share of the total sales value (65%). VSM Group AB has a seasonal demand with sales peak in April-May and October-December.

4.2 Enterprise Systems

At VSM Group AB, in Huskvarna, they use four different computer systems to store and share information.

JD Edwards
The JD Edwards system is used as the main business system. It handles customer orders, finance and demand forecasts.

**PRMS (Pansophic Resource Management System)**

PRMS is the company’s production and material planning system, which is used for production planning, master production planning and material requirement planning. The system is used mainly by the planners and purchasers when making production plans and supplier orders. The system automatically alerts the purchasers with information about which components they should order from the suppliers.

The balance for each component is increased when an order arrives to the factory, and the withdrawal of a component is made when a sewing machine body has been produced. PRMS just shows one balance containing the quantity of components that should be in process somewhere between the arrival registration and when the machine body is finished.

**MHS (Material Handling System)**

The MHS system was originally acquired for controlling the automatic storages, but today it is used for controlling the three main storages at the Huskvarna factory. MHS shows the quantity and location for all the components kept in the main storages.

**DANK (Dynamic Arrival Control)**

The DANK system is used for quality control to assure the quality of incoming components. The system decides whether an incoming component should have its quality tested or not. DANK also provides the quality test checklist and the result is registered in the system.

**4.3 Material Flow**

This section presents a brief description of the material flow, illustrated in figure 7, inside the factory. Two layouts are shown in figure 8 and 9 to better visualize the areas in the factory, where the research was carried out.

**Goods Arrival Area**

The different components that are delivered from the suppliers arrive at the Huskvarna factory by truck. The components are unloaded, checked against the delivery note, registered in the PRMS system and then placed in the goods arrival area. If the DANK system does not demand a quality control for the components, they are sent to the different component storages. However if a quality control is required, the components are sent to the quality control area.
Quality Control

The quality of the components is tested against the quality requirements, specified by the DANK system. If they pass the control, which usually takes some days up to a week, the components are sent to the different component storages, if not approved, the purchasing and planning departments are responsible for deciding what actions should be taken with the components and for notifying and discussing with the suppliers.

Frame Machining and Assembly

The frames for the sewing machines are cast in aluminum and need to be machined before they are used in production. The machining is made in-house in an own department, where they also assemble the upper and lower shaft onto the frame. Afterwards the frames are placed on a carrying wagon and put in the lever part storage before the wagon is moved to the production.

In-house Plastic Production

Several plastic parts for the sewing machines are also produced at the factory in Huskvarna. Smaller plastic parts are produced by internal ordering from the PRMS system; bigger parts, on the other hand, are produced by using a kanban system to feed the pre-assembly stations and the assembly line with parts. The bigger plastic parts are stored in the plastic part storage, inside the plastic department, before they are transported to the production.

The registration of produced plastic components into PRMS is made by the responsible for the in-house plastic production, who manually register each batch of components produced.

Component Storages

The components are stored in three different locations, such as: the automatic box storage, the automatic finished machine body storage and the pallet storage. Besides there are two other storages for pre-assembled parts, the storage for bigger plastic parts and the storage for lever parts.

Automatic Box Storage

The storage handles two different sizes of boxes. Most of the components are delivered to the production in the storage boxes, but some smaller ones are withdrawn in the necessary quantity for filling up the boxes in a material wagon. In figure 2, a picture of this storage is shown.
Figure 2. *Automatic box storage*  

*Automatic Finished Machine Body Storage*

This storage handles mostly the finished sewing machine bodies, but also has spare parts and packaging material for the sewing machines. The figure 3 illustrates a picture of this storage.

Figure 3. *Automatic finished machine body storage*

*Pallet Storage*

This storage handles bigger components, which are delivered on pallets. Pictures of this storage are illustrated in figure 4.
Lever Part Storage

Outside the pre-assembled area for the lever parts, there is a storage place to keep the lever parts before they are moved to the production, as presented in figure 5.

Plastic Part Storage

As mentioned before, the storage stores bigger plastic components, such as the plastic covers for the sewing machines, as shown in figure 6.
WIP inventories: Pallet Rack, Wagons, Shelves and Lever Part Wagon

The lever part and other components stored in the component storages are transported to the production by the material handlers and there they are stored, as WIP, in several different places, such as: pallet rack, wagons, shelves, and the lever part wagon. Afterwards, these components kept on such places are used at the pre-assembly stations and at the final assembly line.

Pre-Assembly Stations

The components are pre-assembled either in pre-assembly area 1 or pre-assembly area 2, depending on the component. In the pre-assembly area 1, which has 17 pre-assembly stations, most of the mechanical parts for the Pfaff Creative Vision model are pre-assembled. In the area 2, there are 38 stations which pre-assemble the most complex parts for the sewing machines. Once the pre-assembled parts are finished, they are placed in boxes and put on the pre-assembled component shelves.

Pre-Assembled Component Shelves

There are three different shelves used to store the pre-assembled components. From these shelves, the components are taken to their respective stations at the final assembly line, by the assembly workers, when needed.

Final Assembly Line

The final assembly line consists of nine assembly stations. In the first four stations is where most of the assembly is done, while in the last five, the adjustments and tests on the sewing machines are performed. The components used at the final assembly line stations are taken from the pre-assembled shelves and placed in boxes at their respective station.
Embroidery Unit Assembly and Embroidery Unit Storage

The embroidery unit supplied together with the Pfaff Creative Vision sewing machine is assembled in a separate assembly area, and there, the embroidery units are pre-assembled, assembled, packed and then stored in the embroidery unit storage. From there, the embroidery units are sent to the delivery department for shipping.

Finished Machine Body Storage, Packaging and Delivery

After the machines are assembled and all the adjustments and tests are performed, they are automatically delivered to the finished machine body storage. From this storage, the machine bodies are delivered to the packaging department when an order for the machine is placed. In the packaging department, the sewing machine bodies are packed in boxes together with general and country specific accessories, and then they are sent to the delivery department for shipping.
Figure 7. Material flowchart
Figure 8. Factory Layout
Figure 9. Assembly and goods arrival area
5 Sewing Machine Production

In this chapter the different stages of the sewing machine production at VSM Group AB in Huskvarna are described. The stages are the same for all models, so the researchers chose to follow the production of one model, the Pfaff Creative Vision. This chapter describes the production stages in the material flowchart, from the previous chapter, more in detail. For a better understanding, a picture of each production area is presented.

5.1 In-house Plastic Production

Most of the plastic components used in the sewing machines are manufactured inside the Huskvarna plant. The plastic department is a supplier for the sewing machine production and delivers according to both orders from the PRMS system and a kanban controlled inventory for larger plastic parts. A picture of the plastic production area is shown in figure 10.

![Plastic production area](image)

Figure 10. Plastic production area

The plastic components produced inside the plant are stored in two different ways. Smaller parts are produced in bigger batches and put in the automatic box storage and then delivered to the production as box kept material on shelves or wagons. On the other hand, the bigger plastic components use a kanban ordering system and are stored inside the plastic production area. From this storage the parts go directly to the pre-assembly or the final assembly line.

5.2 Frame Machining and Assembly

The frame for the lever part of the sewing machine comes from the nearby foundry at Husqvarna AB. At VSM Group AB the frame is machined and assembled together with shafts, pulleys and drive belt in a separate area inside the factory, making the lever part complete for use at the final assembly line. The figure 11 shows a picture of the lever part pre-assembly area.
5.3 Pre-Assembly Stations

5.3.1 Main Motor and Hook

The main motor, for all models, is put together with pulley and cables at one specific station inside the assembly area.

The hook, which is a part of the lower thread feeding, is pre-assembled in the plastic department and is used in all sewing machine models produced in the factory. The figure 12 shows the pre-assembly areas for these two parts.

5.3.2 Pre-Assembly - Area 1

In this area there are 17 pre-assembly stations, where most of the mechanical parts for the sewing machine are pre-assembled, and then stored in the pre-assembled component shelf, before used on the final assembly line. A picture of the area is shown in figure 13.
5.3.3 Pre-Assembly - Area 2

Here, seven different parts of the Pfaff Creative Vision model are pre-assembled, including the sewing head, which is the most complex pre-assembly, and some of the plastic covers for the machine. The finished pre-assembled parts are stored in the pre-assembled component shelves by the area 2. A picture of the area is shown in figure 14.

5.4 Embroidery Unit Assembly

The embroidery unit is an additional part delivered together with the Pfaff Creative Vision model. It is used for making embroideries with the machine. The manufacturing of the unit is performed a part from the sewing machine assembly, in an own assembly area. The figure 15 shows pictures of the embroidery unit and its assembly area.
5.5 Final Assembly Line

The final assembly line consists of nine stations, but each station has two assembly places on each side of the line, where the same assembly task is done. The stations are connected with an automatic conveyor that transports the sewing machines between the stations. The machines are assembled on a fixture that also provides electricity, so the machines can be tested between the stations.

At each station, buffers of a few components are held. These are refilled, when needed, by the assembler at each station. The refilling components are collected at the pre-assembled component shelves, in some shelves and in a wagon that stores the other components.

The finished machines are put on a conveyor and taken to the in-delivery area, at the automatic finished machine body storage.

A picture of the final assembly line is presented in figure 16.
6 Work-in-Process Inventories

In this chapter the different WIP inventories, presented in the material flowchart in chapter 4, and the refilling of them are thoroughly described. The WIP inventories contain both components taken directly from stock and also components pre-assembled in the previous stage of production. A picture of each inventory is shown in the chapter.

6.1 Pallet Rack

The pallet rack is located by the pre-assembly area 2. The rack consists of an upper and a lower floor, can keep 30 pallets in total and the components have designated places in the rack, as illustrated in the figure 17. The upper and lower floor store different components, which are shown in appendix C. Before the pallets are put in the rack, they are stored in the pallet storage. The refilling criterion is when a pallet is empty, and the refilling is done by the pallet material handler that works with transportation of goods to and from the pallet storage. The pallet material handler passes by the rack several times a day and if there is any empty pallet, he refills it later on with a new pallet from the pallet storage. The checking is not scheduled; it is the pallet material handler’s responsibility to check and refill when needed.

![Figure 17. Pallet rack](image)

6.2 Shelves

The shelves are located by the pre-assembly area 1 and 2 and near the final assembly line, named M02 and M03. The figure 18 shows the four different shelves. In the shelves, two sizes of wooden boxes store the components, as shown in the figure 19. These are used since the components are stored in the automatic box storage, which can only handle these two box types. The number of boxes in the different shelves is 38 boxes for area 1, 73 boxes for area 2, and approximately 80 boxes for the shelves M02 and M03. In the shelves M02 and M03, components used at the final assembly line are stored. The type of components kept in the shelves by the area 1 and 2 are presented in appendix D and appendix E respectively.
The idea for most of the components stored in the shelves is to always have two boxes in the shelf, so the refilling with a new box is done when there is only one box left in the shelf. Since the number of components in one box varies between the different components, some with little amount have more than two boxes in the shelf and some with a large number only have one box. The refilling of boxes is performed by the shelf material handler, who is responsible for refilling all the material that is stored in the automatic box storage. The shelf material handler is responsible for checking the shelves, so there will be no lack of material. This checking is not scheduled, but is done few times a day. When the shelf material handler perceives a need for refilling a component, he orders a box of that component from the automatic box storage, and then he transports it to the shelf and places it there.

There are some components stored in the shelves by pre-assembly area 1 and 2 and in M03 that are not stored in the automatic box storage, but in the pallet storage. These components are stored in cardboard boxes and are delivered to the shelves by the pallet material handler.
6.3 Wagons

Smaller components are kept in plastic boxes on a wagon, located near the stations where the components are needed. For the production of the Pfaff Creative Vision model, five wagons are used. Three wagons, W1, W2 and W3, are located near the pre-assembly area 2, the W4 is by the pre-assembly area 1 and the W5 is by the final assembly line. Below, in the figure 20, a picture of a wagon is presented.

The plastic boxes can be of three different sizes, small, medium and large, as shown in figure 21. Each wagon contains about 50 plastic boxes in total and each plastic box stores a different component. Some components are used in more than one area, leading to that the same component is kept in different wagons. The wagons are refilled once or twice a week at a set time, and the refilling is done by the shelf material handler. At the refilling time the wagon is taken from its normal position to the automatic box storage and is refilled there.
The MHS system has lists of the components kept in each wagon and automatically delivers out all the components kept in that certain wagon from the storage. It is up to the shelf material handler to decide if a plastic box should be refilled or not. Since the amount kept in the storage wooden boxes are much greater than the amount in the plastic boxes, the shelf material handler just takes the amount needed to fill the plastic box up. The amount is recorded by weighing the storage wooden box before and after the refilling, and then the MHS system calculates the amount refilled in each plastic box by taking the weight of the refilled components and divides it by the weight of one component, which is stored in the system. Afterwards, the amount in the storage wooden box is updated in the system and the box is put back into the automatic box storage.

6.4 Pre-Assembled Component Shelves

The components assembled in pre-assembly area 1 and 2 are stored on shelves near both the pre-assembly and the final assembly lines. There are three different shelves, one for area 1 and two for area 2. Besides, the front and bottom plastic covers are not stored in the shelves but on wagons that carry both pre-assembled fronts and bottoms, which are moved between the pre-assembly stations and the final assembly line. These four different inventories are presented in figure 22.
The workers at the final assembly line pick a box from the pre-assembled component shelves when they run out of material. The refilling of these shelves is done by the workers in the pre-assembly areas. There is no clear refilling criterion for the workers, but the goal is to have half a day of supply in these shelves. There are a maximum number of boxes that could fit in the shelves for each component, so there are not more boxes than could be fit into the shelf. The boxes are made of plastic and the size differs for different components, depending on the size of them.

### 6.5 Lever Part Wagon

Nearby each final assembly line, a wagon with the lever part, shown in figure 23, is placed, which carries about 80 levers. The production of the levers is made some days ahead of the final assembly of the sewing machines, and the wagons are put in the lever part storage until they are needed at the final assembly line. The goal is to have one wagon by the final assembly line, but when the refilling is done or when there is a change of model, two wagons can be kept there. The transport from the lever part storage to the place close to the final assembly line is carried out by the pallet material handler.
Figure 23. *Lever part wagon near the assembly line*
7 Information in the Enterprise Systems

In this chapter a description of how the information about the components flows within the company and its computer systems is presented. To visualize the information flow, a flowchart is presented. Besides that, the chapter presents an explanation of how the component storages are controlled by the MHS system and what the working routines are for in- and out-deliveries from the component storages.

7.1 Material Information Flow

To provide a better visualization of the descriptions in this section, a flowchart is presented in figure 25.

Supplier

In general, VSM Group AB makes long-term agreements, between 1-3 years, to purchase components from a supplier. To do the actual ordering, a delivery schedule is printed from the PRMS system and sent to the supplier, usually by fax or e-mail. The schedule is usually delivered with information for one year ahead. The orders for the nearest month are fixed orders; between one and three months the orders are preliminary; and three months and more they are forecasts.

Goods Arrival and Quality Control

When the components arrive they are manually registered into the PRMS system by the personnel at the goods arrival area. Then, the information about the components is transferred from PRMS to the DANK system. When the DANK system gets the information, a control document is printed out from the system and attached to the components. The document contains information such as component name, serial number, supplier, quantity, storage location, if there should be a quality test conducted and checkpoints for which tests that should be performed.

If the component passes the quality test, it is sent to the specified component storage in the control document. If faults are detected, the component is blocked until the purchase and planning departments have decided on which actions, for example exemption, return to supplier, rework or scrap that should be taken regarding the component.

Component Storages

The components that passed the quality test and the ones not tested are transported to the designated storage. Before the components are placed in the different storages, they are manually registered in the MHS system, by typing the 9-digit component number and the quantity. The system then adds up the stock levels and stores the location of each component. The components are delivered to production by the pallet and shelf material handlers, but before the delivery they are manually registered out from the MHS system.
Production

In the production there is no registration of where components are placed, how many pre-assembled parts that are available or how many machines that have passed each station in the assembly line. The only interaction with the computer systems is when the sewing machine bodies are finished and are on their way to the automatic finished machine body storage. There, a camera automatically registers the product number and serial number and reports this information to the MHS system, which registers and gives the machine a place in the storage. The in-delivery station to the automatic finished machine body storage, where the registration is performed, can be seen in the figure 24.

![In-delivery station to the automatic finished machine body storage](image)

Figure 24. In-delivery station to the automatic finished machine body storage

Once a day, information on how many machines of each model that has been produced is sent from the MHS system to the PRMS system. Then the PRMS system automatically backflushes the components, used in each machine produced, from the system.

Finished Machine Body Storage and Packaging

The finished sewing machine bodies are stored in an automatic storage, which is controlled by the MHS system. The received customer orders in JD Edwards system are transferred to the MHS system and then the ordered sewing machine bodies are taken out from the storage and delivered to the packaging department. The order information in the MHS system specifies which country specific accessories that should be included and the shipping address.
Figure 25. Information flowchart
7.2 MHS Controlled Component Storages

Most of the components used in the pre-assembly areas and in the final assembly line are stored in the automatic box and pallet storages, which are controlled by the MHS system. The automatic finished machine body storage is also controlled by MHS but does not store any components used in the assembly of the sewing machine body, therefore is not considered in this chapter.

7.2.1 Automatic Box Storage

The automatic box storage has limitations for the size of the supplier’s delivered boxes, since there are just two sizes of wooden boxes used, and the weight of one box, which should not be more than 20 kilos, due to work environment legislations. All the components boxes are not delivered according to these limitations; therefore a certain component box needs to be split into several wooden boxes to fit in the storage. This action adds up extra work for the worker, who performs this task.

Besides, splitting up the boxes can also lead to problems with recording the right quantity of components in each box. The quantity is calculated by the MHS system, by taking the total box weight and dividing it by the weight per piece. However, the information recorded in the MHS system is not always accurate due to human faults and scale errors.

There are two ways of taking out components from this storage, take a full box out or just take out some of the components in the box. For refilling the components stored in the shelves, a full box is taken out, while for refilling the plastic boxes in the wagons just some of the components are taken out from the box. When this second withdrawal is performed, a scale is used to record the weight of the components and then the MHS system calculates the quantity withdrawn and subtracts that number from the total number in stock.

7.2.2 Pallet Storage

When the pallets arrive to this storage they are put temporarily in a rack for incoming and outgoing goods. Then the responsible worker in the pallet storage types in the component number and quantity into the MHS system, which automatically designates a place for that pallet in the storage and records this information.

When there is a need for refilling a pallet in the WIP inventories this should be perceived by the pallet material handler. Then he gives an order to the responsible worker in the pallet storage, who types the number of the component needed to check the availability of it. If it is available, a pallet is chosen and removed from the storage, withdrawn from the system and then put in the pallet rack for incoming and outgoing goods for delivery to WIP inventory.
7.2.3 Exceptions

Some parts are not kept in the storages controlled by the MHS system. These are mainly used for the embroidery unit, the lever part and the bigger plastic parts. They are placed near their production area and no information about them is recorded in the MHS system.
8 Analysis and Proposed Solutions

In this chapter the problems faced by the company today are presented and analyzed according to the theories in chapter 3. Then solutions for how to solve the problems and improve the work situation in VSM Group AB are proposed. The benefits of these solutions are listed and at the same time the drawbacks of them.

8.1 Ordering and Refilling of the WIP Inventories

8.1.1 Description of the Problem

Pallet Rack and Shelves

Today, the material handlers are responsible to check and refill the WIP inventories, so there are always available components on the shop floor. This way of working is time consuming for the material handlers, since they have to search in the WIP inventories for components that should be refilled and they also need to record which components to refill. Besides, the time disparity between the occurrence of the need and the observation of it can be long, depending on how often the material handlers check the WIP inventories. To handle this situation and to avoid lack of material, the material handlers end up having higher level of WIP material than what is necessary.

Wagons

Today several wagons keeping small components are used in the production. Each pre-assembly area and the final assembly line have their own wagon with boxes of components needed in that area. Some components are used in several areas and are therefore kept in several wagons. Storing the same component at several places adds up the number of components in WIP inventory and the shelf material handler needs to refill the same component at several places.

When the shelf material handler refills a wagon today he has a list in MHS for each wagon, which automatically order all the different components kept in the wagon out from the storage. Then when the shelf material handler refills the wagon, he only chooses to refill the plastic boxes which have fewer number of components inside. Given this, there will be excess components ordered out from the inventory, which will not be used to refill a plastic box in the wagons.

8.1.2 Analysis of the Problem

One of the ideas of the lean concept, described by Liker (2004), Dennis (2002), Monden (1998) and Shingo (1989), is the elimination of wastes. Some of the wastes are identified at VSM Group AB.
The material handlers’ work include walking around and look in the shelves and the pallet rack for components to refill, which is a waste of motion because it is not always that components need to be refilled. To stop the search for which components to refill will help the material handlers to work more focused on refilling the right components in the right time, which will also make the work more efficient.

Today there are no specified quantities for most of the components kept in the WIP inventories. Therefore, the material handlers can create own criteria for refilling which often leads to higher levels of components in the WIP inventories than needed. According to Shingo (1989), inventory is a waste that should be eliminated as much as possible. By setting a maximum level for each component, VSM Group AB will have a starting point for reducing the amount in the WIP inventories. With a reduction in the WIP inventories the total amount in storage for each component will be less, however to have a more significant effect on the elimination of inventory waste, VSM Group AB should also lower the levels of components kept in the storages.

For Fogarty et al. (1991) the Just-in-Time philosophy, which is a part of the lean concept, includes the reduction of inventory. According to them, JIT views inventory as a matter of inadequate management and a way of hiding problems and inefficiencies. To work with the removal of excess inventory will help the company to detect problems which before were covered up by high inventory levels. By solving the occurring problems, it is possible to reduce the inventory levels even more. New problems will continue to occur and then the cycle starts again by solving the problems and reducing more inventories. Detecting and solving the problems will give lower inventory levels and make the process more efficient by removing the hidden inefficiencies.

A system that supports JIT is the kanban system. Shingo (1989) refers to kanban as a way of regulate the flow of items, hold stock to a minimum and provide visual control for these functions. The kanban is a card that is used for ordering between stations in the production process. The card is sent from the station where a need for items occurs, and it specifies what and how many items the preceding station should produce (Reid and Sanders, 2002).

To provide more efficiency to the material handlers’ work, a kanban ordering system can be used for refilling the WIP inventories. The assembly workers, who take out components from the WIP inventories, will place a kanban card in the kanban card disposal box when there is a need for refilling a component. The kanban gives information about component name and number, quantity to be refilled and position in the WIP inventory. The material handlers collect the kanban cards and refill the components ordered at set times. This will eliminate the time spent on searching for components to refill, thus removing waste of unnecessary motions and increase the productivity of the material handlers.
To improve the productivity of the material handlers even more, a barcode should be printed to all kanban cards and used for registering the order into the MHS system. This will, according to Wild (2004), speed up the registrations and provide a higher accuracy, than manually keying the component number.

Since the kanban specifies the maximum amount of each component in the WIP inventories, by multiplying the number of cards with the quantity on the cards, VSM Group AB can use the kanban to control the amount of each component in the WIP inventories. By lowering the quantity on the kanban card or removing a kanban card for a component, the level of components in the WIP inventories can be reduced. By doing so, the waste of excess inventory can gradually be decreased.

8.1.3 Proposed Solutions

In order to solve the ordering and refilling problems in the company’s WIP inventories, the researchers propose the use of a kanban ordering system. The kanban system has a potential use for all the different WIP inventories; however there are several ways of running a kanban system, which depends on the characteristics of each inventory and components kept in that. Therefore the researchers propose slightly different solutions for the different WIP inventories. The appendix F presents the changes needed to be made on the original layout for working with the proposed kanban system.

Pallet Rack

In the pallet rack there is one pallet for each component. The pallet is refilled when it is empty or almost empty by the pallet material handler. Today, the pallet material handler is responsible for checking the rack and detecting components with a need for refilling.

The Use of the Kanban

The pallet material handler should no longer be responsible for deciding when to refill a component, instead the assembly workers should make the decision. To signal the need for refilling, a kanban card, hanging near the pallet on the pallet rack, is removed and put in a kanban card disposal box when a pallet is empty or when there are just few components left. The box is placed on the side of the pallet rack.

Since the pallet rack is a one-bin inventory system, where you put the order when you are out of or almost out of material, it is required a short time from the ordering to the refilling of a component.
Thus, when transporting goods to and from the pallet storage, the pallet material handler passes by the disposal box frequently, so he can see if there is a card in the box. He collects the card; goes to the pallet storage; takes a new pallet out of the storage; refills the pallet in the pallet rack; and hangs the kanban card back on the pallet rack. This regular and frequent checking of the kanban card disposal box will keep the time from ordering to refilling shorter.

**The Kanban Card**

The kanban card should contain information such as:

- Component name
- Component number in digits and in barcode
- Batch size on the pallet
- WIP inventory position
- An arrow that shows if the pallet is kept in the upper or lower floor

The size of the kanban card should be 10*20 centimeters and the paper should be laminated with plastic film. In order to provide a better visualization, the color of the kanban cards should distinguish between the different WIP inventories. For the pallet rack, the kanban card should have a yellow color. An example of a kanban card for the pallet rack is shown in appendix G.

**The Kanban Card Disposal Box**

The kanban card disposal box should be mounted on the side of the pallet rack, the size should be 15*15*8 centimeters and it should be painted in yellow to match the kanban cards’ color.

**Shelves**

Today, there are usually two boxes of each component kept in the shelves and the refilling of the components is done by the shelf material handler working with the automatic box storage. The signal for the shelf material handler to refill a component is when there is only one box of a component in the shelf.

**The Use of the Kanban**

Instead of having the shelf material handler passing by the shelves and checking the need for refilling a component, the assembly workers who take the components from the shelves should be responsible for notifying the need for refilling. Each box in the shelves should have a kanban card placed inside it, so you have as many kanban cards for a component as the number of boxes wanted as maximum for that component in the shelves.
When an assembly worker takes the last component out of a box, he removes the box from the shelf and put it in a designated place for empty boxes, which is already done today. When removing the box, the kanban card inside the box should be removed from the box and placed in a kanban card disposal box, placed at the side of each shelf. The cards in the box are then picked up by the shelf material handler two times a day, at 8:00 and at 13:30. Afterwards, the shelf material handler takes out the component boxes needed from the automatic box storage, puts the kanban card inside the box and then places them at their respective inventory position in the shelves. The refilling in the morning and in the afternoon should be completed before 11.30 and 16:00 respectively.

However there are exceptions for some components, kept in the shelves by pre-assembly area 1 and 2 and in M03, which do not come from the automatic box storage, but from the pallet storage. These components are stored in cardboard boxes; therefore the pallet material handler must open the sealed cardboard box and put the kanban card inside the box when he delivers it to the shelves. When refilling these components, the pallet material handler should follow the same routines as when refilling the components in the pallet rack.

The Kanban Card

The kanban card should contain information such as:

- Component name
- Component number in digits and in barcode
- Batch size in the box
- WIP inventory position

The size of the kanban card should be 10*20 centimeters, the paper should be laminated with plastic film and the color should be blue. An example of a kanban card for the shelves is shown in appendix G.

For the components coming in cardboard boxes, from the pallet storage, the kanban card should be yellow, as the kanban cards in the pallet rack, but it should contain the same information and size as the blue cards. The different color of the kanban cards will help the material handlers to identify who has the responsibility for refilling a certain component.
The Kanban Card Disposal Boxes

The kanban card disposal boxes for the blue kanban cards should be mounted on the side of the four shelves, the size should be 15*15*8 centimeters and it should be painted in blue to match the kanban cards’ color.

The yellow kanban cards for the shelf by the pre-assembly area 2 will use the same disposal box as the pallet rack, since the shelf and the rack are located nearby each other.

For the exceptional components located in the shelves by pre-assembly area 1 and in M03, a yellow kanban disposal box should be mounted on the side of the shelf by pre-assembly area 1. This box should have the same size as the other boxes and keep the yellow kanban cards from both shelves.

Wagons

In order to have a more efficient refilling of these components kept in wagons, the researchers propose that the components should be removed from the wagons and instead placed in a pick rack near the automatic box storage.

The three different plastic box sizes, used in the wagons today, should also be used in the pick rack. The size of the plastic box should be the same as used for each component in the wagons today, but there will be two boxes of each component in the pick rack.

The Use of the Kanban

The plastic boxes will have designated places in the pick rack that should be marked with the component’s name and number. The assembly workers using these components come to the pick rack to refill their own containers used in their work station. When an assembly worker takes the last component out of a plastic box, he places the empty plastic box in a specific place by the pick rack. The shelf material handler collects the empty boxes twice a day, at 7.00 and at 12.30, refills them with components from the storage and places the plastic boxes back in the pick rack. Each refilling of the plastic boxes should be completed in one hour, since the shelf material handler is also working with refilling the shelves.

The Kanban Card

In the pick rack the plastic boxes are used as the order trigger. The reason for using the boxes as a kanban card is that these plastic boxes are not exchanged but refilled, in other words, instead of refilling a component with a new box from the automatic box storage; the refilling is done by taking components from the storage’s wooden box and put them in the empty designated plastic box.
The idea is to have two plastic boxes, in the pick rack, for each component, marked with the component’s name and number in digits and in barcode. The signal for the shelf material handler to refill these boxes is when an empty box is placed in a marked area for empty boxes. By looking at the label on the plastic box, the shelf material handler knows which component to refill the box with. The withdrawal of a component is always done from the front box, and when that is empty, the box behind is brought to the front and the withdrawal of components is done from that box. When the shelf material handler has refilled the empty box, he places it back in the pick rack, behind the currently used used box.

**Barcode Identification**

When the material handlers order a component out from the storage today they manually type the component number in the MHS system. This manual typing takes time and can lead to mistakes, which take even more time to correct.

As mentioned before, the barcodes should be included on the kanban cards and plastic boxes, which are collected by the material handlers and are used for ordering new components to refill the pallet rack, the shelves and the pick rack.

Instead of manually typing the component number the material handlers, using a barcode reader, shoot the barcode at the kanban card or plastic box. When the barcode reader reads the barcode, the component number is automatically typed into the MHS system. Then the material handlers continue with the procedures done today to take out the component from the storage and withdraw components from the system.

**Warning System for Stocked out Components**

When the material handlers are trying to refill a component, but the component is out of stock, they should place the kanban card for that component in a warning box. This box should regularly be checked by the purchasers, to get an alert for the components out of stock. Then actions should be taken to solve the problem, if not solved yet.

**8.1.4 Benefits of the Proposed Solutions**

VSM Group AB can gain several benefits from the proposed solutions, such as:

- Increased efficiency for the material handlers’ work, since they do not have to go around and check for components needed to be refilled in the shelves and the pallet rack. Instead they just have to collect the kanban cards from the disposal boxes.
• Better knowledge of the batch sizes kept in each box or pallet. Today the boxes and pallets do not contain information about the number of components in them. By showing the quantity on the kanban card it is easy to check the number of components in the WIP inventories.

• The kanban system is a good tool for reducing the level of material in the WIP inventories by changing the number of boxes in the WIP inventories and the batch size in each box or pallet. If you want to reduce or increase the quantity of each component, this can easily be done by adding or taking away kanban cards or changing the ordering batch size on the kanban cards.

• Better visualization for the need for refilling components in the WIP inventories. The kanban cards, the empty boxes in the pick rack, the kanban card disposal boxes and the area for empty boxes by the pick rack will show all workers which components that are ordered and should be refilled.

• The order for refilling is put directly when the need appears. By transferring the responsibility, from the material handlers to the assembly workers, for making a component order, the order is put as soon as a box or pallet is empty and there is less risk for the material handlers to miss refilling a component.

• By centralizing the components kept in the wagons to a pick rack, this will facilitate the shelf material handler’s work to refill these components. Instead of refilling each wagon once or twice a week, the shelf material handler refills everyday just the components needed. Besides, the components stored in more than one wagon will be kept just in one place, and less ordering will be made from the automatic box storage.

• The combination of a kanban system with barcodes can improve the efficiency of the refilling of components even more. The barcode reduces mistakes of typing wrong component number and speeds up the process.

• Besides the alarm sent by PRMS, which alerts for the purchase of a certain component, the warning system with kanban cards can work as an additional alert for the purchasers when a component is out of stock.

### 8.1.5 Drawbacks of the Proposed Solutions

• The kanban system is a new way of working with the refilling of the WIP inventories. This is likely to meet some resistance from the workers, who do not easily accept changes in their way of working. In the beginning the workers go through a learning phase, and during this time there might be some errors due to lack of experience of the system.
• According to the proposed solution for the pallet rack, which is a one-bin inventory, there is no clear criterion for when to refill the pallets. The order should be placed when the pallet is empty or almost empty and it is up to the assembly worker to judge when to place the kanban card in the disposal box. This judgment should be based on the close future need of a certain component, if the pallet can be empty for some time or not, if not, the order must be placed before the pallet is empty. However, if a component is used at more than one assembly station, the assembly workers might not know the need of the other stations and might then make a wrong decision for when to place the order, thus a shortage can occur.

• By replacing the wagons with a pick rack there will be an increased walking distance for the assembly workers to refill the components kept there. For the different pre-assembly areas and the assembly lines the new distance will be the same as before or increased by up to 40 meters of total walking distance (forth and back). This can increase the time spent for refilling those components, but this will not affect the assembly process significantly, since the refilling of each component is not performed very often. The components kept in the pick rack are mostly small and cheap components, hence they can be kept in higher amounts at the assembly stations since they do not tie up high value in WIP and do not require much storage space at the station.

• The investment needed to perform a kanban ordering system for the pallet rack and the shelves is reasonable since the cost of kanban cards and their disposal boxes are low. However, a barcode functionality for registering the order for the needed component into the MHS system give costs for acquiring barcode equipment and to adopting it to the MHS system. The investment for replacing the wagons with a pick-rack will be to buy or make a pick-rack and to buy and label the plastic boxes. People will be required to perform the changes, therefore costs for wages must also be considered.

8.2 Component Information in the PRMS Systems

8.2.1 Description of the Problem

Unrealistic Inventory Records

Today the PRMS system only shows a total quantity for each component. This number is increased when a load of components arrives from a supplier and is decreased when a sewing machine body leaves the production and goes to the automatic finished machine body storage. The components are mainly located at three different places in the factory: the goods arrival and quality control area, the storage and the production.
If the quality of the components needs to be assured, the components are kept in the quality control area for some days and are not available for use in production yet. However, in the PRMS system, these components are shown as available to production, so when the planners check the availability of components for the coming week’s production, they can get an inaccurate number of available components.

The PRMS system does not keep track of the components, not showing the three different places where the components can be kept, so sometimes the workers have a hard time searching for the components shown in PRMS, which cannot be found in the MHS system.

Besides, it can also be problematic for the purchasers when working with setting or changing the final date for a delivery from a supplier, and not knowing the location and the quantity at each location for the components in the factory.

**Lack of Integration between Systems**

The company uses two separate systems, the PRMS for planning production and the MHS for controlling the inventory. The planners and purchasers do their work tasks in the PRMS system, but if they want to see the quantity in the inventory they have to use the MHS system and search for the availability in that system. The lack of integration between these two systems makes the work too time consuming; therefore the availability in the inventory is often not known by the planners and purchasers since they do not use the MHS system.

**8.2.2 Analysis of the Problem**

O’Leary (2000) states that a single enterprise system enables the integration and information sharing inside the organization. By using a standard data structure companies can eliminate the problem of information fragmentation in multiple information systems. At VSM Group AB they use four different information systems, which do not have a standard data structure, but have some interfaces between each other. To acquire the information needed, the users must access different systems for collecting data, which is time consuming. It is also more problematic to learn and use several information systems instead of one.

According to Fogarty et al. (1991) an enterprise system which provides the right information for decision making is a requisite for successful production and inventory management. VSM Group AB works with an MRP system, the PRMS, but it does not always provide accurate information about the quantity and actual location of the available components.
Toomey (2000) states that inventory reliability problems are often caused by inaccurate inventory records. For him, a way of avoiding inventory inaccuracy is to perform inventory counting on a regular basis. Toomey (2000) suggests the use of cycle counting as the more effective way of counting. By using a more structured and regular way of counting the components, VSM Group AB could increase the accuracy of their inventory records.

To increase the stock accuracy and to have more precise input and output data, Wild (2004) suggests the use of bar coding. He also mentions that bar coding can add a new dimension for tracking and controlling items within stores and through the production process. Also according to Toomey (2000), the use of barcode scanning would help decreasing the errors made when counting.

At VSM Group AB they do not use barcodes to a large extent today. The transactions in MHS and some in PRMS are done manually which takes time and is prone to errors. A barcode system could increase the accuracy and speed of these transactions by simplifying the registration work and avoiding manual typing.

8.2.3 Proposed Solutions

In order to solve the problems of unrealistic inventory records and the lack of integration between PRMS and MHS, the researchers propose to add some features to the PRMS system.

These features will help keeping better track of the components by showing separate quantities for the three main locations where the components are stored inside the factory. So, instead of showing one total quantity for each component, PRMS will present three quantities according to the three main locations: the goods arrival and quality control area, the storage and the production, as presented in the figure 26.

![Figure 26. Improved information about quantity and location shared in PRMS](image-url)
The idea of this improved solution is to change the component quantity in each column by using the in and out registration made in PRMS today and the in and out registration from the storages made in MHS. But since MHS does not share the storage transaction information with PRMS, a new interface has to be constructed to transfer the information between the two systems.

When the arriving components are registered into PRMS, the quantity is raised in the goods arrival and quality control column.

Then, when the components are transported to the different storages, and before they are put in there, they are registered into the MHS system. When the components are taken out from the storages and moved to the production, they are registered out from the MHS system. These two transactions should then be sent to PRMS via an interface between the systems. The transactions from the MHS to the PRMS should be sent every fifth minute, containing a record of the transactions made since the last update.

The quantity registered in (Qt.) is used in PRMS to move the same quantity from the goods arrival and quality control column to the storage column and the quantity registered out (qt.) is used to transfer the same quantity from the storage column to the production column in PRMS.

The quantity in the production column is decreased once a day, when the PRMS backflush the components for all sewing machine bodies produced that day.

**Components not Registered in the MHS System**

The components not stored in a storage controlled by MHS will not automatically be moved into the storage and the production columns, since there would not be any transactions from MHS to PRMS about these components. Instead, the transferring needs to be done manually by either the worker that registers these components, coming from a supplier, into PRMS or by the responsible for the in-house plastic production who registers the bigger plastic parts made there, which are not either stored in a MHS controlled inventory.

Since these components are not stored in a MHS controlled storage, there will be no transactions made from MHS to PRMS, moving these components from the goods arrival and quality control column to the storage column and from the storage column to the production column. Therefore, these components should be registered directly into the production column, since the withdrawal of components from the PRMS system is made in the production column. Otherwise, these components will stay in the goods arrival and quality control column and when components are withdrawn there would not be any components to withdraw from the production column.
Inventory Accuracy

In order to increase the stock accuracy VSM Group AB could adopt the cycle counting. To use this counting, the company needs to split the components into several classes due to cost and importance, which have different counting frequency and margin of error. A schedule for when to count each component should be created; the workload in the schedule should be distributed evenly over time; and working instructions for the counting should be formulated.

The use of barcode readers for registering components in and out from the computer systems will provide more accurate and faster transactions. This will also help the company by providing a better stock accuracy, since less registration errors occur in the systems. The use of barcode readers has already been proposed for registering ordered components that should be taken out from the storages, besides that, barcode readers could also be used for registering incoming components at the goods arrival and quality control area and for registering components delivered into the storages.

8.2.4 Benefits of the Proposed Solutions

The proposed solution provides the following benefits for the company:

- The additional columns in PRMS will increase the track of material, which will guide the workers where to look for components. The time spent with hunting components, which should be available but are not found, can be reduced.

- With the proposed changes, the system will provide information of unavailable components, which are kept in the quality control area for quality audit.

- The proposed changes will give the purchasers and planners better information about the quantities of the components and how the distribution of components is between the three places in the factory. This will improve the decision making for the purchasers and planners.

- With three columns for each component, it will be possible to measure the average quantity at each of the three places in the factory. This will give the company a feedback on how the flow of material inside the factory works and develops over time. With this information the company can work with reduction of components and shorter throughput times in the three places.

- The proposed changes to the PRMS system will show the storage balance, which before were only displayed in the MHS system. The balance information will be easier to access, for workers using the PRMS, since there will be no need to start the MHS system to see the storage balance.
• The use of a more structured way of counting the components in the factory, like the cycle counting, and barcode readers for component registration will give the company a better stock accuracy. More accurate numbers for the components kept at each location will reduce the uncertainty for wrong records and provide a possible reduction of the safety margins used by the purchasers and planners.

8.2.5 Drawbacks of the Proposed Solutions

• For the components not going through all of the three main locations, different transactions in the system are needed. With these exceptions there will be higher probability of errors to occur, since the registration of these components are not performed in the standard way and can be performed differently for different components.

• By taking transactions from MHS into PRMS, PRMS becomes dependent on MHS to function properly, and it is even more important to have correct transactions made in the MHS system. This dependency might give problems if a malfunction in the MHS system occurs, then the balance shown in each column in PRMS would be incorrect.

• The investment for making this change to the PRMS system will include the time spent and the actual cost for making the changes in PRMS and to adopt the MHS system to send information to the PRMS system. At the moment, it is hard to decide the time needed for performing the change, since it is necessary to have a pre-study in order to specify what should be changed in the systems. If some parts of the work need assistance from a consultancy firm, this would create additional costs to the proposed solution.

• A barcode functionality for registering incoming components at the goods arrival and quality control area and at the storages will give costs for acquiring barcode equipment and to adopting it to the PRMS and MHS systems.

• The use of cycle counting usually requires one or more workers that work frequently or all the time with counting material according to a set schedule. Depending on how much time VSM Group AB has dedicated for counting today, more time can be needed to perform cycle counting, which gives higher wage costs.
9 Conclusion and Discussion

In this chapter the thesis is concluded and discussed. In section 9.1, a summary of the results achieved with the proposed solutions is presented. The accomplishment of the thesis, the chosen methodology, proposed solutions and future improvements for VSM Group AB are discussed in section 9.2.

9.1 Conclusion

Today VSM Group AB faces problems with inappropriate inventory management, which cause problems in the WIP inventories. There is no maximum amount for each component set and the criteria for how and when to refill components are not specified.

Nowadays four different computer systems are used to support and control the work at the company. The systems do not have much integration among each other, so the users have to collect information from different systems to get a complete picture of certain matters. The system used for production and material planning, PRMS, has limitations in displaying the components' status and availability, showing only one balance for each component.

In order to help VSM Group AB solving the problems faced, the thesis had the purpose to improve the control of the WIP inventories and the information about the components in the production and material planning system.

To improve the control of the WIP inventories, the researchers proposed the use of a kanban ordering system, which would provide a better management of these inventories by specifying when and how the refilling should be performed and by giving the company a way of setting the maximum level of each component in the inventories. With set maximum levels of components, the company also has a tool for gradually decreasing the number of components in the WIP inventories.

The limitation of the component information in the PRMS system would be reduced if the total balance of each component, showed today, would be divided into three different partial balances representing the quantities in the goods arrival and quality control, the storages and the production. By doing this change in the PRMS system, the company’s purchasers and planners would have more information about the location of the components in the factory and do not need to use the MHS system to retrieve the quantity kept in storage for each component. The information quality in PRMS would be increased and the information about the components’ quantity and location will be condensed into one system.
By performing the proposed solutions the company can gain some benefits. The kanban ordering system would increase the material handlers’ efficiency; provide a tool for setting the refilling quantity, setting the maximum amount kept in the WIP inventories and reducing the WIP inventory levels; give a better visualization of the refilling process; and would provide an alert to the purchasers when a component is out of stock.

The improvements with additional component information displayed in PRMS would increase the track of material; offer better information about component quantity and location for decision making; give the ability for the company to measure the flow and level of material inside the factory; and would integrate the storage quantity information from MHS into PRMS.

9.2 Discussion

9.2.1 Accomplishment of the Thesis

The purpose of the thesis was achieved with support from the five research questions, whose answers were presented in chapter 4-8. The aim of providing useful solutions for the VSM Group AB was reached, since the company has taken part of the solutions and has decided on performing an initial test of the kanban ordering system and has also started searching for the necessary changes in the PRMS and MHS system and the cost of performing them.

The problems faced by VSM Group AB can also occur in other companies in various sectors, since adequate inventory management is a competitive advantage for most organizations. The proposed solutions can also be valid for companies facing such problems as VSM Group AB. The kanban ordering system is already used in many companies and is applicable in different situations. The proposed improvement to the PRMS system is specific for the situation at VSM Group AB, but the idea of displaying the component balance at different places in the process can be suitable for most organizations and enterprise systems. The possibility for generalization of the problems and the solutions gives the thesis a high external validity.

9.2.2 Choice of Methodology

In general the research method and techniques, chosen by the researchers, have supported the thesis work. Since the researchers lacked knowledge about the situation at VSM Group AB, unstructured interviews were held with people at different positions in the company. These interviews were important, since they gave a clear understanding of the problems and guided the researchers in developing the purpose of the thesis.
During the data collection, information about the components used in the Pfaff Creative Vision model and their flow were collected. This work became time consuming and at the end the researchers had collected more data than actually needed for achieving the purpose. The reason for collecting all these data was that the researchers were aiming at setting maximum levels, for each component of the Pfaff Creative Vision model, in the WIP inventories. By discussing this idea with the company, they decided that would be more appropriate to focus firstly on developing the ordering system and afterwards, if the proposed ordering system works properly, establishing the maximum level of components. Due to lack of time the researchers could not set the maximum levels for each component in the WIP inventory. Even though all the data collected were not used in the thesis, the collection process provided a thorough knowledge and understanding of the sewing machine production.

9.2.3 Proposed Solutions

In order to provide useful solutions for the company, it was stressed by them that the cost for changing must be justified and affordable. Therefore, the proposed solution in the PRMS system was limited to using the existing systems, since the cost for buying and implementing a new system is very high.

The proposed transaction update time from the MHS system to the PRMS system was set to five minutes. The optimal would have been if the update was made in real-time, however the system experts at the company said that this would require a more complex interface and more transactions, which could affect the performance of the PRMS system. Updating the system every fifth minute was chosen since it is close to real-time and it was considered as feasible for the PRMS system.

Most of the components are stored in three different storages: the automatic box storage, the automatic finished machine body storage and the pallet storage. The MHS system contains information about in which of these storages the components are kept, and this information could be transferred to the PRMS system. Then information about the level of components in each storage could be added to the proposed storage column in PRMS. However, the purchasers and planners do not need separated storage information, it is enough with having a total amount for all storages. Also to include separate storage information in PRMS requires more advanced interface with MHS.

The presented benefits and drawbacks with the proposed solutions give the company reasons to implement or not implement the solutions. The researchers’ point of view is that the benefits clearly exceed the drawbacks for both solutions and that the company would gain from implementing them.
9.2.4 Future Improvements

The proposed kanban ordering system would probably not give the company significant cost reductions. To accomplish that, the just-in-time philosophy must be used through the whole production process.

In order to achieve more benefits from a just-in-time and kanban system, VSM Group AB could expand the kanban system and try to reduce the total number of components in other areas, besides the WIP inventories.

In order to reduce the amount of components used in the assembly process, a kanban ordering system could help to lower the buffers and the overproduction in the process. By doing this, the previous station in the process would not start producing until there is a need in the next station or buffer. The buffers between the stations should be reduced as much as possible, which would help the company to lower their WIP levels and thereby lower the cost of having unnecessary material in WIP.

To reduce the total amount of components even more, VSM Group AB could lower the average component storage levels, by keeping fewer components on hand in the storages and by revising the order quantities and the order points. To reduce the work with repacking components stored in the automatic box storage, VSM Group AB should make agreements with their suppliers to deliver the components in such a way that minimal repacking work is needed. The result of this can be a significant reduction of the component storage costs, since there would be less repacking work and less total amount of components in the storages.

The reduction of inventory costs can also be increased by reducing the number of finished sewing machine bodies in the automatic finished machine body storage. The gain from reducing the number of machines is significant since each machine has a high value, which creates high holding costs. A way of reducing the costs can be to set a maximum inventory level for each sewing machine model, which varies during the year due to seasonal demand, and then plan the production so the number of machines produced does not exceed the maximum inventory level.
10 References

10.1 Literature References


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10.2 Personal References

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Håkan Johnson – Production planning

Johnny Carlsson – Production planning

Jörgen Larsson – In-house plastic production

Lars-Gunnar Gustafsson – Goods arrival and quality control

Lennart Jonsson – Production planning

Mats Lundqvist – Storages

Paul Engström – Pallet material handler

Peter Andersson – Shelf material handler

Peter Josefsson – IT manager

Stefan Lax – Enterprise computer systems

Urban Andersson – Production engineering
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Appendix A - Interview questions to the material handlers

- How many boxes of each component should be stored in the shelves?
- How often are shelves and wagons refilled?
- Are all wooden boxes replaced with new ones when the refilling is done?
- Why are there often several withdrawals of the same component, in MHS, made in a short time period?
- How accurate are the numbers displayed in the MHS system?
- How often do stock outs occur?
Appendix B - Interview questions to the IT-manager

• Which level of integration exists between the computer systems today?

• If integration exists, how is it carried out?

• Which information is shared between the PRMS and the MHS systems?

• Are there possibilities for expanding the level of integration between PRMS and MHS?

• Do you use all the features in the PRMS system? What functionalities could the system give with the features not used?
### Appendix C - Components stored in the pallet rack

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### Appendix D - Components stored in the shelf by pre-assembly area 1

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<td>Cover embroidery</td>
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<td>Scale, stitch display</td>
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<td>Led plate</td>
<td>412 78 97-01</td>
<td>Custom led light</td>
<td>413 01 98-01</td>
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<td>Key board S.H C3</td>
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<td>413 05 16-03</td>
<td>Spool holder 45mm</td>
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<td>Toggle link</td>
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<td>Gear, servo sec.</td>
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<td>(B) Inverter</td>
<td>413 06 67-01</td>
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<td>Bobbin holder Avanti</td>
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<td>Bobbin case Avanti</td>
<td>412 92 10-01</td>
<td>Reel pin Avanti</td>
<td>413 00 41-01</td>
<td>Racket, thread guide</td>
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<td>412 52 01-03</td>
<td>Avanti</td>
<td>412 94 05-01</td>
<td>Release lever, thread</td>
<td>413 15 04-01</td>
<td>Contact spring,</td>
<td>413 04 58-01</td>
<td>Presser bar guide, servo</td>
<td>412 95 56-01</td>
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<td>413 00 59-01</td>
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<td>Led holder, right</td>
<td>413 04 00-01</td>
<td>(B) Led holder, left</td>
<td>413 04 89-01</td>
<td>(B) Release lever Avanti</td>
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<td>(B) Housing thread</td>
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<td>(B) Thread tension cover</td>
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Appendix F - Partial factory layout including pick-rack and kanban card disposal boxes
Appendix G - Kanban cards

Kanban Card

Component number:
412 99 79-02

Component name:
Stepmotor, Feeder

Quantity:
140 pc.

Inventory Position
Shelf 1

Kanban Card

Component number:
413 05 61-01

Component name:
Handle P80

Quantity:
500 pc.

Inventory Position
Pallet Rack