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IMPLEMENTING LEAN

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Abstract

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Abstract

The topic of this thesis is implementing Lean thinking at PCM Technology Oy. The aim was to identify problems within the company, and to address them with Lean tools. This thesis describes their current continuous improvement tools and makes suggestions on how to build upon them.

The thesis includes a theory part, where the general history of Lean is presented, and the considered tools are introduced. Lean literature was referenced for the Lean methods, as well as Lean consultants' websites.

The practical part of this thesis follows using some of the Lean tools, such as the 5S system as well as the Kanban cards that were implemented in the spare part storage. Stakeholders, such as maintenance workers, engineers and production manager were consulted while making changes to the spare part storage. Microsoft Excel VBA was used to make a system to help the production manager re-purchase parts when needed, and the Kanban cards notify the production manager when parts need to be replenished.

The system has brought order to the spare part storage area and has already been improved upon while in use in the company.

Keywords
Lean, Kanban, 5S

CONTENTS

ABBREVIATIONS AND DEFINITIONS

WIP = Work In Progress

TPS = Toyota Production System

TPM = Total Productive Maintenance

A5 = Paper size, also PCM Technology's own continuous improvement system

OEE = Overall Equipment Efficiency

1 INTRODUCTION

This introduction first presents a brief history of Lean, then the starting point of this thesis, and then introduces the case company.

1.1 Lean Framework

The main idea of Lean is to trim waste from processes and to therefore make processes as efficient as possible. The focus is on flow efficiency instead of the more traditional resource efficiency. Instead of using machines to their full capacity, we instead focus on eliminating large amounts of WIP and improving the flow of material through the process. Lean is a globally recognized way to build, improve and sustain businesses (Williams, 2012).

The history of what eventually developed into the Lean manufacturing we know today can be traced back as far as the 1890’s when early Industrial Engineers, such as Frederic W. Taylor and Frank Gilbreth, began studying individual worker’s methods and motions. Around 1910, Henry Ford made the first Manufacturing Strategy along with Charles E. Sorensen. They made a production line which became incredibly successful, but they did not continue to develop it, which caused the system to begin to break down, and within a few decades it was passed by General Motors in market share.

Starting in 1949, Taiichi Ohno and Shigeo Shingo at Toyota Motor Company began incorporating ideas from Ford production and others into what is now known as TPS (Toyota Production System) (Strategos International, 2019). They were the ones to recognize the importance of inventory, and respecting employees. They activated workers mentally by giving them responsibility for quality and continuous improvement of the system. Shingo also realized the importance of short setup times and batch sizes to productivity.

At the end of the 1980’s, Lean began to enter the corporate world more widely, and many companies tried to copy the success of Toyota, but a lot of companies tried to superficially copy specific tools instead of incorporating the spirit of Lean into their company values. (Strategos International, 2019)

More recently, I have noticed a movement towards minimalism and mindfulness, which perhaps is a version of Lean in the home, which should translate into a professional trend towards Lean thinking and or at least an easier acceptance of Lean principles.

The goal of Lean is to have continuous improvement, wherein processes develop and grow, but the efficiency of which is reflected upon at regular intervals. Lean is not a one-time overhaul, where items are discarded, and the processes are never checked again.

1.2 Starting point

PCM Technology Oy had been interested in Lean tools and ideas for many years before this thesis idea was pitched. I was hired by the company to bring some new points of view and to implement some Lean tools.
The goals of this thesis are to find and implement some lean tools that the client company could build on based on their needs. The focus is on the selection of only a few tools, as well as the implementation of the tools. The sources used for this thesis include books and articles, as well as the PCM Technology Oy's workers' ideas.

The work phase of this thesis was executed in the summer of 2018 and it took a total of 4 months. Throughout the summer, other work tasks were completed alongside the thesis work. During the first month, the thesis worker listed and analyzed problems. During the next two months, solutions were worked on for the chosen problems. During the last month, the data and systems were set up so that it would be easy for someone to continue the work and improvements that were done during this thesis. Also, users were trained how to use the new system.

The first half of this thesis focuses on Lean theory and the prominent tools and thoughts that are usually used when Lean is being implemented in a company. The second half focuses on what was implemented in the client company. The main problem that this thesis focuses on is the disorganisation of the spare parts management and storage. The solution that is implemented in this thesis is a spare part management system that uses Excel VBA and Kanban-cards to simplify reordering and keeps the storage in order. This system has caused the need for the spare part storage to be physically in better order, because shelves needed to be in a logical order for the Kanban-cards to work.

1.3 Company Introduction

The client of this thesis is PCM Technology Oy, a company that produces stainless steel pipe components and fittings, such as reducers and collars. Most of their processes have been automated with industrial robot cells, which include ABB robots. PCM Technology Oy was founded in 2004 by two engineers who had the drive and ambition to improve upon the traditional methods of making collars and reducers. In 2016, they had 18 employees, and 3 445 000 in revenue. (Yrityshaku: PCM Technology Oy, 2018)

2 LEAN METHODS

In this section, a few of the tools considered for the case company will be presented.

2.1 The seven types of waste

In order to trim waste from processes, we must first have a basic understanding of what waste is. To make this easier, Toyota's chief production engineer, Taiichi Ohno, categorized waste into seven main forms. Liker added an eight to the original list (The Toyota Way, 2004). Keeping these wastes in mind can help a business owner keep their business running smoothly and efficiently.
These are the eight main types of waste:

1. **Overproduction**
   When there is a mismatch between orders and what is being produced it leads to waste such as overstaffing and excess inventory, which causes waste in transportation and storage costs. Producing large WIP buffers within production can lead to reduced motivation to improve the process. (Liker, 2004)
2. **Waiting**
   Machine downtime or process inconsistencies causing workers to have to stand around and wait for the next processing step. It can also be a short supply of tools, supplies, parts, wherein the worker must wait. Lot processing delays, bottlenecks, and stockouts also cause waiting, which can lead to worker frustration. (Liker, 2004)
3. **Unnecessary transport or conveyance**
   This form of waste concerns the movement of materials within the factory from receiving the material all the way to the shipping bay. Transporting the raw material, the WIP and the final product can consume many hours and can be many kilometers. Each transport activity increases the likelihood of product damage. (McCarthy & Rich, 2004)
4. **Over processing or incorrect processing**
   "A mismatch between the process needed to make a product and the processes that are in place" (McCarthy & Rich, 2004). Many firms use overly sophisticated machinery to manufacture simple products that would be best produced using simpler, and less expensive technology. This can include producing higher-quality products than is needed.
5. **Excess inventory**
   Inventory is excess inventory when there is not an order for it. This could be the results of over-production. "Excess raw material, work-in-progress, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay" (Liker, 2004).
6. **Unnecessary movement**
   When the production process is poorly designed operators need to engage in stressful activities to handle materials as part of their job. This can cause employees to need more sick days, and even the possibility of large settlement fees from employee claims. Even walking is usually unnecessary movement. (McCarthy & Rich, 2004)
7. **Defects**

The production of materials that need to be reworked or scrapped. This causes wasteful handling through replacement production and inspection and causes valuable capacity to be lost. (McCarthy & Rich, 2004)

8. **Unused employee creativity (Bonus from Liker)**
   This extra one is a new addition. By not engaging or listening to your employees you lose time, ideas, skills, and learning opportunities. (Liker, 2004)

2.2 5S

5S is a popular Lean tool, which objectives are to reduce waste and variation, and to improve productivity as well as quality. 5S is a tool that needs to be used at every organisational level, and it needs to include everyone. The tool has a bad reputation due to overzealous people missing the point. 5S is not only cleaning up, it also includes an entire system of ensuring order in the future. "A common alternative for 5S is the CANDO pneumonic- **C**leanup, **A**rrange, **N**eatness, **D**iscipline, **O**ngoing improvement" (Bicheno & Holweg, 2016).

The classic 5S's are:

1. **Seiri (Sort)**
   During the sort phase, items are sorted into three different categories; Keep, Return, and rid. During this phase, a red-tag area should be made. All items that are going to be thrown out that are not clearly garbage should go through the red-tag area, staying for a maximum of 48 hours. A physical red tag should be attached, so the date it entered the area can be written, as well as the contact person, and who needs to sign off on throwing it away.
2. **Seiton (Simplify)**
   A place should be found for every item. Items should belong close to where they are needed. Everything needs to be clearly labeled. This might be achieved, for instance, by using shadow boards, or colour matching.
3. **Seiso (Shine)**
   Clean the area. It should be part of everyone's job to clean. A clean work environment has a positive effect on a worker's mindset. It is easier to detect problems with clean equipment.
4. **Seiketsu (Standardize)**
   Make a clear schedule and system to keep the area clean and organized.
5. **Shitsuke (Sustain)**
   Turn it into a habit. Raise your expectations.

(Bicheno & Holweg, 2016)

2.3 Kanban

The Kanban system works similarly to supermarkets, where a store's stock is replenished after items have been purchased. A Kanban system prompts reordering of parts and components based on actual the consumption, instead of forecasts or estimates (Williams, 2012). Some of the Kanban methods include the "two-bin" method and the Kanban-card method. In the "two-bin" method, operators have two bins of which one is full, and the other is in use. When one bin empties, it serves as a visual Kanban, triggering replenishment. In the Kanban-card method, the card travels with the inventory and triggers replenishment when the inventory runs out. The card includes such information as the part description, number, and location.

Kanban can improve the flow of the operation, when properly used. The enhanced material flow is a direct benefit from reducing inventory space and creating order within the inventory system by creating the Kanban material flow (Gross, 2003). The Kanban is a rigid set of events that is clear and easy to learn.

2.4 Value-Stream Map

Value-stream maps (VSM) are used to develop plant layouts, either expanding an old one, or for a new facility. It is a tool to reduce work-in-progress and inventory. The process of making value-stream maps can be broken down into two different phases: current-state VSM and future-state VSM.

2.4.1 Current-State Value-Stream Map

The point of the current-state value-stream map is to depict what is the current state of production. It will also serve as the base upon which the future-state VSM is made. The VSM should be made for one product family at a time, otherwise it risks being too complicated.
To make a current-state VSM, you need to lay out all the current process steps, as well as the storages. Information flow needs to be mapped out. Process time data such as the number of employees, changeover time, and cycle time are also recorded on the VSM. Processes can be categorized as either value-added (VA) or non-value added (NVA) activities.
Williams (2012) said that for an activity to be value-added, it must meet all three of the VA criteria:

1. The customer must be willing to pay for it.
2. It must transform the product or service in some way.
3. It must be done correctly the first time.

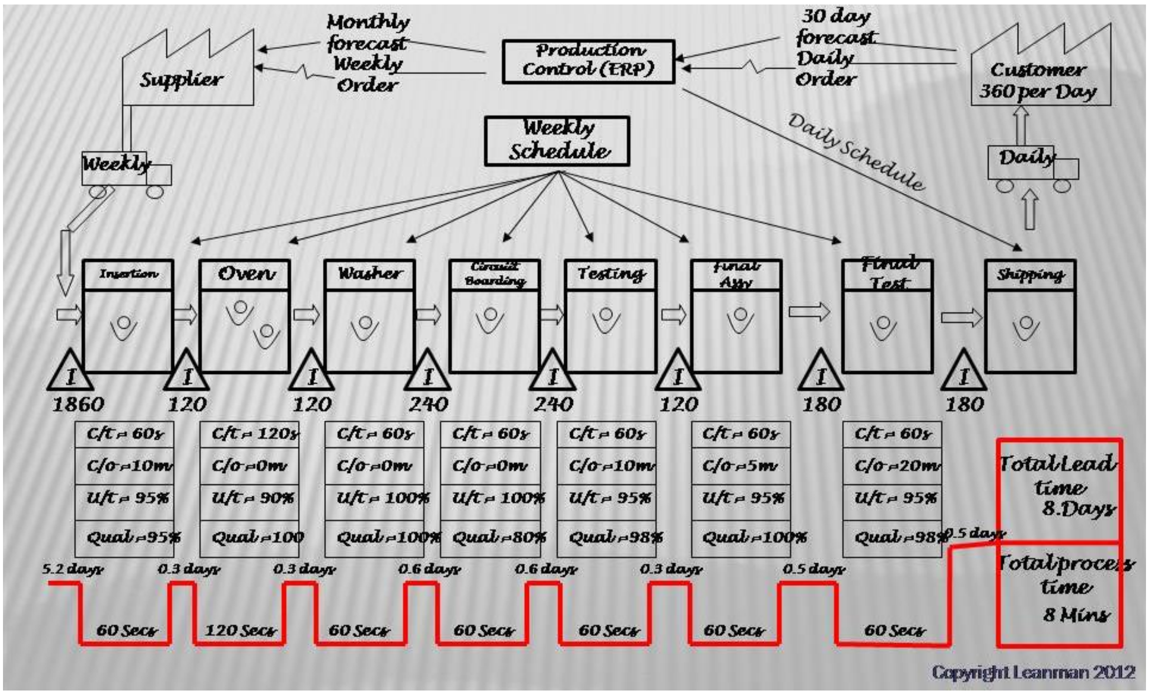

FIGURE 1. An example of a VSM (Earley, 2019)

2.4.2 Future-State Value-Stream Map

The future-state value-stream map is, as the name suggests, what the VSM will look like after implementing the proposed changes. With a future-VSM draft it is possible to see what the processes would look like in the future. With the future-VSM tool, the potential changes do not need to be over-analyzed, instead just repeating the cycle of Current-State VSM and Future-State VSM should track improvements enough (Williams, 2012).

2.5 Maintenance and Spare Part Management

When working in production lines, the most impactful way to reduce wasted time is to minimize unscheduled downtime. In order to decrease unscheduled downtime, preventative maintenance is needed, as well as a stock of critical parts for maintenance, within reason. Usually companies manage their spare parts in a different department than the management of maintenance. The maintenance department can be regarded as the main customer of the spare parts storage (Kelly, 2006).

According to Kelly (2006) the function of spare part storages is to "act as a buffer (or reservoir) between the uncertainties of the supply from the manufacturers (or from the reconditioning workshop – external or internal) and inherent variability of the maintenance demand."

Here are a few things to consider when assessing which spare parts to keep in stock:

- Part lead time
    - How fast can we get this part? Is it available in the hardware store next door?
- Part cost
    - Is it worth having in stock? Part cost vs. downtime cost
- Shelf life
    - Will the part deteriorate or otherwise lose value in storage?
- Multiple uses
    - Is the part used in multiple production lines?

According to Sayer and Williams (2012), Total Productive Maintenance (TPM) can be used to maximize productivity while fully maintaining equipment and tools. The foundation upon which TPM is traditionally built is the 5S system.

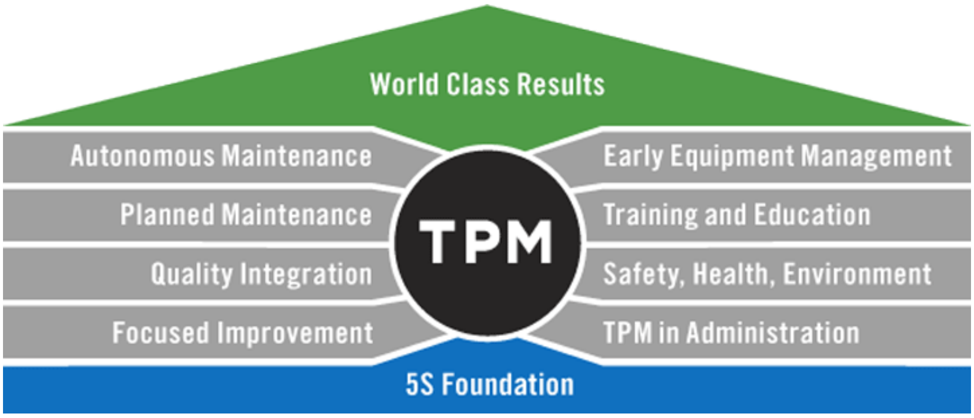

FIGURE 2. The TPM model with eight supporting activities and a foundation of 5S (Vorne, 2019)

The aim of TPM is to increase the Overall Equipment Efficiency (OEE), which according to Bicheno and Holweg (2016) is calculated like so:

$$OEE\% = Availability \times Performance\ Rate \times Quality$$

Which more specifically is:

$$OEE\% = \frac{Actual\ run\ time}{Planned\ run\ time} \times \frac{Actual\ amount\ produced}{Theoretical\ amount\ produced} \times \frac{Amount\ produced\ right\ the\ 1st\ time}{Total\ produced}$$

3 CASE: PCM TECHNOLOGY OY

This section outlines the current situation in the case company, as well as presents the solutions that were implemented.

3.1 Management and Company Culture

PCM Technology Oy currently has a functioning improvement tool, which they have developed by themselves. They use pieces of A5-size paper to report anything from production problems, work safety issues, to client reclamations. The papers are then placed on a board in the coffee room, so that everyone can see current issues. The production manager enters each A5 into an excel sheet and assigns it a number. During the weekly *A5 meeting*, management and the production manager go through each A5 to assign a person responsible. Production related A5s are added to the weekly production meeting agenda, and sales related A5s are handled in the weekly sales meetings. Each A5 is followed up on, and the status is marked in the excel sheet. Upon completion of the A5, the paper is placed in the "completed A5" slot and will be marked as being complete in the next weekly A5 meeting.

The company has many young and active employees, who want to improve their own workplace. They are kept active with the A5 system; however, they have pointed out some issues with the system that need to be addressed. Currently ongoing or reoccurring problems are not given special notice in the A5 system.

3.2 Project Stakeholders

Spare part management influences most processes in a company, from maintenance all the way to sales, and in the worst case can even affect the customer (What is a Stakeholder in Project Management?: Wrike, 2018). However, in this project, the key stakeholders include the owners, the production manager, the maintenance worker and the design engineers as seen in Figure 3.

The owners needed to weigh the financial decisions of the spare part storage, but they also had the most information on the background of the most mysterious parts in storage. The production manager knew the most about the effect of machine downtime, and which factors were the cause. The maintenance worker needed to know where all the parts were in the new system, so especially they were asked during large changes for input, as well as kept up to date on where things were and what the system was. Designers were told about how spare parts would be decided upon in the future, and that it would be a group decision along with the production manager.

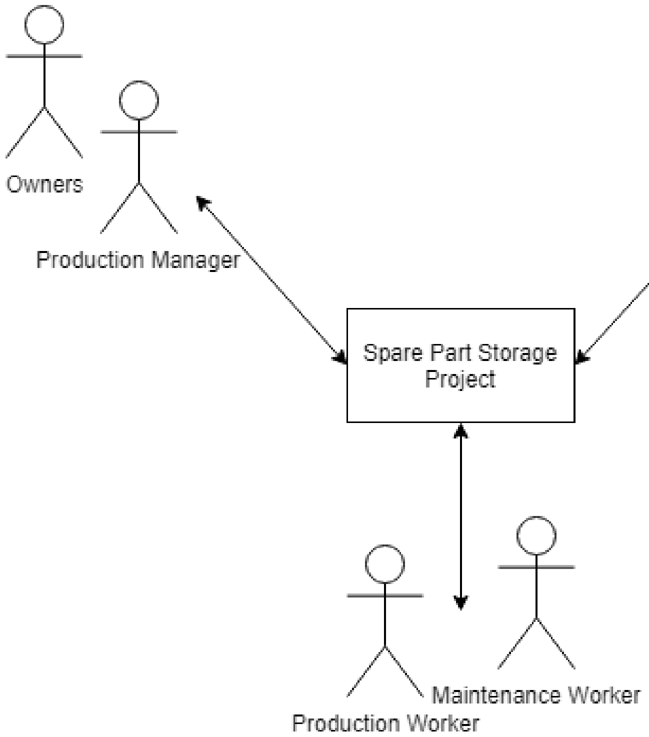

FIGURE 3. The Key Project Stakeholders of this Thesis Project

3.3 Problem Solving

During the first month of work, a lot of questions were presented, and quite a few possible improvement possibilities came to light. However, we wanted to select an issue that would have the most impact for the company, and for which the solution could be somewhat permanent.

We started by making a value-stream map (VSM), because it would give a visual representation of the company's processes. While making the VSM, it was noticed that their development was progressing quite quickly, and that they had already carefully considered throughput times. With so many large projects on their horizon, we did not feel that completing the VSM would have the biggest impact.

While following processes and documenting employees' work methods, we came across some old problems that had been brought to attention previously in the A5 system but were still a problem. When these arose, we made new A5s about the issue. Because of changes in the production cells, solutions to quite a few of the issues were easier to identify (e.g., better technology, different machines in use than before).

One issue that was overlooked in their continuous improvement system was the spare part storage. The storage space was not in a logical order, and most parts were not marked, making identification very difficult. Many important spare parts were stored elsewhere, for instance, on the design engineer's desk or in the production cell. Critical spare parts were not defined. During maintenance, often people would not bother to check the storage room for spare parts and choose to purchase a new part instead.

Solving the problems of the spare part storage was decided as the main project of this thesis, as it was in a clear blind-spot and it would have a clear impact on the business. Fixing the spare part storage might also act as a model for improving other parts of the workplace.

Tools that were considered:

- Company mission, defining company values
    - Progress was made, but the wording posed difficulty, was not completed
        - Asked production workers, sales team, as well as owners about company values, matched well with old named values.
- Office workstation 5S
    - One workstation was organized and photographed
    - The bosses' offices were organized, but there was some pushback, so it was not actively pursued, because of lack of authority
- Production 5S
    - There already were some 5S ideas in use in the workstations, done by someone who was not familiar with 5S, so I believed that they would most likely implement 5S in the workstations after being introduced to the ideas.
- VSM
    - A current-state and future-state VSM was made but was not attached to any future processes or projects, other than a suggestion to have teams make a VSM.
- Kanban
    - This tool was chosen as the main focus of the project, alongside 5S.
- TPM
    - The company already has a regular maintenance schedule, and they keep track of downtime as well as the reasons for the downtime. We focused more on the 5S base.

3.4 Using 5S

The first part of the 5S project was done on a very small scale. The first target was the work station that the thesis worker was assigned. It had items left from the previous owner. We got rid of all the useless items and found the proper places for all useful items. Then a picture was taken of the cleared workspace, it was printed out and posted on the wall next to the workspace. The goal was to have the workspace looking like the picture at the end of each workday.

The second step that we tried, was organizing the bosses' offices. The main idea was to lead by example, but it would also make document and item retrieval easier. Duplicates of office supplies were returned to the supply cupboard and unnecessary items were disposed of.

We decided to use 5S (as defined in section 2.2) for the spare part storage area.

1. **Sort**

We made a "red-tag" pallet, where we placed items that had value, but that we thought probably did not need to be in stock. The maintenance worker and the design engineers could come and check the parts that we were planning to dispose of, to ensure that none of the critical production cell spare parts were being thrown away. One challenge we faced with the pallet was that some items were inadvertently crushed by heavier items. Additionally, it was hard for people to look through the items, as they were all on top of one another.

2. **Simplify**

   For the simplifying stage, we grouped the parts based on which production cell it was for (see machine numbering). We purchased blue stacking bins that allowed for easy access to small parts. Items that could not fit in the bins were labelled using a sticker. Larger items that were previously stored on the floor were allocated to a spot on the shelf.

FIGURE 4. Before and after of shelves

3. **Shine**

   The spare part storage room had a lot of dust and debris on the floor. While organizing the room, a broom had to be borrowed from another space to sweep the floor. A new dedicated broom was purchased for this room, along with a proper holder, attached to the wall, and it is now located by the door.

4. **Standardize**

   For this part, we decided on just assigning a person responsible, the production manager, for the upkeep of the spare part storage. When a new part is presented to the production manager, he decides whether it will be stocked. When a new spare part is added to the spare part storage, it is entered into the excel table via the user form, and two stickers are automatically printed out, one for the box or product label and one for the Kanban card.

5. **Sustain**

   We are expecting the spare part storage development to continue through the A5 system. All users will input their ideas or problems into the A5 system.

3.5 Critical Spare Parts

During the spare part management project, the idea of defining critical spare parts arose. A meeting was arranged between the key project stakeholders to build a framework for categorizing critical spare parts. However, there was not much outcome. It was too large of a task, and a proposal of a plan would have been a better way to deal with the development.

A process chart (Figure 5) was made to guide the decision on whether a part would be stocked as a spare part. This was meant as a prototype chart on which to build ideas. The task was assigned to the production manager to improve it as ideas became clearer on what constituted a spare part within the company.

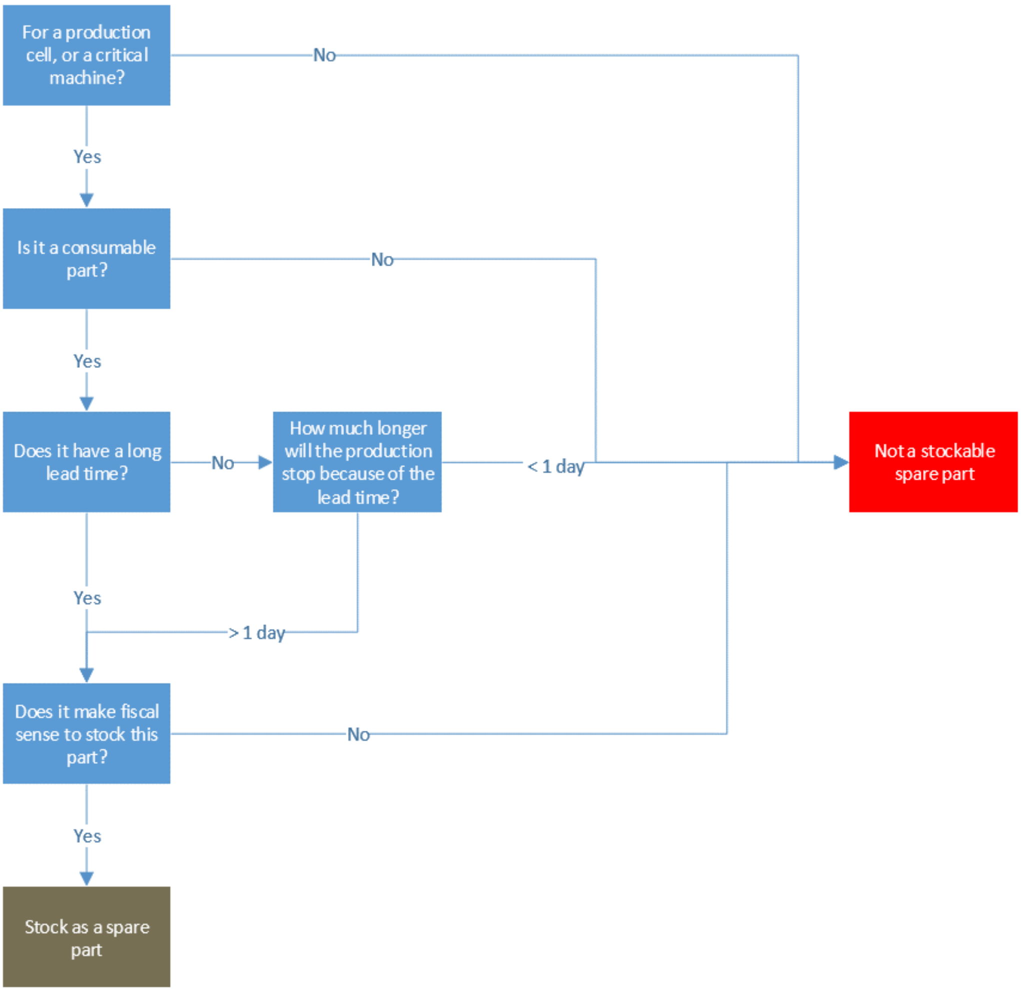

FIGURE 5. Spare part assessment process chart

Through spare part management, we tried to affect OEE, by increasing the actual run time through less unexpected downtime. Keeping track of critical parts in storage makes it so that they do not run out before more arrive from the supplier.

3.6 Kanban System

The Kanban System implementation was the largest part of this project. It was built upon the hard work of organizing the spare part storage with the 5S method, and it was developed as a tool to standardize and sustain the storage space.

3.6.1 Machine Numbering

For the spare part spread sheet, we needed a way to identify the purpose of each spare part. To do this, we assigned a simple identifier for each production line. Options were discussed with a few different people, including the CEO and a software development engineer. One idea was that each line had an identifier number, and each machine within the line had an identifier letter. The CEO insisted everything to be numbers. Existing accounting identifiers were used for the production lines when possible, and new line numbers were created as needed and we created identifying numbers for each machine within the line. For example, the number for the first robot arm (1) within the large reducer line (106) would be 106-1.

We gave each production line a unique number. Most production lines already had a number for accounting purposes. We gave each machine in the production line a number within the production line. There is a machine number list in the spare part storage, so that machine users and maintenance can look up the machines without the use of a computer.

3.6.2 Spare Part Organization

The main problem with the spare part management was that it was not assigned a responsible person. This was remedied by assigning the production manager as the responsible person, since they were also responsible for purchasing spare parts.

We organized the parts by production line, marking shelves with a label maker. A separate shelf was marked for general spare parts, which are used in multiple lines. The goal was to maintain the general order of the spare part storage, as well as to ensure the constant availability of parts. The ability to keep stock visually was especially important. By marking each part or bin with a label, each part will be identifiable.

FIGURE 6. Before and after of centre shelf

3.6.3 The Kanban Card

The Kanban card tool was selected for keeping track of spare part inventory because of its analog properties. The company did not want users to need computer access, nor did they need access to live inventory numbers.

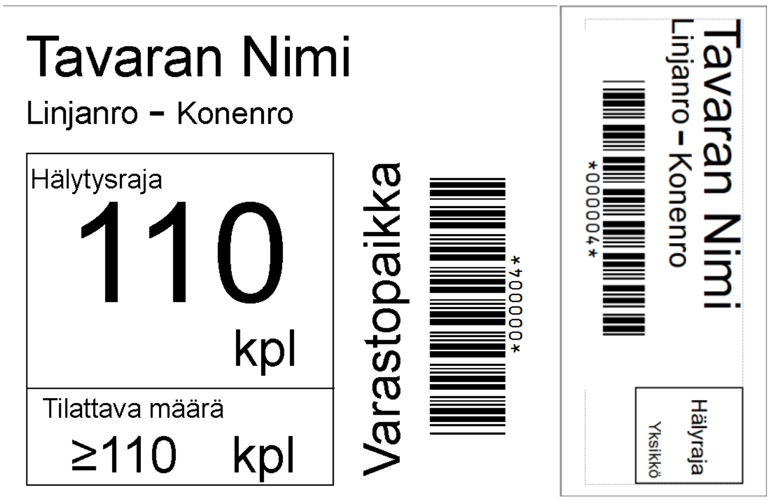

FIGURE 7. Kanban card sticker and box label

The company already had a few Brother Professional Label Printers in use, which had an affect on the decision to use a sticker-based Kanban system. Each part type has two different stickers printed out. The box label sticker, which ideally would be on the picking bins, (but not every spare part fit in the picking boxes, as we opted for only two different sizes) has the item name, the line number, machine number, the reorder point, reorder amount, as well as a barcode. The larger Kanban card sticker, which was glued to a steel “card”, included the same information as the smaller box label sticker, but with the addition of the storage location.

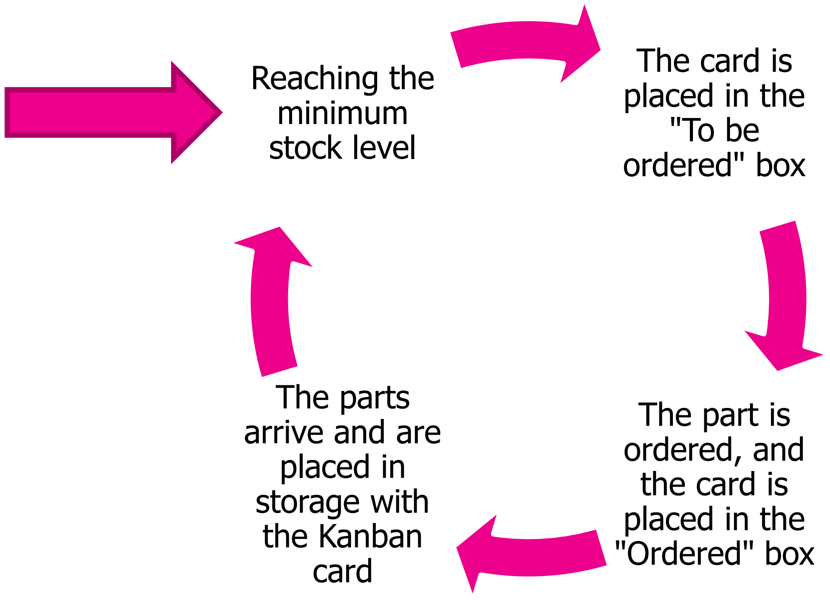

FIGURE 8. The Kanban-card cycle

3.6.4 Use of Excel VBA in Kanban System

Visual Basic for Applications in Microsoft Excel was used to make the spare part storage program. Excel was chosen because the company already had a license to use Excel, as well as the skills to use it. The spare part program was designed with the possibility to transfer to a database in the future in mind. The Excel file is in Finnish because not all the users understand English, and we wanted this program to be as accessible to everyone as possible.

The program makes a list of all the spare parts into an excel sheet, and as new parts are entered, it prints out a box label as well as a Kanban card sticker. The program also has the feature to print existing spare parts labels again, as well as modifying existing spare part information. Both functions work by searching for the part number by scanning the barcode into the corresponding field. The excel has a simple field to scan the Kanban card's barcode into, so that the user can access purchasing information related to that part, making re-ordering parts as they need replenishing easier. The barcode is scanned into the orange field (seen in Figure 9) by the user.

The information that is displayed:

- Supplier
- Contact person
- Phone number
- E-mail
- Part Name
- Part description
- Part ordering number
- Lot size (and unit)

Nimikkeenhaku		
Viivakoodi:	000200	
Toimittaja:	TKP	
Yhteyshenkilö:	0	
Puhelinnumero:	0	
Sähköposti:	0	
Nimike:	OSG-K.Tappi VA-SFT M16 DIN376	
Kuvaus:	M16 kierretappi	
Tilauskoodi:	2710480	
Tilattava määrä:	3	pkt

FIGURE 9. Purchasing table

To enter new spare parts into the excel sheet, a button named clearly for this purpose is clicked. It opens a user form (Figure 10) with the following fields:

- Production line
- Machine number
- Part name
- Minimum stock
- Lot size
- Unit
- Storage location
- Supplier Information
    - Company
    - Contact person
    - Phone number
    - Email
    - Part description
    - Part ordering number
- A checkbox for printing stickers (Print by default)

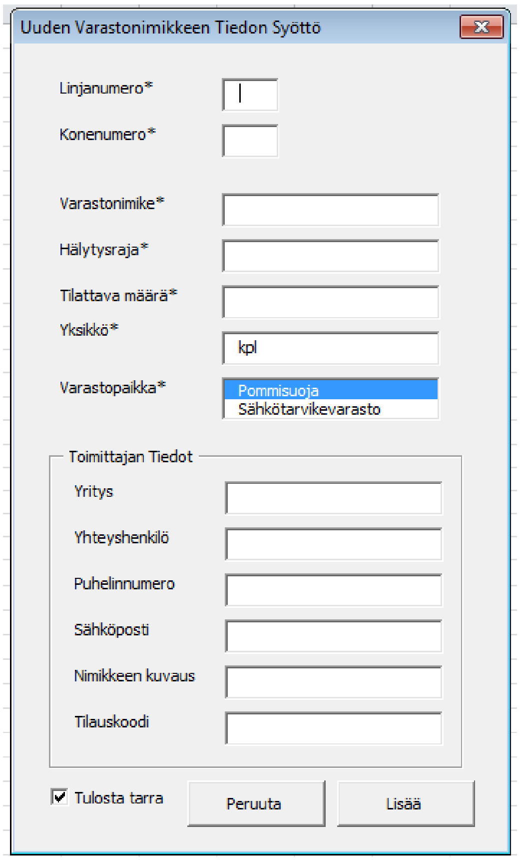

FIGURE 10. New Item Form

4 RESULTS AND CONCLUSIONS

The client company, PCM Technology Oy, already had a surprising number of Lean-like tools in use, such as their own A5 system, and some of the workstation organisation. They seem to be naturally developing in the Lean direction. During this thesis work we introduced some new tools as well as some new ideas on how to approach problems.

4.1 Results and Findings

One month after completing the project, the spare part storage was still in good order. Some items were moved to a better place, indicating that someone is improving the system. The purchaser said that they are inputting the purchasing information into the system, and it will still take time before all the parts have purchasing information, as the information is added once the Kanban card is in the hand of the purchaser.

One problem that arose during the implementation of the Kanban-card system was that when a part was in multiple production cells, the part can only be placed on one shelf. Also, the excel table only has one field for production cell and one machine field, so we separated each production cell and machine with a semicolon. However, this might lead to confusion in the future, and should be remedied. For instance, when the information is being transferred to a database, this problem should be fixed.

Overall, the company seems pleased with the outcome. My professional knowledge has grown immensely, and I have been able to try a more creative sort of development work.

4.2 Suggestions for Future Projects

PCM Technology Oy is on a very good path for continuous improvement, and they clearly have an interest in new technologies and methods. In future 5S projects, I would use a shelf for the red-tag area, so that all the items could be viewed at once. I would also use the physical red tags, as it would be clearer for everyone, and would not require as much verbal communication.

Continuing and expanding the 5S project started in this thesis would allow for more conformity between workers and shifts. Tools being in consistent places will make it so less time will be spent looking for tools.

Using a career ladder that outlines ways for workers to progress in their careers in the company helps with motivation and lowers the attrition rate (Womak;Jones;& Roos, 1990). Another tool for worker motivation could be a group event, where workers make VSM in groups, and explain what kinds of changes they hope to see in the work process.

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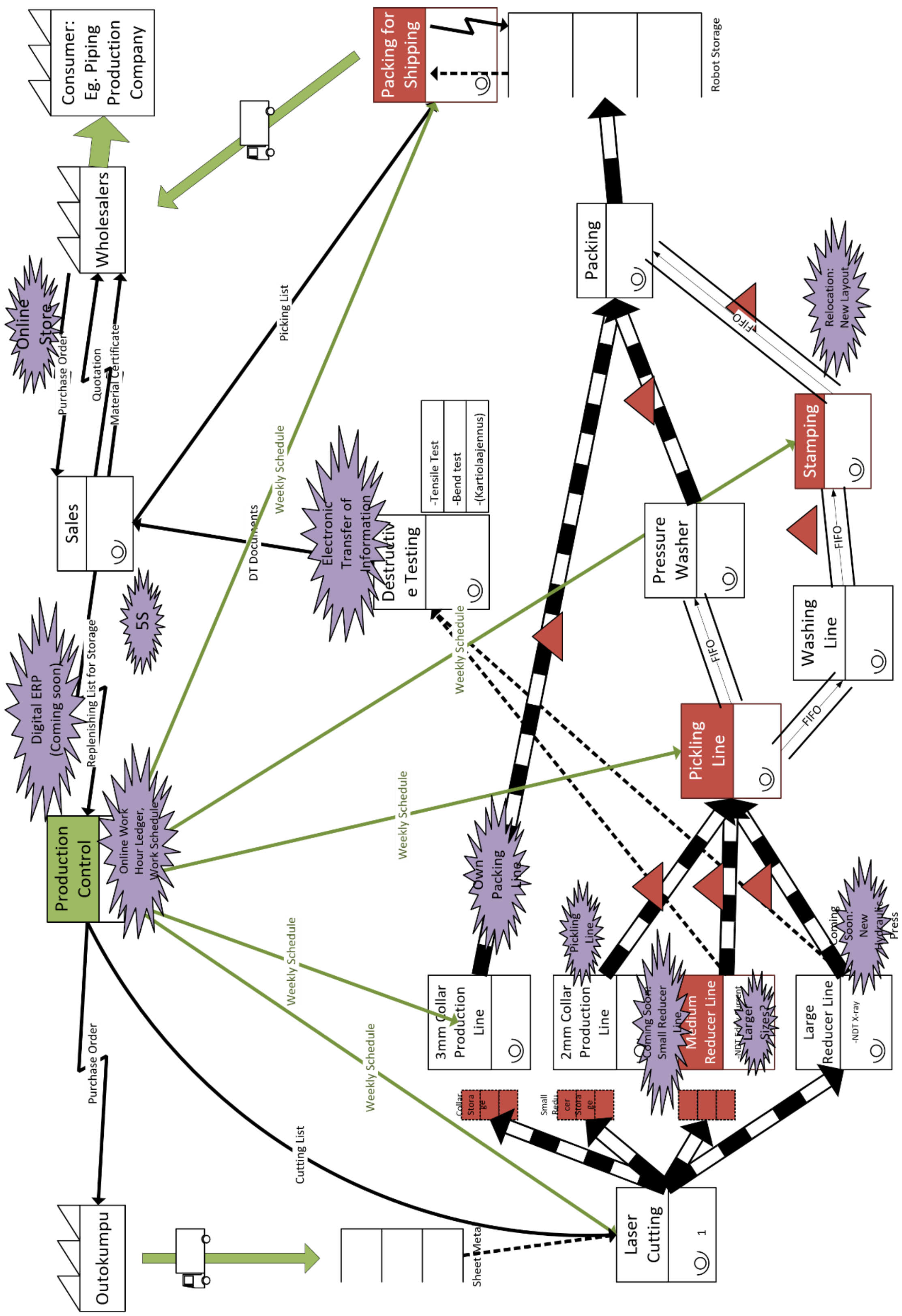
APPENDICE 1 CURRENT-STATE VSM



APPENDICE 2 FUTURE-STATE VSM