Examensarbete i Systemekonomi

A MODEL FOR HOW TO DECREASE VARIATION IN A PRODUCTION PROCESS - A CASE STUDY.

En modell för att minska variationer i en produktionsprocess – en fallstudie

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Abstract (in English)
The purpose of this bachelor thesis is to develop a generic model to be applied on to a Swedish company. In order to reduce variations in quality, production time and work routines. The study starts by investigating of the relevance of this thesis and continues with providing relevant theories on the subject. Then a model was developed for continues improvement projects with different keys that can be applied in the different steps of the model. The keys show the importance of involving the employees in continuous improvements projects. The model is aimed to be applicable to different kinds of project and depending on the size of the project, different keys can be utilized. The purpose of the model in this thesis is to decrease variation in quality, production time and work routines at a case company. The case company in this study is International Färg AB who is a manufacture of protective coatings. During the testing phase of the model, planning, analysis and measurements has been performed in order to achieve suggestions that would lower the variation within the production at the case company. The result of this thesis and the model is that with the use of the model developed in this thesis it is possible to achieve lower variations in the production. The thesis is aimed to be suitable to Swedish industrial companies. The authors provide a generic user-friendly model. From the results recommendations to the case company has been developed. The thesis end with a discussion about topics not fully covered in the report.

Key Words: Variations, Quality, Production time, work routines, employees, model, improvements

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All involved operators at P3-line

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Niclas Freijd                      Tony Sörensen
List of Abbreviations:
TPS – Toyota production system
P3 – Production line 3 at International AB
Lean – Lean manufacturing
TQM – Total quality management
International – International Färger AB
DMAIC – Define, measure, analyze, implement, control
PDSA – Plan, do, study, act
SIPOC – Supplier, inputs, process, output, customers
RACI – Responsibility, accountable, consulted, informed
OEE – Overall equipment effectiveness
IT – Information technology
HR – Human resources
HSM – Health, security, environment [Hälsa, säkerhet, miljö]
Ad hoc - Latin phrase meaning "for this"
KEY TERMS:

Manufacturing lead-time:
“Total time required to manufacture an item, including order preparation time, queue time, setup time, run time, move time, inspection time, and put-away time. For make-to-order products, it is the time taken from release of an order to production and shipment. For make-to-stock products, it is the time taken from the release of an order to production and receipt into finished goods inventory”, (Businessdictionary, 2012).

Continuous improvement:
”Programmed, and an almost unbroken, flow of improvements realized under a scheme such as Kaizen, lean production, or total quality management (TQM)”, (Businessdictionary, 2012).

Process:
“Sequence of interdependent and linked procedures which, at every stage, consume one or more resources [employee time, energy, machines, money] to convert inputs [data, material, parts, etc.] into outputs. These outputs then serve as inputs for the next stage until a known goal or end result is reached”, (Businessdictionary, 2012).

Planning:
” A basic management function involving formulation of one or more detailed plans to achieve optimum balance of needs or demands with the available resources”, (Businessdictionary, 2012).

Variation:
“Inevitable change in the output or result of a system [process] because all systems vary over time. Two major types of variations are common, which is inherent in a system, and special, which is caused by changes in the circumstances or environment”, (Businessdictionary, 2012).

Cost effectiveness:
“Relationship between monetary inputs and the desired outcome, such as between the expenditure on an advertising campaign and increase in sales revenue”, (Businessdictionary, 2012).

Seven wastes:

Routines:
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1. Introduction

This chapter includes the background for this study, problem discussion, problem presentation and the problem formulation. Here we also present the purpose, relevance, limitations and the time frame for this thesis.

1.1 Background

Companies worldwide compete against each other to become the choice of the customers. Companies that fail to attract customers will undoubtedly disappear. The price setting of the products is an important factor. From the companies perspective the price should be set so that an acceptable profit margin can be achieved, preferably it should be set higher. Many manufacturing companies find that it might not always be possible to increase the price in order to increase the profit. Instead a method could be to increase the profit margin by lowering the cost of manufacturing. One of the more famous concepts for making the production more cost effective is Lean Production. Lean originates from Toyota production system (TPS). One of the creators of TPS, Taiichi Ohno says that the goal with it is to decrease cost in the production. Taiichi Ohno believes that to increase profit a company should lower the costs trough different actions, rather than increasing the price for the customer (Yu-lee, 2011).

One part of Lean manufacturing that makes an organization more cost effective is elimination or decreasing waste in the production. In Lean waste is categorized in to 7 different areas. An example for how the engineers looked at waste at Toyota is that they originally used a mass production system where machines were designed to work only on one product. Toyotas engineers saw that when the machine was waiting for parts to process it was just idle. They considered this to be a waste of resources to have machines idling. The Toyota production system developed at Toyota was designed to eliminate waste like this. Other companies also benefit from having this point of view when looking at their production to save resources and become more effective (Yu-lee, 2011).

According to Bergman and Klefsjö (2003) the management in companies has to realize that in order to be successful in today’s market, the whole company needs to be committed to continuous improvements in order to satisfy the customer needs and wants. If they fail to do this their market share will be lost. Continuous improvements should be focused on improving quality, and make the organization both more cost effective and increase customer satisfaction (Bergman & Klefsjö, 2003)

According to Badurdeen & Gregory every company that ever tried to incorporate ideas from lean manufacturing into their own company could utilize the tools available in the Lean Manufacturing like 5s, kaizen or from other concepts like Six Sigma. But to be really successful with continues improvement work and lowering the cost, the human factor should be considered as well. For Toyotas Lean manufacturing the philosophy was continuous improvements and respect for people. Some might think that respect for the people might just be some well sounding slogan. But considering the humans for example by looking on the
culture is very important in successfully utilize the different kinds of improvement methods. It is to respect the people to give the workers the education and possibility to be able to improve in the production. After all, the workers are the ones that are the closest to the production. (Badurdeen & Gregory, 2012).

Most companies nowadays work in various forms with quality as an important strategy to become successful. A misconception about quality is that it may cost a lot. But actually, it is the other way around it saves the organization a lot of money, because it minimizes the inspections, repairs, loss of customers, scrap and rework. And this point alone makes quality improvements important. Today many companies work with TQM (total quality management), Lean manufacturing or Six Sigma to continuously improve their business and the quality across it (Bergman & Klefsjö, 2001).

1.2 Problem discussion
Manufacturing companies experience that the customer demands keep rising, together with the competition. To increase the customer satisfaction a company can do many things, for instance increase product quality, lower the price, and reduce delivery time. In order to improve in these areas there are several strategies to choose from. One strategy could be to implement Lean manufacturing and start to work with continues improvement (Chen, Li, Shady, 2008).

According to Bergman and Klefsjö (2003) it is possible to consider almost every activity in a company as a process. These processes aim should be to deliver products and satisfy their customer. It is possible to determine if a process is satisfying by performing measurements on them and their result. Companies want to decrease variations in their production. If they can get the variation under control then it is possible to predict future results. Causes for variation should be eliminated to make the process more stable and reach a competitive advantage (Bergman, Klefsjö, 2003).

Routines in an organization can be considered one of the main causes to what the organization accomplishes. However the routines developed in an organization can be ineffective and slow. To improve the routines companies can utilize continues improvement methods and quality management. Improving organizational routines could make the organization more effective (Feldman, 2003).

1.3 Problem presentation
Every process should have a desirable outcome for its customer. Preferably the process should be static enough that the end result is delivered with satisfactory quality and within specified time period every time. And the resources used by the process should also be about the same for every occasion. In other words, the process should have as low variation as possible. With low variation it is easier to create a more streamlined environment and make more accurate predictions for the future. Variation can appear in different ways, for instance variation on the quality of the end product. Variations in routines and procedures people have that may impact
quality and/or the time it takes to perform certain tasks. It is not possible to eliminate variations completely. But it is possible to improve processes to make them more reliable and effective.

1.4 Problem formulation
✓ How to decrease the variation in quality, production time and work routines to achieve a cost-effective production?

1.5 Purpose
The purpose of this thesis is to develop a model for making the production more cost effective with respect to work routines, quality, economical and technological factors. The purpose of the model is to decrease variations in the production process from planning to manufacturing of a product and thereby make the production more cost effective.

1.6 Relevance
It is of great importance for companies to lower their cost making the production more effective. If a specific company fails to attend this area, competitors will benefit from it. Therefore to be able to survive long term, this is an important subject for every company. The theories are in many cases wide and often applied to bigger sized companies. It is important to highlight how a company can utilize these methods in order to become more successful.

There are models for continues improvements already, the difference in this model created in this thesis is that it combines the strengths from already created models in a mixture to attend both a technological and human aspect in order to improve in a structured way.

1.7 Limitations
This thesis is limited to be finished during a specific time to develop a model suitable to the task. Because of the limitation in time the authors will not be able to see the implementation of the suggestions delivered to the company. This study is limited to focus on the manufacturing process in the company. Areas that will not have direct influence on the production will either get completely left out or only be mentioned briefly. When developing this model the authors will use theories from concepts focused at these areas. However not all concepts will be considered for this report. The report will focus at ISO9001, Lean, Six Sigma and TQM. All of thesis concepts are widely recognized making it easier to find information regarding the subject.
1.8 Time-frame
In table 1.1 the time-frame for this thesis is presented.

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(Table 1.1, Time-frame)

1.9 Reading instructions
In table 1.2 the reading instructions for this thesis is presented. To understand the whole study it is recommended to read the report in its entirety.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Description</th>
<th>Recommended readers</th>
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</thead>
<tbody>
<tr>
<td>2. Introduction</td>
<td>In this chapter are the methods and strategies for how to collect empirical data and theories presented.</td>
<td>Readers that want to get an insight how the study is performed and which methods that suits for this kind of studies.</td>
</tr>
<tr>
<td>3. Theoretical framework</td>
<td>In this chapter all theories and concepts underlying the later analysis in the study.</td>
<td>Readers who are not familiar with improvement theories or theories of human impact on processes.</td>
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<tr>
<td>4. Model development</td>
<td>This chapter presents the two models the authors has developed</td>
<td>Readers that are interested in a new ways of business improvements.</td>
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<tr>
<td>5. Empirical findings</td>
<td>In this chapter the case company [International Färg AB] is presented. Also a holistic view on the production and a more deeply presentation of the P3 line, the production line we are studying.</td>
<td>Readers that is not familiar with the company or production of coatings.</td>
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<tr>
<td>6. Model implementation</td>
<td>In this chapter the test of the model is presented and analyzed.</td>
<td>Read this to understand how the authors implemented the model into the case company situation.</td>
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<td>7. Results</td>
<td>In this chapter the results for this thesis is presented.</td>
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<td>8. Conclusions</td>
<td>The chapter presents the conclusions of the study.</td>
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<tr>
<td>9. Recommendations</td>
<td>In this chapter the authors present recommendations to the case company and for future research.</td>
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<tr>
<td>10. Discussion</td>
<td>Here the authors discuss the last steps of the model not implemented at the case company.</td>
<td>A reader that wants to read about topics not discussed deeply in the content for the report.</td>
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(Table 1.2, Reading instructions)
2. Methodology

This chapter will present the research methodologies for this thesis. The research perspective, approach and different methods for collecting data will be described. Also the evaluation of results regarding reliability, validity and generalization will be made in this chapter.

2.1 Scientific perspective

In the literature positivism and hermeneutics are described as the two major scientific perspectives (Hartman, 1998), (Hansson, 2011). Scientific perspective can be described as a way for how to look on different researched methods. Positivism is a science philosophy based on social and natural science. The hermeneutics science comes from human science (Hansson, 2011).

Positivism perspective refers to sensory experiences and by using a logical way of thinking. The scientific perspective derived from the 1800 century sociologist Augusto Comte. He meant that you should not go beyond the observable world in the positive stage, rather describe it. The perspective can be seen as a scientific theory in which knowledge consists of theories, which contains terms that can be measured and statements indicating the relationships between them. The perspective refers to that the most important way to gain knowledge is through observation of either natural conditions or by experiment (Hartman, 1998).

The hermeneutics perspective strives for the understanding of people’s life. The perspective is rooted in medieval interpretations of the Bible and was in the 1800s used for interpretation of texts in general. Nowadays it is the principle of interpretation in general. The hermeneutics perspective point that knowledge is not obtained by measurements, but how to interpret people’s behaviour, and tries to empathize with their beliefs about the world (Hartman, 1998).

Both perspectives are important for the implementation for this study. Positivism as the study is based on theories of literature, scientific articles and observations and the hermeneutics perspective because these studies are concerned to interpret both text and humans.

2.2 Research approach

All theories are not empirically testable. Social sciences are forcing a crack between the developed theory and concrete empirical studies. To address the relationship between it two different approaches can be used, deductive and inductive approach. The most widely used approach for developing theories are deductive theory. This means that from a context of systems deriving new hypotheses. These hypotheses can then be used and tested in empirical studies. Through the empirical study one can strengthen or weaken the confidence in the theory. Inductive is to derive conclusions from empirical experience and according to that use own theories and concepts (Ejvegård, 1996).

In this thesis a deductive approach will be used. The information is gathered from empirical observations. The empirical findings will be compared and analyzed with relevant theories.
2.3 Research strategy

Case study is useful in scientific studies, and serves as a research path together with other methods. The purpose with a case study is to find a small part of a bigger pattern and use the case to describe reality. The benefit of this strategy is that it is not necessary to get into the whole business, just on a limited area and still be able to give the reader an idea of how the reality is. Difficulties lie in that a single case can not represent reality, the conclusions should be carefully created in consideration of this. There are many advantages; one is that the researchers can think of several problems and issues during the case. A case study is also more proximity compared to a statistical analysis, the statistics of curves, and stacks are drier compared to the case study (Hartman, 1998).

The strategy for this thesis is based on the case study method. To deal with the problem formulation for this study comparisons between theories with how it works in reality at the case company will be performed. Some statistic analysis will also be conducted to get more information about production variations to deal with the problem.

2.4 Techniques for data collection

There are two main methods for collecting data. Quantitative data collection is data that can be determined by limits and is more trustworthy then qualitative data, also more structured. Qualitative data is based on interpretations and observations and is used to describe different types of information (Hartman, 1998). Data from observations collected directly from first-hand experience, either by interviews or by questionnaires is primary data. To collect secondary data that is the processing of information that is already available, collected for other purposes statistics, literature or databases can be used together (Holme & Solvang, 1991).

In this study quantitative and qualitative methods are used for collecting data, both primary and secondary data is used for this study.

2.4.1 Interview

The most common in research context is to collect data through interviews. Interviews can be divided into qualitative and quantitative interviews (Ejvegård, 1996). The quantitative interview is when every interviewee gets the same instructions. This does not mean everyone understands the information all the same, rather different, which refers to a lot of flexibility in the responses. It can also lead to misconceptions and problems. The power of qualitative method lies in its similarities between a regular conversation. This interview method is where the researcher exerts the least control. The idea of an interview is that people themselves tell about the properties the researcher is looking at (Holme & Solvang, 1991).

Interviews are often time consuming and therefore require careful selection of whom to interview. It is also important to prepare well before the interview session. Because memory fades after an interview, it is important to make notes. Afterwards it is not wrong to send the collected empirical data to the interviewee to allow corrections and avoid misunderstandings.
It is possible to use a group interview method that looks like a discussion, where the focus often lies in examining the group's way of working together (Holme & Solvang, 1991).

To collect empirical data through interviews for this study the qualitative method is used to not control the person that is interviewed. The authors believe that this interview method suits this study in collecting empirical findings, of course notes are documented during the interviews and after the completions of the interview the authors together with the interviewed person ensures that the data is correct.

2.4.2 Observation
Observations are used primarily in two different contexts. Firstly it can be used to provide insight into behaviors and events in natural situations, but also in experimental situations studying behavioral-related reactions to different kinds of impact. Secondly, it can be used for physiological measurements, when one examines how individuals react in different types of processing. An observation is when the observer spends time together with members in the group of one examines (Holme & Solvang, 1991).

The advantage of an observation rather than an interview is that it is independent of the observed individuals’ recollections, since the memory can sometimes deceive us and the answers are not valid. Another advantage is that it does not require waste if time since the observation does not cause extra work for those who are observed. A disadvantage is that it requires more time than an interview for the observer and sometimes it is necessary to have knowledge about the process observed before the observation starts (Hartman, 1998).

Observations of behavior can either be structured or unstructured. A structured observation is based on the interest to study a specific, limited behavior. Structured observations are mainly used when studying hypotheses. The hypothesis should be well structured and precise so it is given what situations and what behaviors that should be included in the observation. An unstructured observation is used in the planning phase of a research, or in a discovery study. Unlike the structured observation it is not predestined what behavior to observe or how the observation is done to collect data in the best way (Hartman, 1998).

Observations can also be divided into open or hidden observations where the difference is that in the open do the participants know that one observes, while in the hidden observations the participants are not informed about the observation. An observer must listen, watch and ask to create a picture what actually happens (Holme & Solvang, 1991).

*For this study open observations are used to collect data on employees’ behavior in different processes and how they work.*

2.4.3 Brainstorming
Brainstorming is a popular tool that helps to generate creative solutions to a problem or come up with ideas. There are different brainstorming techniques: quiet brainstorming, individual, group, question, electronic, guided or direct brainstorming. It also helps to overcome many of
the issues that can make group problem-solving a sterile and unsatisfactory process. One basic idea is that during the session it should be allowed to go on without interruption. There should be no criticism of ideas, quantity often generates quality and all participants should develop and enhance each other's ideas (Ejvegård, 1996).

The brainstorming sessions for this study will be quiet brainstorming to collect ideas and involve the workers in our study and research. Ideas and problems will help to analyze different processes and problem areas.

2.4.4 Literature reviews
A literature is necessary since the authors needs to have knowledge and understand the problem area. Literature study and reviews is based on literature search. Literature is in research context all published material: books, articles, reports and essays. To collect the right and relevant material for the study a systematic research and a critical evaluation of the text must be made. An author should think about what keywords are used, be careful with references, follow instructions and think about the language. Researchers quickly collect a variety of literature, and have to find out what to use. The relevance and usefulness of a source must be defined and evaluated. One must also understand the value of the study to absorb the information and use it in the right way (Ejvegård, 1996).

For this study it is important to make literature reviews and find relevant theories and methods for the problem area.

2.5 Evaluation of results [Reliability, validity and generalization]
By reliability means how trustful the use of a measuring instrument and a unit of measure are. One question is if the results from a research will be the same again and again with same techniques and independent of who performs the research. Observations can be controlled by different measures to ensure that the observation is reliable. Only through continuous and critical testing and accuracy in processing the material, high reliability can be achieved. Reliability is also determined by how the measurements have been performed and how you handled the information. In terms of reliability of information it is a key point that the information also is valid (Holme & Solvang, 1991).

Bjereld, Demker & Hinnfors, (2002) describes Validity as if the study is able to scientifically answer the questions it is expected to answer. Expressed in a more technical way the validity is the degree of consistency between the theoretical and the operational definition. The problem formulation is what you assume in the research. Therefore the problem is important for the research according to the control of methods, material and result.

Generalization is a pattern or regularity that repeats over different circumstances and that can be described simply by mathematical, graphic, or symbolic methods. Generalizations can be divided into empirical and theoretical generalization. Empirical generalization points to studies and number of observations will lead to generalizations, characterized by a good
scope, precision, parsimony, usefulness, and a link with theory (Bjereld, Demker & Hinnfors, 2002).

All the conclusions and considerations throughout this report have been developed in consideration of reliability, validity and generalizations.

2.6 Summary

For this thesis these methods to gather information are used:

- **Scientific perspective** – positivism and hermeneutic
- **Research approach** – deductive
- **Research strategy** – case study
- **Data collection methods** – qualitative & quantitative, primary & secondary
- **Data collection techniques** – observations, interviews and brainstorming
- **Evaluation of results**
3. Theoretical framework

The theoretical framework is divided into three different parts: PART I, PART II and PART III. The first PART is explaining basic concepts for this study. PART II includes theories about improvements methods such as [Sig sigma, Lean, ISO 9000 and TQM]. The last part in the theoretical framework chapter is theories that consider human factors.

[Figure 3.1, Theory presentation]

PART I – BASIC CONCEPTS

In this part of the theoretical framework the authors present basic concept for this study. Concepts that are mentioned during this study are here explained to facilitate the understanding in this study.

3.1 Lead-time

Lead-time is the time from requirement identification to requirement satisfaction. Lead-time can be divides into three different types, production development lead-time, delivery lead-time and throughput time. Product development lead-time aims to the beginning of a development project until the product is launched on the market. Delivery lead-time is the measure for how long time it takes from customer order to delivery. The throughput time is the period required for a material, part or subassembly to pass through the whole manufacturing process, also called manufacturing throughput time (Olhager, 2000).

3.2 Productivity

The production process is described as the process where value is created by using resources in an effective way or where input is converted to output. Total Productivity = Output/Input (Olhager, 2000).
3.3 Working capital
Working capital is primarily the cost for purchases of inputs for the material in stock and in the products in work. Working capital also includes all the additional costs that must be added for storage of the material. These costs may be warehouse areas, material handling equipment and for material handling. This also includes the cost of risk and cost of waste during material handling. The more products in stock and production, the more capital has to be used as working capital (Olhager, 2000).

3.4 Production efficiency
Production efficiency can be explained as the ability to produce using as few resources as possible. Efficient production is when the products are manufactured at its lowest average total cost (Olhager, 2000).

3.5 Profitability
When a company refines its product, i.e. gives its value-added characteristics there will be a cost. The difference between the revenue the company gets when selling the product and the costs that occur in the value-adding process is the company’s results.

\[ \text{Result} = \text{Revenue} – \text{Costs} \]

The result is a measure which is inefficient when you compare different companies. Instead for result a relative measure called profitability is used, where the results is in relation with the company’s capital.

\[ \text{Profitability} = \frac{\text{Results}}{\text{capital}} \]

To get a long time profitability the company needs to have good quality, high delivery safety, be cost effective and flexible (Olhager, 2000).

3.6 Sub-optimization
Sub-optimization is a condition aimed at completing sub task for an area or division instead of optimizing the overall company objectives. It can also be defined as a situation where a process, procedure or system do not get the best possible outcome or output, caused by a lack of best possible coordination between different departments, processes, components or parts. Sub-optimization has its roots in the problem of information gaps between top management and unit managers. A unit manager has often more knowledge about their work than the top manager; it can sometimes create an opportunity for the unit manager to obtain more resources than what is actually required. Factors of sub-optimization may be goals and requirements. To invest more resources on one unit over others also leads to sub-optimization. It thus has its basis in the above situations and is associated with the companies selected strategies for how to get everyone to work through common corporate goals (Benhakker, 2001).
3.7 Quality
The meaning of the word quality has a different meaning for each individual. In this report Bergman and Klefsjös definition of the word has been used. According to Bergman and Klefsjös (2007) quality is the capability of satisfying customer demand and expectations. There are plenty of benefits for organizations with high quality. These are satisfied and loyal customers, more dominant market share, less employee turnover and sick leave rates, high productivity and low cost because of less waste and reworks (Bergman & Klefsjö, 2007).

"Quality is the ability of a product or service is its ability to satisfy needs and expectations for the customer” – (Bergman & Klefsjö, 2007).

PART II – IMPROVEMENT THEORIES
In this part theories for improvement methods and different improvement tools will be presented and explained.

3.8 Six Sigma concept
In literature, there are several definitions of Six Sigma. What all studied literature has in common is an understanding that Six Sigma revolves around process improvement and the reduction of variation in process output, relying heavily on structured process management (Bergman & Klefsjö, 2007), (Sörqvist & Höglund, 2007), (Wilson, 2005), (Pyzdek & Keller, 2010).

The Six Sigma concept use well defined roles and improvement tools and statistical analyzes to solve problems. Six Sigma was developed at Motorola, USA in 1986 (Sörqvist & Höglund, 2007).

(Figure 3.2, Six σ deviation, leantransformation.com, 2012)

Six Sigma came to Sweden by ABB and Ericsson during 1990s. Today, the concept is used by many different organizations in the country. In some cases, the concepts all original structures and names is used, in other cases, the work is conducted under a Swedish version of Six Sigma (Sörqvist & Höglund, 2007).
What makes Six Sigma unique, in comparison with all other improvement concepts is the accurate training of employees, which results in high levels of expertise in improvement work. The main purpose of Six Sigma is to reduce the variation in properties that are important for the quality of the products or service that a company provides, and to get the process to be predictable. By eliminating or at least reduce the undesired variations the costs and the number of dissatisfied customers is reduced, which leads to performance improvements (Bergman & Klefsjö, 2007).

In order to succeed with Sig sigma companies are required to have commitment of the entire organization, from top management down to grass root level. The top leader's role is extremely important. Without the support from top management it is hard to reach success with the Six Sigma concept (Bergman & Klefsjö, 2007).

3.8.1 Define Measure Analyze Improve Control [DMAIC]
In the Six Sigma work a methodology named DMAIC is used, which is divided into five steps, [Define, Measure, Analyze, Improve and Control]. The DMAIC model developed by Edward Deming in 1986 and is a refined version of the PDSA model [Plan-Do-Study-Act]. The model provides a systematic and controlled approach in project form, it does not have to be followed exactly but should be viewed as an aid in the improvement process. The five different steps are shortly described in figure 3.3, (Sörqvist & Höglund, 2007).

(Figure 3.3, DMAIC, ssqi.com, 2012)

The improvement projects include a project manager and a project sponsor, the manager is the one who is responsible for the project and the sponsor the one who owns the project when it’s finished. The manager is often “black-belt” educated, since Six Sigma uses a belt-system similar karate, the coloured “belt”-system explains the level of Six Sigma education and work experience an employee have. The grading starts with “white belts” which often is the operator and project members. If they going through different educations and being more experienced over time the “white-belts” can level up to “yellow-belt”, the next steps are “green-belt”, “black-belt”, “master black-belt” and the last level is the “champion” (Bergman & Klefsjö, 2007).
In the **Define** phase one improvement team identifies projects with high potential. Management should be involved in the development of appropriate projects and evaluate them. The case is evaluated and taken into account if the company can regain customers, finding new customers and increase employee satisfaction. When a project is selected, a number of questions should be asked: Is the problem recurrent? What is the expected deliverables of the work? Is the work manageable? Will the result have such an impact that the work is worthwhile? Could there be resistance to change? The problem must also be measurable so that data can be collected. The project plan clearly states what the purpose and goals of the work is. Common tools for this phase are Pareto charts, SIPOC and flowcharts. The **Measure** phase focuses on two questions; what to measure and how to measure it? In this phase organizations should avoid actions that are based on opinions and subjective perceptions. The measure phase is therefore very important to succeed with Six Sigma. The measurements are not only performed to deal with problems related to variations; it can also include collection of quantitative data. Already in this phase you can see there is a division of the problem solving, quantitative and qualitative analysis. One measurement tool is Ishikawa diagrams.

The activities in the **Analyze** phase is to analyze the data collected in the measure phase, and understand the factors or causes that affects its result. The purpose is to identify the problems causation. Knowledge about the problems root causes is then used to develop appropriate measures and solutions. In the problem solving work different improvement tools is used, depended on the problem. This is normally done with control charts, flowcharts, histograms and Pareto charts. The analyze part can be divides into analysis of variation and analysis of flows.

The fourth phase is the **Improvement** phase, when the problem is analyzed and its causes is identified it is important to determine good suggestions and implement these. The proposed improvement suggestions shall then carefully be tested and later implemented. The success on the improvement project is how well the company influence the individuals’ attitude and manage change resistance. The important part in this phase is to identify possible solutions, chose solution, test solution, plan the implementation, influence the individual and verify the result.

**Control** is the last phase in the DMAIC improvement model. The improvement should now be verified with control-charts. When the problem is successfully solved it remains to ensure that the improvement result is consistent. In this phase companies needs to standardise the process and the operations, plan the control, monitor and verify, write a final report and share experiences (*Sörqvist & Höglund, 2007*).

### 3.8.2 PDSA [Plan, Do, Study, Act]

Figure 3.4 illustrates the Plan-Do-Study-Act improvement cycle. This improvement model can be used instead of the DMIAC model in Six Sigma. The PDSA cycle is also known as the Deming-cycle after its originator Edward Deming. It is used to test and introduce changes, and is a schedule for quality used for systematic improvement work (*Bergman & Klefsjö, 2003*).
When the problems are detected the first thing to do is to define the root causes of the problem. All the decisions for change must be based on facts, this means that you have to look systematically for the causes of the problem using different tools and brainstorming sessions. The cycle starts with specifying an idea for improvement and a theory for how to improve it. **Plan** also includes determining who-where-when-how the pilot test will be done. The pilot test is to test an improvement idea in a small scale. In the **Do** phase an improvement team is given the task to go through the different steps. They conduct the pilot-test of the plan and documents during the test and identify things that are not going according to plan. **Study** is the phase where the result gets analyzed to see if the implementation of the improvement was successful. Study and compare data on the comparison of the idea. Confirms data if it went as planned, increased knowledge and confidence if the change is an improvement. If the data do not confirm the theory, analyze why based on what that is described in the "planning phase". When the P-D-S steps are ready it is a matter of learning and to take advantage of experiences from the improvement process. To complete the improvement cycle it is needed to **Act**, and avoid the same type of problems in the future. If the earlier steps were successful the new better level should be permanent. If it was not successful it is necessary to go through the cycle again and analyze to learn and improve the improvement process. The next step is to check the next process and repeat the cycle over again (*Bergman & Klefsjö, 2003*).

### 3.9 Six Sigma tools

*This paragraph includes presentation of different Six Sigma tools.*

**3.9.1 Flowcharts**

The main purpose with a flowchart diagram is to show the current state of the process and illustrate how it functions i.e. shows the connection between different connections in all the tasks in the process. The design of a flowchart should be developed together with the employees for the specific process. The teamwork and the descriptions from the employees involved will define what the flowchart will look like, with a start and end activity. The
flowchart should give the organization an understanding of problem areas, how to process the ambiguities, double works etc. Flowcharts are primarily used to investigate the time and cost to accomplish the different activities. In figure 3.5 the different symbols in a flowchart is illustrated and shortly described (Bergman & Klefsjö, 2007).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start/end</td>
<td>An oval represents a start or end point.</td>
</tr>
<tr>
<td></td>
<td>Arrows</td>
<td>A line is a connector that shows relationships between the representative shapes.</td>
</tr>
<tr>
<td></td>
<td>Input/Output</td>
<td>A parallelogram represents input or output.</td>
</tr>
<tr>
<td></td>
<td>Process</td>
<td>A rectangle represents a process.</td>
</tr>
<tr>
<td></td>
<td>Decision</td>
<td>A diamond indicates a decision.</td>
</tr>
</tbody>
</table>

(Figure 3.5 Flowchart symbols, smartdraw.com, 2012)

Flowcharts increase the understanding of the process itself and highlight possible improvements which can be the basis for an analysis of the investigated process. Based on flow charts, a process flow analysis can be made. For example, it is possible to examine the entire flow of all production activities or just individual activities (Olhager, 2000).

3.9.2 Brainstorming
Brainstorming is used as a technique for solving problems or to find root causes for them. Brainstorming can also be used as a tool for expressing feelings and thoughts about different tasks. Theory for this is similar to the brainstorming method and is therefore referred to chapter 2, page 7.

3.9.3 Control charts
A control chart is a useful tool to present results of data from a process. In this chart the process result is illustrated in a time perspective. The idea of a control chart is to measure a number of units produced by the process and then check the characteristics of these measures. This information is compared to the standard deviation and plotted in the diagram. The process variation is illustrated and also the process changes. The main purpose with control charts is to identify when a change has occurred in the process that results in a process variation (Bergman & Klefsjö, 2003).

3.9.4 Ishikawa diagram [fishbone diagram]
Once the quality problem is highlighted, the root causes needs to be found. The Ishikawa diagram is used to illustrate causes of a problem. The diagram is designed by first sorting out the main causes of the problem. The diagram consist of a "backbone" that at one end has a "head" where the problem is entered, the “bones” and ends in the possible major cause to the failure. The causes of the quality problem can often be referred to the seven M’s:
Management, Man, Method, Measurement, Machinery, Materials, Milieu (environment). This type of Fishbone Diagram is called 7M charts. Figure 3.6 shows the Ishikawa diagram and how the bones and causes are displayed (Bergman & Klefsjö, 2003).

![Fishbone Diagram](image)

(Figure 3.6 Ishikawa diagram, philosophy.hku.hk, 2012)

### 3.10 Lean manufacturing

Lean is a western interpretation of Toyotas very successful working methods and philosophies regarding improvement work. Toyota began an ambitious quality work already in the 50s that led to good results. Toyota chose to call their approach Toyota Production System, (TPS) and this became a model for many Japanese industrial companies. As a result of the Japanese success the interest increased for their improvement work in the West. Research and studies of Toyotas approach was initiated and resulted in the Lean concept in 1990s. Lean manufacturing is a manufacturing practice about how to handle resources. The purpose with Lean is to identify and eliminate all factors in a production process that does not create value to the end customer. This is achieved through involvement and commitment from the organizations workers. To support this there are a variety of tools, methods and techniques (Sörqvist & Höglund, 2007).

In Lean there are four main aspects and frequently related practices with quality management, pull production, preventive maintenance, and human resource management. Shah, Chandrasekaran & Linderman (2007) describes the components of the lean-concept as:

1. **Quality** - The first step in a lean journey is often a focus on quality.
2. **Flexibility** - When the quality level has stabilized, the next step is to control how much to produce at any given time.
3. **Productivity Improvements** - OEE, measurement to measure and improve production equipment reliability and dependability & 5S, by cleanliness and inspection increases efficiency.
4. **Continuous improvement** - Systematic improvement
5. **Learning organization** - Understanding of Lean in the organization will be built up as the chosen tool is introduced. This requires a lot of training, time for reflection and the employee's ability to influence their own situation.
A lean implementation is considered to improve organizational performance through decreasing the waste. Lean production can be described at different levels of abstraction: it can be defined as a philosophy, as a set of principles and as bundles of practices. It can also be defined as a business and production philosophy that shortens the time between order placement and product delivery by eliminating waste from a product’s value-stream (Shah, Chandrasekaran & Linderman, 2007).

Waste is a contradiction to the value, which the customer is not willing to pay for. The literature distinguishes different types of waste which in Japanese is called muda. By focusing on eliminating all forms of waste obtained it becomes a more cost-effective and lean business with shorter lead times. According to Sandkull and Johansson (2000) the seven wastes in Lean manufacturing are:

- **Over-production** - Produce more than needed or earlier than necessary.
- **Waiting** – Waiting for something to happen.
- **Transportation** - Unnecessary transport, such as placing the material between workstations or around it. Each time a product is transported it is a risk for damage.
- **Over-processing** - To produce more than the customer actually requires. Can lead to unnecessary tests or duplication.
- **Inventory** - Inventory that is larger than it needs to be of for example raw materials, products in progress or finished products.
- **Motion** - People or equipment that is moving or walking more than is required to perform the process.
- **Defects** - Repair and rework of defective products add no value to the customer. Extra costs for rework and re-planning.

The literature also presents other forms of waste; one case is when the product does not meet customer requirements and therefore the waste results in the handling of returns and complaints. In some case it is also the employees' unused creativity like a waste (Sandkull & Johansson, 2000).

### 3.11 Lean tools

_In this paragraph different Lean manufacturing tools are presented._

#### 3.12.1 Standardized work routines

Standardized work routine is a fundamental corner stone of Lean manufacturing. To standardize a method a variety of methods can be evaluated and selected. In Lean manufacturing, activities shall be carried out the same way. This routine shall be the current best and all the workers shall perform the same tasks in the same way. Standardized work routines means that work must be optimal with respect to human factors, machinery capacity and material properties. Standardized work routines are the best way to get consistent quality and production time. When the routines are established the foundations for being able to work with continuous improvements have been increased (Bicheno et al, 2007).
There are three key aspects in terms of standardized work routines:
1. Standardized work is not static so when better working methods are found the process can be updated.
2. Standardized work reduces variation and increases stability of the work carried out constantly in the same manner. In addition, variations in form of quality failures, discrepancies are easy to detect.
3. Standardized work routines are necessary for continuous improvements. This means that companies are able to move from one standard to a better standard without falling back to the past (Bicheno et al, 2007).

Recently the term “learning organization” has become modern. A learning organization can be achieved by documenting the experiences, in other words, set standards that others can learn from. It is important that employees are documenting their own standards and create their own work cycles. Operators must accept the final documentation of any new standard, it is no doubt that for all new work routines implied, the best is if the operator himself has been working out how the task must be performed (Bicheno et al, 2007).

3.12.2 5S
5S is an important element of lean and is a method for creating an organized workplace. 5S can be implemented in the whole organization. The 5S comes from Japan developed by Toyota, and stands for seiri, seiton, seiso, seiketsu and shitsuke in Japanese. The 5S translated in English stands for:

- **Sort** [seri] – sort the equipment and tools on the work places.
- **Straighten** [seiton] – systemize the work place and work areas, mark up equipment etc.
- **Scrub** [seiso] – clean the work place regularly with major cleaning every week.
- **Standardize** [seiketsu] – standardize the daily routines, use to-do list for cleaning machines and facilities.
- **Sustain** [shitsuke] - sustain the work with 5s and improve step-by-step (Kobayashi, Fisher & Gapp, 2008).

3.12.3 Poka-Yoke
One part of the Lean production tools is Poka-Yoke. Poka-Yoke means fail-safing or mistake-proofing and was created by Shigeo Shingo at Toyota. The tool is actually a method where automatic controls and warning signals help in preventing mistakes to result in a defective product. Shingo believed that there was a clear difference between defects and failures. Mistakes will always occur but defects can be avoided completely. The bottom line is that with simple resources as possible make the mistakes so obvious that it does not lead to defective products. There are several types of Poka-Yoke, one type is to find the reason why something could go wrong for example during the assembly work and then eliminating these. It can be some design changes on the components so that they cannot fit more than in one way or colour coding of components. One other type is to make it easy to do a final inspection if
the product is correctly installed. The purpose with Poka-Yoke is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur (Fisher, 1999).

3.13 TQM [Total Quality Management]
Total quality management or TQM is a philosophy of management for continuously improving the quality for processes and products. Bergman and Klefsjö (2003) defines TQM as an ensemble of values, work method and tools that work together to achieve higher customer satisfaction with less resource consumption, where the ensemble can be seen as a management system (Bergman & Klefsjö, 2003).

The TQM concept founders are considered to be W. Edwards Deming, Joseph Juran and Phil Crosby from America. The development of TQM started in Japan during the 1950s, but it took almost 30 years before it was popularized in the United States (Bergman & Klefsjö, 2003).

Company’s top management needs to be in agreement with the company's approach to handle quality issues, they must be role models for quality and participate in the practical work. With committed leadership for quality, together with a corporate culture that has a vision of customers focus, basing decisions on facts, work with processes and work with continuous improvements TQM can be implemented and work appropriately (Munro-Faure, 1992).

TQM also involves the dedication of all employees within a business, the employees should strive to:

✓ Do the right things, only activities that assists in the satisfying of customer requirements should be conducted, and other activities should be analyzed.

✓ Do things right, all activities should be performed in the correct way to ensure the contribution to the customer requirements.

✓ Do things right the first time, additional expenses on correcting products and machines should be minimized. Prevent the error before it occurs.

While these parts are affecting all employees in a business, additional contribution from the top management is required as well for introducing this philosophy. With the help of a strong framework for order and control, full commitment to continuous improvements and the businesses adaptability towards the customer and the customer needs (Munro-Faure, 1992).

TQM involves a wholehearted work to be based on the following key points (Bergman & Klefsjö, 2003):

1. **Customer focus**: It is the customer who decides what high quality is. The internal customers need to be satisfied to do a good work for the external customers.
2. **Base decisions on facts**: All decisions regarding quality should be based on substantiated facts. Decisions will be based on well-collected information and careful analysis.

3. **Focus on processes**: Focus should be on the organization's processes. It is the processes that converts resources into products and create value for customers. By measuring, analyzing and improving the processes companies can achieve higher quality which results in customer satisfaction.

4. **Continuous improvements**: Organizations must continuously work with improvements since the competitors improve and customer requirements increases with time.

5. **Participation**: TQM requires the involvement of all employees in the organization. Only the involved employees and suppliers can contribute to improved quality. Participation is created by giving employees responsibility, empowerment and stimulating task.

3.14 **ISO 9001**

ISO 9001 is an internationally accepted standard in the ISO 9000 series for the determination of quality management and is a standard that companies can be certifying against. ISO 9001 is based on a number of fundamental principles and used by millions of organizations around the world. The standard deals with the organization to be based on customer needs and review the internal working methods to reduce costs (*Bergman & Klefsjö, 2003*).

The International organization for standardization, (ISO) states these principles for ISO 9001:

- Leadership
- Customer Focus
- Process approach
- System Approach to Management
- Employee commitment
- Fact-based decision
- Mutually beneficial supplier relationships
- Continuous improvement

(*International organization for standardization, 2012).*
3.15 Summary improvement methods
Table 3.1 shows a summary for the improvement methods presented in chapter 3 part II.

<table>
<thead>
<tr>
<th>PURPOSE</th>
<th>SIX SIGMA</th>
<th>LEAN</th>
<th>ISO 90001</th>
<th>TQM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove waste</td>
<td>Reduce variation</td>
<td>Quality standard</td>
<td>Continuous improve quality</td>
<td></td>
</tr>
<tr>
<td>Flow focused</td>
<td>Problem focused</td>
<td>Customer focus</td>
<td>Process and customer focus</td>
<td></td>
</tr>
<tr>
<td>Many small improvements</td>
<td>Remove root causes</td>
<td>Improve process and management</td>
<td>Continuous improvements</td>
<td></td>
</tr>
<tr>
<td>Reduce flow time</td>
<td>Uniform output</td>
<td>Quality</td>
<td>Reduced costs</td>
<td></td>
</tr>
<tr>
<td>Less waste and increased efficiency</td>
<td>Less variations consistent output</td>
<td>Increased quality and increased customer satisfaction</td>
<td>Increased customer loyalty, increased profitability</td>
<td></td>
</tr>
</tbody>
</table>

(Table 3.1 Summary theory part II)

PART III – HUMAN IMPACT
In part III theories related to humans such as leadership, changed resistance, models and culture will be presented.

3.16 Corporate culture
The corporate culture is about how the organization really functions. In an organization the corporate culture affects how individuals and groups acts and function. The culture within an organization indicates what kind of behaviour that is appropriate. The culture itself can be used by the management as tool to achieve objectives since the culture affects individuals’ norms and values. An organization with a strong culture can promote cooperation and coordination. It can also give individuals a feeling of belonging (Jacobsen & Thorsvik, 2008).

3.17 Deming’s 14 principles
In the beginning of the 1980 Deming created a list consisting of 14 points or principles that he considered how the leadership and surroundings should be to benefit quality improvements.

1. Create and publish to all employees a statement of the aims and purposes of the company or organization. The management must demonstrate constantly their commitment to this statement.
2. Learn the new philosophy (top management and everybody).
3. Understand the purpose of inspection, for improvements of processes and reduction of cost.
4. End the practice of awarding business on the basis of price tag alone.
5. Improve constantly and forever the system of production and service.
6. Institute training.
7. Drive out fear. Create trust. Create a climate for innovation.
8. Teach and institute leadership
9. Eliminate exhortations for the work force.
10. Optimize toward the aims and purposes of the company the efforts of teams, groups, staff areas.
11. Eliminate numerical quotas for production. Instead, learn and instate methods for improvements
12. Remove barriers that rob people of pride of workmanship.
13. Encourage education and self-improvement for everyone
14. Take action to accomplish the transformation.

Translated from Swedish to English, (Bergman & Klefsjö, 2003, p.54)

3.18 Change resistance
A change in an organization is often met with resistance. Resistance can be seen as a natural reaction for individuals or groups, it’s usually a matter of defending something that is known and which the persons it may concern think is the right thing. Jacobsen and Torsvik (2008) mean that there are ten causes a resistance to a change:

1. Fear of the unknown - a change means moving from one safe state to a situation of uncertainty. It is always a security to do what you have always done.

2. Breaking of a psychological contract – In a change the formal and informal contracts can be affected. When rules and practices may change, which in turn affects the expectations of the individual and the individual may feel cheated.

3. Loss of identity - individuals who have worked for long time in the organization often perceive that what he is doing is important and creates an identity with it, which may lead to that the work pattern is broken and the identity is thereby lost.

4. Change in the symbolic order - A change may lead to that individuals have to change jobs, work station or department. There is no individual who abandon it without struggle.

5. Power relations change - a change also means that you often have to reorganize a stable pattern of power and influence.

6. Demands for new investments - A change can also lead to new demands on knowledge and skills of the individual. The more specific the competence is the greater can the resistance be.

7. Extra work - The change must be implemented while the “old” activities are running. This requires additional resources.

8. Social ties are broken - A change could mean the loss of a contacts or cooperation with coworkers you worked long with. It can also mean, at worst that you have to work together with someone you do not like.

9. Personal loss - Change can lead to direct financial consequences for the individual. At worst, it can lead to job losses. More commonly, it affects the individual's career opportunities.
10. **External actors' influence** - Also external stakeholders in the organization may be affected (*Jacobsen & Torsvik, 2008*).

3.19 **Change management**
Change management is a structured approach to achieving change for individuals, teams, organizations and communities. One definition for change management is "*Change management is the process of assisting individuals and organizations in passing from an old way of doing things to a new way of doing things*" (*Lorenzi & Riley, 2003, p 201*).

The change may for example result in requirements for a new behaviour of an individual, or from a business perspective to be a new business process or technology. A dilemma for organisations today is how to be able to change effectively. Change management's goal is to reduce the change impacts on workers and avoid distractions (*Lorenzi & Riley, 2003*).

Companies need to understand how important it is that the organization has a well thought strategy for changes when a change process begins (*Jacobsen & Torsvik, 2008*).

3.20 **Leadership**
Leadership can be defined as “the process of social influence in which one person can be aided and supported of others to accomplish a task" or "leadership is setting a new direction or vision for a group that they follow" (*Jacobsen & Torsvik, 2008, p.452*). Some sees leadership as a question of personality or the ability to persuade and affect people. When leadership is normally done within an organization, the intention is primarily to get others to work towards the organizations goals, motivate the employees. This means that leadership is primarily a process between individuals, where the pursuance is to influence other (*Jacobsen & Torsvik, 2000*).
4. Model development

This chapter includes the model development, divided into a step-by-step model with different help-keyes for how to improve the production process in a manufacturing industry. The model has been created by the authors according to the theoretical study for the project. This is a model for how to work with an improvement project. All three parts in the theoretical framework is considered in this model. The model considers the basic concepts and the improvement theories where the P-D-S-A and DMAIC is modified and customized into the model to fit different improvement projects. The keys consider the human aspects in this study, the keys purpose is to assist and help the project depending on the projects size.

4.1 Development of steps 1-8

In this paragraph the 8 different steps in the model is presented and explained how the steps is working and how to go through them. Theories are also linked to the steps and tools that can be used are given as examples. For each step it is also stated which keys that are most suitable to use.

(Figure 4.1, Model development 1)

Step 1 - Plan

The first step in the model is where to decide the time frame, resources for the project and project manager. In this step it is important to limit the project and define the scope; a too wide area can result in an unsuccessful project. The planning of the project can also consider plans for costs to calculate later in the project how cost effective the company is after the improvements. Also plan how much the project will cost, and how much is estimated to be earned [cost – revenue]. In this step goals for the project needs to be set, project benefits and which approach it has.
This step can be related to the planning step in the P-D-S-A cycle from Six Sigma. Goals and visions can be found in theories for leadership. This step also considering the use of the right resources and not waste the employees knowledge in improvement projects.

**KEYS:** [R], [E], [I]

**Step 2 – Analyze & learn**
Analyze and get an understanding about how the process works. It is important to learn how the process actually works in reality, not how it can or should work ideally. To get a complete understanding of the process the employees involved in the process have to provide most of the information. They should have the best knowledge about how the process works. It can be suitable to use flowcharts to learn about the process and Pareto for analyzing numbers.

Compared to the measure phase in DMAIC cycle this analyze refer to an earlier step in procedure. The importance of learning how the process currently works can be connected to ISO 9001 and TQM.

**KEYS:** [E], [F]

**Step 3 – Measure**
In a lot of processes it can be beneficial to make different measurements in order to improve the process. The measurements if done correctly can help indicate problems. And it could be possible to draw a conclusion on how big the problem actually is. Furthermore measurements can also serve as feedback later on if any changes are done to the process. By making new measurements after the improvement action and comparing them to the old measurements should give an indication on how the improvement action affected the process. What to measure can be different for every project. Sometimes it can be the time it takes to perform a task, on other occasions it could be number of failures etc.

This step is not like the measure in DMAIC, since it just focuses on variations. This measure step can be related to all types of projects and can be measures for all kinds of data collected.

**KEYS:** [E], [T], [C], [F], [D]

**Step 4 – Analyze and Identify**
Analyze the documentations and the measurements from earlier steps. By analyzing and study the results from the measurements it is possible to see the status of the current process. This analysis shall be the basis for the later improvements. Through the analysis root causes to problems can be identified. Identify the problem area; it is in this area the improvement is most important. In this step it is possible to use the feedback key and analyze together with the employees. When the problem areas are identified control if the project is within the scope and limitations in step 1. If not go back to step 1 and start over and plan for the new tasks.
This step is close to the analyze step in the DMAIC cycle since this step is to analyze the data collected in the earlier steps, and understand the factors, causes and areas that affects the result. The purpose is to identify problems. In this step control charts, Ishikawa diagrams, flowcharts, Pareto and RACI tools can be used.

*KEYS: [F], [I], [T]*

**Step 5 – Improvement / New project**

After the analysis and measure phase is over, it should be clear what needs to be improved and what is the cause for it. In this step a suggestion based on the previous information is created to improve the process. The improvement should be a viable solution within the projects scope. The improvement suggestions can be on different levels. The suggestion can be just to show where the company has problems and where to focus the improvement work. The suggestion can also be presented as an action plan for how to improve or to come up with direct suggestion that can be implemented at the company. This can be conducted by starting a new improvement project by using the model from step 1.

Improvement can be related to all concepts. Lean, TQM, ISO 9001 & Six Sigma highlights the importance of continuous improvements.

*KEYS: [F], [I]*

**Step 6 – Implement**

Implement the suggestion in to the organization. The improvement suggestions shall be well planned and later cautiously implemented. In this step the success of the project can be affect on how the culture in the organization is open for change. Manage chance resistance with proper leadership, and engage the employees in the implementation work.

This step can be related to part III in the theory, how to manage change resistance, leadership, corporate culture and change management. In this step it is therefore important to be aware of the human impact on the suggestions.

*KEYS: [E], [L], [I], [C]*

**Step 7 – Follow-up**

Follow up what happened. Was the actions taken successful? In this step the cost effectiveness for the improvement project can be calculated or to estimate the positive and negative aspect of this project. Did we reach the project goals? Follow-up the results and compare it with the expected outcomes.

*KEYS: [I], [F]*

**Step 8 – Standardize**

If the project had a positive outcome, standardize the improvements on to the whole organization to reach a greater benefit from the project.
KEYS: [D], [E]

4.2 Development of model keys

In this paragraph the different keys in the business project improvement model 1.0 will be explained and motivated with theories that enlighten the importance of these keys for a successful project.

I – INFORM

Inform the workers and employees related to the project about the purpose of the improvement project and define the goals for it. By explaining the purpose and goals of the project the involved employees can understand why the project is important and why improvement needs to be done. Information in the planning step of the project is valid for the understanding and the cooperation for the project. This key can be applicable on many steps in the model depending on how the project is running, but it is most important to inform the involved employees in the beginning. The information can for example be given through meetings, e-mail or project presentations.

The importance of information can be found in theories for ISO 9001, TQM and Lean where it is about to inform the employees for how the production is running and about visions and goals to achieve commitment and engagement. This key is about the projects purpose and goals, in order to use dedicated workers in the project.

F – FEEDBACK

Allow the workers to provide feedback during the project. Listen to them and take advantage of their knowledge. Any feedback is good feedback. This key is important to advise during the different steps in the model and create an environment where the workers openly can give feedback. It can be feedback on measurements, given tasks and cooperation to develop the project in the meantime. Feedback can be given by discussion or brainstorming sessions. To
succeed with the project the resources for the project must be fully utilized, which means that ideas must be taken into account from different actors in the project. Good feedback can lead to new ideas for improvement, new problem areas discovered or detection of lack leadership work.

This step is related to the E- key [engage], since this also points to not waste any human creativity taken from the lean manufacturing concept. This can also refer to Deming’s 14 principles in theory part III, where one principle is remove barriers. Feedback from employees to leaders can break some barriers in organizations.

**C – CONTROL**
The control key is about to control the employees in the project, control measures and given tasks delegated to the workers. Control together with the workers involved if the information is correct. Analysis and current state mapping can be controlled with all the resources determined for the project. To have control is important, so a suggestion is based on facts that actually are true.

To base decision of on facts TQM can be linked to this key, since this key is about to control if there are true values and if the analyzes are correct so decisions will be based on well-collected and controlled information. In ISO 9001 one principle also points to fact-based decisions. This key is also directly linked to involvement and teamwork.

**T – Teach**
Teach the employees in the different steps in the model. Teach them in new techniques and make them understand the important tasks for the project. For instance it can be to teach how to measure and how to analyze data or how to create a flowchart and map the current state. This key is important, the more knowledge it is in the project the better the result of it will be.

In the theory teaching or education can be related to continuous improvements, since it considers the improvement of the employees’ knowledge in the organizations. In Lean one of the components is learning organization, which points to training and time for the employees to develop their work and learning new things. This is also found in Deming’s 14 principles where principle 6 - institute training, 8 - Teach and institute leadership and principle 13 – Encourage education and self-improvement for everyone can be considered in this key. Every employee in the project that needs education must given that opportunity.

**E – ENGAGE**
Engage the employees in the work. They have the knowledge of how the processes works and they are professionals on what they are doing. Involve them in the improvement work and make them feel active. Engage workers in the current state observation and learn from their expertise in the problem areas.
Engage is one important part in almost every improvement theory. In theories for Lean the importance of not waste the human creativity is stated. Six Sigma highlights the importance of involving employees in projects and TQM has determination as a key point. This engagement key can also be referred to ISO 9001 and the principle - employee commitment.

**D – DELEGATE**
Delegating different tasks in the process ad several benefits, the first being is that the workload is spread out among the people. Instead of having one employee responsible for doing everything the work could be shared. Another benefit is that the workers feel more involved in the project when they get tasks to perform. However all task is not suitable to delegate. It could be a less time consuming task, for instance performing measurements.

This key can be compared to theories from lean, use the employees’ to solve tasks for the project is related to not waste human creativity. Deming’s principle for drive out fear and create conditions for innovation can also be related to the delegate key.

**L – LEAD**
It is important to lead and guide everyone trough the project. Leading is especially important to make sure the project stays on track. To not stray away from project scope and that all involved in the projects give the time and resources necessary. The leaders’ role is to motivate and support the workers so they can perform satisfactory within the project.

ISO 9000, TQM, Six Sigma point to use the employees in the improvement projects lead by top management. This key is also taken from leadership theories, where leadership is the ability to influence other to perform tasks, motivate and create a good work environment.

**R – RESOURCE DETERMINATION**
Determining the resources for the project should be done at an early stage. Resources could be about who will be involved and how much time each person will spend in the project. It could also be about a budget for the project or how long the project going to last. When determining the human resources it is important to consider that people in question actually have the time available that is required from the project. The point of this step is to prevent any misunderstandings during the project. The resources given to a project should be balanced to expected outcome.

**DOCUMENT**
For a project of this kind it is important to document in each and every step. Documentation creates conditions for making a good project and helps the project to not waste the collected data and ideas. By utilizing proper documentation it is easier to follow the plan and notice problems for later improvements for how to run the business improvement project model.
For example everything that has been analyzed and learnt about the process needs to be documented in a structured way. For documentation it is possible to use different tools e.g. flowcharts to document the process. Documentation is an important part of the ISO 9000 series and the documentation aspect is very important when establishing routines and standardized practises.

### 4.3 Presentation of model

![Business Improvement Project Model 1.0](image)

(Figure 4.3, *Business improvement project model 1.0*)

This is a model for how to run an improvement project, shown in figure 4.3. The model is presented step-by-step with 8 steps where the P-D-S-A cycle and DMAIC is modified and clarified in this model. The model also includes help keys that has a purpose to assist the different steps in the model. This model can preferably be applied in projects for reducing production variations, but can also be used for health and safety-, management-, inventory-, process optimization- and maintenance improvement projects that can make the organization more cost effective. The model can be used in different branches and for companies with different size. Depending on the size of the project the use of keys can differ for each project.

In other words all key could be suitable to be use in every step, but it depends on the project. For every step it should be decided what part the employees needs to be involved and how this is realized. It depends on if the project needs to be mainly driven by the management or if the employees can take the major part of the project. Follow the model step-by-step from step 1 to 8. The improvement suggestions can also be that a new project needs to be started for the actual improvements. The different steps are presented in paragraph 4.1, where there is an explanation for each how to follow, work and how to apply the keys.
4.4 Objectives

- The model should be simple to utilize
- The model should be possible to adapt to different projects
- The model should be able to take other aspects into consideration, than just production variation
5. Empirical findings

This chapter includes the empirical findings for this thesis. In this chapter the case company and the production process for manufacturing coatings is presented. It is also describe more deeply around one production line [P3] and its current status in different areas. All this information has been gathered by observations, interviews and brainstorming sessions. All information has finally been verified and controlled by the case company representative Johan Sporrong, production manager.

5.1 Company background – International Färg AB

International Färg AB is founded in 1913 and started with production of coating in a plant in Gothenburg. During the period 1974 - 1986 the company expanded in stages and built a new factory in Angered, north of Gothenburg. Since 1998, International Färg AB is a part of the Dutch-Swedish concern group Akzo Nobel.

At the company there are currently 150 employees. About 100 of these works in the manufacturing process or warehousing, the others are distributed over sales and administration. At international Färg AB they manufacture, market and sell marine coatings, protective coatings and yacht coatings. International Färg AB is since 1991 the production center for the concern group's anti-corrosive paints for Europe and Africa. International’s organization is matrix structured, graphically and partly production oriented.

In total International Färg AB in Angered have about 370 different kinds of products that they manufacture with 550 kinds of raw-material. The coatings purpose is to protect and preserve buildings, structures and boats against corrosion, fire etc. Their products has been used at famous locations such as Sidney harbor bridge in Australia, London Eye in England and the world cup arenas in south America to mention a few.

International Färg AB’s main process is defined as: Develop, produce and deliver coatings to customers. This main process has support from IT, HR, HSM, planning, economics, maintenance etc.

The company’s production is dived into 3 lines: P1, P2 and P3, where P1 and P2 is for larger volumes and is more automated. The P3 line is more complex, with smaller volumes, different products and steps with the most variations on products. The production is also divided into different departments. Pre-batching of wet-material, pre-batching of powder, charging for [P1, P2 and P3], and filling for [P1, P2 and P3], lab, warehouse, service and a maintenance department.

This information is gathered from a company presentation on power point the case company use when introducing the company’s history and production for visitors and customers.
Figure 5.1 show how the company’s different departments and production lines are separated. For this study the focus will be on the P3 line since it is the most complex. An organization schedule for International Färg AB can be found in appendix 1.

5.2 Production process – how to produce coatings?
Manufacturing coatings can be a complex process, which can be divided into three steps; pre-batching, charging and filling. One product of coating is in the production called batch.

The first step in the production is pre-batching. In the pre-batching phase all the material has to be weighed correctly. The material that gets weighed can either be in wet form e.g. liquid, or in powder e.g. solid material. The raw material consists of different chemicals that can be toxic. Special gloves and safety equipment has to be used for the more dangerous materials. However there is some toxic material as well that does not require any special safety equipment for the workers.

After the pre batching, it is time for charging. In this step the weighed material get mixed together according to a recipe. The way this is done differ from product to product. Most common is that the material gets put together in a big tank; smaller volumes can be done in smaller pots. The tanks are able to rotate the material inside. When all the material has been mixed in proper way, a sample is sent to lab department for testing of the batch. If the batch do not meet the requirements, it is common to adjust the batch to meet the requirements. When the batch passes the testing phase then it is time to start filling the coating in to cans, this is done manually or with the help of automated machines. The cans differ in size. The filling of the coating is the most time consuming step in the process. The filled cans get put on pallets and loaded on to trucks for shipment to warehouse or customers.
This information is based on observations in the production to understand the process for how to produce coatings.

5.3 Product presentation
This data is collected from the lab department, from their database and from an open interview with one of the employees responsible for new products and quality controls at the lab. The lab department works with quality controls for batches, testing of new products, development of problem batches, complaints from customers. The quality control consists of measures on density, surface, gloss, viscosity, hold-up and color.

International Färg AB manufactures around 370 products. Products with a wide variety of type, manufacture process and colors. The products are anticorrosive coatings, fire-protective, thermal indicators, surface coatings, thinners and hardeners.

The products can be categorized into:
- Primers: Is painted first, purpose is to stick well to the substrate and to be anticorrosive.
- Topcoat: The top of the paint layer, esthetic purpose.
- Thinners: Used in the different batches for manufacturing the coatings.

The primers and topcoats can later be divided into 1 component- and 2 component coatings.
- 1 component: for example it dries faster than 2 component coatings.
- 2 components: better coatings, more expensive raw-material and more expensive to manufacture because it requires an extra process.

The products can also be divided into hardener and base coatings. This affects the production-flow since the equipment cannot be used for both types in order to not affect the quality. The most complex coating to manufacture is a 2 component protective coating, due to the high requirements and the low tolerance on quality. International has focused on 2 component coatings, and to manufacture products with quality. To manufacture 1 component coatings an old technology is used and the competition on the market is tough. The development of new products has a trend to contain less solvent, which mean that the machines needs to run with higher power. The introduction of new products is a process that starts and develops in a lab in England, International gets a recipe, evaluates if the product can be produced or not, if new machines must be invested, if new materials must be used. If International Färg AB begins to manufacture the product samples of 800 gallons are tested and a quality control is made if the coating is approved, and the company can enter the product into the system.
The P3 line produces a broad complicated product mix. They produce hardeners, thinners and coatings and all in different batch sizes.

5.4 Continuous improvements
At International Färg AB they work with continues improvements. The management considers this an important part in becoming a better company. The continuous improvements and the improvement projects is a part of a program International AB calls Angered Vision. Angered Vision is incorporated in to International Färg AB as an initiation to improve the company. Every Thursday there is a meeting to follow up on every project currently running in the company.

Every employee that wishes to do an improvement needs to go through a course called awareness training. The course is done with a small group of 3-6 employees at a time and aims to give the employees knowledge and an understanding of the company purpose behind working with continues improvements.

5.5 Evaluation of production lines and presentation of P3
P1 and P2: Focuses on volumes, bigger batches with smaller amount of different products.

P3: Smaller batches with a more complicated product mix than P1 and P2, all types of coatings included thinners and hardeners. More problem batches and the department in P3 have most problems to hit the weekly plan. 53% of all products, 24% of the volume.

5.6 Quality information P3
This empirical data has been gathered from database information. In the lab department one employee is responsible to handle the quality issues and compiles all the information about the quality in a document. From this document, the information about the quality at P3 line is compiled.

![Pie chart showing quality issues in P3 line](Figure 5.3, Quality information P3)
The P3 line had a total of 97 problem batches during 2011. Where 11 of these were sent to their customers, thus customer rejects. Figure 5.3 shows a summary of the failures that are repeated in the production of P3 and highlights the most typical failures that lead to rework of batches.

In 2011 the P3 line produced 1657 batches. At P3 they also fill thinners, which is a finished product when it comes to International Färg AB and is always right first-time. Therefore the 180 batches of thinners has been moved from the statistics. This compilation is made based on the 1477 batches except the right-first time thinner products in 2011.

\[
\frac{97 - 11}{1477} = 5.82\% \text{ problem batches.}
\]

5.7 Production Lead times P3
Currently all information about production lead times is based on assumptions from the operators. The operators have made approximated times based on their experience.

5.8 Pre-batching powder
The following data was collected from flowcharts, measurements and open interviews with the operator from the department for pre-batching powder. Under the listed issues the authors present their own observations related to each issue in Italian text.

5.8.1 Measurements powder
Figure 5.4 shows the time measures, to find variations in pre-batching powder.

(Figure 5.4, Time measurements pre-batching powder)
5.8.2 List of issues

✓ **Missing or incorrect priority list**

The chargers create a priority list on the order that the different batches are going to be created to. The list helps the pre-batcher knowing what material to prepare first. The list is supposed to be done one day in advance. The problem is when the list is not finished in time, or gets changed the same day. The problem with changing the list the same day is that the pre-batcher might already finished weighting material that might not be used until later.

*This problem can occur on random occasions but is more of a problem during busy times. However the workers can also experience it as an advantage being able to change the list during the day. But this advantage can cause problems for the pre-batchers and problem getting the material on time.*

✓ **Incorrect information about the in house-stock**

It is possible that the IT-system give the wrong information about what is in stock. The problem is when they are out of stock not knowing it, causing a delay on the order.

*According to observations and interviews with the staff, the explanations causing the problem are similarities in the raw-material. When raw material is to similar it is possible that an employee used the wrong raw-material by mistake. Other explanation is that the material is not in the correct space, and the employees could not find it when they needed it making them believe they are out of stock when they in fact where not. Another explanation is waste from material handling. It is also possible that there is a delay form the supplier.*

✓ **Two locations for returning recipes**

When the material has been weighed the recipe for that specific order gets sent back to the chargers. The chargers then know that they can start working with the recipe. Because there are two locations there is sometimes an issue when the chargers do not check both folders.

*The problem is that the routine for returning recipes is not clear. A charger might assume that the order in not ready for charging because he do see the recipe.*

✓ **Similar raw-material**

Some of the raw material is very similar on how it looks and how the package look. Because of this it is possible to pick the wrong raw material.
Observations show that some of the raw material actually is hard to differentiate between. The more experience workers can still handle it. But a moment of not paying attention can causes the problem to happen for experienced worker as well.

- **No high-lift forklifts available**
  This means that the operator just have low-lift forklift to work with, the high-lifter is used in another department at the moment, which means that the powder operator can not lift down material that is placed high. It also affects the ergonomics, as the operator may have lift more material by hand.

  The high lifting forklift is a resource many of the departments benefit from having. And the chargers are in the bottom of the priority list. They do not have one of their own; instead they have to wait for one to be not used. Or sometime ask for help for certain lifts. However their work does not come to a complete stop without an available lift. With the help from others with certain lifts they manage to do their job anyway. Although the work takes slightly longer and cause more stress on the body.

### 5.9 Pre-batching wet-material

This following data was collected from flowcharts, measurements and open interviews with the operator from the department for pre-batchting wet-material. Under the listed issues the authors presents their own observations related to each issue in Italian text.

#### 5.9.1 Measurement wet-material

Figure 5.5 shows the time measures, to find variations in pre-batchting wet-material.

(Figure 5.5, *Time measurement pre-batching wet-material*)
5.9.2 List of issues

✔ Not enough space in p3
Because there is only a small space for putting weighed material in p3, the workers have to put the weighed material either on a different location or stack the material on top of each other. When the material gets put elsewhere, the employees might not find it, or spend time searching for it. The material that gets stacked on each other risk being used in another batch because employees might assume that the stack material belong to the same batch.

*The area for placing material for p3 has been observed and it is an issue being able to fit all the material. It is necessary when it is filled up to either stack the material on top of each other or at a different location.*

✔ Priority list that get changed the same day
The priority list created by the chargers is sometimes changed the same day. The problem can occur from this is if the pre-batcher already started on an order that get changed to be manufactured much later.

*Same as for powder, see page 37.*

✔ No raw material available even though the recipes has been issued
When an order is cleared for manufacturing it gets issued. An order that get issued should have raw material ready for use. However there has been occasion when a recipe has been ordered but there is no raw material.

*Same as for powder, see page 37.*

✔ Uneven work flow caused by missing raw material
When there is a shortage of raw material there is not much to do. But when the material gets delivered there is more to do than normally.

*There is a great amount of different kinds of raw- material needed for the production at international. It is not possible to keep stock on everything. Sometimes information about the stock is incomplete causing a delay because of the waiting time for the raw material to be delivered.*
5.10 Charging
This following data was collected from flowcharts, observations and open interviews with the operators from the charging department.

5.10.1 Observations
The chargers create a lot of batches at the same time. However there is an issue when the staff does to many things at the same time. For instance it may cause that the batch get run to long in the sand mill. And when the shifts change it is possible they leaving workers miss to give information about what has been done. The chargers also sub-optimize their work to make the process as easy as possible, and forget to cooperate with the different departments. The resource allocation between the different shifts is also uneven, sometimes the evening-shift just have one employee while the day-shift has four.

5.10.2 List of issues

 ✓ Raw material shortage
   It can happen that inventory information regarding raw-material is incorrect. When it occurs orders have to be put on hold until the raw-material gets delivered. This affects the weekly plans and the priority list created by the chargers for the pre-batchers.

   When inventory information is not correct there is a delay for orders that need the raw material needed. Also priorities list can be faulty because of it. The problem exists when the employees is not aware of the shortage, when they believe they have raw-material which they have not

 ✓ Priority list
   The chargers are responsible the make priority list for the pre-batchers, and they also try to sub optimize the production planning similar orders right next to each other. The can break down due to insufficient information regarding raw material status, staff problems etc.

   The chargers have to create the priority lists without sufficient information sometimes. The problem can be that they are not sure when raw material is going to be delivered for instance. Another example would be to plan for staff shortage due to sickness, or treatment of child. Also they have missed to check information about planned vacations. This particular problem with staff shortages is something that heavily affecting the performance of p3.

 ✓ Different procedures regarding recipes for pre batchers
   The pre-batchers weight the material. The chargers sometimes marks on recipes what needs to be weighed, in other occasions the pre-batchers mark what has been weighed which sometimes lead to confusion on what has been weighed.
Some of the pre-batchers want to sign on the recipe what has been weighed, themselves. In other cases the chargers sign on the recipe what should be weighed. The difference in procedures can cause issues understanding what has been weighed, and what is going to be weighed.

✓ Clean pots
In order for the production to flow efficiently there need to be clean pots available all the time. Many times there are no clean pots, which mean that production gets held back until a pot is cleaned.

There is always a need of clean pots in the production. But if someone is off sick, or there is heavy load there might not be time to make sure that there are any clean pots available. To handle the problem when it occurs, someone from either the chargers or the fillers need to stop what they are doing to clean the pots.

✓ Staff shortage
It is hard to plan for the production in p3, many unplanned staff shortages happen because of the employees having sick kids etc.

The weekly production planned does never get completed. There is always some of the orders that has to be moved over to the next week. One of the main reason the management and the employees give to not being able to deliver to plan is staff shortage because of sick leaves. Or treatment of sick children, currently this problem is affecting the production heavily.

✓ Control
Chargers can assume that the raw material is correct without actually checking, risking to produce a faulty batch.

The chargers are supposed to check all the material they use in batches that it is the correct material and correct amount. Using the wrong material or not the correct amount will cause rework. Sometimes the chargers do not check for this, increasing the chance for quality issues.

✓ Discolouration in sand mill
If the paint run through the sand mill longer than it should, the pain can get a darker colour than what has been aimed for. To take care about the colour problem additional work on the batch has been done.

If the batch run through the sand longer that it should the coating will get a darker colour. The reason why a batch can run to long is because of the workers can be working on many batches at the same time and miss to check the time. ??
✓ **Cover**

Some of the coatings need cover made by either plastic or different chemicals to protect the paint. This step sometimes gets forgotten if the charger does not check the recipe carefully.

*On all the recipes the chargers follow it is stated if the batch need cover or not. The reason that it gets missed is because it is a step that is done after the batch get sent to the lab. In most cases batches that get sent to the lab are finished batches.*

✓ **Adjust**

A batch that is not approved instantly has to get adjusted to meet quality criteria. If the charges miss to do it the batch will get hold up.

*It is only when a batch gets approved by the lab that the coating gets filled. When the products do not get an approval from the lab, adjustments have to be made. It is currently up to chargers to attend the adjustments at quick as possible to not delay the batch unnecessary.*

### 5.11 Planning

*This following data was collected from flowcharts, weekly plans and from observations regarding the planning for P3.*

#### 5.11.1 Observations

At International Färg AB they have a planner that make a forecast trying to predict what needs to be produced before a coatings run out of stock. Every week he put together a list of suggestions that needs to be produced in the near future. On the list there are some high priority items, these needs to be produced as soon as possible, and others that are important still, but have a lower priority.

Every Thursday there are between 2 and 4 employees spending one hour to create the weekly plan. When they are finished with a suggestion of the weekly plan it gets sent to the planner for approval. If the plan is not approved additional rework and corrections have to be done.

It is problematic for the case company to develop an accurate plan that the production can follow. To be able to create an accurate plan a lot of information is needed. Information such as the time it takes to develop and create the specific products? What machines should be used? Is the material in stock? etc. This is the reason that the people that are creating the plan work in different areas and provide different information on the meetings. However even when there is 2-4 people involved in the planning phase, the accuracy of the plan on average is 81.45 %. As a result of the accuracy around seven orders on average have to be moved to the upcoming week.
Reasons that were given to why the plan was not keep higher than 81.45 on average were sick leaves, machine failures and raw-material shortages.

The plan is made with consideration to volume and the fastest way to produce. The fillers have a representative at the meetings but the plan is optimized toward the production. However in most cases the product takes longer time to fill than it takes in to develop. In other words there is higher capacity available in the production than what they are able to fill with current methods. But the planning is optimized for the production and not the filling.

Our observation it was noticed that the plan is made mostly with information the employees at the meeting have. None other input that what the workers there was used. Time for to produce a batch was every time estimated by the employee from the chargers. The filler representative that was there to try fit in on a schedule when to fill the orders created. A management representative that is most of the times on these meetings try and bring information about upcoming vacations and try to provide a more holistic view on the plan.

### 5.11.2 Planning accuracy P3

**Week 2 – Week 18 2012:**

<table>
<thead>
<tr>
<th>Week</th>
<th>Planned batches</th>
<th>Hits</th>
<th>Misses</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>39</td>
<td>30</td>
<td>9</td>
<td>76.92%</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>27</td>
<td>9</td>
<td>75.00%</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>26</td>
<td>12</td>
<td>68.42%</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
<td>29</td>
<td>19</td>
<td>60.42%</td>
</tr>
<tr>
<td>6</td>
<td>47</td>
<td>43</td>
<td>4</td>
<td>91.49%</td>
</tr>
<tr>
<td>7</td>
<td>43</td>
<td>36</td>
<td>7</td>
<td>83.72%</td>
</tr>
<tr>
<td>8</td>
<td>44</td>
<td>37</td>
<td>7</td>
<td>84.09%</td>
</tr>
<tr>
<td>9</td>
<td>45</td>
<td>40</td>
<td>5</td>
<td>88.89%</td>
</tr>
<tr>
<td>10</td>
<td>49</td>
<td>44</td>
<td>5</td>
<td>89.78%</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>31</td>
<td>9</td>
<td>77.50%</td>
</tr>
<tr>
<td>12</td>
<td>40</td>
<td>36</td>
<td>4</td>
<td>90.00%</td>
</tr>
<tr>
<td>13</td>
<td>37</td>
<td>33</td>
<td>4</td>
<td>89.19%</td>
</tr>
<tr>
<td>14</td>
<td>33</td>
<td>28</td>
<td>5</td>
<td>84.85%</td>
</tr>
<tr>
<td>15</td>
<td>36</td>
<td>31</td>
<td>5</td>
<td>86.11%</td>
</tr>
<tr>
<td>16</td>
<td>43</td>
<td>34</td>
<td>9</td>
<td>79.07%</td>
</tr>
<tr>
<td>17</td>
<td>47</td>
<td>40</td>
<td>7</td>
<td>85.11%</td>
</tr>
<tr>
<td>18</td>
<td>36</td>
<td>26</td>
<td>10</td>
<td>72.22%</td>
</tr>
<tr>
<td><strong>Average:</strong></td>
<td><strong>41.23</strong></td>
<td><strong>33.59</strong></td>
<td><strong>7.65</strong></td>
<td><strong>81.45%</strong></td>
</tr>
</tbody>
</table>

*(Table 5.1, Planning accuracy)*

*This data is a collection compiled from old weekly plans from week 2 to week 18 and 2012. Table 5.1 shows the accuracy from the production planning in P3 line.*
5.12 P3 department brainstorming session

It could be seen as a problem that there is always some orders that get missed from the weekly plan. For instance the in the case for the pre-batchers that might have started to weight something and spent time on it to find out that it is not going to be used right now. And instead he should have weighed something else because that is what they need more now because of changes in the production plan.

The employees on the meeting considered it a problem that the weekly plans are approved, but it is not sure that there is raw material available on that specific date. This can cause many changes and delays in the schedule.

One of the employees that have been attending many weekly plan meetings considers it a very hard process. And describe it as a guessing game to get it correctly, without the information about raw material deliveries and people being sick. Overall the group named sick leaves as the most common reason for not being able to deliver according to plan. Other reason was equipment failure and raw material shortages.

5.13 Summary empirical findings

- **Company background** – presentation of case company International AB
- **Production process** – how to produce coatings
- **Product presentation** – products manufactured by International AB and product areas
- **Continuous improvements** – International AB’s business improvement project
- **P3 line** – Presentation of the production-line P3
- **Quality information P3** – how the status for quality is at P3, and how they work with it.
- **Production lead-time P3** – actual knowledge about lead-times for P3
- **Planning process at P3** – presentation of the current planning work
- **Brainstorming session** – data from employees at P3
6. Analysis

This chapter includes the analysis. The analyses includes the implementation and testing of the business improvement project model 1.0. The model is used for a project for how to improve the production process in a manufacturing industry by reducing production variations in quality, production time and work routines to streamline the production, which in the end can lead to a more cost-effective production. The implementation is presented step-by-step and the use of the different keys are explained to each step in the model. This chapter is also contains analysis on the data collected in the empirical findings.

6.1 Part 1 - Model implementation

The test of the model developed in chapter 4 is described in this chapter. The model is implemented at the case company and adapted for this study to fit a project for reducing production variations. In this case the model is tested from step 1 to 5, from planning to improvement suggestions. Step 5 in the model [Improvement suggestions] is explained shortly and can be found in the recommendations chapter page 62. The last 3 steps in the model cannot be implemented during this study, therefore are these steps discussed in chapter 11.

Expected outcomes:

✓ That this model generally suits this project
✓ Follow the plan and scope
✓ Learn the process
✓ Find suitable measurements for this case
✓ That the keys helps to project success
✓ Identify problem areas for improvements
✓ Find improvement suggestion on different levels to the case company

6.1.1 Plan the project

The project was started by creating a plan. This was made during the first week at the case company together with the supply manager and the production manager. The case company has a wish to be more cost effective in their production. A scope was set, that the project should focus on the production, from the weekly plans of the productions until the products are ready for filling. The aim and goal with the project was to create a base for improvements for variations in production time, quality and work routines.

The human resources for the project was determined to the project to be clear which persons that was going to be involved and how much time each person had to spend each week.

Authors: 20-40 h/w
Production manager: 2-5 h/w
Operators: 0-20 h/w
Facilitator: 0-2 h/w
Planning manager: ad hoc
The time frame for the project was decided to 10 weeks, linked to the time-frame in chapter 1. Expected benefits with the project was to decrease problem batches, more effective production, reduced overtime and reduced lead-time. For later calculations on cost effectiveness produced liters/hours was given to 204 liters/hour.

Potential project barriers were also discussed and change resistance, culture and in accurate information could be problems for the project success.

In this step the authors engaged the employees in the project, informed them about the purpose and determined the resources for the project. This was all documented.

**KEYS: [E], [R], [I], [DOCUMENT]**

6.1.2 Analyze & learn how the process works

To reach an understanding about the production process and the sub processes around the production the first step was to follow the employees trough their work days. When a basic understanding about the processes was reached the next step was to hold individual meetings with employees and their manager from each process area. To document the information a tool called flowcharts was used. The flowcharts in figures 6.1-6.3 are presented in this step and shows the actual process. In the creation of the flowcharts it was important to let the employees describe with their own wording how the process work today. The employees were also asked to give information about all issues within the process that they could come up with. At least two meetings with time between were given to each person. The reason for having several meetings with the same agenda was to be able to gather as much information as possible. At the second meeting it was possible to pick up on information that was missed on the first occasion. After the meetings the flowcharts together with the information on issues in the process got sent out for viewing by all the staff working in the specific process. They could come with additional information if something was missed, If not the documents was approved.

**KEYS: [F], [E], [C], [DOCUMENT]**
### PREBATCHING [POWDER]

<table>
<thead>
<tr>
<th>CHARGING</th>
<th>PREBATCHING</th>
<th>SERVICE</th>
<th>ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gets recipes</td>
<td>Collects recipes and prioritist</td>
<td></td>
<td>Missin priority list from chargers, the wrong products first?</td>
</tr>
<tr>
<td></td>
<td>Check and sort prioritist</td>
<td>Service helps with</td>
<td>No highlift forklifts available, ergonomical effects?</td>
</tr>
<tr>
<td></td>
<td>Creates labels for raw materials</td>
<td>collecting raw material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Warehouse information incorrect, there is no raw material?</td>
</tr>
<tr>
<td></td>
<td>Highlifting forklift available?</td>
<td></td>
<td>Similar raw material can be picked by mistake</td>
</tr>
<tr>
<td></td>
<td>Raw material available?</td>
<td>On order?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check with BN</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>and PT</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Out of raw material?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collect raw material (powder)</td>
<td>Leave receipt to BN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Split bag?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create label</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prebatch after receipt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return leftover raw material</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check against list?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Puts the pre batched raw</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>material at its dedicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>place</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sign recipes and return</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>them to chargers</td>
<td></td>
</tr>
</tbody>
</table>

(Figure 6.1, flowchart pre-batching powder)

In the right column there are issues stated from the meeting with the pre-batcher. The listed issues are located around the area in the process the issue exist.
PREBATCHING [WET MATERIAL]

<table>
<thead>
<tr>
<th>DEMAND</th>
<th>PREBATCHING</th>
<th>SERVICE</th>
<th>CHARGING</th>
<th>ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand control material shortage</td>
<td>Prebatcher mark what to weigh.</td>
<td>Collect recipes</td>
<td>Gets recipes that will not get produced next day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check raw material</td>
<td>Creates a list of priorities</td>
<td>Write the wrong priority list and later change it</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Raw material?</td>
<td>Raw material in stock?</td>
<td>No available raw materials even though the recipes have been issued</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact service about raw material</td>
<td>Deliver raw material to prebatch</td>
<td>Checks are not always made if the raw material are inside or out. Which can create obscure when the information is wrong</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forward the out of stock info to demand and chargers</td>
<td>Inform prebatcher that raw material is out of stock</td>
<td>Uneven load when shortage of raw material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create labels for raw materials</td>
<td>Raw material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Start weighing process from top of recipes to the bottom</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mark and signs the weighed material</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deliver weighed raw material to dedicated area</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Will the raw material be used in other recipes?</td>
<td>Raw material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return raw material to stock</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return recipes to charger</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjust weight and material</td>
<td>Raw material in stock?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Figure 6.2, flowchart pre-batching wet-material)

In the right column there are issues stated from the meeting with the pre-batcher. The listed issues are located around the area in the process the issue exist.
(Figure 6.3, flowchart pre-batching powder)

In the right column there are issues stated from the meeting with the pre-batcher. The listed issues are located around the area in the process the issue exist.
6.1.3 Measure for later comparison
The chargers have complaints towards the pre batching that the capacity is to low with current resources in the pre-batching area. To determine the capacity measurements was performed on pre batching wet-material and pre batching powder in order to get information about the capacity in these areas with current resources. The measurements were directed to give data about the time it takes to complete the weighting of a batch.

To engage the workers in the project, they were performing the measurements them self. To be able to do it they were provided with instructions on exactly what to measure and assigned templates where to fill in the information.

6.1.4 Analyze and identify problem areas
The collected data from measurements (appendix 3), flowcharts (p 47), interviews and observations (appendix 4) were compiled and analyzed. Measurements of the time varied for pre-batching powder and wet-material was made. This was compiled and analyzed by making control-charts and lists of the issues related to each activity.

Based on the data it was shown that there is variations in production time for different batches with different recipes. By analyzing the measurements and the most varied of time, various problems may be directed to the times that are abnormal.

The analysis can be found in the case company analysis [Part II] in this chapter.

6.1.5 Improvement suggestions
Based on the analysis from the case company during the model test improvement suggestions were made. These suggestions can help the case company to reduce production variations in quality, lead-time to make the planning more accurate.

The improvement suggestions can be found in the recommendations chapter. This step in the model implementation is recommendations to the case company based on the analysis and results during this project.

6.1.6 Implement the improvement suggestions
In step 6 the user should implement the improvement suggestions from step 5. Due to the limitations and scope for this thesis this step cannot be completed in this project. How to implement the suggestion is therefore handled in the discussion chapter 11 page 64.

6.1.7 Follow - up what you have implemented, how is it going?
In this step the users of the model should follow-up and evaluate the outcome of the implemented improvement suggestions. This step is also discussed in chapter 11, since the authors cannot implement this step due to the limitations for this project.

6.1.8 Standardize if the suggested improvements is successful
How to standardize the successful improvements is also discussed in chapter 11.
6.2 PART II – Case company analysis

In this part the analysis on the empirical findings (chapter 5) from the case company is presented.

6.3 Continuous improvements

International Färg AB is working with continuous improvements and calls it Angered vision. They involve the employees in their program, and improvement projects. And they also educated their employees in improvement work. This type of program and their work method for improvements is similar to the improvement methods for Lean manufacturing and Six Sigma. Concepts based on continuous improvements. Lean highlights the systematic improvements and Six Sigma how to run the projects and the importance of involve educated employees in the improvement work. Angered Vision is definitely based on these concepts and named as a vision for their goals to constantly improve.

6.4 Quality

The three biggest causes for problem batches are wrong charged material, discoloration and wrong density batches. This leads to quality problems and affects the production time, since the chargers needs to rework and thereby waste time. This is a big problem for the production planning and leads to longer production time, in other words variation in production time. The roots causes to these quality issues are analyzed in Ishikawa diagrams, the root cause analysis are based on the empirical findings and analyzed together with employees involved in the process.

6.4.1 Wrong charged material

Wrong charged material represents 19% of the quality problem batches in P3. To analyze the root causes for this quality problem the Ishikawa diagram tool is used.
The Ishikawa diagram in figure 6.1 shows the root causes to quality problems related to wrong charged batches. The human mistakes are the most common root causes to the problem batches in this case, it is a question of being careful and control. Since two employees can work on the same batch, there can also be misunderstandings of what is charged or not. One employee can also work with batches simultaneously and can therefore miss smaller things. If the material is unclear marked and the worker do not read and check the number it can lead to wrong material charged. One common cause is misunderstandings; this is an affect of the free structured process with interconnections. There is a lack of communication between the workers because they trust each other. The workers have to be aware of this issue and control the material carefully. Lack of knowledge and work routines are also common causes for this quality problem. Other problems and causes are derived trough the Ishikawa diagram in figure 6.4.

6.4.2 Discoloration
Discoloration batches represent 17% of the quality problem batches in P3. To analyze the root causes for this quality problem the Ishikawa diagram tool is used.

Figure 6.5 shows the root causes for discoloration. The causes for discoloration are mostly human mistakes. The operators have sometimes problems due to the interconnections of batches. This affects the control and increase the risk for misunderstandings between workers and departments. When the operator works on two or more batches at the same time it is possible to miss the time for when the product is finished, which causes the finished product run to long in the machine and results in a discoloured product. The lack of knowledge about
the machines, the cleaning of pots and machines and unwillingness to control are common problems at P3. Poor planning leads to stress and reprioritization of batches. Other problems and causes are derived through the Ishikawa diagram in figure 6.5.

### 6.4.3 Wrong density

*Wrong density batches represent 9% of the quality problem batches in P3. To analyze the root causes for this quality problem the Ishikawa diagram tool is used.*

![Ishikawa Diagram](image)

(Figure 6.6, *Wrong density Ishikawa*)

Wrong density batches are mostly caused by charging wrong quantity of the material. This is also most caused by human mistakes, where lack of knowledge, misunderstandings, trust and routines are common root causes. Wrong density is also related to how the process is structured. The interconnections and co-operations require communication and routines. Wrong density is also related to the taps when their volume meters gets dirty occasionally. This is explained in the Ishikawa diagram in figure 6.6.

### 6.5 Production Lead times P3

Lead-times for the different batches and products are based on the workers knowledge and experiences. The chargers know roughly how long it takes to manufacture a particular product. The estimated lead time varies from person to person. This is an important aspect for the production planning and should be taken into account when creating the weekly-plan.

The sheer amount of different products causes difficulties for determining the exact production lead time.
6.6 Value-added and non value-adding time

To get a cost-effective production, it is preferable that as much as possible of the production creates value to the customer. Based on the time measurements in empirical findings analyses have been made.

6.6.1 Supporting value time pre-batching

The supporting value in this process is the time accomplished for weighting the material. Average time for the actual weighting is 3.74h/day for powder and 3.49h/day for wet-material. The time for pre-batching is measured from when the operator starts weighting the raw-material after the recipe for a batch and retrieval of material until the operator comes back from delivery of the raw material to P3 charging. The working time for a day is 7.5h and the employees must clean the work station 30 minutes per day. Figure 6.7 shows a circle diagram of the average times.

![Circle diagram of average times for powder and wet-material](image)

(Figure 6.7, Supporting value)

In average 3.26 hours per day is spent on other activities than to weight the material for powder, and 3.51 hours per day for wet-material. This time consists mainly out of preparation for the actual weighting. It also includes preparation of packaging materials like cans and tanks, control of raw material inventory, writing labels, go through recipes and check prioritization and ordering raw materials out of stock. The time is connected with the listed issues. If it is possible to reduce the time for preparation there is more time for weighing. The more time that is not precise and unclear means that the company have no control for how long time activities take. It is not efficient to waste time on recipes that has no raw-material in stock, as the time is wasted for control and ordering of material, in worst case a started weighing need to be discounted.
6.7 Issues analysis

In this paragraph the listed issues related to the different processes in empirical findings are analyzed. For a more detailed analysis of every issue see appendix 4.

6.7.1 Pre-batching Powder and wet-material

<table>
<thead>
<tr>
<th>Issue</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Not enough space in p³</td>
<td>work routines</td>
</tr>
<tr>
<td>2. Missing or incorrect priority list</td>
<td>planning, work routines</td>
</tr>
<tr>
<td>3. Two locations for returning recipes</td>
<td>work routines</td>
</tr>
<tr>
<td>4. Incorrect information about the in-house-stock</td>
<td>planning</td>
</tr>
<tr>
<td>5. Similar raw-material</td>
<td>work routines</td>
</tr>
<tr>
<td>6. No high-lift forklifts available</td>
<td>resources</td>
</tr>
<tr>
<td>7. Uneven work flow caused by missing raw material</td>
<td>planning</td>
</tr>
</tbody>
</table>

(Table 6.1, Issues pre-batching)

Table 6.1 shows issues affecting the pre-batchers gathered through interviews with the pre-batchers. In the second column the cause for the problem according to the analysis is stated.

The priority list (1) and raw material information (2) caused problems for the pre-batchers by making their work less effective.

Both the pre-batcher needs high-lifting forklifts (5) to make their work easier. Without one it takes longer time and cause more stress on the body. However this is a question about sharing and dividing resources over the whole company. Many times they have the possibility to use a high-lifting forklift. In the cases that they cannot get a hold of one, they can ask for help and receives it if necessary.

The raw material misinformation is also connected to the issues with planning. The waiting time one delivery, dislocation, or not having any raw-material is an issue not only caused at is reasons at the company. It is also down to what the suppliers. But improving upon the planning could increase the efficiency in this area.

The uneven work flow (6) is caused by not being able to do all the work if the raw material is not there. When it arrives they have to catch up the time they waited on the material, which cause an increase in workload when this happen. This issue has a relation to incorrect information about the in-house stock (3) issue. In order to decrease the problems created by this issue, the plan has to be improved together with stock information.
6.7.2 Charging

<table>
<thead>
<tr>
<th>Issue</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Raw material shortage</td>
<td>planning</td>
</tr>
<tr>
<td>2. Priority list</td>
<td>planning</td>
</tr>
<tr>
<td>3. Different procedures regarding recipes for pre batchers</td>
<td>work routines</td>
</tr>
<tr>
<td>4. Clean pots</td>
<td>work routines</td>
</tr>
<tr>
<td>5. Staff shortage</td>
<td>Planning, work routines</td>
</tr>
<tr>
<td>6. Discolouration in sand mill</td>
<td>work routines</td>
</tr>
<tr>
<td>7. Control</td>
<td>work routines</td>
</tr>
<tr>
<td>8. Cover</td>
<td>work routines</td>
</tr>
<tr>
<td>9. Adjust</td>
<td>work routines</td>
</tr>
</tbody>
</table>

(Table 6.2, Issues charging)

Table 6.2 shows issues affecting the charges gathered through interviews with the chargers. In the second column the cause for the problem that needs to be addressed according the analysis is stated.

There are currently several issues affecting the chargers and ultimately it increases the variations in the production process. The issues causes the production to be less effective by increasing the production time and using resources that could have been used for production or other value adding or value supporting activities. From the gathered issues the most common area to attend in order to decrease or eliminate the issues are by attending the work routines. Point 3, 4, 5, 6, 7, 8, 9, 10, and 11 from the figure could be improved by looking over, improving and standardize work routines.

The raw material (1) and priority list (2) issues have the root cause outside pre-batcher process but is affecting the chargers. By improving the accuracy regarding raw material information and the weekly plan, the production would benefit as well. Fewer resources would be wasted by improving in these two areas. The problems with staff shortage due to sickness or treatment of child heavily impact the performance when it does occur. By accounting this in to the planning and improve work routines for when this occur could decrease the negative impact by this issues

6.8 Planning

The data from the weekly plans indicate that there is an issue with the accuracy on the weekly plan. As it is right now the average accuracy over 17 weeks is 81.45% with a peak on 91.49%. The current data suggest that the weekly plan is optimistic and it is not possible with current methods to complete all the scheduled tasks.

There is no relation between the numbers of batches planned and the number of failures. All coatings vary on difficulty and time it takes to produce. But current data suggest that the capacity is limited somewhere around 45-50 batches.

Currently the planning considers the weekly volume as the prioritised parameter when creating the plans. But the reality is that the different products vary in production time and the
efforts needed to create them. The volume parameter alone does not consider the variations in
development time, and difference in difficulty.
Creating the plan with information on top of their head about production time, pre-batching
time, etc is possibly one of the reasons why the plan might fail.

The case company gave reasons to the inaccuracy of the plans: Sick leaves, treatment of sick
child, and equipment failure.

Overall the main issue with the accuracy of the plan is the lack of information when
developing the plan. The production time is estimation from the operators. The true
production time could differ from the estimate. Focusing on volume means that easier batches
should be devolved rather than difficult ones.

Having more accurate data on the planning sessions about production time in consideration to
filling and pre-batching as well as information about raw material delivers should increase the
accuracy of the plan.
7. Results

In this chapter the results from the analysis will be presented. Results from the model implementation at the case company and results on the analyzed empirical findings.

7.1 Model implementation

✓ The model was developed to be suitable to many different situations and different type of projects. The model should be able to handle larger or smaller projects with the purpose of improving the company. The model in this case was mainly used to determine problematic areas related to high variation at the case company. At the case company it was possible identify problematic areas by going through the steps of the model.

✓ Human factors have high influence on the variation on the process. For instance human mistakes and work routines affect the production times. Because of this it is important to involve the employees into the project. The benefit from having the employees in the project is that it creates higher awareness on what is actually going on in the process. They can assist finding the causes to the problems and, if it is necessary to make changes in work routines and processes it is important that the employees comply with the improvement work.

7.2 Case company results

✓ Continuous improvements
The case company have a program for continues improvements. Many of the workers are educated in improvement work and methods. And the systematic use of improvement projects is a proof that the employees’ projects are successful and contributes to the company’s development.

✓ Quality
Among the quality problems at p3 incorrectly charged, discolouration and incorrect density make up 45% of all the reported quality issues. These problems are related to work routines. The root cause to the quality issues at p3 is often linked together in a vicious cycle of problems. An example of this is when an employee dishes pots and fail to clean it properly. The employee that is using the pot later might miss to control the pot if it is clean or not which affects the batch. Overall the work routines related quality issues have a strong connection between controlling. The employees miss to control material, recipes, information etc which causes failures.
The production process is structured in such a way that the employees have to work on several batches at the same time. This cause problem when the communication is insufficient from management and between the employees.

✓ **Production Lead-times**

The lack of knowledge regarding production lead-times is a problem for the company. The company relies on the workers experience to make assumptions regarding time and resources. This causes variations in time for the processes, since the production lead-times just are estimations. The insufficient knowledge about production lead-times also affects the production planning and the creation of a weekly-plan with high accuracy.

✓ **Preparation time pre-batchers**

The time for preparation of weighing is 3.26 hours per day for pre-batching powder and 3.51 hours for pre-batching wet-material. By reducing the frequency or eliminating steps that makes up for this time would make the pre-batchers work more efficient. The current goal for the pre-batchers is to weigh material for the chargers. By increasing the actual time for weighing their output will increase as well. By decreasing time spent on searching for raw-material, forklifts, cans etc will decrease the variation in the process reaching a more stable process.

✓ **Issues**

There are currently many different issues affecting the production effectiveness negatively. By incorporating work routines and guidelines in the issue areas, many of the issues could be eliminated or decreased. All the issues are causing a more unreliable production process with higher variations. By attending the problems and eliminate or decreasing them it would be possible to achieve a more stable process. The main causes behind the different issues stated in this thesis are due to miscommunication, not enough information, work routines, and leadership.

✓ **Planning**

The weekly-plan accuracy is currently averaging at 81.45%. To be able to increase the accuracy of the plan, the people responsible for creating it should consider more parameters than volume and estimated times when developing the plan. The peak on 91.49 suggest that currently the weekly-plan is to optimistic and there is not reasonable to expect the plan to be kept. However the case company could provide better information.
9. Conclusions

*This chapter presents the conclusions for this study. It includes the answer to the problem formulation for this thesis and an evaluation of the developed model implemented in the case company to decrease production variations.*

9.1 Answer to problem formulation

✓ How to decrease the variation in quality, production time and work routines to achieve a cost-effective production?

To be able to solve the problem formulation in this thesis it is possible to incorporate the model developed in this thesis. By utilizing the model it is possible to get a solid foundation to be able to solve the problem. The model was created by incorporating ideas from different improvement theories and customized to be able to solve the problem formulation. By utilizing keys in the model it will be possible to involve the employees in the work solving the problem. By involving the employees in the improvement work it is possible to lower the change resistance if any would occur. The model will determine if the initial area of research is correct to solve the problem. The model will also help highlighting any weaknesses in the current process. The outcome of utilizing the model will help the organisation by also proving areas for future improvement work, to lower variations and stabilize processes which leads to a more cost effective production.

9.2 Critical review to the thesis

✓ The thesis does not contain the implementations of the last three steps, implementation, follow-up and standardize. This is due to the limitation in time.

✓ The thesis contains information that is not necessary to be able to solve the problem formulation, however the information gives knowledge and understanding of the case company.

✓ The model is maybe too generic and could have been more customized to suit a certain problem.

✓ The time measures contains around hundred measure points, to get a more accurate conclusion more measurements should been performed for a longer period of time.

✓ The implementation of the model at the case company did not experience any major problems. One objective with the model was that it should be easy to use, this objective was achieved. The steps were easy to follow during the project.

✓ The use of the different keys in the implementation provided an advantage. The possibility of using the keys on different steps meant that the work through the model was flexible.
Another advantage with the model is that it is general and suited the project for decreasing variations in a production process, even if the case company had a complex production process.

The possibility to start a new improvement project based on the suggestions, mean that companies can run projects in many different aspects.

The model suits Swedish companies where the involvement of the employees in the project requires good knowledge.

A disadvantage can be the free structure of the model. The user needs to obtain knowledge to be able to use tools and how to deal with the employees to run an effective project.

During the implementation it was noticed that the delegations of task required control and leadership from project leaders to be beneficial.
10. Recommendations

In this chapter the authors present recommendations and improvement suggestions to the case company, where Step 6 in the model is applied into this chapter.

10.1 Step 6 – Improvement suggestions

- **Find parameters to improve the planning accuracy and use more reliable information**
  The authors recommend the case company to start a new project with the aim to increase the accuracy of the weekly plan. The weekly plan suffers from being impossible to fully follow as it is now. Finding more suitable parameters and more reliant data to base the plan on could help in achieving a better plan. The complete planning process should be evaluated. By increasing the accuracy of the plan the benefits would also attend some of the issues in the report such as the priority list from the chargers. By creating more accurate plans the production would become more efficient.

- **Timer on sand mills**
  To decrease the chance of the batches running to long time in the sand mill a small investment could be to install a timer on the machines. By having a timer on the machines it would be easier for the employees keeping track on how long time the batch been running. The aim is to prevent the batches from running to long since the discoloration problem should be considered a worse problem than the batch running to short. A batch that has run to long needs more additional work while a batch that has run to short will only need to run longer in the machine.

- **Standardize work routines**
  All employees should work the same way when performing their task. For instance as it is right now there are different procedures about where the pre batchers are supposed to leave finished recipes at p3. There is also a difference when the chargers deliver recipes to the pre batchers if they should mark them or not. The unclear routines in these areas and others are a source to confusion and cause of delays in the production. The authors recommend the case company to create a new project with the aim to improve work routines.

- **Decrease preparing work for pre-batchers**
  If it was possible to eliminate, decrease or speed up the preparing work for the pre-batchers would give the pre-batchers more time to weigh. Current measurements indicate that a large portion of the pre batchers time is spent doing other tasks than actually weighing. The authors recommend the case company to create a new project with the aim to increase the time weighing for pre-batchers.
**Increase raw material information accuracy**

The authors recommend the case company to start a new project with the aim of increasing the accuracy of the warehouse information. Increasing the accuracy of the warehouse would benefit the case company by decreasing the delays in the production caused by this. For instance the time looking for material and being able to re-order before running out of stock.

10.2 Future work

✔️ It would be interesting to implement the model into another company in a different branch. Since the understanding of the complexity for manufacturing coatings, it would also be interesting to use the model where the company have smaller amount of products where variations is easier to compare. While the model was developed one of the objectives was to make it applicable in different branches and to be independent of the company size.

✔️ Complete the model, and implement the last 3 steps not implemented in this case. The implementation of the improvement suggestions, the follow-up and the standardization would benefit if they are implemented by the project owners.

✔️ Implement the model with a less wide scope. Making the scope narrower will give the benefit to stay on track and the model may be more effective. By also having a smaller scope it would be easier to reach a successful result.

✔️ Upgrade the model. This first version needs some more tests to proof the reliability and the generalization of it. If companies strive for continuous improvements the model must also be able to update. Version 1.1 could be developed through more tests and later evaluations.
11. Discussion

In this chapter the authors discuss topics related to the thesis. The implementation of the last 3 steps of the model is also discussed, how the steps can be implemented at a company. This is discussed since the last 3 steps could not be implemented due to the scope and limitations for the project. The authors also present possible expected outcomes from a fully implemented model.

Since the authors could not implement the last 3 steps of the model into the case company for this project these 3 steps was moved to the discussion chapter.

Step 6 - Implement the improvement suggestions

The authors’ improvement suggestions and recommendation to the case company is submitted to the company and the project sponsor, it is now up to the company to implement these suggestions concluded. As early as in stage 1 in the planning of this project it was determined that the case company would take ownership of the improvement suggestions in the end.

If this step had been tested by the authors at the case company the improvements had would be implemented carefully from a plan. The plan would be to actively work to get workers engaged and participating in the improvements. Because it is their work and routines that are affected, it is important that they are the first to benefit from how to implement the various actions, collaboration between those involved in the project and the department concerned would be important for the implementation success.

Step 7 - Follow-up what you have implemented, how is it going?

If the case company implement the recommendations it is up to them to follow-up. The authors have provided the case company with data and expected benefits/outcomes with the project.

In the follow-up step the implemented improvements needs to be evaluated. This could be done with calculations for costs or production effectiveness. It is possible with measures to check the baselines and compare the actual variations from before and after the implementations. The authors’ easiest tip for project follow-up is to use the employees for feedback on the implementations and listen to their thoughts and ideas regarding it. Is there some problems with the implemented improvements and for example the new work-routines the best way to solve it is to have a good communication. If the employees think the process have been improved and the projects aims are achieved the implementations are probably successful.

Step 8 - Standardize if the suggested improvements is successful

If the case company decides to complete the authors’ model test, the standardization can be done after the follow-up. If the implementations of the improvement suggestions are successful the case company can apply these on the whole company.
Possible outcomes for a fully implemented model for this type of project:

- Higher planning accuracy
- Increased employee motivation
- Improved employee satisfaction
- Improved production flow
- Improved teamwork
- Improved work-routines
- Improved quality [less rework, customer rejects, problem batches, double-batches]
- Openness for change resistance
- Shorter lead-times
- Balanced process sub-optimization
- Minimized risk for variation in production time
- Less fire-fighting
- Less human waste [energy, information, internal education]
- Less owned working capital

- A more cost-effective production
- Increased customer satisfaction
References

Literature:


Scientific journals:


Saari S, [2006] Productivity - Theory and Measurement in business , European productivity Conference, Satakunta University, Finland


Internet sources:


Pictures:


Flowchart symbols: http://www.smartdraw.com/specials/images/examples/flowchart-symbols.gif
[accessed 2012-04-18, 15.30]

Ishikawa diagram: http://philosophy.hku.hk/think/graphics/fishbone-general.gif
[accessed 2012-05-3, 08.30]
APPENDIX 1
Organization schedule – supply International AB
## APPENDIX 2

### Flowchart planning

<table>
<thead>
<tr>
<th>PLANNING</th>
<th>CHARGING</th>
<th>DEMAND</th>
<th>ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production suggestions and action messages</td>
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<td></td>
<td>Failure in forecast</td>
</tr>
<tr>
<td>Collect material for the weekly plan</td>
<td>Creates a detail plan</td>
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<td>Priorities products on the planning material for the weekly plan</td>
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<td>Safety stock and product class</td>
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<tr>
<td>OK?</td>
<td>Contact charging</td>
<td>Customer order demand and COS</td>
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</tr>
<tr>
<td>Input data in MFG-pro on work orders</td>
<td>Updated weekly plan</td>
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<td>Business system not updated</td>
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<tr>
<td>Creates filling order</td>
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<td>Print recepies two before production start</td>
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<td>Issue recepie, check rawmaterial</td>
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<td>Informs charging &amp; chargmanager</td>
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<td>Leaves requested recepies to charging</td>
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<td>Contact demand</td>
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<td>Long deliverytime?</td>
<td>Keep planning</td>
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- Failure in forecast
- Business system not updated
- Not clear exactly on different planning stages
# APPENDIX 3

## Measurements

### Powder:

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<th>Time</th>
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<th>EPA142 (two at the same time)</th>
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**Total time / batches:** 3.35h / 7b

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| EPA142 X2       | 15 |
| EVA056          | 13 |
| SYA076          | 23 |
| EDA ELLER EPA 142 | 5 |
| EGA870          | 25 |
| EGA153          | 10 |
| SYA160          | 40 |
| QNA056          | 35 |
| PHA100, PHA140  | 22 |
| **Total time / batches:** | **4.67h / 16b** |

| FWA221          | 58 |
| SYA076          | 60 |
| HFA060          | 15 |
| EPA142          | 20 |
| SYA100          | 15 |
| QGA100, PMA130  | 65 |
| **Total time / batches:** | **3.72h / 7b** |

| HFA409          | 13 |
| EPA142          | 10 |
| SYA076          | 41 |
| PHA100, EGA236  | 12 |
| HTA097          | 18 |
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APPENDIX 4
Brainstorm agenda / Analysis list of issues

**Brainstorming session 1.0**
**AGENDA:**

1. **The weekly plans just hit 80% and 7 batches per week on average gets misses. Why?**

2. **Problems related to the plan?**

3. **Teamwork!**

4. **Work routines?**

5. **Free to speak!**

**Issue analysis pre-batching**

1. **Not enough space in p3**
   The area for storage in p3 is quite small. When there is a lot of material waiting to get used for production the problems arise. When the area is full the workers can choose to either stack the material or either place it somewhere else. Both actions require communication between the staff to not cause problems. The problem is also caused when there are changes in the priority list. If the pre-batcher already finished weighing material he put the material in this area causing it to fill up.

2. **Missing or incorrect priority list**
   The problem with changing the list is when time gets wasted preparing an order that is not going to be created until later. The problem can be caused by an incorrectly weekly plan or incorrect information about the stock of raw material. One of the effects of changing the priority list one to short notice is that the pre-batchers might not have the time to weight the desired material. If this is the case the chargers are forced to help out weighting the material them self instead of producing.

3. **Two locations for returning recipes**
   By having two locations to return the recipes it can cause confusion about what has been done or not. The problem can cause delays in the production.

4. **Incorrect information about the in house-stock**
   There are several different potential causes to why the information about the in-house stock is inaccurate. The incorrect information can cause delays in the production. Not
only is the waiting time on the order causing a delay. All the time spent searching for the material could have been used for other orders.

5. **Similar raw-material**
The similarities between the raw-material cause the employees to use the wrong material when they believe that they picked the correct material. This can cause failure on products, raw material shortage and rework.

6. **No high-lift forklifts available**
The waiting and searching time for special forklifts take makes their workdays less effective from a company perspective. If they get a hold of a high lifting forklift instantly it will speed up their work.

7. **Uneven work flow caused by missing raw material**
There are many different kinds of raw material needed to able to produce all the different products. Because of the great amount of raw material that is needed for all the products it is hard to have everything in stock all the time. The uneven workflow is caused by the delay in ordering and delivery of raw-material. Making it so that the pre-batchers have less to do when they waiting, on raw material deliveries. When the material arrives they have more to do because they have to catch up the time wasted when waiting.

**Issue analysis charging**

1. **Raw material shortage**
When there is a raw material shortage for products that has been planned, it causes delays in the production. It also makes the chargers work with priority list harder. They may have to change the list on short notice if they just found out material is missing or that a delivery just arrived.

2. **Priority list**
The priority list is supposed to be created one day in advanced. But sometimes the list is not finished our not created at all. There are reasons why the list is incomplete, mainly it depends on lack of information, for instance about raw material, when it is going to be delivered. The problem with creating a priority list has connections with the weekly plan inaccuracy. This problem causes delays in the production and a risk of using resources for less prioritized objects.

3. **Different procedures regarding recipes for pre batchers**
The process on who marks the recipe is not clear and is related to what the pre-batchers prefer on an individual level. If they prefer not having the recipes marked by the chargers, then the chargers do not mark. But the standard procedure is to mark the recipes. It can cause delays in the production because of miscommunication and not knowing what has or hasn't been done.

4. **Clean pots**
Clean pots are vital to keep the production running smoothly. Unplanned cleaning leads to delays for either the filling department or the chargers. The delay is the waiting time it takes to get a clean pot. One person has to stop whatever they were doing to clean pots. Taking staff from either the chargers or the fillers makes it harder to keep up to schedule

5. **Staff shortage**
   Many of the employees in p3 have young children that then need to be home and take care of when they are sick. The weekly plan is made so that all the staff has to be there to have a chance of completing it. Any unplanned leaves results in orders have to be moved over to upcoming week.

6. **Control raw material**
   The problem is caused by the employees not double checking the material. When the problem occurs it leads to faulty bathes that has to be reworked.

7. **Discolouration in sand mill**
   The product has to run a specific time in the sand mill. Too long or to short time in the sand mill causes problems. If the products run to long in the sand mill it will cause a darker colour on the product If the Staff is working with many batches at the same time the chance for the batch to run longer than it should increases.

8. **Control**
   It is possible to forget or miss to control the viscosity pressure workflow. This can lead to rework and longer development time for the batch.

9. **Cover**
   Some of the products need a special protection layer at the top for various reasons. Forgetting or miss to put on the cover is down to the routines of the workers. Forgetting can cause a delay on the finish date and/or cause rework.

10. **Mark recipes**
    When a batch is complete the employee that created the batch should mark the recipe and send the recipe to the lab for testing of the batch. If the recipe is not marked the lab do not test the batch. Instead they will assume it is not ready for testing, causing a delay on the order.

11. **Adjust**
    When lab requires additional adjustment on the batches it means that the batch doesn't meet required quality. The chargers get the information about what needs to be performed from lab. If they are busy in the production they can prolong the time it takes for them to attend the batch to complete it. The batch will then be using up space and delaying the finished date until they have the time to correct it.