Maintenance role in the company’s business
A case study at Strålfors

Underhållets roll i företagets verksamhet
En fallstudie hos Strålfors

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Abstract

In today’s market, the companies have a lot of demands from the customers. These demands involve such things like faster deliveries, cheaper products, etc. To be able to deal with these demands, the company has to have a smooth and efficient production without unnecessary unplanned stoppages.

In this thesis, we show how to work with the maintenance so it will help the company with the higher demands. To be successful in the maintenance work, it has to be well organized and systematic to achieve the goals. The management’s engagement is really important, both to motivate and support their workers to work with continuous improvements.

The maintenance work affects many different aspect of the company, like quality, LCC and availability.

We are also showing how the company can choose suitable maintenance software, for their type of business.

Key Words:
Maintenance, Overall equipment effectiveness, maintenance software, TPM

Sammanfattning

Företag har många olika krav på sig, på dagens marknad. Dessa krav handlar om såna saker, som kortare leveranstider, billigare produkter, etc. Företagen måste ha en säker och effektiv produktion utan onödiga oplanerade stopp, för att kunna handskas med dessa krav.


Underhållet påverkar många delar av företaget, som kvalité, livstidskostnad och tillgänglighet.

Vi kommer också att visa hur ett företag kan välja en programvara för underhålls arbetet, som passar deras tillverkning.

Nyckelord:
Underhåll, Total utrustnings effektivitet, programvara för underhåll, TPU
**Preface**

In this preface we would like to thank the persons, who have assisted us while we have written this diploma work in Terotechnology.

We are very grateful for the help we got from our two tutors at the company, Bo Westlin and Lars Carlsson, and the other people at the company, who helped us by answering our questions, showing us around and giving us needed materials for our study.

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Summary
A well-functioning maintenance is one of the most important things in a production company. It takes a lot of engagement, knowledge and understanding from everyone in the company, if the maintenance is going to work in an efficient way. There are many things that have to be considered, like cooperation between the departments and improvements and the management engagement. Every change has to be established firmly, from the management to the worker at the machine. Well educated workers, which know what they are doing and get feedback from the management, are more motivated to learn new things.

The maintenance has to make the production smoother with fewer stoppages, less scrap and less irritation. But it can’t cost too much money and can’t disturb the production or deteriorate quality.

We try to find a way to improve the maintenance in our case company and find a computer based maintenance system software. There are a couple of criteria to consider making a good choice. We think that the problem with bad working maintenance can be found in many companies and that it is often a question of bad organization, lack of cooperation between departments and economical limits.

We analyze the current maintenance system and the maintenance department; we look at how they report the failures, the management’s engagement, and improvement work and how to handle and collect data. We suggest that a foreman for the maintenance department is employed to divide the work and receive the report of failures. We also come up with important things to consider when choosing a computer based maintenance system software. The machine operators are very experienced and that knowledge could be used by starting improvement groups and we also think that they can do more maintenance work if they get some education. There has to be more detailed instructions of the operator’s maintenance task and every thing has to be signed in a list or in a computer program. We think that the management should show much more engagement; especially when changes are made or the personnel are coming up with suggestions for improvement.
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1. Introduction
In this chapter we are going to explain the background. We are going to describe our problem, purpose and limitations. We are also going to show the time plan for our work.

1.1 Background
In today’s industries every cost is important to investigate and see if it can be reduced. If that is possible, the end product gets cheaper to produce which leads to lower price for the customers and better reputation on the market. By investigating the costs, the company can find the machines that have high maintenance costs. Machines, with high maintenance costs, maybe should be replaced with new ones, which may save money for the company. In order to know if a replacement would save money, the company should investigate this, according to economical and production related terms. The demands are getting higher and higher on the manufacturing systems, so an efficient maintenance situation is needed. (Al-Najjar & Alsyouf, 2000)

The manufacturing systems are getting more complicated and if the company wants to compete on the market, they have to maintain their system. This is no easy task, but it is important to do, according to Al-Najjar & Alsyouf, (2000).

The terms for the producing companies are reliability and availability, just to mention a few. These are depending on the maintenance system, in order to develop in a positive way. Within the companies there are connections between quality, logistics, production and maintenance. The maintenance approach affects the company, in different ways. If the maintenance work now focuses on repairs, the possibility to change the way of working is many. (Al-Najjar & Alsyouf, 2000)

The maintenance is something that shouldn’t cost anything but should generate in less stoppages and increased availability and quality. This is what some company managers think, according to Al-Najjar, (2001), but in the reality the company has to invest money in a working maintenance to be able to see the positive changes in the production. It’s not an easy job to convince the managers to invest in something that are seen just as a cost for the company. A change in the way of working with maintenance can take a long time to see, it depends on the availability of historic data, present data and other things. (Al-Najjar, 2001)

To do no preventive maintenance at all and only concentrate on repairs is what the break down maintenance is all about. This strategy for maintenance can create higher costs and longer stoppages. With the higher demands from the customers the company has to have a smooth production, without unplanned stoppages. (Johansson, 1997)

1.2 Problem discussion
Almost every company needs some kind of maintenance. The strategy for the maintenance has to consider what the company needs, in order to be efficient. The road from repair-focus to a better-suited strategy is filled with processes. These processes help the company to evaluate the current situation. One process is to gather relevant data, this could be by interviews or by observations. (Johansson, 1997)
A company is probably struggling with a lot of minor problems, which affects the effectiveness. It could be that there is not enough time to prevent these problems to occur or that the staff is uneducated or that the manager is not willing to invest money, this list can be very long if we should write every reason behind a bad working maintenance strategy. (Al-Najjar&Alsyouf, 2000)

The breakdown maintenance, which focus on repairs, is many times consider to be inefficient in both economical and production aspects. This can’t be decided until an economical investigation has taken place. In some cases the breakdown maintenance can be the most cost effective. (Johansson, 1997)

The maintenance work is very important, but it should try to affect the production time as little as possible. That’s why the integration between the departments is so important. The work has to be scheduled and carried out, because a failure stoppage costs more and can take longer time than a scheduled stoppage for maintenance. (Sherwin&Bossche, 1993)

In the maintenance work, there are many things to keep in order. These things can be scheduled services, exchange dates for components and historical data. To make these job easier, maintenance systems has been developed. These systems are computer based and contain a lot of different functions. Every company needs to consider what the different systems can help them with and how easy they are to use. This is an investment for the company, which demands an investigation before the purchase is done. (Johansson, 1997)

1.3 Problem presentation
Our problem is to see if the maintenance work can be done more efficient. The maintenance job shouldn’t disturb the production so it has to be planned in advance. To simplify the maintenance work, we are also going to look on how to select maintenance software that can make the job easier.

1.4 Problem formulation
We are going to analyze the current maintenance situation and give suggestions to improvements. Our problem formulation is based upon these two questions:
1. How should the steps for a change in the maintenance work look like?
2. How should a company select maintenance software?

1.5 Purpose
The purpose behind this study is to highlight different aspects about working with maintenance. We want to show a suggestion, for developing a company’s maintenance by making the problems and their reasons visible. We also investigate if maintenance software can be at help in the maintenance work.

1.6 Relevance
We think that this study is important, because a lot of manufacturing industries, we have visited during our studies at Terotechnology program and according to Ljungberg, (2000), have a poor maintenance and has the attitude that maintenance work steals production time and that all stoppages are negative (both planned and unplanned). We want to show how an evaluation of the present situation is done and how a change in maintenance strategy can be developed, with the aspects of quality
and cost effectiveness. We also want to show how companies can choose a maintenance software.

1.7 Limitations
We chose a company, where we were given the ability to study their way of working with maintenance in detail. This work takes a long time and we only have one semester, so we chosen to make a detailed study on one production line within this company. We couldn’t test and implement the model, because it would take a lot of time and money but it is important to do.

1.8 Time frame
2. Methodology
In this chapter we are going to explain and present the different types of research methods. To get the highest possible validity, the usages of good research methodologies are very important. The research methodologies also show how we have performed our studies at our case company. In the last subchapter we are going to show which methodologies we have used.

2.1 Methods to collect data
Here we are going to describe three different methods to collecting data, these three basic methods are; interviews, observations and experimentation. When you collect data you have to understand the differences between primary and secondary data.

2.1.1 Different types of data
The data, that is collected by the researcher is called primary data and is necessary when there is no data available from the past. It’s often a time consuming task to do, but on the other hand you get fresh data directly without the parse from other people who has handled the data. The important thing to consider is which data is useful in your case, so you don’t collect data that you don’t use. (Backman, 1999)

Already existing data is called secondary data. It can be data collected for other reasons or other thesis, but relevant for your purpose. Using secondary data saves a lot of time because you don’t have to collect it, but you must check carefully if all the data is relevant for your thesis. The most important thing to remember, when collecting data at Internet, in magazines, at the library and so on, is to use your common sense to see if the data is reliable. (Backman, 1999)

In this report we are both using primary and secondary data. We collect the primary data through interviews and observations. The secondary comes from the case company’s computer system and literature to the theory chapter.

2.1.2 Interviews
You can describe an interview as a social interaction between two persons, used as a data-gathering instrument. (Baileys, 1987) Interviews can be conducted in several ways and for several different reasons. One of these intensions is to get information about a certain event, problem etc. There are two basic tasks, which have to be completed with the interview for the interviewer. The main one is to maximize the flow of valid and relevant information and the other is to maintain an optimal interpersonal relationship between the interviewer and the asked person. (Gordon, 1969)

An interview can be planned ahead, so that the “right” information is revealed. The planning should be done very carefully, due to what type of data the interviewer wants to get. One thing, the interviewer has to consider, is the formulation of the questions. The questions shouldn’t be leading to a particular answer. One example of a leading question can be: “Don’t you think that Liverpool FC is going to win the Premiership this year?” (Gordon, 1969)

One can expect that, what is said by a representative selection of respondents in interviews would reflect what the whole population at large would say, if all the members were interviewed. The actual process of sample collections is wending its
way through diverse practically eventualities, from cost considerations to physically located respondents. Researchers don’t check the competence in the assumptions that surrounds the words that they use to define the population from the beginning. (Holstein&Gubrium, 1995)

We have performed interviews with the personnel, which the company and we find most representative. We tried to carry out the interviews, like ordinary discussions with predetermined questions.

2.1.3 Observations
Observation is in most cases about collecting data by the senses that is visual, hearing, touch or smell. There are two kinds of observations, participant and non-participant. In a participant observation, the researcher takes an active part in the observation. In the non-participant observation on the other hand, the researcher doesn’t take an active part in the observation. (Holly, Anubhav, Patrick, 2000)

We used the participant observations, for collecting primary data, such as cycle time and other measurements. Other types of data we have got from company are observations, which we don’t have participated in.

2.1.4 Experiments
Experiment is the premier method for inferring the existence of casual relationship between one or more independent variables and one or more dependent variables. The investigator observes and collects data over a period of time and measures at more then one interval, which provides studying change over time. Data analysis and hypothesis is easier to do, because of the ultimate control that experience offers. You can ask yourself if it’s really possible to actually demonstrate empirically or prove that there is a connection between two or more variables. One negative thing about experiments is that the sample size can’t be large. (Andersen, 1994)

We have not performed any experiments, because of lack of time and money.

2.2 Method of investigation
There are two ways of defining search of data.

2.2.1 The qualitative method
This is a method where you see the reality in an objective way. The reality is an individual, social and cultural construction. This method is about how the human being sees the reality and how they experience the reality. In this method you will collect data and write an empiric. At last you can formulate hypothesis or theory and conclusions. In the qualitative research, you often use a case study in the scientific work. This case study could consist of many case studies. The case study could have two different intentions, descriptive and investigating. (Backman, 1999)

The qualitative research process is very flexible and dynamic, which give you some space for variation. In this research process there are several elements:

1. Question
2. Literature examining
3. Analysis unity
4. Problem
1. Question
All the questions start with how and why. (Backman, 1999)

2. Literature examining
This moment consist of:
- Summary over earlier knowledge
- Show the problem
- Determine the research
- Indicate the problem
- Problem formulating
- Specification and definition of the conception
- Methodise turn-up, designer and procedure
- Different interpret alternative
- Historical view (Backman, 1999)

3. Analysis unity
The case study can be an organization, institution, company and so on. You can use endless of combinations to do this case study. Early in the project, it is good to read the scientific literature to know the criteria for the project. (Backman, 1999)

4. Problem formulating
Problem formulating is continuous when collecting the data. It can be changed during the project. (Backman, 1999)

5. Observation
The observation is a hard process because the observatory is an interpret subject. The observation can be split up in to four parts:
- The first part is instruments and methods. The most common, in this part, is to perform interviews. It can seem that this part is an easy one, but you need to be very critical. Sometime you need to use a trained observatory, to have them perform the interviews. The second part is to choose the persons, which should be participating in the experiment. The third part is treatment and manipulation. The qualitative researcher chooses the naturalist condition. The last part is design. This part is different and resemblance between the individual in different references. (Backman, 1999)

6. Analysis
This moment will be done continuously, during the data collection. (Backman, 1999)

7. Interpret
The project wills here be a comprehensive picture of the reality and lead to an understanding. (Backman, 1999)

8. Report/Documentation
These reports do not have any recommendations, this is up to you. It’s best to make the decision in the beginning, if not it can be very hard when you write the report. (Backman, 1999)

2.2.2 The quantitative method
Quantitative method is an assembly name for the way of working where you systematically gather data. The data should be empiric and quantifiable. After the gathering you summarize the data in a statistic form and analyse it in a hypothetic approach. The quantitative methods are often formalized and every step in the process is well defined and isolated from each other. (Egeby&Söderberg, 1999)

You start with representative selections in groups and investigate this, with help from different forms of measuring instruments that can illustrate connections, distribution and variations inside the group. (Egeby&Söderberg, 1999). Quantitative methods and its techniques are direct connected with studies of big populations. The researcher doesn’t have to participate in the investigation, and this makes it more objective due to some people. (Nationalencyklopedin 11:e bandet, 1993)

There are two kinds of selections, the free random and the systematic. The free random selection can be done like this: you number all the units in the population and then you chose the numbers by for example a random generator. Thanks to the randomly selection you can get the medium value and the measure of spread in very exact figures. (Egeby&Söderberg, 1999)

The systematic selection also begins with a numbering of the population, and then you select for an example an end number and take every one in the population, that have that end number. Other criteria can be chosen, depending on how big part of the population that should be selected. (Egeby&Söderberg, 1999)

2.2.3 Differences between the qualitative and the quantitative methods
The resemblance in these two methods is that they have the same purpose and will give a better view of the reality, which we live in. In the quantitative method you can change the information in to numbers. After this, you can do a statistic research. This is different from the qualitative method where it is interpreted, motive and social processor. (Holme&Solvang, 1997)

Questions to help you to know if you like to use a qualitative method:
Do we like to have a total perspective and/or a complete understanding?
Do we like to put hypothesis and shade off interprets? Do we like to build up theories and to create frame of references?
Do we like to understand different social process?
(Holme&Solvang, 1997)

Questions to help you to know if you like to use a quantitative method:
Do we want to say anything about the group that has been selected?
Do we want to have a cross section of the phenomenon, that we studying to do some comparison?
Do we want to show how strong some connection is or which comprising of a phenomenon has?
(Holme&Solvang, 1997)
2.2.4 Combination of quantitative and qualitative methods
A combination of these two methods gives a much better result than if you just chose one of them. The combination can be that you first do a qualitative investigation and then a quantitative investigation. The first part will be an understanding and the second part will be these questions that you have decided before. The quantitative information gives a general overview on what you need to investigate in the qualitative method. In this way you are sure that you will have a general overview and deeper knowledge in some important questions. When collecting information it is good to use the both methods, because the methods are performing better together. A collection of qualitative information is later quantifiable during the analysis. (Holme&Solvang, 1997)

In our paper we use both the qualitative and quantitative methods. We use the qualitative method when we do interviews, analyse and conclusions. We use the quantitative method when we collecting data and perform observations.

2.3 Scientific perspective
There are two major theories of how the humans get their knowledge. These two are positivism and hermeneutics.

2.3.1 Positivism
Positivism has its roots in empiric/natural sciences, like real experience, research and experiments and scientific examination of reality. All research should be based on concrete observations and facts. Everything has its root in physical and mathematical laws. The positivism was developed by the French philosopher Auguste Comte (1798-1857), according to Thurén, (2000). According to Comte positivism was the third period in the spiritual history of humanity. The first phase was religion. The second part was the metaphysical periods, where everyone believed that the reason, for all that happens, lies in the nature. The third part was positivism. The human has two sources of knowledge, one observes with the senses and the other can solve with logic. Observation is the knowledge gained by the five senses. Nowadays the word positivism basically means logic and rational way of thinking and a testing of theories and statements. (Egidius, 1986)

We use the positivistic approach, when we study the quantitative data from our measurements, because we make our opinions based on facts.

2.3.2 Hermeneutics
Hermeneutics is about theory/science of interpretation, it’s about study, interpret and try to understand basic conditions for the human existence. It’s often said to be the opposite of positivism. In the 19th century hermeneutics was developed into a general methodology in human science, before that it has been used to interpret text in the bible during the 17th and 18th. Hermeneutics has become an existential philosophy that tries to understand the human condition, where the language is the essential. The hermeneutic scientist wants a comprehensive picture of the problem, he uses his experience, thoughts and expression as resources to interpret and understand the problem. (Patel & Davidson, 2000)
In the last chapter of our paper we use the hermeneutic approach, there we understand, interpret and investigate the reasons behind the problem.

2.4 Research approach
There are three different approaches, while a research is conducted. These three are: deduction, induction and abduction.

2.4.1 Deduction
Deduction reasoning works from general to more specific, sometimes called a “top-down” approach. When we have a theory about something that interest us, we split up the theory into more specific hypothesis that we can test. Then we move on to observations that confirm or conflict the hypothesis.

THEORY → HYPOTHESIS → OBSERVATION → CONFIRMATION
(Patel&Tebelius, 1987)

We use the deductive way, when we search in the literature in this field. We read to get knowledge about different theories and modify them to suite our company.

2.4.2 Induction
Induction reasoning is the opposite of deduction. It starts with a specific observation and work to a broader generalizations and theory. Induction is often called a “bottom-up” approach. From the specific observation you find patterns and regularities formulate tentative hypothesis to explore and then developing some general conclusions of theories.

OBSERVATION → PATTERN → TENTATIVE HYPOTHESIS → THEORY
(Patel&Tebelius, 1987)

We use the inductive approach, when we draw conclusions from our observations and interviews.

2.4.3 Abduction
Abduction starts with the discoveries in reality, induction, with a theoretical aspect, deduction, that is considered during the whole study. Theoretical studies are done at the same time as you analysis of the collected data.

\[
\text{THEORY} \downarrow \downarrow \text{Induction} = \text{Abduction} \quad \text{REALITY}
\]
(Patel & Tebelius, 1987)

We have also used the abduction approach, during the interviews. We have formulated question before the interviews and during the interviews we asked follow up-questions, based on the previous answers.

2.5 Validity, reliability and generalization of results
To conduct a good research and analyse these three things are important.

2.5.1 Validity
The term validity can be defined, as a statistic term that tells if a test measurement is measuring what it should. There are two kinds of validity, internal and external.
validity. Internal validity is the connection between theoretical and empirical parts in a project. To get high validity in a project you must learn about the author’s background, education and experiences. You must know how the data is collected; the validity may be improved if the data is collected over a longer period of time. You must also know how the authors have analysed the data and see the problem from different point of view. External validity is more about how the reader understands the project. The reader then has to decide if it’s possible to find a generalisation of the authors analyse or not. To make that decision you have to consider: how, for who and on which condition the result can be applied. (Ejvegård, 2003)

We have tried to get as high validity as possible, through conducting a careful investigation of which data we needed for our analysis and if it is reliable.

2.5.2 Reliability
To get reliability, you have to perform the measurements in the correct way. Every time you do the measurement by the same method, it should give you the same result. The reliability depends on how the measurements are done, and how exact the handling of the information is done. You can do the same research at different times or by different researcher and you get different views of the same research. You must measure the right things that give you a result that you can use in the research. Remember that high reliability does not guarantee high validity and high validity does not anticipate high reliability. (Ejvegård, 2003)

We try to reach as high reliability as possible, by using references and theories from different authors just so we don’t base our work at one author’s knowledge. We have also interviewed many people to insure the reliability of their answers. There are explanations of what we have done and how we have performed it.

2.5.3 Generalisation of the results
The question, you have to ask yourself after you have the result of the study, is: can it be generalized? Can the result of a study in a company be generalized and be used to solve a problem in another company? Is the result valid for other companies? It is good to compare different studies to get a generalization. What conclusions can you make and how can it be used in other companies? There are many questions to find answers to before you can make the generalization. (Ejvegård, 2003)

2.6 Our selection of methodologies
In this report we are using both primary and secondary data, because of the time factor. It should take us a long time to measure everything every event. Maybe it won’t occur during our time at the company. We gather the primary data through interviews and observations. We have tried to conduct the interviews like discussions, so that no misunderstanding would take place. The observations were made in an objective way and performed exactly the same every time. We make sure that the collected data is suitable for its task, which increases the validity.
We have used both the quantitative and qualitative approach, in the paper. When we collected the data and made the investigations, we used the quantitative approach. When we did our interviews and analyse, we used the qualitative way. By using different approaches, we made sure that we get the highest possible reliability.

We used the positivistic approach when we study the quantitative data from our measurements. We made our opinions based on reality. In the last chapter of our report, we used the hermeneutic approach, which is to first of all understand the problem and after that interpret it and at last investigate the reasons behind it.

Induction has been the way of research, and then we have performed interviews and observation and make our conclusions based on them. We have used deduction when we searched for suitable theories for our problem. We worked after the abduction approach, during the interviews with the follow up-questions. We used follow up-questions to make sure that we understand the answers correct and therefore reach a higher reliability.
3. Theory
In this chapter we are going to present the theories, which we think are necessary to know before reading our work. The theories are going to be described, so that the reader gets an introduction to them.

3.1 Overall Equipment Effectiveness, OEE
OEE is expressed as a percent figure, usually defined as a calculation that is found by multiplication of theoretical availability, real performance and measured quality. It’s a way to measure the use of the effectiveness, which exists in the company. (Ben-Daya&Duffuaa, 1995)

The OEE can be used as different things, like a benchmark for measuring the effectiveness or it can be an identifier for the “worst” machine. It is really important, to understand the measuring and the result. It can be disturbances, in the result. The disturbances are divided in two categories. These are chronic and sporadic. The chronic disturbance is often very small, complicated and hidden. The sporadic are more obvious and make a bigger impression than the chronic ones. (Bamber, 2003)

Availability is the time of the available time that is used for production. The formula for this is:
Availability = (planned time – stoppages) / planned time

To get how effective the availability time is used, you measure the operator performance:
Operator performance = cycle time * produced items / total productive time

The cycle time is the optimal time that the machine is constructed for. The cycle time is very difficult to decide, because of the lack of specifications of the equipment by the companies or because reconstructions of the equipment. A cycle can be for example the time it takes to complete a print. (Johansson, 1997)

Quality = produced items – defect items / produced items. (Johansson, 1997)

OEE = availability * operator performance * quality (Nissen, 2002)

3.1.1 Availability
The availability is very important for the system; because it is the time there the system is functionally correct. Many things are depending on how the system is working, for example the production planning. The Overall Equipment Effectiveness has the availability as one of the three parameters, because it’s important. If a machine has high effectiveness and quality rate but bad availability, so will the OEE-value be low. It isn’t going to produce the numbers of item that it have to, because of the short time it is working. (Bergman&Klefsjö, 1995)

There are different formulas to calculating the availability for a system, in the one we choose there are two different figures used. These are Mean Time To Failure (MTTF) and Mean Time Between Failure (MTBF). MTTF is the time between the starting time and the first failure and MTBF is the mean time between failures. The formula for availability is A=MTBF / (MTTF + MTBF). (Bergman&Klefsjö, 1995)
3.2 Maintenance systems
The most common red line for all kinds of companies is to improve and maintain the production process both technical and economical as a measure of effectiveness to a low price. Because of this the choice of a cost effectiveness maintenance strategy is very important part to help the production. (Al-Najjar, 1996)

To operate maintenance system rationally in a company, it demands optimal dimensioned organization, system and working methods. The cycle of working for maintenance activity contains: plan, do, study and act and all centered on continuous improvements. The different parts in the activities are (Johansson, 1997):

**Plan:**
- estimate the extent
- decide the time point
- preserve and/or obtain resources.

**Do:**
- failure based maintenance
- preventive maintenance
- condition monitoring, modifying
- change of equipment
- data collection about failure, standstills, costs and so on
- working and result presentation

**Study:**
- establish high maintenance- and standstill costs
- establish technical causes
- prepare proposal to measurements
- value economical exchange

**Learn:**
- By repeating the cycle several times, the improvement work will be done continuously (Johansson, 1997)

3.3 Maintenance approaches
There are some different ways of performing the maintenance work, some just repair the machines then they stop and others try to prevent the machine from stopping.

3.3.1 Break down maintenance
Break down maintenance can also be called failure based maintenance, and be shortened to BDM and FBM. When no maintenance work is performed, until a failure has occurred, that is break down maintenance. The maintenance staff doesn’t do anything, until the machine stops. Their task is to repair the machine, as fast as possible and try to generate as little downtime as possible. (Johansson, 1997)

This way of working requires a large spare part storage, which will increase the maintenance costs. An unplanned stoppage both costs more and can take longer time to correct than a planned one. With a planned stoppage, the maintenance staff or/and the operators can prepare tools and spare parts, depending of what they are going to do. (Johansson, 1997)

This type of maintenance can be used to units, which are easily replaced and don’t take long time to replace. Examples for such units can be light bulbs. In order to use
BDM, some kind of economical and production related analyse should take place before implementing this method. This analyse is going to show if it is economical and effective for this unit to use BDM. (Johansson, 1997)

3.3.2 Preventive maintenance
PM is the shortening for preventive maintenance. This method of conducting maintenance, focus on replacing the parts before it breaks down. It means that parts are changed after a predestined interval. These intervals can be based on number of produced items or time, just for mentioning a couple and decided by recommendations from the manufacturer. The maintenance costs can be reduced, by optimising the intervals. The optimizing of the intervals should be based on the machine, not just the single components. This is important, because it costs money to stop the machine. An analyse, of the critical parts and their replacement intervals, is important to do. (Ljungberg, 2000)

One of the goals with PM is to reduce the number of random stoppages and therefore reduce the unplanned downtime for the facilities. This will increase the overall equipment effectiveness, because one of the factors in OEE is the availability. The availability is not the only thing that PM increases, also the quality rate increase because of the fact that the machines run smoother. (Gupta, Günalay & Srinivasan, 1999)

There are some risks with preventive maintenance. It is always a risk that creating a potential defect of various types, while performing the planned maintenance tasks. The human factor and the start up period for the newly installed components can lead to failures, on the machine where PM work has been conducted. To minimize these risks, there are several things to do. Educate the staff, who performs the maintenance work, and having exact and clear instructions, how to perform the inspections, is two things, which will decrease the risks. (Worsham, 20040225)

Preventive maintenance can have some of these affects, on a production system:
- Reduced production downtime
- Increased life length of machines and their parts
- Improved safety and quality conditions
(Worsham, 20040226)

Some of the preventive maintenance must be done every day or once a week, this to insure the production. These different activities can be summarized, like:
- Cleaning – This prevents dust and other unwanted particles to get stuck on or in the machines, which affects the machine.
- Lubrication – This prevents the machine parts from getting to warm or wear out.
- Control of the bolts – This control assures that the bolts are tightened and won’t come off. If the bolts should come off, vibrations can occur which lead to wear.
(Nakajima, 1992)

3.3.3 Condition based maintenance
This method builds upon the idea of making the deviations in the machines visible in order to correct them. By making the deviations visible, faults can be prevented. Most
of the machines show a deviation in their system before they stop, by using this maintenance strategy, this stop can be prevented from happening. The implementation of CBM can take a long time and demand a high level of knowledge. (Al-Najjar, 2001)

To implement this strategy, these following six steps should be followed:

- Choose the equipment and investigate what type of faults occur
- Understand the equipment’s fault reasons, effects, consequences and warning signals
- Choose the most cost effective technique and analyse if CBM is suitable
- Identify where and how often the measurements should be conducted
- Check (maybe change) the alarm levels
- Find the reasons behind the problem and make sure the right maintenance strategy is used

(Barron, 1996)

Condition monitoring can be divided in to two parts:

- Subjective condition monitoring, that is
  - See
  - Listen
  - Feel
  - Smell
- Objective condition monitoring
  Giver and measuring system gives values for either direct judgement or receive basis for trend analysis.

(Johansson, 1997)

Both types of condition monitoring are important but the objective condition monitoring has increased in importance. The reason to that is increasing complexity within the machines and low crew production. By following the variations that comes up, one can monitor a parameter like temperature, in a control diagram. The variations should lie between two control boundaries. (Barron, 1996)

3.4 Reliability centered maintenance

Traditionally maintenance is often repair oriented, instead of being safety oriented. Experiences aren’t gathered systematically. The development with unmanned production, complicated machines have done that one must work with a technique that integrates construction and usage phase. That’s where the RCM-methodology comes in and covers the whole life cycle. (Johansson, 1997)

Conditions:

The conditions for the RCM-technique are that the consequences of a fault must be clearly noticeable for example safety, high standstills costs or maintenance costs. The complexity of the system should be over average and experience data should be available for actual system or similar system. RCM is meant to use condition monitoring, if safety aspects or economic aspects motivate it. (Johansson, 1997)

Routine:

When applying the RCM-technique one can discover four phases:
1. Definition of the structure of the system and the most important in/out functions. Sampling of data concerning construction – usage and reliability.
2. Identifying the units that mainly affect the availability and safety or the units that has high maintenance costs.
3. Decision of which PM-measurements that will be taken and time intervals for these. This will be put in a PM-system.
4. Collection and work on data from the plant.

(Johansson, 1997)

Problems:
One of the hardest points to fulfill is the gathering of fault data. Notice that what one really wants is the cause of fault, fault modes and fault effects, how the fault was discovered. This affects the choice of PM-method. Often it is the one who handle the data that has to try to deduce the fault mode. The fault reason is often easily found but the fault symptom can sometimes be hard to find. The faults influence “down” in the system is often described but the influence “up” in the system is often forgotten. There is often not a notice about under what conditions the system was working in when the fault occurred. (Johansson, 1997)

Advantages:
By carefully analysis of the fault amount of PM can be reduced or be replaced by AM. Instead of making big reviews at decided time schedules one has been able to change to more point aimed efforts. Spare parts storage has been reduced and bad construction solutions are discovered at an early stage. (Johansson, 1997)

RCM doesn’t consider the aspect of maintenance in an economic perspective, on the plant level. It focuses on improving an existing plant, rather than make a new one right from the beginning. The usage of condition-based techniques in RCM is not adjusted, so that CBM come to its right. RCM uses periodic measurements to find faults and do repairs, which isn’t an active preventive maintenance. (Al-Najjar, 1996)

3.5 Total productive maintenance
TPM is a shortening of Total Productive Maintenance. This is a philosophy for the whole company to work with. The goal with this strategy is to increase the OEE and to develop the company’s production processes. The whole company is involved in this extensive change, to eliminate all types of unnecessary losses. (Ljungberg, 2000)

This strategy comes from Japan and has been developed from the 70ies. In Japan it becomes a big success. It is built upon the idea of team-based preventive and productive maintenance. TPM develops the relationship between every department in the company, but specialises on the relations between the production and maintenance departments. (Sun, Yam, Wai-Keung, 2003)

Total means that it comprises everything, like machines, tools, humans and how these cooperate together when it comes to producing. This involves everything, not just the production. Productive involves that the company not just keep a certain level of efficiency, but also immerge improvements. Maintenance means to keep the machines in such good condition as possible. (Johansson, 1997)

TPM has three important part, these parts is:
• Follow ups on stoppages – the brain
• The operator maintenance – the heart
• Improvement groups – the muscles
(Ljungberg, 2000)

The first one focuses on the reality, so the company can see their faults. The key words here are facts and data. One of the most common measurements is to measure the machine’s total effectiveness. In TPM the OEE value is measured and calculated, which focus on the production. (Ljungberg, 2000)

The second focuses on that the operator should take care of his/hers machine, and know how it’s working. The none existing knowledge is a large problem for the company. The reasons behind this problem is many, one example of this is that the companies has prioritised short-term production before long-term maintenance. The transference of machine care to the operators, from maintenance staff, is the heart. (Ljungberg, 2000)

When the operators have learned how their machine’s works, they should participate in improvement groups. The reason to this is that they know their machine and should be able to perform some maintenance and service themselves. The management has to motivate their workers, so that they feel important and that their suggestions are considered. These improvement groups are organised, but doesn’t have the same structure as the ordinary organisation within the company. The groups meet at a continuous basis. (Ljungberg, 2000)

Improvement groups:
The type of improvement groups isn’t project-based, but is based on continuous production improvement. The groups don’t disband, because its work is continuous. The purpose of these groups is not to solve the problem as soon as possible, but to make the processes within the company more efficient in the long run. (Ljungberg, 2000)

The participation, in the groups, is something everybody has to do. Every operator is involved in an improvement group. The reason, why the operators should participate is that they have a lot of experience and that continuous improvements should be as a natural thing in their everyday work. (Ljungberg, 2000)

By working with improvement groups many positive things appears, like increased work morale and that the changes are often well thought through. The workers, who are involved in the decision-making, are also concerned of them. (Ljungberg, 2000)

The implementation process:
To implement the TPM, the company has to be well prepared to this way of working. There are four phases, with different steps to do the changes. These phases and steps are:
• Preparation (phase 1)
  1. The management makes the decision to implement TPM
  2. Start a campaign to introduce and present TPM
  3. Start a organisation for the changes
  4. Formulate the goals and policy for TPM
5. Formulate the plan for the TPM introduction
   • Introduction (phase 2)
   6. Kick off
   • Implementation of TPM (phase 3)
     7. Measure and analyse the machines effectiveness
     8. Develop and implement operator maintenance in 7 steps
     9. Change the maintenance organisation
    10. Increase the competence in production and maintenance
    11. Maintenance prevention
   • Stabilization (phase 4)
     12. Complete the TPM introduction and set higher goals

(Ljungberg, 1997)

Maintenance performed by operators:
An effective production is depending on both the production department and the maintenance department, but the relationship between these two can sometimes be strained. If the operators participate in the maintenance work, the maintenance situation is going to get better. The operator maintenance is one of the most important parts in the TPM method. It makes the machine operator to a process leader, for both the production and the maintenance at his machine. The management has to support the operators, so that they have the ability to perform the maintenance. (Ljungberg, 2000)

Before the change to operator’s maintenance, a large cleaning process of the environments and work places is necessary. One effective way of doing this is to use the five s’s, which are, in Japanese (the English explanations between parentheses):
   • Seiri (Clean the workplace from unnecessary material)
   • Seiton (Mark and place the material at its place)
   • Seiso (Clean the workplace and equipment)
   • Seiketsu (Analyse the reasons behind the filth)
   • Shitsuke (Make rules and routines to ensure making the cleaning)

(Ljungberg, 2000)

There are several key elements, which have to be fulfilled in order to the operator maintenance to success. Some of these are:
   • Education for the operators
   • Support and effort from the management
   • Cooperation between departments and improvement groups

(Ljungberg, 2000)

The seven steps to operator’s maintenance:

Step 1: The initial cleaning: The operators clean their machines, to prevent them for unnecessary wear. This gives the operators knowledge about their machines and how different situations occur. This is going to help them perform the preventive maintenance. Their work environment and situation gets much nicer. (Ljungberg, 2000)
Step 2: Attend to the reasons behind the filth: Prevent the filth to spreading from the source. This can be done in some cases just by using some local protection, like transparent protection around strap gears. This prevents the straps from creating dust and is easily overlooked, because it’s transparent. (Ljungberg, 2000)

Step 3: Create standards for cleaning and greasing: Create checklists for the cleaning, so that the operators can easily see what to do. Decide the time intervals for the activities, so they are performed at the right time. (Ljungberg, 2000)

Step 4: Public inspection: Here the operators are trained in maintenance and ways of conducting inspections. The maintenance personnel are supervising this training and performing lectures in these subjects. (Ljungberg, 2000)

Step 5: Independent inspection: The operators put together a standard for performing the cleaning, greasing and inspections. At this stage the responsibility for the maintenance are divided between the operators and the maintenance staff. This means that the operators takes over some task from the maintenance department, like different types of preventive maintenance. (Ljungberg, 2000)

Step 6: Organising the work place: The operator’s responsibilities are here appointed, so that the losses in the production can be minimized. The effectiveness and the quality are measured, so that the improvements makes visible. Every job at the work place is reviewed, timed and discussed, so the work can be as efficient as possible. (Ljungberg, 2000)

Step 7: Independent operator maintenance: At this point the operators can perform the inspections, maintenance and also some repair jobs. The fact that they now know so much about their machine, motivates them to work smarter and more efficient. (Ljungberg, 2000)

3.6 Total Quality Maintenance
TQM is a concept for continuously improve and maintain the technical and economical effectiveness of the production process. It can be described as a tool for monitoring and controlling deviations in the process condition and the product quality. It’s also a tool for detecting failure causes and potential failures, to control production/operation, environmental condition, quality control, personnel, methods and materials. (Al-Najjar&Alsyouf, 2000)

Total Quality Maintenance doesn’t consider just the machine, it also consider all the important elements that are involved in the production process. TQM is based upon an effective usage of real data and analyse, to discover deviations or hidden faults. This is important to discover in an early stage, because of the fact that it is easier to do something to prevent the fault from creating sequences of faults. (Al-Najjar&Alsyouf, 2000)
TQMain helps the operators to select the best-suited maintenance strategy for the machine and continuously improve it, by using data and analyse methods. (Al-Najjar, 2001)

The properties in TQMain are:

- A common and complete database, which helps to avoid losses like production stoppages, unnecessary replacements and low productivity. The database, which consists of significant values, should be updated continuously with real data.
- An effective usage of real data and analyse, to discover the reasons behind production stoppages or/and bad product quality. This should be done at an early stage to be able to prevent these faults and increase the life length of the machines.
- Implementing condition based maintenance (CBM), for example vibration based maintenance (VBM) makes it possible to improve the maintenance policy after every replacement or renewals that are done at the machine. This can be done, by looking at previous data and measurements. (Al-Najjar&Alsyouf, 2000)

Total Quality Maintenance is a strategy that makes the user able to maintain and improve continuously the economical and technical effectiveness of process elements. The role of TQMain is to be a mean to monitor and detect deviations in a process condition and product quality. Before a fault influences the effectiveness of the production, it can be discovered and the failure causes can be identified. This makes it easier and more economical to correct, before a stoppage occur. (Al-Najjar, 1996)

According to Basim Al-Najjar, (1996), the implementation of the TQMain strategy can be done easily, if the integration is done in steps and expanded after every successful extension. The decision of which activities, to be accomplished next is based on importance, cost-effectiveness and critically.

Common database:
To have a big common database helps the company to integrate and plan different activities. The database can integrate vibration-based maintenance with production/operation, quality and other important parts. The data should be gathered and put into the common database, so that every need for a particular figure should have the ability to see it. To have a common database integrated with a wide-company IT-system would be cheaper than to keep the maintenance data separated from the other systems within the company. (Al-Najjar, 1996)

3.7 Quality
The definition of quality, according to Bergman and Klefsjö, (1995), is “The quality of a product (goods or service) is their ability to satisfy, or at the best exceed, the customers need and expectations.”

Many organisations have made their own definitions about their quality. They have also decided goals, both in numbers and in texture. In the quality aspect, the customers are one of the most important factors. The quality should bring the customers to the company and their products. The quality work has to be related to what type of customer, the company has. (Bergman&Klefsjö, 1995)
Every company is competing and one of the most important parameter to compete in is quality. To get the customer to choose your company, the reputation is very important. The company has to convince the customer, to pick their product. Therefore the companies always try to improve their product’s quality. The quality work can’t affect the product price so much, because the price is also an important factor, when competing about the customers. (Al-Najjar, 2000)

To improve the quality many things has to be effective, like maintenance and manufacturing system. The company can use different tools, to ensure the quality rate. The choice of maintenance strategy is also important. If the company work with Condition Based Maintenance (CBM), they can see deviations, in such things like temperature, if they compare it with previous data. This deviation can decrease the quality and if that product is being delivered to the customer and breaks, the company’s reputation can be damaged. (Al-Najjar, 2000)

There are many different types of quality dimensions. These dimensions can be:

- Operation security
- Performance
- Maintainability
- Environmental friendly
- Appearance
- Freedom of faults
- Safety
- Sustainable

(Bergman & Klefsjö, 1995)

### 3.7.1 The seven quality control tools

These seven tools are used to collect and analyze the collect data. In Japan they realized that everyone within the company has to participate in the improvement work, so the tools they should use has to be simple and efficient. The seven QC tools are:

- Data collection
- Histogram
- Paretodiagram
- Ishikawadiagram
- Dividing data
- Relation diagram
- Control diagram

(Bergman & Klefsjö, 1995)

**Data collection**

The data collection is very important in the quality improvement process. The data constitute the foundation for the decision-making. It is important that the collected data is relevant to the case and that it is not incorrect, because then can’t any analyzing method help. Before starting with gathering, these questions have to be answered:

- What is the quality problem?
- Which data are needed to in light this problem?
While collecting the data, it is good to have a predecided form to fill in. This will help to simplify the collection and analyze of the data later. (Bergman & Klefsjö, 1995)

**Histogram**
The histogram helps to illustrate the data, by grouping it together in a kind of diagram. The y-axis gives the number of events and is divided in by numbers from 0 to N. N can be equal to any number, it depends on the demand. The x-axis depends on what is measured. It could be for example the thickness of a printed-paper in the unit of millimetres. If many measurements are performed and the investigation allows it, the possibility to group the data occurs. The grouping can be done, after the x-axis. (Bergman & Klefsjö, 1995)

**Pareto diagram**
A company has often more than one problem, which will show during the collection. The Pareto diagram helps to illustrate the problems and shows which is the largest according to the percentage. It is a kind of diagram, which shows both number of occurrence of each problem and the percentage of each problem according to the total numbers of occurring problems. The y-axis shows the percentage of the total for each problem. The x-axis contains the problems. The number of occurrence of a problem illustrates with separate stack and the percentages of each problem can be as a line, connecting the problems. (Bergman & Klefsjö, 1995)

**Ishikawa diagram**
Then a quality problem is selected, the company has to find the reason behind this problem. With the reasons and the problem, an Ishikawa diagram can be constructed. This type of diagram is also called fishbone diagram, which is how it looks.

(Bergman & Klefsjö, 1995)

The reasons are just roughly described in the diagram above, after this step it is time to develop each reason-arrow. Every reason is broken down, so every reason-arrow is going to have more arrows pointing at it. Like this:

(Bergman & Klefsjö, 1995)
Every arrow represents a more detailed reason. An Ishikawadiagram is best, with a lot of arrows. The starting reasons often are a couple of these:

- Management
- Human
- Method
- Measuring technique
- Machine
- Material
- Environment

(Bergman & Klefsjö, 1995)

**Dividing the data**

To get the data more structured, the data has to be divided in subcategories. The data is now more easily illustrated, with for example an Ishikawadiagram. One important thing to remember is that data from different origin should not be mixed. Dividing the data can be based on different criteria. (Bergman & Klefsjö, 1995)

**Relation diagram**

The relation diagram is a way of illustrating the relationship between the different product properties and different parameters. This is a good tool, to find divergences that occur under certain situations. This diagram can look in different ways, but the most common one is with one x-axis and one y-axis. For example the product property can be the x-axis and the parameter the y-axis. By monitor a process parameter, instead of control it, on a finished product, it goes easier to prevent a fault on the end product. (Bergman & Klefsjö, 1995)

**Control diagram**

One way of controlling the production quality is use a control diagram. The idea is to pick out a couple of products and test them, according to preselected limits. The limits are defined after the products specifications. The purpose of using a control diagram is to quick notice, if a change in the production has taken place. The selection of parameter and the limits can be decided, according to the customers’ specifications. (Bergman & Klefsjö, 1995)

**3.8 Just in time**

Just in time is shortening to JIT. It is based upon a very simple idea. This idea is to do as little as possible until there is a need for it. As little as possible means that there are such departments, like the business department, which works in a normal way, but the production departments don’t do any producing actions. This is a pull system, where the customers demand pulls the product through the production chain. This way of working needs a good control of such things, as production time and spare parts. (Christopher, 1995)

**3.9 Life cycle cost, LCC**

The life cycle of the product consist of different phases: planning, development, production, usage, maintenance and scrap. Quality activities are important all the way, during all the phases from idea to scrap. (Bergman & Klefsjö, 1995)

The life cycle cost are the costs of direct, indirect, recurring, non-recurring, and other related costs, which are estimated to be incurred and included costs associated with
design, research and development, investment, operations, maintenance, and support of a system over it's life cycle. (http://www.mtain.com/logistics/loglcc.htm)

These costs can be illustrated like an iceberg with only the direct costs for production, research and development over the surface. Under the water surface are more costs like education costs, spare parts storage costs, energy costs, personnel costs and so on. You can’t disregard the cost under the surface because you don’t know which costs, which are the most important cost under a product’s life length. Very simple you can say that LCC answer the question: “How much will the new machine/equipment/component cost over the period I want to use it?”

LCC can be used as a steering instrument to minimize the cost already in the idea- and project stage. You can use an LCC-model to see in which stage the costs of the product will be, and perhaps do a redesign if necessary. A very low LCC value can be used as a very good sales argument. LCC can also be used as a follow-up cost calculation, to see if the calculations are the same as the reality if not the company has to change their way of doing predicament. It’s also a way of checking if the supplier is delivering the products he said he would, or isn’t it as good as he promised. Sometimes the antagonism against the implementation of LCC is large. All because it’s hard to have to admit, that you have purchased a machine for example that needs expensive spare parts and so on, and that’s what you sometimes finds out when implementing LCC. The most common obstacles when implementing LCC:

1. The LCC policy isn’t rooted in the whole company
2. Inertia in the organization
3. Non interest of operation- and maintenance costs
4. Insufficient LCC competence
5. Insufficient operation- and experience follow-up
6. Costs of time and money in increased purchased work

(Johansson, 1997)

3.10 Selection of maintenance software

In general you can say that you should first have used a manual system and from there go to a computerized system. To succeed to implement a computerized system following conditions must be applied (Johansson, 1997):

- Facts about the maintenance objects have to be documented since earlier
- The system should be user friendly
- Every one involved should be present from the beginning
- The personnel is motivated
- The system should be improved continuously by good trace of the results

If the system isn’t user-friendly, the workers will not learn and if they haven’t learned they will not use it. A very important part in the construction of a maintenance system is to decide how the structure for the system should look like, wrong structure take a very long time to change afterwards. (Johansson, 1997)

3.10.1 Specification of requirements

Before deciding which software to invest in, there has to be a requirement analysis to be certain of what the company and their employees want to have. There are different ways of finding out, it can be done by interviews, scenarios and proto types. (Tekinerdogan&Aksit, 2004)
After this analysis is made, the investigator has to generalize the requirements, so that same thing has the same name everywhere. This is made, because different people can call the same thing with different names, and it will occur confusing during the presentation of the requirements. The investigator has to rank them, according to the outcome of the analysis. (Tekinerdogan&Aksit, 2004)

There are two different requirement specifications to be made, these two are system- and user specifications. The user requirement is what the users would like to have within the program and what features the software should have. The system specifications are to see if the now existing computers can live up to the software’s requirements. (http://www.s2.chalmers.se/iths/pdf/F10.pdf, 2004)
4. Empirical findings
Our purpose is to describe how a production company works with their maintenance. We have made the fieldwork at a company, called Strålfors Svenska AB. This company and the results from the interviews will be presented below.

The chapter 4.1 and 4.2 presents the company and the people, who we have interviewed. To answer question number 1, in our problem formulation (on page 9), we use the chapters 4.3 to 4.4.4. We use these parts in these chapters to develop and highlight different aspects of the maintenance work, to our model. The question number 2 is handled in the subchapter 4.5 and 4.5.1.

4.1 Introduction of the company
Strålfors is a printing company. Their products are (for mentioning a few):
- Gambling bills for Svenska Spel AB and the Japanese market
- Medicine instructions for AstraZeneca AB
- Tax marks for Vägverket

Strålfors has 1750 employees, established in 12 countries and has a turnover of three milliards SEK. The head office lies in Ljungby, Sweden, where 750 persons work. Strålfors B-stock is noted on Stockholm’s stock exchange since 1984. Strålfors business concept is:

“Strålfors is an IT-focused Business-to-Business company with graphic tradition working with overall solutions within the information transforming area. Strålfors develop, produce and deliver systems, service and products for effective communication of business secrecy information.”

4.1.1 History
Already in 1919 Thage Carlsson started a paper role printer in Ljungby. In 1956 Strålfors started to produce punched cards and six years later they increased their assortment with own manufactured data forms. In the middle of the 60’s Strålfors became pioneers by personalized cheques and the international expansion began. In 1970 a complete assortment of data accessories was available at Strålfors. The graphic activity was increased in 1975, when the first label company was acquired and in 1981 the production of gambling bills for horse race began. The machine system Lasermax was presented in 1985 and in 1986 came solutions for electronic transfusions of information and e-business. Cards for electronically pay services and data base management were introduced in 1996-1998 and were increased by products for GSM-telephony. By a solid base within information transfusion Strålfors developed their competence for information technique, which today is established as one of three divisions. A strong position at the home market Scandinavia, value adding products and high customer orientation gives the company potential to increased international growth.

4.1.2 Strålfors objectives
- Leading position in Scandinavia and a solid actor at other key markets in Europe
- 20% profit on operating capital
- 10% yearly organic turnover increase
- The turnover shall be approximately 5000 MSEK year 2005

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4.1.3 Strålfors strategy

- Delivery solutions for information transformation that support the customer’s possibility to concentrate on their main activity. Strålfors collect, refine, store and deliver the customer’s business secrecy information.
- Offering the right solution for information transformation independent of technique or material. Deliver graphic information carrier - label and form – as well as cards and electronic solutions.
- Combine effective production with time- and cost saving logistic and deliver solutions.
- Prioritize profitable, repeatable business or transactions.

4.1.4 Strategy for continuously improvements

Tomorrow’s market will be distinguished of that resources are used more effective at the same time as negative environment influence is avoided and the social engagement increase.

4.2 Interviews

We have performed interviews to get a good picture about the maintenance situation on our case company. The interviewed persons are all employed by Strålfors, in Ljungby. The interviewed persons are presented below, to show their experience. These interviews are the foundation of the “empirical findings” chapter. The questions for the interviews are in the appendix 1, of this report.

We have interviewed following persons:

**Plant manager**
He has been at the company for 41 years, and 3 years on his current position. His education is 8 years of elementary school and some courses in management, which Strålfors has, send him to. He started out as an errand boy and has climbed position for position. The experience from the different tasks, within the company, has made him aware of the maintenance work. His current tasks are to lead the company both economical and production-wise.

**Maintenance & product development manager**
He has been employed for 34 years. The maintenance task he has had for one year. He has engineer degree and military construction education. He has a lot of tasks, in both maintenance and product development, like lead the maintenance personnel and come up with smart solutions to their products.

**Production manager**
He has been at the company for 33 years and has had the current position for one year. He has had every position, within the production of this company. His education is 2 years of upper secondary technical school. His task is to make the decisions, so the production produces the desired products.

**Production leader**
The production leader has been at the company since 1962 and as a production leader for 18 years. He has got some management courses from Strålfors and before that he has gone to elementary school. His tasks are personnel follow-up, as for example absence holidays and so on.
Quality & environmental manager
He has worked within the company for 35 years, and the last 3 years at his current position. His education is elementary school, with several courses in his field and management. He has had a lot of different positions, like punch card operator and shift leader. His current tasks are to keep the quality and environmental system updated and perform internal audits. He also leads many different projects within the company.

Shift leader at the form department
He has been working at Strålfors since 1960 and as a shift leader for three years. His education is elementary school and some courses that Strålfors has arranged. His task is to check if the work force is complete in the beginning of the shift, to plan the work for the day and to get information from the other shift leader and maybe take some actions or make decisions.

2 machine operators at machine no.222
One of them has been employed at Strålfors since 1976 and the other started working there 1987. They have worked at that machine since 1982 and 2000. Their education is elementary school, in both cases. Their tasks are to run the machine and test and compare the products.

One representative from the maintenance staff
He has worked at Strålfors for 20 years, and has had the same duties all the time. His education is 2 years of upper secondary technical school. His current duties are to perform the maintenance, participate in moving machines and janitor duties.

4.3 The current maintenance situation
Strålfors uses two different strategies for the maintenance, these are the break down maintenance and preventive maintenance. How they work with these strategies is explained in the following sub chapters. We have chosen to divide the current maintenance situation, in the following areas:

- Operator maintenance
- Maintenance department
- Reporting of failure
- Improvement work
- The management’s engagement

Our selection of sub chapters to chapter 4.3 is made, so the different aspects of the maintenance work are represented, according to Johansson, (1997).

4.3.1 Operator maintenance
The operators have to do some maintenance work. The maintenance work is scheduled, with periods: every week, every month, each fifth week, every six-month and once a year. Here below will a description of the maintenance work be presented, during these maintenance periods:

- Every week the operator should clean his machine, it’s scheduled under the Friday afternoons. Other actions during this time are checking the oil level (and maybe fill up), check filters and lubricate different parts. This depends on what type of machine it is.
Check the filters for the pressure rollers and the bearings, change them if it is necessary. This action is for the presses in the company.

At every fifth week there are other actions to perform, some of them involve an electrician. The actions can be whipping the UV-lamps with alcohol (if the machine has such), clean the cooling water tank and change filters.

Every sixth month is other maintenance jobs, which are performed like lubrication.

The maintenance, which is performed once every year, is called service and includes the maintenance staff. The number of maintenance workers, who are involved during a service, is depending on how much other work they have. The service is scheduled during one week every year. The actions, which are performed under this service, are cleaning the entire machine, exchanging parts (such as pressure rollers, UV-lamps) The services is very often postponed, due to high order number.

The intervals for these actions have come in use, from experiences and the machine manufacture. At every machine there are instructions, what to do at every maintenance period. These actions can be done under the time between orders. At the same paper as the instructions, there is a signing list, where the machine operator should sign when he has done something according to the list.

At the machine number 222 (the machine we are going to look closer at), there were zero signatures on the signing lists for the maintenance periods. The production leader said that he didn’t know if the actions are performed or if the operators just missed the signing. The operators said that they have performed it, but forgot to sign the lists. Some other operators have too little knowledge for performing their maintenance duties. The instructions is very simple and don’t exactly describe where the actions should be performed and how (See appendixes 3 and 4 on page 69 and 70).

The machine operators also repair their machines, if something causes a stoppage and if they have the knowledge needed for the repair. At every machine there is a list for the machine operators, to fill in if they know something that need to be changed or corrected. These lists are handed out at the machine a couple of weeks before the planned service, so that the maintenance staff can fix it during the service. This also helps the maintenance staff to order the needed spare parts. The machine operators only write the things, which can be postponed until the service.

4.3.2 Maintenance department
Under the manager in the organisation (See Appendix 2 on page 68), the maintenance work is divided in three areas, these are:

- Electrical - In the electrical area there is a group leader and two electricians. The electricians have the whole company to work in. They are doing work in the office building and in the production.
- Ventilation&Sanitation - The ventilation&sanitation is handled by a single person, who has the whole company to work in.
- Machines - Six persons are involved in the machines, these six are divided into two groups with three members each. The production is divided, into three areas. The first area is the press machines. It is 20 of that kind. This area has one of the work groups to do their maintenance work. The second area is the
printers, there the maintenance has been outsourced, because of the cost and expertise. The last area includes all the other machines in the company and they have the other work group assigned to this.

There is cooperation between all three areas. The electrical and machines areas share an office, which is directly connected to the production. The ventilation & sanitation has another office also directly connected to the production.

The maintenance staff gets their work from the shift leaders or machine operators. They always carry phones with them, so they can be reached. Some operators run after them instead of using the phone. Then they get the hold of them, the maintenance staff has to make a priority depending on what other jobs he has to deal with for the moment. Some operators feel that a certain producing department always become prioritised before their own. The operator seems to understand why a priority is needed.

The maintenance staff works between 07.00 and 16.00. Other times during the day they have on-call duty. There is one from the machine area and one from electrical, who have on-call duty from 16.00 to 07.00. The staff is rotating this, so that they always have someone on-call. They have that duty once every sixth weeks. If something occurs during the evening or night, the machine operator talks to the present shift leader. The shift leader then has to decide if they should use the maintenance department’s on-call duty. The shift leader checks the planned production for the next day and how they are doing with their current production, if there is a possibility to wait with the repair and scheduled the planned production on some other machine.

4.3.3 Reporting of failure
When a failure happens, machine operators should report it to the shift leader. The shift leader should contact someone of the maintenance depending on which type of fault it is. Today some of the machine operators either call or run after the maintenance personnel, because it goes much faster and it is easier to explain directly to them. Who of the maintenance staff they talk to depends on what type of faults it is and which machine it is. Within the maintenance groups (for the machines) the personnel can repair a certain machine better than another. This knows the operators and shift leaders, so they always try to contact the person that usually repairs that machine. The machine operators also choose which in the maintenance staff they will call, based on how much work they are willing to do. Some calls about small things, which the machine operators should perform themselves. Some in the maintenance staff performs that type of tasks for them.

4.3.4 Improvement work
The company had a project, where the introduction of improvement groups for machine operators should be implemented. This project didn’t succeed, because of a contemporary project took all the time. The company has a form of improvement group, for the managers and other office members. In this group there are certain people, who either participate in the meetings or are informed by mail about the discussions and decisions. The group members try to in light suggestions from the workers. Strålfors doesn’t have any system for the workers to give suggestions, in
form of suggestion boxes or scheduled meetings. If the workers would like to give a suggestion, they should talk to their shift leader. The workers attitude to this way of contributing in the improvement work isn’t so good. They feel that they don’t have had any response on their previous suggestions and therefore stopped giving any suggestions at all.

4.3.5 The management’s engagement

The management sees their experience, from the production floor, like a good thing. Almost everybody in the management has been at the company for about 30-40 years and started their carrier from the bottom. It’s often hard to change things and everything has to be proved by economical calculation, before approval from the management. The plant manager is well aware of that the maintenance manager is overbooked with work and that the yearly services at the machines are often moved forward in time. He is positive to start improvements groups (and told us that they have started to implement improvement groups once before but at the same time they had another project going on that took all their time and attention.) and he thinks it’s a good thing to restart them again.

The maintenance manager is very engaged in the company and especially in the different machines and different constructions. He has been involved in the building of almost every machine, and he has constructed many solutions over the years for example the tax-mark to the cars, where the specification from the costumer was a “trisslott”. A “trisslott” is gamble lot, where the player scrapes to see if he has won anything.

The maintenance manager thinks that the maintenance personnel should be involved, in the machines, already when the company is going to invest in a new machine. The maintenance personnel have experience when it comes to how easy the machine is to maintain, how easy the spare parts is to buy and how expensive the spare parts are and so on. He feels that he hasn’t time enough to do all the things he has to do, so his wishes is to have a work leader to the maintenance department, that can divide the work and have the comprehensive responsibility and report to the maintenance manager. He said that it is hard to get the maintenance budget approved, and he thinks that a great deal of the costs that are charged on the maintenance account, aren’t actually maintenance costs. There has been discussions about introduce a kind of bonus system again. The old one got so unfair and complicated at last so they froze the salaries at the level they where at that time. Now they feel that it would be a good way of rewarding good workers and show their appreciation to personnel who work very hard or have special skills and are a good example for other at the company.

When they are going to do an investment, they start a project that gets the facts they need for a calculation so they can do an investment request. First they have to convince the plant manager about the investment and then he has to discuss it with his manager. Everybody is full responsible for his department, but has to explain and report to the man above. Sometimes they do little things to make the personnel more comfortable at the work, like free coffee in the coffee machine. The working morale was a bit lower last year when the company had some problems and had to dismiss 12 people. They try to give the workers information about how the company is doing, how the production is at meetings. They have discussed to put up big boards for visualization of the economical and production-related goals.
4.4 Description of machine no.222
Our machine is a Goebel press and has been at the company for 25 years.
The raw material for this machine is huge papers rolls. They have to be acclimatized in storage before use, for best quality at the print. Machine 222 can print products from roll to roll, from roll to sheets and from roll to folds. The operators receive the order from the shift leaders. The order contains information about measurements, perforation and template.

When they receive the print plates they make a first print and compare it with the template and then they approve it or do some adjustments until approval. When starting a new order, they log in the work in the pc. The pc has software, which the operators report that they have started and later finished the order. They have computers next to the machines. Between the perforator station and the width cutting station there is a monitor for visual supervision of the process. The camera can x-ray the printed-paper and you can see both sides at the same time or one side at the time. The machine can print on both side of the paper; it just turns the whole paper up side down when the first side is printed. There is a bar code meter inspector between the width and length cutting stations that check the bare codes for the different colours. The bare code is placed near the perforated area at the printed-paper. Every plate has its own bare code with its own colour. The bar code meter inspector checks that all the colours are printed, that there is just right amount of ink and that the ink is dry. There are UV driers to dry the ink, because they use so-called UV ink at this machine.

4.4.1 Process description
Here comes a short description of the production process, from the start to the end. We have chosen to keep it simple, so it wouldn’t get so complicated to understand. To see a view over the machine, see appendix 7.

- Feeding and stretch station
  The process starts with a huge paper roll, which is fed in the machine and stretch to get a plain surface to print on.

- Press cylinders
  There are five press cylinders that print with different colours, so you can print with five colours at the same time. Every cylinder has different print plate, depending on what you should print with just this colour.

- Number- and fold cylinder (press cylinder)
  This cylinder can be used for numbering the products, for folding but also for printing with an additional colour, that is a sixth colour.

- Perforator station
  The costumers may want holes in the side of the products or other marks in the paper and that are done in the perforator station.

- Cutting station (width)
  Here the width is cut to a decided measure with knifes.
Cutting station (length)
Knives are cutting the length of the product in this station.

Cutting station (sheet)
This station have knives that cuts the products in to sheets.

Packet station
At this station at machine 222, the products are tied together and the operators pack the products for delivery.

4.4.2 The maintenance job at machine no. 222
The maintenance staff has checklists, of what to do during the services of the machines. Our machine also has a check list (See Appendix 6). On these the maintenance staff has to sign every part in the service, so that nothing is forgotten. Other duties under the services for the maintenance staff are the list from the machine operators (See Appendix 5). The list contains different things, which has to be check and maybe corrected, which the machine operators noticed during their time by the machine.

During the services, the machine operators handles the cleaning and some other duties on their machine and maintenance staff handles the more technical advanced things, such as exchanging the knives in the colour roller. The members of the maintenance staff, who are involved in the service, can’t stay at the machine the whole time. This is due to the fact that other machines need to be repaired. The service is scheduled during one week every year. The maintenance staff doesn’t participate during the whole time, said the operators. There are many things, on this machine, that the experienced workers can perform themselves.

The service on this machine has been postponed the last two years. The reason behind this is that the maintenance staff has not had the time to participate due to various reasons. The machine operators thought it was understandable, because the lack of personnel in the maintenance staff and the high demand from other departments.

4.4.3 Common faults
Many things can occur, on a machine like this one. We are here going to list a couple of them and explain the reasons behind them. The faults are:

- The paper tints – The reasons behind this is that the damp system has not been cleaned. This is easy corrected before an unplanned stop occurs, but if its not been cleaned for some time it will affect the product quality. This fault can cause other faults.
- Uneven cuts – This is because that the paper knifes has become too blunt. To fix this is just to exchange the paper knives with new ones.
- Uneven prints – This fault can have been caused by many things. For example that the bearings within the roller cylinders can be worn out and to correct this it’s to exchange them with new ones.
4.4.4 Collected data
We gathered the data, to be able to calculate the OEE value for our machine. These figures are gathered by our own measurements, interviews and Strålfors business system.

The total working hours:
- Monday- Thursday 18 hours (times 4)
- Friday 8 hours 30 minutes

Working time in minutes per week:
(18*60)*4+(8*60+30)= 4830 minutes/week

Planned stoppage time:
Breaks:
- Monday- Thursday (1,25*60)*4=300 minutes
- Friday 0,75*60= 45 minutes

Total break times: 345 minutes/week

Planned maintenance:
- Friday 2*60 = 120 minutes/week

Unplanned stoppages losses:
The unplanned stoppages during a regular week is calculated, by using the total amount of stoppage during the last six month and divided by the number of weeks during the six month.
The unplanned stoppages were 17383 minutes, between 20030920-20040320. During this period of time was 25 weeks.

17383 minutes / 25 weeks = 695.32 minutes/week

Set up losses:
The set up losses is calculated the same way as the unplanned stoppages.

The total amount of set up time was, under the time period between 20030920-20040320, 51682,8 minutes. Number of weeks during this period was 25.

51682,8 minutes / 25 weeks = 2067.312 minutes/week

Number of produced items:
Number of produced items is 17 507 251, under the examined six month period. The mean value for each week is 700 290.04.

The actual cycle time: 0.00155 minutes

Quality rate:
We discussed with the quality manager about the quality rate. He said that our machine is performing around the average value in the factory. The average value is 99%. We are going to use that value for our calculations.
4.5 The current computer based system
Movex is Strålfors business system; where they have their registration of storage, spare parts, and register of articles, delivers, work orders and economical posts. The spare parts data doesn’t work, according to the maintenance staff. Sometimes when they have had ordered some parts to use in the near future, somebody else has taken them to another machine.

By each work place there is a computer, with a system they call Mps. Their computer department has designed the Mps-system. In the Mps-system the operator starts the work order, do calculations and this system report to Movex. This Mps-system handles a little amount of historical data, such as running time for specific orders. Some of the machine operators use this tool, to know how they are performing. The data doesn’t specify why the machine has stopped for example.

4.5.1 Requirements for a computer based maintenance system
The most important criteria at the company, when choosing a data based maintenance system are that the system is compatible with the data systems that already exist in the company, according to the plant manager, Movex and of course it must be user friendly. It’s very important that the system is easy to use and easy to find what you are looking for in the system or else it’s very hard to get the employees to use it the way it was meant, said the plant manager and quality manager. The system should also contain history like repairs, replacements and aspects for economy and supplier-contacts, according to the maintenance manager and his staff. One of the most important parts for the maintenance personnel and the operators is the order form for repair. Machine drawings are another requirement from the maintenance personnel. Spare parts and time for stoppage are also something that is required, according to everyone except the workers and maintenance staff.

A very important aspect is that it should be possible to expand and develop the system if new requirements are needed in the future. Of course the support and education offered when buying the system is very important. The data knowledge among the personal is very varying. The plant manager would of course like to see economical posts that show how the company is using their money. If they can see that a machine costs far too much in spare parts or/and repair hour, then perhaps they can decide that they are going to buy a new one and scrap the old one, based on the historical facts, according to the plant manager. Everybody seems to agree about that they all will learn how to use the system and that the system will be useful to everyone in the company in one way or another. The maintenance staff is uncertain about if they have time to sit in front of the computer and report what they have done. They agree with the rest of the company that historical data would be a help to them, when they search for failures or when they exchange some part in a machine.
5. Analysis
In this chapter we are going to analyze the company, with the aspects on our problem formulation, the theories in chapter 3 and the empirical findings.

In this chapter we analyze the company's way of working, according to question number 1 in our problem formulation (on page 9), in the chapters 5.1 to 5.2.3. Question number 2 is handled in the subchapter 5.3, there we analyze the needs of a maintenance software.

5.1 The current maintenance situation
The strategies, they work with, is break down maintenance and preventive maintenance. To see if the break down maintenance is the most cost effective strategy, there has to be an investigation made, according to Johansson, (1997). The investigation contains information about:

- Changing times – If it takes longer time to exchange the part when it’s broken than it takes do it when it isn’t.
- The price of the part
- Consequence faults – If the part breaks, does it affect other parts to brake as well?
- Repair time – How much a repair costs and how long it takes.

These different figures should be analysed to see which way is the best to go. Strålfors has not performed such investigation, therefore we think that they don’t have anything to support their way of working with break down maintenance. By using the most cost effective maintenance strategy for a machine, the machine’s life cycle cost could be decreased. The life cycle costs include every cost, which the machine needs to function during its entire life time, according to Johansson, (1997).

Their time intervals for the preventive maintenance are based upon the recommendations from the manufacturer and their own experiences. According to Ljungberg, (2000), the time intervals can be optimized to keep the stoppages limited. Strålfors time intervals for preventive maintenance aren’t optimized. We think that the company should try to optimize the intervals, but they don’t have any historical data to look on to do the optimizing. By using the historical data, they can see pattern behaviour for the part and from these decide a more optimized interval for the exchange. Therefore we think that the company should start to collect running times for the parts within the machines.

We continue our analysis according to the sub chapters we used in chapter 4. In this way we focus on one aspect of the maintenance work at the time. The sub chapters are:

- Operator maintenance
- Maintenance department
- Reporting of failure
- Improvement work
- The management’s engagement

5.1.1 Operator maintenance
When Strålfors started with their type of operator maintenance, they didn’t follow the seven step program from Ljungberg, (2000). We aren’t saying that every step in the
program must be performed, but it helps to see how the initializing could be performed. According to Ljungberg, (2000), a large cleaning is necessary, before trying to start the operator maintenance. This cleaning can be done, after the recommendations from the five s’s. Strålfors has some problems, with disoriented equipment. We think it’s unnecessary for the operator, to have to look for the equipment/tools before each maintenance task.

The operator maintenance is planned and scheduled, with different intervals. There is instructions and signing list, for the workers to check what to do and sign, when they have performed the actions. The signing lists are not so valuable, because they often aren’t signed at all. We think that the instructions of the maintenance actions aren’t clear. The instructions are written very shortly, which makes it hard for an untrained operator to understand.

The experienced operators also repair the machine, if they can. We think this is good, because that saves time for the maintenance staff and also decreases the stand still time. One negative aspect of this is that the operator doesn’t have the knowledge to fix every fault and the maintenance staff maybe raises their demands on the operators, because they think that the operators can perform more than they actually can. Another thing is that the level of knowledge is very different within the production staff, this can be a factor for the inexperienced workers to feel unmotivated to perform a good work. The inexperienced workers can get the feeling that they can’t do anything, which relates to none existing education on the machines. We believe that the level of knowledge is difficult to get equally distributed between the workers. Some of the workers see their work like just an income and others are real interested and want to learn more.

According to Ljungberg, (2000), the education is one of most important thing to have, if the company wants to have a successfully operator maintenance. The education level should be increased among the workers, they should get an introduction of the machine they are supposed to work at. The idea about the education level is different between the staff members and the workers. The workers say that no education is performed when the company hires new personnel. The staff members say that there is an education for the new hired employees. That education brings up the most essential knowledge, which they need to have to run the machines but no maintenance information, is included. We have realized that no education is performed on maintenance tasks. The workers get some education about how to run the machine, but there is nothing about maintenance. The company has the possibility to introduce the maintenance tasks for them during the production education, but doesn’t do that.

5.1.2 The maintenance department
Within the department the cooperation works fine and the manager for the department has a close contact with his staff. The staff felt that they are motivated to do a good work, which is good because of that a motivated worker often performs better than an unmotivated one according to Johansson, (1997). The close connection between the maintenance staff and the manager for that department is working well, because of the manager’s experiences from developing and repair the machines. We think that the manager’s knowledge is very useful and that makes the staff respect him. The respect is important for a manager to have.
The maintenance staff likes the feeling of being saviours, when something has gone wrong. This feeling is possible for them to get when a machine stops, and it is not occurring when they perform preventive maintenance tasks. We believe that the maintenance staff should get motivation from their managers, and not from unplanned stoppages and the involved production personnel. The preventive maintenance is harder to perform, because of the production personnel’s thoughts about the maintenance department just steals valuable production time. This is due to the attitude from the higher positions in the organisation. The understanding for maintenance, of the machines, is that it is impossible to schedule, and it takes too much time and that every stoppage is bad.

The manager tries to schedule services for the machines, but there is almost always something that gets in the way of performing them. One reason behind this is that the Order & sales department has the ability to plan production during the week that the service is planned. If an order is to be produced under the service week, the shift leader tries to reschedule the service, and there are many who do the same thing. That is the reason why the service schedule doesn’t work. We believe that this way of working is strange, because one department can carry out orders that destroy the work planning from another department.

The maintenance staff is very often interrupted by phone calls and machine operators. This increases the time of their present work, because of the time spent on the phone call and to orientate their work again. We think this makes the jobs take longer time than needed and that it affects the performance of the maintenance staff. The priority making shouldn’t be handling by the single maintenance worker, because he doesn’t have the knowledge about the production planning. Therefore it is important that all maintenance tasks, is reported to the shift leader and not to the maintenance staff directly. The production has different types of customer demands, therefore a certain area in the production department is prioritised.

The maintenance staff also has the janitorial duties, which takes time for the maintenance tasks they have. The time for this type of duties is limited and almost impossible to plan, because of the large amount of acute stoppages. The maintenance staff feels that these duties takes time from their ordinary job. We think that the workload on the maintenance staff is too large to handle for them. They have too many tasks, such as machine movements, maintenance jobs, repairs and janitorial duties.

5.1.3 Reporting of failures
The maintenance personnel are often stressed, because machine operators are chasing them for help and their telephones are ringing all the time and disturb them when they are repairing a machine. The department called “Gamble and tickets” must run all the time, so if a machine stands still at this department the maintenance personnel have to quit what they are doing and fix the machine at this department right the way, and it happens rather often. We believe that constant interruptions make the maintenance staff’s efficiency decrease, according to Johansson, (1997), and create a work situation, where things easily get forgotten.

The written notes, that the maintenance personnel get or write themselves to remember what to do or what they have done is often forgotten and thrown in the
wastepaper basket. The operator that waits for help gets irritated, when the help isn’t coming because the maintenance personnel have forgot. Sometimes there are disputes about when a machine part was exchanged last time and it’s often hard to find out when it was done. Because the notes often are thrown away there is no history at all, except some details that the maintenance personnel write down themselves. We think that the lack of historical data is one thing that makes the maintenance staff’s time go to waste, just by have to remember when a machine part was changed.

5.1.4 Improvement work
Strålfors once tried to start improvements groups but at the same time they had another big project going on, so they had to put the improvements groups aside. Many of the workers have worked at Strålfors for many years and know their machine well. Some of the workers think that many ideas, which come from the office staff don’t work in the reality and they think it’s very strange that they don’t ask them, if it would work or how they want it. Some of the operators are also a little skeptical to improvement groups, because they don’t think the company would listen to their suggestions. According to Ljungberg, (2000), the idea of changes has to be accepted among the workers before starting with it, otherwise there is going to be conflicts and the workers don’t accept the changes. We believe that the changes, which affect the workers, should be discussed with them and the management should listen to their idea and not just decided without them.

5.1.5 The management’s engagement
The management seems to care about the workers and listen to them even, if some of the workers are skeptic. The management is also aware of how much the maintenance personnel have to do and that they sometimes should need more personnel. The economical aspect is very important, and everything has to be shown in economical prognosis and terms.

Almost everyone in the management has worked at the floor, so perhaps they remember what it’s like and can understand the workers problem in a good way. We believe and according to Ljungberg, (2000) that the company has to listen more to their workers and has to try to motivate them, as much as they can. The management for the company has decreased the budget for the maintenance department, despite the fact that the machines are getting older. The management should realize that their machines LCC are increasing, because of lack of performed services.

The maintenance costs are affected by other costs, which should not be included in the maintenance costs. We think that they should be able to separate the actual maintenance costs from the other costs, which increase the costs now.

5.2 Machine no. 222
In this sub chapter we are going to show different problems and measurements of our machine, with the help of the theories in chapter 3.

The machine can manage a lot of different types of products, which we believe is good because it has the ability to “help” other machines during stoppages. This ability can also be a negative thing, because the machine’s set up times will increase, when a lot of different jobs are scheduled to it.
5.2.1 Ishikawadiagram
This diagram helps to identify the reasons behind a problem. The arrow in the middle (here numbered with 1) shows the main problem, and the other shows the reasons. The reasons go deep into the causes, and by visualize them the problem can be corrected. (Johansson, 1997)

1. Quality faults
2. Uneven print
3. The bearings are worn out
4. The yearly service has not been done
5. The paper tints
6. The damp system is sealed
7. The system has not been cleaned
8. The yearly service has not been done
9. Ignorance
10. Print fault
11. Lack of information
12. Carelessness

Different fault, that can affect quality rate, are for example uneven print, the paper tints or print fault. Uneven print means that the printed picture or/and text is not printed with the same thickness all over the paper. This can be caused by for example worn out bearings, that haven’t been changed in time for example at the yearly service. The paper can be tint, when the damp system is sealed because it hasn’t been cleaned caused by a not performed yearly service or sometimes by ignorance. There can sometimes be faults in the print, caused by mistakes in the print plates, which can depend on carelessness or lack of information.

There is a very big difference between the knowledge, the skills and the willingness to do the maintenance tasks, which the machine operators are supposed to do. The checklist that they have in a file by each machine isn’t always used and signed, and if
it depends on that they forget to sign or if they don’t perform the tasks you really don’t know.

By not performing the services yearly, many parts in the machines start to wear out. The parts should last longer, if they were continuously checked. The machine’s LCC becomes higher, because of the unnecessary replacements of parts.

5.2.2 Calculation of OEE

To see how the machine no. 222 is performing, we choose to calculate the overall equipment effectiveness. Under this headline we are going to show the different figures we used to calculate this. Between the parentheses the calculations are shown.

I Total amount of working hours = 4830 min/week

II Planned stoppage time = 345+120 = 465 min/week

III Unplanned stoppage losses = 695.32 min/week

IV Set up losses = 2067.312 min/week

V Available production time = 4830 – 465 = 4365 min/week (I-II)

VI Actual time for production = 4365- 695.32 – 2067.312 = 1602.368 min/week (V-III-IV)

VII The availability = 1602.368/ 4365 = 0.3671 = 36.71% (VI/V)

VIII No. of produced items/ week = 700290.04.

IX The actual cycle time = 0.00155 minutes

X Operator performance = (700290.04*0.00155)/ 1602.368 = 0.6774= 67.74% ((VIII*IX)/VI)

XI Quality rate = 99%

XII Overall Equipment Effectiveness = 0.3671*0.6774*0.99 = 0.2426 = 24.26% (VII*X*XI)

5.2.3 Analysis of OEE

The value of OEE for this machine is very low, because of the low availability at that machine. We can directly see that the set up losses is higher than the actual production time. In this type of company the set up losses is necessary, because the machines don’t produce the same thing all the time. The problem is that the Order&Sales department doesn’t think about the set up times when they scheduled a machine with different types of orders after another. The Order&Sales department together with the production leaders sometimes breaks up an order in to two parts, which increases the set up time. If the variety of products could be smaller for the machine, the set up times will decrease which will increase the OEE-value. One other reason behind this
OEE-value is that the machine stops for problems in almost 12 hours every week, these stoppages is caused by lack of performed service and other maintenance tasks. The reasons behind this are that the operators don’t have the knowledge or the interest to perform the maintenance tasks.

5.3 Requirements for a computer based maintenance system

We have performed interviews and explanations, how the system is supposed to be used, to get the information we needed to do a user requirement specification, after the recommendations by Tekinerdogan&Aksit, (2004).

Here we have listen and ranked the preferred features, according to the answers from the interviews:

1. It is compatible with Movex, just so the company doesn’t have to update things in two different systems and eliminate misunderstandings and confusion.

2. User-friendly, so that it is easy to use for all levels in the company. The system has to be easy to use, because of the different levels of computer knowledge among the staff. Otherwise no one will use it, and then it is unnecessary to spend money on it.

3. Historical data, so that the maintenance department can optimize the time intervals for the preventive maintenance and unnecessary discussions can be eliminated.

4. Order form of wanted repairs - handling, so that the operators can send a message, of what needs to be done with their machine. We think this could eliminate the running after the maintenance staff.

5. Economical figures, so that the costs can be broken down on machine-basis. This is needed, because the maintenance department can see how much a machine costs in form of repair hours and spare parts. We believe that this feature could be useful in the discussions about new investments.

6. Handle machine-drawings and machine parts, so that the maintenance department can look at which parts is needed before a service or a repair. This system should know how the machine is put together and which parts it is consisting of, so that the ordering of spare parts can be handled easier.

7. The ability to expand and develop the system, if the company needs and wants new features to be added they should have the ability to add them.

According to Basim Al-Najjar, (1996), it is important for a company to have a database and not having many different databases. It is cheaper to maintain and update one system than to do it with a lot of different systems, therefore we put the point “It is compatible to Movex” first. The database should contain historical data, such as:

- The time for exchange for the different parts
- How long a part has been used
- The service record
This data is necessary to be able to conduct preventive maintenance, according to Ljungberg, (2000). The system should be as user-friendly as possible, because a system, which is complicated to learn, isn't being used, according to Johansson, (1997). The ability to handle wanted repairs is important, because it can decrease the hunting after the maintenance staff and therefore not stress the maintenance staff. The economical figures, we believe, is important so that the company can see how much money they spend on each machine, in form of repairs and maintenance. The software should handle the spare part-inventory, so that the parts can be reserved for a certain service, because this is a problem according to the maintenance staff.
6. Result
This chapter contains general suggestions for a company to have in mind while working with their maintenance. The more specific recommendations to Strålfors come in chapter 7. We have used the theories in chapter 3, the empirical findings and our analysis in chapter 5, to make these suggestions.

In this chapter we handle question number 1, in the problem formulation at page 9, in the following sub chapter: from 6.1 to 6.2. Question number 2 is handled in the subchapter 6.3.

6.1 The maintenance work
In order to work with maintenance, there are several things to think about. In this sub chapter we are going to present and motivate different things to do. We have divided our suggestions into the following categories:

- Operator maintenance
- Maintenance department
- Reporting of failure
- Improvement work
- The management’s engagement

To work with maintenance, we recommend the cycle of plan- do- study- learn. In this way, the company can develop their own way of working with maintenance according to their conditions. This cycle is explained in more detail, in chapter 3.2 on page 20.

6.1.1 Operator maintenance
If a company wants to have a successful operator maintenance program, the company could look at the seven step program, on page 25, from Ljungberg, 2000. This program can help identify the different obstacles, which are important to know before the initializing. The program doesn’t have to be followed precisely, but can be used as a guide.

Before the implementation of the operator maintenance, a complete cleaning, of the production areas, should be performed, according to Ljungberg, (2000). This cleaning process could be done after the recommendations, from theory about the five s’s. The five s’s helps the company to create standards for the cleaning actions. It also helps to detect the reasons behind the filth, so it can be prevented. By preventing the filth to develop other problems, the machine’s LCC can be decreased.

Each machine should have their own instructions, for operators to follow when needed. These should tell the operators how to perform the maintenance and include the cleaning. The instructions should be much more specified, so the inexperienced operator also can perform the tasks. According to Johansson, (1997), the instructions should contain simplified drawings over the machine, so it is shown where the actions should be done. The workers should confirm that the tasks are made. This confirmation could be done, by signing a list or report it to a maintenance software (if that is available).

The operators should get education about their work, according to Ljungberg, (2000). Our suggestion is, when the company employs new operators, to have an education. The education should contain the tasks, which the operator should do. These tasks
should be explained, so the worker knows what to do. The education should bring up both the production and maintenance tasks. The company should have constantly recurring education of the operators, so the experienced workers also get an education. Because even if a worker has been employed a long period of time, he might not know exactly how he should be working.

6.1.2 Maintenance department

The organization for the department should be clear, so that everyone knows exactly what their tasks are. A foreman, to schedule the work and act as a contact person for the maintenance staff, can be a good idea. Because then the production knows, who to contact if a failure occurs. A close contact between the maintenance staff and their leaders is very important, according to Johansson, (1997). This can be reach, through having meetings and discussions about different activities. The manager should root his decisions, with the staff’s experiences and knowledge. The maintenance department can be divided up to smaller work groups, if it is suitable for the company. For example, the company can divide the machines into groups, according what type of machines it is. Then maintenance staff doesn’t have to have knowledge about every type of machine, the company has.

The manager for the maintenance department shouldn’t have more tasks, than to lead the maintenance department. If the manager has a lot of different tasks, some of them can be neglected. The manager should motivate his staff, so that they feel important and want to do a good job, according to Johansson, (1997).

Then there is a service scheduled, the maintenance staff should decide who is going to attend the emergency situation, which may occur. The staff, which works on the service, shouldn’t be bothering by phone calls and such things. Because it takes longer time to perform the service, with constant interruptions than without.

6.1.3 Reporting of failures

The maintenance department should have a contact person, who is responsible for the emergency situation. The operators or the shift leader contacts that person, by phone call or by the computer based maintenance system (if such is available). The contact person, who could be a foreman, have to decide who, he is going to inform about the problem. The contact person therefore has to have knowledge about the production planning and other areas, so he can make the decision, based on fact, if the action should be attended to or not. Maybe a service is scheduled for next week, and the production can be moved to another machine, therefore the problem doesn’t have to be corrected until the planned service.

6.1.4 Improvement work

Companies have the ability of use the workers’ knowledge, by implementing improvement groups. According to Ljungberg, (2000), the improvement groups shouldn’t be project-based, instead should the work be continuous. The groups work with making the processes within the company as efficient as possible. We think implementing improvement groups is a good idea, because the workers probably have a lot of ideas about their own work place. Not everyone in the work force should be involved in improvement groups, but should have the ability to make suggestions. To give them that ability, suggestion boxes can be placed out around the production
floor. In these boxes, the workers can leave their suggestions for the improvement groups to discuss.

The meetings can be scheduled, after or during the working hours. It depends on the type of production, the company has. During the meetings, there should only be representatives, from the production workers and the maintenance staff, present. When a suggestion has come, a small report should be handed into to, for example, the production manager.

If a company would like to implement improvement groups, it is important to understand that the work shouldn’t be rushed and that the management has support to the groups. The management’s engagement is very important, therefore we have that in the next sub-chapter.

6.1.5 The management’s engagement
In a company, the management has to make all decisions, which affects the whole company. Therefore it is important, that all decisions, which are made, are rooted in the involved departments, according to Johansson, (1997). We think that the management has to be keen to the needs and wants from the workers. Also listen to the workers ideas, about the changes, is important and can deliver interesting aspects.

The management has to understand and motivate their workers, according to Johansson, (1997). If the management decides a change in the maintenance work, it is necessary to discuss the change with the affected workers. This discussion take place with the entire company or just the improvement groups, if it is possible and the management thinks that the groups are representatives for the affected workers.

If the management decides to implement the TPM – philosophy, the first phase, in the 12 step program on page 24 (Ljungberg, 2000), is preparation. This first phase contains decisions from the management and so on. We think all, of the first five steps, should be discussed with the maintenance and production workers. A change is more acceptable, if it has been discussed with the affected parts. We aren’t saying that only the production and maintenance department are affected, by a change to TPM. The largest changes are done, within the production and maintenance department.

6.2 Strategy for changing/developing the way of working with maintenance
In this chapter, we are going to present a strategy for changing (or developing) the way of working with maintenance. This strategy can helps companies, through highlighting the important aspects while changing/developing a new way of working with maintenance. We based this model upon our own experiences, theories, the empirical findings and our analysis in this paper. Our experiences come from our previous attended courses at our education program.

We present each step here, but some parts are cycles, so to see how the model is structured, see the appendix number 9 on page 75.

1. Define a goal. The goal should be realistic, because that motivates better than an unrealistic one, according to Ljungberg, (2000). The discussion about the goal should include different positions, within the company, so that everyone
has their chance to affect the goal definition. The goal can involve just one machine or the whole company.

2. Decide the needed data. In order to change something, the right conditions should be available. The needed data can be economical figures, machine-specific details, failure times and much more.

3. Is the data available? Control if the needed data already exists or if a collection of data is necessary. If the data is available, go to step 6.

4. Discussion about maintenance software. If the needed data isn’t available, suitable maintenance software could be purchased/developed. This is a good time to do this, because the needed data is already decided. If a purchase (or development) of such system, it could be filled with fresh data. In order to see how to choose maintenance software, please see chapter 6.3 on page 54.

5. Collect the needed data, and if a maintenance system is available, update it by using the new collected data.

6. Make sure that the collected data is relevant, to the problem. If not go to step 2 again.

7. Analyze the relevant data, according to the defined problem. To analyze the data, we recommend using the seven quality tools. For example, the Pareto diagram can help (see page 29 for more information), with specifying the number of occurrences the problems have. This helps to illustrate, which problem is the largest. The Ishikawa diagram could be used (see page 29 for more information), to visualize the reasons behind the problem. It is important to find the reasons, behind a certain problem, according to Johansson, (1997). The fault pattern is also important to find, because a single fault can cause a number of other faults.

8. Identify the needed maintenance tasks, according to the problem and analysis. It is done by looking at the reasons, behind the problems in Pareto diagram.

9. Develop a couple of solutions, which will solve the problem. These solutions should involve the different methods and strategies for working with maintenance. This depends on the goal, because the strategies are more suited for the whole company.

10. Investigate the solutions, according to economical and production aspects.

11. Implement the most cost effective and efficient solution.

12. Collect more data, after the implementation.

13. Analyze the collected data, according to the historical data. See if any improvement has occurred, if not go back to number 7. If improvements have occurred, standardize the way of working.

To be able to test the system, step 12 and 13 should be done continuously with decided time intervals. If no improvements has occurred, it can be corrected by either collect new data or perform a new analysis. We therefore recommend analyzing again, a reason behind the problem could have been overlooked.

6.3 Selection of maintenance software
When a company chooses maintenance software, there are several things they should keep in mind. Two of these things are the user - and the system specification. The user specification should be done, so it helps the company decide which features they demand from the software. In this, the most important is that the system is user friendly, according to Johansson, (1997). If the system is hard to use, it is not going to be used. The company should present the available software for the workers, so they
can tell what they think about the user interface. It is important to remember that the computer skills can differ from staff members to the production floor.

The system specification tells the company what the software requires from the computers it is going to be installed on. The company should control this, and see if they can use it. The requirements differ from the available software, so it is an unnecessary cost to buy a system that demands investing in new computers.

The company need to find out, which different features the software should have. This can be done by interviewing the workers and staff members, which are required to work with the system. After this interview process, someone should gather and rank the different features, according to the needs and wants from the involve personnel.

When this ranking is finished, the company should collect information about the available software. The company can sort the available software, according to the requirements from the personnel and the system specifications. If the software doesn’t live up to the demands from the company, it shouldn’t be interesting to discuss further. When this sorting is over, the company can investigate the software, which supports the demands. This investigation should contain:

- Price for purchase – How much the system costs to purchase and what is included in the price (such as number of licences)
- Education – If education is available, and how much it costs, to get from the supplier of the system
- Support – If there is an available support to get help from
- Security of the supplier – How secure the supplying company is. So that our company doesn’t have a system, there the supplying company has gone bankruptcy and no support is available to our purchased software.

After the investigation, the company should be able to pick a more suitable maintenance software for their business.
7. Recommendations
In this chapter we are going to present our ideas about the company’s way of working with maintenance and motivate our suggestions for changes.

In this chapter we handle question number 1, in the problem formulation at page 9, in the following sub chapter: from 7.1 to 7.2.2.
The question number 2 is handled in the subchapter 7.3.

7.1 Improving the current maintenance situation
The most important thing is to make the yearly services work. When a service is planned, it has to be very difficult to place an order at that machine. If the service is moved, it has to be planned in as soon as possible again. During the services, the maintenance personnel shouldn’t have their phone available, for others to call and disturb the work. There has to be other maintenance personnel that can take care of emergency alarms, while a service is conducted.

Computer based maintenance software should solve the problem with disturbances and a foreman for the maintenance department should improve it. With a computer based system the maintenance personnel don’t have to be chased all over the company and don’t have to be disturbed by the phone when conducting a service or a repair. A foreman can divide the work and see to that the maintenance personnel can perform the services without interruptions. We think the maintenance department could be better organized.

We believe that our strategy (chapter 6.2 and appendix 9 on the pages 53 and 75), for developing and improving the maintenance work, should help the company to decide an effective way of working.

We have written our recommendations about the maintenance, according to the following subchapter:

- Operator maintenance
- The maintenance department
- Reporting of failures
- Improvement work
- The management’s engagement

7.1.1 Operator maintenance
If the company would like to implement operator maintenance in full scale, they should follow the seven step program that we present in chapter 3.5 on page 25.

We think that they could integrate the present education with an introduction about the maintenance tasks. Perhaps they could get some kind of bonus, depending on how much extra maintenance work they can do on their machine. That could encourage the workers to learn more about their machine and how to maintain it in the best way.

If they could connect all the equipment, like printing cassettes and so on to a machine that use it often, then the workers by that machine has responsible for the maintenance for them too. The equipment, which belongs to the machine you work with, should be cleaned and ready to be used. If it’s broken you have to repair it or let the maintenance personnel do it. To keep the equipment and tools in the right place and
keep them maintained and cleaned saves time and money. They won’t have to look for them all over the place, before they have to use them. The equipment is working and can be used when it is supposed to, if someone has the responsibility for them. The responsibility means that you have to keep them clean and maintained. The five s’s should be implemented, to deal with these problems. We have described the five s’s in chapter 3.5 on page 25.

7.1.2 The maintenance department
The manager of the department has many tasks, such as maintenance and development, within the Strålfors group. He travels a lot between the different locations. We don’t think there is enough time for him to focus on both, therefore we suggest a foreman for the maintenance department. To see how we would like to place the foreman, within the maintenance department’s organisation, see the Appendix 8 on page 74. We think that the foreman should have several different duties. Here comes the list of duties and the reason why we think these should be handling by the foreman:

- Lead and plan the maintenance work, so the maintenance workers know what to do and when to do it. The foreman then knows where his workers are and what they are doing. When the workers are finished, they should contact the foreman to get the next job. They should also give an explanation of what they have done. The explanation is just to let the foreman know if any spare parts should be ordered and keep the maintenance software updated.

- Act as a contact person for the acute work. The foreman should have the knowledge of which to call when an unplanned stoppage has occurred on certain machine, so that the others can continue with their work and not be bothered about things, they don’t have the time or knowledge of performing.

- Report to the maintenance system. When the worker picks up his next job, he should tell the foreman what he has done with the last machine, so that the foreman reports this information into the maintenance system.

- Order spare parts. Today the maintenance staff has to order the spare parts themselves, which takes a lot of time because all the parts isn’t numbered at the supplier. The staff then sometimes has to take photos of the part and send to the supplier, this task can be done by the foreman instead to save valuable time for maintenance staff. The foreman also has to keep track of the storage, so all the parts, which are needed during a service, is available then the service should be performed.

We think that the Order&Sales department shouldn’t have ability to reschedule services, and if some important customer should demand the company to produce his order during that week and no other machine has the possibility to produce it, they should discuss it with the production manager and maintenance manager, if there were some way to reschedule the service. The amount of rescheduled services should only be a few and the production leader should have to explain it for the workers, so that they understand the reasons behind the rescheduling.

We think that the higher positions in the organisation must understand that a good maintenance with fewer stoppages saves production time instead of the opposite. When they have understood it, they should present and explain how and why planned stoppages are better for the production staff. It is impossible to change the workers minds, when their managers haven’t changed their minds.
7.1.3 Reporting of failures
The reporting of failures would be much easier with a data based maintenance system. When they are arguing about when a machine part was changed last time, they can just check the history part in the maintenance system. Our suggestion is to employ a foreman for the maintenance department that should divide the work among the personnel. The operator’s just report the failures (not the acute failures that needs to be done immediate) in the maintenance system and the foreman check the failures in the software and send the best man for the job as soon as he can. The emergencies, that need to be taken care of right the way, aren’t supposed to go through this system, just the works you can call “next-week” jobs. The foreman should also handle the ordering of spare parts. When a maintenance task has been conducted, the maintenance personnel reports to the foreman. The foreman feed it in the data system, so the history is updated all the time.

7.1.4 Improvement work
We think that the personnel have a lot of competence and experience that the company could use. Improvement groups could be one way of getting the employees’ ideas and suggestions in the open, especially if there is some kind of bonus for good suggestions. It’s the operators, which work by the machines every day, which surely have ideas about improvement, of how to make their work more efficient. We think it would be suitable with groups, which have 4-5 persons in them. These groups should meet and discuss improvements and suggestions, a couple of times each month. They should consist of workers only and not any persons from the management, because we think it’s easier to talk and come up with proposals if it is only work-mates present. When they have proposals that they want to present, they (or one of them that represent the group) present it in a small written report to the production leader. He brings it up on the next staff meeting, for approval or disapproval. When a proposal is approved and can be implemented, the department that comes up with the suggestion gets a bonus. The bonus could be for example a sum of money, which the department can use for a common thing like a pub visit or a trip or a theater visit, something that increase the solidarity and the work morale.

Another way to use the workers experience and competence is to have proposal boxes, where they can leave notes with their suggestions. In this way the workers don’t have to show their name, just write down which department, and the whole department can get eventual bonus for the suggestion.

7.1.5 The management’s engagement
The engagement of the management is the most important thing, when it comes to changes in the way of working or a new way of thinking. Even if everybody in the management have a lot of experience and had climb up from the work floor and through the whole chain up to the management, they can’t sit in their office and only think of how much money the company earn or loose. They have to listen to the workers and really show their engagement, when implementing new things.

It’s too easy to think that this and that have worked in a good way for twenty years, so that must be the best way of working. The younger generation must be given a chance to show they can and come up with new ways of working and feel that someone listens to them. Too much bureaucracy can often get the most creative worker to give
up and stop caring about improvement suggestions. The workers must feel that the management really listens and that good suggestions can be reality.

7.2 Machine no. 222
We think the personnel at this machine have a lot of knowledge of their machine and can do a lot of maintenance tasks. The yearly services have to be performed, because some of the problems and stops at this machine certainly happens because of services aren’t done. If the services are performed, the LCC of their machines decreases. There has to be a way to plan the orders, so there is time for service and to decrease the setup times.

7.2.1 Suggestions to minimize the current problems
Educated personnel, clear information and a well functioned preventive maintenance are the most important issues to improve the situation at the company. The company has to prioritize the yearly services more than they do now.

7.2.2 The OEE-value
The low OEE-value at machine 222 depends on the very long setup hours, there were more setup times than production time in the period 030920-040320. Because of the variety of products to print at very low volumes, the setup time get very high. Every time you change product you have a setup time, the time it take to make adjustments for the new order. That and the lack of yearly services that sometimes causes stops, make the availability very low.

7.3 Choice of computer based maintenance software
The criteria, when choosing computer based maintenance software, are that it is compatible with Movex, the system that already exists in the company. In that way, you have access to the data in Movex and don’t have to store and update the data in two systems. The “user friendliness” is of course very important or else the system won’t be used as planned. The computer skills among the personnel are very varying and it has to be easy and quick to use the system. The chance to get historical data is very necessary, to optimize the service intervals and get rid of discussions, about when a spare part was changed the last time. An economical aspect has to be in the software, to get a clear view of how much the different machines cost in spare parts and working hours. This part can be useful, when it comes to new investments and scrap of old machines. The software would be very useful for the company, when they calculate the LCC of their machines.

The order part, where the operators can get service, repair and spare parts, from the maintenance department are very important. The software should be able to handle machine drawing, which a desire from the maintenance staff. And finally the ability, for expand and develop the system for future needs, is preferable.
8. Conclusion
In this chapter, the conclusions of this study are presented.

8.1 Answers to the questions in the problem formulation
The problem formulation for this study was:

To analyze the current maintenance situation and give suggestions to improvements.

Our problem formulation is based upon these two questions:
1. How should the steps for a change in the maintenance work look like?
2. How should a company select a maintenance software?

The answer to the first question is the model in chapter 6.2 (on page 53), for highlighting the problems faced when a change should take place. The model shows the importance of relevant data. It also highlights that continuous analysis is important, so the company knows if improvements has occurred or not. The model has a step, where a discussion about a maintenance software should occur. We think it is important to highlight that a software can help companies’ with their maintenance work.

The second question is answered in chapter 6.3 (on page 54). In that chapter, we explain the differences between user – and system specifications and recommend performing interviews, to see what features the employees wants. After these interviews, we recommend that the requirements should be ranked. The company should collect information about the available software on the market, and see which of them that fulfils the requirements. The software, that fulfils the requirements, should be investigated according to purchase price, education for the staff, support and the security of the supplier. When the company knows what they want the supplier are invited to the company to show what they can offer and submit an offer. After this, the company should be able to pick the software, which suits them the best.

We think that this study contributes to the field of maintenance improvement, and to the field of maintenance software. We have found no theory about how to choose a maintenance software, but we believe that the software can help companies to organise and detect the needed maintenance work.

8.2 Criticism to this study
The collected data in chapter 4.4.4 (on page 41) is gathered through the case company’s data system, to use in our OEE-calculation. Therefore we can’t be sure that our OEE-calculation gives the right result.

The model has not been tested, but the purpose with it is to highlight the importance of relevant data, maintenance software and continuous analysis.

We have only interviewed two operators and two members, of the maintenance staff, so maybe the result of our specification of the user requirements regarding the maintenance software could be different, if all of the operators and maintenance staff have participated in the interviews.
9. Future work
Our suggestions for future research:

- The model has not been tested, so a test of the model could be conducted.

- The user requirements about a maintenance software don’t involve the business department, therefore we suggest involving them in the selection process.

- To use our research about a maintenance program, to form a model for the selection.
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Appendix 1 Questions for the interviews

Common questions
To answer question number 1 in our problem formulation (on page 9) we asked the following questions:

1. What is your work task?
2. For how long have you had this assignment?
3. For how long have you been at the company?
4. What type of education do you have?
5. Do you have time to perform a good work? Are you often stressed?
6. What kind of cooperation do you have with other departments?
7. Are you involved in the maintenance work? If yes, how?
8. Do you know how the maintenance work is performed? If yes, how?
9. How do you think the maintenance is working at the company?

To answer question number 2 we asked the following questions:

10. If we would implement maintenance software, which functions do you think is important for your work?
11. What computer skills do you have?

Questions to the maintenance staff
To answer question number 1, we asked the following:

1. Do you do any preventive maintenance, if yes what type?
2. Is it most repairs or preventive maintenance?
3. How is the organization of tools and other equipment for the maintenance?
4. Do you participate in the maintenance planning?
5. Should you prefer if the operators could do more maintenance work themselves?
6. Would you like to educate the operators in maintenance work?
7. How is your motivation? Do you get appreciation from the management or from someone else?
8. Do you get help from the operators to make your job easier?
9. Should measuring certain parameters do your work easier, if yes which?
10. In general, does the preventive maintenance or repairs take the longest time?
11. How is the machines health within the company?
12. Do you think that the production area is clean?
13. Do you have any suggestion to make the maintenance better?
14. Would you participate in an improvement group?
15. How are you contacted then an immediate failure occurs? Is it the right way of doing that?

To answer question number 2:

16. Would it make it easier for you to plan your work if necessary jobs are listed in the computer screen?
17. Would a database, with historic data of the machine, make planning process and seeking failures easier?
18. Do you use the drawings for conducting the maintenance?
19. Do you do any documentation about performed maintenance/repairs?

Questions to the machine operators
To answer question number 1:

1. Which machine do you work at?
2. How long time does it take for one “run”?
3. Are there often problems/stop in the production?
4. Are you fixing eventual problems yourself or do the maintenance personnel fix it and if so how long do you have to wait?
5. Which parts are in most cases broken?
6. Is there any co work with the machine operator at the other shift?
7. Are you involved any improvement work?
8. Should you participate in improvement groups, if you had the chance?
9. Are you contributing to the maintenance work?
10. Are you prepared to do any maintenance work in the future?
11. What kind of education do you get when the company is investing in a new machine/equipment/tool?
12. Would you like more cooperation between the maintenance personnel and other machine operators?
13. How are you supposed to act then a failure occurs on your machine?

To answer question number 2:
14. Should it make your work easier if the reports of failure would be handled in a computer software instead of phone calls and notes?

Questions to the shift leader, quality & environmental manager and production leader

To answer question number 1:
1. What are you producing?
2. Who are your customers?
3. Which kinds of machine failures are most common? Are they occurring often?
4. How is the machine operators supposed to act, then a failure occurs on his/hers machine?
5. Do you do any quality controls?
6. Are there any service occasions?
7. What are the maintenance personnel/ the operators’ tasks?
8. Which is your responsibility area?
9. What do you think could be improved in the maintenance work?
10. In what way are you investing in the maintenance work?

To answer question number 2:
11. Can a maintenance software be of any help while planning the production?
12. Do you see it as a positive thing, to be able to control what the machine operator’s reports to the maintenance staff? Motivate.

Questions to the maintenance manager

To answer question number 1:
1. How do you feel about your current maintenance situation?
2. Do you have any other type of maintenance than break down maintenance, if so what type?
3. Are you using any analysis in the maintenance work to see what can be improved and so on? If, what methods are you using?
4. Are you doing reviews on the maintenance?
5. Do you think there is a connection between the work place environment and maintenance?
6. What are you doing to improve the work environment?
7. Do you have any further education within the company?
8. Is the experience of the maintenance personnel and the machine operator considered when you are investing in new machines/equipment?
9. How do you feel about operator maintenance?
10. Are you involved in new investment process, if yes how?
11. How do you prioritize immediate faults?
12. Are certain machines prioritized? If yes why?
13. Is it hard to get money for maintenance work?
14. Can you influence your budget?
15. What is the largest problem for you to do your work, as you want?
16. How is the operator supposed to act then a failure occurs on his/hers machine?

To answer question number 2:
17. Do you think that a historic database would make your planning of the maintenance work easier?
18. What is the key factor while selecting a maintenance system?

Questions to the production manager
To answer question number 1:
1. What do you think about your current maintenance?
2. Do you have any suggestions to improve the maintenance?
3. Do you think there are any connection between a healthy work place environment and maintenance, if yes how?
4. Do you know that the five s’s is, if yes do you think that the company perform any of the five now?
5. Would you like to do any new investment to increase the maintenance, if yes what?
6. Do you perform any investigation how the maintenance work is perform, if so what?
7. Do you know the goals for the maintenance department if yes what are they?
8. Are you involved in the new investment process, if yes does the maintenance department participate and how?
9. How do you investigate the production performance?
10. Have you heard about OEE (Overall Equipment Effectiveness)?
11. Do you do anything to motivate your workers?
12. Have do you feel about improvement groups?
13. Do you think that the workers follow the time plan for breaks and such?
14. How has the maintenance work been decided for each machine?
15. Is there any education for the workers on new machines, if yes who performs the education?

To answer question number 2:
16. Which data system do you use, and how do they work?
17. What are your thoughts about a computer program for repairs and maintenance? Which types of functions would you like it to have?
18. Can a computer based maintenance system be of any help for your work?
19. Is any historic data about the production performance saved?

Questions to the plant manager
To answer question number 1:
1. Is the maintenance allowed to cost money?
2. What are the goals for the maintenance department?
3. How much in percentage of annual turnover does the maintenance cost?
4. How is the maintenance budget conducted?
5. What happens if the maintenance department spends more money than the budget allows?
6. Have the company has to increase or decrease the maintenance budget the last couple of years, if yes why?
7. The implementation of a maintenance strategy takes time and demand some changes in the organization, how do you feel about that?
8. Are you involved in the maintenance-planning, if yes how?
9. What are your thoughts about operator maintenance?
10. If the workers should participate in improvement groups, how should you deal with their suggestions?
11. Does the company anything to motivate their workers?
12. Do you think that the workers follow the time plan for breaks?
13. Do you think that the work morale can be decreased, if some key factors would be visual to them?
14. Do you think that an economic investigation, of the most efficient maintenance system, needs?
15. How is new investments planned? (ex. Machines)
16. Which are involved in the new investment process?
17. How is the maintenance department’s achievements followed up?
18. Does the company have any education for the maintenance employees?
19. Does the company any investments for a better maintenance, if yes how?
20. What do you think about your current maintenance situation?
21. Do you know what the OEE (Overall Equipment Effectiveness) is?

To answer question number 2:
22. Which data system does the company use, and how does it work?
23. Does the company have any historic data for the maintenance work, if not do you think it needs?
Appendix 2 Maintenance organisation

Bilaga 1

ORGANISATIONSSCHEMA

Bo Westlin
Teknik & Underhållschef
Maskiner, Projekt
Utveckling
IK/QS-ansvarig

Börje Torstensson
Underhållstekniker
Maskiner

Gino Ahlberg
Underhållstekniker
Maskiner

Paul Ståhl
Underhållstekniker
Maskiner

Lars Göran Brunskog
Elektriker /Gruppledare
Behörighetsansvarig
IK-Brand ansvarig

Timo Pakarinne
Underhållstekniker
Mekanik

Krister Terkildsen
Underhållstekniker
Maskiner

Bertil Johansson
Underhållstekniker
Maskiner

Jan Ove Karlsson
Elektriker
Maskiner
Fastigheter

Magnus Fransson
Elektriker
Maskiner
Fastigheter


Rev | Datum     | Uppgjord | Godkänd | Ändrad på sida |
---|-----------|----------|---------|----------------|
E  | 2003-12-01| Bo Westlin|         |                |
---|-----------|----------|---------|----------------|
--- | 1995-06-15| R. Å Filmhäll|       | / / / / / /
Appendix 3 Operator maintenance

OPERATÖRSUNDERHÅLL 2002

Maskin nr. 222-1

A = Kontrollera nivån i oljebehållare.
   Vrid spaltfiltret för centralsmörjningssystemet 2 varv
   i angiven riktning.
   Oljesmörjning och fettsmörjning, röd markering.
B = Fettsmörjning, gul markering och formalinerhålshjul.
   Kontrollera att filtren för tryckvalsarnas bärningar
   är hela, smörj vid behov
C = Fettsmörjning, silvermarkering.
D = Kontrollera huvudmotorns filter. Rengör eller byt vid behov.
E = Rengör alla fotoceller.

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Intervall

1 vecka
1 månad
6 månader
1 vecka
1 vecka
Appendix 4 Operator maintenance (UV lights)

**OPERATÖRSUNDERHÅLL  2002**

Maskin nr. 222-2

UV-lamphus
A = Blås lamphusen rena med tryckluft.
   Torka av lampor och reflektorer med en trasa fuktad med alkohol.
   *Påbörja aldrig arbetet utan att en elektriker först kontrollerat att utrustningen är strömlös.*

Vattenkylare
B = Rengör smutsfällan framför vattenutflödet (stäng ventilen).

Fuktvattenkylare och fuktvattenbehållare
C = Kontrollera filtret. Rengör eller byt vid behov.

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Intervall 5 veckor
**Appendix 5 Suggestions for actions during the services**

**Strålfors**

**ÅTGÄRDER SOM BÖR GÖRAS VID MASKINSERVICE.**

Maskin nr.......................... Avdelning.........................

Service är planerad att utföras i vecka..............

För att göra arbetet så effektivt som möjligt är det viktigt att veta vad som ska göras. Notera på denna blankett de åtgärder ni vill ha utförda under servicen och lämna den till **ansvarig på Underhållsavdelningen** senast en vecka före service så att nödvändiga förberedelser kan göras.

1. Byte av samtliga knivar och gavlar i

2. Nya kopringar till omöranne

3. Nya band till fältbandet

4. Nya knivar till skärtrissorna

5. Grundlig inställning av hele fuktsystemet

6. Åtgärda glapp i rimiggeinställningen

7. Lät nya dekter matas 2-3

8. Se över tryckverket i verk 4 (gör ej att spänna på platserna tillräckligt)

9. Byte av rökteverket (det rollar stop i ett när maski:n skinner)

10. Uppmätning och justering av backboard

11. Byte av flertalet valsar

12. Röstlet till en mark är trasigt

Brytare till stora kolven

Skriv gärna på andra sidan också om raderna ej räcker till.
Appendix 6 Check list for service

SERVICERAPPORT, Maskin nr. 222 / Goebel, tryckpress

Blanketten skall användas för att rapportera kontroller och åtgärder som utförts vid FU-arbete. Markera i rutan att maskindelen är kontrollerad avseende funktion och tillstånd.

OBS! Om dessa kontroller ej utförts på någon maskindel, skall orsak till detta anges på raden och ingen markering göras i rutan.

Om åtgärd vidtagits, skriv kortfattat vad som gjorts.
Notera brister och svagheter som behöver åtgärdas inom den närmaste tiden.
Ange även artikelnummer eller annan identifikation på utbyta reservdelar.

FÖREBYGGANDE UNDERHÅLL, PLANERAD VECKA 44 UTFÖRD U. 2 SIGN. 

MASKINDEL

AVRULLSTÅLL, Broms, Rullaxel

KANTSTYRNING

VARIATOR

TRYCKVERK, Nr.1

TRYCKVERK, Nr.2

TRYCKVERK, Nr.3

TRYCKVERK, Nr.4

TRYCKVERK, Nr.5

NUMRERINGSVERK

ARKIVHÅLNINGSENHET

FORMHÅLNINGSENHET

LÄNGSPERF./SKÄRUTRUSTNING

TVÄRPERF. ENHETER

UPPRULLSTÅLL, Rullaxel

FALG/AVL. BORD

ARKBORD

MOTORER/ELUTRUSTNING

BANVAKTER, funktionskontroll

UV-TORKAR, enl. underhållsinstruktion

KLAGREGAT, fuktvatten, vätskylning, enligt underhållsinstruktion

SMÖRJNING/ÖLJEBYTER, enligt smörjschema

ÖVRIGT

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Appendix 7: View over machine no: 222

1: Feeding and stretch station
2-6: Press cylinder
7: Number- and fold cylinder (press cylinder)
8: Perforator station
9: Cutting station (width)
10: Cutting station (length)
11: Cutting station (sheet)
12: Packet station
Appendix 8 Our suggestions for the organisation of main. Dep.
Appendix 9 Strategy for working/developing the maintenance