

Maximizing flexibility through minimizing changeover time

HEINEKEN brewery Zoeterwoude

N.W. Schreuder

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Graduation Committee University of Twente:

Dr. P.C. Schuur
Dr. ir. S. Hoekstra

Supervisors Heineken:

MSc. Inge Schrama
MSc. Arjen van Diepen



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Author:
Niek Schreuder
Master student Industrial Engineering & Management
Track: Production, Logistics and Management

Supervisors Heineken
MSc. Inge Schrama
MSc. Arjen van Diepen

Graduation Committee University of Twente
Dr. P.C. Schuur
Dr. ir. S. Hoekstra



TY
GER BEER

MARK

BECK'S

COAILLE D.L.M. PARIS 1875
GRAND PRIX PARIS 1889

Management summary

As there is a declining trend in the beer market, Heineken Nederland Supply (HNS) needs to increase the innovation rate. Many markets introduce new pack types, designs, label changes etc. This results in a growing number of changeovers on the packaging lines.

Research proposal

To minimize the impact of the increasing trend of changeovers, the flexibility of the lines must increase. Therefore the management of Heineken Zoeterwoude asked for an investigation of the flexibility on the lines. In order to execute a successful research we focused this investigation to the 'One way bottle lines'.

In this report there is a distinction between the production and planning perspective. From the planning perspective the focus is on the reliability of the plan, and a reduction of the frequency of the changeovers. From the production perspective, the improvement of the quality and the decrease of the duration of the changeovers have been investigated.

"The objective of this research is to analyze the planned down time losses generated by changeovers and to look for opportunities to minimize these losses. In addition, this research has to come up with a clear improvement for the losses due to changeovers."

The main question guiding this research is:

What improvements can be made in the execution and planning of the changeovers on the packaging lines to minimize their total duration and maximize their quality in order to reduce the total (planned) downtime?

To answer the main research question above, this research comes up with a masterplan to improve the flexibility of the lines, clearly motivated by a structured analysis and research of the changeovers.

Research method

After an extended analysis of the current situation the factors that influence the changeovers are defined. Based on the stakeholders and literature these factors are prioritized. To enhance the relevant factors, a structured masterplan is developed based on the TPM philosophy and other literature.

Conclusions

Challenges

- 1) Over the year 2013 the available production time is affected by the changeovers with 5%. Over a period of one year this means more than 3600 hours. One hour downtime costed (on average) 250 euro. This means that the changeover costs are almost one million euro per year;
- 2) The check of the planning parameters of the changeovers isn't performed on a regular basis. Therefore there is haziness around the real impact of the changeovers;
- 3) The execution of the changeovers isn't checked on a regular basis. Therefore, the current performance of the execution of changeovers is unclear and improvements are difficult to realize.
- 4) The data registration is not reliable at the moment. Therefore the real duration of the changeovers is hard to get;
- 5) Over a period of six months (last part 2013 and beginning 2014) the label switch has the highest impact on the total changeover time. There are no clear standards, however, for the execution of a label switch;
- 6) There are seven variables which give a measure for the quality of the changeover. At the moment they are not reliable enough to give a good measure of the performance;

Improvements

- 7) The different types of changeovers and switches are most clearly described by a serial number of six numbers where each of these numbers gives an indication about the location(s) of the switch or changeover;

- 8) Based on their relevance and current state the relevant factors founded in the literature are analyzed on their relevance for Heineken. These relevant can be improved by the following main interventions; Standards, training and clear responsibilities for every stakeholder.

Recommendations

Long term

- 1) Develop a continual improvement by performing the 4 steps of the PDCA circle as follows

Plan: Defining masterplan

(june 2014)

- a. Answer research questions
- b. Fill in masterplan Planned Downtime-Pillar (TPM)
- c. Ask all stakeholders to be a part of the Pillar
- d. Explain and check the check the masterplan together with stakeholders

Do: Give priorities to Masterplan and divide them over stakeholders (june 2014)

- a. Priorities brewery and stakeholders
- b. Focus with the implementation

Check: Meetings PD-Pillar

(september-december 2014)

- a. Communicate together about the developments.
- b. Clear problem and targets

Act: Re-define priorities and set new deadlines for the masterplan (december 2014)

Short term

- 2) *Team-leader rayon 2:* In order to get more reliable data an organized report for the SMED-operator should be developed where the performance of the switches and changeovers can be discussed in the weekly meeting with special attention to data registration.
- 3) *Rayon-manager rayon 3:* In order to reduce the impact of the switches standards should be developed for every workplace;
- 4) *Team-leader rayon 5:* To restore the SMED-system in the right condition the organization over the line and the evaluation of the performance of the changeover must be define by the documents and training of the SMED system;
- 5) *Senior scheduler & Analyst tactical planning:* In order to produce a reliable planning for production the planners has to use reliable planning parameters. Therefore planning has to develop a standard to check the difference between their planning and the realization of the planning on a regular basis;
- 6) *TPM-facilitator:* To use the right standards and reintroduce the SMED system, the training material and documentation of SMED has to be updated and structured;
- 7) *Planned Downtime pillar leader:* For further development and future World Class Performance, it is important to visit some other companies and breweries who are dealing with the same (increasing) trend of changeovers;
- 8) *Production specialist:* As a part of the changeover the washing part is not optimal at the moment. The parameters of the washing procedure have to be redefined to save time.

General

- 9) Collaboration between planning and production is essential for the success of the Planned Down pillar. Therefore it is important to work, as Planned Down pillar, together with the Plan pillar.
- 10) Changes on the information system of production (MES 2.0) are implemented very slowly because of a shortage of industrial engineers. This is an important cause of the rigid way of production department.

Glossary

Abbreviation	Description
Colonne	Line
CS&C	Customer Service & Control
CS&L	Customer Service & Logistics
DCS	Daily control system
DFC	Design For Changeover
DFM	Design For Maintenance
DFQ	Design For Quality
DMADV	Define Measure Analysis Improve Verify
DMIAC	Define Measure Analysis Improve Control
FI	Focused Improvement
FTE	Full Time Employee
HNS	Heineken Nederland Supply
(K)PI	(Key) Performance Indicator
OEE	Overall Equipment Effectiveness
OPI	Operational Performance Indicator
OPI-NoNa	Time of 'good product' output (based on maximum speed) as percentage of 'effective working time'.
OTIF	On Time in Full
PDCA	Plan do check act
Pillar	The TPM methodology is divided in several pillars which consists out of a multidisciplinary team which has its own focus on improvements
PM	Preventive Maintenance
Rayon	A rayon is part of the packaging department at the Zoeterwoude brewery which contains one or more lines
RCM	Reliability Centred Maintenance
Shift	Employees of the brewery are working in shifts of 8 hours starting at 7 AM, 3 PM or 11 PM.
SMED	Single Minute Exchange of Dies
TPM	Total Productive Maintenance
TQC	Total Quality Control
TQM	Total Quality Control
ZW	Zoeterwoude

Preface

This report is the indisputable evidence of my executed research at the Heineken brewery in Zoeterwoude in order to fulfil my master degree of Industrial Engineering and Management with the specialization track 'Production, Logistics and Management'.

First of all, I want to thank all the people at Heineken who supported me with their cooperation, providing me with useful information. It was nice to experience the general willingness to help and the enthusiasm about their craft. Special thanks to my two supervisors from Heineken, Inge Schrama and Arjen van Diepen who gave me the freedom and opportunity to investigate my own findings and develop a suitable assignment. Furthermore, I want to thank my supervisors of the University of Twente, Peter Schuur and Sipke Hoekstra. They provided me with useful feedback being flexible and critical at the same time.

Of course I want to thank my family for their support during my whole study. Special thanks to Simone who trusted in me and give me the spirit to work hard.

Last and most important of all, I want to thank God Who gave me the strength each day for what I had to do. *"I will lift up mine eyes unto the hills, from whence cometh my help. My help cometh from the LORD, which made heaven and earth."* (Psalms 121 verse 1,2)

Niek Schreuder
June 2014



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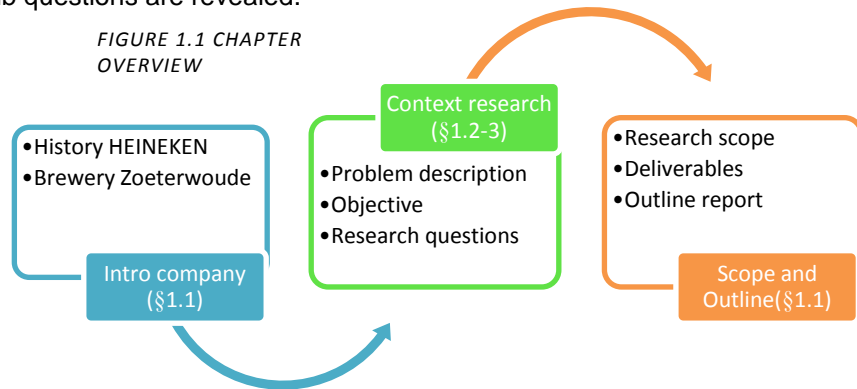
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Chapter 1: Research proposal

This chapter contains the research proposal for a master thesis of the master Industrial Engineering and Management at the University Twente. The main subject of this research is about changeovers at the Heineken Company in Zoeterwoude.

The chapter starts with a short introduction of HEINEKEN (§1.1). In §1.2 the research topic is described with a short problem description and the main objective of the research. In §1.3 the main research question and the sub questions are revealed.

Next, the scope for this research is defined in §1.4 and §1.5 gives the deliverables of this thesis. The last section contain the outline for this research with the research design (§1.6).



1.1 History and facts Heineken

Heineken is one of the leading companies in the brewery industry worldwide. They have an annual turnover of more than 18 billion euros and employ 76.191 people of which 4.053 FTE's are working in the Netherlands. The rich history of Heineken dates back to 1864, the year when the company was founded. In 1928 Heineken started to become a truly international player, starting with export to Asia in 1929 and to the United States in 1933. In the past 15 years numerous mergers and acquisition changed the brewery landscape significantly, resulting in an increase in market share for the 4 main global players from 22% in 2000 to 41% in 2012. The most recent major acquisition was in 2012, when Heineken acquired APB (Asian Pacific Breweries). Today, Heineken has 165 breweries worldwide, serving customers in no less than 178 countries.

Besides Heineken, the world's leading brand in the International Premium Segment (IPS), the company offers an extensive range of products comprising approximately 250 brands (some examples in figure 1.2), including various beers, cider and other beverages. The export of Heineken beer almost a century ago created a solid foundation for becoming a strong international brand. In addition, Heineken has many global marketing campaigns that maintain its global and premium image and to outperform its competitors. This is why Heineken is by far the beer with the highest export volume throughout the world, accounting for 29.1 million HL.

Brewery Zoeterwoude

More than 10 million hectoliters of beer is brewed within the Netherlands to be transported over the globe. In total, this is about 7% of the HEINEKEN beer volume worldwide.

The beer is brewed and packed in three breweries in Zoeterwoude, Den Bosch and Wijkre and then transported to the customer by different means of transport. The breweries produce the Heineken brands in all kinds of packing types and for all kinds of markets. Heineken Nederland Supply exports to more than 150 countries worldwide.

FIGURE 1.2 SOME OF THE BRANDS OF HEINEKEN



The brewery at Zoeterwoude is divided into five divisions: brewing, packaging, technical service, service business technology and Safety, Environment & Health. The organization of the brewery is displayed in figure 1.3.

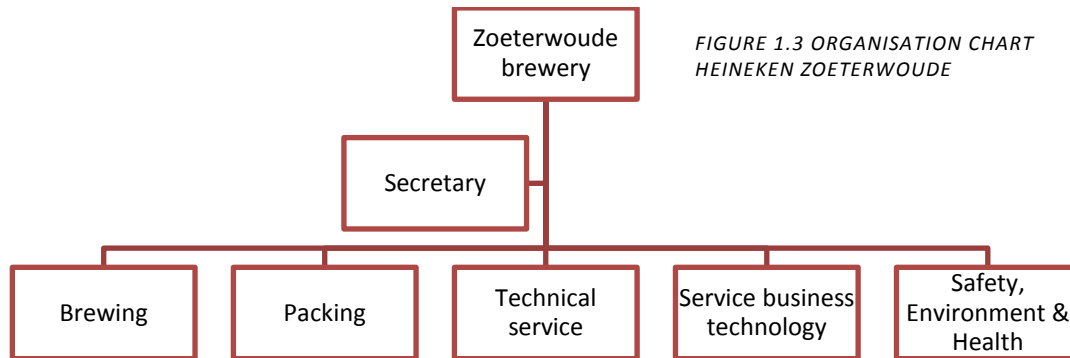


FIGURE 1.3 ORGANISATION CHART
HEINEKEN ZOETERWOUDE

1.2 Research topic

Because of the declining trend in the beer market HEINEKEN needs to increase the innovation rate. Many markets introduce new pack types, designs, label changes etc. This results in an increase in the number of changeovers on the packaging lines.

“The increase of changeovers has a negative impact on the production capacity.”

To minimize the impact of this increasing trend of changeovers a thorough research is needed. This can be done from two perspectives. In this report the distinction will be made between a production and planning perspective. Figure 1.4 visualizes the two different perspectives

The planning perspective looks to the planning point of view and focuses on the reduction of the frequency of the changeovers. The production perspective looks from the production point of view and focuses on the improvement of the quality and the decrease of the duration of the changeovers. Both perspectives will be included in the research project.

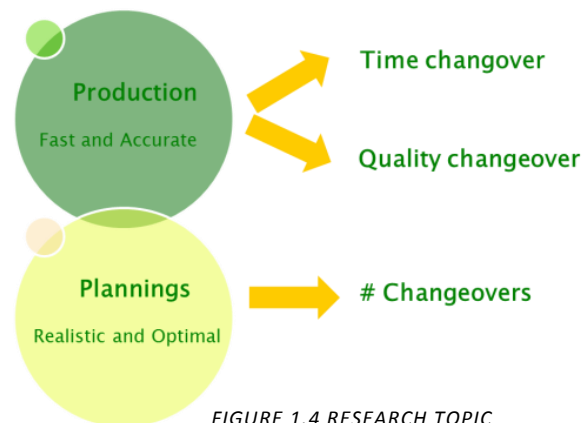


FIGURE 1.4 RESEARCH TOPIC

“The objective of this research is to analyze the planned down time losses generated by changeovers and to look for opportunities to minimize these losses. In addition, this research has to come up with a clear improvement for the losses due to changeovers.”

Figure 1.5 gives a visual explanation of the trend in Heineken Zoeterwoude. The increasing complexity and number of New Product Innovations (NPI's) require a higher level of flexibility which means more changeovers.

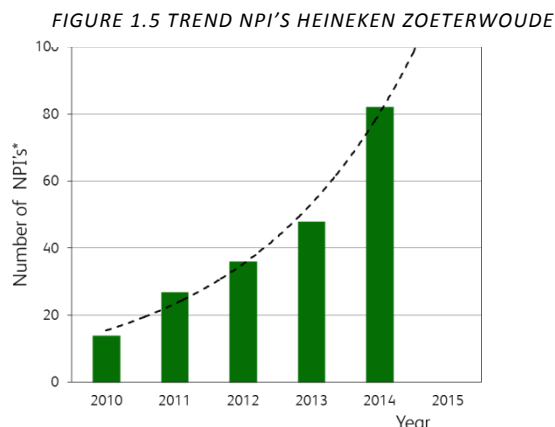


FIGURE 1.5 TREND NPI'S HEINEKEN ZOETERWOUDE

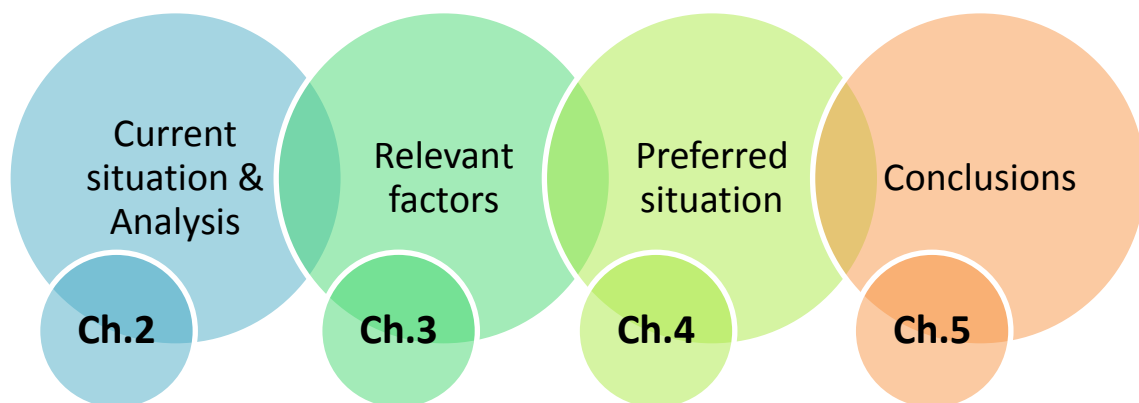
1.3 Research questions

The main question guiding this research is:

What improvements can be made in the execution and planning of the changeovers on the packaging lines to minimize their total duration and maximize their quality in order to reduce the total (planned) downtime?

There are several different stages to answer the main research question, visualized in figure 1.6. First of all the packaging lines are described shortly. Then the data is analyzed to get a clear view of the current down time. After the current situation is clear the factors that can judge the current situation are defined and used to judge the current situation and make a current performance. After that this research will give some the possible improvements.

FIGURE 1.6 STAGES RESEARCH



In order to answer the main research question 10 sub-questions will be answered.

Current situation and analysis (Ch. 2):

1. What is the contribution of the changeover time to the total downtime?

Production

2. How are the packaging lines organized?
3. What are the different types of changeovers?
4. What is the frequency and duration of the changeovers on the packaging lines?
5. How is the quality of the changeovers on the packaging lines measured?

Planning

6. How is the current planning system organized?

Relevant factors/variables (Ch. 3):

7. Which factors affect the impact of the changeovers on the throughput of the packaging lines?
8. Which factors affect the total planned changeover time?

Literature study

9. Which factors affect the impact of the changeovers based on the literature?

Preferred situation (Ch. 4):

10. Which improvements are most relevant and applicable for Heineken?
11. Which interventions improve the factors in order to decrease the impact of the changeovers on the throughput of the packaging lines?
12. Which steps have to be taken to achieve a world class level changeover performance

1.4 Scope

Changeover time

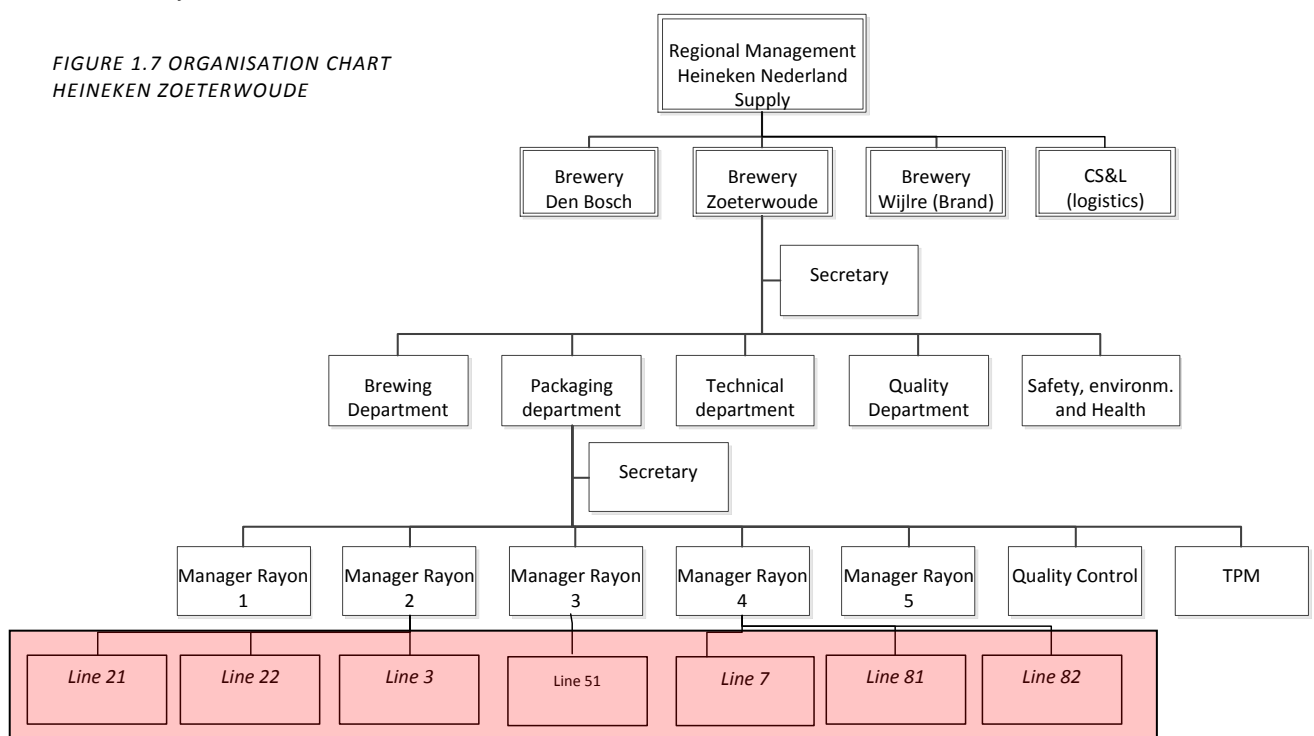
Because of the declining trend in the beer market HEINEKEN needs to increase the innovation rate. Therefore, in many markets they are introducing new packaging types, designs, label changes etc. more often. This results in an increase in the number of changeovers on the packaging lines and a decreasing length of the runs.

This research focuses on the impact of the changeovers on the planning and on the production lines.

One way bottle lines

To limit the size of this investigation this research will only focus on the 'One way bottle lines' in Zoeterwoude. A 'One way bottle line' is a line that produces bottles for the export markets. They call it a 'one way line' because the empty bottles don't come back. Since these export markets were always quite constant, the batch sizes on these lines were very long. The new development of new introductions and changes to these products are a big change for these lines. Figure 1.7 shows the seven one way bottle lines.

FIGURE 1.7 ORGANISATION CHART
HEINEKEN ZOETERWOUDE



1.5 Deliverables

The purpose of this research is to analyze the planned down time losses generated by changeovers and to look for opportunities for improvement. In addition, this research has to come up with a clear improvement for the losses due to changeovers.

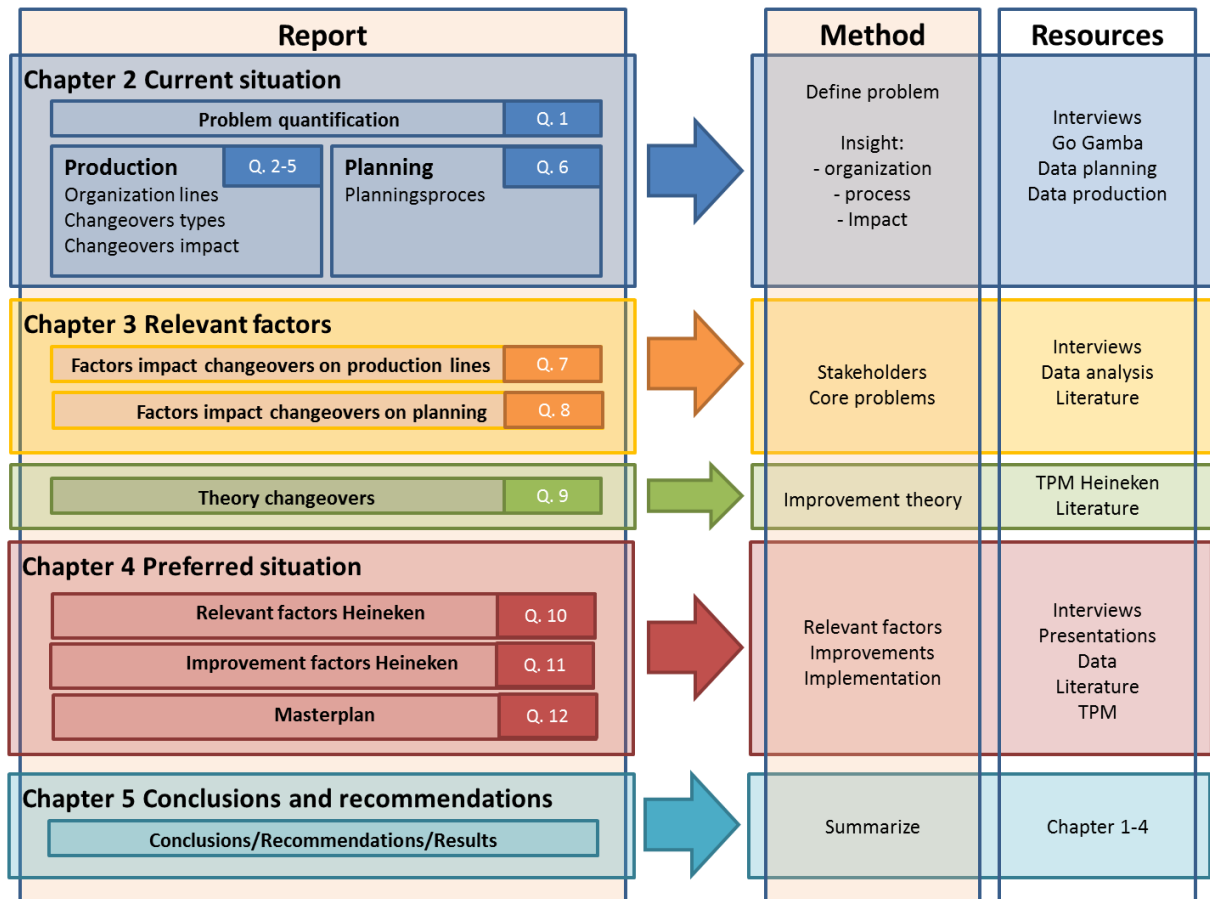
The deliverables will therefore include:

1. Research on the planned downtime of production lines
2. Analysis of the number of changeovers, the duration, the frequency, the complexity and the startup curve after the changeover to define the priority workplaces to start improving
3. Proposal with solution directions and key findings to reduce the planned down time
4. Implementation and developing of a masterplan 'planned downtime'

1.6 Outline report

Figure 1.8 shows the outline of this research with the different chapters and questions which are answered in these chapters. Furthermore the method and used resources are mentioned in the right part of the figure.

FIGURE 1.8 RESEARCH FRAMEWORK

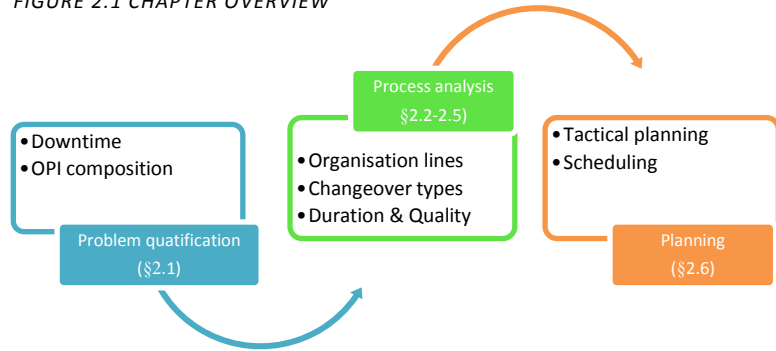


Chapter 2: Current situation

In order to get some insight in the problems and possible improvements for the changeovers this chapter explains the current situation at the Heineken Company in Zoeterwoude. It begins with a problem quantification to get some insight in the impact of the subject. After that a process analysis is done to understand of the process and get more detailed insight about the changeovers. Furthermore the planning process is explained. In this chapter the answer is given to the first six sub-questions.

In the first section (§2.1) the main causes of downtime and their contribution to the total downtime are given. In §2.2 the organization of the lines is shortly described. In §2.3 the different types of changeover are described. In §2.4 the frequency and the duration of the different changeovers are analyzed. In §2.5 the quality of a changeover is described. Section 2.6 gives insight in the current planning system.

FIGURE 2.1 CHAPTER OVERVIEW



2.7 Conclusion chapter 2

This chapter has explained the current situation of the Heineken Company in Zoeterwoude with respect to planning and execution of the changeovers on the one way bottle lines.

Problem quantification

The planned downtime is 9% of the total time available (manned time). Changeovers are part of this planned downtime with a total of 5%. This means that yearly 3600 hours is spend on changeovers over the one way bottle lines in Zoeterwoude and Den Bosch. One hour downtime cost (on average) 250 euro which gives an approximate total costs of almost one million euro per year.

- Downtime
- OPI composition

Problem quantification
(§2.1)

Process analysis

Based on activities on the different machines on the lines and the different types of products we conclude that the 21, 22, 03 and 07 are the 'changeover-lines'. In general they have the most changeovers.

Process analysis
§2.2-2.5)

- Organisation lines
- Changeover types
- Duration & Quality

The different changeovers are divided by code with 7 binary numbers which give insight in the type of changeovers. Based on this code the frequency and duration of the different changeovers is analyzed. The label switch and the label switch in combination with a carton change are the two changeovers with the highest frequency.

Because the realization of the time needed for the changeover is hard to get we take average of the planned times as an approximation for the duration of the changeovers. With these approximation we calculated the total changeover time per changeover type. We conclude that the label switch is also the changeover type with the highest total changeover time.

The quality of the changeovers is measured by 7 variables. Unfortunately it is hard to measure their current performance because the data is not reliable. At the moment the most common way to measure the quality of the changeover is the number of short stops per hour. On line 3 this is measured per hour by the operators for 10 hours after the changeovers.

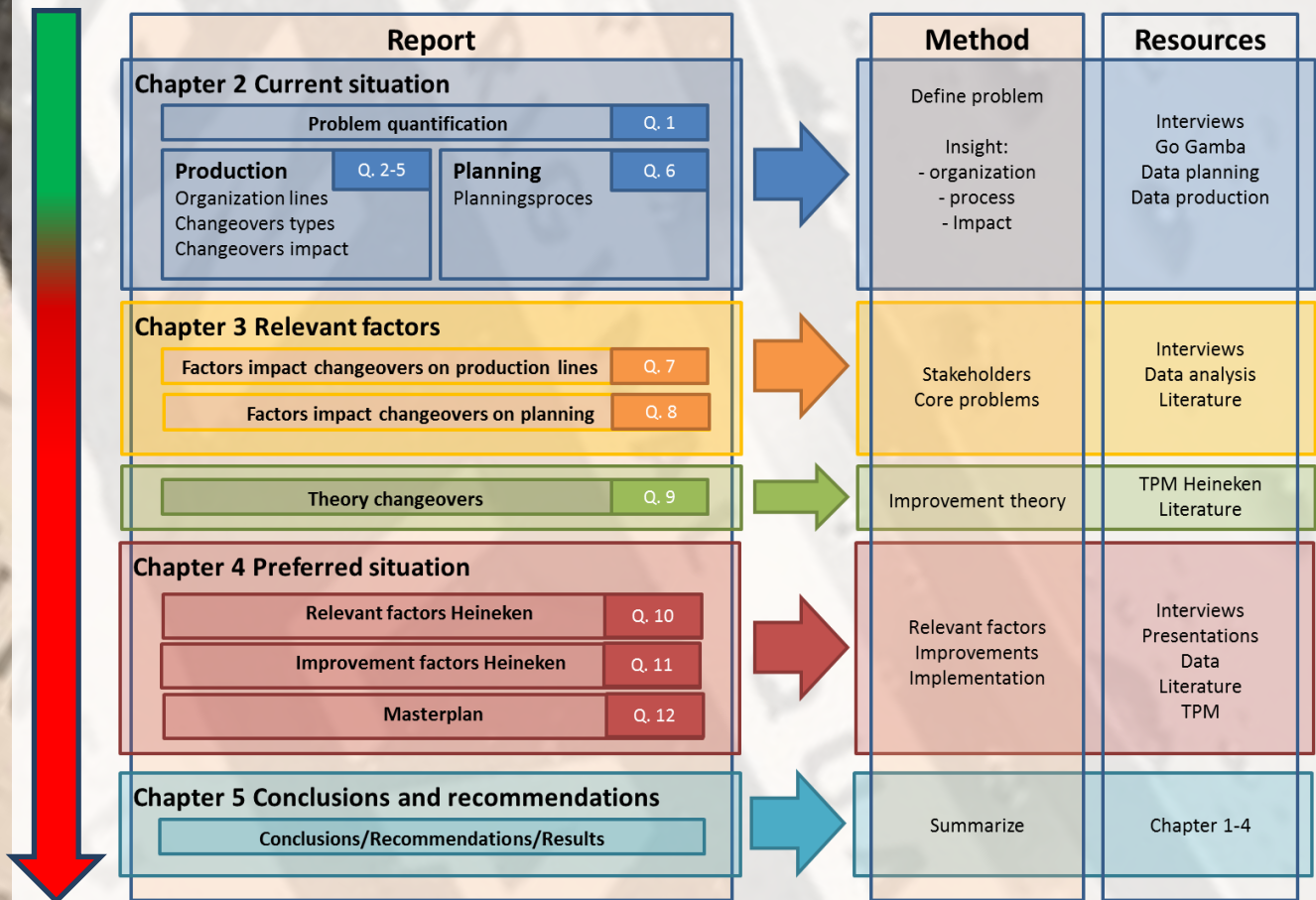
Planning

Tactical planning calculates the production time on basis of global averages of the total planned downtime and changeover-time and several other values. They discuss these planning parameter with the rayon-managers of production. Based on these parameters and forecasting they make a plan for the coming 13 weeks. On Tuesday, when tactical planning has calculated the production, they fill the software program of scheduling 'AS' and give it to scheduling.

- Tactical planning
- Scheduling

Planning
(§2.6)

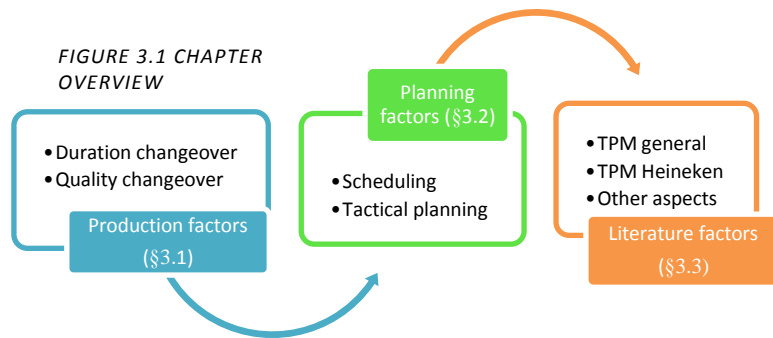
Since tactical planning uses a global standard planning sequence over 2 weeks (based on the bottle/beer/packing type), in that last week the scheduling department take care of the sequences, materials and transport of the products. The scheduling department make use of a changeover matrix and changeover rules to plan the times needed for the changeovers. It is remarkable that the check of the values in the changeover matrix and the changeover rules isn't performed on a regular basis.



Chapter 3: Relevant factors

This chapter explains the relevant factors with respect to the changeovers. Answer is given to the two sub-questions about the factors.

First of all the factors which have an impact on the throughput of the packaging lines are defined (§3.1). The second section gives insight in the factors which influence the planning of the changeovers (§3.2). The last section gives insight in the factors which influence the changeovers based on the literature (§3.3).

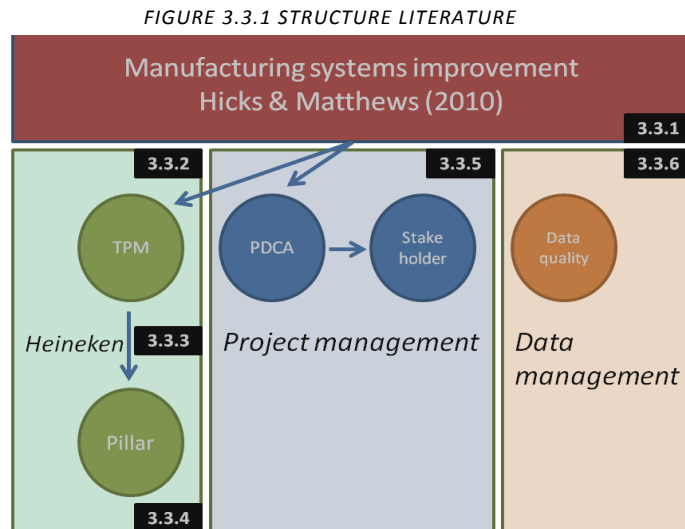


3.3 Which factors affect the impact of the changeovers based on the literature?

First of all an overview is given of the improvement systems of manufacturing. Secondly the improvement method TPM is discussed in general and the usage of TPM inside Heineken is explained. Furthermore several other subjects are researched on their impact on the changeovers.

Figure 3.3.1 gives an overview of these different subjects. From the manufacturing systems improvement of Hicks and Matthews (2010) TPM and PDCA are further explained. Also the usage of TPM at Heineken is discussed.

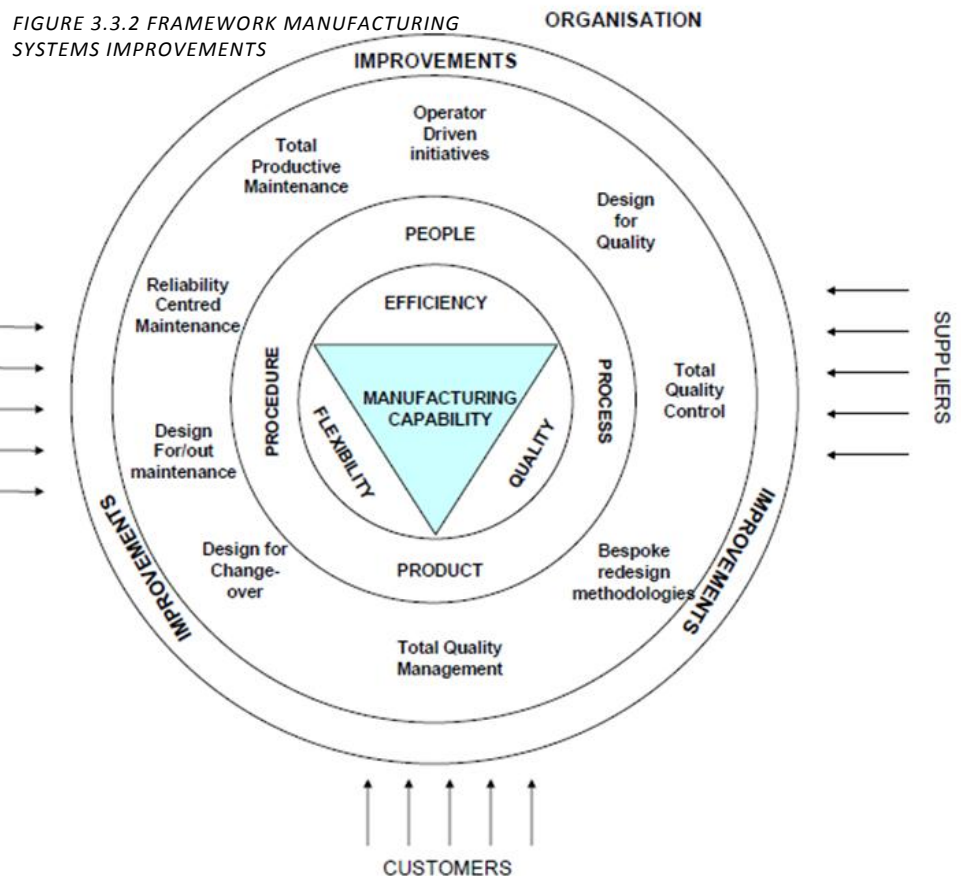
Furthermore we found some literature interesting because of their practical usage during the execution of this research. This literature has to do with project management and data management.



3.3.1 Improvement systems manufacturing

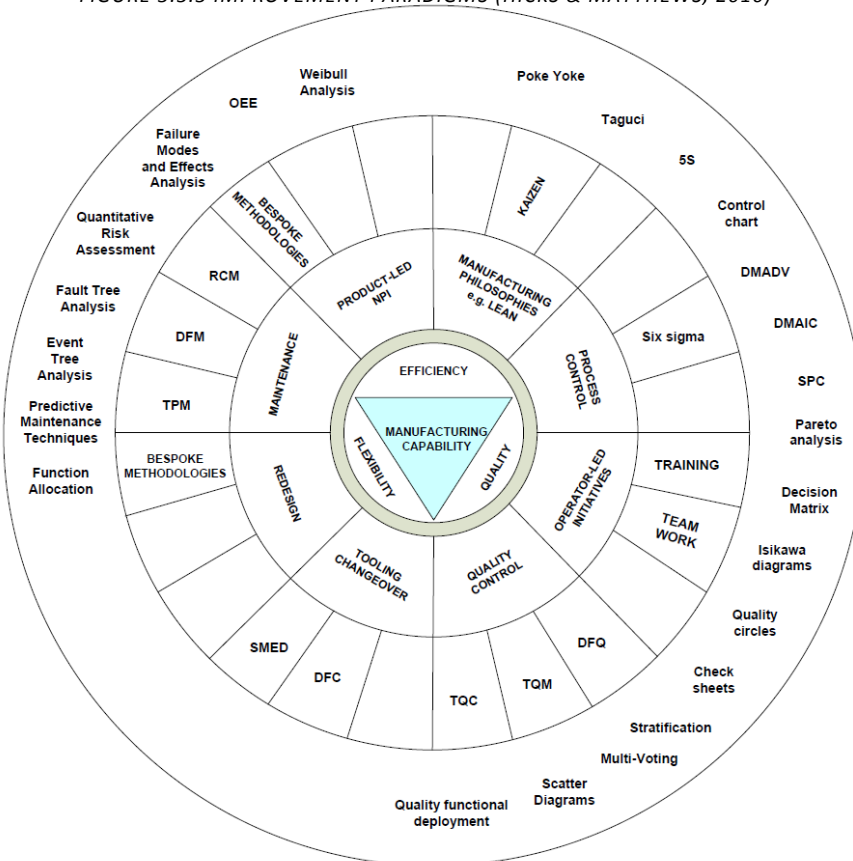
In order to get an overview of the paradigms for manufacturing systems improvement we use the investigation of Hicks and Matthews (2010). These researchers researched the causes of failed implementations, using these different paradigms. For this investigation they used a framework of methods and tools. This framework is based on all relevant earlier researches about manufacturing systems improvements.

Figure 3.3.2 shows the framework of manufacturing systems improvements (Ben J. Hicks & Matthews, 2010). This framework consists out of 5 layers with as core objective manufacturing capability. The first layer contains quality, efficiency and flexibility which are critical to achieve manufacturing capability. People, process, product and procedures form the second layer. These four elements are used to adapt, improve and evolve within the complex, changing business environment of today (Brian, 1991).



The third layer shows the complexity of manufacturing production systems and the variety of tools, methods and approaches to achieve manufacturing capability. The fifth and last layers represent the environment of an organization and consists of business environment, customers and suppliers.

FIGURE 3.3.3 IMPROVEMENT PARADIGMS (HICKS & MATTHEWS, 2010)



In addition to the theoretical framework in figure 3.3.3 Hicks and Matthews (2010) applied this framework to several improvement paradigms which they split into eight parts:

- 1) Process control
- 2) Operator led
- 3) Maintenance
- 4) Quality
- 5) Tooling design and changeover
- 6) Equipment redesign, modification and replacement
- 7) Product modification and new product introduction
- 8) Other.

Figure 3.3.3 has the same core and first layer as the theoretical framework. The eight paradigms stated above form the second layer. The third layer supplements the second layer with the accompanying methods and the fourth layer contains their corresponding tools. The eight paradigms are shortly described below.

1) Process control.

Because the levels of automation (of changeovers and machine setup) increase it is necessary to explicitly define parameters and setup rules. Although there are several successful examples of intelligent monitoring and controlling (Hou, Liu, & Lin, 2003; Landers, Liang, & Hecker, 2004; Murdock & Hayes-Roth, 1991; Uraikul, Chan, & Tontiwachwuthikul, 2000) it requires profound knowledge of the relationship (upstream and downstream) between product variation and process variation.

2) Operator-led.

Successful training of the staff is an important element to the effective manufacturing process. An effective training gives an in-depth understanding of the content to develop a common and shared understanding across all the trainees in order to generate the same intended learning outcome(s) (Adebanjo & Kehoe, 2001; Davis, Davis, & Van Wert, 1998).

3) Maintenance.

Especially in today's just-in-time production environment with the reduced stock levels, maintenance (corrective and preventive) is important (Eti et al. 2006). Design for Service (DfS), Total Productivity Maintenance (TPM) and Reliability Centered Maintenance (RCM) are some of the approaches for these types of maintenance. The use of this approach depends on the understanding of the function of the process, the influence of machine settings on process performance, the impact of wear on the process, and the effect of operating conditions (Ben J. Hicks & Matthews, 2010).

4) Quality.

Total Quality Management (TQM), Quality Function Deployment (QFD) and aspects of Six Sigma are methods that support quality, control, improvement and assurance. Using these methods it is necessary to understand their function and its relationship to quality, and to know the interaction between process and (Thomas & Webb, 2003).

5) Tooling design and changeover.

"The ultimate aim of improving tooling design is to improve production performance and in particular flexibility without compromising efficiency." (Ben J. Hicks & Matthews, 2010). Two examples of methods using this principle are Single-Minute Exchange of Die (SMED) (Shingo, 1985) and Design for Changeover (DFC) (McIntosh, Culley, Mileham, & Owen, 2001). Hereby it is important to specify in advance the range of variation that is necessary to determine the most appropriate design or configuration of tooling in order to process all product variances and minimize the number of changeover and/or changeover time. The design is defined both in terms of physical geometry (size, profile and number of) and control of the tooling (kinematics - motion, velocity and acceleration, timing and clearances) (B. J. Hicks, Medland, & Mullineux, 2001).

6) Equipment redesign, modification and replacement.

Where an increase in manufacturing capability has the consequence that the equipment is not sufficient anymore it must be modified or redesigned (Ding, Matthews, McMahon, & Mullineux, 2009; Matthews, Singh, Mullineux, & Medland, 2007). The factors that determine the limitations of the current equipment must be converted to rules which are necessary for successful improvement manufacturing capability.

7) Product modification and new product introduction.

In today's market new sizes, materials and modified configurations are quite common. Central to achieving these changes is the need to determine the machine settings that enable the product to be produced. Both, the determination of settings for a new product and the improvement in process capability through product modification give the need to understand the capability of the production process and its relationship with the properties and characteristics of the product (Frey, Wysocki, & Otto, 2000).

8) Other philosophies.

In addition to the seven areas mentioned above there are a number of philosophies existing to support improvements in manufacturing and management. Lean thinking and Business Process Reengineering are the two most common used. The term 'lean' describes the main aim of the philosophy, the reduction of waste throughout a company's value stream (Womack, Jones, & Roos, 2007). Elimination of waste guarantees that every part of the value stream (process) adds value to the product. In contrast to lean, business process reengineering (BPR) focuses on improving the efficiency and effectiveness of the overall business processes that exist within and across an organization (Hammer & Champy, 1993). By assigning responsibility for those processes to teams and systems this effectiveness is achieved.

This section gives an overview of all the improvement systems manufacturing. Because Heineken uses Total Productive Maintenance (TPM) as improvement methodology, the next section will discuss the development and usage of TPM in general.

3.3.2 Total Productive Maintenance

Total Productive Maintenance (TPM) is a maintenance methodology which is developed in Japan (Nakajima, 1988). Nakajima (1988) gave the following description: "TPM has been accepted as the most promising strategy for improving maintenance performance in order to succeed in a highly demanding market arena". Tsuchiya (1992) defined TPM as follows: "TPM is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, spanning all equipment-related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small-group activities." (Tsuchiya, 1992). Nowadays the methodology is still a very useful and successful manufacturing strategy, for achieving core competence in the competitive environment (Ahuja, Singh, Sushil, & Wadood, 2004).

The improvement methodology TPM is designed to optimize the equipment reliability by executing an efficient management of plant assets. This is done by a company-wide approach to maintenance management which is usually divided into short-term and long-term elements. The short-term approach focuses on an autonomous maintenance program for the production departments, a planned maintenance program for the maintenance department, and skill development for operation and

maintenance personnel (McKone, Schroeder, & Cua, 1999). The long term approach focuses on new equipment design and elimination of sources of lost equipment time. Nakajima (1988) defined TPM as: “an approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce.” So the underlying fundament of the maintenance part of TPM seems to be a structured basis for continual improvement of the production effectiveness.

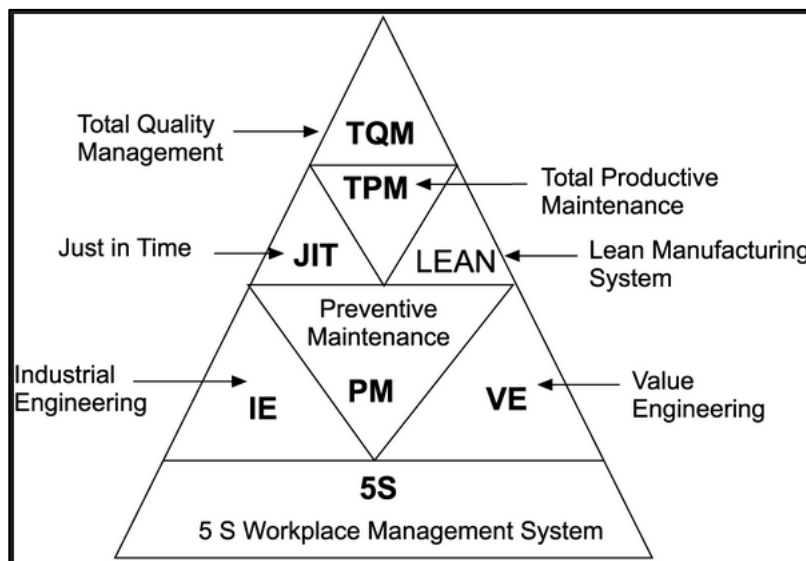
TPM as management principle

Nowadays TPM is not just a maintenance program but an effective management principle. This management principle can be divided into five different parts (Waeyenbergh & Pintelon, 2002).

- The goal of TPM is to maximize the efficiency, and improve the overall effectiveness of the equipment.
- TPM gives an entire productive maintenance program for the whole lifetime of equipment.
- TPM stimulates the participation of all the different stakeholders in the whole organisation and focusses on teambuilding.
- TPM has influence on all levels of the organization; from the production floor operators to the top management.
- TPM promotes productive maintenance and implement autonomous maintenance.

The concepts of Six Sigma, Lean manufacturing and TQM are combined in the philosophy of TPM. TPM continuously manage, optimize and improve a supply chain by eliminating all losses, involving all employees of the organization (Ahuja et al., 2004). The major differences between TPM and other concepts is that the operators are also made to involve in the process; it is not just a method for the maintenance department, the whole company needs to be involved (Chan, Lau, Ip, Chan, & Kong, 2005). Ahuja & Kamba (2008) state that the TPM methodology forms the corner stone activity of Lean manufacturing. Figure 3.3.4 shows the relationships between Lean philosophies and TPM.

FIGURE 3.3.4 TPM PILLARS AHUJA & KAMBA (2008)



TPM has several pillars which are the basis of the methodology. The 5S forms the foundation for the TPM pillars and they are required for implementing TPM (Venkatesh, 2005; Assen et al., 2007). These are the 5S:

- **Sorting (Seiri):** eliminate all unnecessary tools, parts and elements by sorting the essential ones.
- **Straightening (Seiton):** Arrange all tools in standard order to eliminate waste to find a tool
- **Sweeping (Seiso):** A clean workplace gives insight in the way things are organized
- **Standardizing (Seiketsu):** all processes should be performed precisely the same for all locations and/or persons
- **Sustaining (Shitsuke):** Maintain the standards

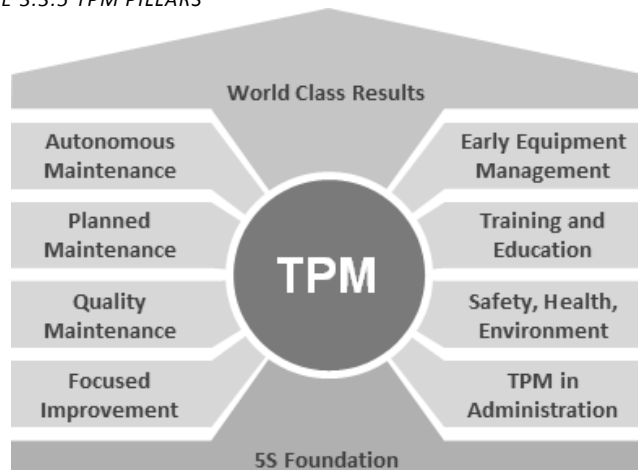
The next section will discuss the TPM methodology in more detail by explaining the several pillars.

FIGURE 3.3.5 TPM PILLARS

TPM Pillars

TPM consists of eight different pillars and, as mentioned before, based on the 5S. There are eight commonly used pillars; autonomous maintenance, focused improvement, planned maintenance, quality maintenance, education and training, safety, health and environment, office TPM, and development management (Rodrigues, Hatakeyama 2006).

Figure 3.3.5 gives a graphical presentation of the pillars. The different pillars together are the basis for World Class Results.



Some of the main results of successful TPM implementations are a longer equipment life, lower maintenance costs and therefore also lower operating costs. There is a method to score all aspects of the equipment manufacturing in one measurement. This system is called Overall Equipment Effectiveness (OEE) and help to check the current performance.

Autonomous maintenance (AM): This pillar focuses on the development of operators to take care of several maintenance tasks. This means that the maintenance people have more time to do their specialized maintenance (or there are less specialized maintenance people needed). Examples of tasks the operators can do are cleaning, lubricating, tightening and inspection.

Focused improvement (FI): This pillar performs analysis to identify the different forms of loss types at a strategic level. It divides their TPM deployments over several autonomous teams who eliminate the losses. Therefore the pillars trust their workforce to achieve the objective by using the right skills and motivation.

Planned maintenance (PM): Planned maintenance focuses on the development from a reactive approach to a proactive method. Hereby the maintenance specialists can help the operators to do the maintenance as well as possible.

Quality maintenance (QM): This pillar has as goal to deliver the highest quality by producing with zero defects. Hereby is a focus on the tracking of the root causes of the (equipment) problems. By checking the conditions of the machines and time between defect standard values are achieved to avoid break downs. Also there is the trend from reactive to a proactive approach.

Training and Education (T&E): The goal of good, motivated, multi-skilled employees with objectives corresponding to the organization goals can only be achieved by the right training and education. Not only know what to do but also why is important. These skills and trainings have to be evaluated and updated periodically.

Safety, health and environment (SHE): This pillar has to ensure a safe working environment for all the staff in the organization. They want to eliminate the incidents, injuries and accidents. Therefore they make standard operating procedures.

TPM office: The TPM office have to coordinate the communication between the different pillars with a focus on productivity and efficiency in the administrative functions. They also apply the 5S in the office working areas. Of course the TPM department is also responsible for the measurement of the TPM performance.

Development management (DM): This pillar works to minimize the problems of introducing new product on new equipment. They try to learn from existing developments on the current systems to deal with new systems.

3.3.3 TPM Heineken

Heineken wanted to improve the effective use of their resources. They want to create a perfect process and an excellent way of working. In order to accomplish these targets they need a process of continuous improvement. Therefore they started in 2003 with the implementation of TPM in the brewery in Zoeterwoude

The four phases of implementation are:

- 1) Preparation
- 2) Pilot
- 3) Expansion
- 4) Stabilization

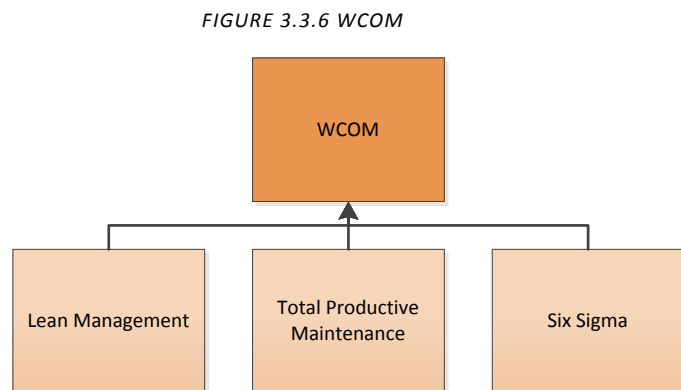
Current situation TPM

Based on these phases, Heineken developed criteria for 3 awards: bronze, silver and gold. For the bronze award all pillars must be developed completely. The Zoeterwoude brewery gained the Bronze Award in 2013. The Silver award can be obtained by showing good results, based on trained employees. The Gold award can be obtained by showing the ability to perform at a World Class Brewery Organization (WCBO) level.

the aim of TPM at Heineken is to perceive one common language for running operations and improvement of processes. TPM at Heineken is the methodology for achieving: World Class Operations Management (WCOM).

The three pillars of WCOM at Heineken consist of Lean Management, TPM and Six Sigma. In the years following 2003, the TPM methodology is tested and fine-tuned for the Heineken organization.

By structuring processes, setting up standards and by minimizing waste, the variability in production performance will be minimized. Looking at the supply chain, this has an enormous impact on suppliers, in-house stakeholders and customers.

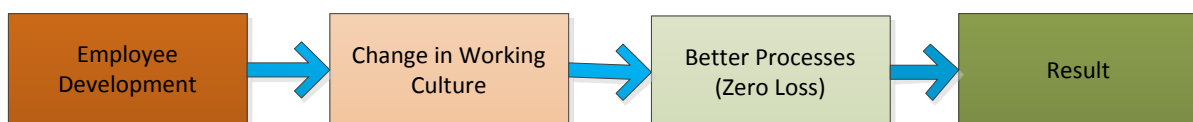


TPM focuses first on the basis of the production company. A good basis is necessary for further improvements and final results will also come. By training employees (People Development Pillar) in the TPM-philosophy of continuous improvement and preventive maintenance, the aim is to create a mind-shift in the working culture (TPM-Heineken, 2010).

This culture shift will lead to better processes with a zero-loss goal. And better processes will enable the organization to perform at its best.

In order to get shopfloor excellence through developing the culture they use several different methods (5S, AM/PM, DCS). Importantly, this development is a continual process.

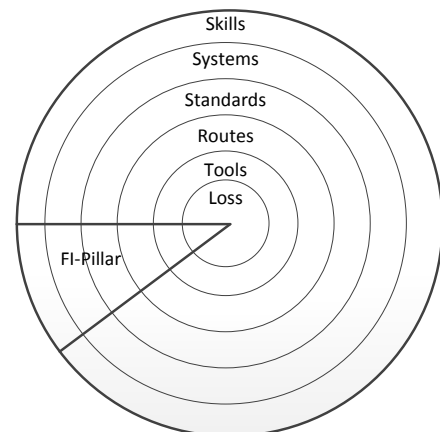
FIGURE 3.3.7 WORKING CULTURE DEVELOPMENT



When looking at the drives of improvement, 6 layers can be identified:

- Losses
- Tools, are used to eliminate them
- Routes, defined processes to using tools
- Standards, determined by these Routes
- Systems, made up by the standards of all processes, machines, materials and methods
- Skills, determine how good these systems are and how well they are operated.

FIGURE 3.3.8 LAYERS IMPROVEMENT



The six TPM pillars at Heineken are: Focused Improvement (FI), Autonomous Management (AM), Planned Maintenance (PM), Progressive Quality (PQ), Training and Education (T&E) and Safety and Environment (S&E). These pillars are departments that contain the parts of all the five layers, mentioned above, focused on one subject.

Figure 3.3.8 shows the structure of the organization and the place of the pillar. As a consequence of the new structure, all production lines interfere with the pillars. By performing the processes in the different pillars, the organization can improve its skills.

With these skills, the production line can improve its processes and consequently its performance, therefore increasing result. This structure also has the advantage that the lines communication and collaborate with each other which means that the best practices of the lines are shared.

3.3.4 FI-Pillar Heineken

The improvement method TPM consists out of several pillars which can be divided into several layers (see figure 3.1.1). The pillar where changeover time belongs to is the Focuses Improvement-Pilaar (FI). This pillar has several different steps where the planned downtime belongs to step 2; 'Standardize, deploy and attack planned activities' which consists out of 4 different steps.

- 1) Restore basic conditions
- 2) Define visual management standards for the site
- 3) Deploy line/machine losses and define priorities for improvement
- 4) Manage horizontal expansion of solutions and long term actions to achieve world class level.

These steps first of all focus on the work standards, then the visual standards and good practices, then the data deployment and Pareto analysis and the last step is to retain the improvements and keep further improving.

SMED: COTR Team Route)

In order to get a more detailed view of the vision of TPM figure 3.1.2 shows the roadmap of a 'Change Over Time Reduction' team (COTR-team). Based on the steps there are several factors which are important for changeovers.

The COTR Team reduction route steps 2 till 6 are interesting with respect to the question answering in this section. Step 2 suggests that it is important to have some insight in the performance of the current changeovers and emphasis the need for good data and a performance checker.

Step 3 shows the importance of standards and dividing the changeover into three categories; pre,- internal and post-changeover.

Step 4 looks to the sequence of the different tasks and the visual management of these tasks. Step 5 focuses on the minor stops during the run up after the changeover. Step 6 looks to the

FIGURE 3.3.9 COTR TEAM ROUTE



sustainability of the solutions and improvements and looks for horizontal expansion of the good/best practices.

TPM tools

Inside Heineken there are several commonly used tools. Table 3.3.1 shows these tools with their objective.

TABLE 3.3.1 TPM TOOLS HEINEKEN

Objective	Tools
Standardize improvement method	Kaizen
Minimize changeover time	Single minute exchange of die (SMED)
Finding main problem	5x why
Solving main problem	Break down analysis (BDA)
Reduction minor stops	Minor stop analysis sheet(MSAS)
Eliminate chance errors	Poka Yoke
Improve quality	Six sigma
Improve effectiveness operator	Team Effectiveness inventory(TEI)
Find category problem	4M Method
Knowledge management	One point lessen(OPL)
Optimizing location	CILT
Increase safety	Almost accident labels

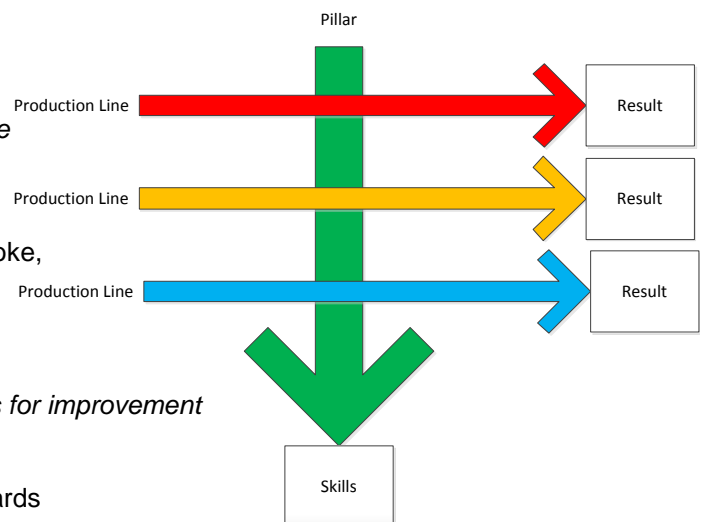
These tools are commonly used because they are simple to use because of their stepwise approach. They also need a multidisciplinary team that increases the chance of success (Eti, Ogaji, & Probert, 2004).

Masterplan

The FI-Pilaar consists out of several steps. The second step is the planned downtime with the changeovers. This step can be divided in the following steps and sub steps which are summarized in a masterplan (TPM-Heineken, 2010)

- 1) *Restore basic conditions*
 - 1.1 Re-introduction of the importance of standards
 - 1.2 Collect standards and check them
 - 1.3 Re-introduce standards if necessary
 - 1.4 Implement standards/ sops
- 2) *Define visual management standards for the site*
 - 2.1 Get insight in standard for visualisation
 - 2.2 Determine visual standards for the future (communicate with AM, PM, PQ)
 - 2.3 Look for new standards and ideas (Poka Yoke, etc.)
 - 2.4 Look in organization for best practices line/machine/product
- 3) *Deploy line/machine losses and define priorities for improvement*
 - 3.1 Loss-deployment for product/line/machine
 - 3.2 Define priorities for improvement
 - 3.3 Improve standards using appropriate standards
- 4) *Manage horizontal expansion of solutions and long term actions to achieve world class level.*
 - 4.1 Knowledge management
 - 4.2 World class level

FIGURE 3.3.9 STRUCTURE PILLARS



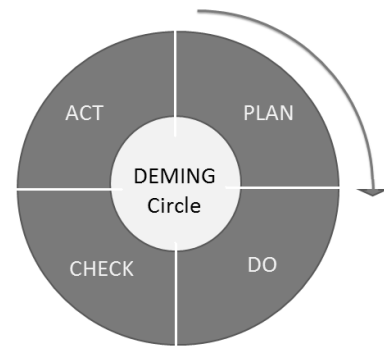
3.3.5 Project management

Besides the TPM methodology there are several other aspect from the literature relevant for the changeovers. On basis of the experiences and factors already given from the stakeholders we decided to look in this section to two different aspects out of the literature; the PDCA circle and stakeholder engagement.

PDCA Circle

The plan-do-check-act (PDCA) cycle is a well-known model for continual process improvement. It teaches organizations a structured method by following these four steps; plan an action, do it, check to see how it conforms to the plan and act on what has been learned (Johnson, 2002). Since the model is applicable to all types of organizations and to all groups and levels in an Organization the model supports improvement efforts in a full range from the very informal to the most complex (e.g. introduction of a new product line or service for a major organization) (Moen & Norman, 2006).

FIGURE 3.3.10 PDCA CIRCLE



The PDCA cycle enables two types of corrective action, temporary and permanent. The temporary action is aimed at results by practically tackling and fixing the problem. The permanent corrective action, on the other hand, consists of investigation and eliminating the root causes and thus targets the sustainability of the improved process (Sokovic, Pavletic, & Pipan, 2010). This is why the PDCA cycle is effective in both doing a job and managing a program.

The four steps for improvement or change in the PDCA cycle are:

1. **Plan:** Recognize an opportunity, and plan the change.
2. **Do:** Test the change.
3. **Check:** Review the test, analyze the results and identify learn-ings.
4. **Act:** Take action based on what you learned in the check step. If the change was successful, incorporate the learnings from the test into wider changes. If not, go through the cycle again with a different plan.

The continual application of the PDCA cycle has been found far more effective than adopting “the right first time” approach. Deming's PDCA cycle is also the most appropriate method to use in this case because of the effectiveness in the development and deployment of quality policies. Other continuous improvement tools as DMAIC (Six Sigma) and DMADV (DFSS) focuses more on the project life-cycle (PLC) and the implementation and close-out of Six Sigma projects (Sokovic et al., 2010).

Stakeholder engagement

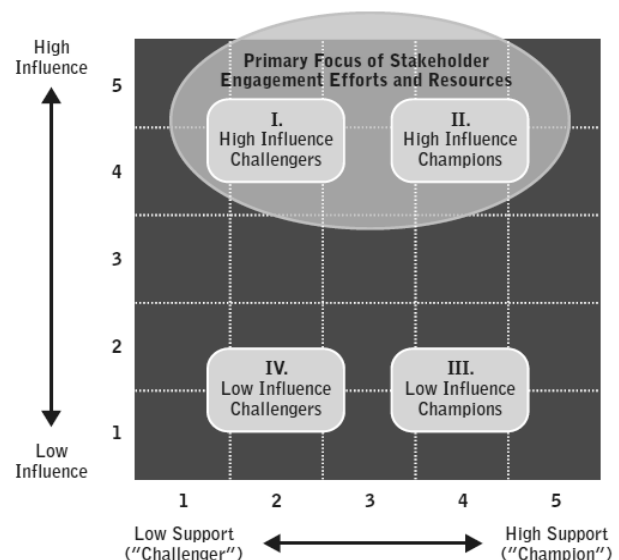
Today almost every project takes place in a context where stakeholders play a major role in the accomplishment of the tasks. Often the project is sensitive to actions and decisions taken by the stakeholder (Karlsen, 2002). In order to implement a project or program it is necessary to think about the stakeholders which are involved and who have influence on the final result.

“Large-scale supply management initiatives can easily fail when they neglect to engage key stakeholders early and often. Too often, project teams spend months gathering data and developing strategies that are never implemented due to insufficient internal and external support. The key is to follow a disciplined process for identifying, wooing and continuing to engage stakeholders” (Sharma, 2008).

Figure 3.3.11 shows a stakeholder prioritization matrix with four categories. The categories are based on the influence and the support of the stakeholders. When these two variables are high it is necessary to engage this stakeholder actively in the plans because they can seriously harm or derail the program.

FIGURE 3.3.11 PRIO STAKEHOLDERS

Stakeholder Prioritization Matrix



Sharma developed six principles of stakeholders management (Sharma, 2008):

- 1) Get to know your stakeholders (vertical and horizontal in the organization)
- 2) Engage as early as possible (in phase that changes in plan are quite easy)
- 3) Listen with both ears open (take opinions serious, also when they are not in line with the plan)
- 4) Communicate
 - a. Awareness communication (everybody knows about developments)
 - b. Change management communication (Clear explanation of changes)
 - c. Knowledge transfer communication (Training, best practices, learnings)
- 5) Use policy as carrot, not stick (policy must support underlying vision, not the rules which have to be followed)
- 6) Create communities (how to share best practices with partners on the other side of the world?)

3.3.6 Data integrity

As part of this research also the data management is important. This section gives some attention to the quality of data.

Dirty data

Dirty data is defined as follows; *The sources of dirty data include data entry error by a human or computer system, data update error by a human or computer system, data transmission error by a computer system, and even bugs in a data processing computer system (Kim, Choi, Hong, Kim, & Lee, 2003).*

The life cycle of data includes its capture, storage, update, transmission, access, archive, restore, deletion, and purge. The focus of dirty data is not on the 'access' aspect by a user or application. As such, the data is dirty if the user or application ends up with a wrong result or is not able to derive a result due to certain inherent problems with the data (Kim et al., 2003).

Relevance data

Besides the dirty data, data quality assessment should take into account how user requirements with the accessed service can vary. It is not sufficient to evaluate data quality by considering only the source in which data are contained (dirty data). Indeed, user expectations vary along different variables and the same data can be perceived in different ways by different users (Francalanci & Pernici, 2004). For a more complete view of the data quality and their 'fitness for use' Vaziri and Mohsenzadeh developed a phase in order to achieve useful list of dimensions which assess the data quality (Vaziri & Mohsenzadeh, 2012).

3.3.7 Factors changeovers

Given from the several subjects of the literature the given factors from the stakeholders (section 3.1 and 3.2) are reviewed. When a factor is not in the literature it is not relevant to look at that factor. Table 3.3.2 gives an overview of the already mentioned factors and the new factors given from the literature.

TABLE 3.3.2 FACTORS CHANGEOVER TIME

Categories factors		TPM	PDCA Circle	Data integrity	Stakeholders
	Sub-categories factors				
1.	Flexibility operators	X			
2.	Usage of SMED standards	X	X		
3.	Technical knowledge	X			
4.	Cleaning changeover parts	X			
5.	Number of (skilled) operators	X			
6.	Timing changeover			X	
7.	Organization	X			
8.	# switches/changeover in a period				
9.	Workstandards SMED	X			
10.	Differences in material	X			
11.	Production cycle	X	X		

12.	Fixed sequence products (type)	X	X		
13.	Dynamic sequence orders	X	X		
14.	Accuracy parameters (changeover rules / matrix)	X	X	X	
New factors based on literature					
15.	Visual standards	X	X		
16.	Tracking performance	X	X	X	
17.	Reliable data	X			
18.	Relevant data	X	X		
19.	Communication			X	X
20.	Engaging stakeholders				X
21.	Horizontal expansions best practices	X			X

Table 3.3.2 shows that almost all the factors given by the stakeholders are part of the literature. Especially the theory of TPM supports most of the factors. This is quite logical because TPM is the used improvement method at Heineken. Only the number of switches and changeovers in a period is eliminated. But these factors are also influenced by other factors like reliable data and accuracy parameters planning. Furthermore there are several new factors which influence the changeovers. In the next chapter the factors are analyzed on their relevance for Heineken.

3.3.8 Conclusion question 9

This section gives insight in factors out of the literature that have influence on the changeovers. The factors are divided over the methodology TPM, PDCA, data quality and stakeholder engagement. The following new factors are found; visual standards, tracking performance, reliable data, relevant data, communication, engaging stakeholders and horizontal expansions best practices.

Question 9: "Which factors affect the impact of the changeovers based on the literature?"

TABLE 3.3.2. FACTORS CHANGEOVER TIME LITERATURE

New factors influence impact changeovers literature	TPM	PDCA Circle	Data Integrity	Stakeholders
Visual standards	X	X		
Tracking performance	X	X	X	
Reliable data	X			
Relevant data	X	X		
Communication			X	X
Engaging stakeholders				X
Horizontal expansions best practices	X			X

The factors of the stakeholders given in section 3.1 and 3.2 are evaluated based on the literature. Almost all the factors are supported by the literature, only the number of switches and changeover in a period is not relevant based on the literature.

Next question

Answers are given to the questions about the impact of the changeovers, the organizations of the lines, the different types of changeovers, the volume and duration of the changeovers, the quality of the changeovers, the organization of planning with respect to the changeovers and the factors that influence the impact of the changeovers (from literature).

Question 10: "Which factors are most relevant and applicable for Heineken?"

The next section gives the answer to question 10; "Which factors affect the total planned changeover time? "

3.4 Conclusion chapter 3

Chapter 3 gives insight in the factors that (may) have an influence on the flexibility of the lines. These factors are divided over three different categories; production, planning and literature. The factors of production and planning are gathered by the stakeholders. Because the factors from the stakeholders can be irrelevant we will also look at the literature.

Production factors

The factors are given by the stakeholders of production and are divided over two categories. The duration and the quality of the changeover. The following factors may affect the (duration and quality of the) changeovers:

1. Flexibility operators (Duration)
2. Usage of SMED standards (Duration)
3. Technical knowledge (Duration + Quality)
4. Cleaning changeover parts (Duration + Quality)
5. Number of (skilled) operators (Duration)
6. Timing changeover (Duration)
7. Organization (Duration)
8. # switches/changeover in a period (Quality)
9. Standards of SMED (Quality)
10. Differences in material (Quality)

- Duration changeover
- Quality changeover

Production factors
(§3.1)

Planning factors (§3.2)

- Scheduling
- Tactical planning

Planning factors

The factors which may influence the planning are given by the stakeholders of tactical planning and scheduling.

11. Production cycle (Tactical planning)
12. Fixed sequence products (Tactical planning + Scheduling)
13. Dynamic sequence orders (Scheduling)
14. Accuracy parameters (Scheduling)

Literature factors

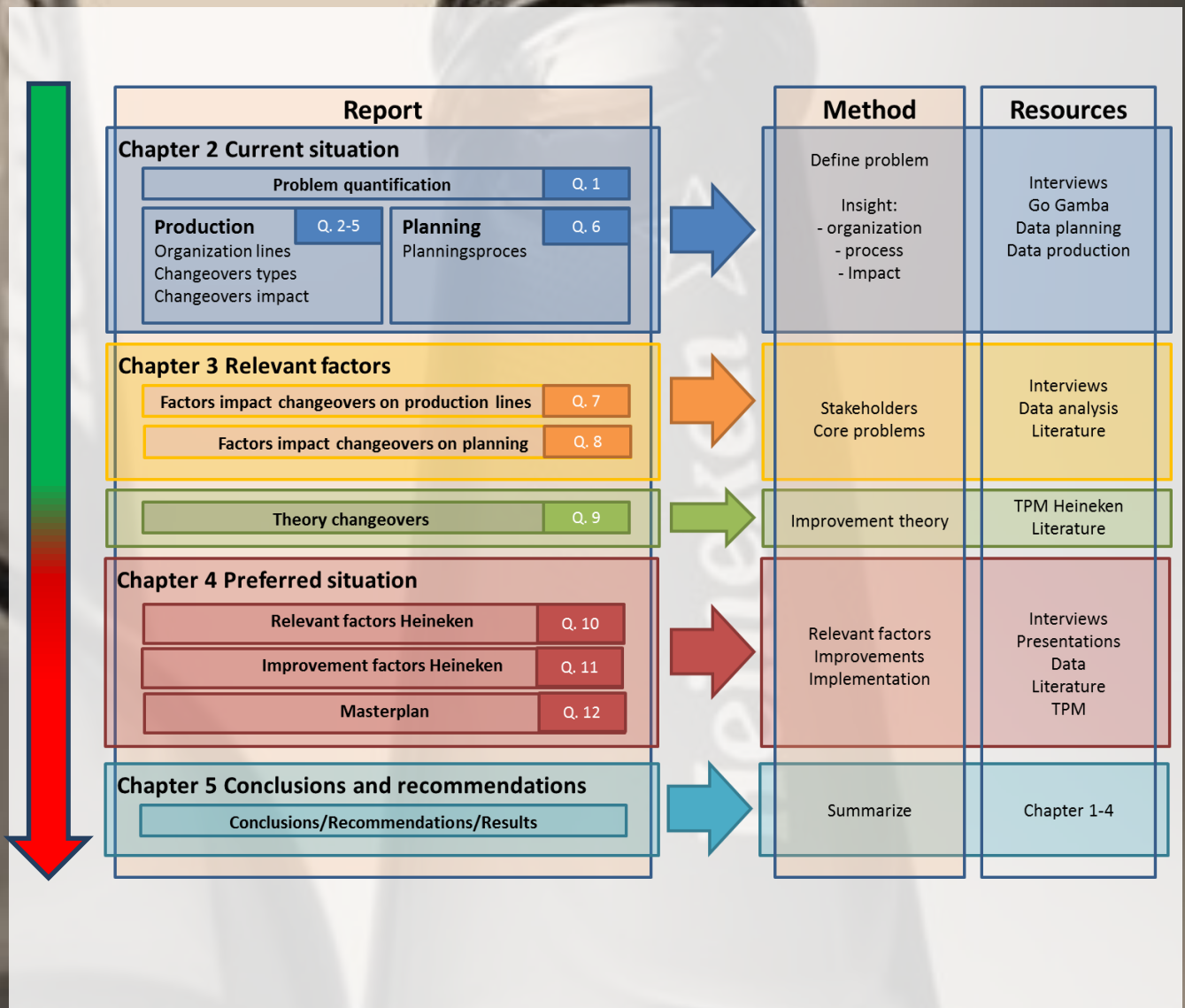
The factors given in the literature are based on the improvement methods which are generally used in manufacturing. These improvement methods give several factors which may improve the current situation. Therefore these factors affect the current performance of the changeovers:

15. Visual standards (TPM & PDCA)
16. Tracking performance (TPM)
17. Reliable data (TPM)
18. Relevant data (TPM & PDCA)
19. Communication (Data quality & Stakeholders theory)
20. Engaging stakeholders (Stakeholders theory)
21. Horizontal expansions best practices (TPM & Stakeholders theory)

- TPM general
- TPM Heineken
- Other aspects

Literature factors
(§3.3)

The factor 'number of switches and changeovers in a period' is eliminated based on the literature. All the other factors given from the stakeholders are supported by the literature.

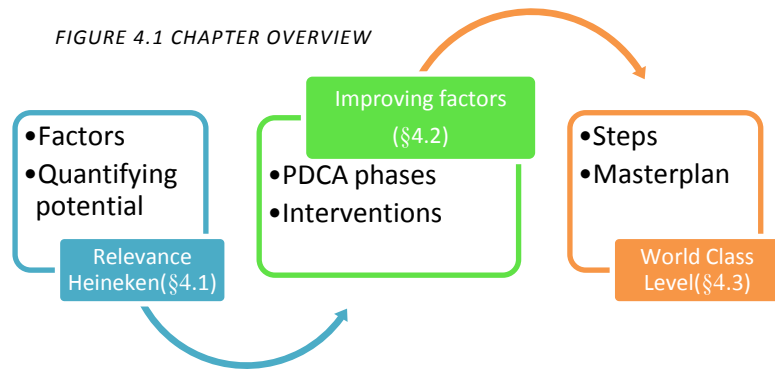


Chapter 4: Preferred situation

This chapter gives insight into the preferred situation with respect to the changeovers.

Answer is given to question 10. First of all the different factors found in chapter 3 are mentioned and their improvement potential is discussed (§4.1). The second section gives the interventions which will improve the factors with improvement potential (§4.2).

FIGURE 4.1 CHAPTER OVERVIEW



4.4 Conclusion chapter 4

This chapter gives insight into the preferred situation by analyzing the factors given by the literature and stakeholders in chapter 3. Looking at the opinion of the members of the PD-pillar, the future development (trends) and the possibility to improve, the relevant factors are chosen. The most relevant factors are; Usage of SMED standards, Organization, Accuracy parameters (changeover rules / matrix), Tracking performance, Reliable data and Communication.

- Factors
- Quantifying potential

Relevance Heineken (§4.1)

The factors that are less important but also relevant for Heineken are; Cleaning changeover parts, Timing changeover, Working standards SMED, Engaging stakeholders and Horizontal expansions best practices.

Remarkably the factors which are most important are both in the middle of the planning part and the production part. These factors are important because at the moment the collaboration between planning and production isn't optimal. The production department and the planning department don't know from each other what they do and why they do it.

Improving factors (§4.2)

- PDCA phases
- Interventions

The several important and relevant factors have to be improved to decrease the total changeover time. Therefore interventions are developed for the relevant factors, based on the PDCA methodology. Since several different factors improve by doing the same intervention, the number of interventions can be limited to the following:

- **Plan:** Training, clear working instruction and realistic planning parameters
- **Do:** Usage of the standards
- **Check:** Check performance and check realistic planning parameters
- **Act:** Horizontal expansion new developments

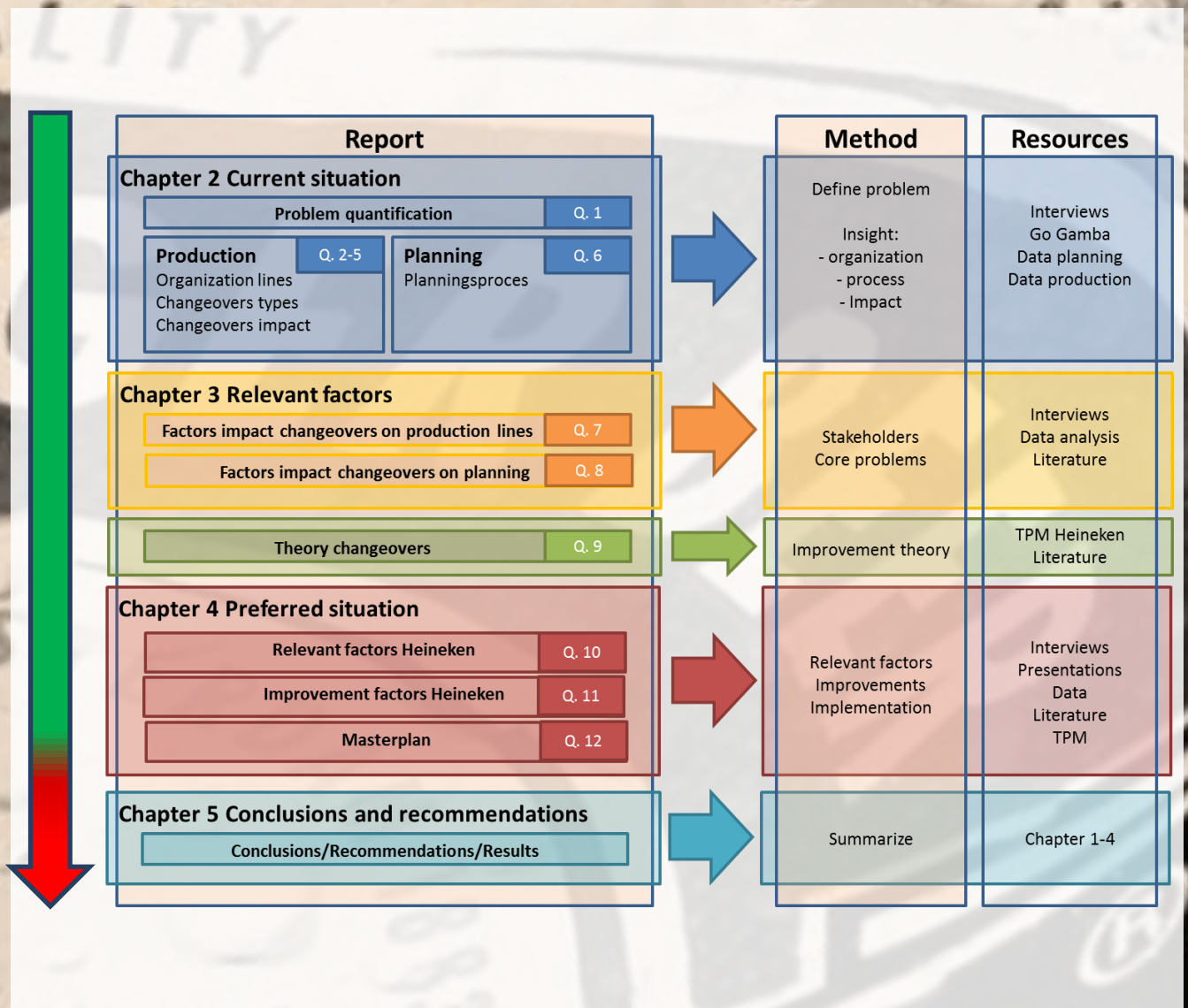
The interventions of the Plan phase and the Check phase both need a collaboration between planning and production. Therefore all the different stakeholders have to be involved in the development of the steps to execute these interventions

Based on factors and the interventions, the steps, needed to achieve a world class level changeover performance, are developed. The standard format for the masterplan of the PD-pillar is filled with the insights given from the PDCA circle of the founded interventions. Although the masterplan is an important part to achieve the WCL there are other steps important as well. Therefore we defined a new PDCA to support the PDCA inside the masterplan.

- Steps
- Masterplan

World Class Level (§4.3)

1. **Plan:** Defining masterplan
2. **Do:** Give priorities to Masterplan and divide them over stakeholders
3. **Check:** Meetings PD-Pillar
4. **Act:** Re-define priorities and set new deadlines for the masterplan



Chapter 5: Conclusions and recommendations

This chapter contains the conclusions (§5.1), recommendations (§5.2), and first results (§5.3).

5.1 Conclusions

Many markets introduce new packaging types, designs, label changes etc. in order to stop the declining trend in the beer market. This results in a growing number of changeovers on the packaging lines. This report contains an investigation about the flexibility on the lines at Heineken Zoeterwoude. The main question guiding this research is:

What improvements can be made in the execution and planning of the changeovers on the packaging lines to minimize their total duration and maximize their quality in order to improve the available production time?

Conclusion sub-questions

To answer the main research question above this research is divided in 12 questions which are all answered in the previous sections. This section states the most important conclusions of these questions:

- 1) Over the year 2013 the available production time is affected by the changeovers with 5%. Over one year this means more than 3600 hours. One hour downtime costs (on average) 250 euro. This means that the changeover costs are almost one million euro per year. In the future the number of changeovers will increase even more because the number of New Product Developments (NPI's) is increasing with almost 40% to 82 NPI's in 2014;
- 2) On the one way bottle lines there are a lot of different changeovers and switches performed. At the moment these different types are not clearly described. In order to perform a good analysis about the different types of the changeovers a new binary code of 6 numbers is developed. Each of these binary numbers say something about the location(s) of the switch or changeover;
- 3) The label switch has the highest volume in comparison to the other switches and changeovers. The label switch has also the highest impact on the total changeover time. Despite the short duration of the switches we can conclude that they are an important part of the total changeover downtime because of their high frequency;
- 4) The total duration of the changeovers is hardly to define because the data registration in MES 2.0 is not reliable at the moment. As approximation of the total changeover time the planned time is multiplied by the realized number of changeovers;
- 5) The 7 variables which give a measure for the quality of the changeover are not registered in the right way so they are not reliable. Therefore it is not possible to give a reliable review about the performance of the execution of a changeover;
- 6) The parameters of planning (both tactical planning and scheduling) are not regularly checked which has the consequence that planning and realization sometimes differ a lot. Besides the extra work and costs for the whole supply chain these differences can also have an impact on the number of changeovers and switches;
- 7) Based on their relevance and current state, from the founded 20 factors which influence the total changeover time, the following 12 factors are relevant for Heineken Zoeterwoude; *Usage of SMED standards, Cleaning changeover parts, Timing changeover, Organization, Working standards SMED, Dynamic sequence orders, Accuracy parameters (changeover rules / matrix) , Tracking performance, Reliable data, Communication, Engaging stakeholders, Horizontal expansions best practices*;
- 8) The most important interventions to improve the relevant factors are clear standards, training, communication and realistic planning parameters. Improving these interventions will decrease the total changeover time;

General conclusions

- 9) The collaboration between the Planning pillar and the Planned Down pillar is not good enough. Therefore some problems are overlooked and the main causes of the problems aren't solved.
- 10) The communication between production and planning in general is not good enough. Therefore it is hard to check where the differences between the planning and reality comes from and there is no possibility for continual improvement in order to reduce these differences.
- 11) The way of working at the production department and the planning department is quite rigid. Although there are solutions to improve the current way of working changes are difficult and it take a long time to implement these improvements.

5.2 Recommendations

The recommendations are divided over three categories. First the recommendations which follows directly out of this investigation are stated, divided over the long term and the short term. Furthermore we stated the more general recommendations.

The specific recommendations for Heineken based on this research are divided into nine different recommendations;

Long term recommendations

- 11) Develop a continual improvement by performing the 4 steps of the PDCA circle as follows

Plan: Defining masterplan

(june 2014)

- e. Answer research questions
- f. Fill in masterplan Planned Downtime-Pillar (TPM)
- g. Ask all stakeholders to be a part of the Pillar
- h. Explain and check the check the masterplan together with stakeholders

Do: Give priorities to Masterplan and divide them over stakeholders (june 2014)

- c. Priorities brewery and stakeholders
- d. Focus with the implementation

Check: Meetings PD-Pillar

(september-december 2014)

- c. Communicate together about the developments.
- d. Clear problem and targets

Act: Re-define priorities and set new deadlines for the masterplan (december 2014)

Short term recommendations

- 12) *Team-leader rayon 2:* In order to get more reliable data an organized report for the SMED-operator should be developed. In the weekly meeting with all the operators this report can be checked and the performance of the switches and changeovers is discussed with special attention to data registration.
- 13) *Rayon-manager rayon 3:* In order to reduce the impact of the switches standards should be developed for every workplace;
- 14) *Team-leader rayon 5:* To restore the SMED-system in the right condition the organization over the line and the evaluation of the performance of the changeover must be define by the documents and training of the SMED system;
- 15) *Senior scheduler & Analyst tactical planning:* In order to produce a reliable planning for production the planners has to use reliable planning parameters. Therefore planning has to develop a standard to check the difference between their planning and the realization of the planning on a regular basis;
- 16) *TPM-facilitator:* To use the right standards and reintroduce the SMED system, the training material and documentation of SMED has to be updated and structured;
- 17) *Planned Downtime pillar leader:* For further development and future World Class Performance, it is important to visit some other companies and breweries who are dealing with the same (increasing) trend of changeovers;

- 18) *Production specialist*: As a part of the changeover the washing part is not optimal at the moment. The parameters of the washing procedure have to be redefined to save time.

General recommendations

- 19) In order to perform a structured analysis over the different changeovers the binary code of 6 numbers is easy to use because it gives information about the several locations on the line where the switch and changeover is measured.
- 20) A good collaboration between planning and production is essential for the success of the Planned Down pillar. Therefore it is important to invite new members from the Plan pillar to the Planned Down pillar. The different perspectives will keep the masterplan complete and trigger to execute the different parts of the masterplan in an optimal way. Another way to stimulate this collaboration is to develop the right individual targets with both perspectives in it.
- 21) Changes on the information system of production (MES 2.0) goes very slowly because there is a shortage of industrial engineers who are able to change MES 2.0. This is an important cause of the rigid way of production department.

5.3 Results

Achieved results

The results are given based on the steps to achieve a World Class Level changeover performance given in chapter 4.3. Only for the last phase 'Act' isn't anything achieved yet which is normal because that phase follows the other phases and needs more time.

Plan:

- 1) The presented masterplan is discussed and accepted by the Planned Down pillar
- 2) The presented masterplan is accepted by the management of production
- 3) The presented masterplan is accepted by the management of Supply Chain Planning and the masterplan of the Plan-Pillar is adapted where necessary
- 4) A member of the Plan pillar of the Supply Chain Planning has joined the PD-Pillar

Do:

Based on the short term recommendations every stakeholder in the PD pillar is given an assignment with a clear description and horizon. The next results are the beginning of the results because of these assignments:

- 5) Training SMED
 - a. An overview is made of the current training materials for SMED and in cooperation with the stakeholders a format is made to get the documents complete and up-to-date
- 6) Data registration
 - b. In collaboration with the SMED-operators from rayon 2 we developed a format for a report which gives the necessary information about the changeovers and switches. With this report the SMED-operators can check the data registration. The request for developing the report is send to the industrial engineer.
- 7) Re-introduce basis SMED system
 - c. The team leader of rayon 5 and SMED-operators started with a plan to restore the SMED-system to their basis.
- 8) Standard switches
 - d. A kaizen is done to find a good standard for a switch and for counting on the line. The kaizen is successfully executed and the average duration is changed from 35 minutes to 20 minutes which is a difference of 1.500 minutes which means a yearly saving of 6.200 euro.
- 9) Check planning parameters
 - a. The planning department made a plan to look not only in general to the parameters (especially efficiency) but also check on a regular basis the other planning parameters.
 - b. The maximum planning speed of the lines on rayon 2 are changed to their actual maximum speed which gives a more accurate planning.
- 10) Benchmark
 - a. The PD-Pillar visited Diversey in Enschede
 - b. The software company Infor gives the names of several companies who use the same scheduling software (AS)
- 11) Kaizen Washing
 - e. The kaizen for washing has as first result a reduction of 15 minutes of cold washing. The washing happens 2400 times per year (800 in the weekend) and saves therefore 400 hours working time and saves 84000 hectoliter water. This is a total saving of 10.000 euro for the water and 120.000 euro (300 euro per hour) for the time which is a total saving of 130.000 euro.

Check:

- 12) Scheme is made for the meeting of the PD-Pillar for 2014

Possible future results:

Of course there are a lot more savings possible when executing the several steps to achieve WCL. As an example we calculate the savings for the standards of the switches.

- 13) Reduce total time switches (yearly 48000 minutes) with 50% because of good standards is a yearly saving of 24000 minutes for the one way bottle lines only. This is a difference of 400 hours which is a total saving of 120.000 euro. This is just for the one way bottle lines, this type of saving can be introduced on every line in the brewery!

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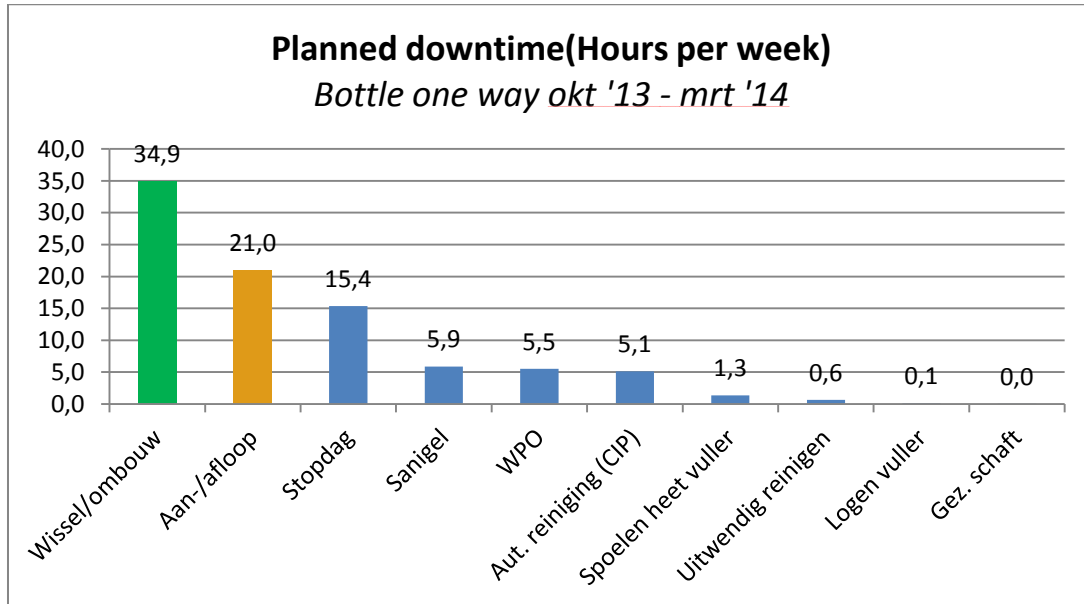
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Appendix 1: Data problems

There are quite some problems with the data registration at Heineken Zoeterwoude. This appendix gives several examples of problems that are founded during this research. In this appendix attention is given to the planned downtime, changeovers and speed (planned).

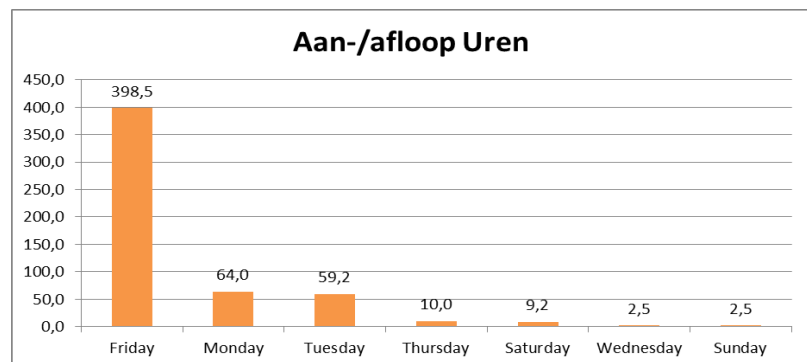
FIGURE A1.1 DIVISION PLANNED DOWNTIME



The division of the different aspects in figure A1.1 seems to be clear but it needs some explanation. First of all the green part over the changeovers is not about the realization but it is an approximation based on the volume of the realization.

FIGURE A1.2 EXPIRATION

The other aspects are based on the data of the realization. But when we zoom in on the expiration it is clear that there is an error in the data. Figure A1.2 shows the time measured per weekday. Surprisingly the Friday is far too high. This is because in the weekends the machines give a false status 'expiration'. So when zooming in on the data, totally different outcomes are given.



Because the data of the realization is hard to get and not very reliable, the data in this section is based on planning. So these data can be different in reality. Section 2.4.1 will go further in detail about the 'data problem'.

Problems data reliability

Because the data of the realization is hard to get and not very reliable most data in the last section is based on planning. So these data can be different in reality. Table A1.1 gives an overview of the differences between a data-tool from MES and a calculation based on raw data (the order sequence).

TABLE A1.1 RELIABILITY CHANGEOVER

Reliability volume changeovers		
Serial number	Data changeover	Realisation (raw data)
000	34	1076
001	206	302
010	22	28
011	41	74
100	1	13
101	9	16
110	26	35
111	29	51

Problem 1: Not all changeovers are registered in reporting system (MES)

Table A1.2 shows the changeovers that are registered in MES. The problem is that these changeovers have to be reported by the operators that are responsible for SMED. But they don't report every changeover and when a changeover isn't reported they don't come in the data-tool of changeovers.

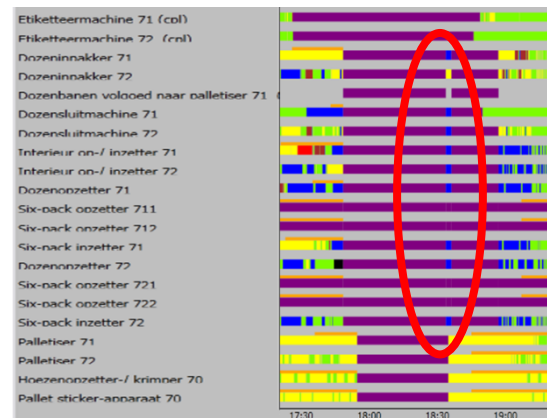
TABLE A1.2 CHANGEOVERS REGISTRATION

Changeover in data-tool			
Line	Reported	Not rep.	Total
Lijn 21	68	12	80
Lijn 22	15	5	20
Lijn 3	60	4	64
Lijn 7	169	12	181
Lijn 81	113	3	116
Total	426	36	462

Problem 2: Not all changeovers are reported in MES

The changeover time is measured out of the machine status. This status is based upon the time between two batches. But there is a rule that a batch cannot be invoked until the machine in front of the current machine has invoked its batch.

So it often happens that the machines at the dry part (the packer et al.) are ready sooner with the changeover but their status change after the labeling machine has invoked the new batch.



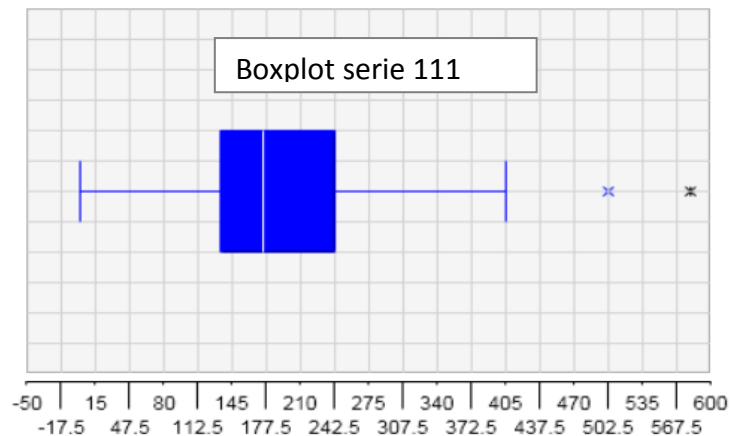
Problem 3: Machines have to wait for their predecessor so bottlenecks always occur somewhere in the end of the process

When looking at the changeover times in the reporting tool there are some unreliable measures. These changeover times are measured by looking at the last box of the old batch and the first one of the new batch.

When looking at the changeover 111 (beer, bottle, label, - change) there is a lowest value of zero and a highest value of 4737 minutes. With a median of 175 minutes there are quite some outliers.

FIGURE A1.3 OUTLIERS DATA

Q1	136,5
min	0
median	175
max	4737
Q3	236,5
n	35



Problem 4: Measures of changeover times in MES are not reliable

The performance of the lines is measured by the performance of the filling machine because in general this machine is the bottleneck of a line. The control of the data is very generally done by a controller but he checks only the data of the filling machine and not from the other machines.

Problem 5: Only the data from the filling machine is (generally) checked

Refresh and check all the planning parameters

In order to minimize the differences between the realized OPI and the planned OPI the parameters of the OPI has to be refreshed every time there is a trend that the current parameter isn't appropriate any more. At the moment Heineken only refreshes the efficiency every time. But there are a lot more parameters which change over the time and also influence the efficiency.

$$\text{Efficiency} = \frac{\# \text{ Trays (output)}}{\# \text{ Hours} * \text{Speed}}$$

Hours = Available production time

Speed = Technical max. speed bottleneck

There are the following types of parameters:

1) Maximum line speed

When looking at the data of the realization and the raw data of the realization there are some interesting differences. In order to get a good planning the different aspects of the planned OPI must be checked once in a while.

Since it was a long time ago that the machines where checked and the differences of the realized OPI are minimized by changing only the efficiency there are some differences.

TABLE A1.4 SPEED

Realized speed vs. Planned speed				
Colonne	batchtype	Planned	Realized	Verschil
Col 21/22	207	40008	42000	105.0%
	250	40008	42000	105.0%
	330K2	40008	40000	100.0%
	355K2	40008	40000	100.0%
Col 22	650	22500	23000	102.2%
Col 3	330K2	79992	84000	105.0%
	355K2 (C 12)	79992	84000	105.0%
	355K2 (C 18)	73080	84000	114.9%
	330SOL	79992	84000	105.0%
Col 7	330K2	79992	80000	100.0%
	355K2	79992	80000	100.0%
	330SOL	79992	80000	100.0%
Col 8	355EU	64992	65000	100.0%
	355K2	64992	65000	100.0%
Col 5	355K2	79992	80000	100.0%

TABLE A1.3 SHARE PER BOTTLE

Percentage of type orders per line		
description	Fles1	Percentage
Lijn 21	207	17.60%
Lijn 21	250	43.50%
Lijn 21	330K2	2.19%
Lijn 21	355K2	36.71%
Lijn 22	330K2	4.96%
Lijn 22	355K2	12.33%
Lijn 22	650	82.70%
Lijn 3	C 18	40.45%
Lijn 3	C 2x12Cl	59.55%

Table A1.4 shows that the differences in speed only are measured on rayon 2. The other rayon is planned with the same maximum speed as in reality. On line 3 there is a product type that is almost 15% higher than planned!

TABLE A1.5 REALIZED EFFICIENCY PER PACKING TYPE

Bottle type	Packing type	Realized efficiency
330K2	C 2x12Cl	0.60
330SOL	C 2x12Cl	0.63
355K2	C 18	0.90
355K2	C 2x12Cl	0.73

Table A1.5 shows the efficiency for line 3. The 355K2 C 18 plans with a speed that is almost 15% lower than realized (!) which results in a very high efficiency. Table A1.6 gives the differences for the maximum line speed.

Average planned speed

The table A1.6 suggests that there must be a correlation between the hours difference between planning and realization at the end of the week and the products which are produced in a week but this isn't the case. This is because the planning discusses the realization with the rayon-manager and when there are differences the efficiency of the lines are increased or decreased.

Only the share of the bottle 250/207 has influence on the differences between planning and realization of line 21. For this line it is proven that there is a correlation between the amount of production 250/207 bottle in a week and the difference in hours planning vs. realization (table A1.6).

TABLE A1.6 CORRELATION SPEED

Line 21 Week	% werkcolli 250/207	Hours difference end week
201342	51.35%	-4.9
201343	93.45%	-0.6
201344	100.00%	10.9
201345	100.00%	2.13
201346	100.00%	7.12
201347	100.00%	11
201348	4.30%	-17.08
201349	8.47%	-8.59
201350	41.23%	-9.31
201351	36.88%	-7.17
201352	100.00%	10.23
20141	81.12%	10.23
20142	0.00%	5.52
20143	79.43%	18.07
20144	51.00%	-7.67
20145	47.74%	5.81
20146	0.00%	1.26
20147	28.99%	-0.81
20148	0.00%	10.35
20149	46.20%	-0.46
201410	81.94%	10.30
201411	98.11%	13.53
201412	100.00%	8.19
201413	100.00%	32.10
Correlation		0.567

Times in the changeover matrix

Since the times inside the changeover matrix are never checked they are not accurate anymore. Also the start-up after a changeover is not planned within these times. As can be seen there is only a correlation at line 7 between the amount of changeover time and the hour's difference at the end of the week (table A1.7)

TABLE A1.7 CORRELATION CHANGEOVERS

Week	Lijn 21	Lijn 22	Lijn 3	Lijn 51	Lijn 7	Lijn 81	Lijn 82
201342	270	250	240	100	540	540	50
201343	320	310	510	120	600	460	70
201344	230	540	260	150	430	500	40
201345	410	250	330	100	670	360	90
201346	260	440	375	50	430	420	40
201347	320	200	375	160	540	310	90
201348	215	180	210	100	360	370	80
201349	160	110	450	190	690	520	90
201350	420	210	890	90	490	360	30
201351	300	140	355	110	690	530	90
20141	335	50	80	20	150	230	40
20142	100	220	260		290	330	40
20143	350	330	415		130	440	70
20144	285	180	330		420	420	30
20145	305	120	400	80	670	300	80
20146	130	420	290	90	510	550	
20147	590	160	705	110	820	720	10
20148	100	210	400	30	430	380	30
20149	540	70	220	170	670	560	80
201410	435	300	385	120	550	450	50
201411	525	240	395	140	760	460	30
201412	275	420	270	130	250	410	70
0.087304 0.163402 0.114064 0.243905 -0.6619 0.213878 0.223049							

Table A1.8 shows the actual speed versus the planned speed over a half year (oct'13 – march'14) in order to get some insight in the difference in reality. As can be seen line 3 has the biggest difference.

TABLE A1.8 CORRELATION CHANGEOVERS

Line and order type	Planned speed (Average)		Realised speed (Average)	% Difference
	Dzn	flesjes	flesjes	
Col 03 (gewogen)	3627	77196	84000	108,8%
Col 03 (18-Pack)	4060	73080	84000	114.9%
Col 03 (2x12-Pack)	3333	79992	84000	105.0%
Col 21	1667	40008	41222	103.0%
Col 21 (330/355)	1667	40008	40000	100.0%
Col 21 (207/250)	1667	40008	42000	105.0%
Col 22 (gewogen)	-	25528	25940	101.6%
Col 22 (650)	1875	22500	23000	102.2%
Col 22 (330/355)	1667	40008	40000	100.0%

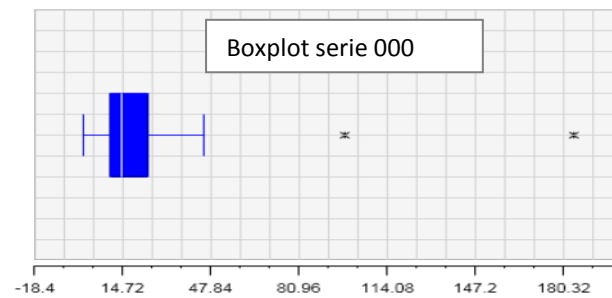
The consequence for the OPI of the lines can be found in table A1.9. While the target for the line is measured by their OPI they want to achieve a higher OPI. That is why they want to change only the efficiency and not their maximum planning speed.

TABLE A1.9 REAL OPI

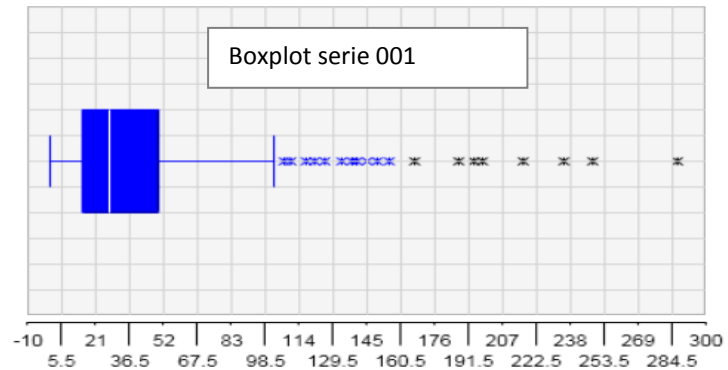
	Lijn 21	Lijn 3	Lijn 22
Average OPI Before	70.2%	67.4%	61.1%
Average OPI After	69.3%	62.0%	59.8%
Vershil OPI	.9%	5.4%	1.3%
Doel OPI	60.6%	62.9%	62.3%

Appendix 2: Boxplot analyse

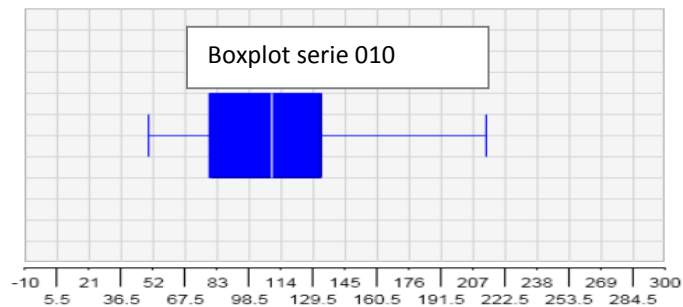
Q1	10,5
min	0
mediaan	14
max	184
Q3	23
n	30



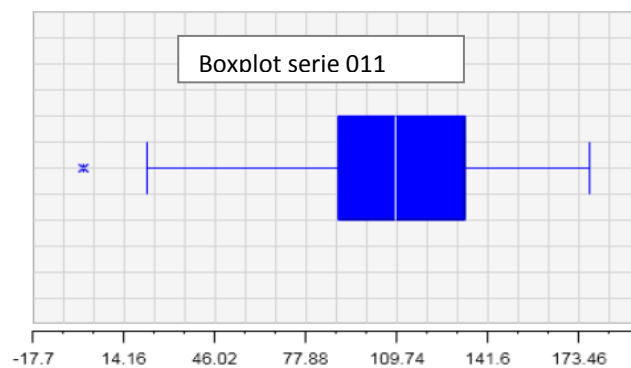
Q1	15
min	-208
mediaan	27
max	868
Q3	48,5
n	228



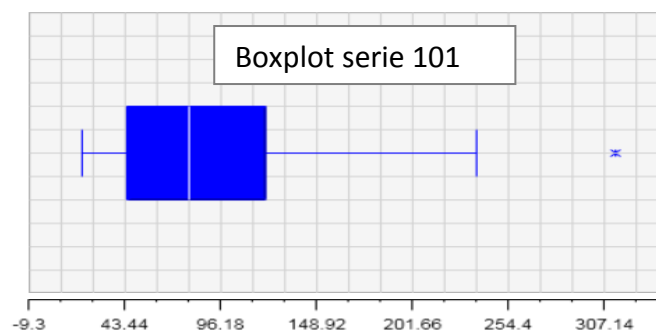
Q1	79,75
min	50
mediaan	109
max	2272
Q3	129,5
n	24



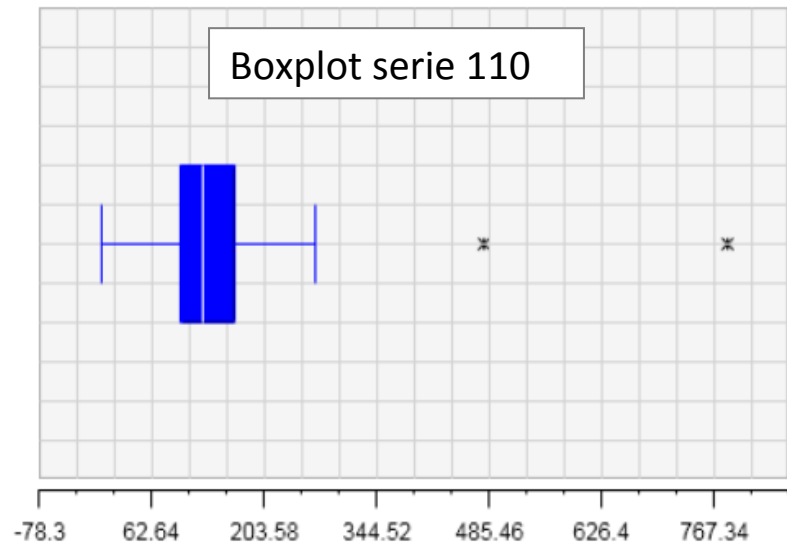
Q1	92
min	30
mediaan	112
max	177
Q3	133,75
n	42



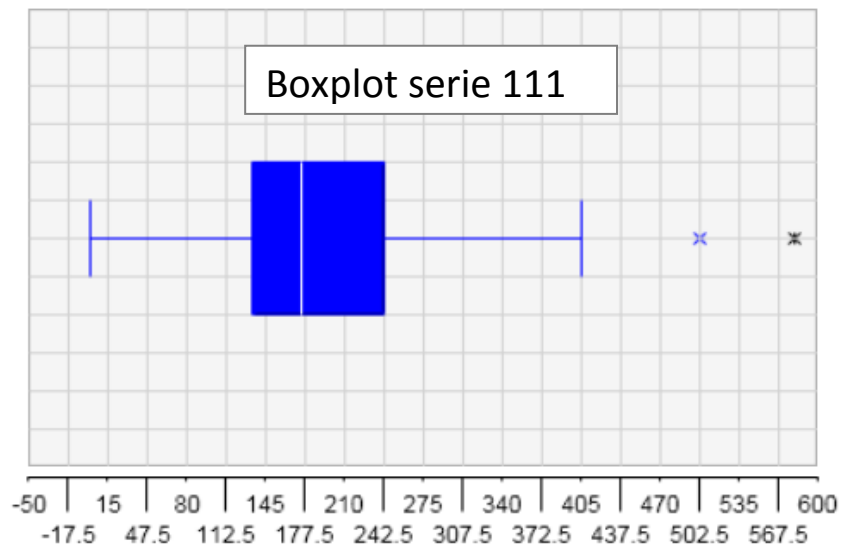
Q1	44
min	20
mediaan	78,5
max	313
Q3	118,75
n	10



Q1	98
min	0
mediaan	125,5
max	783
Q3	162,5
n	34



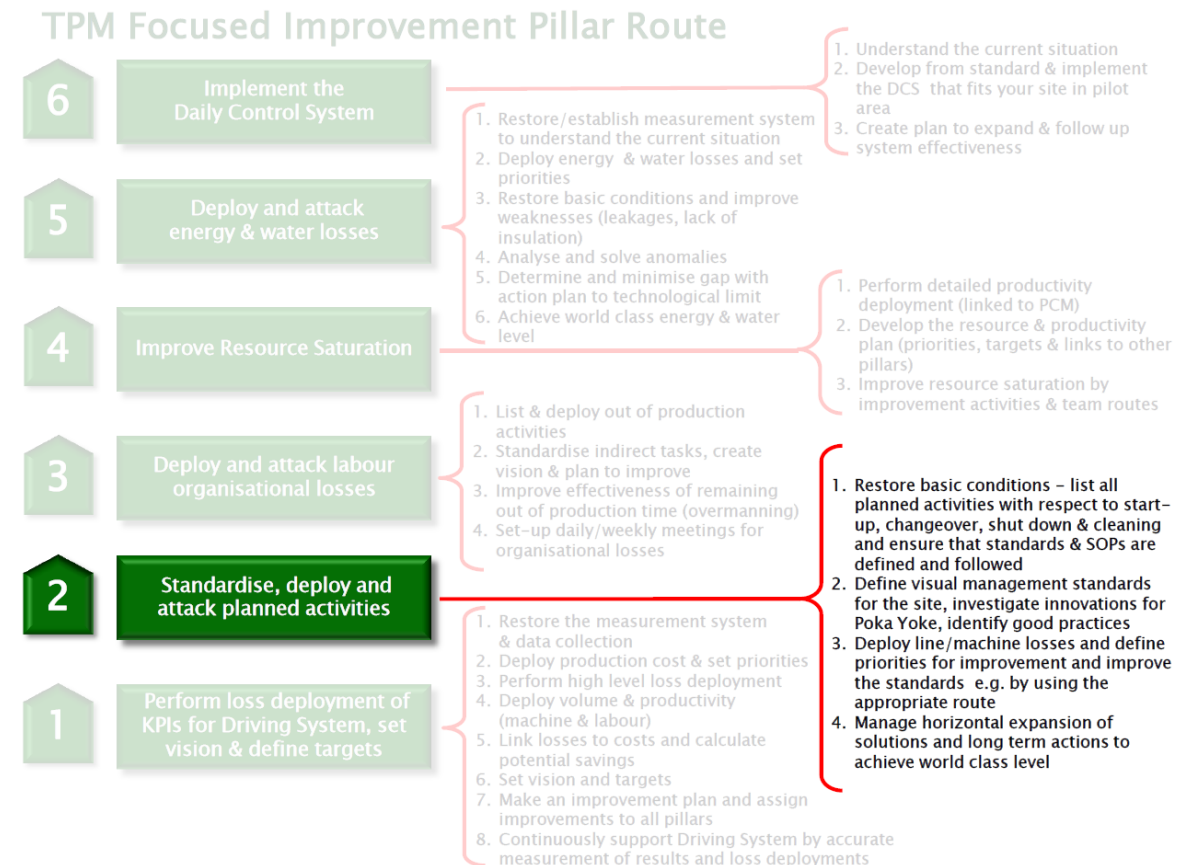
Q1	136,5
min	0
mediaan	175
max	4737
Q3	236,5
n	35



Appendix 3: TPM Routes FI changeover

FI-Pillar

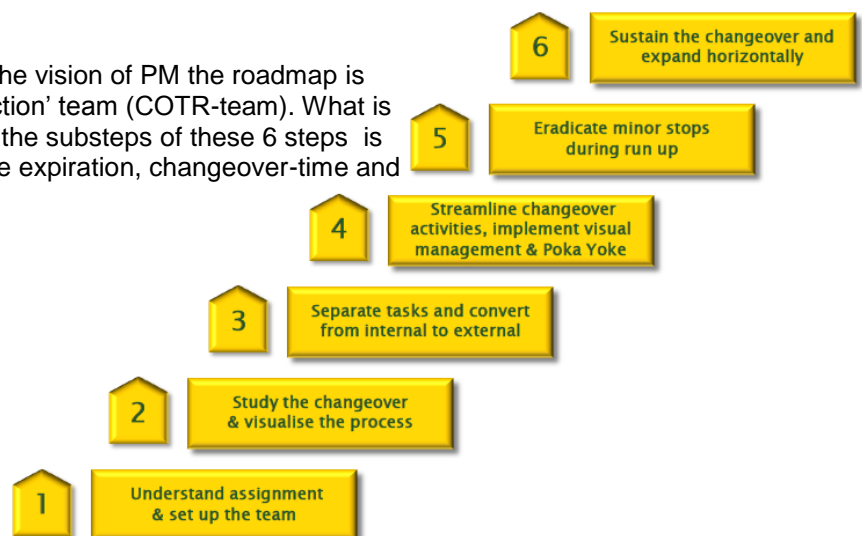
The planned down time is the second step of the FI-pillar. This step is called 'Standardize, deploy and attack planned activities' and consists out of 4 different steps.



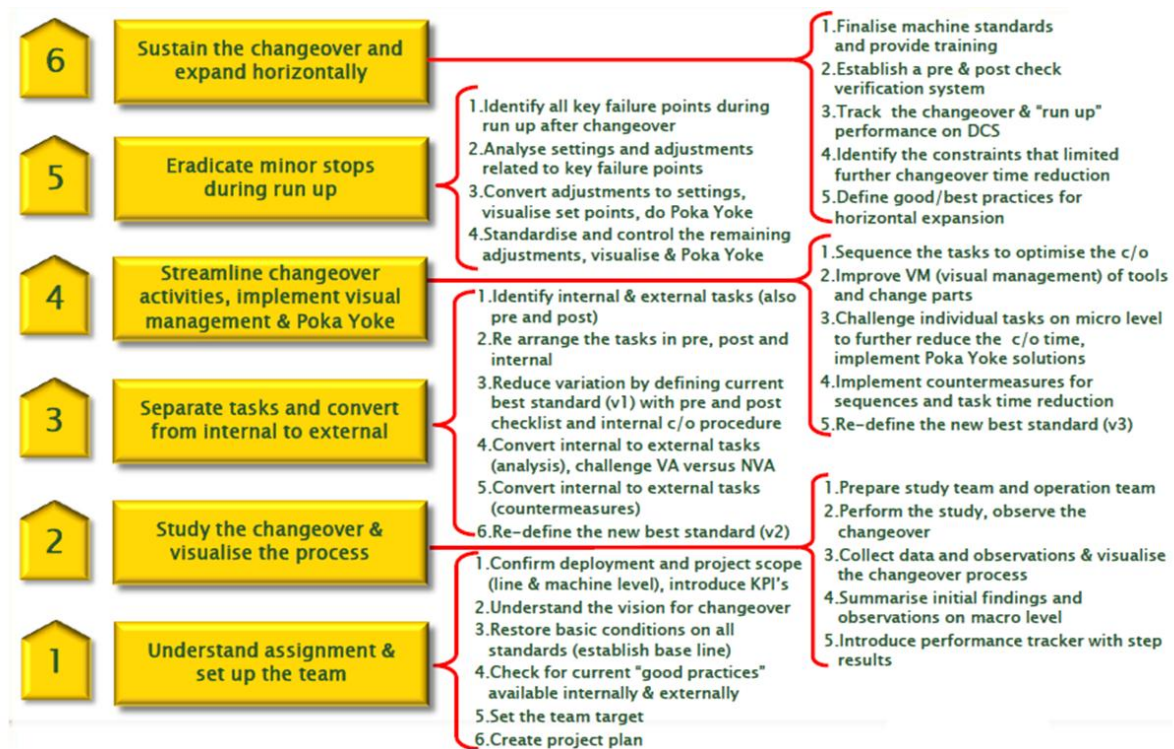
These steps first of all focus on the workstandards, then the visual standards and good practices, then the data deployment and Pareto analysis and the last step is to retain the improvements and keep further improving.

COTR Team Route

In order to get a more detailed view of the vision of PM the roadmap is showed of a 'Change Over Time Reduction' team (COTR-team). What is not clear in this figure but comes out of the substeps of these 6 steps is that they make a distinction between the expiration, changeover-time and the run-up after the changeover.



The COTR Team reduction route steps 2 till 6 are interesting with respect to the question answering in this section. Step 2 suggests that it is important to have some insight in the performance of the current changeovers and emphasis the need for good data and a performance checker.



Step 3 shows the importance of standards and dividing the changeover into three categories; pre,- internal and post-changeover. Step 4 looks to the sequence of the different tasks and the visual management of these tasks. Step 5 focuses on the minor stops during the run up after the changeover. Step 6 looks to the sustainability of the solutions and improvements and looks for horizontal expansion of the good/best practices.

Appendix 4: Real OPI composition

The main causes of downtime are given in figure A.6.1. The figure shows that planned downtime is 9% of the total time available (manned time). Figure A.6.1 shows the parts inside the planned downtime.

FIGURE A.6.1 OPI VALUES BASED ON PLANNING

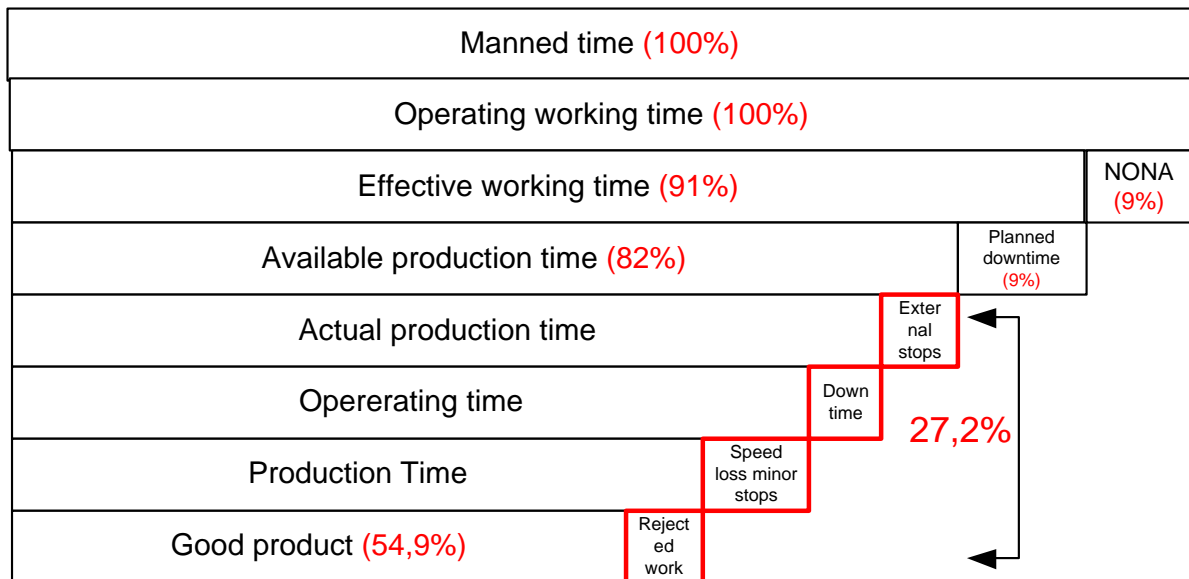
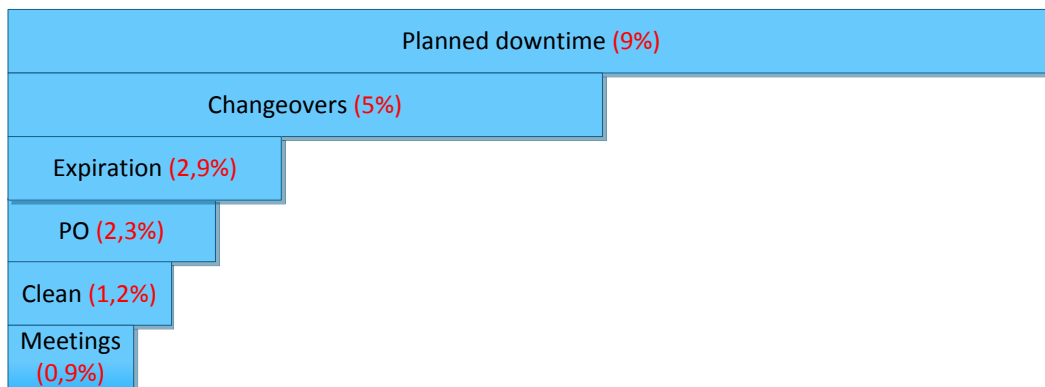


Figure 2.1.4 shows that the available production time is mostly affected by the changeovers (5%, yearly 3600 hours). One hour is (on average) 250 euro which gives an approximate total cost of almost one million euro per year.

FIGURE A.6.1 OPI VALUES PLANNED DOWNTIME



Because this data is from planning it only gives an approximate insight of the composition. In reality this proposition may differ a bit but for now this gives a good indication of the current situation.