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IDENTIFYING PROBLEMS IN THE WAREHOUSE PROCESS
Case China

Master's thesis in
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ABSTRACT:
The aim of the thesis is to identify and improve problems in the warehouse process in the case company, which is located in China. Improving the process is based on a warehouse design framework. The framework's purpose is to guide the company to improve overall performance in the warehouse process. The research problem is based on company's interest and the actual study is accomplished in Shanghai, China during autumn 2011.

The study was conducted by normative case-study method. The study is composed of theoretical literature survey and empirical part. The theoretical part presents the process of warehouse management and introduces warehousing design framework. In addition the study includes relevant theory of Chinese culture aspect in process improvement project. The empirical part concentrates on stages of process development. Current stage of the process is analyzed by interviews and data from the company's information system. Actual process improvement is conducted with help of benchmarking and design frameworks.

The result of the study is the designed framework and new warehouse process. Design framework includes receiving process design, warehouse sizing design, warehouse layout design and staffing process design. Financial impact of the results is remarkable, but fastest savings are gained by warehouse layout design. With the help of new layout, utilization of fill rate is improved and it is authenticated that expansion of the warehouse facilities is not relevant. In addition, results include analysis of Chinese culture impact on warehouse improvement process. Main findings in this area consist of guanzi aspect.

KEYWORDS: materials handling, warehousing, processes, China, layout

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TIIVISTELMÄ:
Tutkielman tavoitteena on selvittää varastoprosessiin liittyviä ongelmia ja kehittää niitä kohdeyrityksessä Kiinassa. Kehitysprosessi perustuu varastoinnin suunnittelumalliin, jonka tarkoituksena on tehostaa varastoprosessin toimintaa. Tutkimuskysymykset on aseteltu yrityksen toiveiden mukaisesti. Tutkimus on toteutettu Shanghaissa, Kiinassa syksyllä 2011.

Tutkimus perustuu normatiiviseen case-study menetelmään. Tutkimus koostuu teoreettisesta kirjallisuus- ja tutkimuskatsauksesta sekä empiirisestä osuudesta. Teoriaosuus esittelee varastoprosessin johtamiseen liittyviä asioita sekä varastoinnin suunnittelumalleja. Lisäksi tutkimus sisältää ongelman kannalta oleellista tietoa kiinalaisesta kulttuurista liittyen prosessin kehittämiseen. Empiirinen osa keskittyy prosessin kehittämisen vaiheisiin kohdeyrityksessä. Nykytila analyysi on toteutettu puolistrukturoitujen haastatteluiden avulla. Tämän lisäksi yrityksen tietojärjestelmässä olevaa tietoa hyödynnettiin. Prosessin uudistus on toteutettu benchmarking -menetelmän sekä varastoinnin suunnittelumallien avulla. Benchmarking -tutkimus koostui avoimista haastatteluista neljässä eri yrityksessä.

Tutkimuksen tuloksena kohdeyritykselle suunniteltiin uusi varastoprosessi, joka koostui eri osa-alueista. Pääpaino oli vastaanottoprosessissa, varaston tilantarpeen määrittämisessä, layoutin suunnittelussa ja varastotyöntekijöiden osaamisprofiilin kartoituksessa. Tutkimustulosten taloudelliset vaikutukset kohdeyritykselle ovat laajat, vaikuttaen muihin yrityksen prosesseihin. Nopeimmat säästöt saavutetaan uuden varasto layout-suunnitelman avulla. Uudella mallilla varaston täyttöastetta saadaan tehostettua ja tutkimus todentaa, että nykyisiä varastotiloja ei ole tarvetta laajentaa. Tämän lisäksi tutkimustulokset sisältävät analyysiä Kiinan kulttuurin vaikutuksista varastoinnin prosessin kehittämisen eri vaiheissa. Tärkeimmät tulokset tältä osa-alueelta keskittyvät guanzi-käsitteeseen.

AVAINSANAT: materiaalitalous**,** varastointi, prosessit, Kiina, layout

1. INTRODUCTION

1.1. Thesis background

Within the past decades China's economy has been growing extremely fast, as 10 % development of GDP per year since 1978 presents. Today more than 70 % of China's GDP is covering private and non-state sectors, when 30 years ago private business did not exist. After 2001 when China joined the World Trade Organization (WTO) Chinese firms became active doing international business and foreign firms were boomingly investigating on China (Fang, Zhao & Worm 2008). Today after the China phenomenon has been settled almost all the biggest Western companies are operating in China and some of them are returning back home already.

There are many publications about Western firms operating in China and about the problems they are facing when trying to do business there. Most of the researches are involving problems related to culture and history. For example according to (*Flynn, Zhao and Roth 2007)* Western companies cannot gain success without understanding where Chinese manufacturing has come from, what it has been through and the culture in which it lives. However there have been also statements that are not explaining the problems relying on culture and history. Article from (*Fang and Faure 2010)* includes the contention that "it is difficult to say that there is anything that is specific to China, anything that you don't see everywhere in the world. The only thing that is really different is speed of change."

Chinese infrastructure is dogmatic and maybe that is one of the reasons why development is not that fast. Logistics and warehousing are improving all the time, but according to international logistic performance index, China is on 27th place compared to Finland, which holds 12th place in ranking list (World Bank Institute 2012). Development of IT infrastructure is also slow, because 40 % of warehouse operations were handled manually and only 16 % of warehouses had some automation or IT used in their operations by 2006 (Chang 2006).

1.2. Research problem and objectives

This thesis has been conducted for Metso Paper Technology Shanghai, China. The company is playing vital role in China and their operations are growing fast. Despite the fact that the company has been operating in Shanghai for six years, there is improvement work needed in operational level. Topic for the thesis, identifying problems in warehouse process, was formed according to company’s needs. Problems in a warehouse process are reflecting to other department’s processes in a way that daily work is becoming difficult.

Purpose of the thesis is to identify problems in warehouse process and improve them within Chinese culture aspect. The main research questions are:

1. Why warehouse process causes problems to other departments?
2. What are the main problems at warehouse process?
3. What is the root cause that will be further studied?
4. How Chinese culture impacts on process development?

Scope of the thesis

Stages of process development include measuring the process. The thesis does not cover measuring in case company warehouse process, because the measurements have to be determined after process implementation. The scope of the research is to examine warehouse process from purchasing to pre-assembly, as figure 1 presents. Research will not include warehouse of work in progress and maintenance. In addition, foundry items are not within the scope. Research will neither include examination of warehouse of finished items. The purpose of the thesis is to identify the problems in warehouse process and improve the process. Implementation work is not included, but supportive tasks to daily operations are required. The thesis includes four months of working in Metso Paper’s Shanghai location.

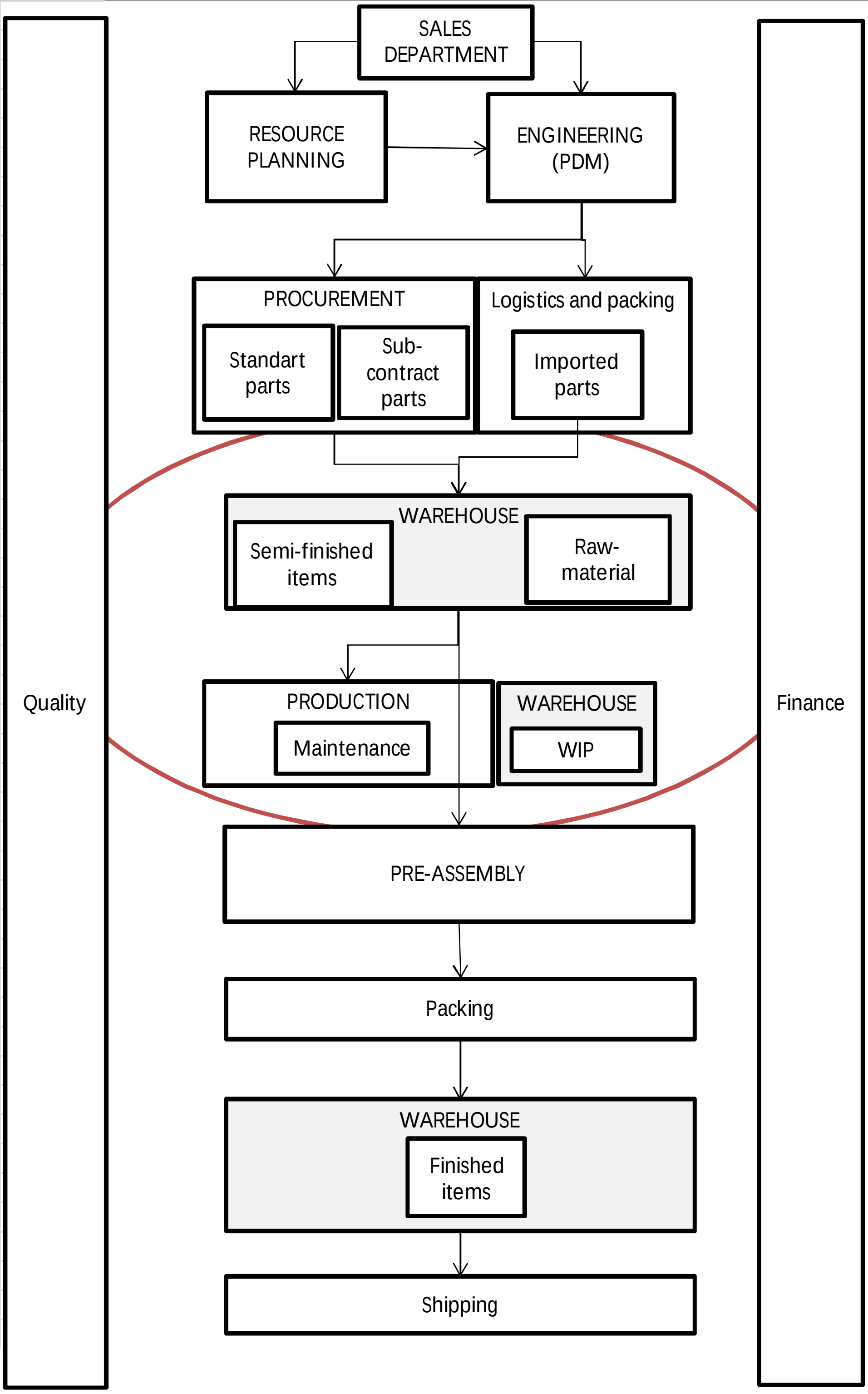


Figure 1: Scope of the thesis

1.3. Thesis structure

The thesis consists of five main chapters (figure 2). First chapter introduces the thesis. Second chapter consists of theoretical part of the thesis introducing process of warehouse management and design. Third chapter includes the empirical part of the thesis, which is accomplished according to stages of process development. First part consists of description and model about warehouse process starting from purchasing to pre-assembly. After that current status of the process is examined and problems are determined. Problem determination is accomplished by interviews including warehouse, procurement, production, quality, IT and finance departments. Actual process improvement is completed with help of benchmarking and warehouse design framework. Chapter three introduces designed processes and eventually the new warehouse process. Chapter four analyzes the results and new designed processes. This part also includes discussion about the Chinese aspect of the research. Finally chapter five summarizes the results and managerial implementations.

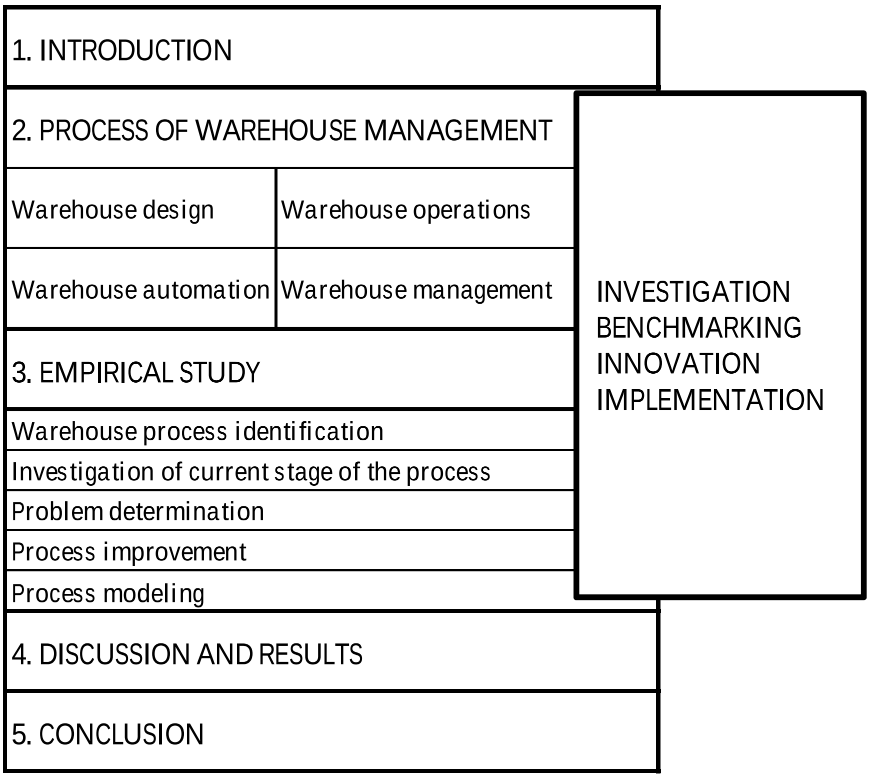


Figure 2: Structure of the thesis

2. PROCESS OF WAREHOUSE MANAGEMENT

Warehousing is a common term and many people have a picture of what it is, but the field is far more complicated than most observers would think (Jenkins 1990.) Nowadays warehousing has become more complex and costly, due to e-commerce, supply chain integration, globalization and just in time methodology. Main target is to increase productivity and accuracy, reduce cost and inventory whilst improving customer service (Richards 2011). This chapter introduces the concept of warehouse management in today's business environment. The aim is to discuss general concepts of warehousing and identify the different problems that may arise in the context of warehouse management.

2.1. Warehouse design

Warehouse design has achieved wide attention in literature and academic journals within past few decades. Especially planning and controlling has been widely studied within supply chain perspective (Rouwenhorst 2000). In spite of that, it is stated that there is still a gap between the published warehouse research and the practice of warehouse design and operations (Gu 2010). It is acknowledged among literature that warehouse design is highly complex and there is no optimum solution that can be applied (Baker 2009).

Usually process of warehouse design consists of five different areas: determining the overall warehouse structure, sizing and dimensioning the warehouse and its departments, determining the layout, selecting warehouse equipment and selecting operational strategies (Gu 2010). Relatively little has been written about the total warehouse design process, but different stages can be identified. Used framework and tools varies among companies, because there is no optimum solution that can be always applied. According to Baker (2009) warehouse design includes the following steps and tools.

Table 1: Warehouse design

Step	Tools	References
1. Define system requirement	Literature, Scenario planning, Warehouse role framework, Role checklist	Christopher (2005), Sodhi (2003), Baker (2007), Higginson and Bookbinder (2005)
2. Define and obtain data	Checklists, spreadsheet, database	Rowley (2000), McGinnis and Mulaik (2000), Bodner et al. (2002), Frazelle (2002) and Rushton et al. (2006)
3. Analyze data	Database, spreadsheet models , activity profiling technique, warehouse flow charts	Frazelle (2002), Rushton et al. (2006).
4. Establish unit loads to be used	Analytic and simulation approaches	Roll et al. (1989)
5. Determine operating procedures and methods	Cluster of decisions, warehouse zoning, flexibility frameworks	Rouwenhorst et al. (2000), Rushton et al. (2006), Baker (2006 and 2007)
6. Consider possible equipment types and charasteristics	Spreadsheet models, decision trees, heuristic, analytic and simulation method	Ashayeri and Gelders (1985), Naish and Baker (2004), Rowley (2000), Rushton et al. (2006)
7. Calculate equipment capacities and quantities	The analytic and simulation methods	Ashayeri and Gelders (1985)
8. Define services and ancillary operations	Checklists	Several
9. Prepare possible layouts	CAD software, outline steps and methods, a warehouse relationship activity chart	Mulcahy (1994), Hudock (1998), Frazelle (2002)
10.Evaluate and assess	Simulation software, analytic models	Kosfeld (1998)
11.Identify the preferred design	Quantitative (e.g. financial business case) and qualitative (e.g. SWOT analysis) methods	Several

Despite of what kind of designing method is used; warehouse design is always based on processes and its operations. Frazelle (2001) introduced warehouse master planning methodology, which specifies on world-class warehousing operations and is particularly used for reengineering warehouse operations. Methodology is used to guide warehouse process improvement projects. The main theme is flexibility which is carried through process design, system selection and layout configuration. Purpose of the warehouse master planning methodology is to examine warehouse operations with help of three stages: investigate, innovate and implement, as figure 3 presents.

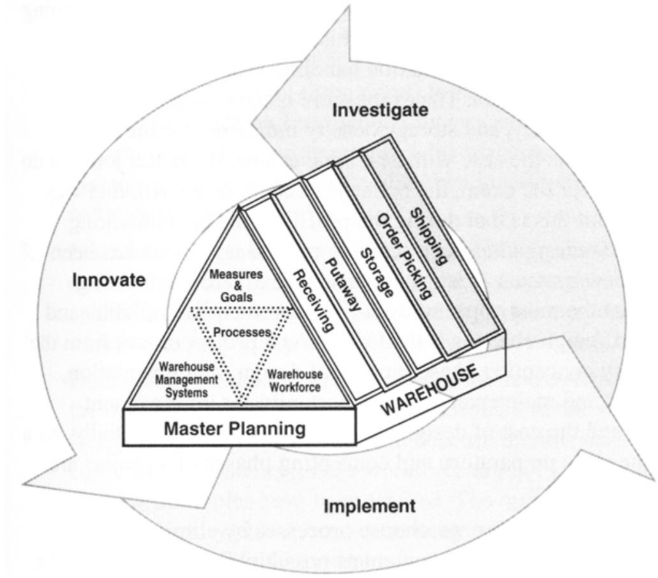


Figure 3: Warehouse master planning

First stage includes *investigation of warehouse operations*, which means determining the root cause of failed process and benchmarking other companies' warehouse processes. Second stage concentrates on *innovating, optimizing and simplifying warehouse operations.* Warehouse operations are classified as receiving, putaway, storage, order picking and shipping. Automation and management of workforce is examined in this stage also. Third stage concludes process with actually *implementing new warehouse designs* (Frazelle 2001).

2.2. Warehouse operations

Even though there are many kinds of warehouses such as raw-materials warehouses, semi-finished items warehouses, finished goods warehouses or distribution warehouses, all of them include the same functions that can be classified as: receiving, putaway, storage, order picking and shipping. In order to examine warehouse process, all of these functions must be studied separately starting from receiving, which is interface to purchasing.

Receiving

Receiving is the first part of the warehouse process, which links it to procurement operations. It is the point at which responsibility of the goods is given to the warehouse. Purpose is to control that 7p's are accomplished by supplier (Mulcahy 1993). If receiving is not done properly, it will be difficult to accomplish other warehouse operations. The receiving process includes unloading of shipment, updating of inventory and receiving inspection.

Putaway

Putaway is the act of transferring coming products to storage locations. It includes material handling, location verification and product placement. Sometimes it may also include repacking. Putaway can be direct or indirect, depending on whether item needs quality inspection or not.

Storage

Storage is a physical place for items that are waiting for demand. Used storage methods depends on types of goods stored, the type of storage facilities needed, the throughput and the size of orders. Items can be stored in many ways, but the classical deviation is to either group functional related items together or group fast moving items together or group physically similar items together.

There are two basic systems how to locate the items: fixed location and floating location. Advantage of fixed location is that it makes possible to store and retrieve items with a minimum of record keeping, thus it usually has poor cube utilization. Fixed-location systems are usually used in small warehouses, where throughput is low, space is limited and there are few SKUs. Instead floating location system is mainly used at modern warehouses, which are usually computer based systems. Advantage of the system is high utilization of space, because goods are stored wherever there is free space for them. In order to use floating system there must be accurate and updated information of the item location and availability of the empty storage place (Arnold 2001).

Order Picking

Order picking is a function where items are collected from warehouse in response to a specified customer request. Customer can be inner customer of the process for example production department or outer final customer. Order picking has been studied widely in a literature, because it is most labor-intensive and costly operation in a warehouse as figure 4 presents.

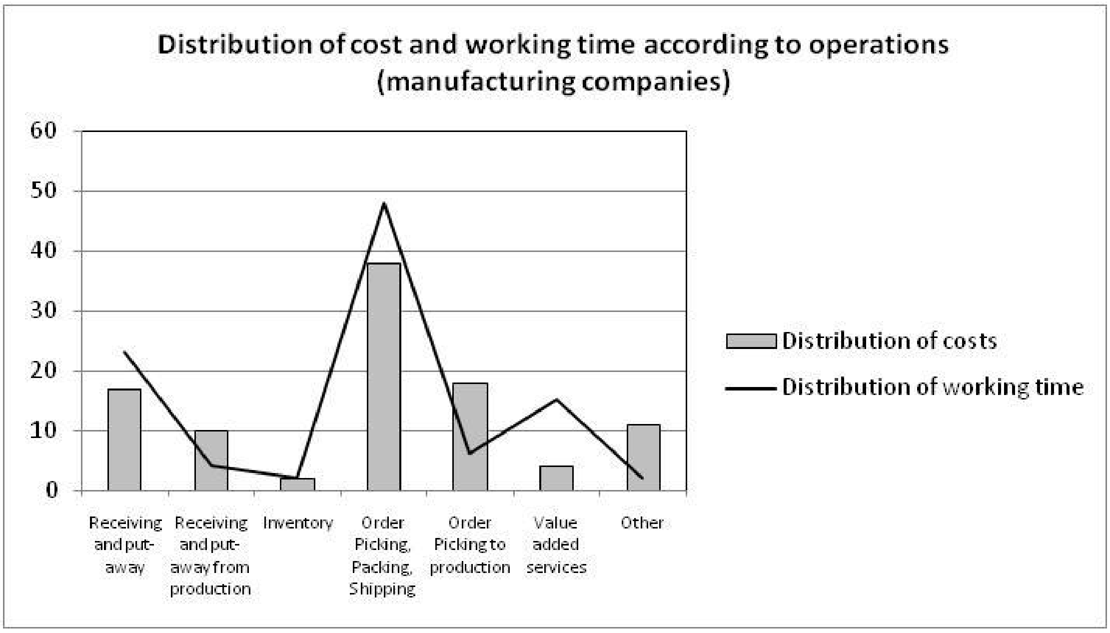


Figure 4: Distribution of cost and working time according to operations

VTT Research (Aminoff 2004).

Picking operations has been changed over the past 20 years, because of automation. Previously, full case and pallet picks were the most used ones, while now automated picking systems, such as carousels and robots have become popular.

2.3. Investigating warehouse operations

In order to find the root cause of failed process it must be examined carefully. Warehouse activity profiling is a tool to find the root causes and pinpoint the major opportunities for process improvements as well as help project-team decision making. Profiling ensures that biased decisions are not made, because there is data analyzed and figures given. There is no right and only way to do activity profiling; it should be rather formed according to company's needs. There are seven profiles introduced: customer order profile, purchase order profile, item activity profile, calendar-clock profile, activity relationship profile, inventory profile and automation profile as table 2 presents. Purchase order profile is introduced next in more details in order to give an example of the activity profiling (Frazelle 2001).

Table 2: Warehouse design profiles

Planning and Design Issue	Key Questions	Required Profile	Profile Components
1. Order picking and shipping process design	Order batch size, Pick wave planning, Picking tour construction, Shipping mode disposition	Customer order profile	Order mix distributions, Lines per order distribution, Lines and cube per order distribution
2. Receiving and putaway process design	Receiving mode disposition, Putaway batch sizing, Putaway tour construction	Purchase order profile	Order mix distributions, Lines per receipt distribution, Lines and cube per receipt distribution
3. Slotting	Zone definition, Storage mode selection and sizing, Pick face sizing, Item location assignment	Item activity profile	Popularity profile, Cube-movement/ volume profile, Order completion profile, Demand correlation profile, Demand variable profile
4. Material transport systems engineering	Material handling system selection and sizing	Calendar-clock profile	Seasonality profile, Daily activity profile
5. Warehouse layout and material flow design	Overall warehouse flow design, Relative functional locations, Building configuration	Activity relationship profile	Activity relationship distribution
6. Warehouse sizing	Overall warehouse space requirements	Inventory profile	Item family inventory distribution, Handling unit inventory distribution
7. Level of automation and staffing	Staffing requirements, Capital-labor substitution, Level of mechanization	Automation profile	Economic factors distribution

Purchase order profiling

Purpose of the purchase order profiling is to use it in receiving and putaway process design. With help of purchase order profile it is possible to plan receiving mode disposition, putaway batch sizing and putaway tour construction. The main areas of analysis are order mix distributions, lines per receipt distribution and lines and cube per receipt distribution.

Order mix distribution is used for plotting warehouse operation strategy. There are three distributions used: family mix, the handling unit and order increment. For example with help of family mix distribution it is easy to figure out whether warehouse should be zoned according to item families based on receiving. *Lines per receipt distribution* instead is helpful when determining putaway batch sizing with help of categorizing received purchase orders according to lines per order. It will help to evaluate different operating strategies for example showing the percentage of orders that only includes one order line. *Lines and cube per distribution* is sort of similar, but it is also noticing space requirements and packing. With help of analyzing received lines and cubes per order it is easier to plan putaway operations. In addition it is useful when thinking about packing issues and batch sizes (Frazelle 2001).

Benchmarking and measuring

After completing the activity profiling, benchmarking is the next step of process design. Benchmarking can be internal or external, meaning that it can be done inside the company or among other companies. The purpose of benchmarking is to identify highest standards and excellence for products, services or processes and then making the improvements necessary to reach those standards called 'best practices' (De Koster 2008).

Warehouse benchmarking can be done in many ways. Researchers have developed different benchmarking tools for warehouses including qualitative and quantitative methods. Typically tools are measuring warehouse performance, such as *financial, productivity, utilization, quality and warehouse cycle time* as table 3 presents.

Table 3: Warehouse key performance indicators

	Financial	Productivity	Utilization	Quality	Cycle Time
Receiving	Receiving cost per receiving line	Receipts per man-hour	% Dock door utilization	% Receipts processed accurately	Receipt processing time per receipt
Putaway	Putaway cost per putaway line	Putaways per man-hour	% Utilization of putaway labor and equipment	% Perfect putaways	Putaway cycle time
Storage	Storage space cost per item	Inventory per square foot	% Locations and cube occupied	% Locations without inventory discrepancies	Inventory days on hand
Order Picking	Picking cost per order line	Order lines picked per man-hour	% Utilization of picking labor and equipment	% Perfect picking lines	Order picking cycle time
Shipping	Shipping cost per customer order	Orders prepared for shipment per man-hour	% Utilization of shipping docks	% Perfect shipments	Warehouse order cycle time
TOTAL	Total cost per order, line and item	Total lines shipped per total man-hour	% Utilization of total throughput and storage capacity	% Perfect warehouse orders	Total warehouse cycle time = DTS + WOCT

Financial tools are based on cost structure of the warehouse including cost of labor, space, equipment, overhead etc. It is useful to measure financial performance according to warehouse activity-based costing program. Meaning that financial cost should be measured according to each warehouse operation: receiving, putaway, storage, picking and shipping.

The most popular measurement of warehouse performance is *productivity*. The formal definition of productivity is the ratio of the output of a resource to the inputs required to achieve that output (Frazelle 2001). Productivity is usually measured among labor, space, material handling systems and warehouse management systems. According to a survey in 2009 the most commonly used measurements of productivity in warehouses were (Richards 2011):

- order picking accuracy
- on-time shipments
- average warehouse capacity used
- order fill rate

- annual workforce turnover
- fill rate by line
- on-time ready to ship
- peak warehouse capacity used
- dock-to-stock cycle time in hours
- percentage of supplier orders received with correct documents.

However there is a problem with these measurements when trying to benchmark these numbers within other companies. The problem with these measurements is that they are not mutually independent and that each of them depends on multiple input indicators. The results may vary according to size of the warehouse, level of the automation and size of assortment. DEA, Data envelopment analysis, is a tool that concentrates on measuring operations efficiency. Efficiency of an operation is defined as a weighted sum of output indicators divided by a weighted sum of input indicators. With the help of DEA it is possible to measure the relative efficiency of a set of comparable decision-making units (De Koster 2008). Even though DEA is a good tool for measuring efficiency it is argued that warehouses should be comparable. This tool is especially used in global benchmarking, but it does not consider cultural differences or local working hours. Based on DEA there was another tool formed which is based on single facility tour and can be carried out within two hours including some questions and answers (Q&A). The tool is used more in quantitative analysis and it includes 11 study areas at the warehouse. For each of the areas there is a questionnaire available (Lahmar 2008).

When measuring the *quality* performance of a warehouse there is usually four indicators used. Two of them are measuring input performance: putaway accuracy, inventory accuracy and two of them output performance: picking accuracy, shipping accuracy. Instead for *cycle time* measurement there are two indicators presented: dock-to-stock time (DTS) and warehouse order cycle time (WOCT). DTS means the time between item arriving until the picking operations. WOCT instead counts the time from order release to shipping including picking and packing operations (Frazelle 2011).

2.4. Innovating, optimizing and simplifying warehouse operations

Warehouse layout design

There are many researches, consultants, material-handling companies and universities that have studied warehouse layout design. There are few real methodologies described in the literature, because usually planning depends on the designer and it is formalized according to checklist of requirements. However content of the layout design is usually the same, but different approaches to planning problem are taken. For example some researches approach the problem by listing objectives that need to be maximized, while some start planning according to warehouse operations (Baker 2009).

The quality of layout alternatives will usually depend of the skill and ingenuity of the layout planner. Unfortunately, layout planners often lack creativity and they approach the problem with a preconceived idea about what the solution should be. According to *Smith* layout planning includes five stages:

1. Define the location of fixed obstacles- Obstacle should be identified and placed in the layout first, before objects with more flexibility are located.

2. Define the location of the receiving and shipping functions - Receiving and shipping are high-activity areas and should be located to maximize productivity, improve material flow and properly utilize the warehouse size.

3. Locate the storage areas and equipment, including required aisles - All storage areas must be clearly identified and materials have to be stored accordingly. The types of storage area and used equipment determine the configuration of the storage layout and aisle requirements.

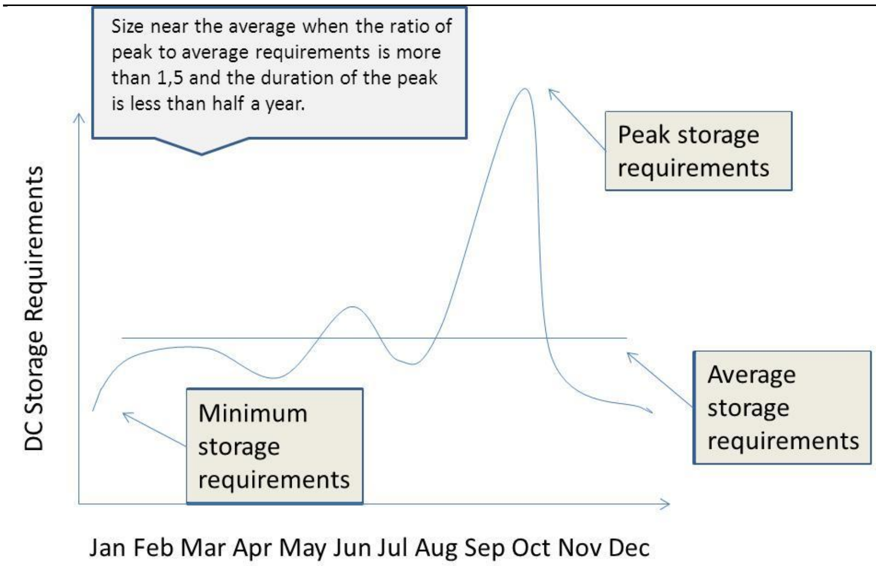
4. Assign the material to be stored to the storage location - Ensures that storage allowances have been made for all the items to be stored.

5. Repeat the process to generate other alternatives - When the first layout plan is accomplished, the process must be repeated many times to generate additional layout alternatives (Smith 1988).

Before starting to accomplish these five stages, data must be gathered first. Planning should be based on calculations about required space for each warehouse operations including receiving area, picking areas, packing area, dispatch area, offices and restrooms. According to study (Baker&Perotti 2008) deviation of these areas on a warehouse are: 52 % of storage, 17 % of picking, 16 % of receiving and dispatch, 7 % of value-adding services and 7 % of others, such as empty pallet storage area. Receiving and dispatch area can be calculated with the help of the following pattern (Richards 2011). :

$$\text{Space} = \frac{(\text{ number of loads x hours to unload })}{\text{Time of shift}} \quad \text{x (number of pallets x space per pallet)}$$

Calculation of storage area instead is more complicated. First of all there should be decision made about the portion of peak storage. If the duration of the peak is determined as short-lived and the ratio of the peak to average ratio is high, then temporary storage area should be planned to accomplish the temporary need for example with the help of outside storage area. In contrary if the duration of peak is for an extended period and the ratio of the peak to average ratio is low, then warehouse should be sized near to peak requirements, as figure 5 presents (Frazelle 2001).



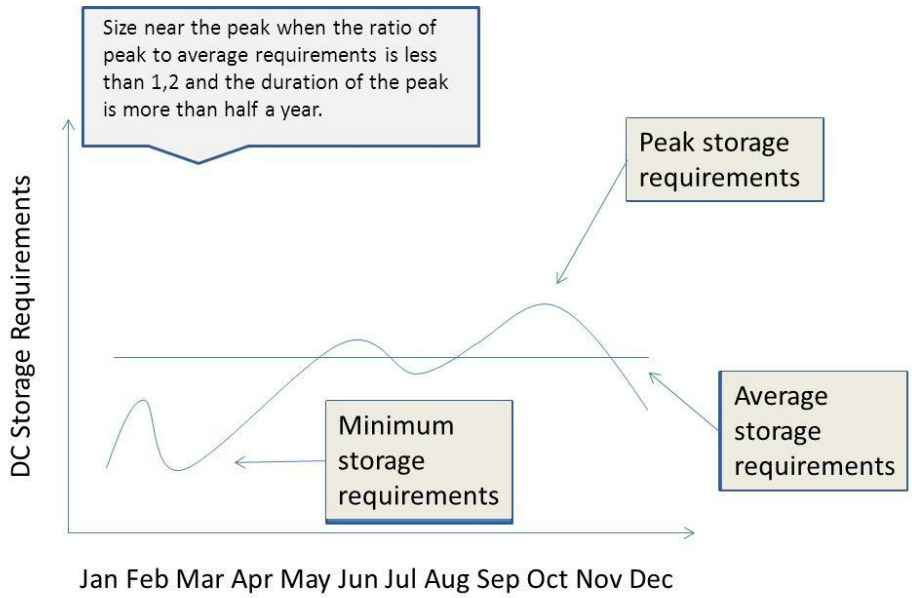


Figure 5: Storage capacity requirements

Required storage needs can be calculated in many ways. Some designers use simulation programs while some measure the exact dimensions of warehouse facility and do calculations on paper. One way to determine the required warehouse space is to calculate the number of pallets that can be stored within a given cubic area when using standard adjustable pallet racking. The calculation formula is based on width, length and height of the modules and pallets. It takes into account the aisle between the racking, but do not consider aisles and gangways at the front of the racking. Required space can be calculated as (Richards 2011). :

(Number of width x pallets in a module width) x (number of length modules x pallets in module length) x number of height modules

There are also some other factors that should be taken into account when calculating space requirements. First of all it is studied that utilization of the space should be 85 %. If the rate is exceeding, then it will effect on productivity and safety. Another thing is pallet orientation, meaning that it should be considered whether to store pallets on short facing or long facing. Storing the pallets with short facing increases flexibility since more pallets can be stored in a length of racking. Instead storing the pallets with long facing helps picking operations (Richards 2011).

Storage and handling equipment in warehouse layout design

The design of storage and handling equipment should be included in the design of warehouse layout, because it impacts on design of aisles, space requirements, utilization of the cube, storage assignment, movement and flow of the warehouse. There should be decisions made about storage method, depth of storage, the type and dimensions of unit loads and the type, number, and capacity of handling equipment. In addition the dimensions of racks, the number of bins and their numbering system should be determined. Furthermore the design of conveyor paths, the selection of a sortation system, determining its location, designing its flow system and specifying the level of mechanization of all equipment should be included in designing (Hassan 2002).

Palletized systems

Usually the wooden pallet is the most common unit load that is used in warehouses, because it enables standard storage and handling equipment utilization. There is a huge range of equipment available for moving pallets, from simple manual aids to sophisticated computer-controlled equipment (Baker 2006).The choice of the equipment depends on many factors such as type of pallet, type of storage, type of operation, warehouse dimensions, overhead obstructions, surface and gradients, working area and environment (Richards 2011.) Table 4 presents the comparison of four models based on traveling distance, traveling speed and cost (Lahmar 2008).

Table 4: Different material handling equipment

Truck model	**Traveling Distance (d in ft)**	**Travelling Speed (fpm)**	**Capital Cost Per Unit Equipment ($)**
Hand-pallet truck	$d \leq 100$	150	1000
Electric-pallet truck	$100 < d \leq 250$	220	12000
Stand-up rider truck	$250 < d \leq 500$	616	20000
Cushion tire lift truck	$d > 500$	959, 2	35000

There are also many storage systems available for palletized goods, from simple block stacking to advanced computer-controlled systems. Some of the systems include a range of technology, but might actually require a large amount of warehouse space. Comparison between different storage systems is usually done according to space utilization with help of calculations based on handling equipment characteristics, available warehouse height and pallet dimensions. Table 5 presents the most common used storage types and their space utilization range (Baker 2006).

Table 5: Space and location utilization examples

Storage Type	**Pallet Spaces per m^2**	**Location utilization factor**	**Pallets per m^2**
Block stack (four deep)	1, 5	70 %	1, 1
APR (reach truck)	1, 5	95 %	1, 4
Double deep	2	85 %	1, 7
Narrow-aisle	2, 6	95 %	2, 5
AS/RS - single deep	4	95 %	3, 8

Non-palletized systems

Although pallets are very widely used in warehouse operations, there are many types of products that are not suitable for pallets, for example nuts, bolts, electronic items and steel bars. These items must be stored in another way for example using carousels, mini loads, conveyors, cranes and AVGs. The storage method is chosen by product characteristics and picking methods. They are varying according to used automation level, utilization of the space, security, cost, flexibility and picking rate (Bozer 1996). Table 6 presents the comparison of small parts storage options.

Table 6: Comparison of small items storage systems

Storage type	Net Unit Cost/ available ft^3 ($)	Floorspace Requirements (ft^3 of inventory housed per ft^2 of floorspace)	Pick rate (Order line/ person-hour)	Item security	Flexibility
Bin Shelving	10-30	1-1.2	25-125	Average	High
Gravity Flow Racks	9-15	0.7-0.85	25-125	Average	High
Storage Drawers	31-38	1.8-2.5	25-125	Excellent	High
Horizontal Carousel	40-70	0.8-1.25	50-250	Good	Medium
Vertical Carousel	65-100	5.0-6.0	50-300	Excellent	Low
Miniload ASRS	38-50	4.0-5.0	25-125	Excellent	Low

2.5. Warehouse automation

Warehouse automation has been described as “The direct control of handling equipment producing movement and storage of loads without the need for operators or drives” (Rowley, 2000.) In spite of this definition warehouse automation includes also computerized warehouse systems, such as *bar code scanning, RFID and WMS* (Warehouse management system). Computerized warehouse systems are developing all the time, because there is a trend towards paperless warehouses. It is argued whether automation is the solution for the problems, because paper-based and spreadsheet warehouse systems can fulfill the need and manage stocks as efficiently as automated ones. “Automation should not be the first, but rather the last resort” (Frazelle 2001.)

A warehouse can be managed in many ways and nowadays there are automated systems available for this, called *WMS*. WMS is similar to many other software solutions such as ERP and it is also based on database. WMS can be integrated to other software solutions in a company also. With help of WMS it is possible to follow items that are stored, their quantity and place information. The purpose of the warehouse management system is to cover all the handling operations in the warehouse, while improving stock control, traceability, productivity levels and better management reporting (Emmet 2005.) There are plenty of WMS vendors and different kind of solutions available, so it is essential to specify required functions, before selecting the system. In addition, before implementing the system it is vital to make sure that the vendor understands the company’s warehouse process.

Thus not every warehouse needs a WMS. A warehouse could benefit from some of the functionality, but implementing cost and ongoing cost of the system might not cover the benefits in a long run. WMS is a big, complex and data intensive application. It tends to require a lot of setup work, system resources to run and ongoing data management to continue to run. In reality a company needs to manage the warehouse management system itself (Piasecki 2012).

Barcodes

Warehouse management systems often utilize some other computerized systems such as *barcode scanners*. The purpose of the barcode scanners is to scan a symbol (bars and spaces) with a laser light. With the help of a scanner the light is converted to an analog signal and to a digital signal. Signals are processed into an ASCII language or binary digits and simulated as a keyboard input and finally read by computer (McCampbell 1994).

Bar code technology is quite an old invention and it is widely used in warehouse operations. Nowadays, it is argued whether usage of barcodes in supply chain operations is needed, because other solutions such as RFID- technology are getting more popular. However, changing the most common used system in a supply chain will require time and some researchers are confident that barcode technology will not be substituted by new ones (McCathie 2005).

The main advantage comparing to other systems is price. Barcode labels and scanning equipment are rather cheap. In addition bar code equipment is easy to use and it speeds up the operations. The main advantages in a warehouse are gained with inventory control, reduction of errors, better utilization of time, improving location inaccuracies, item identification and flexibility.

In warehouses the barcode system is used to identify items and stock locations. With its help, items are sorted and routed through a handling system and tracked as they move through the system. It also simplifies stock checking and many other data input and capture functions (Baker 2006).

Implementing a barcode system in a warehouse consists of five steps, as table 7 presents. Before implementing a barcode system in a warehouse, it requires careful planning and investigation. First of all, there should be detailed analysis made about the operations and their timing in order to prevent operational bottlenecks. It is essential to understand where to utilize barcode and how; in receiving, inventory control, order picking, shipping or all of them. Secondly, the interface to other departments must be studied and they need to be involved to the project team also, such as purchasing. In addition possible boundaries, such as other IT systems in a company, must be investigated. Thirdly systems design involves hardware and software selection, which should be carried out according to company's environmental factors. Fourth stage instead is about development, where system is actually constructed and detailed documentation is required. After accomplishing the fourth stage the system is ready for testing and training (Manthou 2001). Usually used training methods consist of manual training and video tapes. Average barcode system training time per user is 8-20 hours, while some 4% might require over two weeks of formal training (McCampbell 1994).

Table 7: Stages for the development and implementation of a bar code system

	Data / information input	Actions
Stage 1		
Preliminary investigation	Vendors of barcode technologies.	Problem definition
	Technical characteristics of the system.	Goals establishment
	Surveys of similar installations.	Constraints determination of the proposed system.
	Initial feasibility study of the interested company.	Statement of expected benefits.
	Requirements, expected benefits and costs.	Cost estimation.
	Time needed.	Time estimation.
		Preliminary investigation report.
Stage 2		
System analysis	Host system summary reports, end users knowledge.	System boundaries definition.
	External primary and secondary data. Performed tasks (what, when, who, how, where, why).	Calculation of throughput.
	Existing hardware technical characteristics.	Examination of efficiency of working procedures.
	Existing software characteristics.	Reorganization of working procedures.
		Documentation of information flows.
		Hardware and software interface specification.
		Requirement's documentation.
Stage 3		
Design	Hardware and software configurations of the proposed system.	System design specifications.
	Interface configuration.	Request for Proposals (RFP).
	Response time of barcode system.	
	Data structure.	
	Duration time of transmission to the host computer.	
Stage 4		
Development	System Design specification	Program documentation.
		System documentation.
		Operations documentation.
		End-user documentation.
Stage 5		
Implementation and evaluation	Performed tasks	Integration.
	New or modified business operations	Testing.
		Training.

2.6. Management of workforce

In order for a warehouse to operate efficiently it requires an experienced, knowledgeable and well-trained manager, a motivated team of supervisors and operators. Technical systems in the warehouse might be the best ones, but without motivated and committed workforce there are no results gained. According to a study the reflection of having unmotivated people is 3-4 % per annum what comes to staff turnover rates and absenteeism (Emmett 2005).

Warehouse workforce should be trained with the help of an ongoing program in order to prevent low rate of productivity with high operating cost. First of all a training program for new warehouse workers should be identified according to tasks. Usually it includes training of equipment, company, safety, order picking methods, warehouse layout, labor regulations, math skills and reading skills. Length of the training is also essential, while shorter programs are less costly than longer ones; the shorter programs are more likely to result in inadequate preparation (Murphy 1992).

Secondly all the staff should receive an induction, meaning that the new employee understands what his task in organization is and how it is related to other processes within the company. A simple process flow map should be provided showing the end to end supply chain and how each step impacts the final customer (Richards 2011). Thirdly training should be an ongoing process, which should encourage the development of workforce. There are many strategies how to maintain continuous training, for example utilizing cross-training or soko circles. Cross-training means that workers are trained to work in multiple areas and tasks within the warehouse. Soko circles instead are quality circles working in warehouse operations. Purpose is that warehouse workers will gather together in teams and try to solve some problem related to warehouse operations (Frazelle 2001).

There is no real methodology about the skills that warehouse workers should have. For the warehouse operations manager instead there is standard job description given by

Canadian Supply Chain Sector Council. Even though methodology is missing, there are some job roles in a warehouse that can be identified, as table 8 presents (Emmett 2005).

Table 8: Warehouse job roles

Job titles	Tasks	Accountability	Outcomes
Level 1. Operative or labourer	Basic skills in using tools, plant, equipment . Applies knowledge of procedures. Performs physical job requirements. Training . May require a licence to drive/operate equipment.	Under immediate supervision. Works from verbal and written instructions. Follows operational procedures. Follows health and safety procedures. Is able to resolve basic questions and problems.	Safe, successful and timely completion of all the assigned tasks.
Level 2. Storekeeper or senior operative	Knowledge of all regulations that apply in the specific operation. Undertakes varied duties such as unloading, picking, loading. Has skills in operating equipment and may need a licence.	Works under direct supervision. Selects from a variety of procedures to accomplish assigned tasks. Resolves routine questions and problems but refers complex issues to the next level. May be responsible for leading other people.	Accurate work completion in accordance with procedures.
Level 3. Senior store keeper or supervisor or first line manager	Applies knowledge of specific warehouse operations. May plan, but will coordinate single or several activities. Resolves competing demands from customers and users. Applies supervisory management practices and principles.	Has strong technical and supervisory skills. Organises, directs and controls staff. Measures employees' outcomes and takes any appropriate action. Is able to independently resolve daily operational problems.	Efficient and safe/secure handling of goods while giving good customer service.
Level 4. Manager	Plans, organises, directs, prioritises and assigns work to staff. Controls and evaluates the effectiveness of operations. Plans and implements operational and procedural improvements. Manages using extensive warehouse and management experience.	Has strong technical and managerial skills. Independently resolves any management issues that involve people, customers, resources, procedures and practices.	All warehouse operations to be efficient, safe/secure and within company budget and company goals.

In addition there are many skills that are usually required when working in a warehouse, such as computer skills, reading skills, writing skills, forklift-truck skills etc. It is essential to analyze skills of each worker in order to monitor, motivate and schedule each task. There is an official skill matrix available, which is used to develop focused training plans to maximize flexibility and to enhance the development of every individual. Skill matrix is a simple visual tool that helps managing, controlling, resource planning and monitoring of skill levels. It displays all the tasks and skills that are required for each work and the current level of ability of each worker to do that task (Beyondlean 2012).

3. EMPIRICAL STUDY OF WAREHOUSE PROCESSES

The following chapter includes the empirical part of the thesis. Chapter 3 starts with an explanation of the methodological framework of the study. After that it describes the case company. It then continues investigating the current stage of the warehouse process and determining problems within this continuum. Next stage consists of innovating, optimizing and simplifying warehouse operations with help of designing methods. Finally description of the new process is conducted and it is ready for implementation. Chapter 4 sums the study with results and discussion.

3.1. Methodological framework

Research methodology was based on a normative case-study. There are many descriptions about case studies, but usually it is a study that focuses on a contemporary phenomenon with some real-life context including investigator, that has little control over the events (Yin 2003). Case study can be either qualitative or quantitative. Research work usually involves fieldwork, archival records, verbal repots, observations or some combination of those (Yin 1981). Case study is often used, when trying to investigate answer for “how” and “why” questions.

This research was based on qualitative and quantitative study. Quantitative material consists of spread sheet model, because processing and analysis of research data was primarily conducted in Microsoft Excel and AutoCAD. Qualitative material instead was gathered with interviews. Interviews within case company included IT-, finance-, warehouse-, production-, procurement- and quality departments. The purpose of the interviews was to analyze the current stage of the process and try to find all the functions that were influencing the performance of the warehouse department. With the help of interviews current process was modeled and root causes were further investigated. In addition research included benchmarking study, which was concluded also with interviews and discussion. Benchmarking companies were Valtra Oy Ab, Moventas Wind Oy, Metso Paper Jyväskylä and Metso Paper Shanghai, Waigaoqiao. Results of the benchmarking were such that there was only a small amount of information that could be applied to the thesis. Main reason was that processes in Metso Paper Technology Shanghai were not developed enough in order to actually accomplish something. Though many ideas were gained from the benchmarking companies and some ideas were further modified to case study company.

3.2. Investigation of warehouse operations

3.2.1. Background of case company

Metso Paper Technology Shanghai was established in 2006, when Metso bought all shares from Shanghai Chenming Paper Machinery Co., Ltd. Metso Paper Technology Shanghai is part of the Metso PFT's (Paper and Fiber Technology) global production network, which mainly serves the Chinese market and extends to other markets in Asia Pacific area. Business scope of the Shanghai unit is to manufacture paper and board machine sections and components as well as components and equipment for stock preparation, tissue and fiber production.

Role of the warehouse in organization

The warehouse plays essential role in logistics chain, because it functions with many departments. Smooth production flow requires inventory at each stage of the process. Inventory is held at four phases of the chain including WIP as figure 6 presents. The first warehouse inventory spot is between supply and manufacturing. This spot includes mainly inventory of raw-materials and components, which are named as standard parts. The second warehouse inventory spot is between production and pre-assembly, where subcontracting parts, imported parts and parts from own production are stored. The third inventory spot is after pre-assembly, where machine is dismantled back to parts before shipping. The final inventory spot is between packing and shipping, where finished items are waiting for supply.

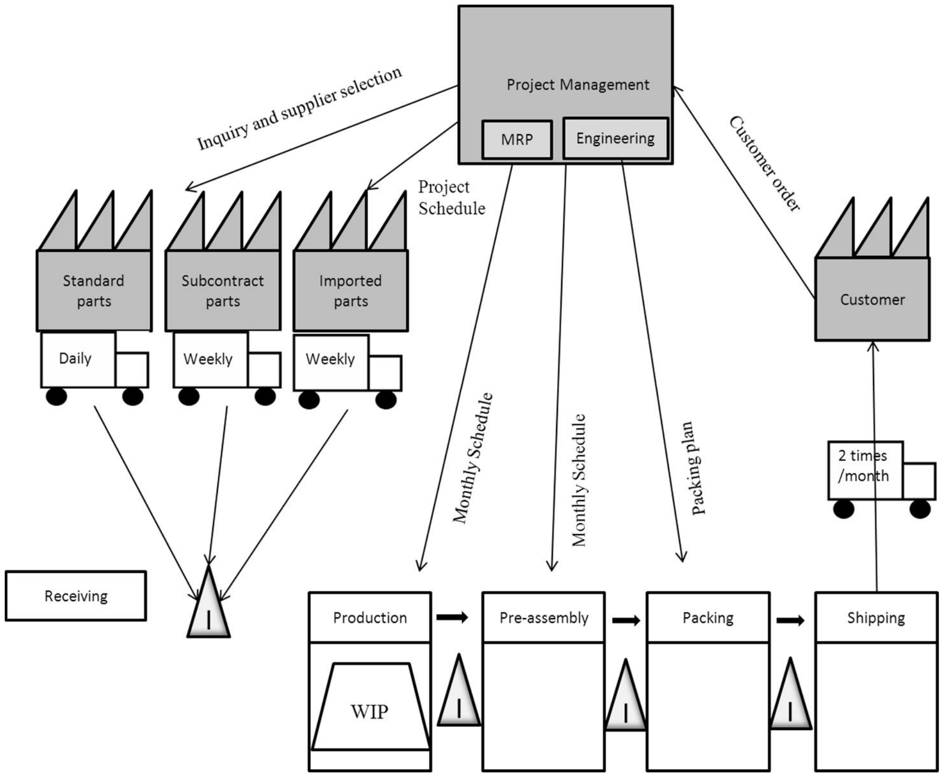


Figure 6: Value stream map of warehouse process

Location of the warehouses

Metso Paper Technology Shanghai plant consists of 140.000 square meters, which includes 1080 m² of inside warehouse area and approximately 4990 m^2 of outside area. Figure 7 presents the locations of warehouse areas. The outside warehouse at area 1 is located under crane with 50 tons lifting capacity. Storage consists of raw-materials, semi-finished items and finished items. Some of the raw-materials are placed at the same spot, but for other parts there are no fixed areas.

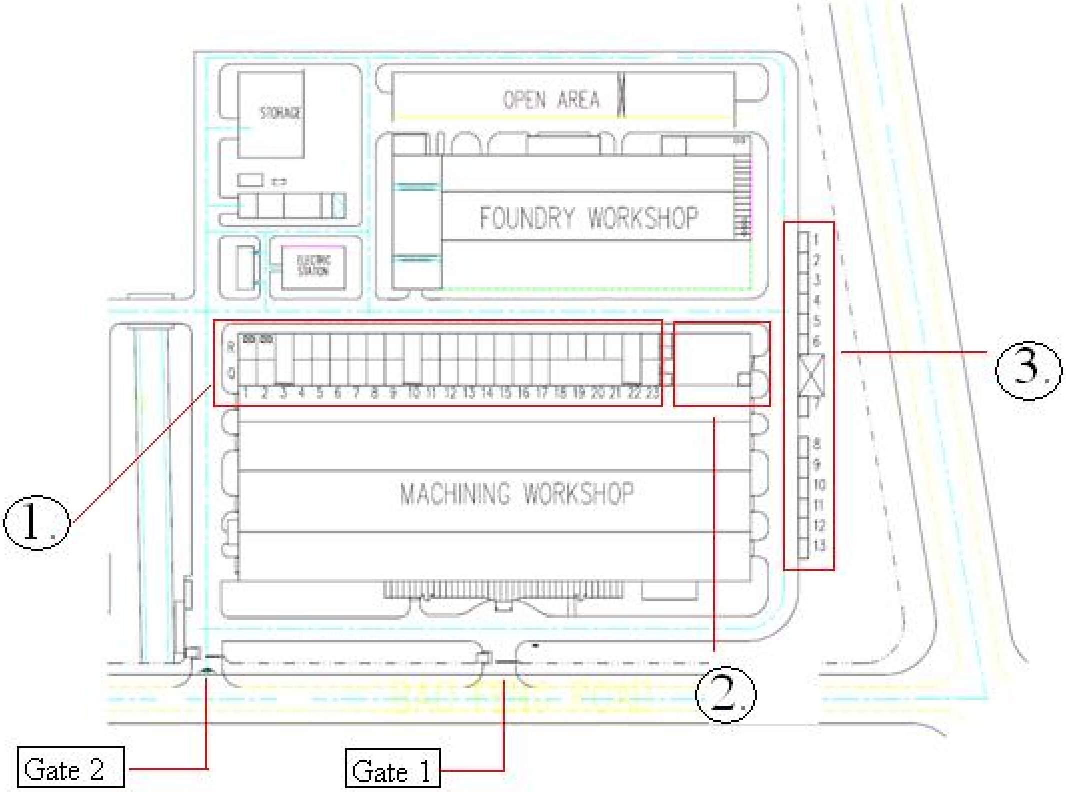


Figure 7: Warehouses at factory area

The inside warehouse area 2 is divided into two sections. First part consists of standard parts for example screws and bearings. Another part is placed with sawing machine and some raw-materials. Used storage systems are based on crane with five tons capacity and pallet shelves. The third named warehouse area is located outside, right site of the factory. The area is divided to 13 locations and it is covered with tarpaulins. Storage is mainly used for warehousing sub-contract parts and parts that comes from other units within Metso Corporation. In addition this warehouse includes miscellaneous parts and some storage equipment.

Additional space for warehousing the parts is also needed, because of the poor forecast and planning of the operations. Factory sideways are occupied constantly with castings, semi-finished items and finished items. There is neither separated area for finished items, so they are also placed on sideways, storage area 1 or storage area 3. However, factory area involves separated storage that is owned by Metso Paper China. Storage includes mainly spare parts and tools, which are used in site operations. Metso Paper Technology Shanghai uses also the same parts, but they are rarely utilized from this storage, because units are handled separately.

3.2.2. Warehouse process

Organizationally warehouse is part of the production department processes. Actual warehouse process is controlled by warehouse manager, who is the supervisor for 24 employees. Every worker has their own responsible area at warehouse, which is divided according to item group. Worth noticing is that only three persons are working with the ERP system in the warehouse.

There is no description of the warehouse process or any process flow chart in a paper. It is rather formed from old practice and work habits. Guidelines for the workers are made, but they are not actually implemented. In its current form the warehouse process from purchasing to production can be divided to four stages: receiving, putaway, storing and order picking, all thought process itself is not clear. Figure 8 is simply clarification of the current process flow.

Receiving, putaway and storing

In a practice process starts when vehicle arrives from the gate 2. Average arriving rate per day is 10 vehicles. There is no specific place for unloading, but usually vehicle drives near to actual warehousing place. Raw-materials are unloaded in area 1 in spot 10, because of the crane. For the standard parts there is defined unloading area, but it is not actually used. Unloading will be done randomly to area that is currently available. After unloading the shipment by responsible person he fills out the receiving form manually. The form is then transferred to another person who is responsible of receiving in Baan system. After receiving in Baan documents are stored.

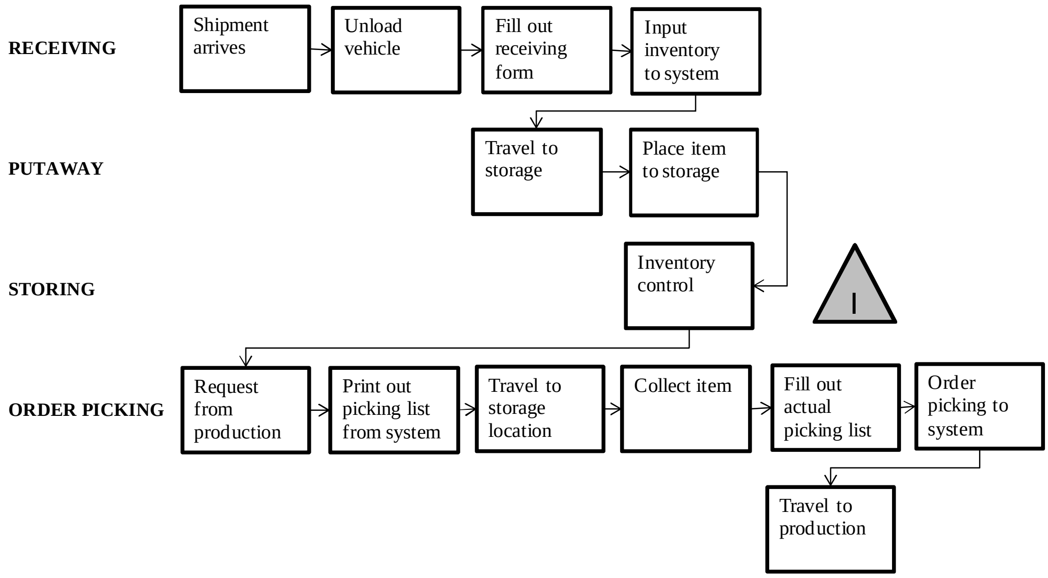


Figure 8: Warehousing process in the case company

Order Picking

Internal customer for the warehouse is pre-assembly. When department is requiring parts from the warehouse a production worker will come to the warehouse and give project number to person who is responsible of Baan actions. That person prints out the picking list and gives it to production worker or some cases to warehouse worker, who will then pick-up the item from the warehouse. After that the actual responsible person for the item prints out the list of picked items and hands it to the responsible person of Baan, who will then issue the material in Baan.

3.2.3. Problems in the warehouse process

Current warehouse process consists of many problems covering information flow, material flow and cash flow. Based on discussions with warehouse department there were five main problems determined:

1. All the items are not added to the ERP system.
2. There is not enough space at the warehouse.
3. There are not enough skilled workers in warehouse.

4. Items are difficult to find from the warehouse.
5. There is no information about the shipping schedules.

In order to find the scope of problems in a warehouse other departments were interviewed also. Based on interviews problems were categorized. Figure 9 illustrates the range of problems, which influences on the performance of other departments such as purchasing, production, IT, finance and quality. Distribution of problems reveals that problems reflect to the whole process at the moment. Next part includes description of problems related to warehouse operations in warehouse process.

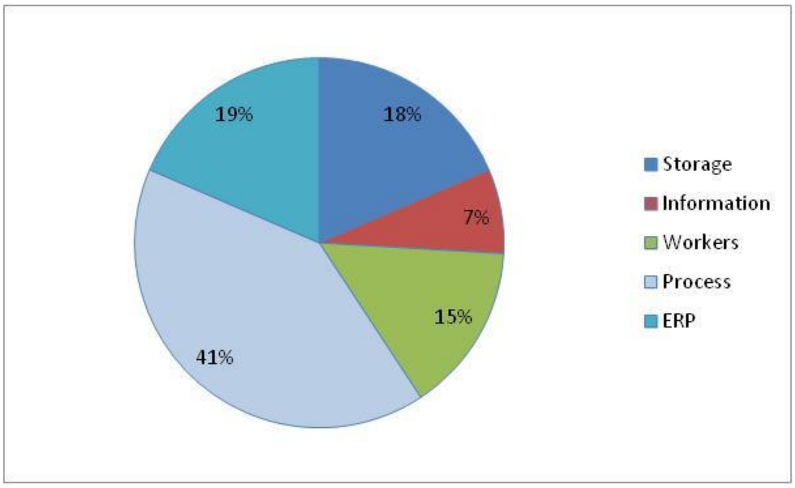


Figure 9: Distribution of warehouse problems

Receiving and putaway

Receiving is the first stage of the warehousing process and interface to purchasing in logistics chain. From process point of view problems start when vehicle arrives. There is no specified unloading area or receiving area used, so items are getting lost already at this stage. In addition delivery of some items is carried out after official working hours and accepted by occasional person, so no registration of receiving will be executed to ERP. Instead shipments that arrive within official working time will be added to ERP, but registration is delayed. Accordingly no updated information from the ERP can be found and purchasers must inquire the parts from the warehouse all the time. After receiving is added to ERP another issue occurs. Usually shipments arrive with no labels on the pieces which normally would include information about the supplier, item code or project number. No labels are stamped either on the pieces at warehouse, which makes identification particularly hard at next stage of the process.

Another problem is that receiving inspection for all the items is not successfully implemented. Especially receiving inspection for standard parts is hardly ever done. Small boxes are opened randomly in order to check quality and quantity of the components. One reason for this is that some of the warehouse workers are not able to identify parts, because they do not have enough technical knowledge about the components. In practice it means that there is wrong component, with wrong quantity and quality at the warehouse. Eventually consequence of this problem is production delays which have a bull-whip effect to whole supply chain.

Storage

Main problem with storage is that there is no warehouse design used including material flow, sizing and dimensioning, layout, storage equipment selection, material handling equipment selection and order picking method selection. In practice this means that there is no fixed location for items, items are not found from warehouse, broken boxes and pallets are used, items are stored the same way and material flow is not controlled. Obviously result is that performance of operations is slow and inefficient, process is full of waste and there is lack of safety.

Order Picking

The main problem is that process flow and responsibilities are not understood among the warehouse workers and production. Access to the warehouse is free, so production workers usually pick up necessary items from the warehouse by themselves. Reason for this is that they have technical knowledge of the items, which is needed, when identifying. Even though process is currently functioning that way, items are recorded to ERP by warehouse person.

3.3. Innovating, optimizing and simplifying warehouse operations

The following parts analyze data further and accomplish the actual warehouse designing process. Design is based on five problems that warehouse determined to be the most urgent ones. It does not include the investigation of fifth problem, because shipping operations were out of the research scope. Table 9 shows the designing process.

Table 9: Warehouse design framework

Problem	Warehouse design
1. All the items are not added to the ERP system.	1. Receiving process design
2. There is not enough space at the warehouse.	2. Warehouse sizing design
3. Items are difficult to find from the warehouse.	3. Warehouse layout design
4. There are not enough skilled workers in warehouse.	4. Staffing process design
5. There is no information about the shipping schedules.	Not included.

3.3.1. Receiving process design

One of the most important parts of receiving is to add items to Enterprise Resource Planning (ERP) system, because of inventory and process flow. After discussion with case company’s representatives this issue turned out to be the most critical problem in current warehouse process. In addition some other issues related to ERP were discussed:

1. How to handle items that are coming from other units in ERP.
2. Items are not recorded to ERP system fast enough.
3. No detailed warehouse location in ERP.
4. Usage of bar codes in warehouse and related ERP functions.

In order to investigate why items are not added to ERP system questionnaire was created. Receiving person filled out the data of receiving for three weeks. Gathered information included item group, quantity and input error as exhibit 1 illustrates. Input error occurred when it was impossible to do receiving in ERP. There were totally seven situations within three weeks that error occurred covering 8 % of the received shipments. In three cases error occurred, because of quality problem of the item. Another three cases instead included quantity problem, meaning that received amount was different from information in ERP. One case instead consists of missing item code.

Gathered data and results were surprising. Within this continuum it seems that there is no actual problem with receiving or data is not valid. In order to disqualify the latter option further research was done. Information for the research was gathered from the ERP system and it consists of the receiving data including the same time period as questionnaire study. Data from the ERP revealed that actually there were 1264 receiving lines done instead of 84 lines within the same time period. Accordingly it can be stated that gathered questionnaire data was not valid, because apparently all the receiving information was not added. Within this continuum next issue concerning coming parts from other units was studied, because of failed result of previous one.

1. **How to handle items that are coming from other units.**

Problem with the parts that are shipped from other units within the corporation is that they are not added to ERP. In order to find out the reason and solution for the problem IT department from Finland, local IT and warehouse arranged meeting together. Result was that there was no solution to add these parts to ERP, because they were only transferred via local factory forward to the end customer. Solution was to continue using excel sheet, but not only for warehouse purposes. Main problem was that there was information lacking about these parts, so in the future modified excel sheet was shared also with other departments in company’s database.

2. **Items are not recorded to ERP system fast enough.**

Next issue to study was that items were not recorded to ERP fast enough, meaning within 24 hours after shipment. At this stage there was no data gathered with the help of questionnaire, because of previous results. Analyzed data was taken from the ERP and it included receiving information from August 2011. Investigation of data revealed that only 16 % of receiving was accomplished after the day that shipment arrived. Further study showed that 80 % of delayed receiving was not done in warehouse; it was related to issuing materials in workshop. Due to findings another project started concerning issuing materials from the warehouse to workshop. Some investigation about the issuing in ERP was done and figuration was made. IT department did not finish the project, before end of the thesis, so it is still under work in case company.

3. No detailed warehouse location in ERP.

One of the problems was that location information in ERP system was not accurate enough. There was only some warehouse locations named, but no information about the exact storage positions. Due to this problem it was impossible to try to find item from stock based on location information in ERP. First thing to do was to assign storage locations inside warehouse and add the locations into ERP. Storage locations were assigned according to numbers and alphabetical letters (figure 10), for example 1-B-05-location means first storage line, b-row, fifth storage position.

Figure 10: Storage location markings

After adding the location information to ERP one warehouse worker made a list of all the inside storage items and their detailed locations. Information from the excel list was then transferred to ERP. In addition IT opened some new screens for the location management in this stage. After that almost all the inside warehouse items had a detailed location in ERP, but outside warehouse areas were still not named. Process with outside warehouse areas was removed to next year after completing the total improving process in inside warehouse.

4. Usage of bar codes in warehouse and related ERP functions.

Based on discussions and lean six sigma -project, case company wanted to also investigate whether they could start using bar code system in warehouse operations. Investigation of implementation were planned to be accomplished according to five stages, introduced in chapter 2. First two stages were executed within the time period of thesis in a case company. Other stages were planned to be implemented during year 2012.

Stage 1, Preliminary investigation

First thing to do was to determine goals and investigate in which operations to utilize bar code scanning. After discussion it seemed that with receiving operation bar code scanning would require lots of effort and co-operation from suppliers. In order to fully utilize the system suppliers should print stamp including barcode and put it into the item before shipping. Planning group was not that convinced whether this would be possible, but some further investigation with suppliers were planned to be made. Instead the highest utilization rate of the barcode system was analyzed to be in picking operations and inventory. Based on this, planning group agreed to continue implementing process of barcode system in a warehouse.

Stage 2, System analysis study

Before continuing the process, there were many improvements that were required to be done, before actual implementing. First of all Finnish IT and local IT had meeting together, where system was analyzed from IT point of view. Meeting included also integration investigation with ERP system and some changes that had to be done. Based on meeting the label printer Zebra ZDesigner 105SL 203DPI was decided to be ordered, because there were no labels used in receiving. After the printer came there were some problems with it, which IT department modified. Work with the thesis in a case company ended right after receiving the printer, but project continued.

In the future in order to continue the project labels should be first used in a warehouse in every receiving operation. After that storage locations should be stamped with labels that include barcodes. At this point wireless networks should be also installed in warehouse. There was also discussion about ordering one portable bar code scanner for test purposes at first, in order to pinpoint the possible flaws in a system. In addition with help of test device it would be easier to slowly start training warehouse workers. Project will continue with three other stages within year 2012.

Other issues related to receiving designing process

Designing of receiving process included also other things, even though the focus was on issues related to ERP. Receiving process was modeled and in this paper it is introduced in chapter 3.4 with the total warehouse process flow chart. In addition, in order to understand the structure of the receiving, a receiving profile was created, as figure 11 presents.

Data for the receiving profile was gathered from the receiving information during September 2011. Information included a number of the receiving lines in each category. According to data it seems that over 50 % of the receiving lines consist of small items. Usually these items, such as fasteners, are relatively cheap and categorized as C-items. Data revealed the current receiving problem. By utilizing the results, creating new layout solutions for warehouse, as introduced in section 3.3.3, was easier.

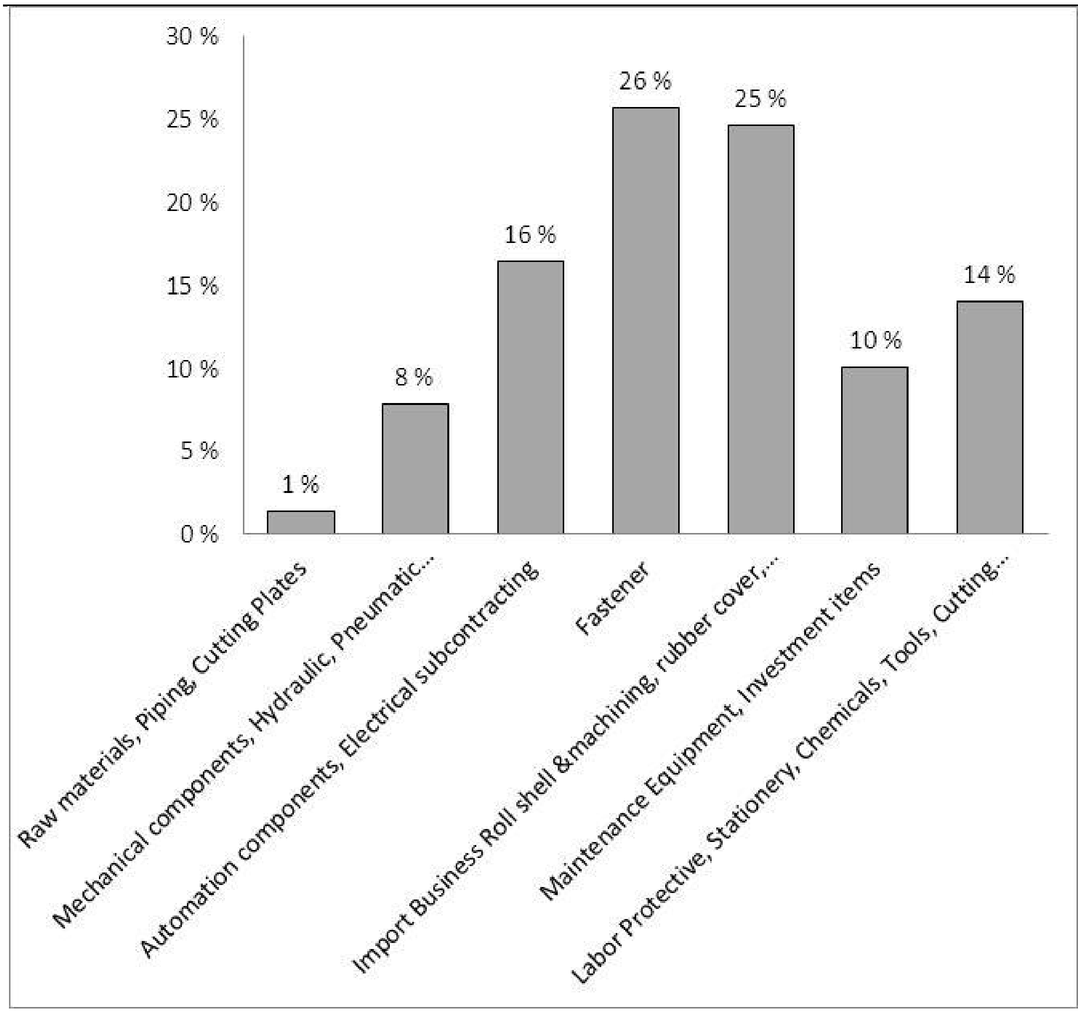


Figure 11: Receiving profile based on number of receiving order lines

3.3.2. Warehouse sizing design

Based on the results of the interviews every department pointed out same issue: size of the warehouse was too small. In pursuit of investigating whether the statement was valid, more detailed research was carried out and calculation model was invented, exhibit 2. Data for the model was gathered from the packing unit and it was modified with help of excel. Main idea was to compare previous project to coming ones and estimate the required space by utilizing the data that was currently available. Schedule for the coming projects was formed by the information of pre-assembly space reservation. Actual required warehouse area was then calculated with five weeks purchasing frame and pre-assembly schedule.

Weakness of the model is that it does not include warehouse of finished items. Another issue is that at present it can only give rough estimations about future, because there is no data gathered before about required warehouse area per project. In addition model should be updated according to real situation in pre-assembly, not from the pre-assembly reservation schedule. However this model is useful for the company and it is definitely needed in order to forecast requirements for the actual space. In order to actually implement the usage of model there should be one person with enough technical knowledge of product structure and spread sheet models named to update it.

Results of the current sizing problem

Warehouse area forecast profile starts from week 47 and it ends on week 11. According to the current schedule it seems that there is fluctuation among required warehouse area. Average storage requirement within this time period is 2639 m^{2,} when current capacity of the warehouse is 3047 m^2. According to results most of the time current space is enough, but in February, from week 6 to 9, capacity is exceed with 25 % as figure 12 presents. This statistic reveals that 1000 m^2 of more space is required permanently, because of the peak.

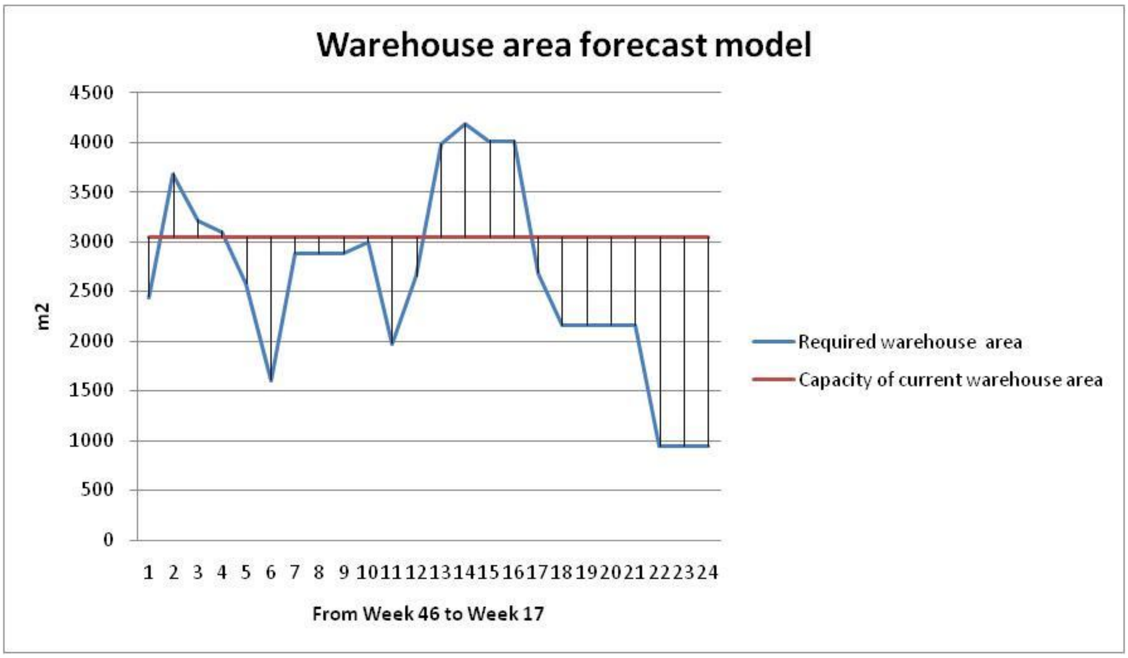


Figure 12: Warehouse area forecast profile

According to research, which is presented on theoretical part, size of the warehouse should be calculated near the average storage requirements, when the ratio of the peak to average is more than 1.5. As calculated in this case ratio of the peak is 1.54 and it consist of four weeks within 24 weeks. Based on this it can be stated that capacity of the current storage is enough, when there is separated storage for finished items also. For those four weeks, when additional capacity is required there are some areas that can be used. For example additional tarpaulin area can be added to the right side of the factory. Red places in the exhibit 3 illustrate the spots. However with help of this solution only 450 m^2 of more capacity is increased and spot for the 550m^2 must be still investigated. There are also some areas available near to canteen, where items can be placed for a while. Thus model is estimation from the current situation, which will change every week, so it might be that these spots are not even needed eventually.

3.3.3. Warehouse layout and material flow design

After investigation of the required warehouse area, storage layouts were further examined. Layout designing included the design of inside and outside warehouse areas, though the focus was on inside warehouse. The following parts include detailed description of the current problems and suggestions for the new layouts.

Outside warehouse area

Currently main problem in the outside warehouse is not actually lack of space as figure 12 presents; it is rather disorder of the items. Semi-finished parts, imported parts and finished parts are mixed together and there are no fixed storage areas for them. Some of the parts are also placed in factory sideways and covered with tarpaulins. Naturally tarpaulin warehouse area and sideways are not marked in ERP as a storage location, which cause problems to find the parts. Moreover parts cannot be identified, because there are no labels used. Another problem is also that there is no inventory policy used, so old useless parts are stored and they are utilizing the actual capacity from the warehouse. Safety of the outside factory area is obviously also poor, because parts can be placed anywhere. In addition there is no driving route for vehicles, which means traffic from the two directions and blocked walkways. Accordingly there is neither separated unloading and loading area, so that forklift trucks operate among the traffic.

Improvement actions

Firstly in order to clarify the traffic within factory area, it must be organized with only one driving direction. New entrance for the coming vehicles should be opened at the west side of the Baofeng road, because of the receiving location. Vehicles should drive directly to receiving, where they would give instructions where to do actual unloading or loading. After the loading vehicles would then exit from the gate 2. Exhibit 3 presents the driving direction and receiving spot.

Secondly, in order to shift the items from the sideways to actual named warehouse areas, reorganizing must be done with help of kaizen event and 5S. Event would require one weekend of working with full capacity of employees and some preparation during the week. Kaizen event would include the following stages:

1. Identifying current parts at tarpaulin warehouse area
2. Sorting of the parts with help of different colored stamps (5S)
   a) Parts that are related to current projects –stamp including name of the project and item description
   b) Parts that have been stored more than 24 months without no usage
   c) Parts that include quality problems
   d) Warehouse equipment, - tarpaulins etc.
   e) Other
3. Organizing the tarpaulin warehouse area according to projects, a) parts, and removing all the other parts away
4. Marking the tarpaulins with information paper including project number and item numbers
5. Scrap the b) parts with help of quality department and finance department

6. Contact purchasers regarding c) parts and decide whether parts will be returned to supplier or scraped with help of quality department
7. Arrange separated area for storing warehouse equipment d)
8. Sorting and clarifying of other parts e)- find out the responsible person for the parts and restore them to their right place

Thirdly, the warehouse under the crane should be also re-organized. Plates should be stored at bundle racks. Currently they are covering a lot of space under the crane, but with help of better organization, space would be utilized efficiently. In order to accomplish the task the purchaser should be involved, because order points should be reorganized as well. In addition warehouse areas for the casts should be separated and marked accordingly. Small casts should be also stored on pallets, because of the material handling issues.

Inside warehouse

As mentioned in previous chapter there is no actual warehouse design completed in inside warehouse, though lean six sigma project is currently running. Many improvements have been done and layout changed once, but actual completed design is still missing. Next parts include description of the current problems with layout and introduction of new layout proposal.

Current storage layout consists of five different areas: *block area, longer parts area, inspection area, small items storage and pallet shelves area*, as exhibit 4 shows. *Block area* is named in a layout, but it is not actually used. Instead *longer parts* are stored on their place, but location creates problems for unloading. First of all access to the warehouse with vehicle is difficult, because of too narrow aisle between the shelves. Secondly the storage area is another side of the entrance, so truck blocks the whole aisle, as figure 13 presents. Thirdly inspection area is placed in front of the longer parts storage, which hinders the unloading.

Figure 13: Main problem areas in storage

Small items storage area is located left corner of the layout in three smaller shelves row next to office. Actually the area consists of four rows and two separated shelves, covering 64,5 m^2. Currently small items are stored in different kind of boxes as previous figure 13 presents. Stored items are divided into two groups: project items and standard items. Project items are purchased related to specified project, but standard items can be used to several projects. Items are mainly physically small and cheap, such as screws, bolts and nuts. Warehouse profile, figure 14, represents the situation more clearly. First four shelves consist of small items storage area.

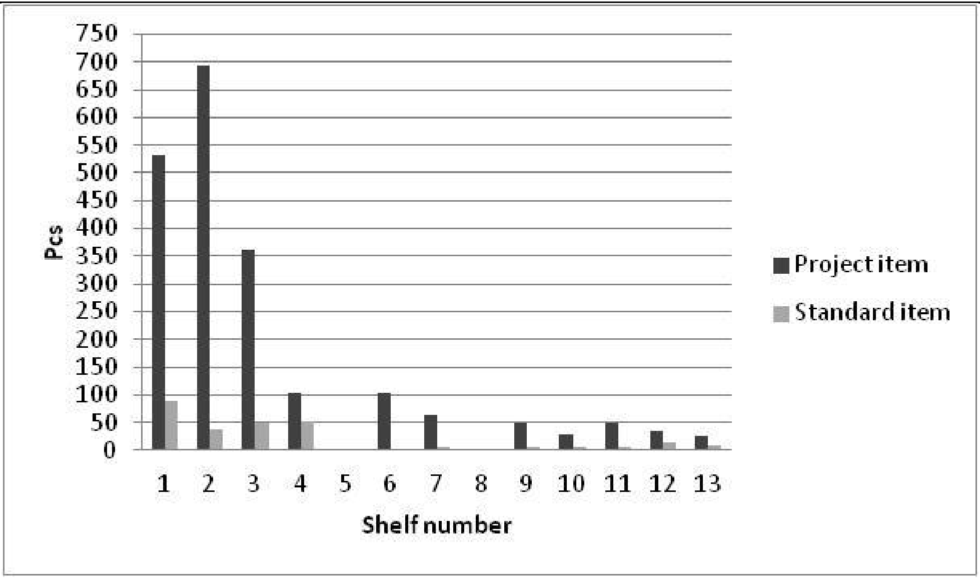


Figure 14: Warehouse item profile by pieces

Pallet storage consists of two different areas with 792 pallet places. Six shelf rows next to inspection were installed during the writing process for storing the bearings. Another area consists of 12 pallet shelf lines with 576 pallet places for EUR-pallets. Currently there are no standard pallets used and packing units are varying. In addition shelves are not installed according to instructions, because there is fluctuation between the spaces of the shelves. For example some shelves include 10 cm space while others 30 cm. Due to this pallets must be always stored on long facing, because turning them to short facing would hit the pallets on other site of the shelf. That is why maximum capacity of one storage location is two standard pallets. Instead if shelves would be installed according to instructions capacity would rise to three standard pallets per location. Based on this, when calculating the current fill rate it will only reach 65 % as figure 15 presents.

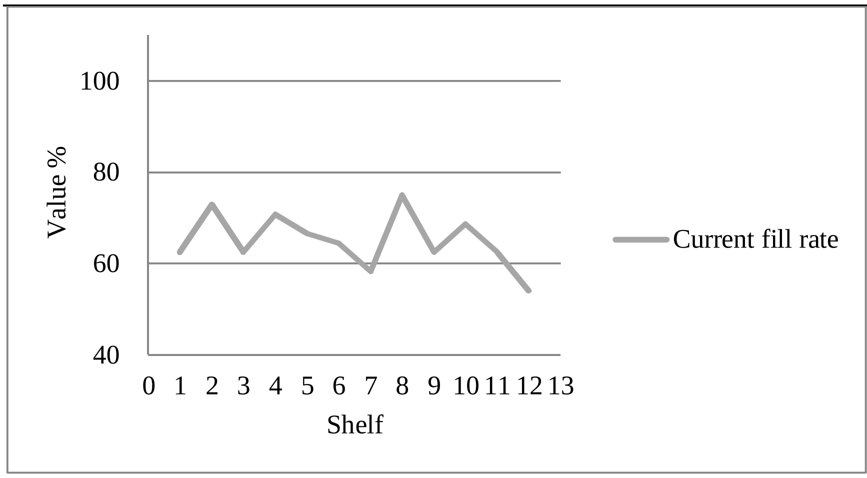


Figure 15: Warehouse fill rate chart

New layout proposal

As described before, current layout is not efficient and performance rate is low. Due to this, new layout design was accomplished with help of eight steps. Stage of defining and obtaining data was challenging, because there was no reliable data from purchasing available. Procurement was not able to give any estimation about the delivery times and ERP did not include enough valid information about shipments. Due to this the planning was based on physical sizing, simplifying and reorganizing the different warehouse areas.

Warehouse design started with determination of fixed obstacles, which are two offices, work-wear storage, stairs and doors. Currently the door near to offices is used and there is no actual designed material flow. In addition warehouse includes the crane with five tons capacity, which can be now utilized mainly only for the longer parts.

According to new layout design material flow was determined to be as through-flow starting from the door, which is near to longer parts area (exhibit 5). That spot was the only choice as unloading area, because of the traffic in another door. Currently there are some unloading, loading, packing and manufacturing functions performing at the same time on that door and there is no place for coming vehicles. Second step was to define the location of receiving and shipping functions and locate storage areas. Most suitable location for the receiving area was near to unloading area, because of short travelling distance. In addition current work-wear storage was determined as new receiving office.

Old layout did not include the separated receiving, which caused many problems. Purpose of the design of separated receiving area was to control that every item will be added to ERP. Idea is that item cannot be moved from the area, before it is in Baan. After receiving in Baan it will be moved either to actual storage location or to inspection area. Inspection area is only used for quality inspection and it should be noted that actual receiving inspection will be done in earlier stages.

In new layout proposal actual storage area consists mainly of the pallet shelves. Thus there is separated shelf area for the longer parts and two shelves for the small items. Number of the pallet places will remain the same with 792 pieces, but the difference is that storage locations will be utilized more effectively. Utilization is relying on re-assembly of shelves and using only EUR-pallets 800 mm*1200 mm for storing. New dimensioning of the shelves is introduced at exhibit 5. The main idea is that in the future three pallets can be used in one storage location instead of two, because of the EUR-pallets and 350 mm space between the shelves adding 35 % more capacity to the warehouse. Aisles between the shelves instead will be 3000 mm, because of the used forklift truck.

Within this continuum safety aspect of the warehouse was considered in the new layout. New plan includes the safety walk ways for the people and separated working areas for the forklift trucks. Area will be separated with safety handrails, which are market as thicker black line in exhibit 5.

New layout includes only two shelves for the small items. Reason for this is that all the project items will be replaced to production, because they are mainly used there.

Production department is in charge of the project, so there was no calculation attached to the thesis concerning small parts storage. Current plan is that three vertical carousels will be bought by production department. However standard parts still require space from the warehouse, because they can be used for different projects. According to current situation they would need 5 m^2 of space, which means only 20% of the shelf area. Another part of the shelves could be used within this plan for the parts that are now in Metso Paper China’s storage. That storage area would be then free for the other purposes such as sub-assembly place for production.

New layout includes also separated picking area, because of the pre-assembly operations. Purpose of the picking area is to combine some component groups together before sending them to pre-assembly. In addition it is possible to do some sub-assembly for the smaller parts in this area. Area is dimensioned for eight standard EUR-pallets, which will be recycled from pre-assembly back to the warehouse. System will be based on Kanban method, so that empty pallet in pre-assembly is impulse to warehouse that there is demand for new parts in pre-assembly.

Accordingly one layout proposal was introduced, but totally three proposals were made. This layout was chosen to be introduced, because of many benefits it includes. First advantage of this layout proposal is that there is no need for new investments. Only new EUR-pallets, safety rails and some stamps must be bought. Secondly with the help of this layout utilization of fill rate is more efficient. Currently cost of one pallet place is averagely 214 RMB (25 euro) per pallet per month, but with the help of new layout it will be 139 RMB (16 euro). Figure 16 presents the situation in monthly level. Cost of one pallet place is calculated according to cost structure of the warehouse including in-direct labor-, overhead-, machine-, and allocation costs.

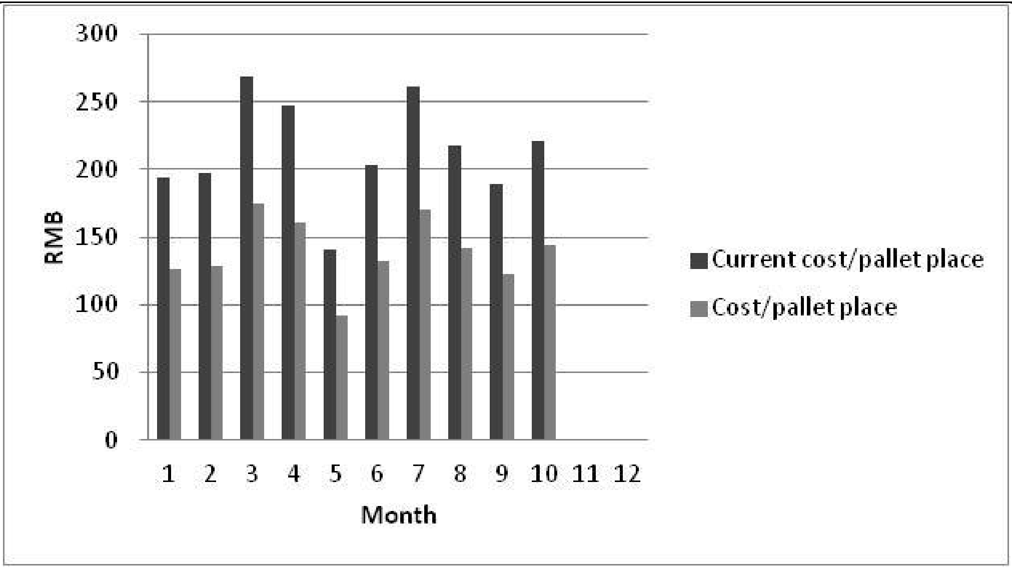


Figure 16: Cost of pallet place

3.3.4. Staffing process design

According to the results of the interviews many departments were complaining that there are not enough skilled workers at warehouse. Some people were complaining about the technical knowledge of the items and some about the skills related to Baan. In addition warehouse manager pointed this issue also based on discussion. In order to clarify skills of warehouse workers, skill matrix was created. Matrix included basic information about the workers and skills related to their work, as exhibit 6 presents. Purpose of the matrix was to investigate what areas should be trained and how training should be divided among workers. Evaluation was based on scale from 0 to 4, meaning that with 0 score there was no knowledge / person need to be trained and with 4 score there was excellent knowledge / can teach others.

Based on the matrix it seems that the most urgent training needs are on computer skills and skills related to ERP (Baan skills). These two areas gained only 10 points, while the highest, ability to follow instruction, reached good level with 50 points. All in all, the warehouse matrix skills profile reveals that there should be accomplished training in many areas, because 78 % of the skills are not reaching the satisfactory level. In addition it is worth of noticing that there is even one worker with no skills at all.

When analyzing the reasons behind the figures, warehouse age structure and distribution of working years reveals something. First of all average age of warehouse worker is 42 years and standard deviation is 12, as figure 17 presents. This means that 53 % of workers are more than 46 years old. When comparing age to computer and ERP skills it can be stated that mainly young people have those skills. Somehow the results are surprising, since 63 % of the warehouse workers have been working in a company more than seven years without computer skills at all.

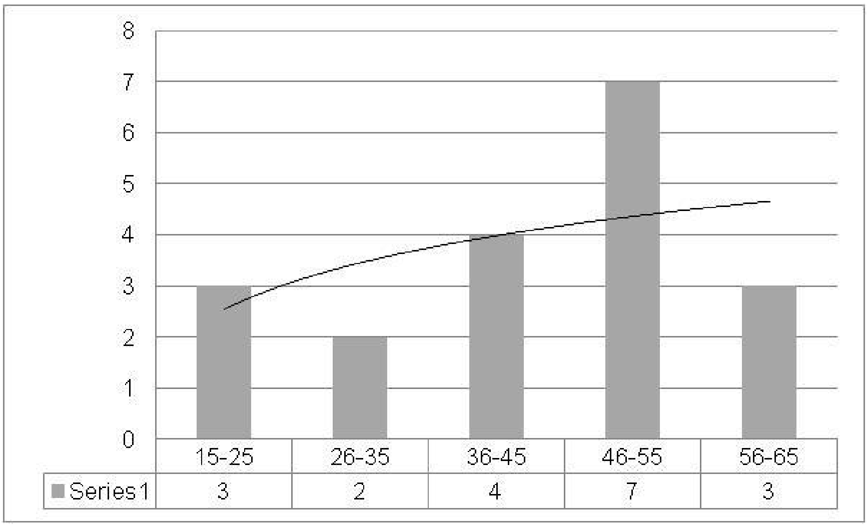


Figure 17: Age distribution, staffing profile

Training program

In order to motivate workers, develop individuals, maximize flexibly and increase effectiveness warehouse workers need to be trained. Based on this, training program for the warehouse workers was created in rough level including the following:

Day 1:

- Introduction of new warehouse process, exhibit 7
- Introduction of new instruction related to process

Day 2:

- Workshop regarding new warehouse process
- Group assignments: how to ensure that new process will be implemented in a daily work
- Preparation of assignment : daily situations from work- how to solve them

Day 3:

- Training of basic computer skills – Office

Day 4:

- Training of Baan operations

Day 5:

- Training of Baan operations
- Customized training programs in small groups

Day 6:

- Quiz between groups about the training topics, best group will be rewarded

First of all the new process should be introduced and instructions presented. After that there should be a day for discussion where workers would give their solutions and opinions about the new process in form of group assignment. It is essential to create the assignments in a way that would actually bring some answers and involve people to discuss. After that training would continue with the most important training area at the moment: computer skills and ERP.

Training of those areas is significant, because in order to implement barcode system in warehouse, workers should have at least basic computer skills. Otherwise it will be difficult for them to understand the structure of the system if they do not know how system interacts with computer and ERP. Even though not all workers will use computer in their daily job, but in order to prepare for the coming changes and fluctuation of workers it is essential that everybody will attend the training concerning computer skills.

Fourth and fifth day consist of training program of ERP. Training should be accomplished in different stages: first stage would include all the warehouse workers. In this stage IT- department would introduce total warehouse process and its functions in ERP. During the second stage warehouse workers would be divided into different groups according to organization: standard parts, shipping, subcontractor, raw materials for foundry, steel and office stationary. Every group would then have a customized training day according to profiles that they need to use in ERP. In addition training group would include people from other department related to those operations, such as operating purchasing person. This is vital in order to understand how warehouse operations in ERP are related to other department functions and where is the interface between them. Finally the training program would be finished with help of quiz, where skills of the workers would be evaluated again in a group.

3.4. New warehouse process

After concluding the process designing the total process of warehouse was modeled, as presented in exhibit 7. There was no flowchart drawn before about the warehouse functions, so this was also requirement from the quality department. Warehouse process starts from its interface; purchasing or engineering. Standard parts and sub-contract parts are handled from purchasing, where purchasing order is created to Baan. After creation of the order purchasing department informs quality department whether purchased part needs to be inspected according to the instructions by quality department.

In some cases parts are delivered from other units within Metso. Those parts are not handled by purchasing, they belongs to engineering. Engineering department includes packing planning and shipping functions, why it makes sense to control those parts in that department. Before shipment arrives engineering informs warehouse about the coming items that are in port.

Shipment arrival at Metso Paper Technology Shanghai will start from controlled receiving point, where dispatch note and other documents are checked. After that vehicle will be quid to drive on specific unloading place, where unloading is accomplished by warehouse worker. Standard items are unloaded to receiving area in inside warehouse, raw-materials to outside area and sub-contract parts + imported parts to tarpaulin area. After unloading warehouse worker will check whether the shipment is according to packing list. If there are some differences occurring, warehouse worker contacts purchaser and marks the item with specific sticker.

In case where packing list and shipped items equals to each other receiving information is added to the Baan and label is printed out from the system. With imported parts receiving cannot be done in Baan, so separated excel-sheet is filled and then items are marked with separated stickers that cannot be printed from the system. After receiving, warehouse worker will inform quality department about the coming items, which will then inform warehouse whether inspection is needed or not. If there is no inspection accomplished, items are moved to their actual warehouse place from receiving area. Overall tarpaulin area and inside warehouse places are organized according to projects. In optimal case there is no need to place items on a warehouse, because they are needed in further operations. Task of the warehouse worker is to find out where received parts will be needed next and contact the right department, for example pre-assembly, painting or machining.

If quality inspection is needed, then parts in inside warehouse are removed from receiving area to inspection area and in outside in separated inspection area (tarpaulin place number 1). After the quality inspection items are also moved to actual warehouse place. When all the pieces are on their actual storage Baan will be updated again with information about the detailed storage place.

When production is requiring parts from the warehouse, production order in Baan is created. After that quantity is checked and items are picked from the warehouse. Different areas of the manufacturing are controlled in various methods, so form and place of production order differs. For example small parts in pre-assembly are controlled by Kanban-method, so visual sign is also impulse to production order.

After dis-assembly there will be quality inspection for the ready parts. After inspection parts will be packed by packing firm according to packing plan, which is done in engineering department. After that pieces are removed back to responsible of warehouse. Finished goods are then moved to separate warehouse, where they are waiting for demand and shipping. After items are placed on finished items warehouse they will be updated as ‘packed’ in a Baan system.

In order to implement new process there should be bunch of instructions made in Chinese and English. Instructions are important part, because if all the functions are not detailed, there is a possibility that process operation will vary according to completer. There should be following instructions made:

- Receiving process instruction
- Picking process instruction
- Instruction about the warehouse layout and location system
- Safety instructions.

3.5. Implementing new designed processes

Warehouse process improvement project started on September 2011 at the case company. Main reason for starting the improvement was the lean six sigma project that included investigation of warehouse operations also. Objects for the lean six sigma project were to reach 99 % inventory accuracy level, design fixed storage locations for items and receive items in Baan system within 24 hours with help of bar-code. Focus of the project was in purchased items and inside warehouse. Process was scheduled starting from September 2011 and closed in March 2012. Work with the thesis started at the same time and it was also noticed within lean six sigma project. Function of the thesis was to support project and give advices for improvement.

Within inside warehouse there were some improvements gained already at the end of December, when actual work with thesis ended. First of all right side from the warehouse was cleaned from the steel bars and sawing machine was removed. In addition six lines of shelves were installed and receiving area added. New areas were marked with help of signs. Figure 18 presents the changes that were made.

Figure 18: Right side of the warehouse before and after

Improvements on left side of the warehouse instead were mainly involving some cleaning work, as figure 19 presents. First of all it was agreed to use only pallets for storing the parts and keep aisles free. In addition storage locations were marked and new stamps ordered. In this stage storage locations were also added to ERP system and items updated according to storage places.

Figure 19: Left side of the warehouse before and after

There were also some other improvements made in warehouse. First of all label printer was ordered and implementation work started. Receiving function was separated and it included labeling the pieces before removing them to storage. Secondly there were many layout options created within the thesis and within the lean six sigma project. Implementation work with layouts was decided to postpone to year 2012.

4. DISCUSSION AND RESULT

Purpose of the thesis was to identify problems in a warehouse process and improve them. Many problems were found, but four of them were further studied, because of the company interest. Process development was accomplished with the help of warehouse design method, which is introduced in theoretical part of the thesis. After process designs, there was also total new warehouse process described by using flow chart model. Actual implementation work with the new processes is ongoing in a company in different stages and it will continue. Next paragraphs explain the implementation situation in more details.

Problem	**Warehouse design**
1. All the items are not added to the ERP system.	1. Receiving process design
2. There is not enough space at the warehouse.	2. Warehouse sizing design
3. Items are difficult to find from the warehouse.	3. Warehouse layout design
4. There are not enough skilled workers in warehouse.	4. Staffing process design
5. There is no information about the shipping schedules.	Not included.

Receiving process design included mainly improvements with ERP- system and many projects were started regarding different improvement areas. Some of the following problems were solved and some of them are still on process:

- Handling items that are coming from other units in ERP.

  Developing on process, currently local IT tries to find solution.

- Items are not recorded to ERP system fast enough.

  Developing on process, material issuing with workshop.

- No detailed warehouse location in ERP.

  Project finished with inside warehouse. Project will continue with outside warehouse on March 2012.

- Usage of bar codes in warehouse and related ERP functions.

  First three stages accomplished. Next stage is to monitor that label printer is actually used and after that ordering the test device.

Warehouse sizing design included new model for forecasting required warehouse area. There was nobody named to update the model by the end of year 2011. One reason for this might be the attitude. Problems in a warehouse were many times explained relying on the view that there was not enough space. Many people were also suspicious, whether result was valid. On other occasion after asking whether information for the model is valid enough, people agreed this data to be good for the estimation. Decision whether model will be utilized in a future, have to be made in managerial level. Even though model will not be used in daily life, it was essential to show actual situation of the warehouse capacity. It revealed that problems are not in a facility, they are deeper issues related the whole process itself.

Warehouse layout design included layout proposals for inside warehouse and improving plan for the outside warehouse. Designed layout for the inside warehouse was not implemented before end of year 2011. It was introduced for the board of managers, but there was no decision made about the usage of layout. One reason for this might be that warehouse manager was also inventing new layout for the inside warehouse at the same time. Main differences between those layouts were that warehouse manager's layout included expansion plans with new office buildings while the one invented within thesis required no investments, while adding 35 % more capacity. Result was that decision of the new warehouse layout was postponed to year 2012.

Because lean six sigma project was running at inside warehouse during the year 2011, there was no capacity to improve outside warehouse areas at the same time. There was a decision made during September that improvement action regarding outside warehouse will be done after lean six sigma project is ended at March. After that outside warehouse area will be re-organized with help of introduced plan.

Staffing process design included skill matrix of the warehouse workers and training plan for the department. Usage of skill matrix is relying on warehouse manager. At this point there was no implementation done or started with the training. Proposed training plan is a guide and implementation work is up to training department and decision of management group.

4.1. Challenges in process improvement and implementation

The most challenging task in process development in foreign country is to “implement global processes and planning that are flexible enough to accommodate local and regional conditions”. In order to succeed, the company should “think and plan globally but execute locally, in the local language and according to the local culture” (Hansen Harps 2003).

These challenges were also recognized within the thesis and meaning of localization had a new perspective through daily work. It was realized that reading about culture is not the same as working there and one year is not enough to fully understand the aspect of culture and language. Process development in China requires time and it cannot be accomplished within four months. Next paragraphs describe problems that were faced during the process development and implementation with help of relevant studies concerning China.

Organizational problems

One major improving area within the thesis was problems related to ERP in warehouse. There was lots of discussion why all the items were not added to ERP. After investigation within the organization it revealed that input data concerning warehouse operations from purchasing was not correct. For example it was hard to accomplish receiving of one batch in ERP, because purchasing order row consists of many items.

All in all it seemed that departments were using ERP in a different way, which might be explained due to ERP implementation problems in China. According to research only one third of the ERP implementation projects in China have been found to be satisfactory (Liu 2005). One of the main reasons might be that these companies have not been changed their management processes, reconsidered their organizational structure and reengineered their processes, which is needed in ERP implementation in China (Markus 2000). In addition it is stated in many research (Nunes 2011, Avison 2007) that ERP implementation processes has been failed not concerning the technical problems, but instead of culture and human factors. Problems have included limited employees involvement meaning that operational staff is unwilling to use ERP system, poor communication, time aspect and language problems.

Another issue related to organizational aspect in a company was the structure of it and power of individuals. Daily work in warehouse revealed that the structure of organization chart is not applied in practice, which is also noticed in research of *Liu 2010*. Decision making and managing in an operational level is more or less depending on guanxi, which involves people from different departments and sometimes even external members forming their own guanzi. In practice it means that for example developing projects with other departments might face a border due to strong influence of some people in a guanzi network. Even harder is that someone outside of the guanzi can see that it exists, but it is hard to say who the members are eventually?

Relationships

Chinese people have many options about how to avoid open discussion and engagement (Peng 2011), because it is not their way of communication. It is usual to agree on something within the discussion or meetings, but actual action is harder to achieve. In addition frequent meetings are more about discussion, but actual decisions are hard to achieve. Especially in the first meeting there should not be expected any decisions made, it is more about getting to know each other first (Liu 2010). In addition authority structure in a work place plays important role. Manager is highly respected and it is important for workers that they have good relationship with the boss and they have good profile on a factory (Li 2010).

All of these things were also noticed within daily work and maybe they were influencing in a way that valid data for the research was hard to get, project proceed slowly, there were communication problems with warehouse people and agreed things were not accomplished.

4.2. How to solve problems related to process improvement

Business process reengineering has been used in process improvement projects in China, but still many researches are complaining about the same issue, implementing is difficult and long-lasting improvements are hard to achieve. Business process reengineering is used, when companies need fast change and dramatic improvements to their business processes (Willmott 1994). In re-engineering it is vital that senior managers are committed to the change, because of the scale of the change they represent. The scale of change is part of the organization’s strategy and need support of those who formulate and implement that strategy (Burgess 1998).This is not an easy task, because it forces changes in management style. Management must change the way they think, organize, plan, deploy, inspire and reward the performance. They must create an environment where generalists are replaced with specialists and cross-functional teams are created between various departments (Attaran 1990).

Even though Chinese culture is highly respected to hierarchy and power of manager is strong it might be that powers of the existing guanzi networks are even stronger. Actually cross-functional teams between various departments are supporting the guanzi network thinking. The most challenging thing in re-engineering in China might be the fact that existing guanzi organizations are not visible to others. You only know them when you are part of them. The main problem might be that how to re-engineer the process if you do not know the strong guanzi network. In order to implement the best re-engineering solution in organizational level would be re-engineering the organization simply according to guanzi network, which is also involving people from different departments. In this way commitment for the changes would be stronger, because open discussion would be possible and polite rules according losing face would not play that important role. Meaning that “in quanzi everyone needs to open oneself by showing true feelings and thus building up trust (Fang 2010.)”

Nowadays companies have started to think if they should move their production from China to other low cost country, because it is estimated that by 2015 manufacturing in some parts of the USA will be just as economical as manufacturing in China (BCG 2011). Most of the researches that are addressing problems related to China always end up with the same solution; the main problem is its unique culture and guanzi. If that is the case, then there is no sense for those companies operated more than 10 years in China leave from there, because building up guanzi is usually achieved within ten years. More comprehensive solution would be to stay there and do re-engineering again based on guanzi networks. Probably re-engineering has been done already at least once, but after ten years, structure of the guanzi network should be so clear, that re-engineering could be done based on that. According to research by (Liu 2010), guanzi need to be eliminated in order to success. All in all this might not be the solution, solution would be adapting the guanzi and investigate what kind of guanzi networks are existing in a company, how they are organized, who is the dominating person there and how wide they are in departmental and hierarchical level.

4.3. Future suggestions for the company

The easiest task in warehouse process improvement is to clean and organize all the warehouses in factory area and implement the new layout. Physical operations and improvements can be done, but actual process change requires more. Warehouse is the inner customer of purchasing within the organization and unfortunately warehousing process cannot be changed before input actions from purchasing are clear enough. It is essential that before introducing the new warehouse process purchasing department improve their process, especially the ones related to ERP.

After purchasing has developed their process and interface functions are clear, new warehouse process can be introduced. At the same stage introductions are also presented to warehouse workers. The most challenging task is how to commit warehouse manager and workers to the new process and instructions. One of the solutions might be tangible incentives, because Chinese can be motivated on that way. On the other hand commitment might also require changes in organization structure, since there were some conflicts noticed within daily work. There might be some investigation needed how hierarchy structure is actually formed and how guanzi is affecting to the organization. In addition co-operation with purchasing and manufacturing department must be closer and there should be clear contact persons to each worker. If possible, it is recommended that there should be re-engineering done based on guanzi networks.

5. CONCLUSION

The goal of the thesis has been to identify problems in warehouse process and improve them within Chinese culture aspect. There were four main research questions that have been studied within the thesis:

Why warehouse process causes problems to other departments?
What are the main problems at warehouse process?
What is the root cause that will be further studied?
How Chinese culture impacts on process development?

Thesis was structured based on stages of process development. It included description and model of warehouse process starting from purchasing to pre-assembly. First there was investigation of current warehouse process and analysis of why it caused problems to other departments. Study revealed that the main reasons were issues related to whole warehousing process with 41 % of the answers. After that main problems within process were determined and four of them were further studied. Problem determination was accomplished by interviews including warehouse-, procurement-, production-, quality-, IT- and finance departments.

Actual process improvement was done with the help of a design framework and benchmarking. Benchmarking was accomplished with Metso Paper Jyväskylä, Metso Paper Waigaoqiao, Moventas Wind Oy and Valtra Oy Ab. Design framework was formed of combinations of relevant theories and research based on warehouse designing methods and tools. Tools were involving different design profiles: receiving profile, warehouse area forecast profile, item profile and staffing profile. There was no direct profile and design method used based on literature, because profiles should be designed according to company needs.

Even though designed profiles were unique they can be utilized. Idea of warehouse area forecast model is helpful for companies that are performing in project industry and size and structure of the projects are varying a lot. In addition it is useful if there is no accurate data available about coming shipments from purchasing. Staffing profile instead was based on skill matrix. Skill matrix is used in production and maintenance operations, but there is no research about utilizing it in warehouse operations. Though this study proved that skill matrix is good tool in warehousing also.

As a result of this study the new warehouse process was introduced including new designed frameworks. The main objectives were attained and company was satisfied with the results. Process implementation is in process and it is essential that it will be accomplished for many reasons. Warehouse operations are not only influencing on inner customer, but outer customer as well. Currently 11 % of the claims that are coming from the customer are concerning issues related to missing parts. The problem is significant and it has impact on customer service. In order to enhance customer service warehouse process must be more efficient. When process is efficient it will automatically reflect by lowering warehousing and handling costs.

Cost reduction can be achieved with the help of implementing the designed processes. First of all it is essential that all the items are added to ERP, because of the right inventory value and doubled purchasing order lines. In addition forecasting and monitoring the required warehousing area decreases the double handling and unnecessary movements in warehouse, which lowers the warehousing cost. One major part of the warehousing cost is the staff. With help of improving training it delivers productivity improvements of 5 to 10 %.

However the fastest savings will be gained with the help of new layout. Currently one pallet place in inside warehouse costs averagely 25 euros per month, while with new introduced layout it cost is 16 euros per month. On a yearly level it means that 85 536 euros are wasted every year in inside warehouse, because poor utilization and planning of the operations. There is no sense to do expansion in the warehouse, if there is no capability to utilize the current one. In addition as summarized in this study there is no need for extra space; current problems can be solved with help of reorganizing the operations and physical layouts.

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Interviews

Metso Paper Technology Shanghai:

Material Procurement Supervisor and Purchasers, 16.09.2011
Production Department Manager, 09.09.2011
System Manager & Senior System Specialist, 05.09.2011
Quality Department Manager, 21.09.2011
Warehouse Supervisor, 01.09.2011
Business Controller, 19.09.2011

Metso Paper (Shanghai) Co., Ltd., Waigaoqiao, Shanghai:

Warehouse Supervisor, 03.11.2011

Metso Paper Jyväskylä:

Development Manager, 23.08.2011

Maintenance Technician, 13.07.2011

Manager, PDM Development, 19.08.2011

Purchasing Engineer, 25.08.2011

Workshop Manager, 25.08.2011

Moventas Wind Oy:

Logistics Manager, 18.07.2011

Valtra Oy Ab:

Supply Chain Manager, 16.08.2011

7. EXHIBITS

Exhibit 1: Receiving file and data

RECEIVING FILE

接受文件

Processing date	*Item group*	*Quantity*	*Input error*	
批准日期	項目小組	數量	输入錯誤	
			Yes有(Y)	No无(N)
2011-11-7	small parts related to rolls	6		N
2011-11-7	fastener	3		N
2011-11-7	tools	1		N
2011-11-7	mechanical components	2		N
2011-11-7	small parts related to rolls	2		N
2011-11-7	fastener	1		N
2011-11-7	fastener	22		N
2011-11-7	mechanical components	1		
2011-11-8	mechanical components	1		N
2011-11-8	small parts related to rolls	9		N
2011-11-8	bearings	11		N
2011-11-8	mechanical components	5	Y	
2011-11-8	bearings	1		N
2011-11-8	automation components	18		N
2011-11-9	mechanical components	1		
2011-11-9	mechanical components	2		
2011-11-9	mechanical components	1		N
2011-11-9	fastener	113	Y	
2011-11-9	automation components	2		N
2011-11-10	mechanical components	8		N
2011-11-10	small parts related to rolls	2		N
2011-11-11	fastener	10		N
2011-11-11	small parts related to rolls	5		N
2011-11-11	automation components	26		N
2011-11-11	automation components	9		
2011-11-11	mechanical components	2		N
2011-11-11	mechanical components	1	Y	
2011-11-11	automation components	1		N
2011-11-11	small parts related to rolls	2		N
2011-11-11	automation components	13		N
2011-11-11	fastener	51		N
2011-11-11	fastener	7		
2011-11-11	small parts related to rolls	2	Y	
TOTALLY		341	4	29
	Receiving error rate			**12%**

SHJRenja:
QUALITY PROBLEM

SHJRenja:
PART NUMBER ERROR

SHJRenja:
QUALITY PROBLEM

SHJRenja:
QUALITY PROBLEM

RECEIVING FILE

接受文件

SHJRenja:
QUANTITY PROBLEM

Processing date	Item group	Quantity	Input error	
批准日期	項目小組	數量	输入錯誤	
			Yes有(Y)	No无(N)
2011-11-21	imported parts, Finland	15	Y	
2011-11-21	fastener	2		N
2011-11-21	bearings	22		N
2011-11-21	automation components	20		N
2011-11-21	tools	1		N
2011-11-21	fastener	31		N
2011-11-21	mechanical components	9		
2011-11-21	automation components	7		N
2011-11-21	automation components	3		N
2011-11-22	imported parts, Finland	44	Y	
2011-11-22	mechanical components	29		N
2011-11-22	fastener	4		N
2011-11-22	mechanical components	15		N
2011-11-23	small parts related to rolls	1		N
2011-11-23	fastener	1		N
2011-11-23	fastener	1		N
2011-11-23	mechanical components	2		N
2011-11-23	mechanical components	2		N
2011-11-24	automation components	1		N
2011-11-24	automation components	15		N
2011-11-24	small parts related to rolls	1		N
2011-11-24	fastener	2		N
2011-11-24	mechanical components	3		N
2011-11-24	automation components	2		N
2011-11-24	mechanical components	1		N
2011-11-25	mechanical components	1		N
2011-11-25	mechanical components	2		N
2011-11-25	fastener	47		N
2011-11-25	fastener	4		N
2011-11-25	fastener	1		N
TOTALLY		289	2	28
	Receiving error rate			**7%**

SHJRenja:
QUANTITY PROBLEM

RECEIVING FILE

接受文件

Processing date	*Item group*	*Quantity*	*Input error*	
批准日期	項目小組	數量	输入錯誤	
			Yes有(Y)	No无(N)
2011-11-28	fastener	1		N
2011-11-28	automation components	37		N
2011-11-28	fastener	25		N
2011-11-28	fastener	8		N
2011-11-29	fastener	1		N
2011-11-29	small parts related to rolls	8		N
2011-11-29	automation components	41		N
2011-11-29	automation components	2		
2011-11-29	small parts related to rolls	8		
2011-11-30	imported parts, Finland	3		N
2011-11-30	fastener	4		N
2011-11-30	automation components	3		N
2011-11-30	automation components	4		N
2011-11-30	fastener	2		N
2011-11-30	automation components	74	Y	
2011-12-1	fastener	4		N
2011-12-1	imported parts, Finland	30		N
2011-12-1	fastener	2		N
2011-12-2	mechanical components	1		N
2011-12-2	automation components	1		N
2011-12-2	small parts related to rolls	210		N
TOTALLY		469	1	20
	Receiving error rate			**5%**

SHJRenja:
QUANTITY PROBLEM

Exhibit 2: Warehouse area forecast model

	m2	PROJECT	week 46	week 47	week 48	week 49	week 50	week 51	week 52	week 1	week 2	week 3	week 4
Assy 1 / 49 m	113	**LSPPM6 7250 Dryer Section**	113	113	113	113	113	113	113	113	113	113	
	114	**LSPPM6 Sizer**	114	114	114								
	113	**LSPPM6 Reel**	113	113	113	113	113	113	113	113	113	113	
	1803	**IPSP26 6850 Multifourdrinier (Wire length 41 m)**							1803	1803	1803	1803	1803
Assy 2 / 30 m	113	**L&M PM17 Reel**	113	113									
	321	**OJI Wet Lap Cutter Layboy 4800 (20 m)**	321	321	321	321	321	321	321	321	321	321	321
	114	**IPSP26 Sizer**										114	114
Assy 3 / 30 m	680	**OIJ Wet Lap Press section 4800**	680	680	680	680	680	680	680	680	680	680	
	645	**OIJ Wet Lap Wire section 4800**	645	645	645	645	645	645	645	645	645	645	
	681	**SUZANO PD1 Cutter Layboy 7600 (20 m)**											
Assy 4 / 35 m	1495	**GREENPAC PM1 9050 Multifourdrinier (Wire length 34 m)**	1495	1495	1495	1495	1495						
	680	**SUZANO PD1 Press section 7600**		680	680	680	680	680	680	680	680	680	680
	645	**SUZANO PD1 Wire section 7600**		645	645	645	645	645	645	645	645	645	645
	680	**SUZANO PD2 Press section 7600**											
	645	**SUZANO PD2 Wire section 7600**											
Required warehouse area /week			3594	4919	4806	4692	4692	3197	5000	5000	5000	5114	3563
Reserved area at preassembly			1145	1233	1586	1586	2114	1586	2114	2114	2114	2114	1586
Required warehouse area			2449	3686	3221	3107	2578	1612	2886	2886	2886	3000	1978
Capacity of current warehouse area			3047	3047	3047	3047	3047	3047	3047	3047	3047	3047	3047

Warehouse area m2	
Outside warehouse area 2	455
Inside warehouse	1080
Outside craine area	4536
Available outside craine area	1512
Capacity of current warehouse area	3047

Exhibit 3: Improved outside layout

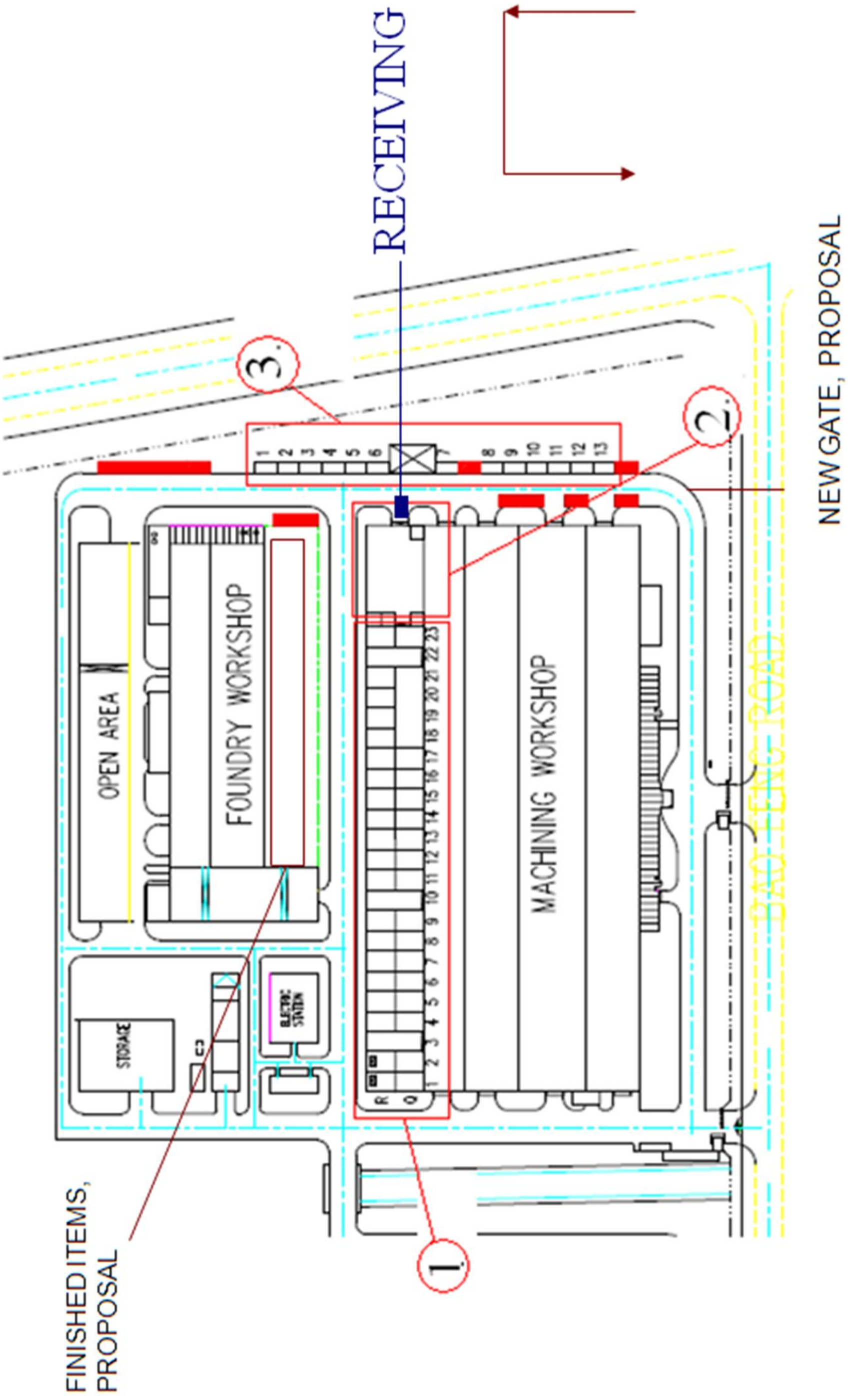

Exhibit 4: Old layout

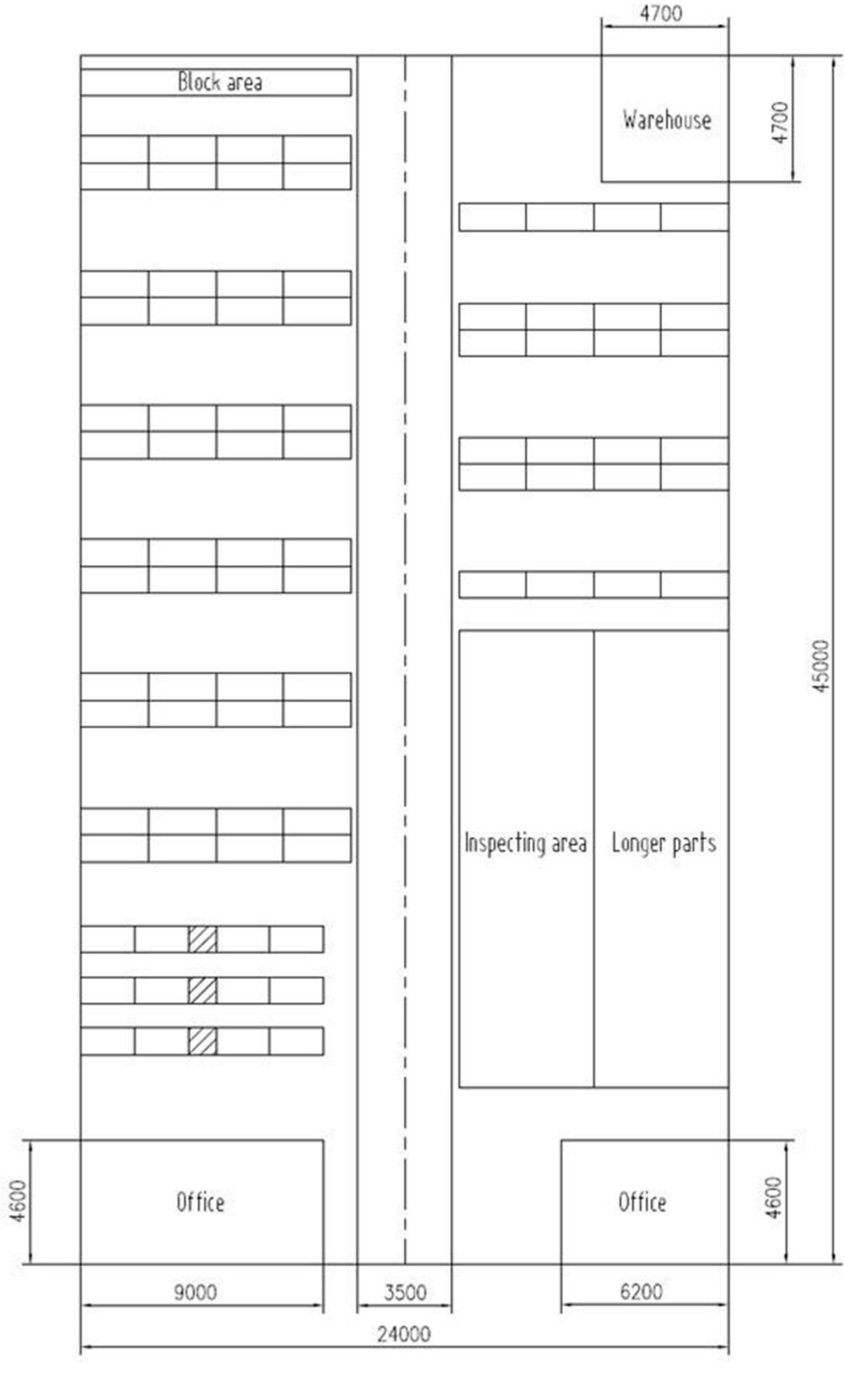

Exhibit 5: New layout

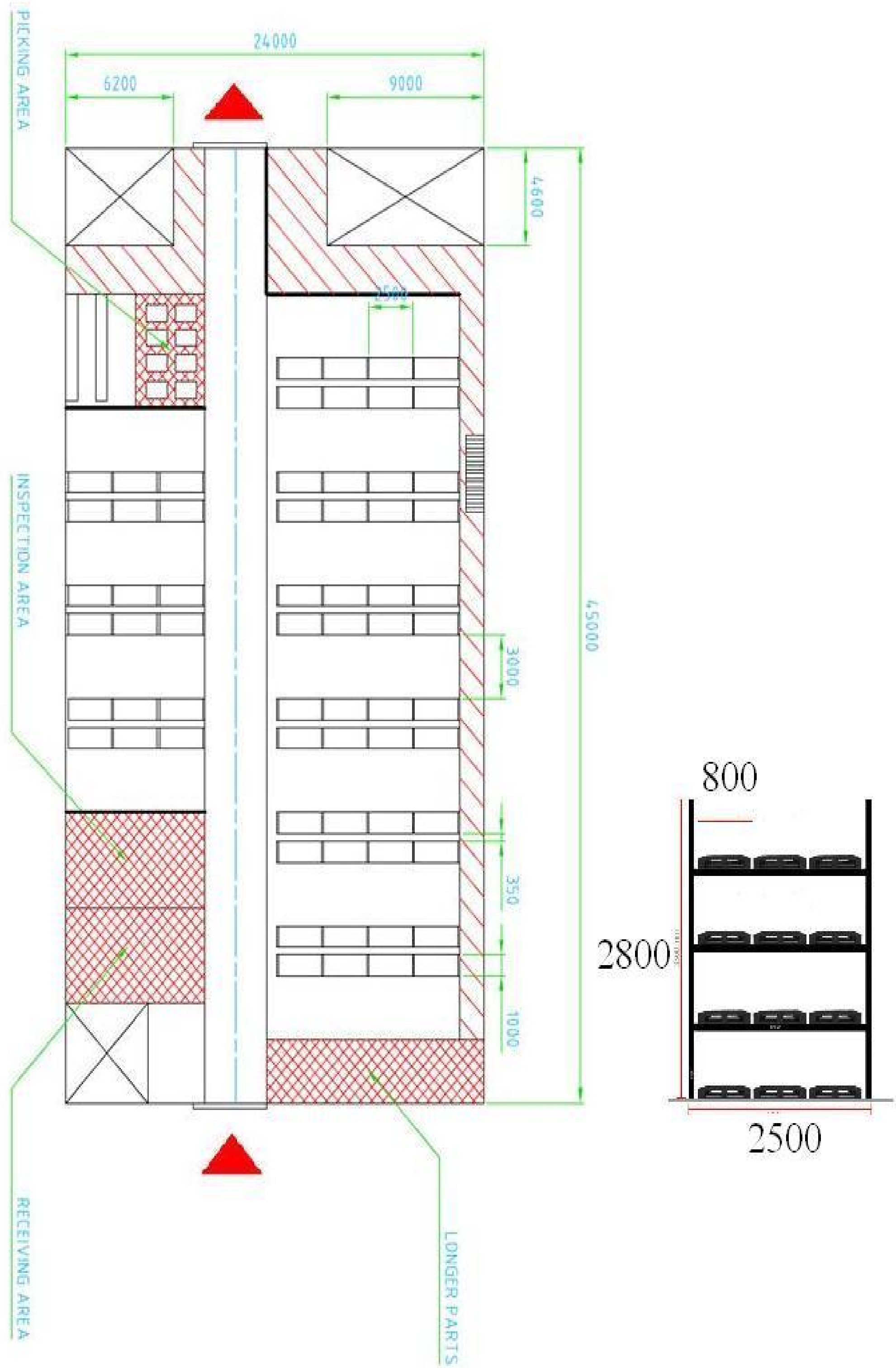

Exhibit 6: Skill matrix of warehouse workers

metso	Computer skills	Baan skills	Reading skills	Math skills	Oral communication skill	Teamwork skills	Ability to follow instructi	Technical knowledge of	Forklift truck skills
X X Age: X In Metso: 8 yr	1	1	1	1	1	1	3	0	0
X X Age: X In Metso: 5 yr	0	0	0	1	1	2	2	0	0
X X Age: X In Metso: 1 yr	0	0	0	0	2	2	2	0	4
X X Age: X In Metso: 9 yr	0	0	0	0	1	2	1	0	0
X X Age: X In Metso: 9 yr	0	0	0	0	2	2	2	0	4
X X Age: X In Metso: 1 yr	1	2	2	3	3	3	3	4	0
X X Age: X In Metso: 8 yr	3	3	3	3	3	1	3	4	0
X X Age:X In Metso: - yr	1	2	2	3	3	3	3	0	0
X X Age: X In Metso: 7 yr	0	0	3	3	3	3	3	4	0
X X Age: X In Metso: 9 yr	0	0	0	4	3	3	3	4	0
X X Age: X In Metso: 8 yr	0	0	0	4	3	3	3	4	0
X X Age: X In Metso: 9 yr	0	0	0	4	2	2	2	4	0
X X Age: X In Metso: 9 yr	0	0	0	4	3	3	3	4	0
X X Age: X In Metso: 9 yr	0	0	0	4	3	3	3	4	0
X X Age: X In Metso: 9 yr	0	0	0	0	0	0	0	0	0
X X Age: X In Metso: 9 yr	0	0	0	3	2	2	2	3	0
X X Age: X In Metso: 2 yr	0	0	0	3	3	3	3	0	0
X X Age: X In Metso: 2 yr	2	2	2	3	3	3	3	3	0
X X Age: X In Metso: 1 yr	0	0	0	2	3	3	3	3	0
X X Age: X In Metso: 9 yr	2	0	2	3	3	3	3	4	0

Exhibit 7: New warehouse process flow chart