



**SAVONIA**

THESIS - BACHELOR'S DEGREE PROGRAMME  
TECHNOLOGY, COMMUNICATION AND TRANSPORT

# RE-WRITING CW2500 BOARD PACKING LINE MAINTENANCE MANUAL

Case company: CrossWrap

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Field of Study Technology, Communication and Transport			
Degree Programme Degree Programme in Mechanical Engineering			
Author(s) Nikita Sosipatrov			
Title of Thesis Maintenance Manual			
Date	06.06.2019	Pages/Appendices	30
Supervisor(s) Mikko Nissinen			
Client Organisation /Partners CROSSWRAP OY			
<p><b>Abstract</b></p> <p>This thesis was an update and re-design project of a packing line maintenance manual. The customer of the project was CrossWrap Oy Ltd. It is a Finnish company that produces machines and offers solutions for the waste industry. Wrapping and bale opening machines are manufactured by the company for RDF, SRF, MSW and recyclables. They focus on providing excellent solutions for wrapping, storing, transporting, opening, de-wiring and packaging material bales and finished products. They have delivered over 500 machines to 55 countries. Technology and method of their wrapping and de-wiring machines are one of the top solutions available on the market. With their machines they strive to enhance the company's productivity, safety, sustainability, customer satisfaction, and overall profitability.</p> <p>The aim of the thesis was to update and fix the existing maintenance manual. The reasoning for the update was the accumulated and updated information that wasn't implemented to the maintenance manual for a long time. The whole manual was in a state of a rough note that was 11 page long, with decent instructions and bad structure. The idea for the manual was to make it easy to read and understand for the potential customer with no prior knowledge of the machine, to have updated information and instructional pictures and to have a preliminary version of the manual layout and content, before machine launch in Russia.</p> <p>The theoretical part of the thesis consisted of defining the meaning of maintenance according to an SFS standard, studying prior works on the topic of maintenance definition and various internet articles. It would be used to understand how good maintenance effects other business departments inside the company, understand what maintenance divisions exist and find out what type the maintenance manual represents. Once the main tips for manual writing are defined, then all the accumulated theory will be synthesized into a guideline that will be used during the process of updating the maintenance manual.</p>			
<p><b>Keywords</b></p> <p>Maintenance, MM, Board Packing Machine, PM</p>			

## ABBREVIATIONS

MM - MAINTENANCE MANUAL

PM – PREVENTIVE MAINTENANCE

CM – CORRECTIVE MAINTENANCE

IM - IMPROVEMENT MAINTENANCE

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## 1 INTRODUCTION

Maintenance in today's production is getting more and more important. Upgrading the production line might take too much capital investment, improving the production line can turn out to be a very complicated process, but applying simple maintenance actions and paying more attention to the machines in the production can result in increased production efficiency, minimized equipment maintenance costs and prolonged lifecycle of the machines. It is important to monitor maintenance and if maintenance monitoring is not dedicated to at least one person, there is a prospect for improvement with small investing costs.

The thesis also revolves around the topic of maintenance. The main objective of which was to update and re-structure the maintenance manual. The situation in the case company shows that neglecting maintenance can lead to future problems that can have negative effect on company performance. After taking appropriate measures it is possible to resolve the situation quickly and efficiently.

The maintenance manual is an essential part of any device, especially if the device has many parts that interact with each other constantly. When developed, it helps with understanding the machine better by the writer and helps future users of the machine to cut their learning process. The work will cover finding principles of writing a maintenance manual and applying them to improve it.

## 2 CROSSWRAP COMPANY

This section will give information about the case company of the thesis and help with understanding what solutions they bring to the market and the machines they use for it.

### 2.1 General information

Founded: 1993

Address: Teollisuustie 6, Siilinjärvi, 71800, Finland

Website: [www.crosswrap.com](http://www.crosswrap.com)

Key executives:

Ms. Satu Kivelä

**CEO&MD**

Kalle Kivellä

**Founder and Sales Director**

Mr. Heikki Jyrkinen

**Sales Director and Head of Sales Team**

"Cross Wrap Oy Ltd. Manufactures automatic wrapping machines and bale openers for the waste industry, including RDF, SRF, MSW and recyclables (Crosswrap Oy, 2019)". They focus on providing excellent solutions for wrapping, storing, transporting, opening, de-wiring and packaging material bales and finished products. As they represent the make-to-order working principle and the complexity of the device manufacturing they do not have a constant turnover as many businesses in machine production. Their statistics are presented by the amount of machinery sold and the diversity of the orders. They have built, delivered and installed 500 machines serving clients in 55 countries with orders being completed at the same time as the thesis work. (Crosswrap Oy, 2019.)

### 2.2 CrossWrap solutions

Cross Wrap machines are built to solve an array of different problems inside the waste treatment industry. They offer solutions in four directions of material treatment, as described on the Cross-Wrap website (2019):

#### **Bale wrapping**

A comfortable way of transporting bales to minimize littering and pollution. Cross wrap uses its unique "all sides covered" wrapping method. The wrappers are compatible with all balers and with all bale sizes. Compatible with over 23 different baler brands.

#### **Bale opening**

Can often be a difficult task and tedious as well. The bale openers cut film and bale wires automatically, safely removing them from the baled material and making a bundle from it that is easy to handle.

#### **De-wiring**

The process of removing steel wires and plastic straps automatically, reliably and safely. The wires are formed into small and tight bundles for easy recycling.

### **Board packing**

Very common operation that is performed automatically and packs a variety of stacked board sizes, all on the same line. The method of wrapping is innovative, efficient using only stretch film. No straps or corners required.

## **2.3 Produced Machines**

For the solutions that CrossWrap offers it builds and assembles their own machines. All of them have their specific field of work inside the waste treatment industry. They produce the following machines, as described on the CrossWrap website (2019):

### **CW 2200 Bale Wrapper**

A fully automatic bale wrapper. It is compatible with all bale sizes and they offer an industry-leading 80-tonn-per-hour capacity. It specializes on wrapping RDF and SRF materials reliably.

### **CW3600 Bale Opener**

Bale openers enable safety and reliability into opening and loading of rectangular and round bales. Machine can automatically open wrapped bales.

### **CW De-wiring Machine**

Automatically and safely removes steel bale wires. Can have an in-feed and out-feed conveyors.

### **CW Direct Bale Wrapper**

Has the same functionality as the CW 2200 Bale Wrapper but equipped with a funnel through which the waste is fed to the machine. It is litter-free with minimum bale conveying.

### **CW Packing Line**

The board packing line insures protection of boards against multiple handlings.

## **2.4 CW2500 Packing line**

CW2500 is a fully automatic CW Board Packing Machine that is designed for packing boards with an efficient system (Figure 1). The machine closes the packages tightly from six sides using special stretch film. No straps, covers or bottom pallets need to be used. (Crosswrap Oy, 2019.)

"Electrically operated machine is an efficient all-in-one solution for industrial packaging needs. It suits well for any boards such as plywood, veneers, MDF, OSB, plasterboards, doors, fibrocement boards, particleboards and many more! (Crosswrap Oy, 2019, Brochure)".



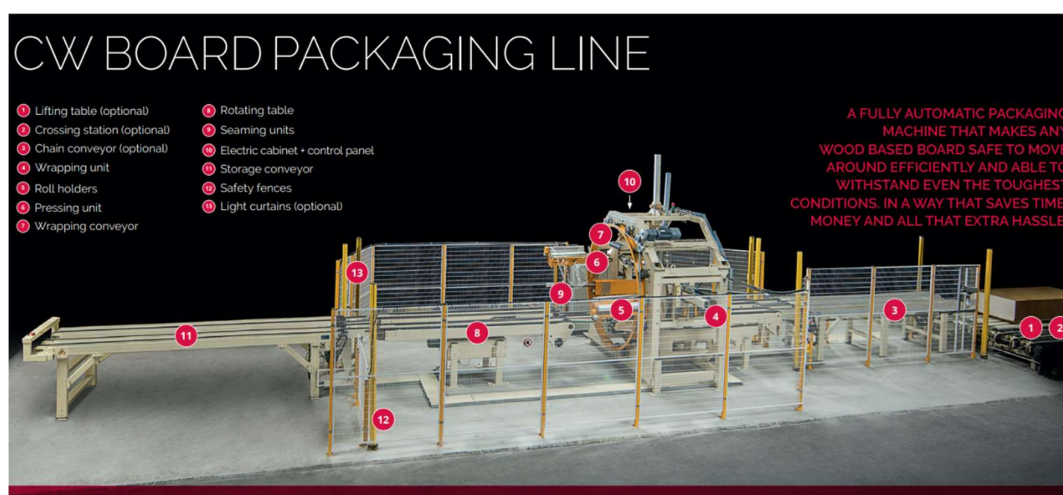


Figure 1. CW Board Packing line components. (Crosswrap Oy, Brochure, 2019)

The packing line consists from the following operating units, as described on the CrossWrap website (2019):

### **Wrapping unit**

Packs board stacks of different sizes without manual operations. There are three crosswise wrapping stages to ensure durability and keeping the bottom skids in place. The film consumption is controlled and can be adjusted.

### **Roll holders**

They are responsible for film control during the wrapping process. There are 1-2 roll holders (depending on production volume) and three stretching options.

### **Pressing unit**

It holds the board stack together. It holds the stack firmly together starting at the beginning of the wrapping cycle. Optimal use with thin materials such as veneer.

### **Wrapping conveyor**

Ensures accurate positioning of the board packs during the wrapping process. It is equipped with a smooth start & stop feature.

### **Rotation table**

Enables an accurate horizontal wrapping of board packs. Closes the package and strengthens the package sides.

### **Seaming unit**

It is responsible for seaming the final layers of film together at the end of the wrapping cycle.

**Electric cabinet + Control panel**

Is used to set programs for wrapping different sizes of board packs and adjusting the process for your needs. It is equipped with a touch screen with a user-friendly interface. The minimum protection class is IP (Ingress Protection) 54 depending on customer needs. Profinet is a communication protocol, and Profibus makes the customization. The system can connect to the internet that gives the ability to control, monitor and modify the settings remotely.

**Storage Conveyor**

Transports the packages to the storage area. The dimension of the conveyer may vary and turning or lifting table options can be added.

**Safety Fences**

Protect the users from the working space inside the machine. The fence is equipped with interlocked system and transparent impact glass.

**Light curtains (Optional)**

They enable the safe connection of the wrapping line and the existing production line. They prevent access to hazardous areas and human injuries.

**Lifting table (Optional)**

It is used to lift the board stack to the level of the wrapping unit from the height of the existing production line. It can be equipped with a chain and roll conveyor.

**Crossing station (Optional)**

Directs the board package to the correct wrapping direction. Can have rubber covered chains.

**Chain conveyor (Optional)**

Increases production with its buffering feature if situated before the wrapping unit. The dimensions of the conveyor can vary according to package size. Also has a smooth start & stop feature. Can be equipped with an automatic or semi-automatic bottom skid feeding.

### 3 PROBLEM DEFINITION

This section will talk about how the thesis work was found. It will also cover the scope of the project and how the problem has formed within the company.

#### 3.1 Work division in the company

Crosswrap is a company with many completed orders and quite a few machines that they produce, but the amount of their staff is not very big. The company has 3 automation engineers, 5 mechanical engineers and a business marketing team. The business team and representative staff are active all year round traveling to business events. The automation engineers are the heart of the machine deployment, as soon as the tuning of the control panel interface is ready. They make sure that the system works correctly and make modifications for every order. The mechanical engineers are moderately busy during the year with new ideas and design modifications, which include testing and prototyping.

#### 3.2 Root cause of the problem

The problem has occurred with the documentation of the new features of the machine. When new modifications were made, they were not written in or badly phrased in English, which made the instructions hard to read and understand. Some parts of the manual are made like draft notes and left in the manual.

The latest order for the company was a few board packing machines. The maintenance manual for it was in a very bad condition and not up to date. It was based almost entirely on the wrapping machine. Most parts were taken without change directly to the manual.

#### 3.3 Defining tasks for problem-solving

The MM needed a technical update as well as a structural update. This was the thesis task. The progress of writing the MM was supervised by CrossWrap representative.

The schedule was set for mid/end of march. That is when the first machine would be assembled and ready for use at its destination point in Russia. The author was sending updates to the company's newly hired documentation engineer. He was the main engineer for the task, and changes or new ideas to the manual were made according to his guidance.

#### 3.4 Schedule Estimation

A preliminary schedule for the thesis was stated at the beginning of the thesis, but the final plan was changed to the machine deployment and installation schedule (Figure 2). MM needed to be ready to a semi-finished state before the launch of the first machine. That was the main idea

forming the work schedule. The thesis writer reported to the company representative every two weeks with the completed progress.

Product size	Contract signed by	Advance payment paid by	Loading date in Finland	Installation & commissioning start	Launch
4x8	week 39/2018	week 40/2018	week 6/2019	week 9/2019	week 12/2019
4x8, 5x10	week 39/2018	week 40/2018	week 9/2019	week 11/2019	week 14/2019
4x8, 5x10	week 40/2018	week 41/2018	week 12/2019	week 15/2019	week 18/2019
5x5	week 40/2018	week 41/2018	week 14/2019	week 17/2019	week 20/2019

Figure 2. Timetable of deadlines for board packing machine deployment. (Happonen, 2019)

## 4 MAINTENANCE

This section will analyze the meaning of maintenance and see how its meaning should be updated over the years to be as accurate as possible. It will show the importance of maintenance for companies from a financial and a quality point of view. It will show how important maintenance is and why it should not be neglected.

### 4.1 Maintenance definition

As this thesis revolves around the word "maintenance" very often, it is there for a necessity to analyze the topic and have a clearly defined idea on it before proceeding forward.

Fundamentally maintenance is a "combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (SFS-EN 13306:2017)".

Even if fundamentally maintenance is what the SFS-EN 13306:2017 states, there are a few additional ideas that are important to mention. The actions described should not only retain and restore but also improve and enhance the reliability and effectivity of workshop machines. The scope of performed operation should be broadened to fulfil the expectations of modern maintenance. It must include more operations, such as safety management, lifecycle management, identifying and improving weaknesses, maintaining operational performance and monitoring production quality (Juho Selin, 2014, p.9.)

### 4.2 Importance of maintenance

Around 20-30 years ago middle and corporate level management ignored the importance of maintenance and its effect on product quality and production costs. It was considered as a necessary evil rather than a way to lower the cost, increase productivity and lower the maintaining costs. (Mobley, 2004, p.2.)

Since frequently maintenance results that influence different indicators of production are not monitored, all the merits go to the departments where improvements are recognized. Maintenance plays an important role in a company's ability to compete. "Also, when looking at maintenance expenditure's effect on profits, it has been concluded that a reduction of 1 million in maintenance expenses contributes as much to profits as increasing sales by 3 million (Juho Selin, 2014, p.10)". In addition, maintenance can also improve quality of manufactured products, lower the average defect rate and extend the life time of machines. (Juho Selin, 2014, p.10.)

Very often updating a maintenance program can significantly decrease the total life-cycle maintenance cost. Revision of American Navy ships maintenance program has decreased costs by 15% and

some ships were able to serve reliably for 8-10 years after their expected life time. (Smith and Hinchcliffe, 2004.)

## 5 MAINTENANCE DIVISIONS

### 5.1 Types of maintenance

Inside the SFS-EN 13306:2017 standard we can find how maintenance is divided into maintenance types. There are a few parameters for maintenance division. The first tree diagram shows us two main parameters of maintenance division (Figure 3). First is, changes made or not made to intrinsic dependability characteristics. Second is, maintenance performed before or after failure.

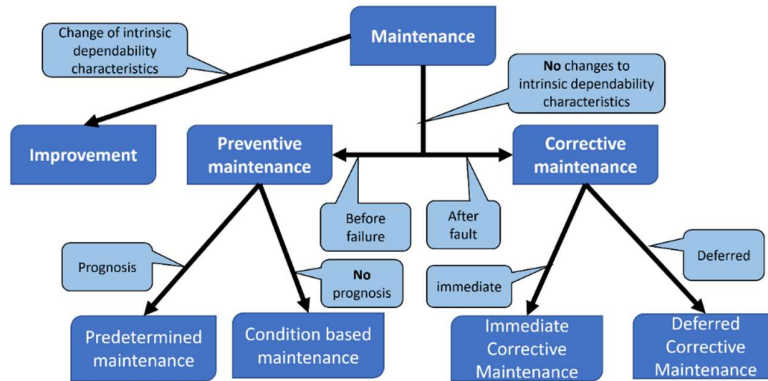


Figure 3. Maintenance divisions (Sosipatrov, 2019)

As a different type of division, we can also see a tree diagram where the maintenance division is done according to the action being Scheduled or unscheduled and preventive/before failure or corrective/after failure. (Figure 4)

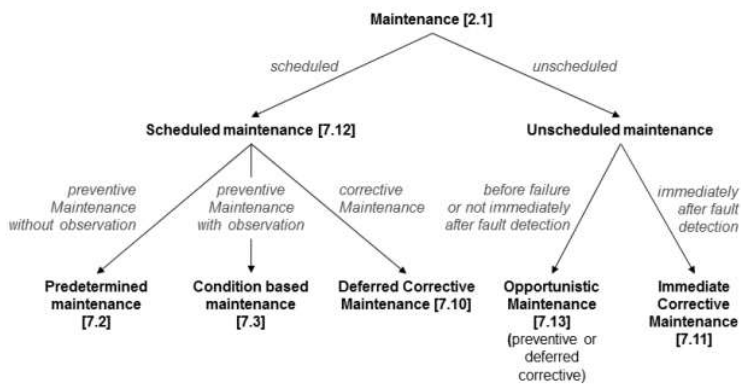


Figure A.2 — Scheduled versus unscheduled maintenance

Figure 4. Scheduled and unscheduled maintenance deviation (SFS-EN 13306, 2017)

#### 5.1.1 Improvement maintenance

As shown in Figure 3, IM is characterized in the SFS-EN 13306:2017 standard as a "combination of actions, not only technical, but also administrative and managerial, intended to improve reliability or maintainability, without changing the original function of a machine or part (SFS-EN 13306:2017)".

IM strives to identify repeating faults and seek their root cause to eliminate the possibility of their recurrence. This is often done by redesigning of an existing machine/part or rethinking of the existing process which it is part of. For improvement to be made a fault or a series of faults need to occur or a goal for increasing the efficiency should be set to find bottlenecks of the machine operation. (Juho Selin, 2014, p.10.)

### 5.1.2 Corrective maintenance

As shown in Figure 3, corrective maintenance is a process that does not change internal reliability characteristics, and which is done after the fault has accrued.

In the terminology of the SFS-EN 13306:2017 standard CM is explained as, "maintenance carried out after fault recognition and intended to restore an item into a state in which it can perform a required function (SFS-EN 13306:2017)".

CM is the simplest approach to maintenance. Once a fault is found, it is fixed and forgotten about until the next time it breaks. Making the action intellectually effortless, has concaveness on production capacity, leads to high spare part inventory and high overtime labor amounts. This indicates that there are almost no companies that have a full CM strategy and if it is installed it indicates poor maintenance planning. On the other hand, "sometimes CM is the only reasonable procedure to employ. All the faults can't be foreseen, which leaves corrective maintenance the only available option. Secondly, at times, replacing a worn part before a fault occurs is not necessarily the most economical option. This is the case when a fault will only cause a minor disturbance to the capacity utilization rate or machine is of low value to the company (Juho Selin, 2014, p.10)".

### 5.1.3 Preventive maintenance

Preventive maintenance is defined by the SFS-EN 13306:2017 standard as, "maintenance carried out intended to assess and/or to mitigate degradation and reduce the probability of failure of an item (SFS-EN 13306:2017)". This definition states, that PM is a pre-emptive action, that either predicts the servicing times and schedules them appropriately or repelled by the condition of a machine or part to notice the failure before it happens. This makes PM time or condition driven. (SFS-EN 13306:2017.)

"The process consists of four main elements: maintaining operational conditions, inspections, planned repairs and modernization. These elements comprise of regular procedures such as tracking and inspection of fault producing causes, lubrication servicing, structural maintenance, uphold of clean operating conditions and pre-planned repairing of machine (Juho Selin, 2014, p.10.)". It is a better decision to spend money on preventive maintenance, if forecasting the faults is less expensive than fixing them upon their occurrence. The maintenance strategy does not have to be 100% PM. CM situations will occur on their own. The servicing should always hold that in mind (Juho Selin, 2014, p.10.)



## 6 INSTRUCTION MANUAL

### 6.1 General information

Communication between different steps of product manufacturing is very important in device and machine development. It needs to be timely and informative. This is needed for creating a logical and thorough instruction manual.

An instructional manual by the information from Collins Dictionary is "a booklet or book, usually accompanying an appliance, device, computer game or vehicle, which contains written guidelines informing how to use it (Collins English Dictionary, 2019)".

Instructional manuals which are also called users guides or owner's manual (usually car exploitation manual) are very important in the lifecycle of complex devices. Size and thoroughness of the instruction is directly connected with the amount of device/apparatus parts and their interconnection with each other. Many machines in today's production need detailed instruction of their assembly, use and maintenance.

### 6.2 Examples of user manuals in the past

Instruction manuals took different forms and to this day they are available in many variations. They take many forms, use different methods of conveying information, convey instructional information to an array of people from different parts of the product lifecycle not only from the field of technology or production. Manuals are not something new or even recent. There are simple manuals that date back for at least two centuries. (Schumacher, 2018.)

"The earliest instruction manual that Bridgman found during his tenure was attached to a machine made by famous engineer James Watt (Figure 5). But the machine wasn't a steam engine: it was an office copier. Watt realized that copies of his letters would be very useful to others and so he invented a machine that transferred damp ink from a freshly written letter to another sheet of paper, creating a copy of it (Schumacher, 2018)".

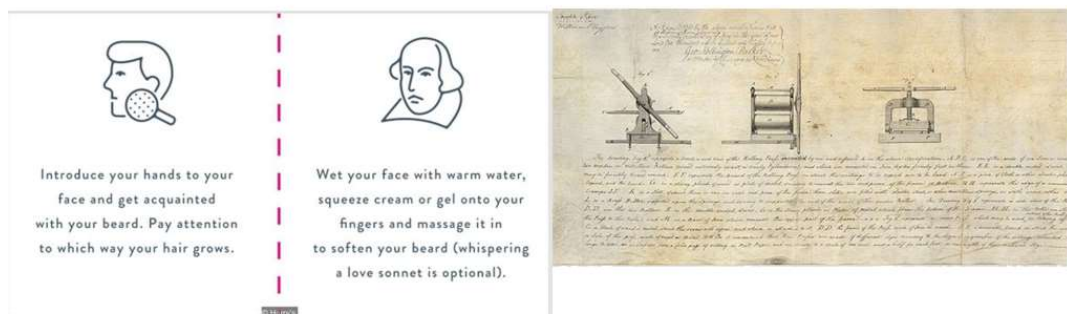


Figure 5. James Watt's office copier (on the right), Kodak Box Brownie camera (on the left) (Schumacher, 2018)

Another example of an early age manual is an instruction for Kodak Box Brownie camera (Figure 5). It didn't only tell you how to prepare the camera for taking a picture, but also helped you with how to take photos in a professional manner. (Schumacher, 2018.)

A harder job for a manual is to explain a complex machine in a simple and understandable manner, which is well accomplished by car user guides. They are extremely popular and know even to individuals that have no interest in vehicles. A very popular company making vehicle and other manuals a couple of decades ago was Haynes. Their manuals surprised users with their high-quality technical advice that is easy to understand and practical to use. The secret to their success is detailed technical drawings and in-depth instructions on testing, repair and maintenance, which are accompanied by photographs. (Schumacher, 2018.)

### 6.3 Writing a good user's manual

Every text and every instruction should have a good form. The information is useful and easy to learn if it has a good structure that gives a visual representation of its logic. There are a few general guidelines that should be followed when making a user's manual:

1. It is good to present instructions as step-by-step procedures
2. Tell the user what functions there are and what they are for as supporting information after explaining how to use them
3. Writers are part of the design team
4. Write the manual in sync with the product development process
5. Write the manual with full access to the product and full understanding of its work

One of the important nuances of manual writing is the use of right keywords and giving an understandable structure that would help the user find the information he needs. The following steps would make the manual more user friendly:

1. Divide the text into sections that are organized by: functionality, chronology of use and the frequency of use, etc.
2. Organize information hierarchically
3. Avoid unnecessary cross-referencing to other parts of the user manual
4. Visually point out the stepping stones
5. Lengthy paragraphs should be avoided
6. Do not assume that the user has prior experience or product knowledge (Hodgson, 2007.)

### 6.4 Maintenance manual

A crucial and a very useful part of many instruction manuals is their MM. It is a good way to systemize and plan the maintenance of your machine, doing the maintenance in a well-organized manner

and on a regular basis. As a result, the MM helps to prolong the lifetime of device parts, efficiency of work and optimize upkeeping costs. (Inspecta, 2019.)

Reading the MM is the second important step after obtaining a product. The first is doing the assembly right. As reading the MM is the second most important step its quality might be neglected but should not. It is important that the writer of the maintenance manual is familiar with the technical aspect of the product, its design, production and assembly, and knows how to present the information to the customer group. In complex machinery it is helpful to use a second-party writer. Because he is less familiar with the machine, he understands the point of view of the customers better. This is crucial for the manuals clarity and reading ease. A good maintenance manual needs to also have plenty of pictures for every part it is describing. The user is new to the product and this will be most effective to teach and to visualize the entire device and its parts.

## 7 MANUAL RE-DESIGNING PROCESS

This chapter will talk about the steps that need to be taken for solving the problem and creating a clear and well-managed maintenance manual. The chapter will include the following steps for identifying important background information and using it along with the theory analyzed earlier to re-structure the manual:

1. Revising the manual state
2. Gathering information from Crosswrap
3. Inspecting the state of the machine
4. Applying changes to the manual

### 7.1 Manual state revision

The first task on the list was to analyze the state of the maintenance manual when starting the thesis project.

It was an eleven-page manual that:

1. Consisted of only text, with hard to define topics
2. Needed detailed prerequisite knowledge of the device
3. Did not create/have a clear picture of the packing line
4. Had outdated information about the machine systems

Only the additional reading of the installation manual helped to understand the form of the full device. The manual was informative, but some of the actions needed to be explained in detail. In addition, when looking through the user's guide for assembly and use, it was very hard to understand how to operate the command panel and the explanations were making the manual for it more complex than it should be.

### 7.2 Gathering information from Crosswrap

This is an important stage to have in order to write an accurate maintenance manual. Mostly all the information had to be gained through the company, because there was not a lot of information available to the public eye. The information needed for the writing process was obtained gradually and the visit to the assembly station was held quite some time after first changes were applied to the manual.

#### 7.2.1 Companies wishes

In the beginning stages there were a few meetings about the possible tasks, that could be chosen for the thesis topic. Once the topic of the maintenance manual was picked the manual was received from the company and needed to be read through. The maintenance manual was studied along with the assembly manual and their translation into Russian. After that another meeting was held where the work plan was discussed and goals for the project were set. Some objectives were set for the manual improvement:

1. Pictures showing every unit
2. Putting the maintenance description right under the servicing interval table for every unit
3. Rephrasing and an in-depth explanation of every servicing action
4. Removing the servicing of non-existing parts

These objectives were preliminary, but the main part of the work. A little after, the final meeting was organized with the addition of a supervising teacher from Savonia and the following objectives were added:

5. Photos showing specific unit part maintenance should be added right after the text
6. The seeming-gripping unit needs a more detailed description

### 7.2.2 Information on the machine development process

To understand the machine better, a clear knowledge of its production process needs to be obtained. The main points to be learned are:

1. Where is the machine produced?

Machine is assembled, parts welded and painted at a special workshop in Kajaani. The parts are delivered from different manufacturers. The workshop is a big hangar where multiple companies produce their parts and machines. It is a quite chaotic from the point workplace organization, which is hard to fix with such a big amount of different companies. After it is assembled and tested for malfunctions and a full program is run through it is also used for teaching the future team that will be servicing the machine how to do it and what are the main functions of the machine. After all these steps are completed, the machine is disassembled into smaller parts and transported to its destination. Since the assembly process is not that easy. Usually the company sends their own mechanics to assemble and teaches the buyer's maintenance personal.

2. How are the modifications tested and implemented?

A team of design and automation engineers are working together in Siilinjärvi office. Both engineers can communicate with each other and discuss their views. There is a small workshop garage, around 30 meters long and 10 meters wide for testing new equipment or improvements for the different units of the machine. The garage is not big enough to fit a whole board packing line inside the premises. The automation engineers also make changes to the machine controlling system at the premise with a control panel at the office. This should support good information communication and keeping the whole development unit constantly updated.

3. What is the process of innovation work documentation?

When the engineers are working on an improvement it is usually a process of creating and a form of trial and error, which usually gets documented mostly in the form of a 3D model and sometimes as a text in the user's guide. But the quality of the description could be low due to rapid documentation. Automation engineers change their text regularly, but also not all the time perfectly.

### 7.3 Machine inspection

A very important part for getting this instructional manual ready was to visit the production and assembly facility located in Kajaani. This was a very important part of the process of writing the manual. It was needed to understand how the machine works and go through every unit of the machine to identify step by step how the procedures needed to be done.

The key objectives for the manufacturing/assembly site were:

#### **Examine the machine's current state**

When arriving to the workshop every part of the machine was quickly examined to compare the text to the real unit. Nothing new was found the machine looked as previously described. To fully grasp an in-depth idea on every part of a unit a servicing person for the machine is necessary.

#### **Make changes by going through every unit description in the manual**

English and Russian manuals were used side by side during the examination to see, if any statement in the translation is false or conveys information differently. Starting from the wrapping ring every unit was thoroughly examined. In addition to finding some badly phrased information it was noticed, that the hydraulic system was totally removed from the entire machine but was still in the maintenance instruction. At times the translated version had more distinctive and correct phrasing, which was translated to the manual immediately. New procedures were created after analyzing every unit. Rough notes were created and used in the later stages of maintenance manual writing.

### 7.4 Summarizing the knowledge learned

After analyzing the manual writing theory and examples of common practices from different product types the author came to the following conclusions:

1. Maintenance manual has instructions that can be classified as Preventive maintenance by maintenance type and is a preventive activity, that does the diagnosis of degradation. In it the following tasks are implemented:
  - a. Monitoring, noninvasive inspection
  - b. Examination, internal inspection

2. Using only text could be enough for simple instructions of a familiar device, but for a complex device, there is a need for the illustration of the entire unit and joining point of parts or mechanisms. The manual is going to have many pictures.
3. The MM is written with the perspective and help of all the personnel from every point of machine development.
4. MM needs a hierarchical system for machine units
5. MM needs step-be-step instruction for every unit
6. When MM is approached by a person that is not familiar with it or the machine, he is the best for identifying its flaws in explanation and level of needed detailing.

#### 7.5 Applying changes to the manual

After hearing out the needs of the company and getting some theoretical background on the task at hand the work on the thesis could start heading towards its final stage. At the beginning stage after analyzing the old manual and getting it in a new shell the author could start his work on applying changes to the manual.

The first modifications to the manual were:

##### **Applying changes to the structure**

The MM had a paragraph that had servicing intervals displayed in a table format and separate paragraphs following it, that described in detail about the servicing tasks. That is a bad method of data structuring. The format was changed. The service intervals were then followed by a description of each interval.

After the visit to the company where the machine unit work was explained and updated notes were made about the function of each unit, the following improvements could be implemented:

##### **Adding more descriptions to maintenance tasks**

Many tasks were intended for experienced users of the machine. Explanations were added to them as well as corrected previously written comments

##### **Adding descriptive pictures for some maintenance tasks**

Especially complicated parts were explained with pictures to avoid misunderstanding among MM future users.

After the changes were made, the manual was sent for revision. The revision from the company came back with additional tasks to do, sentencing of multiple parts of the text to be changed and

technical misunderstanding issues explained. During this final stretch of the work following tasks were completed:

1. A picture where the whole unit could be seen was added after every service interval
2. More than three pictures were added for every unit.  
They were displaying all the needed visual information with added arrows to describe what parts are shown.
3. Almost every service task was written in detail  
To every activity in the service interval table was explained thoroughly to eliminate any possible mistakes from the user.
4. Additional tasks were added to the service interval tables

The company and the thesis writer have reached a decision, on the last meeting, that after all the changes made to MM the objective of the work was reached and its further development can be continued inside the company. The information written by the thesis writer was used and transferred to the main company file. It was agreed, that a single unit maintenance procedure can be shown in the thesis, it will be attached to the appendix. (Appendix A)



## 8 RESULTS

During the thesis process for the case company the Board packing machine was analyzed thoroughly by the thesis writer as well as by the new Documentation Engineer from the company. It helped to detect flaws in the documentation that is situated with the machine. They were corrected and new maintenance procedures were added to the maintenance manual. The manual was also restructured in order to make it easy to read, understand and remember. Part of the restructuring process was to add descriptive pictures to nearly every maintenance procedure and describe the prior in a step-by-step manner.

Conclusions were made on the topic of maintenance importance for efficient and productive manufacturing. It also contributes to increasing the value for the buyer, as well as company's reputation. It could be understood, that if maintenance does not provide benefits to the company, then it is likely to be poorly monitored and its results to be claimed by other departments.

The company has received a final draft version from the thesis writer. That draft was further developed and customized inside the company. The draft was needed in order to have a base on which the company can then further make design changes to the needs of their buyers. After that the work for the company was finished the thesis report was finalized. The company representatives had positive reviews on the accomplished results and were satisfied with the final draft of the maintenance manual.

## 9 CONCLUSION

This thesis process is a good example of how often quite important technological companies on the market can outsource their duties to subcontractors or students, giving them an opportunity to gain experience. That was the ground on which the thesis kicked off.

It is very often when a technology-based company can lack manpower in systematization and documentation departments. The problems arise when enough problems accumulate and start to affect the realization of the product. When the idea for the thesis was being developed, company had to re-evaluate the state of their departments which turned out to be good solution for both parties involved.

The project was very similar to real life working experience. It involved a lot of communication, evaluation and systematic work. The thesis took some job responsibilities from the documentation engineer or made the task easier for him to manage. By accomplishing the objective, the company gained good text and structure for the MM that they can develop further inside the company. The MM became easier to read, got many useful pictures and has updated information on the machine. MM manual could not be fully put into the thesis except for one maintenance instruction for the Rotation table. The schedule was not met, but decent quality for the manual was reached before any complaints from the buyers could arise.

The development process was defined with the company from the beginning and the knowledge gained during the theoretical part of the thesis was use partially. Most of the time personal ideas and companies' feedback/wishes shaped the MM in the end. The work on the manual could be continued further, with the possibility to create instructional videos for the whole maintenance procedure or for every unit separately. The manual can also be transferred to a presentation format to be more interesting and less tiring to read. The idea of a separate check list for all the necessary maintenance tasks was taken out of the thesis scope, due to company's decision and customer feedback on the idea.

## REFERENCES

Mobley. K. R. 2004. Maintenance Fundamentals: 2nd Edition. Kuopio: Savonia UAS; eBook.

Finnish Standards Association. 2017. SFS-EN 13306:2017:en. Available: SFS Online.

Smith. A. M.; Hinchcliffe. G. R. 2004. RCM—Gateway to World Class Maintenance. Kuopio: Savonia UAS; eBook.

Juho Selin. 2014. Design and Execution of Preventive Maintenance Program. Mechanical and Production Engineering. Product Development. Tampere UAS. Thesis. [Accessed 19.04.2019]. Available from: <http://urn.fi/URN:NBN:fi:amk-201405137678>.

Collins English Dictionary. [Accessed 06.05.2019.] Available from: <https://www.collinsdictionary.com/dictionary/english/instruction-manual>.

Schumacher, H. 2018. Inside the world of instruction manuals. [accessed 01.05.2019]. Available from: <http://www.bbc.com/future/story/20180403-inside-the-world-of-instruction-manuals>.

Inspecta – Maintenance manual. [Accessed 09.04.2019]. Available from: <https://www.inspecta.com/en/Our-Services/Technical-Consultancy/Building-services/Maintenance-Manual/>.

Hodgson, P. 04.06.2007 Tips on writing user manuals. [Accessed 12.04.2019]. Available from: <https://www.userfocus.co.uk/articles/usermanuals.html>.

Bloomberg. Overview of Crosswrap Oy Ltd. Company information. [Accessed 15.04.2019]. Available from: <https://www.bloomberg.com/research/stocks/private/people.asp?privcapId=2010976>.

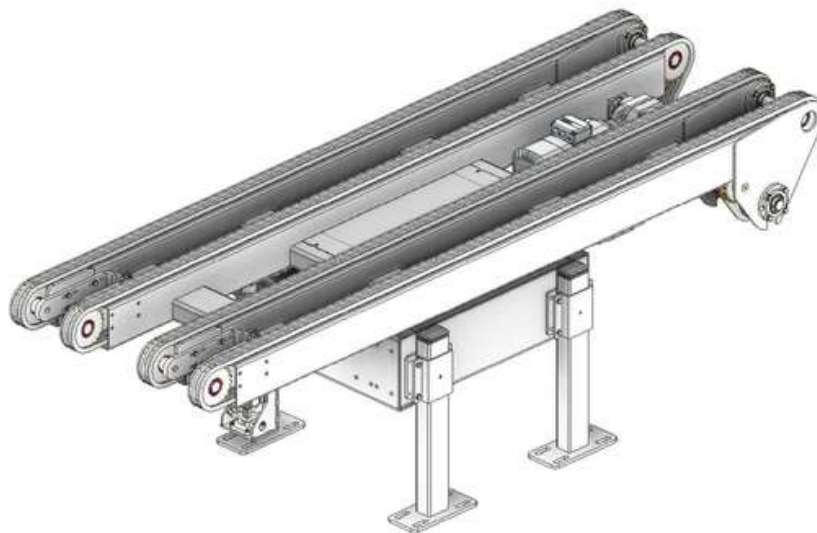
Crosswrap Oy Ltd. Official Crosswrap company. [Accessed 12.03.2019]. Available from: <https://crosswrap.com>.

Crosswrap Oy Ltd. Crosswrap Industrial packing brochure. [Accessed 12.03.2019]. Available from: [https://crosswrap.com/wp-content/uploads/2018/12/Cross\\_Wrap\\_Industrial-packing-brochure-2018.pdf](https://crosswrap.com/wp-content/uploads/2018/12/Cross_Wrap_Industrial-packing-brochure-2018.pdf)

## APPENDIX A: ROTATION TABLE SERVICING INTERVALS

**2.2.4 Rotation table**

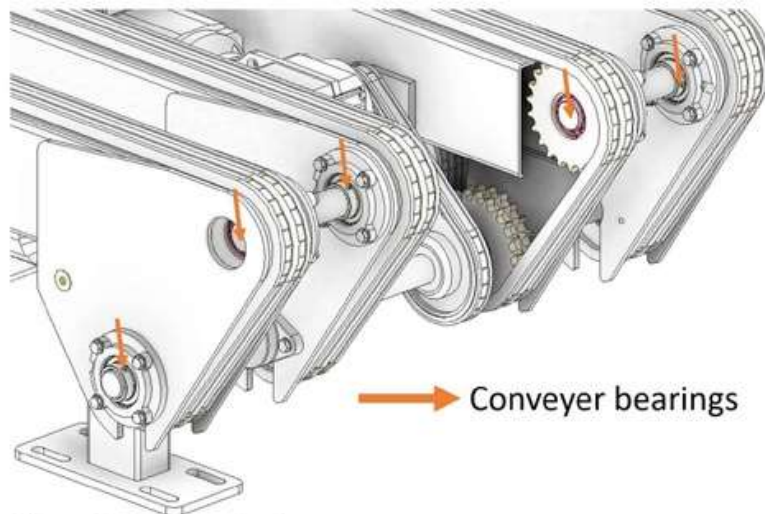
Action	Service interval	Duration (minutes)	Note!
1. Cleaning.	Daily	6	Pressurized air
2. Grease bearings.	Monthly	6	Universal grease
3. Check the chain adjustment and condition.		6	
4. Check bearings.		6	
5. Check chain slides.		6	
6. Grease slewing ring.		6	Universal grease
7. Check turning motor clearance.		12	0,18-0,24 mm
8. Change chains.	Every 5 years	60	If necessary
9. Change chain slides.		120	
10. Change electrical motors.		60	If necessary

*Picture 27. Rotation table.***1. Cleaning (Daily).**

Clean the dust and dirt away from the unit daily.

**2. Grease bearings (Monthly).**

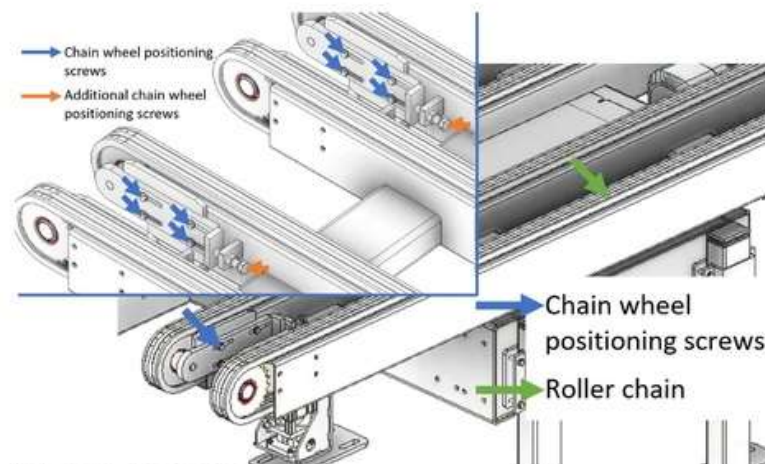
Grease conveyer bearings after every 3,000 hours of operation or at least once every six months. All the bearings are situated on the edges of the rotation table (Picture 27).



Picture 28. Conveyer bearings.

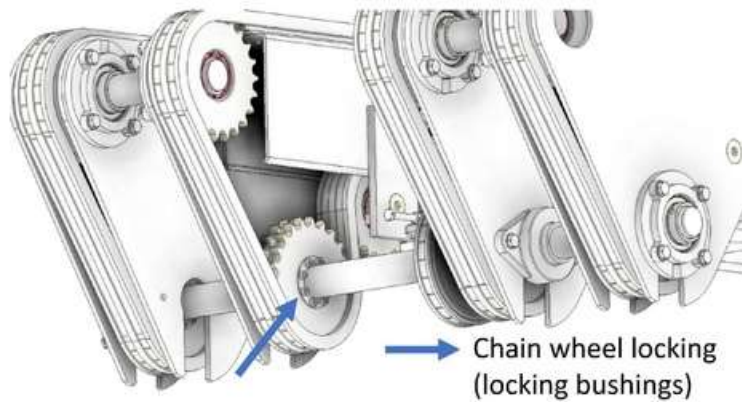
### 3. Check the chain adjustment and condition (Monthly).

Check the roller chain tension and adjust, if necessary. To check the chain tension, you need to lift it up in the middle of the conveyor, if it can be lifted around 40mm the chain tension is good. Roller chain tension is adjusted by moving the chain wheels of the conveyor with four adjuster screws for each wheel. Another bolt makes small adjustments to the tension which pushes the plate held by adjusted screws (Picture 28).



Picture 29. Chain adjustment

Ensure that the chain wheel locking has not got loose (Picture 29). Tighten the screws in the locking bushings to 41 Nm in order (not crisscross).



Picture 30. Chain wheel locking

#### 4. Check bearings (Monthly).

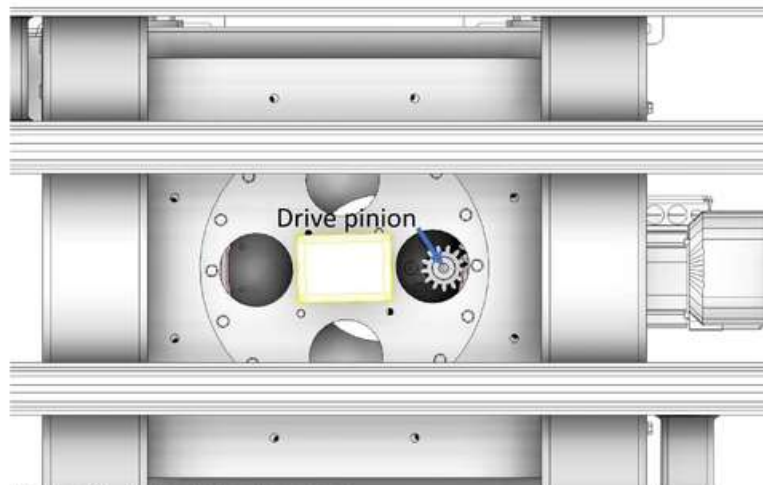
Bearings should be checked for wear or damage when greasing is performed. Any physical deformation indicate that it should be changed. Any unusual sounds coming from the bearings indicate that they should also be checked or examined.

#### 5. Check chain slides (Monthly).

Check chain slides under the roller chain for any damage to the integrity of the part, replace if necessary.

#### 6. Grease slewing ring (Monthly).

Grease slewing ring (4 lubrication nipples and teething) every 500 hours. Inspect fixing screw torque every 500 hours (8.8 screw, M12=65Nm, M16=165Nm). Check the clearance between drive pinion and raceway (0.18-0.24mm) (Picture 30).

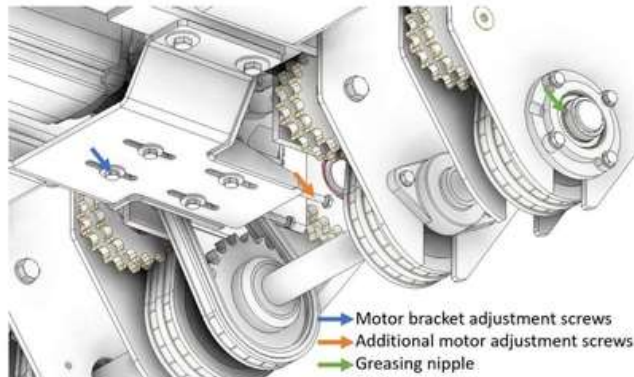


Picture 31. Drive pinion clearance.

#### 7. Check turning motor clearance (Monthly).

Check the drive chain tension of the chain drive and, if necessary, adjust. The chain tension is adjusted by moving the motor in its mounting bracket. In case of sagging of the drive chain,

release the screws in the mounting bracket, move the motor and tighten them back. Two bolts on the side of the motor are used to tighten it after locking it in the bed. Lock down the adjustment with the screws in the mounting bracket (Picture 28).



Picture 32. Drive chain adjustment.

#### **8. Change chains (Every 5 Years).**

Chains should be changed every five years or upon finding crucial defects or malfunctions. Loosen the chain tension before dismantling.

#### **9. Change chain slides (Every 5 Years).**

If the chain touches any of the bottom bolts the slides need to be changed. Take off the roller chain before dismantling the slides.

#### **10. Change electrical motors (Every 5 Years).**

Change the electrical motors in case of defects, efficiency drop and every 5 years.