Success of Early Equipment Management, Autonomous Maintenance and Training & Education in the start-up of a new production line
A CASE STUDY AT HEINEKEN
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PERSONAL
Author D.J.W. Querido
Student number 1330071
Email D.J.W.Querido@student.tudelft.nl

COMMITTEE
Chair Prof. Dr. Ir. P.M. Herder (Section Energy & Industry)
First Supervisor Dr. T. van der Lei (Section Energy & Industry)
Second supervisor Dr. P. de Vries (Section Systems Engineering)

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TPM, EEM, AM, T&E, Production Start-up
Preface

This thesis presents the results of my graduation research project for the MSc program Systems Engineering, Policy Analysis and Management (SEPAM) at Delft University of Technology. This research was performed at the packaging department of Heinekens Brewery at Zoeterwoude. The introduction of Heinekens new green Start Bottle for the Dutch market required a new production line, which had to be started up. This event was a great opportunity for me to perform my graduation project. This thesis contributes to a better understanding of what to consider making the Total Productive Maintenance elements Early Equipment Management, Autonomous Maintenance and Training & Education more successful in production start-ups, by looking at these elements from different literature perspectives. This resulted in new insights in TPM literature as well as new practical insights for Heineken.

I would like to take the opportunity of thanking a few people, because they were of great support to achieve this final result.

First of all I would like to thank the members of my graduation committee for their criticism and advice: Prof. dr. ir. P.M. Herder, dr. T. van der Lei and dr. P. de Vries.

Next, I would also like to thank all the employees at Heineken for which I have been working with during my six month internship, in particular Ir. T. van Dieren for his wise lessons, not only content wise, but also looking at my further career. Everybody at Heineken took their time for me long interviews, discussions or informal talks were never a problem.

Not to mention, I would like to thank my fellow students with whom I shared joys and sorrows during my student days.

Finally, I would like to thank my personal society and in particular my parents who have always supported me during my study and beyond. They always kept faith in me and especially during my graduation they were very involved.

D.J.W. Querido

Delft, July 2013
Executive summary

Manufacturing organizations have to become more competitive as before. In the fast consuming market there are two important things organizations can do; introduction of new products and create more efficiency in every day operations. First, introducing a new product sometimes means building a new production line. Building a new production line means starting up a new production line, which can be quite a complex process. Secondly, to become more efficient, production philosophies like Total Productive Maintenance (TPM) can be used. Especially in the start-up of a new production line, the TPM elements Early Equipment Management (EEM), Autonomous Maintenance (AM) and Trainings and Education (T&E) are important. In this research production start-up and TPM come together. The purpose of this research is to look at what factors influence the success of these three elements in the start-up of a new production line. The meaning of success differs for the three elements. Success per element will now be stated:

- **EEM**: Equipment satisfaction and a vertical start-up of a new production line.
- **AM**: Quick and successful implementation of AM step three in the start-up of a new production line.
- **T&E**: Aspects that operators find important in a T&E program during the start-up of a new production line.

The answer to what could possible influence the success of these three elements could not explicitly be found in literature. Research is needed and in this case performed at the packaging department of Heineken. EEM, AM and T&E are investigated in a case study during the start-up of a new production line at Heineken. The approach of this research was the following.

EEM success is determined in different life cycle stages or parts, the two most important ones for this research are investigated; the design, manufacture and installation part (DMI) and the start-up part. For both parts factors are found which might influence equipment satisfaction and a vertical start-up. TPM literatures is not adequate to provide enough factors and for both parts supporting theories, that show relations with the DMI part and the start-up part, are used to provide extra influential factors. For the DMI part theory on systems engineering (SE) is used and for the start-up part theory on production start-up (problems) and project & process management is used to provide more factors that might influence EEM success.

AM needs to be implemented fast so that operators take ownership over their equipment quick. Literature is quite poor in showing what might influence the process, especially in organizations that are already familiar with AM. The case at Heineken did suggest that next to AM barriers, also general TPM implementation barriers are applicable when implementing AM in a new production line. Therefore both are investigated on their influence on a quick and successful implementation of AM step three.

T&E is important to close operators knowledge gaps which new production start-ups generate. Again TPM literature is not clear on what operators might find important in T&E during start-ups. This research used learning improvement theory to provide base factors on which operators could elaborate, so that it becomes clearer what they find important.

To investigate the proposed factors (and their influence on success) extensive interviews/discussions with important parties (different for each element) together with observations were performed. Per elements the most important results will be stated.
Most important result in the EEM DMI part was:
Factors from TPM literature are present in the LE0 case and influence both equipment satisfaction and vertical start-up. A very important factor is focus on design reviews. Factors from SE theory also seem to influence both EEM goals. A very important factor is outsourcing.

Most important result in the EEM DMI part was:
No factors were found in TPM literature. Factors from start-up theory especially seemed to influence the vertical start-up. A very important factor is inappropriate management decisions. Factors from project & process management were present, but their influence to EEM success was hard to demonstrate. Only an adversarial relation with the supplier influenced the equipment satisfaction.

Most important result in AM was:
Both Am barriers and general TPM implementation barriers seem to influence a quick and successful implementation of AM step three in the start-up of a new production line. A very important factor is management support.

Most important result in T&E was:
Theory on learning improvement was very useful to create more insight in what operators find important in T&E during a start-up. However many other factors have to be considered making T&E really successful.

By describing the most important influential factors, relations between them became visible. Especially the important factors mentioned in the latter paragraph seem to play a central role in relation to other factors. The thorough descriptions of the factors, together with insight in the relations, made it possible to state really tangible recommendations for Heineken on the three elements. The most important recommendations per element will be stated.

Most important recommendations for EEM are:
- Create a more transparent and mutual relationship with the supplier about EEM
  - Perform design reviews with supplier
  - More cooperation in managing the integration of the total system
- Create more understanding and commitment towards EEM within the company Heineken
- Create more alignment, cooperation and commitment between project members

Most important recommendations for AM are:
- Ensure more management support looking at the following:
  - Initiating 5s
  - Creating an environment for communication and initiate this
  - Steer on using AM system to solve problems from the early start
  - Provide enough AM knowledge within every AM responsibility
  - Every step and associated step is thoroughly analysed
  - Clear objective on production vs. AM

Most important recommendations for T&E are:
- Make sure the trainings contribute most to operator learning by:
  - Choosing trainers that can motivate operators
  - Ensuring that practical trainings should immediately follow theoretical trainings
Making the circumstance of practical trainings as optimal as possible (small groups, quite environment and running machines)

- Make sure the knowledge distribution is equal in each shift when scaling up
- Supporting tools or documents should be available and easy accessible from the early start
- Make sure every operator interacts with support
- Beware that T&E does not suffer too much from the focus on production

All in all this research showed that by spitting EEM in two parts and using supporting theory on systems engineering, production start-up and project & process management, gave more insight in what to consider for EEM success (equipment satisfaction and vertical start-up). Next to that did this research show that apart from existing AM barriers, general TPM implementation barriers can be used to create more insight in how to quickly and successfully implement AM step three in the start-up of a new production line (in a company familiar with AM). Finally this research showed that theory on learning improvement is applicable to operators and gives more insight in what operators find important in T&E when starting up a new production line.
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## Abbreviations

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<th>Description</th>
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<tbody>
<tr>
<td>5S</td>
<td>Sort, Set order, Shine, Standardize and Sustain</td>
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<tr>
<td>AM</td>
<td>Autonomous Maintenance</td>
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<tr>
<td>AO</td>
<td>All Round Operator</td>
</tr>
<tr>
<td>CILT</td>
<td>Cleaning, Inspecting, Lubricating and Tightening</td>
</tr>
<tr>
<td>DMI</td>
<td>Design, Build and Install</td>
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<tr>
<td>EEM</td>
<td>Early Equipment Management</td>
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<td>KHS</td>
<td>Filling and packaging equipment supplier of LE0</td>
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<tr>
<td>LE0</td>
<td>New packaging line at Zoeterwoude</td>
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<tr>
<td>LOI</td>
<td>List Outstanding Items</td>
</tr>
<tr>
<td>MI</td>
<td>Manufacturing Inspection</td>
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<td>MP</td>
<td>Maintenance Prevention</td>
</tr>
<tr>
<td>NVA</td>
<td>Non Value Adding Costs</td>
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<tr>
<td>OEE</td>
<td>Overall Equipment Efficiency</td>
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<tr>
<td>OPI</td>
<td>Operational Performance Indicator (in this research the same as OEE)</td>
</tr>
<tr>
<td>PCO</td>
<td>Process Control Operator</td>
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<tr>
<td>TPM</td>
<td>Total Productive Maintenance</td>
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<tr>
<td>SAT</td>
<td>Site Acceptance Test</td>
</tr>
<tr>
<td>SE</td>
<td>Systems Engineering</td>
</tr>
<tr>
<td>SO</td>
<td>Specialist Operator</td>
</tr>
<tr>
<td>VA</td>
<td>Value Adding Costs</td>
</tr>
<tr>
<td>WPO</td>
<td>Werk Plek Organisatie</td>
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1. Introduction & Research Proposal

This chapter will give a short introduction on TPM and production start-up. Furthermore this chapter builds a research proposal that will be executed during this research.

1.1 Introduction

This research will investigate what could influence the success of the Total Productive Maintenance (TPM) elements Early Equipment Management (EEM), Autonomous Maintenance (AM) and Training & Education (T&E) in the start-up of a new production line, by identifying factors from several underlying theories. Success for the three elements is defined differently and will be explained during the course of this chapter. This research concerns a case study performed at the packaging department at Heineken Zoeterwoude. This introduction gives a quick impression of the importance of production strategies like TPM and will give a short introduction to TPM and production start-ups.

The beer market is becoming more competitive, even the largest breweries cannot only rely on economies of scale and have to come up with new solutions to stay competitive (Heineken, 2011). There are two important things a brewery like Heineken can do to realize this: be more efficient in every day production processes and introduce new products to create more consumers welfare (Hausman & Leonard, 2002).

Efficiency in today’s organizations is becoming more and more important. To survive and remain competitive in today’s challenging environment organizations must excel in their activities, the beer industry is no exception (Heineken, 2011). For these kinds of manufacturing organizations, this means realize safe and maximum equipment performance with minimal downtime. To achieve this, an effective production program is essential. This way an organization can stay competitive and realize profit. Especially in today’s dynamic environment, reliability of a production system is depending really much on maintenance management and therefore maintenance is becoming more than ever a strategic issue for many manufacturers (Ahuja, 2011a).

Operation of equipment is the major contributor to the performance and profitability of manufacturing systems. Hence, equipment management is an indispensable function in a manufacturing organization. Nowadays maintenance is an important aspect of equipment management. The objective of maintenance is to reduce breakdowns and ensure maximum availability and reliability against minimal costs (Shamsuddin et al., 2005). In countries with high labour costs particularly, increased automation has been a widely used strategy to reduce costs (Ahmed et al., 2005; O’Sullivan et al., 2011). A highly automated plant will have fewer employees, but more expensive and complex machinery. More automation does not mean that labour becomes superfluous, operations and maintenance may become less or easier, but are still of vital importance for smooth running machinery (Rolfsen & Langeland, 2012).

To stay competitive by more efficiency, manufacturing organizations try to achieve world-class manufacturing. To become world-class, organizations have to perform according to very high overall equipment efficiency level (OEE) (Elbadawi et al., 2010). There are several production concepts that could contribute to a world-class status, such as: Total Quality Management (TQM), Total Productive Maintenance (TPM), Just-In-Time (JIT) and Total Employee Involvement (TEI) (Ahuja, 2011b).
TPM is a methodology that could meet the current ambitious production demands (Ahmed et al., 2005). Looking at the world-class programs motioned above TPM was introduced last. TPM stands for Total Productive Maintenance or Management, in which:

Total = All-encompassing by maintenance and production individuals work together.
Productive = Production of goods and services that meet or exceed customers’ expectations.
Maintenance = Keeping equipment and plant in as good as or better than the original condition at all times.

TPM originated in Japan in the 1970’s and is developed by extending preventive maintenance to become more like productive maintenance. TPM focuses on the identification and elimination of waste, inefficient operation cycle time and quality defects in manufacturing and processes (Ahuja, 2011b). The ultimate goal of TPM is zero defects, zero breakdowns and zero accidents. TPM seeks to engage every level of the organization to maximize effectiveness of production assets, but the real emphasis lies on the relation between operations and maintenance (Ben-Daya et al., 2009). In TPM, there is a large responsibility for production employees (operators). Operators are not only designated to operate machines, but also to detect abnormalities, perform small maintenance tasks and keep the shop floor organized and clean (Ahuja, 2011b). TPM has a unique eight-pillar approach for excellent planning, organizing, monitoring and controlling practices. The eight pillars are manifested on the basis 5S, which means the creation of a work environment that is clean and well organized. The TPM pillars are shown below in figure 1. A lot of companies struggle with implementing TPM, causes are for instance: lack of management support, employee resistance (Cooke, 2000), to much workload for operators, lack of time for TPM activities, too much focus on production (Rodrigues & Hatakeyama, 2006), lack of training, lack of communication (Ahuja & Khamba, 2008a) and wrong pace of implementation (to much at ones), lack of operators willingness to learn, inadequate training, non encouraging workplace in the absence of 5s, (Ben-Daya et al., 2009).

Apart from becoming more efficient by executing TPM, the other thing that manufacturing companies can do to stay competitive is introducing new products. New product introductions are very important to stay competitive in the fast moving consumables market, because the introduction of new products increases customer’s welfare (Hausman & Leonard, 2002). The introduction of Heinekens Start Bottle on the Dutch market is an example of this. Sometimes the introduction of a new product results in the need for a new production line, this also applies for the Start Bottle. When a new production line is build, it also has to be started up.

Apart from the difficulties of implementing TPM, the start-up of a new production line with new equipment, is also not an easy task. For most companies it is important that the start-up of new

Figure 1 Eight TPM pillars and 5s (Ahuja, 2011)
production reaches its desired volume as quickly as possible. Literature calls this process time-to-volume. If the time-to-volume is delayed according to the forecast, revenues will be postponed. Therefore, it is desirable that the start-up of a new production line reaches its desired volume level as quickly as possible and that the return on investment and return on assets payback period will be short. Last, a good start-up is important for the manufacturer’s market share, because revenues can be lost and reputation can be damaged if the delivery to customers is delayed (Ball et al., 2011). To reach the desired production volume quick, the start-up curve (OEE) has to be as vertical as possible. Figure 2 below shows the difference between a traditional start-up and a vertical start-up.

In this research TPM and production start-ups come together while this research investigates the success of TPM in production start-ups. There are three TPM elements important in a start-up; EEM, AM and T&E. EEM is about designing machines with lessons learned from the use of older machines and also aims at a vertical (problem free) start-up of new production lines. AM is more or less self-management of the work floor by operators and T&E fills employees knowledge gaps in performing daily tasks. For EEM success this research will look at which factors could influence the mentioned goals; design machines with lessons learned (so equipment satisfaction) and a vertical start-up. For AM success this research will look at what factors influence a quick and successful implementation of AM step Three in the start-up of a new production line. Last for T&E success this research will look at what operators find important for a successful T&E program in a start-up. The three elements will broadly be explained in chapter three. All this information is lacking at Heineken, but also to a large extend in literature. The next chapter will give more clarification on the problem that Heineken has and states the theoretical gaps that exists in TPM literature.

1.2 Problem definition

This research is executed at the manufacturing firm Heineken Zoeterwoude, Heineken is therefore the problem owner and client of this research. Still this research is not particular written from a practical ‘’Heineken’’ point of view, but with the intention to give more meaning to TPM success in production start-ups and thereby giving scientific value to this research. First Heinekens problem will be elaborated and after that the theoretical gap in literature.

1.2.1 Heinekens problem

The introduction of Heinekens Start Bottle requires a new returnable packaging line for the domestic market. Heineken calls this project LE0. The main reason for LE0 is that the old production line (line 11) is not capable of processing the new materials. The basic technology and functioning behind the
new equipment is known, however the machines are state of the art and require different user requirements from operators (Dieren, 2012).

At the beginning of this research (one month before start-up) the German manufacturer KHS is seven days a week busy to construct the new line for Heineken. After construction, the production start-up period can begin. New production start-ups are inevitably accompanied with problems and LE0 is assumed to be no exception. Possible start-up problems and their relation to TPM success will be treated in the course of this research. Start-up problems generally express themselves by a lower OEE as desired (see figure 2). Literature states it, but Heineken also previously experienced bad start-ups.

When the operation of a new line starts, initially processes are poorly understood and over time, through learning about processes and equipment (T&E), knowledge and capacity utilization can go up (Terwiesch & Bohn, 2001). The knowledge gap that arises by the introduction of new equipment needs to be closed. However operator knowledge is not the only thing that has to be taken into account when building and starting up a new line, also the system design (EEM) (Shirose, 1984) and a quick implementation of AM have to be considered.

To set the scene and create a sense of urgency on the importance of good start-up management, the last start-up of Heinekens packaging line eight will be described. The description is based on two extensive conversations with Heinekens employees, one with a team leader (operator manager) at that time (Gorter) and one with a technical manager at that time (Pronk), both very close involved during the start-up period and the period after start-up of line 8.

In 2008, a new production line in Zoeterwoude was constructed, line 8. This line is packing Heineken and Amstel light for the United States market. In contrast to LE0, which is a returnable packaging line, line 8 is a one-way line. In a one-way line there are no crates involved, only new batches of bottles are being filled and put in carton. The main supplier and contractor for the equipment was Krones, a German firm that develops and manufactures machines and complete lines in the field of process, filling and packaging technology (Krones.com). TPM within Heineken was not very mature yet and EEM did not even exist, also AM, T&E and 5s were moderately present. Because the lack of EEM, the machines that Krones delivered were standard Krones machines with no extra Heineken requirements.

The strategy in which Heineken tackled this start-up would be different as before. T&E would get extra attention for instance. However, the project of line 8 ran out of budget and the reserved budget for trainings was put down to a minimum. This meant that there was only some basic pre training and Krones engineers would support operators during the start-up. Unfortunately Krones was too much in charge of the machines the first weeks, which inhibited the knowledge gaining of operators. Heinekens T&E approach in the start-up of LE0 is totally different and could be called quite innovative. A group of skilled operators are trained in advance (in theoretical and practical trainings) and have to be more in charge of the machines from the early start of production. The manufacturer is still present, but has a more supporting role. Not all the operators are trained in advance and the ones who did receive training have to teach others on the shop floor, when the shifts scale up and non-educated operators enter LE0. How successful this new T&E strategy of Heineken is, is uncertain. How operators experience all this and what they find important for T&E in start-ups has to come forward during this research. This information should help Heineken in considering T&E programs in future start-ups.
Another very important change is that in LE0 EEM is being used. This broadly means that lessons learned from the use of old equipment is translated into the design of the new equipment (Strater, 2012). Next to that is Heineken also aiming at a vertical start-up by using EEM. Because EEM is rather new in Heineken Zoeterwoude (LE0 is the first line that is really build under the flag EEM), there are probably a lot of lessons to be learned to make this concept a success. Heineken has little insight in what factors could influence the success of EEM. Again EEM success in this case means equipment satisfaction and a vertical start-up.

Last, short after the production starts, the machines and operators have to be in AM step three. This means that operators have to be able to manage their workplace and perform many small maintenance tasks autonomously. This is very important since deterioration of machines starts from day one and the machines have to stay in new, basic, conditions as long as possible. This makes maintenance easy, extends the lifecycle and decreases downtime of equipment. On top of that does a proper AM level indicate that operators are able to autonomously operate their machines and environment, which is necessary when the supplier leaves. Fact is that Heineken operators are quite familiar with AM, but the process has to be initiated and implemented all over again in a new line. How to manage this tight, time pressing process and which factors influence this success is not yet clear. The immediate implementation of AM in a complex start-up process, in which new technologies have to be mastered is very ambitious and may encounter problems, but which factors really influence the success of this process is uncertain.

It is now clear that Heineken is approaching the start-up of LE0 with a new strategy, it is therefore questionable how things will turn out in reality and whether there might be new unforeseen bottlenecks, problems or points for improvement in their strategy. The whole start-up process (and design of the new line), will be used as a case study to create more insight in factors that influence the predetermined success of EEM, AM and T&E during start-up.

1.2.2 Theoretical gap
Since the foundation of TPM in 1970s in Japan, quite some literature evolved on this topic (Ahuja, 2011). However, if one takes an overall look, most literature is about the general implementation of TPM, the organizational success factors or barriers of TPM implementation and the benefits of TPM in manufacturing/production plants. Examples are: [Ahuja, 2011a] [Ahuja & Khamba, 2008a] [Bamber et al., 1999] [Tsarouhas, 2007] [Sum, Yam, & Wai-Keung, 2003] [Ahmed et al., 2005] [Ahuja & Khamba, 2008a] [Park & Han, 2001] [Cooke, 2000] [Lycke, 2003] [Ahuja & Kumar, 2009].

Heineken implemented the TPM philosophy in 2006 (Jacobs, 2012). Literature states that most companies take and average time of 3 to 5 years to successfully implement TPM. This period is required because organizations must undergo a change that has to be supported by every member in the organization (Blanchard, 1997). If one takes this time factor into account, Heineken should already have quite a high maturity level in executing TPM. Although it does not express itself always, most Heineken employees have quite a high level of TPM knowledge and skills (Ipskamp, 2013). In the start-up of Heinekens new production line LE0, the TPM elements EEM, AM and T&E play an important role. The concept of AM is pretty well known within Heineken, but has to be implemented all over again in a new line. Nowhere in literature could be found if companies that are familiar with AM implement and adopt this process easy in a new production line and if there are certain factors
that influence a quick and successful implementation of this process. This research will therefore try to find factors that could influence this.

EEM is fairly new in Heineken, but seems to be the only TPM element that has a direct link to production start-ups, because it states something about a vertical start-up and designing equipment that is ‘‘maintenance free’’ (Shirose, 1984). However how to achieve these EEM goals and which factors could influence this, is rather lacking in literature. Both scientific authors as well as Heineken employees don’t have one shared understanding of what EEM really means and how it could contribute to a start-up process. This research tries to give more body to EEM and tries to discover possible factors that could influence successful EEM in start-ups.

Last at Heineken a production start-up approximately takes ten weeks, at least the commissioning period does. Ball et al. (2011) state that the start-up of a new production line is a key learning moment for organizations. New technology is used and adjustments to products and processes might be needed to achieve the desired level of output (in our case the desired OEE). The start-up of a new production line can be seen as a learning process in which the system is incrementally understood until a certain maturity level. Operators learning by participating in the start-up process can be seen as autonomous learning and induced learning and this should contribute to the knowledge increase of individuals (Lapre et al., 2000). However, what aspects they really find important during a T&E program in the start-up of a new production line is not elaborated in literature and has to come forward during this research.

Heineken is applying EEM, AM and T&E in their new production line, which creates a great opportunity to investigate the three elements. Stating and observing factors that influence EEM, AM and T&E success in a start-up could open new doors in literature and avenues for follow up research.

1.3 Research objective(s)

The theoretical gaps automatically result in the research objective(s) of this thesis. The overall research objective can be defined as follows; create a better understanding on factors that influence the success of the TPM elements EEM, AM and T&E in the start-up of a new production line, by adding and investigating factors from TPM as well as supporting theories. Because success of the three elements varies very much for each element sub objectives will be stated. The three sub objectives of this research are the following:

- Early Equipment Management
  The EEM research objective is to give more body and understanding to the concept EEM by trying to identify what factors influence the success of EEM in the start-up of a new production line, by investigating factors from TPM and possible supporting theories.

- Autonomous Maintenance
  The AM research objective is try to identify what factors influence a quick and successful implementation of AM step three in the start-up of a new production line, by investigating factors from TPM and possible supporting theories.
• Training and Education

The T&E research objective is try to identify what operator find important during a T&E program in the start-up of a new production line, by investigating factors from TPM and possible supporting theories.

One could see that success for the three elements varies very much. This research often elaborates on the success of EEM, AM and T&E, therefore one has to keep in mind that this success is different for each element. All the knowledge and data needed for this research will be gained through literature research, a view on historical and current experiences in Heineken, interviews with different actors involved in the start-up process, small conversations and active participation and observations in the start-up process of the new production line (LE0) at Heineken.

1.4 Research questions

Main question
What factors have to be considered making the TPM elements EEM, AM and T&E in new production start-ups successful, what theories give more insight in this and how to manage all this?

Sub questions
1. What does the literature say about TPM and in particular EEM, AM and T&E and what influential factors derive from this?
2. What does the literature say about production start-ups, the possible problems and what influential factors derive from this?
3. What supporting theories could be used to create insight in the success of EEM, AM and T&E in production start-ups and what influential factors derive from this?
4. To what extend are the assumed influential factors present in the Heineken case, are there additional factors and do they have to be considered for EEM, AM and T&E success in production start-ups?
5. What recommendations should Heineken consider making the TPM elements EEM, AM and T&E in production start-ups successful?
6. What is the added value of the findings in this research to the existing knowledge on TPM?

1.5 Research approach

This research is meant to create more theory around TPM in production start-ups; therefore this research could be described as theory building explorative research. The research strategy comprises a case study. According to Verschuren & Doorewaard (2010) there are two types of case studies; the single case study and the comparative case study. The investigation in the start-up of LE0 determines the fact that this research contains only a single case study. All the data used for this research derives from one company; Heineken. The most important data for this research comes from interviews with Heineken employees and observations. How this was approached will be explained chapter seven. Looking at the research questions, this research project can be divided into three phases, namely: the exploration phase, the data gathering phase and the recommendation and evaluation phase. The sub questions can each be assigned to one (or more) of these phases. This chapter will shortly state, which questions belongs to which part, how the questions will be answered and why they are important for this research.
The exploration phase
Sub questions one to three could be assigned to the exploration phase of this research. Since this research, according to Verschuren & Doorewaard (2010), can be described as theory building explorative research, the exploration phase of this research is very important and covers a large part of this research. Sub question one can be answered through an extensive literature study on TPM and in particular EEM, AM and T&E. Answering this question creates a first list with factors that could influence the success of EEM, AM and T&E in start-ups. Sub question two tries to identify possible problems that a start-up can entail. This is important information because this could also influence or have relation to the success of TPM in a start-up. This research therefore tries to derive factors from start-up theory that could influence EEM, AM or T&E success. This question will be answered by consulting literature. Answering this question will add more influential factors to the list that was already created answering sub question one. Sub question three can be answered by looking at EEM, AM and T&E at Heineken. This should create more insight in supporting theories that could add factors to EEM, AM and T&E, to investigate what influences their success. Using Heineken data, performing small conversations and using observations will partly answer this question. Deliberating supporting theories must create more insight in which factors could influence EEM, AM and T&E success. On top of all this does it become clear if Heineken has adopted TPM as literature describes it. The end product of answering this question will be a final list with factors that could influence the success of EEM, AM and T&E in start-ups.

The data-gathering phase
The data-gathering phase basically covers the entire research period at Heineken, because important data is gathered from day one. However answering sub question four covers the most important data gathering. Answering this question makes it clear which factors, in what way could influence the success of EEM, AM and T&E. On top of that could additional factors that were not stated in advance come to the surface. It also clears if other theories can support TPM elements and have to be taking into account looking at the success of TPM in start-ups. To investigate the factors, important actors (different for each element) are interviewed and observations are done by actively participating in the start-up. Which actors are interviewed for which TPM element will be explained in the data approach and results chapter of this research (chapter seven). Also the strategy used in the interviews will be explained in that chapter.

The recommendation and evaluation phase
Sub question five and six could be assigned to the recommendation and evaluation phase of this research. This phase is meant to transform the outcomes of this research into recommendations for future start-ups and to see to what extent this research adds new knowledge to the existing theory on TPM. Sub question five can be answered by translating the findings of this research into managerial recommendations for EEM, AM and T&E success in future start-ups. This information is important since Heineken is inexperienced in TPM policies in production start-ups and very keen in getting more insights in the success of TPM in start-ups. Also literature fails when it comes to TPM in production start-ups. The answer to sub question six will give theoretical meaningfulness to this research. Concluding if existing TPM literature and new additional literature will help to create a better view on what influences the success of EEM, AM and T&E in production start-ups will be the answer to sub
question six. It will become clear if other theories have to be taking into account or could help TPM to be more successful in production start-ups.

To give more clarity on how to derive to possible factors that could influence the success of TPM in start-ups, the line of reasoning in this research will be shortly explained and visualized in the next chapter.

1.6 Line of reasoning

The in depth view on EEM, AM and T&E as well as the possible start-up problems are gathered by a thorough literature survey (sub question one & two). All this will form a basis of factors that could influence the success of EEM, AM and T&E. To give more body to EEM, AM and T&E, with factors that could influence the success of these elements, additional literature could be helpful. The insight and choices for supporting theories are the result of experiences and observations during the case study at Heineken. Supporting theories will be consulted to derive more influential factors and add them to the existing factor list. It can therefore be concluded that the creation of the final factor lists in this research is an incremental process that makes use of experiences as well as literature throughout the case study. To visualize the line of reasoning the structure of this research is given in figure 3.

![Figure 3 Research structure](image-url)
1.7 Further reading guide

This chapter is meant to name the different chapters and describes what the purpose of each chapter is. This overview can be found in the figure below. The goal of this research is to find factors that influence the success of EEM, AM and T&E. These factors are found in various chapters in this research. There are three chapters that will add influential factors; namely: chapter 3, 4 & 6. In the beginning of every chapter the figure below returns and highlights where we are in this research and what one can expect for the relevant chapter.
2. A new domestic returnable packaging line called LE0

This chapter is meant to give the reader a better idea what the new packing line LE0 is about and how a returnable packaging line like this works. The information is needed because this research can refer to machines, parts or the environment of LE0. The figure below shows the progress of this research and the purpose of this chapter.

2.1 Why?

As stated in the introduction Heineken is introducing a new green bottle in the Netherlands. Everywhere in the world the green Heineken bottle is introduced, except in the Netherlands. According to Heineken the main reason to introduce the green bottle in the Netherlands is:

‘‘A strategic imperative to rebalance the price-value equation, this will enable us to grow market share and in time be in a better position to increase price’s (Heineken, 2011)

2.2 What?

With the advent of the new bottle, Heineken is in need for a new packaging line because the old line 12 is not capable of processing the new K2 start bottle. Together with the main contractor KHS the LE0 project was initiated and executed. EEM would play an important role in this project and this process will be broadly investigated during this research.

A returnable line like LE0 differs from other packaging lines at Zoeterwoude, because it has to process empty bottle in crates that return from the market. This requires more handlings than most (exports) lines at Zoeterwoude that have only new bulk bottles as input. To get a better grip on how a returnable packaging line like LE0 works the machines will be discussed in chronological order from the moment pallets with crates containing empty bottles enter till the moment pallets with crates containing full bottles leave. Figure 4 shows a simplistic overview of the main machines that LE0 has (some detection machines are missing).
As one can see LE0 is divided in two main parts; the wet area and the dry area. The chronological order of machines from depallitizer till pallitizer will now shortly be described.

**Depallitizer.** This machine receives pallets with crates containing empty bottles from CS&L (the logistic branch of Heineken) and restacks the crates by putting the crates on a conveyor in the direction of the unpacker.

**Unpacker.** This machine lifts the bottles out of the crates and puts them on a conveyor in the direction of the bottle washer. The empty crates go to the crate storage and do or do not get store (this depends on the surplus of crates). If the packer requests crates they directly go through the crate washers in the direction of the packer. Otherwise the crates get stored and go later on.

**Crate storage.** This machine makes sure the balance of crates is at the right level, so if there is a surplus of crates, crates get stored and the other way around.

**Bottle washer.** Empty bottles that are unpacked by the packer continue their way to the bottle washer. In the bottle washer empty bottles get thoroughly cleaned. The new bottle washer in LE0 has a capacity of washing 90.000 bottles per hour.

**Fillers.** When leaving the bottle washer, bottles continue in the direction of the fillers and thereby enter the wet area. There are two fillers in LE0, both having a capacity of 40.000 bottles per hour. The fillers fill the bottles with beer and seal the bottles with a crown cap. Before and after the fillers the bottles get checked. Before the fillers bottles get checked on their contour, volume and any other abnormalities. After the fillers the bottles get checked on pressure. If bottles do not meet the requirements they are automatically removed from the system and end up in glass containers.

**Pasteurizer.** After the fillers bottles go through the pasteurizer. In the pasteurizer beer in the bottles get pasteurized, so that the expiration data get extended.

**Labellers.** After the beer is pasteurized, the bottles continue their way to the two labellers. Before they enter the labellers they get blown dry. In the labellers bottles are provided with a front, back and neck label.

**Packer.** Leaving the labellers the bottles go in the direction of the packer and thereby leave the wet area again. The packer gets supply of empty crates from the crates washers and market ready bottles from the labellers. The packer puts bottles from the conveyor into the crates.

**Toplayer.** Crates with filled bottles go through the two toplayers machines. These machines put a crate cover on the crates. Green glass has a different light sensitivity and this could influence the beer taste.
The final machine is the palletizer. This machine makes sure the crates get palletized again and puts and stretch foil around the stacked crates with a barcode sticker. After leaving this machine, pallets fall under the responsibility of CS&L.

A lot of small, most of the time inspection, machines are not mentioned. Also one large machine is not mentioned and that is the bulk destacker. This machine is especially in the beginning months important, because there are not empty bottles from the market available. New bottles are provided by Heinekens bottle supplier and enter the system via the bulk destacker. Again to make sure this machine has enough supply, falls under the responsibility of CS&L. Bulk bottles enter the system stacked on a pallet without crates, it is therefore necessary that also empty crates be pushed into the system via the depalletizer.

2.3 Where?

The new line LE0 is part of Rayon 1 of the packaging department in Zoeterwoude. Rayon one consists of three packaging line: line 9 (beer kegs), LE0 (new line 11; domestic 330 cl bottles Heineken) and line 12 (domestic 330 cl bottles Amstel). Line 9 can be seen as a line that manages its own business and has not so much to do with LE0; also the operators are not mixed. There is also a physical border between line 9 and LE0. Line 12 however has a lot to do with LE0. Both are returnable packaging lines for the domestic market and one large group of operators is occupying both lines. So it could be that one week a shift (for instance shift A) is working on LE0 and the other week the same shift works at line 12. LE0 and line 12 are separately occupied, but interaction between operators is possible. LE0 and line 12 are located next to each other and operators can easy walk from LE0 to line 12 (to help each other for instance). Figure 5 visualizes the situation.
3. World of TPM

Since this research investigates the success of TPM and in particular EEM, AM and T&E in production start-ups, this chapter gives the reader more insight into the world of TPM and especially EEM, AM and T&E. The chapter will start with some definitions of TPM by different authors to get a first grip on the philosophy behind TPM. After that, the basics principals of TPM are discussed and eventually the concepts EEM, AM, T&E will be discussed more in depth. This deeper view should give a first look on which possible factors could influence the success of EEM, AM and T&E. The figure below shows the progress of this research and the purpose of this chapter.

3.1 Definitions of TPM

‘‘TPM is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce’’ (Nakajima, 1989);

‘‘TPM is a partnership between maintenance and production function organizations to improve product quality, reduce waste, reduce manufacturing cost, increase equipment availability, and improve organization’s state of maintenance’’ (Rhyne, 1990);

‘‘TPM is a maintenance improvement strategy that involves all employees in the organization and includes everyone from top management to the line employee and encompasses all departments including maintenance, operations, design engineering, project engineering, inventory and stores, purchasing, accounting finances, and plant management’’ (Wireman, 1990);

‘‘TPM is a production-driven improvement methodology that is designed to optimize equipment reliability and ensure efficient management of plant assets’’ (Robinson & Ginder, 1995);

‘‘TPM is keeping the current plant and equipment at its highest productive level through the cooperation of all areas of an organization’’ (Besterfield et al., 1999)

‘‘TPM is about communication; it mandates that operators, maintenance people and engineers collectively collaborate and understand each other’s language’’ (Witt, 2006)

There can be a lot of similarities noticed in the descriptions of authors. The terms that are important during this research are itallic market and will return in the course of this research.
3.2 TPM in general

As stated in the introduction TPM is founded in 1970 by Nakajima, also seen by many as the godfather of TPM. The existence of TPM does not come from nowhere and descended from earlier maintenance concepts. Since 1950 maintenance was subjected to major changes. TPM is a unique Japanese philosophy, which has been developed based on productive maintenance, maintenance prevention and computerized maintenance management systems. Nippon Denso Co. Ltd. of Japan, a supplier of the Toyota Motor Company, first introduced this concept in 1971. Total Productive Maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce. TPM brings everyone, from machine operator, equipment designer to manager together to work in small autonomous groups to improve quality, reduce waste, reduce manufacturing costs, increase equipment availability and improve the overall state of maintenance (Shamsuddin et al., 2005). Especially the cooperation between maintenance and operations is very important, since operators shift from pure operational tasks to a more all-round shop floor management role (Ahuja, 2011b). TPM is an aggressive maintenance strategy that focuses on actually improving the functioning of the production equipment (Tsarouhas, 2007). TPM is especially used in organizations with a high level of equipment automation (Rolfsen & Langeland, 2012). The packaging department of Heineken has such a high level of equipment automation. The ultimate goal of TPM is zero defects, zero breakdowns and zero accidents. Since zero defects, zero breakdowns and zero accident are an illusion and a goal that will be never reached, TPM is continuously seeking for improvements and this endeavour should never stop. The performance of TPM is expressed in overall equipment efficiency and will be explained in the next chapter.

3.3 OEE

TPM can be measured in terms of overall equipment efficiency (OEE), which can be considered as a combination of the operation maintenance, equipment maintenance and available resources. According to Nakaiima (1988) OEE measurement is an effective way of analysing the efficiency of a single machine or an integrated manufacturing system and its function of availability, performance rate and quality rate. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products (Dal et al., 2000).

\[
OEE = \frac{\text{Availability (A)} \times \text{Performance efficiency (P)} \times \text{Rate of quality (Q)}}{\text{Loading time} - \text{Downtime}} \times 100
\]

3.4 5s and the TPM pillars

TPM consists of eight pillars or focus areas, as mentioned in the introduction. The pillars rest on the foundation of 5s. First the concept 5s will be explained and after that the eight TPM pillars will be described briefly in table 2. 5s is a lean concept that is also used in TPM to organize the work floor. 5s appropriates its name to the fact that it contains five elements; seiri, seiton, seiso, seiketsu, and shitsuke (Sharma et al., 2006), in English:
• Sort. Eliminate all unnecessary tools, parts, and instructions.
• Set in order. Arranging tools, parts, and instructions in such a way that the most frequently used items are the easiest and quickest to locate.
• Shine. Clean the workspace and all equipment and keep it clean, tidy and organized.
• Standardize. All workstations for a particular job should be identical.
• Sustain. Maintain and review standards. Once the previous four steps have been established, they become the new way to operate (a new standard).

Many authors see 5s as the basis for many TPM activities (Sharma et al., 2006). The idea is that if the work floor is not organized and neat, it has no use to implement other TPM elements. Now the foundation of 5s is clear, the TPM pillars will be described in table 1. The pillars are briefly described using a combination of the paper from Rodrigues & Hatakeyama (2006) and the paper from Ahmed et al. (2005).

<table>
<thead>
<tr>
<th>Pillar</th>
<th>Brief description</th>
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<tr>
<td>Focused improvement</td>
<td>Focusing in a clear way on the wished improvements in business, the elimination of losses and improvement of design.</td>
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<tr>
<td>Autonomous maintenance</td>
<td>Self-management and control of operators in daily operations of their workstation. Maintenance of the base condition and prevention of deterioration.</td>
</tr>
<tr>
<td>Planned maintenance</td>
<td>Effectively planning and controlling of maintenance, with daily, weekly, monthly, yearly planning and planning of stops to prevent failures.</td>
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<tr>
<td>Education and training</td>
<td>Enhancing personal relationship, technical and management skills of maintenance people and operators. Skill up operation, maintenance and supporting groups.</td>
</tr>
<tr>
<td>Early equipment management</td>
<td>Attendance of maintenance and operational people since the conception of new projects or acquisitions. Aim for vertical start-up; reliable, safe, low operation costs, flexible, zero defects.</td>
</tr>
<tr>
<td>Quality maintenance</td>
<td>Establishment of a zero defect program. Setting optimum conditions to eliminate defective processes/products/services and maintaining control.</td>
</tr>
<tr>
<td>TPM in the office</td>
<td>Efficiency involvement of the administration processes, increase the office efficiency and automation to support manufacturing operations.</td>
</tr>
<tr>
<td>Safety and environmental management</td>
<td>Establishment of a health, safety and sustainable environmental system, with zero accidents and zero environmental pollution.</td>
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The pillars and focus points of TPM are now clear, but to implement and maintain this in organizations is not an easy task (Bamber et al., 1999). Many companies have failed to implement TPM in their organization. The next chapter will elaborate on this.

3.5 Implementation barriers of TPM

According to Larry Rubrich, the president of WCM Associates LLC, TPM is the most complicated lean tool to implement. This is mainly because TPM implementation requires a total culture change in organizations (Rubrich, 2012). Many authors echo the struggle that most companies have
implementing and maintaining TPM. There is a lot of similarity in the barriers that authors mention. Different authors have pointed out many barriers for TPM implementation in different case studies. A few authors and the barriers they mention are discussed in table 2.

<table>
<thead>
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<th>Table 2 General TPM implementation barriers</th>
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<tr>
<td>Middle management’s resistance towards offering empowerment and recognition of operators</td>
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<td>Little empowerment to operators to take equipment related or improvement decisions</td>
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<tr>
<td>Lack of training</td>
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<td>Lack management support</td>
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<td>Lack of communication</td>
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<td>Lack of structure</td>
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<td>Wrong pace TPM implementation</td>
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<td>Lack of understanding importance</td>
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TPM is already implemented in Heineken, but AM has to be implemented all over again in LE0. It could very well be that there are again some barriers as mentioned in table 3 that influence the success of the AM process. However if these barriers are applicable to look at a successful AM implementation will come forward during in chapter five on AM at Heineken and LE0.

The basic concept of TPM must be clear now, however because this research focuses on EEM, AM and T&E, the three concepts will now be elaborated more in depth.
3.6 In depth study on EEM, AM and T&E

The pillars of TPM are already briefly described in table 2, but especially the to be investigated pillars EEM, AM and T&E need more explanation to find factors that could influence their success in start-ups. Therefore this chapter will go more in on the elements EEM, AM and T&E and tries to identify factors that influence the success of these elements.

3.6.1 EEM

EEM is a TPM pillar that is not recognized by every TPM author. On top of that are the authors who do mention this pillar not consistent in the name they use. Some authors mention the term Development Management, like (Ahuja, 2011b), (Ahuja & Khamba, 2008b) and (Ben-Daya et al., 2009) and others mention the term Initial Flow Management, like (Blanchard, 1997) and (Chan et al., 2005). However, most authors mention the term EEM and because Heineken is also using the term EEM, this research will only use the term EEM. Next to that, authors who recognize the EEM pillar are not always consistent on the content and goals of EEM. EEM is a TPM pillar that is still quite underexposed in literature. To give an idea of what EEM is about some authors descriptions are given and the after that the different parts of EEM will be described.

Ben-Daya et al. (2009) in their handbook on maintenance call EEM a concept that:
- Minimizes problems and running time on new equipment
- Utilize learning’s from existing systems to new systems
- Maintenance improvement initiatives

Ahmed, Hassan, & Taha (2005) in their paper on TPM mention EEM to be a concept that aims for a vertical start-up and equipment that is reliable, safe, has low operation costs, is flexible and has zero defects. EEM policy should aim at:
- A vertical start-up of equipment with effective utilization of maintenance prevention (MP) information and design review
- A strong equipment supplier partnership
They also mention some problems with EEM:
- Minimal focus on design reviews
- Minimal manufacturing process data being used

Schlie (2007) in her paper on EEM describes that EEM consists of the following four elements:
- Life Cycle Costs (minimize the LCC)
- MP design (this is the core of EEM’s spirit and uses the latest maintenance data and technology when planning or building new equipment, to promote greater reliability, maintainability, economy, operability and safety, while minimizing costs and deterioration-related losses)
- Vertical start-up (shortest start-up that is right the first time, ideally without any modifications to the equipment)
- Quality

Shirose (1984) in his book on TPM states that EEM means minimizing the time to achieve stable operation (no breakdowns and minimal defects) during the installation, test-run and handover period. Equipment operating flawlessly is very rare, mainly because of some problems:
- Problems during design phase (poor selection of materials)
• Problems in fabrication stage (incorrect part dimensions, assembly errors)
• Problems during installation and test runs (insufficient operation levels and installation errors)

Good EEM tries to discover these problems and make improvements. Shirose (1984) describes the concept MP to be part of EEM. In his view, MP design means those activities aimed at preventing breakdowns and defects in newly installed equipment by applying preventive maintenance techniques during the design process. MP tries to discover weak points in currently used equipment and is giving feedback data to design engineers.

**EEM parts**

EEM is spread over the whole lifecycle of equipment. According to Schlie (2007) there are five major stages or parts in which EEM is important. First of all there is an equipment need, this is followed by designing, modifying and purchasing new equipment, after that the equipment is build, installed and started up, after that operations starts and eventually the equipment is decommissioned. Especially during the operations lessons are learned for the design of new equipment. This research is interested in the design part and the start-up part of EEM. The different parts and the focus of this research can be seen in figure 6.

One remark has to be made and that is that this research will divide the two focus parts a little different as Schlie (2007) does. This research wants to give specific attention to the start-up and will therefore divide the two parts as follows:
- Design, Manufacture and Installation part (EEM DMI part)
- Start-up part (EEM Start-up part)

As one can see the start-up part is unlocked and build and install is added to the design part. For both parts factors will be investigated that influence the success of EEM. The success of EEM will be measured by looking at two goals of EEM: equipment satisfaction goal (design) and the vertical start-up goal (OEE).

**3.6.1.1 Conclusion & first factors influencing success of EEM in start-ups**

Looking at all the statements on EEM, it can be concluded that there are some shared views on EEM. For instance, the fact that learning’s on current equipment have to be translated to new equipment design. However, some authors capture this in EEM, while others assign it to MP (as being a part of EEM). Another shared view on EEM is the fact that this concept has to ensure a vertical start up with minimal problems, however what hampers this is unclear. A final shared view on EEM is that the life cycle costs of equipment should be taking into account and should be minimal. The minimization of the total life cycle costs will be left outside of the scope for time and quantity reasons. To eventually measure the influence that factors have on the success of EEM the two other goals of EEM will be used as dependent variables, namely:
- Equipment satisfaction
- Vertical start-up
These goals could be hampered looking at some problems descriptions of authors. The problems mentioned are the following:

- Minimal focus on design review
- To little MP data used
- Poor selection of construction materials
- Wrong fabrication of equipment
- Installation errors

Looking at these factors it can be concluded that they only appear in the EEM DMI part. This research is particularly looking for factors that could be present during the start-up part; therefore the search for factors is not over. Chapter five on production start-ups will go further on this and will try to find factors that could be present during the start-up part.

### 3.6.2 AM

The main idea of AM is that operators perform routine maintenance tasks and keep improving their system. These tasks include daily cleaning, inspecting, lubricating and the tightening that equipment requires. Because operators are closer involved to their equipment than anyone else, they are able to quickly notice any abnormalities (Hamacher, 1996). One of the main ideas of TPM is that the role of operators will become more important, therefore some authors state that AM is the most important pillar of TPM and resembles the real TPM thinking (Gotoh & Tajiri, 1999). To give an idea of what most authors mean by AM, some descriptions are given.

Ben-Daya et al. (2009) in their handbook on maintenance mention AM to be a concept that:

- Fosters operator skills
- Fosters operator ownership
- Perform cleaning, lubricating, tightening, adjustment, inspection, readjustment on production equipment.

Ahmed et al. (2005) in their paper on TPM mention AM to be the self-management of workstation by operators, maintenance of base condition and prevention of deterioration and measurement of deterioration and restoration. AM policy should aim for:

- Developing equipment ownership
- Technical competent operators
- Harmonious workplace

They also mention some problems with AM:

- Low knowledge level of operators
- Lack of moral
- Low level of 5s
- Waiting for support to do repairs

Ahuja (2011a) states that AM:

- Eliminates major losses and raises OEE
- Educates workers in equipment-related knowledge and skills
- Improves equipment, change workers approaches and revitalize the workshop
Venkatesh (2005) in his piece on TPM call AM the development of operators to take care of small maintenance tasks and thus taking over tasks from maintenance people. Operators are responsible to upkeep their equipment and prevent it from deteriorating. AM policy should aim at:

- Uninterrupted operation of equipment
- Flexible operators that operate and maintain equipment
- Eliminating defects at the source through active employee participation
- Stepwise implementation of AM

According to Shirose (1984), to determine if AM is well implemented or applied AM audits can be held. The reasons for this are the following:

- To determine if each level is fully determined
- To aid small groups by proving feedback from management on the strengths and weaknesses of their AM activities
- To make clear what needs to be achieved and how to best achieve it

AM steps

AM consists of a seven step program (Gotoh & Tajiri, 1999). Because AM requires operators to completely change their old behaviour of only operating machines to more responsibly managing their work floor, the implementation of AM can be a tough and time consuming job. Most of the production lines in Heineken Zoeterwoude do not go beyond AM step three and because LE0 is required to be in AM step three a few weeks after start-up, the first three steps of the total seven step AM program will briefly be discussed.

- Step 1: Initial cleaning and finding sources of contamination and hard to access areas
  By cleaning, operators discover abnormalities (cleaning is inspecting). In a new production line it could be possible that there are abnormalities or wrong installed parts. AM is therefore a great tool to discover faults from the manufacturer or to early discover things for improvement. Another element of step one is finding sources of contamination and hard accessible areas, which can only be done if machines are thoroughly cleaned.

- Step 2: Eliminate sources of contamination and inaccessible area
  Eliminate the source of contamination or at least as good as possible. Improve areas that are inaccessible for cleaning and inspection, this includes the areas that require a lot of time to clean. This step should really emphasize on the joy of making improvements.

- Step 3: Creation and maintaining of standards for cleaning and lubrication
  Operators use experience of previous steps to determine the optimal cleaning and lubrication conditions of their equipment and to draft preliminary work standards for its maintenance. Operators should set their own standards because then they feel more commitment. If the standards are set from outside the operator team, the commitment from operators to do the job is far less.

3.6.2.1 Conclusion & first factors influencing success of AM

Looking at all the statements on AM, some similarities can be distinguished. The main idea is that operators have to understand their equipment and build more skills and ownership over their equipment, so that they can operate and maintain it autonomously. Therefore the different AM steps have to be implemented. AM should contribute to more efficient operations and thus a higher OEE, this research is however not interested in the effect of AM, but in what is influencing a quick and
successful implementation of AM in a new production line. The dependent variable here will therefore be a quick and successful implementation of AM step three in the start-up of a new line. The operators working in LE0 are familiar with AM, but does this also mean that it can be quickly and successfully implemented? In literature on AM some problems that can occur implementing AM are distinguished, they are listed below.

- Low knowledge level operators
- Lack of moral
- Low level of 5s
- Waiting for support

If one looks back at the general TPM barriers mentioned in table 3 some similarities can be found, for instance the low knowledge level and low level of 5s. This could mean that general barriers for implementing TPM could also apply when AM has to be implemented in a new line (in an organization that is familiar with TPM and AM). Chapter five must give more insight in this when AM at Heineken and LE0 is elaborated.

3.6.3 T&E

T&E seems a pretty straightforward concept that could apply to many organizations and not only to the ones that work with TPM. T&E is something that is very important in knowledge-based organizations, where learning is important to stay competitive. This research is specifically focused on the start-up of a new production line; therefore it is interesting to see what is really important for T&E during a start-up. The operator’s perspective is most important in this case, because T&E has to meet the operators learning framework (Vries, 2013). To give an idea on what most authors (within TPM literature) mean by T&E, some descriptions are again given.

Ben-Daya et al. (2009) in their handbook on maintenance mention T&E to be a concept that:

- Imparts technological, quality control and interpersonal skills
- Multi skilled employees
- Aligns employees to organizational goals
- Gives periodic skill evaluation and updating

Ahmed et al. (2005) in their paper on TPM describe T&E that is something that skills up operation, maintenance and supports people. T&E aims at:

- Productivity improvement through employee development and involvement
- Building a team of technically skilled and thinking employees

Problems they mention with T&E are that:

- Operators get only production process training (not enough technical skill or AM training)
- Technicians get only basic technical/equipment training (not for problem solving)
- Engineers/managers get equipment and management tools (no TPM education and problem handling strategy education)

Venkatesh (2005) in his piece on TPM described T&E for operators as follows:

T&E aims at having multi-skilled revitalized employees whose morale is high and who are eager to come to work and perform all the required functions effectively and independently. Education must upgrade operator’s skill. The goal must be to create a factory full of experts (Venkatesh, 2005). To achieve all this T&E policy should aim for:

- Focus on improvement of knowledge, skills and techniques
- Creating a training environment for self-learning based on employees needs
• Training curriculum, tools, assessment etc. conductive to employee revitalization
• Training to remove employee fatigue and make work more enjoyable

The goals of T&E should be:
• Zero losses due lack of techniques, skills or knowledge
• 100% participation in suggested training & education programs

3.6.3.1 Conclusion & first factors influencing success of T&E
Looking at all the statements on T&E, some similarities can be distinguished. Generally T&E focuses on:
• Upgrading skills, techniques and knowledge of employees and closing knowledge gaps
• Skilling employees according to the organizational goals
• Create commitment by upgrading knowledge and skill building

There is only one problem mentioned by Ahmed et al. (2005) and that is that operators might get only production process training and not enough AM training. This problem seems more appropriate to be assigned to the factors that influence a quick and successful implementation of AM. Apart from the problem, it mentioned that there should be an environment where training provides the necessary skills. Concluding, this chapter makes the goals of T&E clear, but what really influences successful T&E in a start-up, does not come forward in TPM literature and therefore additional theory is needed.

3.7 Factor list till now (1)
Looking at the literature on TPM (EEM, AM and T&E) there can be some assumed influential factors identified. Looking at EEM, only for the DMI part factors were found. There is nothing stated on factors that could be present during the start-up, which we also expect to influence at least the vertical start-up goal of EEM. Next to the EEM start-up part also for successful T&E during a start-up almost no influential factors can be found, only that training seems necessary. The next chapter will elaborate more on production start-ups, to find more influential factors. Table 3 shows the influential factor list till now.

<table>
<thead>
<tr>
<th>EEM DMI part</th>
<th>EEM Start-up part</th>
<th>AM</th>
<th>T&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPM literature</td>
<td>-</td>
<td>TPM literature (AM barriers)</td>
<td>TPM literature</td>
</tr>
<tr>
<td>Minimal focus on design review</td>
<td></td>
<td>Low knowledge level operators</td>
<td>Training</td>
</tr>
<tr>
<td>To little MP data used</td>
<td></td>
<td>Lack of ownership and commitment</td>
<td></td>
</tr>
<tr>
<td>Poor selection of construction materials</td>
<td></td>
<td>Low level of 5s</td>
<td></td>
</tr>
<tr>
<td>Wrong fabrication of equipment</td>
<td></td>
<td>Waiting for support to do repairs</td>
<td></td>
</tr>
<tr>
<td>Installation errors</td>
<td></td>
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</tbody>
</table>
4. Production start-up

This chapter describes what a production start-up means by elaborating on the different stages and the possible start-up problems. Since EEM is aiming at a vertical start-up, start-up problems might influence this goal. Hopefully the factors concluded in the latter chapter three can be extended with factors emerged from this chapter. The figure below shows the progress of this research and the purpose of this chapter.

4.1 Production start-up stages

Unfortunately, literature is rather thin when it comes to production start-ups. Nevertheless is the start-up of a new production line, with new equipment and advanced technology, an interesting topic. First, to create a better idea on what a production start-up means figure 7 shows how most manufacturing start-ups look like and shows the different stages.

![Figure 7 Production start-up stages (Ball et al., 2011)](image)

In the beginning, often to validate the system, pilot productions run. In the beer industry, the products produced in the pilot runs are often waste, because the quality is not sufficient to be sold on the market. Many quality validations run during pilot production and most of the time also during commercial production, at least at Heineken. After the pilot production the commercial production starts, in figure 7 indicated as manufacturing start-up. From this moment on the production needs to ramp up and reach its desired efficiency/production level. When new manufacturing equipment is installed, it is not possible to produce high volumes immediately (Ball et al., 2011). First all the machines have to be integrated and work proper as one system. It can take quite some time to make sure the entire equipment is bug free and to create high-level steady production flow. How long a manufacturing start-up stage takes, cannot be found in literature. The only thing that can be provided here is Heineken's start-up data. At Heineken a start-up normally takes about ten weeks. The next chapter will elaborate on the problems that could occur during start-ups.
4.1 Production start-up problems

A lot of problems can happen during the start-up of a new production line. The use of new technologies for instance, is often accompanied with start-up problems. Unfortunately literature on problems that could occur during a production start-up is not very extensive. Almgren, a Swedish scientist did some research on production start-ups in manufacturing organizations. Two of his articles will be used to get more insights in the problems that can occur during production start-ups. In Almgrens (1999) article on the start-up of advanced manufacturing systems, the following start-up problems are being distinguished:

- Inappropriate management decisions
- Use of not-yet-verified technologies
- High frequency of minor stoppages

Inappropriate management actions can be the result of the fact that organizations (also Heineken) experience very infrequent start-ups (last start-up was in 2008). Therefore there can be a struggle to predict the effect that ‘routine’ changes in operating policies and procedures may have during a start-up. Management must realise that policies that are effective during steady-state operations are often inappropriate during start-ups. On top of that could events that have minor effect during steady state operations seriously interrupt start-ups (Baloff, 1970).

In another article, Almgren (2000) investigated the quantity performance and quality performance during a production start-up. Quantity performance is the number of products produced and quality performance are the number of products that are suitable for the market. His conclusion was that the main disturbances for quantity performance are:

- Lack of materials
- Lack of material quality and status of material
- Breakdowns
- Minor stoppages
- Personnel performance
- Late engineering changes

It must be said that that both the aticles from Almgren are based on case studies performed in firms with advanced manufacturing technologies in the automotive industry. The packaging department at Heineken is a different niche, but also a manufacturing environment with advanced technology. It could therefore be expected that some of the problems that Almgren mentions also appear in the start-up of LE0.

Apart from the latter problems, Terwiesch & Xu (2004) state that time pressure during start-ups could result in the fact that:

- process engineers often cut some corners in the optimization of the production processes
  (Terwiesch & Xu, 2004).

The start-up problems that are mentioned in this chapter are very divers and some are more specific then others. For instance high frequency of minor stoppages is a very concrete problem, the root cause may not be evident, but the negative influence on the efficiency of production is certain. Other problems are less specific like inappropriate management decisions, also their impact to the start-up may be less evident and the impact on the production will mostly be indirect. All the problems
mentioned are problems that could occur during a start-up, since EEM was divided in the DMI and startup part, these problems can be added as factors for the EEM start-up part.

### 4.4 Factor list till now (2)

Looking at the literature on production start-ups, some problems can be identified. Since these problems could hamper the EEM vertical start-up goal, and maybe even the equipment satisfaction, these problems are added to the EEM start-up part. Table 4 shows the supplemented influential factor list till now.

<table>
<thead>
<tr>
<th>EEM DMI part</th>
<th>EEM Start-up part</th>
<th>AM</th>
<th>T&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TPM literature</strong></td>
<td><strong>Production start-up literature</strong></td>
<td><strong>TPM literature (AM barriers)</strong></td>
<td><strong>TPM literature</strong></td>
</tr>
<tr>
<td>Minimal focus on design review</td>
<td>Inappropriate management decisions (through inexperience in start-ups)</td>
<td>Operators are not technically skilled enough</td>
<td>Training</td>
</tr>
<tr>
<td>To little MP data used</td>
<td>Not-yet-verified technologies</td>
<td>Lack of morale</td>
<td></td>
</tr>
<tr>
<td>Poor selection of construction materials</td>
<td>High frequency of minor stoppages</td>
<td>Absence of 5s</td>
<td></td>
</tr>
<tr>
<td>Wrong fabrication of equipment</td>
<td>Lack of materials</td>
<td>Waiting for support</td>
<td></td>
</tr>
<tr>
<td>Installation errors</td>
<td>Lack of material quality/status</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breakdowns (less in proven technology)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low personnel performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late engineering changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corners cut in optimization of processes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Looking at table 4, still only one factor that could give insight in succesfull T&E are identified. Except from factors that influence the success of T&E also more additional factors that influence the success of EEM and AM are to be found, by finding and exploring supporting theories. To create a better view on which theories might be appropriate, EEM, AM and T&E at Heineken will be elaborated. This should create eye openers for appropriate theories to add more factors to EEM, AM and T&E. The next chapter describes how Heineken interpreted TPM and describes the TPM elements EEM, AM and T&E in Heineken and LE0.
This chapter is meant to see how Heineken adopted TPM and in particular EEM, AM and T&E. The TPM elements EEM, AM and T&E at Heineken and LE0 are described and these descriptions together with pre-studied literature are used as eye-openers to find supporting theories that might supplement factors that influence the success of EEM, AM and T&E in production start-ups. Striking terms that might show links to other supporting theories are italic marked. Input for this chapter are interviews, small conversation, observations and desk research at Heineken. The figure below shows the progress of this research and the purpose of this chapter.

5.1 TPM at Heineken

Heineken introduced TPM at Kaizer, a subsidiary beer facility in Brazil. The soda and beverage production site Vrumona (i.a. Pepsi, Crystal Clear and Sisi) firstly implemented TPM in the Netherlands, Heineken Zoeterwoude followed in 2006. Heineken defines TPM as follows:

“TPM is the continuous and consistent quest to eliminate losses in all processes through active participation of all employees in the organization” (Heineken, 2008).

The big difference between TPM in literature and TPM in Heineken is that TPM in Heineken stands for Total Productive Management. The term management is used because Heineken wants to extend TPM to all its processes in the supply chain. However the current focus is still only on production. The reason for this is that there is quite some room for improvements in this area. The main TPM facilitator at Heineken Jacobs explains that TPM activities in purchasing and distribution of materials and products are useless if production is still very unstable. Therefore, the Heineken TPM focus is still only on production and the term Total Productive Maintenance or Manufacturing is appropriate. If production becomes more efficient and stable TPM activities will expand more to purchasing and distribution activities. Figure 8 shows the TPM focus in Heinekens supply chain.

![Figure 8 TPM focus at Heineken](image-url)
Heineken’s overall aim is to excel in the World Class Manufacturing measures (Cost leadership, Quality, Customer Satisfaction, Organization & People Management and Social Responsibility). The focus now is mainly on cost leadership. Heineken recognizes marketing, sales, distribution, production and administration as costs. Furthermore, the company distinguishes value-added costs (VA) and non-value-added costs (NVA). The implementation of TPM aims to eliminate NVA (losses), which is more or less the same goal as TPM in literature (zero losses). NVAs are those things that the customer is not willing to pay for, because it adds not extra customer value to products, examples are training and maintenance. Especially in a start-up of a new production line training seems vital, but it must be efficiently implemented, so that no unnecessary losses occur, this also counts for AM and EEM.

The TPM pillars EEM, AM and T&E including the concept of 5s that TPM literature mentions, are recognized and used by Heineken. The only pillar that is not yet implemented at Heineken Zoeterwoude is TPM in the office. TPM in Heineken reflects a lot of how literature understands TPM. The only big difference is the name Heineken is using. Though, this difference in name does not withhold us to use TPM literature parallel to TPM at Heineken, because Heineken is still only focusing on TPM in production processes and the purpose of TPM is the same as in literature. How Heineken gives substance to the EEM, AM and T&E will be discussed in next chapters.

5.2 EEM at Heineken & LE0

EEM is a fairly new concept in Heineken Zoeterwoude and LE0 is the first production line that is really build under the flag of EEM. This chapter will start with some general descriptions by Heineken employees to see what they understand EEM to be.

Pronk (Technical experience expert involved in start-up of line eight and LE0) describes EEM to be a concept in which Heineken designs its machines in such a way that they are completely conforming Heineken requirements and standards. His remark on this is that perfect EEM will never be feasible because equipment suppliers have certain design standards and complete custom-made machines would be far too expensive (Pronk, 2013).

Strater (Rayon one Technician and also a technical supervisor of LE0) describes EEM to be a concept in which equipment is designed in such a way that it is as reliable, maintainable and cost effective as possible and that its reaches the desired OEE as quickly as possible. All the TPM pillars (standards) have to feed well-designed equipment. For instance, the AM pillar feeds the design with maintenance improvements and the safety pillar feeds the design with more safety standards (Strater, 2013).

Vink (Head of the project bureau of Heineken) does not really think in definitions. He rather describes EEM to be a concept of TPM that focuses on the proper introductions of new equipment in organizations. There are two main objectives in EEM: realize a vertical start-up and minimize the total lifecycle costs (Vink, 2013).

The different opinions about EEM clarify that there is not really one shared understanding on what the concept EEM really means. Looking at the literature all three descriptions contribute something to what literature calls EEM. The definition of Strater seems most extensive and covers almost everything literature states on EEM. The definition of Vink is rather short, but also covers the content of EEM quite well, except the fact that equipment is designed with lessons learned. Pronks definition resembles the maintenance prevention (MP) concept quite well, however the goal of EEM during the actual start-up is lacking. It is clear that a real shared understanding is lacking. The fact that EEM is a
rather new concept in Heineken might be an explanation for this. This research should therefore also bring more clarity to Heineken on what EEM really means and how it should be managed. To give more clarity on how Heineken is now performing EEM, the next chapter will continue with the description of the EEM project route that Heineken is using in their projects.

5.2.1 EEM project route at Heineken
To see how Heineken is using EEM, the project route of EEM at Heineken will be explained. There are four basis steps in Heineken's EEM project route, these are: Scenarios Development & Conceptualization Engineering, Basic Engineering, Detailed Engineering and Installation. The goal of each EEM step will be discussed. Also some important remarks on how this turned out in the LE0 project are stated. Statements and sayings on Heineken's EEM route are based on a conversation with Vink (head of the project bureau of Heineken), documentation of Heineken and observations during the case study.

1. Scenarios Development & Conceptualization Engineering
The goal of this step is to create an overview of possible scenarios and choose one to further develop into an investment application. In this step the business need for Heineken is confirmed and the use of second hand equipment is considered. This step results in most preferred scenarios that will go into a further scenario study. The machines in LE0 are not all new and some are being reused. The new machines are from a different supplier (KHS) than the old ones (Krones). In the LE0 project, the decision for the most preferred design took a very long time and put more pressure on the subsequent EEM steps that will now be explained.

2. Basic engineering
The goal of this step is to create and submit an investment application. In this step a list with required machines and possible suppliers is created, by using MP, or EEM data (lessons learned). According to Vink (2013) MP is a somewhat unfortunate term because it is not only focusing on designing new equipment that is maintenance or almost maintenance free, but it also focuses on designing equipment that is more reliable, safer to use and everything that extends the lifetime and usability of machines (same interpretation as literature on MP). Looking at the MP definition in literature the design data has to come from all TPM pillars.

3. Detailed engineering
The goal of this step is to design, purchase and manufacture the equipment. It is very important that a Final Manufacturing Inspection (MI) is performed. During the MI the client can check if the system is designed and manufactured according to the needs. If there are points for improvement, the supplier can make adjustments, the points that are still remaining will end up in the list with outstanding items (LOI). Adjustments to machines at the manufactures site are ten times easier then adjustment during and after installation at Heineken, because the machines are still ‘naked’. Having an early MI seems vital for good EEM results. Unfortunately the MI for LE0 that Heineken did at KHS in Germany was one week before the actual shipping of the equipment, which means that there was hardly time for adjustments and almost all the adjustments ended up in the LOI list, which has to be finished at Zoeterwoude.
4. Installation
The goal of this step is to install the equipment in the plant, to hand it over to production and maintenance and do an evaluation to close out the project. During installation and start-up of a new production line it is very important that the system and its functioning is closely monitored by Heineken. Things that are not properly installed or do not function according to the requirements that Heineken sets end once again up on the LOI list and have to be adjusted by KHS. Observations during the case study at Heineken showed that this is an erratic process, because of the political game between supplier and client Heineken. During installation, Heineken does not want to reprove KHS in a very early stage, because Heineken is willing to give the supplier freedom and time to make adjustments (this also has a positive influence on the relation with the supplier). Finally it is important that Heineken tests the performance of the new production line. To test this a site acceptance test is performed (SAT), this is a test to see if the supplier really delivers what they promised and that the line can produce against a certain predetermined efficiency level. The SAT normally takes place a few months after start-up. To achieve the test, KHS will continuously try to optimize the production processes from the early start-up on. Again this can be an erratic process and what KHS finds proper might not be good in the eyes of Heineken. Unfortunately the moment of SAT falls outside the time range and thus scope of this study.

What is striking is that it is not elaborated on how to organize the start-up process itself. In fact, how to map and tackle shop floor problems was determined a few weeks before the actual start-up of LE0. How this process was executed will be discussed in the next chapter.

5.2.2 Handling start-up problems
Next to the LOI list there was a special problem list created in which operators could state specific problems that they encountered during start-up. Operators were free to state every problem or abnormality they noticed during start-up. The problem list was digitally present on the work floor and operators were instructed how to fill in their problems. The problem list for operators was a new way of collecting start-up problems in Zoeterwoude and was successfully implemented since operators showed commitment by stating their problems. The problems on the list were discussed in the daily operational morning meeting. The most important parties in the morning meetings were operational management, rayon technician, quality department and sometimes operators. A lot of problems that ended up in the operator list were unforeseen and came to the surface when using the system. Nevertheless was a quick response to the problems often needed. During the daily operational meetings the problems were more or less immediately valued on their severance (possible impact to the production) and follow-up actions were planned. Often when operators were not present there were not always good views on the problems and different opinions on the nature of the problems between project parties raised. Problems on the list that could not be fixed on short notice were copied to the LOI list, which was discussed during the daily technical meeting with KHS. The researcher was never present in the technical meetings, only in the daily operational meetings (where KHS was not present). Because the researcher was present during all the daily operational meetings, a lot of observational data was gathered.

5.2.3 Conclusion & supporting theory to add factors to EEM
As stated in chapter three the concept EEM will be looked at from the design, manufacture and installation part and the start-up part. If one looks at other literature then TPM, the systematic approach that Heineken is using in their EEM route is more or less resembled in the steps that are taken in Systems Engineering (SE). Similarities are for instance:
- Conceptual engineering
- Basic engineering
- Detail engineers

The EEM project route of Heineken almost exclusively covers the DMI part of EEM, this research therefore assumes SE to be appropriate to give at least the DMI part of EEM more substance and to add factors to this part. To find additional factors that could be present in the EEM DMI part of Heineken, chapter six will elaborate on SE.

Next to the DMI part the start-up part also plays an important role in EEM. The actual start-up of a production line is enclosed in the installation step of the Heineken EEM project route, but is (like in literature) not very well elaborated on. This research tries to give more attention to what factors could especially occur in the start-up part. Of course the factors that are present in the DMI part could also influence the start-up part. However, this research also tries to find factors that are especially present in the start-up part. There are several observed aspects of the start-up that could lead to supporting theories. Three things strike the eye:

- The political relation between KHS and Heineken
- The many unforeseen problems during the start-up
- The differences of opinion among involved parties during a start-up

These aspects show a lot of similarities with aspects in project & process management, therefore this research suggest that theory on Project & Process Management could play an important role to find factors that are present in the start-up part of EEM and thus can be of influence for EEM success.

5.3 AM at Heineken & LE0

The following two lines are copied from Heinekens lectures on AM.

"Autonomous Management enables us to manage our packaging lines with a high level of quality, reliability and performance, through direct participation of operators in maintaining equipment and secure stable equipment conditions for a reliable OPI and a basis for continuous improvement".

"AM is the direct participation of production operators in the management of the processes & machines through effective cleaning, daily checks, lubrication, early detection of abnormalities and replacement of parts or small repairs"

Latter are two statements on what Heineken purposes AM to be. Furthermore Heineken states that in average 70% of the failures and downtime in the process and packaging industry are caused by lack of equipment’s basic conditions & lack of proper cleaning, inspection, lubrication and tightening standards. AM tries to attack these failures and downtime. Because the new machines in LE0 are in basic condition, it is important to keep them in this condition. Therefore a quick and successful implementation of AM step three is important. The AM steps at Heineken are discussed in the next chapter.

5.3.1 AM steps

The goal of Heineken is that all shop floor working areas reach AM step five and or six, this is a very ambitious goal, since most production lines are not further than step three. The AM steps according to literature are already briefly described in the chapter four, to make sure Heineken is interpreting AM the same way, a short description of how Heineken interprets the AM steps will be described. Again only step one to three will be discussed, since LE0 has to start up in AM step three.
Step 1: Initial cleaning
Step 2: Eliminate sources of contamination and difficult to clean & inspect areas
Step 3: Create and maintain cleaning, inspection & lubrication standards

If one compares this with literature, Heineken is interpreting the AM steps the same as in literature. To perform AM Heineken has adopted a very important operator tool: CILT, this concepts will be explained in the next chapter.

5.3.2 CILT
CILT stand for Cleaning, Inspection, Lubrication and Tightening. CILT is the most important tool to execute AM in Heineken. Every machine has special CILT tasks that have to be performed by operators on a daily, weekly, monthly or yearly basis. Apart from machines there are also safety and 5s tasks to keep the whole work floor safe and clean. One of the ideas behind the AM program at Heineken is that cleaning time is reduced and that sources of contamination, difficult to clean & inspect areas are eliminated. The CILT list must therefore be or become as short as possible, since one wants to solve (all) sources of contamination. To optimize the CILT, the CILT tasks are closely monitored and continuous improvement in setting CILT standards is important. In the CILT lists the duration of different tasks are determined. Operators have to fill in the CILT lists on a daily basis and must show if they: performed the task, not performed the task, if the to be cleaned area was already clean or if the task took longer than the determined time. This information is valuable to see patterns for improvement and steering of CILT tasks it is also important to monitor the proper working of a machine. For instance, if one area that has to be cleaned according to the CILT list is always clean, one could investigate if the CILT task duration can be reduced or that the CILT task can be even removed from the list. On the other hand, if a task takes longer than the determined time, every time it is performed, there might be an external source of contamination, which has to be eliminated or reduced. The goal is to keep the CILT list as short as possible and eliminate all sources of dirt and difficult to reach and inspect areas as much as possible.
When starting up a new line one basically starts with a very narrow CILT list and tries to keep it as short as possible (eliminate all sources of contamination and difficult to clean areas). The challenge is to keep this list as short as possible and only put cleaning activities on it that cannot be avoided.

The next chapter will explain how Heineken is organizing and maintaining their AM system with operators.

5.3.3 AM; organize your own work floor
AM in literature is described as a concept in which operators create ownership of their machines and manage their own work floor. Heineken adopted this AM vision and came up with a system to stimulate and organize this. The system that Heineken has implemented is called ‘werkplek organisatie’ (WPO).
WPO is a system in which operators get more responsibility of their working environment. Every involved operator in a production line gets one or more responsibilities. These responsibilities seem to go beyond cleanings and maintaining, all AM (thus TPM) facets are included, like safety, planned maintenance, quality maintenance, 5s and training & education. Every role is of high importance because if one aims at managing the work floor, aspects as safety and T&E are even as important as keeping the work floor clean. AM is a typical pillar in which TPM pillars overlap each other.
The responsibilities that operators get vary very much, the core AM responsibilities (like CILT roles and 5s roles) are for instance: manage sources of contamination, hard accessible places, cleaning &
inspection, lubrication and 5s. But there are also roles like safety and T&E. The basic idea is that an operator keeps updating the latest adjustments or changes concerning his or her responsibility and that he or she manages that certain tasks get done. The operator is responsible that the documentation concerning his role is up to date, not only digital, but also on the shop floor. The biggest incentive for operators to take their role serious is the fact that they need to justify their role during the weekly WPO meeting. During this meeting all the operators have to give an update on the status of their activities and if there are new developments.

By attending some WPO meetings it becomes clear that there is a real diversity of operators in term of knowledge, but also commitment to their responsibility. Some operators are really good prepared and tell a clear story on the current affairs, while others are obvious not well prepared and cannot reflect very well on their role and the current affairs. If one looks at AM at LE0, the unfolding of the AM process was not always as quick and smooth as is could be. During conversations on the shop floor operators often blamed the production pressure or the ‘first getting to know the machines’ for the slow implementation of AM. AM implementation in LE0 is facing some drawbacks and if one looks back at table 3 on TPM implementation barriers, a some overlap can be found. Drawbacks might not be very surprising since AM is one of the most difficult pillars to implement (Gotoh & Tajiri, 1999).

5.3.4 Conclusion & supporting theory to add factors to AM

Looking at the way Heineken interpreted AM, a lot of similarities with literature on TPM can be seen. For instance Heineken copies the AM steps that literature mentions. The AM tools that are used are of course specific for Heineken, but they don’t changes the basic idea behind AM. The purpose of AM at Heineken is more or less the same as in literature. However this research is not interested in the effect of AM, but in how to implemented it quick and successfully. Unfortunately from the theory on AM as well as the practice at Heineken there is not really a supporting theory that stands out and could support AM.

However if one looks at the AM implementation process in LE0 some drawbacks could be recognized. Some of these drawbacks show a lot of similarity with general TPM implementation barriers mentioned in table 3 of chapter three, like:

- Diversity of knowledge base operators
- (Lack of) commitment (moral)
- Production pressure (focus on production)

There can be direct links seen between barriers observed when implementing AM in LE0 and general TPM implementation barriers that different authors mention in table 3. This research therefore assumes that some general TPM implementation barriers also appear when applying AM all over again in a new production line (in an organization familiar with AM). The next chapter six will elaborated on which of these factors are investigated in future research.

5.4 T&E at Heineken and LE0

Since the introduction of TPM, there is a dominant continuous learning atmosphere at Heineken. The Heineken vision 2015 also states that Heineken has to improve on all 4m areas, which includes improvement in human performance. The contribution of the T&E pillar is that all losses created by knowledge gaps of employees have to be eradicated and compromized by proper T&E. This is important since people are still making the difference in manufacturing organization like Heineken (Kleppe, 2013). Wages are an important percentage of the total costs and investing in new expensive high tech equipment is useless if people are not capable of operating them properly. Also the goal to achieve higher efficiency rates is only possible if the knowledge of operators (and other employees) grows simultaneously.
When it comes to T&E in start-ups, this research only focuses on operators, since they are responsible for proper working equipment and they are the ones experiencing T&E. On top of that are operators the core of TPM thinking, since TPM is really a bottom up continuous improvement policy. In the continuous learning thought of Heineken much attention is given to raising the knowledge and skills of operators. Heineken stimulates this by introducing new function profiles for operators. These way operators can get more responsibility and have the possibility to apply for higher job profiles. Since November 2012, three operator profiles can be distinguished; from high skilled to low skilled the following profiles are introduced:

- Process control operators (PCO); master every machine and area (wet & dry, see chapter two), show leadership and act as the right hand of the team leader
- Specialist operators (SO); master one area and one machine from another area
- All-round operators (AO); master one area

5.4.1 T&E strategy LE0

As mentioned in the introduction the training and education approach in the start-up of LE0 is new for Heineken Zoeterwoude and is quite innovative. Never was there a trainings program for operators with such afford as the one in LE0. The idea is that the operator’s knowledge gap has to be minimized by a proper T&E start-up program. Because line twelve (the other domestic returnable line for Amstel, see figure 5) is producing seven days a week and the operators from line twelve and LE0 are mixed, the availability of operators before and during the start-up is scare. Also the new policies regarding fewer operators on the work floor make the occupations of rayon one tight. Mainly for these reasons Heineken decided to give only the high skilled operators intensive theoretical and practical training. The start-up team only consists of PCO’s and SO’s (see the latter chapter). There were thirteen operators involved in the start-up team. Three of them are responsible for all the documentation for LE0, which basically means making all the machine manuals and supporting documents. It depends on the skills and field of expertise which kind of training operators got. Especially the PCO’s got almost all the trainings, because they eventually have to master the whole work floor, this is not the case for the SO’s. Operators in the start-up team were dedicated to LE0 and did not have other jobs to perform before and during the early start-up of LE0.

For the new KHS machines there were theoretical trainings and practical trainings. Especially the more sophisticated machines like the filler, bottle washer, palletizer and depalletizer got extra attention in theoretical trainings. This means that there were multiple days of theoretical classroom trainings. The theoretical trainings were classroom lectures in which operators got machine instructions and were guided by beamer presentations. At the end of the theoretical trainings operators had to perform a short test to show if they understand what was educated. The theoretical trainings started before the start-up of LE0, the practical trainings began just before start-up (end of installation) and lasted till a few weeks after the start-up. Operators were told how to perform certain handlings, got practical instructions and eventually had to execute handlings. Next to all the trainings, in the contract with KHS was decided that KHS would support the start-up of LE0. This means that during the entire start-up period there is KHS support available to help operators.

During the first weeks only the start-up team operates LE0 in a one-shift program. The start-up of LE0 would scale from one shift (early shift) to two shifts (early, late shift) to three shifts (early, late, night shift) and finally to a seven shift program (seven days a week early, late, night, mixed over two lines; LE0 and line twelve). The initial planning can be seen in table 5.
In the first operational weeks of LE0 only the start-up team is operating LE0, this is also a time in which a lot of practical trainings are performed. After a few weeks the shifts scale up and operators from outside the start-up team enter. The idea behind this strategy is that operators from the start-up team, teach operators from outside the start-up team. How this processes evolved and how operators experienced all this will come forward in the data analysis chapter of this research. To discover even more what operators find important the visions and experience of KHS will be elaborated in the next chapter.

5.4.2 Training vision of KHS

First of all, KHS thinks that operator training is very important when a new production line is delivered. They state that a good start-up can only be realized if the training is proper; these way operators don’t waste time on finding out basic handlings like starting up and shutting down machines. In the trainings both the theoretical part as the practical part are important according to KHS. Especially with large complicated machines like the filler it is useful to first give theoretical trainings and later on practical training. In the theoretical trainings new machine feature can be discussed, this is important, because almost all operators in the start-up team have been working for more than twenty years with older machine types. They really think in the old equipment and are used to pushing buttons and not operating machines with a software interface. The new machines have to be operated using touch screens, consisting of multiple menus. Also there are more automatic options and operators (especially older ones) can struggle with this. Especially the practical training tries to tackle these difficulties.

The moment to start with the practical trainings is one of the difficult things in a training program. In LE0 the practical trainings started when the line started producing and production output becomes important. This immediately creates a contradictory relation between training and production. KHS states that other customers sometimes take a week for the practical trainings and don’t look at production rates. At Heineken there was room for practical trainings, but production output is leading. When production rates are not good practical trainings are often first to blame, because they require production time.

If one looks at the target group, operators are not the easiest people to educate and they can easily be distracted. Therefore it is interesting to see to what extend KHS makes sure there is enough engagement of operators during trainings. Of course as stated before, the start-up team of LE0 consists of the highest skilled operators that rayon one has, but this does not automatically mean that they are committed to trainings. Because operators are mostly not used to get classroom trainings, the engagement of them is really important. When it comes to engagement in the trainings, KHS states the following.
It might seem rather childish, but first of all the break is very important and frequent coffee and cigarette interruptions are vital to keep the operators engaged. Secondly, trainers must not only talk, but interaction and operator activities are important. Sharing own experience and let operators talk about their experience is important and creates more mutual respect. Activities are also important. Activities are active training methods to see if operators understand their system and to stimulate and engage them in gaining knowledge.

It is clear that KHS sees the trainings as an important aspect of a good start-up and tries to distribute as much knowledge as possible. Still everything has to be experienced and adopted by operators, getting to know what influences this, also beyond the trainings, is a goal of this research.

5.4.3 Conclusion & supporting theory to add factors to T&E

Looking at the way Heineken interpreted T&E, a lot of similarities with literature on TPM can be seen. For instance the fact that Heineken wants to eliminate all the losses due lacking knowledge and align all employees to the organizational goals. If one looks at LE0, it is clear that an active and broad T&E program was set out. Since this program was never so big at Heineken, it is interesting to see how operators experienced it. The important question is, what do operators find important for a successful T&E program in the start-up of a new line? To answer this question there has to be a certain baseline of factors on which operators can elaborate. Looking at the T&E strategy Heineken is using, some factors (that are italic marked in the text) could be distinguished, like:

- Selecting high skilled operators
- Theoretical training
- Practical training
- Mutual shop floor learning
- Support during start-up

The factors above show a lot of similarity with theory on learning improvement points. Therefore theory on *learning improvement points* could be useful to add factors to this research on which operators could elaborate. Furthermore if one reads the T&E strategy of Heineken only the high skilled operators get training. The trainings they receive is depending on their expertise, this means that not only there basic knowledge, but also the knowledge gained from trainings is varying among operator (in the start-up team, but certainly between the start-up team and other operators). This could mean that tacit knowledge could also play a role in the success of the T&E. The next chapter, chapter six will further elaborate on learning improvement and tacit knowledge.
6. Supporting theories to add factors to EEM, AM and T&E

The previous chapter assumes that there are underlying theories that have affinity with EEM, AM and T&E and could provide factors that influence the predetermined success of these elements. For all three elements the supporting theories that were concluded in the latter chapter five will be elaborated and deriving factors will be stated. EEM will again be separated in the DMI part and the start-up part. At the end of this chapter the final factor list will be stated that covers all the elements, the (supporting) theories and the factors. The figure below shows the progress of this research and the purpose of this chapter.

6.1 EEM

This research tries to make an approach to a better understanding on the success of EEM and to do so, as argued before; the concept will be divided into two parts; the DMI part and the start-up part. As concluded in chapter five when one looks at designing, manufacturing and installing new systems or equipment (DMI), systems engineering seems to show a lot of similarities. When one looks at the start-up process, project & process management seems suitable (next to factors from start-up theory that were already added). To derive factors from these supporting theories and state a final lists with factors, the theories and enclosed problems are now elaborated.

6.1.1 Systems Engineering

Looking at the characteristics of EEM, SE could play an important role in this concept, especially in the DMI part. According to Blanchard (2008) SE could be described as:

‘System engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on finding customers’ needs required functionality early in the development cycle, documenting requirements and then proceeding with design synthesis and system validation while considering the complete problem. Systems engineering considers both the business as the technological needs of all customers with the goal of providing quality product that meets the user’s needs (Blanchard, 2008)’.

As described by different authors EEM has a lot to do with lessons learned from old and current equipment, because system engineers are the main users and contributors to lessons learned systems, SE is very much related with EEM (NASA, 2007). SE is all about setting requirements and therefore lessons learned have to be translated into new system requirements. Drafting requirements is one of the most important aspects of SE and at the same time a very difficult task. Blanchard (2008) mentions the following challenges in defining good requirements.
• **Difficulty of defining requirements**

The requirements for systems are changing very rapidly worldwide and it is often difficult for system users to define the real requirements, because the lack of a good problem definition. It could also be that customer requirements are not technically specific enough, which could lead to customer dissatisfaction about the system. On top of that, customers often have no clear view on what they could ask for, because they have not enough knowledge about the latest technology (Ludema, 2011).

• **More outsourcing**

There is more outsourcing and procurement from external sources as ever before. Therefore, there needs to be a very good early definition and allocation of system requirements and a good developed set of specifications. All this requires close cooperation and coordination between client and supplier.

• **Too much emphases on systems**

Nowadays there is a greater degree of emphases on total systems versus the components (or subsystems). The functionality of the total system is important but the subsystems realizing this are even as important. By integrating all the subsystems together, they can fulfil the purpose for which the system was designed. Interface requirements are therefore of major importance, but often overlooked.

Next to the difficulty of stating system requirements it is, according to NASA (2007), also very important that requirements:

• **Are written correctly**

Identify and correct requirements, “shall” statement format errors and editorial errors.

• **Are technically correct**

A few trained reviewers from the technical department should identify and remove as many technical errors as possible before having all the relevant stakeholders review the requirements.

• **Satisfy stakeholders**

All relevant stakeholder groups identify and remove defects.

It is interesting to see if Heineken also experienced problems in defining requirements and if this has influenced the start-up and the equipment satisfaction.

To overcome all challenges in SE and derive from a conceptual idea to an operating system, certain steps have to be completed. Validation after each step is a very important system engineering aspect to see if one is still on track in designing/building what is needed and requested. Figure 9 shows the v-model of system engineering and represents a holistic view on the steps that have to be completed in successful systems engineering. Steps on the left hand side of figure 9 show a lot of similarities with the EEM project route of Heineken as discussed in chapter five.

![Figure 9 V-model system engineering](image)

After each design step (on the left side of the wing in figure 9) it is important that there are good reviews on the designs. Final user satisfaction can only be realized if there are good *design reviews* to
make sure that the system successfully fulfils its purpose or mission (Misra, 2008). One of the problems that came forward in TPM literature about EEM is that there often is a minimal focus on design reviews. This is again an indication that SE could play an important role in EEM and that the difficulties in SE are also applicable in EEM. The difficulties (factors) that came forward from SE literature are added to the factor list for the DMI part of EEM and can be seen in figure 10. In the figure the factors from TPM literature can also be found. Furthermore can one see the two goals that will be investigated for EEM success; equipment satisfaction and vertical start-up.

<table>
<thead>
<tr>
<th>Factors EEM DMI part</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TPM Literature</strong></td>
</tr>
<tr>
<td>- Minimal focus on design reviews</td>
</tr>
<tr>
<td>- To little MP data used</td>
</tr>
<tr>
<td>- Poor selection of construction materials</td>
</tr>
<tr>
<td>- Wrong fabrication of equipment</td>
</tr>
<tr>
<td>- Installation errors</td>
</tr>
<tr>
<td><strong>Systems Engineering</strong></td>
</tr>
<tr>
<td>- Difficulty of defining requirements</td>
</tr>
<tr>
<td>- Outsourcing</td>
</tr>
<tr>
<td>- Too much focus on systems instead of subsystems and interfaces</td>
</tr>
<tr>
<td>- Correctness of requirements</td>
</tr>
<tr>
<td>- Stakeholders approval and validation</td>
</tr>
</tbody>
</table>

![Figure 10 Factors EEM DMI part and the to be investigated EEM success](image)

6.1.2 Project & Process management

Looking at the whole start-up process, project & process management could play an important role in this process. During the start-up process, the supplier (KHS) plays an important role. KHS is an external supplier that delivers, installs, integrates and supports the LE0 project/start-up. KHS is thereby delivering tangible products and services as well as intangible knowledge and skills that are needed to understand and operate the system. Often, there are adverse interests during a project, between contractor and client. Generally, relations between the client and a contractor working on the project could best be characterized as adversarial. The objective of the client is to get the project as cheap and fast delivered as possible. The contractor’s objective is to make as much profit as possible with the least possible effort (Meredith & Mantel, 2010). This is the will be the first derived factor.

- Adversarial relation between client and contractor

Beside these different goals between client and contractor, there are also often conflicts between other parties involved in a project. Meredith & Mantel (2010) describe three main conflicts that happen between project members:

- *Groups working on the project may have different goals and expectations*
- *There is considerably uncertainty about who has the authority to make decisions*
- *There are interpersonal conflicts between people who are parties-at-interests in the project*

Some conflicts relate to the fact that the day-to-day work on projects is usually carried out by many different units in the organization, which differ in expectations about the project, its costs and rewards, its relative importance and its timing.

Other conflicts can be assigned to the fact that both technical as administrative aspects are important procedures during a project. Uncertainty about who has the authority to make decisions on resource allocation, on administrative procedures, on communication, on technological choices and all other matters affecting the project procedures could conflict between the project parties.
Finally, some conflicts arise because human beings are an integral part of the project. In an environment that depends on the cooperation of many persons, it seems inevitable that some personalities clash. However this type of conflict will be left outside of this research because of ethical business reasons.

Next to these conflicts a lot of decisions in a complex and uncertain start-up process have to be made. The decisions that have to be made during the start-up, have to be made in an environment were different parties have different perceptions on problems (also one of the conflicts mentioned in the latter paragraph on project management). Parties involved in the LE0 project may have different perspectives, but they are very much dependent on each other to make the project a success (Bruijn & Heuvelhof, 2008). Decision making on solving start-up problems might be difficult because of colliding interest and people that tend to behave strategically. On top of that, in a time pressuring stressful start-up process there are often problem perceptions rather than clear problem statements. If a problem during the start-up arises, the real core of the problem is often unknown. This could mean that different actors have different solutions to the problem (perceptions) (Bruijn & Heuvelhof, 2008). There are (vague) problems perceptions, but still decisions on solving them have to be made quick. Different interests and different knowledge might collide during the start-up phase, but could on the other hand be very valuable input during start-up meetings and other decision moments to come to proper decisions. Parties involved have to learn from each other and together make quick decisions that create win-win situations. This brings us to the next problem:

- There could be different perceptions on problems and solutions by involved parties.

The factors derived from project & process management are added to the EEM start-up part and can be seen in figure 11, again the success (goals) of EEM can be seen. It is interesting to see if the assumed problems mentioned in project & process management are present in the EEM start-up part and if they influence EEM success.

<table>
<thead>
<tr>
<th>Factors EEM Startup part</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Startup Literature</strong></td>
</tr>
<tr>
<td>- Inappropriate management decisions (through inexperience in start-ups)</td>
</tr>
<tr>
<td>- Not-yet-verified technologies</td>
</tr>
<tr>
<td>- High frequency of minor stoppages</td>
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<tr>
<td>- Lack of materials</td>
</tr>
<tr>
<td>- Lack of material quality/status</td>
</tr>
<tr>
<td>- Breakdowns</td>
</tr>
<tr>
<td>- Personnel performance</td>
</tr>
<tr>
<td>- Late engineering changes</td>
</tr>
<tr>
<td><strong>Project &amp; Process Management Literature</strong></td>
</tr>
<tr>
<td>- Adversarial relation between Heineken and KHS</td>
</tr>
<tr>
<td>- Difference of goals and expectations among project parties</td>
</tr>
<tr>
<td>- Uncertainty about who has authority to make decisions</td>
</tr>
<tr>
<td>- Different perceptions on problems and solutions among project parties</td>
</tr>
</tbody>
</table>

![Figure 11 Factors EEM Start-up part and the to be investigated EEM success](image)

**6.2 AM**

This research makes an approach to a better understanding of what influences the success of a quick and successful implementation of AM step three in the start-up of a production line. From chapter five can be concluded that there is not really a supporting theory that could help this find more insight in factors could influence this process. However, according to literature, AM seems one of the most
important and difficult TPM pillars to maintain. Observations during the case study at Heineken confirmed this. A lot of general TPM implementation barriers were noticed when looking at the AM implementation in LE0. Some TPM barriers from table 3 can directly be copied like: lack of moral and too much focus on production. However there are other plausible factors from table 3 that will be investigated. In table 3 one can see TPM implementation barriers from five different articles. If barriers retuned in more than one article the barrier is taken into further analysis to see if it also influenced a quick and successful implementation of AM. The barriers that return in more than one article can be seen in figure 12. The factors that were observed are included anyway. The success that is being investigated is also stated. One could see that the investigated success of AM is very different from EEM.

<table>
<thead>
<tr>
<th>Factors AM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TPM Literature (AM barriers)</strong></td>
</tr>
<tr>
<td>- Low level of 5s</td>
</tr>
<tr>
<td>- Lack of moral</td>
</tr>
<tr>
<td>- Operators are not technically skilled enough</td>
</tr>
<tr>
<td>- Waiting for support</td>
</tr>
<tr>
<td><strong>TPM Literature (general barriers)</strong></td>
</tr>
<tr>
<td>- Amount of implementation</td>
</tr>
<tr>
<td>- Lack of training</td>
</tr>
<tr>
<td>- Lack of communication</td>
</tr>
<tr>
<td>- Workload</td>
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<tr>
<td>- Focus on production</td>
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<tr>
<td>- Resistance</td>
</tr>
<tr>
<td>- Lack of understanding importance</td>
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<tr>
<td>- Lack of management support</td>
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</tbody>
</table>

![Figure 12 Factors AM and to be investigated AM implementation success](image)

### 6.3 T&E

This research tries to investigate what is important in a T&E program according to operators. Chapter five concluded that literature on learning and in particular, what could improve the learning of individuals could be suitable theory to find factors, so that operators could elaborate on them. The next chapter will elaborate more on learning and how learning of individuals could be improved.

#### 6.3.1 Learning

In an organization based on knowledge, it is essential to measure the use of knowledge for continuous improvement of the organization. Unfortunately knowledge about a firm’s production function is typically incomplete and cannot be fully articulated and codified in blueprints. Instead, knowledge resides for a large part in organizational routines and often takes the form of tacit knowledge (Levin, 2000). Tacit knowledge is hard to measure as well as learnings within organizations. Tacit knowledge as concluded in chapter five is one of the factors that is assumed to influence successful T&E in startups.

Learnings are necessary to stay competitive, because one can improve employee performance, but could on the other hand be very intangible to measure. It is therefore expected that individual learning patterns in LE0 are also hard to notice. Therefore this research is not interested in the exact learning curves of operators, but what operators find important in T&E and how they experienced the start-up. To do this there have to be some kind of baseline of factors to investigate. As indicated in chapter six, theory on how to improve learning seems appropriate to support T&E thinking in a production start-up. To show what could be important for operators, theory on factors to improve individual learning can be useful. Chase et al. (2006) writes on learning and how this could be improved.
Chase et al. (2006) state that learning’s can be observed from both an organizational as an individual perspective. Individual learning is improvement that results when people repeat a process and gain skill or efficiency from their own experience. That is, “practice makes perfect.” Organizational learning results from practice as well, but it also comes from changes in administration, equipment, and product design. In organizations, one can expect to see both kinds of learning occurring simultaneously. In the context of LE0 one could also indicate individual and organizational learning. Organizational learning is very much captured in the concept of EEM, especially looking at lessons in the design of new equipment. Individual learning in the LE0 environment is vital to understand the new technology and make the start-up a success. This type of learning has to be improved by T&E. Chase et al. (2006) describe how individual learning could be improved. The factors below could improve learning.

- Proper selection of workers
- Proper training
- Motivation
- Work specialization (the simpler the task the faster the learning)
- Do one or very few jobs at a time. Almgren (1999) in his piece on production start-ups also mentions that the dedication of operators to a specific station has shown a significant impact on the downtime of stoppages.
- Use tools or equipment that assists or supports performance
- Provide quick and easy access for help (support)
- Allow workers to redesign their tasks

The factors that chase et al. (2006) mentions, together with tacit knowledge will be investigated during this research. TPM literature already mentioned that training is important for T&E, but this factor is also mentioned by chase et al. (2006), therefore this factor will be assigned to the factors from Chase. Figure 13 shows the factors that could influence learning improvement when starting up a new production line.

<table>
<thead>
<tr>
<th>Factors T&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Improvement Literature</td>
</tr>
<tr>
<td>- Proper selection of workers</td>
</tr>
<tr>
<td>- Proper training</td>
</tr>
<tr>
<td>- Motivation</td>
</tr>
<tr>
<td>- Work specialization</td>
</tr>
<tr>
<td>- Do very few jobs at a time</td>
</tr>
<tr>
<td>- Use tools or equipment that support performance</td>
</tr>
<tr>
<td>- Provide quick and easy access for help</td>
</tr>
<tr>
<td>- Allow workers to redesign their task</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>- Tacit knowledge</td>
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</tbody>
</table>

![Image](424x-24 to 549x101)

**Figure 13 Factors T&E and the to be investigated T&E success**

All the elements and their supporting theories are now discussed. On the next page a final overview of the three elements, the existing TPM literature and factors, the supporting theories and the derived factors can be seen in table 6. If these factors will return in the LE0 case and if they are related the to be investigated success of EEM, AM and T&E will be elaborated in chapter seven that follows on data approach and results.
6.4 Final factor list (3)

<table>
<thead>
<tr>
<th>EEM DMI part</th>
<th>EEM Start-up part</th>
<th>AM</th>
<th>T&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TPM literature</strong></td>
<td>Production Start-up literature</td>
<td>TPM literature (AM barriers)</td>
<td>TPM literature</td>
</tr>
<tr>
<td>Minimal focus on design review</td>
<td>Inappropriate management decisions (through inexperience in start-ups)</td>
<td>Operators are not technically skilled enough</td>
<td>Training</td>
</tr>
<tr>
<td>To little MP data used</td>
<td>Not-yet-verified technologies</td>
<td>Lack of morale</td>
<td></td>
</tr>
<tr>
<td>Poor selection of construction</td>
<td>High frequency of minor stoppages</td>
<td>Waiting for support</td>
<td></td>
</tr>
<tr>
<td>materials</td>
<td>Lack of materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrong fabrication of equipment</td>
<td>Lack of material quality/status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation errors</td>
<td>Breakdowns (less in proven technology)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Systems Engineering literature</strong></td>
<td>Personnel performance</td>
<td><strong>TPM literature (general TPM barriers)</strong></td>
<td></td>
</tr>
<tr>
<td>Difficulty of defining requirements</td>
<td>Late engineering changes</td>
<td>Amount of implementation</td>
<td></td>
</tr>
<tr>
<td>Outsourcing</td>
<td>Corners cut in optimization of processes</td>
<td>Lack of training</td>
<td></td>
</tr>
<tr>
<td>Too much focus on systems instead of subsystems and interfaces</td>
<td></td>
<td>Lack of communication</td>
<td></td>
</tr>
<tr>
<td>Correctness of requirements</td>
<td><strong>Project &amp; Process Management literature</strong></td>
<td>Large workload</td>
<td></td>
</tr>
<tr>
<td>Stakeholders approval and validation</td>
<td>Adversarial relation with supplier</td>
<td>Focus on production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difference of goals and expectations by project members</td>
<td>Resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uncertainly about who has the authority to make decisions</td>
<td>Lack of understanding importance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Different perceptions on problems and solutions by project members</td>
<td>Lack of management support</td>
<td><strong>Other</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Learning literature</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Proper selection of workers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Proper training</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Theoretical</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Practical</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Motivation</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>During trainings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>During startup</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Work specialization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Do very few jobs at a time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Use tools that assist of support performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Easy access for help (support)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Other</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tacit knowledge</td>
</tr>
</tbody>
</table>

**Notes:**
- **TPM** refers to Total Productive Maintenance.
- **AM** refers to Advanced Manufacturing.
- **T&E** refers to Teaching and Education.
- **Barriers** include various elements that can hinder or delay the implementation of TPM, AM, or T&E initiatives.

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*Source: D.J.W. Querido, 2023*
7. Data Approach & Results

This chapter describes all the data that was gathered during this research and derives conclusions on the assumed factors influencing the success of EEM, AM and T&E in the start-up of LE0. All three elements will separately be treated and concluded. All the data described in this chapter is gathered by interviews, small talks and active participation and observation in the start-up process of LE0. This chapter will start with an explanation of the respondents, the validity, the interview technique and why observations were done. After that, the analysis on EEM, AM and T&E factors will follow and be concluded. The figure below shows the progress of this research and the purpose of this chapter.

7.1 Respondents, validity, interview technique and observations

For every element different respondents were questioned. For each element will be argued which respondents were questioned (and why), how validity in answers is secured and how the interviews where performed. This chapter will start with an overview of the number of respondents in table 7.

<table>
<thead>
<tr>
<th>Table 7 Overview respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respondents</strong></td>
</tr>
<tr>
<td>7 important project parties (+observations)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

7.1.1 EEM

For the EEM part of this research important project parties involved in the LE0 project were interviewed and next to that a lot of observations during the six-month case study were done. Respondents that were questioned had different involvement in the project. The research focuses on the DMI and start-up part of EEM. Basically all respondents were very much involved in the DMI part of LE0 and a majority was involved with both the DMI and the start-up part. The following parties were interviewed:

- Experience expert (involved in the DMI and Start-up part)
- Rayon technician (involved in the DMI and the Start-up part)
- Project manager (involved in the DMI and the Start-up part)
- Industrial engineer (mostly involved in the DMI part)
- Project member safety (mostly involved in the DMI part)
- Project member quality (involved in the DMI and the Start-up part)
- Project member planned maintenance (mostly involved in the DMI part)

As one can see for each part at least three important parties were interviewed, so triangulation of sources as Verschuren & Doorewaard (2010) describe it is secured. Triangulation of sources in a single case study is important to gather valid data also because respondents could give strategic answers. To
give even more validity to the outcomes, observations regarding the factors were done that could be held against the answers of respondents, this way also triangulation of methods is secured (Verschuren & Doorewaard, 2010). It must be said that for the DMI part almost no observations were done because the researcher was not present in these project phases. Looking at observations, there are two types of observational schemes that a researcher can follow; the pre structured variant and the open variant (Verschuren & Doorewaard, 2010). In this case study the open variant is used since this research only has some points of interest (the assumed influential factors) that where observed.

If one looks at the interviews, the respondents were questioned in semi-structured interviews because the exact relations between the factors and EEM success is not precisely known in advance and new insights can come to the surface. On top of that could additional factors come to the surface and could there be relations between factors identified, that were not foreseen in advance. The descriptions that the respondents give to the factors really determine the conclusions of this research.

To get valid answers during the interviews, respondents were not only asked if factors were present, but also to explain why and how they were present and to give examples if possible. This seems a valid way to see if factors were present, because respondents really have to think about their answer and cannot just say yes or no. Respondents were also asked if the presence of factors influence the EEM goals. It is impossible to state the precise effect of the factors during interview, but this research is also not meant to do so. This research is merely meant to see which factors were present and if they influence the EEM goals, so that this can give new insight in EEM theory, opens doors for research and could give Heineken advise on how to manage future start-ups.

7.1.2 AM

Looking at the AM part of this research skilled operators from the LE0 start-up team and a TPM facilitator, specialized in AM was questioned. Operators are the most important and closest involved in the whole AM process, their view is therefore very important. There were only operators from the start-up team asked because they are capable of understanding questions, have insight in the consequences of factors and are capable of giving proper answers. This is mostly not the case looking at operators from outside the start-up team. Next to interviews, also observations were done since the researcher was very much involved in the whole AM implementation. Especially during the two AM audit that were held (to check the level of AM) important observations were done. The following individuals where questioned:

- 3 Process Control Operators (highest skilled operators)
- 4 Specialist Operators (high skilled operators)
- TPM facilitator specialized in AM

Also here triangulation of sourced is secured since seven different operators were questioned. To make the answers more valid the same interview was done with a TPM facilitator specialized in AM (an independent party closely involved in the LE0 start-up). This could be needed since there is a change that operators are somehow giving strategic answers to save their own interests. Again also observation were done to make the answers even more valid. For the observations again the open variant was used (Verschuren & Doorewaard, 2010). For the interviews the same strategy as with EEM is used. Semi-structured interviews were used, because the exact relations between the factors and AM success is not precisely known in advance and new insights can come to the surface. On top of that could additional factors come to the surface and could there be relations between factors identified, that were not foreseen in advance.
Also here to get valid answers during the interviews, respondents were not only asked if factors were present, but also to explain why and how they were present and to give examples if possible. Respondents were again asked if the presence of factors influence the success of AM (not the goals of AM cause this is not an quick and successful implementations). Again this research is meant to see which factors were present and if they could influence the success of a quick and successful implementation of AM, not the precise impact of AM on production.

7.1.3 T&E

Looking at the T&E part of this research the same skilled operators from the LE0 start-up team were questioned as in the AM interviews. On top of that were operators from the start-up team the only one who really got intensive training. Operators are the most important parties, because they experience the T&E strategy and they have to learn and gain knowledge. Apart from what Heinekens purpose of the T&E program was, will be investigated what operators find important in a T&E program during a start-up. Next to the interviews, observations were done during trainings and during the start-up. All the operators that were questioned are very much involved in the T&E program and experienced the whole start-up learning process. The following individuals were questioned:

- 3 Process Control Operators (highest skilled operators)
- 4 Specialist Operators (high skilled operators)

Triangulation of sources is partly secured since only operators were questioned. In this case this seems enough, because strategic answers seem unnecessary since there is no interest for operators to do so (there are not being judged on the T&E program). However also here, to make the answers more valid observation were done. For the observations again the open variant was used (Verschuren & Doorewaard, 2010). For the interviews the same strategy as with EEM and AM is used. Semi-structured interviews were used, because the exact relations between the factors and T&E success is not precisely known in advance and new insights can come to the surface. On top of that could additional factors come to the surface and could there be relations between factors identified, that were not foreseen in advance. The difference between T&E and EEM and AM is that there for T&E some additional questions were asked that were not derived from factors that came from literature. This was merely meant to create an even better view on what operators find important in T&E.

To get valid answers during the interviews, respondents were again not only asked if factors were present, but also what they find important looking at these factors.

The whole elaboration of all the EEM, AM and T&E interviews and observations can be found in appendix I, II and III. This chapter will continue with the results of the data analyses on EEM, AM and T&E.

7.2 Results EEM

This chapter is meant to see if the purposed factors have influence on the success of EEM. This chapter will therefore make an analysis of the purposed factors, with input from the various interviews. This all should create more insight in the concept of EEM and what influences this. The analyses will be done as follows. First the factors that the respondents found present will be stated. Afterwards from the present factors will be determined if they influenced the success of EEM. The EEM DMI part and EEM start-up part will be elaborated separately. All this creates more insight in the success of EEM and therefore also in EEM generally.
7.2.1 Analysis EEM DMI part

First one has to determine from the interviews which factors were present in the LE0 case. This research assumes that a factor is present if a majority of the respondents state so; this means more than three (out of seven). In figure 14 one can see per factor how much respondents state that a factor was present in the LE0 case.

![Present factors EEM DMI part](Image)

**Figure 14 Present factors EEM DMI part**

**Present factors and discussion**

One can see that according to the respondents six out of nine factors are dominantly present in the EEM DMI part, namely: too little focus on design reviews, poor selection of construction materials, wrong fabrication of equipment, difficulty of defining requirements, outsourcing and too much focus on system instead of subsystems and interfaces. Those were not are: too little MP data used, incorrect requirements, lack of approval and validation of stakeholders and installation errors. Most respondents states that there was enough MP data used, but that the gathering took too much afford and time, because the lack of data structure in the TPM pillars. It is however expected that this factor (if present) could have impact on at least the equipment satisfaction. Unfortunately this research could not demonstrate this. Next to that do most respondents state that the requirements were correctly stated and on top of that, that this cannot be a burden for EEM, since there has to be mutual understanding with the supplier on requirements. Heineken should state functional requirements and the supplier has to give technical interpretation to his. Since this mutual understanding was lacking at Heineken, one could argue that correct requirements are important, also for equipment satisfaction, again this could not be demonstrated in this research. Next there was enough (internal) approval of all the stakeholders looking at the requirements. This was partly caused by the fact that stakeholders (TPM pillars) all stated rather accessible requirements without great depth. Nevertheless seems this factor crucial for equipment satisfaction, at least for the pillars individually. One could expect that if EEM gets more sophisticated and requirements reach higher levels, this factor becomes more important. Last were there not really significant installation errors. Some minor things went wrong, but not worth mentioning. If there were installation errors, they would, like wrong fabrication of equipment, of course influence the equipment satisfaction and the vertical start-up.

Now one knows which factors were present, the influence that these factors have on the success of EEM (equipment satisfaction and vertical start-up) will be investigated. Factors are assumed to have
influence on the EEM goals if more than one respondent, which found the factor present, states that it has influence one or two of the EEM goals (success). When it becomes clear which factor has influence to which EEM goal(s), the general thoughts of respondents will be briefly stated so that it becomes more clear why and how present factors influence EEM goals. First in figure 15 one can see if the present factors have influence on EEM success, afterwards explanations follow.

<table>
<thead>
<tr>
<th>Present DMI factors influence on EEM success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too little focus on</td>
</tr>
<tr>
<td>Poor selection of construction materials</td>
</tr>
<tr>
<td>Wrong fabrication of equipment</td>
</tr>
<tr>
<td>Difficulty of defining</td>
</tr>
<tr>
<td>Outsourcing</td>
</tr>
<tr>
<td>Too much focus on</td>
</tr>
</tbody>
</table>

**Figure 15 Influence DMI factors on EEM success**

**Explanation of factors influence and discussion**

On can see that too little focus on design reviews, poor selection of construction materials, wrong fabrication of equipment, outsourcing and too much focus on systems instead of sub systems and interfaces influence the equipment satisfaction and difficulty of defining requirements don’t. Too little focus on design reviews, wrong fabrication of equipment, outsourcing and too much focus on systems instead of sub systems and interfaces have influence on a vertical start-up and difficulty of defining requirements and poor selection of construction materials don’t. To give the reader more clarity on why these factors influence or do not influence EEM success, per factor a small explanation will be given. These explanations are based on answers respondents gave and observations done during the case study.

**Too little focus on design reviews**

There were some internal reviews, but not in cooperation with the supplier, which resulted in a lot of wrongly, interpreted requirements and surprises. This both influenced the equipment satisfaction and vertical start-up, because of the misinterpreted requirements and a lot of things that have to be changed during start-up, which caused downtime.

**Poor selection of construction materials**

There were a lot of wrongly interpreted requirements, which sometimes resulted in a poor selection of construction materials. The communication with KHS was not optimal and Heineken talked too much with the wrong people (commercials instead of engineers). There was also too much freedom in requirements, so the supplier was too free in choosing unsatisfactory construction materials. This sometimes resulted in dissatisfaction about equipment, but did not really harm the vertical start-up. It could be expected that if the choice of construction materials has more impact on production (like too many failures due to bad materials) that this factor could also influence a vertical start-up.
Wrong fabrication of equipment
Again a lot of things were interpreted wrongly, which resulted in wrongly fabrications. Again the communication between commercial people and engineers at KHS did not go well. This resulted in a lot of dissatisfaction about certain equipment. It also influences the vertical start-up since these things had to be adjusted on site at Heineken.

Difficulty of defining requirements
This factor was present, because of the following:

• Suppliers techniques are getting more sophisticated, but still have to comply with Heineken standards
• There were too little standard TPM specifications in Heineken
• Different visions on requirements within Heineken (visions top down is cheap and suppliers standards, vision bottom up is more EEM)
• How (technically) specific the requirements had to be was uncertain

However respondents could not demonstrate the influence on the equipment satisfaction or the vertical start-ups. However it is expected that this factors could have influence on both EEM goals since it is stretching the DMI phase, which means less time for design reviews or negotiations with the supplier. Also does it shows that Heineken is not very clear on what to ask for, this could result in the fact that one asks for something one doesn’t want. Unfortunately this did not came forward during this research.

Outsourcing
It seems that outsourcing influences a lot of the other factors. There was not enough sparring time with the supplier on what was possible and what not (design reviews, difficulty of defining requirements). The supplier is also dependent on delivery times, which narrowed the whole process. Heineken also talked mainly to commercial people who translated things to engineers, which not always went well. For good EEM suppliers need guidance and good explanations on the requirements. Also one really has to know the process behind the supplier (delivery times and third party outsourcing). This all resulted in the fact that Heineken was dissatisfied about certain equipment and also the vertical start-up suffered from this, because a lot of things had to be changed and also a lot of things did not work the way Heineken desired.

Focus on system instead of subsystems and interfaces
Because KHS was the integrator, there was not enough focus on the integration requirements of all the machines, which resulted in problems, because machines were not integrating well. Also the integration of machines with materials was not always well, this also created problems. From Heineken's side there had to be more support to KHS in the form of a detailed integration plan or a functional design. This definitely influenced the equipment satisfaction since machines were not always working or interacting with each other the way they supposed to. Downtime was often the result, which also influenced the vertical start-up.

One now has a clear view on which factors were present in the EEM DMI part and which of these influenced EEM success. To wrap this up, a final overview is given in table 8.
Table 8 Final overview EEM DMI part

<table>
<thead>
<tr>
<th>EEM DMI part</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors</td>
<td>Equipment satisfaction</td>
</tr>
<tr>
<td>TPM literature</td>
<td></td>
</tr>
<tr>
<td><strong>Present</strong></td>
<td></td>
</tr>
<tr>
<td>Too little focus on design reviews</td>
<td>✓</td>
</tr>
<tr>
<td>Poor selection of construction materials</td>
<td>✓</td>
</tr>
<tr>
<td>Wrong fabrication of equipment</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Not present</strong></td>
<td></td>
</tr>
<tr>
<td>Too little MP data used</td>
<td></td>
</tr>
<tr>
<td>Installation errors</td>
<td></td>
</tr>
</tbody>
</table>

| Systems Engineering literature | |
| **Present** | |
| Difficulty of defining requirements | × | |
| Outsourcing | ✓ | ✓ |
| Focus on system instead of subsystems and interfaces | ✓ | |
| **Not present** | |
| Incorrect requirements | |
| Lack of approval and validation of stakeholders | |

7.2.2 Analysis EEM start-up part

Again like the DMI part one first has to determine from the interviews which factors were present in the LE0 case. This is done the same way as in the DMI part. In figure 16 one can see per factor how much respondents state that a factor was present in the LE0 case.

![Present factors EEM startup part](image)

Figure 16 Present factors EEM startup part

Present factors and discussion

One can see that according to the respondents nine out of thirteen factors are dominantly present in the EEM DMI part, namely: inappropriate management actions, corners cut in optimizations of processes, lack of materials, lack of material quality, bad performance personnel, late engineering changes, adversarial relation with supplier, difference of goals and expectations among project members, different perceptions on problems and solutions by project members. Those were not are: high frequency of minor stoppages, the use of not yet verified technologies, breakdowns and
uncertainty who has authority to make decisions. Minor stoppages were present, but are needed for commissioning and were not excessive. The observations however concluded different and the researchers experience was that minor stoppages certainly influenced the vertical start-up. To what extend this is normal for commissioning is not for the researcher to judge. Next LE0, or Heineken, uses a lot of advanced technology, but everything is more or less proven. Heineken almost never makes use of not yet verified technologies. The effect of this cannot be investigated in this research, but literature stated more failures happen in new technologies, compared to proven technologies (Almgren, 2000). Breakdowns were also not dominant in the start-up of LE0; there were breakdowns, but not more than in existing lines. Finally was there no uncertainty on who had authority to make decisions during the start-up. The processes of decision-making went via really clear and tight lines and one almost never deviated from this. Fact remains looking at the start-up of LE0 that a lot of decisions had to be made very quickly, so this factor is very important for a vertical start-up with little delays.

Now one knows which factors were present in the LE0 case, the influence on EEM success (equipment satisfaction and vertical start-up) will be investigated. This is done the same way as in the DMI part. In figure 17 one can see if the present factors have influence on EEM success, afterwards explanations follow.

![Figure 17 Influence DMI factors on EEM success](image)

**Present startup factors influence on EEM success**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Amount of respondents state influence on equipment satisfaction</th>
<th>Amount of respondents state influence on vertical startup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inappropriate</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Corner cut in optimization</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lack of material quality</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Inappropriate</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Late engineering changes</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adversarial relation</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Difference of goals and expectations</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Explanation of factors influence and discussion**

On can see that late engineering changes and adversarial relation with the supplier influences the equipment satisfaction and inappropriate management decisions, corners cut in optimization of processes, lack of materials, lack of materials quality, personnel performance, difference of goals and expectations by project members and different perceptions on problems and solutions by project members don’t. Inappropriate management decisions, lack of materials, lack of material quality and late engineering changes have influence on a vertical start-up and corner cut in optimizations of processes, personnel performance, adversarial relation with supplier, difference of goals and expectations by project members and different perceptions on problems and solutions by project members don’t. To give the reader more clarity on why these factors influence or do not influence EEM success, per factor a small explanation will be given. These explanations are based on answers
In the end additional factor(s) that came to the surface in the interviews will be stated.

**Inappropriate management decisions**
This is quite a general factor and can express itself in a lot of forms. However, this factor is merely meant to see if indeed management inexperience led to inappropriate decisions, which could influence EEM success. Management decisions during the start-up have to be made very quick and one can only say that there were wrong decisions afterwards. What one could see is that there was not enough Heineken expertise on the right places during the start-up. Heineken has a lot of expertise in commissioning machines; this knowledge must be used well. If there was more expertise on the right places, problems would have been noticed earlier and the start-up would have been more vertical. Next to that, were problems sometimes pushed forward, because the severance to management was not clear. The main reason for this was that there was not always enough operational knowledge on the moment when one decided on problems. Last the day to day planning of activities on the shop floor during start-up could have been better; quality checks and late engineering changes could have been planned more efficient (this also requires full cooperation and transparency of the supplier). Respondents see a string link to damaging a vertical start-up, but the influence to the equipment satisfaction was not recognized. However if there are no proper decisions in the planning of late engineering changes the end result of the system might not be optimal.

**Corners cut in optimization of processes**
To help production on the short term, some shortcuts in the optimizations of processes were taken. There were a few machines options that did not work proper and generated a lot of failures (but if they had worked properly generate a lot of benefits) these options were disabled, so the process would run better on the short term. This all has no influence on the vertical start-up (or a least no negative influence), it also has no influence on the equipment satisfaction. One could think that shortcuts could have a positive contribution to a vertical start-up, but if they are not straightened afterwards, have a negative influence on the equipment satisfaction. This research was too short to show this result.

**Lack of materials**
There was sometimes lack of materials, all the data cables for instance were delivered too late. This resulted in mechanical proceedings on moments that were planned for production, which influenced the vertical start-up. There was no influence on equipment satisfaction since everything was delivered eventually.

**Materials quality**
Respondents state that if a production line is new, how the quality of the materials performs is always questionable. The quality of the labels was not good, at least not suitable for the label machine. The bottle washer was also not capable of properly washing off the labels from the returned bottles and left glue residues behind. Again this was due to bad (or not suitable) quality of the labels. These problems were solved eventually, but this damaged the vertical start-up. There was no influence to the equipment satisfaction, because after a while the system worked properly. It seems that these kinds of things need more attentions in the EEM DMI part (interface requirements).

**Performance personnel**
Respondents agreed on the fact that there was a real difference in personnel (operator) performance. It is however hard for respondents to say if this influenced the vertical start-up, because it is something
that organizations always have to deal with, one states. It has also nothing to do with equipment satisfaction. More on performance of operators will follow in chapter 7.3 and 7.4 on AM and T&E.

Late engineering changes
There were a lot of late engineering changes, mainly because of the wrong courses in the DMI part, like the lacking of design reviews. There were also new additional things discovered on site that had to be adjusted (the long operator problem list). The early start-up did not really suffer from these changes, because most of them were planned during downtime (there was plenty because one was working in one shift). However observations showed that sometimes engineering changes took places quite abruptly, mainly because KHS drew their own plans. This could have been managed better, also to avoid annoyance on the shop floor. During the later stages of the start-up, when operator shifts scaled up, less time was available for adjustments and production sometimes had to stop to make mechanical adjustments, this influenced the vertical start-up. The problem with the late engineering changes is that there are too many to solve all and this can result in dissatisfaction about the final system. Therefore, it becomes very important for Heineken to state priorities for KHS and try to solve other things their selves. KHS must really focus on engineering changes that Heineken is not capable of doing.

Adversarial relation with supplier
There were sometimes different opinions looking at the functioning of machines. The supplier often falls back to his standard specifications and Heineken feels that the machines have to perform better. The problem that often rose was that if Heineken wants to changes the supplier’s specifications, it is at the expense of supplier’s warranty. Also Heineken's TPM thought during the start-up is not shared with the supplier. Machines suppliers are really constructors and do not really think in processes, this sometimes collides. This all did not really influence the vertical start-up, but creates some dissatisfaction about certain things (supplier standards), however these are really things that should have been dealt with in the DMI part. What one also could see during the start-up there were sometimes different thoughts on late engineering changes. What has priority for Heineken, sometimes does not have priority for KHS, this can have influence on the latter satisfaction about the equipment. This shows that a strong relation is not only needed during the DMI part, but also during the start-up part, to make EEM successful.

Difference of goals and expectations by project members
Especially between quality and production there were often different goals and expectations according to the respondents. As the start-up progressed the production pressure increased, this made the quality ethics for production parties looser. There was sometimes too much focus on production by (production) management. Quality parties often had different expectations about when to stop production and on the quality-production priorities. LE0 showed that it is very hard to prioritize between quality and production when production pressure is increasing. Respondents did not indicate the influence on the vertical start-up, but the fact remains that if the quality of products is not proper enough to be sold to the market (which happened in the start-up of LE0), the OEE decreases (because OEE is also depending on quality, see chapter 3.3). Respondents did not see a link with equipment satisfaction, which is assumable.

Different perceptions on problems and solutions by project members
Observations showed that there were some differences between operators and management. Management sometimes did not see the severance of problems that operators stated. The communication and understanding between these two parties is therefore extremely important during
the start-up. The influence on the vertical start-up was not indicated during this research, but one could expect that if the cooperation and communication between operations and management was better the vertical start-up could benefit from this. There was also no relation with equipment satisfaction discovered, which is like the latter factor assumable.

Too much focus on production (additional)
This extra factor came to the surface during the interviews. This factor merely came to the surface when discussing the factor difference of goals and expectations among project members, with respondents. Especially from production management there was much focus on production. This could lead to production that keeps running while the risks for quality defect are high. In the end will quality defects occur and because the OEE is partly calculated by quality (see chapter 3.3), the overall OEE will drop. Therefore too much focus on production in a start-up can in fact decrease the efficiency rate, because the quality level can decrease. The focus on production also ensured that production sometimes got priority over late engineering changes, which could influence the equipment satisfaction in the end.

One now has a clear view on which factors were present in the EEM start-up part and which of these influenced EEM success. To wrap this up, a final overview is given in table 9

Table 9 Final overview EEM start-up part

<table>
<thead>
<tr>
<th>EEM Start-up part</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors</td>
<td>Equipment satisfaction</td>
</tr>
<tr>
<td><strong>Production Start-up Theory</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Inappropriate management decisions (through inexperience)</td>
<td>✗</td>
</tr>
<tr>
<td>Corners cut in optimization of processes</td>
<td>✗</td>
</tr>
<tr>
<td>High frequency of minor stoppages</td>
<td>✗</td>
</tr>
<tr>
<td>Lack of materials</td>
<td>✗</td>
</tr>
<tr>
<td>Materials quality</td>
<td>✗</td>
</tr>
<tr>
<td>Performance personnel</td>
<td>✓</td>
</tr>
<tr>
<td>Late engineering changes</td>
<td>✓</td>
</tr>
<tr>
<td>Not present</td>
<td></td>
</tr>
<tr>
<td>Use of not yet verified technologies</td>
<td></td>
</tr>
<tr>
<td>Breakdowns</td>
<td></td>
</tr>
<tr>
<td><strong>Project &amp; Process Management Theory</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>Adversarial relation with supplier</td>
<td>✓</td>
</tr>
<tr>
<td>Difference of goals and expectations by project members</td>
<td>✗</td>
</tr>
<tr>
<td>Different perceptions on problems and solutions by project members</td>
<td>✗</td>
</tr>
<tr>
<td>Not present</td>
<td></td>
</tr>
<tr>
<td>Uncertainty who has authority to make decisions</td>
<td></td>
</tr>
<tr>
<td><strong>Additional factor that came to the surface</strong></td>
<td></td>
</tr>
<tr>
<td>Too much focus on production</td>
<td>✓</td>
</tr>
</tbody>
</table>
7.3 Results AM

This chapter is meant to see if the purposed factors have influence on a quick and successful implementation of AM (step three) in the start-up of a new line. This chapter will therefore make an analysis of the purposed factors. This all should create more insight in what to consider too quick and successfully implement AM step three in a new line. The analysis will be done the same way as with EEM. First the factors that the respondents found present will be stated. Afterwards from the present factors will be determined if they influenced a quick and successful implementation of AM step three.

7.3.1 Analysis AM

First one has to determine from the interviews which factors were present in the LE0 case. This is done the same way as with EEM. However in this case eight respondents were questioned (seven operator and one AM specialist), a factor is present if four or more respondents state so and if the AM specialist agrees. In figure 19 one can see per factor how much respondents state that the factor is present.

### Present factors AM

![Present factors AM](image)

**Figure 19 Present factors AM**

**Present factors and discussion**

One can see that according to the respondents nine out of twelve factors are dominantly present, namely: low knowledge level of operators, low level of 5s, waiting for support, amount of implementation (too much at ones), bad communication, large workload, too much focus on production, lack of understanding importance, lack of management support. Those were not are: lack of (AM) training, operator resistance and lack of moral. A majority and also the TPM facilitator did not see the importance of AM training, therefore this factor was not lacking. Repetition could not harm, but special AM training seems not necessary and thus not present. There was also no resistance to the implementation of AM system according to the respondents, they state that operators are used to it after a few years and feel no resistance against it. It must be said that observations sometimes showed differently. This could however be the result of other factors like the large workload and the focus on production. Last, also the moral was not lacking according to most operators and the AM specialist, observations confirmed this.
Now one knows which factors were present in the LE0 case, the influence on AM success (a quick and successful implementation of AM step three) will be investigated. This is done the same way as in the EEM analysis. In figure 20 one can see if the present factors have influence on AM success, afterwards explanations follow.

![AM factors influence on AM success](image)

**Figure 20 Influence AM factors on AM success**

**Explanation of factors influence and discussion**

One can see that all the factors that are present in some way influence a quick and successful implementation of AM step 3 in the start-up of a new production line. To give the reader more clarity on why these factors influence AM success, per factor a small explanation will be given. These explanations are based on answers respondents gave and observations done during the case study.

**Low knowledge level of operators**

Respondents state that especially when starting up a new line the difference in the AM knowledge level of operators becomes extra visible. If the whole system has to be implemented all over again, one could see that some operators are missing knowledge. Most respondents state that there are always skilled operators that have to pull the AM system and other operators. They also together with the AM specialist state that operational management plays a very important role in this and they have to guide, support and initiate AM processes.

**Low level of 5s**

Almost every respondent state that 5s is the basis for AM and that it cannot be seen separate from it. If the environment is not neat, organized and clean, performing AM is difficult. Managing the shop floor is easier when 5s is in order. When starting up a new line, especially 5s step one and two are important (sort and set order, see chapter 3.4). This means that all the tools and materials to perform operations and maintenance are in the right place and easy accessible. Some respondents state that 5s creates more commitment towards AM, because of more inviting working circumstances. In the case study at Heineken it became clear that performing 5s step one and two in the start-up, can be a tough job. There are multiple reasons for this.

- The ideal walking routes for operators are not determined yet and this is more of an evolitional process, therefore it is not easy to quickly set fixed places in the workplace and on top of this is was there resistance against this.
• Which areas get more contaminated than others is not yet visible after a few weeks of operations. This is also a process that takes more than a couple weeks. The ideal locations for cleaning tools can therefore not be determined in advance.

• The supplier is still present and the work floor sometimes still has the look of a construction site, on top of that are external parties not very dedicated to 5s and they tend to litter their tools and waste. This irritates operators and does not stimulate them to keep the work floor clean an organized.

Nevertheless is it important to start with 5s as soon as possible, because if 5s stays behind, AM will stay behind according to most. Management plays and important role in initiating this process.

Waiting for support
Especially during a start-up when the expertise of the equipment supplier is present, problems or things to solve are easily pushed to the supplier. To let AM be successful in a start-up, more problems have to be adopted and solved in the AM system from the start. This way operators are getting feeling for AM again in the new line. The AM auditors stated that the border of what was in the project (and thus for the supplier responsibility) and which things fell under operator’s responsibility (AM) was too vague, which showed that there was not enough operator ownership (which is crucial for AM success).

Amount of implementation (too much)
Almost every operator and the TPM specialist shared the view that going directly to AM step three is too much. AM step one and two cannot be finished quickly and need thorough attention to let AM be successful. AM step three contains standards for cleaning (see CILT in chapter 5.3.2). One could really see that operators are forgetting the basics of AM (AM step one and two) and jump to solutions and (wrong) standards (AM step three). Ideally in AM, one has as little cleaning standards as possible (small CILT list, see chapter 5.3.2), because the root causes for dirt must be solved as much as possible (AM step one and two). One could really see that the focus on these steps was not good. The importance of AM step one and two is also underestimated in a new line. One often thinks that new machines don’t have sources of contamination, but this is a wrong thought. Therefore first thoroughly finishing AM step one, then two and finally three seems better in the eyes of most (also specialists). These views are confirmed by the results of the two AM audits that were held in LE0’s start-up. One could really see that in the first audit, AM steps one and two scored better, the results can be seen in the AM audit result in appendix IV.

Lack of communication
Most state that communication is vital for AM because every operator has to know the status quo on the floor, unfortunately this was sometimes lacking in the start-up of LE0. Operators have to know new developments so that they know what to do and don’t. One of the reasons for the lacking communication was that LE0 was not directly adopted the WPO (see chapter 5.3.3). Because of that, one became very depending on the communication skills and own initiative to share information of operators. This did not go well, some operators are willing to share and bring information to others, but there are also operators that do not.

Large workload
Most respondents state that successful implementation of AM in a new line requires time and a lot of afford. It is not something that is quickly finished. Especially in a start-up, operators are really struggling getting to know the machines. They have to know how to operate and solve for instance
minor stoppages. This (large) workload, results in the fact that AM is easily seen as additional work. Almost every operator states that the start-up process is very labour-intensive, especially with the tight occupation of LE0. This ensured that a focus on AM was often lacking.  

Too much focus on production  
The AM specialist and also some operators state that AM should be a inextricable part of production, but like said in the explanation of large workload, AM is still seen by many as additional work. AM should ease the work of operators and should increase the efficiency and thus production rate, but this view is still not shared by every operator. The production focus and pressure in the start-up of LE0 really hampered the success of AM. Especially when production management imposes this pressure. If production pressure increases, the focus on AM decreases, this is a logical consequence. Operators are demanding clear targets on production and AM. This way operators know how much time they can spend on production and AM related things. Requesting 100% focus on AM and 100% focus on production does not work, because production will always get priority by operators, especially when management is pushing on production rates.  

Lack of understanding importance  
Respondents state that this factor is really influenced by the large focus on production (by management). Also the large workload plays and import role in this, operators share the idea of first run and understand operations and then create more time for AM.  

Lack of management support  
Almost every respondent shares the idea that management support is a crucial factor in the success of AM and that this was sometimes lacking. It also shows a lot of relations to other factors mentioned, which again shows the importance. There are multiple reasons why management support is very important:  
- Operators are forgetting the basics and need support (knowledge level and amount of implementation).  
- Operators must communicate; communication opportunities must be provided and initiated (WPO).  
- Setting clear targets relating production and AM. There cannot be 100% focus on both, because then production always gets priority.  
- Creating sense of urgency for AM activities. AM has to starts as quickly as possible otherwise one will always runs behind the facts, because machines are losing their basic conditions.  
- To make the AM process more accessible and thorough by not expecting too much at ones. This really hampers good and thorough AM analysis.  

One now has a clear view on which factors were present looking at AM and which of these influenced AM success. To wrap this up, a final overview is given in table 10.
<table>
<thead>
<tr>
<th>AM Factors</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick and successful implementation of AM step three in the start-up of a new production line</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TPM Theory (AM barriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
</tr>
<tr>
<td>Low level of 5s</td>
</tr>
<tr>
<td>Low knowledge level of operators</td>
</tr>
<tr>
<td>Waiting for support</td>
</tr>
<tr>
<td>Not present</td>
</tr>
<tr>
<td>Lack of moral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TPM Theory (general TPM barriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
</tr>
<tr>
<td>Amount of implementation (too much)</td>
</tr>
<tr>
<td>Lack of communication</td>
</tr>
<tr>
<td>Large workload</td>
</tr>
<tr>
<td>Too much focus on production</td>
</tr>
<tr>
<td>Lack of understanding importance</td>
</tr>
<tr>
<td>Lack of management support</td>
</tr>
<tr>
<td>Not present</td>
</tr>
<tr>
<td>Lack of (AM) training</td>
</tr>
<tr>
<td>Operator resistance</td>
</tr>
</tbody>
</table>
7.4 Results T&E

This chapter is meant to see if the purposed factors could give more insight in what operators find important for successful T&E program in the start-up of a new line. The analysis goes a little bit different as with EEM and AM. The first part stays the same, first conclusions will be drawn on which factors are present and which not. After that per present factor will be explained how the operators experienced these. Therefore there will be no analysis on how many operators think a factor has influence to T&E success. The present factors are used as reference points, so that operators could give their opinion about these factors and state what they find important looking at these factors.

7.4.1 Analysis T&E

First one has to determine from the interviews which factors were present in the LE0 case. This is done the same way as with EEM, if a majority of the operators state that a factor is present the factor is assumed to be present in the LE0 case. In figure 21 one can see which factors were present looking at T&E.

![Figure 21 Present factors T&E](image)

**Present factors and discussion**

One can see that according to the respondents eight out of eleven factors are dominantly present, namely: proper selection of workers, trainings (both theoretical and practical), motivation (during training and start-up), tools or equipment that support performance, support, tacit knowledge. Those were not are: work specialization, do very few jobs at a time and allow workers to redesign their tasks. Work specialization did not seem to be present, since operators where working on multiple machines that require different control and handlings. Skilled operators have to master more than one machine, so this factor did not really count for them. It might well be that this is an important factor for less skilled operators, but these were not questioned.

Very few jobs at a time seem to have a lot in common with work specialization, but did not really came forward during the interview because this factor was not very well understood. What are a few was often the question. Could operate one machine be seen as one job? Apart from operating machines operators had to perform other jobs like AM. Because this factor was not really understood and assumed not to be present, it is not taken into further an analysis. Also the factor allow workers to redesign their task was not really understood by operators. The tasks in a start-up are not yet very clear for operators, so redesigning their task is not a realistic issue yet. Maybe this factor becomes
important when tasks are better understood and operators are more capable of designing their work processes. This factor will therefore also assumed not to be present.

Now one knows which factors were present in the LE0 case, the research further investigates what operators find important looking at these factors. If aspects are more than once mentioned (so more than one operators elaborates on this) these will be stated in the following factor descriptions.

Explanation of factors and discussion
These elaborations are based on the answers respondents gave in the interview and observations. In the end additional factor(s) that came to the surface in the interviews will be stated.

Proper selection of workers
This factor already came forward in chapter 5.4.1 when the T&E strategy Heineken is using is explained. For operators it is hard to make comments on this. Operators stated that this was the best Heineken could do and also the most efficient since not everybody can receive trainings. Fact remains that other operators have to be educated (which were not questioned), because the new line cannot only be operated by the start-up. Observations showed that operators that were not part of the start-up team and did not receive training, sometimes felt a little discriminated, which did not encourages a pleasant learning environment.

Theoretical trainings
Half of the operators experienced the theoretical trainings as useful and half didn’t. Positive points operators mentions are:

- Training materials were very extensive and useful.
- Catchy real life examples.
- Interaction with the trainer.

Negative points mentioned were:
- The theoretical trainings did not always go into depth and were sometimes quite superficial.
- Theoretical trainings were not always followed up by practical training, which inhibited the learning experience.

Practical trainings
Generally the practical trainings were valued useful and good. Almost all operators state that this is the real learning moment. Positive points mentioned are:

- Try machine options without major negative effects.
- Operators prefer learning by doing.

However there were some points for improvement:

- Group size, the groups were too big. Sometime eight operators were standing in front of a control panel and only the two in front could see what was happening. Operators mention it, but observations also showed that after a few moments operators in the back lose their motivation and stray away.
- The environment was too noisy. It was very difficult to understand the trainer, because the line next to LE0 (line twelve) was fulltime running (language barrier worsens this problem).
- Some practical trainings were given at machines that were not running yet; many operators state that this is useless.
Motivation during training
Operators state that the following things stimulated them to engage in trainings:

• Performance of the trainer, some trainers performed better than others and this had a huge influence on the motivation.
• Trainers sharing experiences from abroad made the trainings extra interesting.
• Sharing own experiences and interactions with trainer (like stated in theoretical trainings).

Motivation during start-up
Operators from the start-up team were very motivated during the start-up and had been waiting for this moment for a long time. What got them motivated, first of all, everything is new and existing. During the one shift program the first weeks, operators (from start-up team) sometimes made days of sixteen hours and were still motivated. The idea was that nobody wanted to stay behind and everyday new things were experienced and learned. Every time one wanted to make that next step. The start-up team was really motivated, but this also has influence to operators from outside the start-up team. Some jealousy could be sensed and operators from outside the start-up team sometimes felt a little discriminated. It is therefore important to keep everybody motivated. Motivation during the start-up is not only needed to perform good work, but also to have a good relationship with the supplier. If operators are not motivated, the learning experience by interaction with the suppliers (support) is not maximized.

Tools that support performance
Operators state that tools are needed especially for the less skilled operators. Manuals or instruction must be easy accessible. Sometimes instructions were missing, which really influenced the performance of operators. Operators were sometimes not capable of handling the machines or did the wrong things, which resulted in stoppages.

Support
The support of KHS during the start-up was generally experienced as good and operators see this as a vital part for T&E in start-ups. KHS programmers and engineers were always open for questions and behaved quite open. Of course some KHS people are friendlier than others, but that is something one has to deal with. Operators did mention that the learning experience from support has to come from both sides (KHS and operators). One cannot expect that KHS pushes all the information, but also not that operators have to pull all the information, there has to be a pleasant balance. One could see that especially the less skilled operators were sometimes really hesitating to ask something to KHS and sometimes even walked away from problems. It is a system of pulling and pushing information. This is a sensitive process that needs serious attention by management, so that the learning experience, also for less skilled operators is maximal.

Tacit knowledge
Almost all the operators stated that this factor was present and have to be dealt with. There are one or two operators who know everything and this makes it difficult to always have enough knowledge present on the shop floor. Especially in the seven-shift program, tacit knowledge was sometimes a problem, because there was not always enough knowledge available. Another problem that was stated was that operators that have tacit knowledge are not always good at distributing this knowledge and sometimes take certain knowledge for granted.
Mutual knowledge sharing (additional)

This can be a laborious process, because not every operator has the same attitude. A lot of knowledge has to be shared between operators from the start-up team and operators from outside the start-up team. This mutual process can be tough, because it is again a process of pushing and pulling. Not every operator from outside the start-up team is willing to pull information and there comes a moment that operators from the start-up team get fed up with this and stop pushing information. Some operators are even afraid to ask things because they don’t want to look stupid or ask the same things a couple of times. Of course this is the vision of the start-up team and operators from outside the start-up team might have a different opinion.

Shift scaling (additional)

This factor builds on the latter point of mutual knowledge sharing. Scaling from one to two to three shifts did not give a lot of problems operator state, because the knowledge was quite equally divided over the shifts. It became a little problematic when the seven shift program started. Operator’s knowledge was not equally divided over the shifts and the negative results were visible. The few (only) skilled operators in the weak shifts really had to pull their team and this was often too heavy. This all did not stimulate the working atmosphere and some operators became stressed and upset.

Early involvement of all operators (additional)

Many operators state that early involvement of operators from outside the start-up team is important. The knowledge difference was really big when other operators joined the teams. One really creates a big gap between skilled and less skilled operators with this T&E strategy, if there is no early involvement. Of course as stated before there is not enough money and time to give all the operators training (this would also be not efficient), but in the early start-up operators from outside the start-up team could have been more involved. For instance operators that were operating line twelve next to LE0 could have been more intertied in LE0 and on the times that they were not that busy, take a (learning) look at LE0. Early involvement could also have a positive effect on the motivation of operator from outside the start-up team.

Too much focus on production (additional)

First of all, this factor seems to return in all three TPM elements investigated in this research and also seems to have a central role in the success of all three elements. Operators state that because of the production pressure sometimes a three-days training was reduced to a one-day training. This was a missed opportunity in the eyes of most. Also KHS stated that trainings on the job were often blamed for bad production results. The learning process certainly suffered from the focus on production.

One now has a clear view on which factors were present looking at T&E and what operators find important looking at these factors. To wrap this up, a final overview is given in table 11 on the next page.
<table>
<thead>
<tr>
<th>T&amp;E Factors</th>
<th>Important points according to operators</th>
<th>Learning Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Present</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Proper selection of workers | Only skilled operators capable of receiving training  
Operators outside selection also have to be educated  
Operators outside selection might feel discriminated |                 |
| Theoretical trainings | Positive:  
• Extensive  
• Catchy examples  
• Interaction with trainer | Negative:  
• Too general  
• Not always followed by practical training |
| Practical trainings | Positive:  
• Try machine options without major negative effects  
• Operators prefer learning by doing | Negative:  
• Groups too big  
• Noisy environment  
• Trainings on not yet running machines |
| Motivation during training | Performance trainer  
Trainers sharing catchy examples (from abroad)  
Personal interaction and sharing knowledge |                 |
| Motivation during start-up | New equipment is exciting  
Nobody wants to stay behind  
Motivation for startup team could mean demotivation for operator from outside the startup team |                 |
| Tools that support performance | Especially important for less skilled operators  
Must be easy accessible |                 |
| Support KHS start-up | Vital for startup  
Learning experience has to come from both sides (operator and supplier)  
Less skilled could struggle with interaction |                 |
| **Not present** |                                        |                 |
| Work specialization |                                        |                 |
| Very few jobs at a time |                                        |                 |
| Allow workers to redesign their task |                                        |                 |
| **Tacit knowledge Theory** |                                        |                 |
| **Present** |                                        | Knowlegde distribution between shifts has to be equal |
| Tacit knowledge |                                        |                 |
| **Additional factors that came to the surface** |                                        |                 |
| Mutual knowledge sharing | Again process of pushing and pulling information  
Less skilled could struggle pulling information |                 |
| Shift scaling | Make sure the knowledge distribution is equal over the shifts |                 |
| Early involvement of all operators | Minimize knowledge difference between operators  
Create more pleasant working atmosphere |                 |
| Too much focus on production | Don’t let T&E suffer under too much focus on production |                 |
7.5 Results and link to the theory

This chapter will discuss on the theories that were used for adding factors to EEM, AM and T&E.

EEM DMI part

Factors that were derived from TPM theory were present in the LE0 case and also influence both the equipment satisfaction and the vertical start-up. Examples are too little focus on design reviews (also mentioned in SE literature) and wrong fabrications of equipment.

Additional theory on SE was used to create a better view on factors that could be present in the DMI part and have influence on EEM success. There were some factors present, which also influenced the equipment satisfaction and the vertical start-up. The factors that (Blanchard, 2008) mentions like outsourcing and focus on systems instead of subsystems and interfaces are present and both seem to influence the equipment satisfaction and the vertical start-up. SE aspects could therefore play an important role in EEM and considering SE will help EEM to be more successful. The SE factors mentioned by (NASA, 2007) were not present in the LE0 case. Biggest reason for this is that EEM does not mean to bite in requirements, but is more about a mutual understanding with the supplier.

EEM start-up part

There could be not factors found in TPM literature that might occur in the start-up influencing EEM success. For this part it was essential that additional theories were found, since this research is looking for factors in the start-up that could influence EEM success.

Theory on Production start-ups and Project & Process Management were used to create a better view on the start-up part and what could possible influence EEM success. Looking at the factors from production start-up theory, factors from (Almgren, 2000), (Almgren, 1999) and (Baloff, 1970), showed presence in the LE0 case. Interesting to see is that apart from late engineering changes, none of these factors showed influence to equipment satisfaction. Their influence on the vertical start-up was more evident and inappropriate management decisions, lack of materials, lack of materials quality and late engineering changes seem to influence the vertical start-up. This research indicates that a variety of start-up problems can occur in a start-up like LE0. This means that the problems from Almgren's studies, which took place in advanced manufacturing organizations in the automotive industry, also occur in an advanced manufacturing environment like LE0. The fact that advanced technologies are used is probably decisive for this.

Secondly also theory on Project & Process Management (Meredith & Mantel, 2010) and (Bruijn & Heuvelhof, 2008), was used to create a better view on factors that could be present in a start-up and influence EEM success. The factors from these theories were definitely present, but their influence to EEM success was hard to find in this case study. No influence to the vertical start-up could be indicated and only the adversarial relation with the supplier seemed to have influence on the equipment satisfaction. The project & process management factors did influence the whole start-up process but their exact influence to EEM success (at least by respondents) was not indicated. Nevertheless are the factors difference of goals and expectations among project members and different perceptions on problems and solutions by project members important influencers of management decisions (which influence the vertical start-up) and their role in EEM should be investigated in the future.

If one looks at the two EEM parts that were set in this research (DMI and start-up) one could see that the equipment satisfaction is mainly determined in the DMI part, but that there are also factors during the start-up that influence this. If one looks at the vertical start-up, there are factors in the DMI part that have huge influence on this, but there are also factors that occur in the start-up part, that have influence on this.
AM
Literature mentions some problems with AM that were investigated in this research. The factors that were present from this theory low knowledge level of operators, low level of 5s and waiting for support all three seem to influence a quick and successful implementation of AM step three in the start-up of a new line. This research was looking for more factors and noticed some overlap between AM barriers and general TPM implementation barriers. Some of these dominant general TPM barriers (factors) were present in the LE0 case and also seem to influence AM success. One can carefully draw the conclusion that although TPM and AM is known within the organization still a lot of barriers could raise that hampers a quick and successful implementation of AM step three in a new line. Theory on general TPM barriers gave give insight in this. AM is a process that needs continuous attention (by management) to be successful, especially when starting up a new line.

T&E
TPM literature is lacking information on what is needed for a successful T&E program for operators (in the start-up of a new line). It only states that training is needed, but this seems rather obvious. This research investigates what operators find important in a T&E program when starting up a new line. To investigate this a baseline with factors is needed as a starting point for gathering this information. Theory on learning improvement points seemed suitable. The theory from Chase et al. (2006) on learning improvement points really helped this research in finding points that operators find important in T&E. Most of the points Chase et al. (2006) mention are present in the LE0 case and create a good view on the strong and weak points of the T&E strategy Heineken is using. Next to Chase, also the theory on tacit knowledge (Levin, 2000) seems to be important to keep in mind managing successful T&E in start-ups, since this was present.
8. Relations between factors and recommendations

Looking at the results of the latter chapter seven, relations between factors are noticed. Especially in the explanations of the factors overlap and relations are distinguished. One reason for this could be that some factors are on a higher aggregation level or higher in hierarchy as others. This chapter will describe and visualize the relations between factors. The factor explanations of the latter chapter seven, together with the visualizations and descriptions of the relations between factors in this chapter are brought together in recommendations for Heineken to make EEM, AM and T&E more successful in future start-ups. Again per element the relations will be described and recommendations will be given. The figure below shows the progress of this research and the purpose of this chapter.

8.1 Relations between factors EEM

First the DMI part will be described, after that the start-up part and finally the relations between both parts, because latter chapter also showed that there are relations between the two parts.

8.1.1 Relations EEM DMI part

First of all, outsourcing seems to play a central role and has influence both EEM goals; on top of that does it influence other factors, which once again shows its importance. In the LE0 case, outsourcing resulted in the fact that there was too little focus on design reviews between Heineken and the supplier. There were enough internal review, but not in cooperation with the supplier, this resulted in misunderstandings between the two parties. Outsourcing also made it difficult to define requirements, because Heineken was not aware of all the techniques that the supplier had and what one could really ask for. Also how specific the requirements had to be, so that the supplier does not misinterpret things, was uncertain. The influence of difficulty of defining requirements was not demonstrated by respondent, outsourcing showed influence on both EEM goals (equipment satisfaction and vertical start up) which suggests that (although it was not demonstrated) difficulty of defining requirements should also have influence on the EEM goals. Finally outsourcing created a system view at Heineken, instead of a more detailed view on subsystems and interfaces. Heineken relied too much on the fact that KHS would integrate all the machines without problems, which was not the case.

If one looks at the factors on the right side of figure 22, the difficulty of defining requirements ensured that there was sometimes a poor choice of construction materials by the supplier, because Heineken let too much freedom for own interpretations of the requirements. This could have been prevented by good design reviews, but these were lacking. So finally, too little focus on design reviews resulted in a poor selection of construction materials and wrong fabrication of equipment. The relations between the EEM DMI factors can be seen in figure 22.
8.1.2 Relations EEM Start-up part

First of all, the influence of difference of goals and expectations among project members and the different perceptions on problems and solutions by project members to EEM success was not indicated during this research. Looking at the descriptions of these factors it does show that these factors could invoke inappropriate management decisions (which influences a vertical start up). The management decisions on quality (how much priority has production) must have been better thought of and the cooperation and mutual understanding between quality members and production management could have been better. There was too much focus on production by management, which sometimes resulted in less quality products and thus a less vertical start-up (OEE is partly calculated by quality).

Also the relation between operators and management could have been better, to get more feeling for priorities in solving start-up problems and late engineering changes. The late engineering changes could have been managed better, by setting good priorities. Too much focus on production by management did not encourage proper dealing with engineering changes. On top of that ensures an adversarial relation with the supplier that engineering changes were not always performed the way Heineken desired, because the supplier had different perspectives on this. This all influences equipment satisfaction (in the end) and a vertical start-up.

Finally did inappropriate management decisions result in a lack in materials quality. There should have been more attention to this in the DMI part, but there should also have been more monitoring of risky interfaces during the start-up. If Heineken had managed this better, the lack of material quality was discovered earlier and much OEE could have been saved, resulting in a more vertical start-up. The relations between the EEM start-up factors can be seen in figure 23.
8.1.3 Relations between EEM DMI and EEM start-up part

To show that the EEM DMI part and the start-up part are inextricably connected to each other the relation between the two parts will be described. These relations can directly be derived from the descriptions of the factors in chapter seven and the latter relations between factor from the EEM DMI and start-up part.

Common sense maybe, but one of the main contributes for not having a vertical start-up are the many late engineering changes that had to be done in the LE0 case. The main reasons for all the late engineering changes are poor selection of construction materials; wrong fabrication of equipment and focus on systems instead of subsystems and interfaces. Management is responsible that these engineering changes are executed efficiently, but a real vertical start-up is impossible when a lot of engineering changes have to be done.

Next to that was the lack of a detailed view on interfaces, partly responsible for the lack of materials quality. If there were better analyses on what kind of quality was needed for this system much start-up delay could have been prevented. Better analyses on risky interfaces, like machines with material, were needed. The relations between factors from the EEM DMI and EEM start-up part can be seen in figure 24.

![Figure 24 Relations between factors EEM DMI and Start-up part](image)

8.1.4 Recommendations EEM

What one could see in the LE0 case is that outsourcing plays a central role in EEM success and must be improved to make EEM more successful. Because of outsourcing Heineken is struggling to set good requirements for their system, because it lacks the technological knowledge that the supplier has. What is realistic to ask for? How far is technology evolved and does this fulfil Heinekens requirements? These are typical questions that have to be answered in close cooperation with the supplier. This requires a lot of transparency from both sides. It must be said that the relation with the supplier was not the only reason that Heineken experienced some difficulty in defining requirements. Also internal circumstances hampered this process. There is not one shared vision within Heineken how to deal with EEM and how deep this concept should go (how customs made the machines have to be). Also the data gathering to set requirements was tough, because there are not enough TPM standards available to easily state EEM requirements. This brings us to the following recommendations:

- Create a more transparent relation with the supplier on current techniques and the connection to Heinekens EEM requirements, so that it becomes easier to set requirements.
- Create more shared understanding and commitment towards EEM in Heineken, so that it becomes easier to set EEM requirements.
• Create more standards in TPM pillars, so that requirements can be easier set. Secondly to make EEM even more successful and really benefit from the latter three recommendations, there need to be regular design reviews with the supplier. It is important that these design reviews are performed with the right persons at the supplier’s side (engineers instead of commercial people), to prevent that requirements are interpreted wrongly. Frequent design reviews could even make stating good requirements less important, because it ensures mutual understanding. This brings us to the next recommendation:
  • Determine fixed slots for design reviews with supplier’s engineers, so that more shared understanding is created and there will be fewer surprises.
Finally, because of outsourcing there was not enough focus on subsystems and interfaces. An equipment supplier does not think in processes and Heineken has to understand that although the project is outsourced, there is still a large responsibility for them in making the system work (according to their needs). This brings us to the next recommendation:
  • Set more detailed subsystem and interface requirements or support the supplier with an integration plan, so that the system is integrated first time right.

The DMI part described in the latter paragraph, influences factors from the start-up part, which really effects EEM success. In figure 24 one can see that poor selection of construction materials, wrong fabrication of equipment and focus on systems instead of subsystems and interfaces are main contributors to late engineering changes during the start-up. Recommendations for these factors are already stated in the latter paragraph. However figure 24 also shows that little interface requirements could result in materials that are lacking in quality. This brings us to the next recommendation:
  • Execute proper analyses on risky interfaces and set requirements, so that surprises on lack of quality in materials are minimized.

This research shows however that next to the DMI part the start-up part also has to be managed well, to ensure EEM success. The choice of cutting EEM in two parts is therefore justified.

One could see in figure 23 that the decisions that management takes during the start-up play a central role and are influenced by the difference of goals and expectations among project members and the different perceptions on problems and solutions by project members have. Operational management has different opinions on production rates focus than quality members. There could also be different opinions on start-up problems and solutions between operational management and operators. These factors caused for instance inappropriate management decisions on when to stop production and on which late engineering change should have priority. This brings us to the next recommendations:
  • Create more alignment between the goals of quality members and operational management, so that more appropriate management decisions on production vs. quality can be taken.
  • Create better perceptions on problems and solutions through closer cooperation between operational management and operators, so that more appropriate management decisions on priorities in late engineering changes can be taken.
To make priorities in late engineering changes successful, operational management should not only closely cooperate with operators, but also with the supplier, since their relation can sometimes be adversarial. This brings us to the next recommendation:
  • Consider, in close cooperation with the operators and the supplier, proper planning and priorities in late engineering changes, so that they can be executed most efficiently.
Finally, because not all risks could be excluded in the DMI part, management must also make sure there is enough monitoring of risky interfaces during start-up. These way quality problems come to the surface much quicker. This brings us to the final recommendation:

- Monitor risky interfaces closely during a start-up, so that quality deviation can be discovered quickly.

8.2 Relations between factors AM

Management support seems to play a central role in the success of AM step three implementation in the start-up of a new production line and shows relations with other influential factors. First of all, should management steer on early use of 5s. Making temporary fix places for instance really helps operators to discover optimal locations for materials and tools. Management must also make clear agreements with external suppliers on construction debris. It is important that 5s is initiated quickly, because it sets more commitment towards AM. Secondly, should management ensure that there are proper communication facilities (like WPO) in the early start-up and they should stimulate that individuals communicate with each other, especially in the seven-shift program. Thirdly management must really consider that especially when the supplier is present, operators tend to push problems to the supplier. In a start-up, the border between what is in the project (and thus for the responsibility of KHS) and what falls under AM (and thus for the responsibility of operators) can be very vague. Some problems that have to be captured in AM are pushed to the supplier; this does not stimulate the AM process. Management must really steer on the use of the AM system to solve problems and ensure that not every problem is pushed to the supplier. Fourthly does management have to consider the knowledge difference that is present among operators. Some operators are really struggling to perform their AM role, because they have to set it up all over again and are missing basic knowledge for this. Management has to recognize this and make sure there is enough strength in each AM role and provide support if needed. If the knowledge distribution is not well divided, some operators have a bigger workload as others; which is not desirable and creates annoyance on the work floor. Fourthly, management must really consider the amount of AM implementation. Management must be aware that reaching AM step three successfully is not an easy task and needs quite some time and afford. AM step one and two need thorough attention. All the production pressure together with unattainable AM goals ensures that the workload for operators becomes very large. This sometimes creates annoyance and an unpleasant working environment. Sixthly, management must make clear objectives on the targets for production and AM and cannot ask 100% of both. With all the pressure on production there is not enough room for AM. In the worst case could operators hold the management production focus against them by stating that they have not enough time to perform AM, because the have to spend all their time to production (even though they might have enough time). This production pressure and focus, like stated increases the workload for operators. Seventh and last, does the focus on production and the large workload for operators (first getting to know the machines), hampers the understanding of a quick AM implementation. Management really has to create a sense of urgency for a quick successful AM implementation. First thing to do is to lower the production focus (pressure), state clear objective between production and AM and make sure that the operator workload allows AM attention. Figure 25 shows the described relations between factors.
8.2.1 Recommendations AM

Like in the EEM start-up part, (operational) management plays a central role in a quick and successful implementation of AM step three in the start-up of a new production line (see figure 23 & 25). Almost all the factors that influence AM success can be shaped by proper management support. The most important recommendations to make future AM implementation in new production lines more successful are the following:

- Initiate arranging 5s as soon as possible, to create more commitment and ease in AM.
- Create an environment where communication between operators is facilitated and stimulate communication of individuals, so that every operator knows the status quo of the new line.
- Make sure that AM is used to solve problems as quickly as possible and that not everything is pushed to the supplier, so that AM is initiated and understood quick.
- Make sure there is enough AM knowledge in every AM role and support operators if necessary, so that AM steps are thoroughly passed and there is not too much workload for skilled operators.
- Make sure the amount of implementation is not too much and ensure that operators walk through every AM step very thoroughly, so that AM is proper executed and the workload for operators is not too large.
- Make clear objectives regarding production and AM, so that operators know what to focus on, understand the importance of AM and don’t have too much workload.

8.3 Relation between factors T&E

The first relation that came forward describing the different factors is between theoretical training, practical training and support. Theoretical trainings are only useful if the knowledge gained can quickly be applied in practical trainings. Operators indicated what motivated them during the theoretical and practical trainings and indicated that some aspects ensured more engagement during the trainings. What motivated them can be seen in table 11. Too much focus on production can harm a T&E program since trainings could be cut. Looking at the trainings, strong and weak points operators elaborated can also be seen in table 11. Practical trainings are only useful if there is on-going support, so that all the things that were not threatened during the practical trainings will be intercept by support. Support during the start-up is a process of pushing and pulling information and is better utilized when operators are motivated and dare to ask questions. Secondly, in Heinekens T&E approach only a selection of (high skilled) operators got theoretical and practical training. This choice has some
important consequences for the total T&E program and success of this program. Giving only a selection of operators trainings make sure that:

- Mutual knowledge sharing between operators is needed
- The presence of tacit knowledge should be considered, which influences mutual knowledge sharing
- Operators that did not get training might feel discriminated and the motivation during the start-up can drop
- It is important that operators outside the selection are early involved in the start-up, so that their motivation and knowledge level can grow

Thirdly, the scaling up ensures that tacit knowledge starts to matter, cause some (crucial) knowledge might only be present in certain shifts. This makes it again harder to have good mutual knowledge sharing. Mutual knowledge sharing is however of major importance when the shifts start to scale up. There are two other things that are also important when the shifts scale up, those are support and tools and equipment that support performance. Support becomes important because the less skilled operators really need this to perform operations, but they also need tools that support their operational performance. Figure 26 shows the described relations between factors.

![Figure 26 Relations between factors T&E](image)

**8.3.1 Recommendations T&E**

The factors with their description in chapter 7.4.1 together with the relations described above ensure that there is a much better view on what to consider making T&E in a start-up successful. Looking at this, the most important recommendations for future T&E programs in start-ups are:

- Choose trainers that can motivate operators in theoretical trainings (strong interactions and sharing catchy examples), so operators are engaged.
- Theoretical trainings should be quickly followed by practical trainings to make the learning experience maximal.
- Make the circumstances for the practical trainings as optimal as possible (small groups, quite environment and running machines), so that operators are engaged and the learning experience is maximal.
• Make sure that when the shifts scale up, the knowledge distribution of operators is equal in each shift, so that mutual knowledge sharing can be maximal and tacit knowledge has minimal influence.
• Make sure that when the shifts scale up there are, except support, tool and equipment that support the performance of less skilled operators, so no losses due to lack of knowledge occur.
• Make sure that there is enough motivation during start-up by involving every operator early, so that everybody interacts with support (manage this sensitive process closely), the knowledge base is more equal and there is a more pleasant work atmosphere.
• Make sure that the T&E program does not suffer from too much focus on production.

All the recommendations for EEM, AM and T&E stated in this chapter are starting points to make EEM, AM and T&E more successful in future production start-ups. The next chapter will elaborate if the findings of this research can be generalized.
9. Generalization of results

This chapter is meant to see to what extent the finding of this research can be generalized. The figure blow shows the progress of this research and the purpose of this chapter.

According to Ritchie & Lewis (2003) there are three kinds of generalizations: representational, inferential and theoretical generalization. In representational generalization the question raises whether what is found in a research sample can be generalized to, or held to be equally true of, the parent population from which the sample is taken. In inferential generalization the question raises whether the findings from a particular case study can be generalized, or inferred, to other settings or context beyond the sampled one. Last theoretical generalization looks if theoretical propositions, principals or statements from the findings for a more general application can be drawn. Looking at these three generalizations, inferential generalization seems most important since this research is based on one single case study. The question raises to what extend the outcomes could be applicable to settings outside this case study. The best way to do this is to consider what aspects made this case study unique? If one looks at the whole design of this research where the elements EEM, AM and T&E are always treated separately, therefore also conclusions on inferential generalization will be threatened separated for these elements.

9.1 EEM

Question rises if the EEM outcomes of this case study can be generalized to settings beyond the sampled one. Looking at the LE0 case study there was some characteristics that shaped this EEM project and thus also the outcomes of this research. These aspects have to be taken into account when applying inferential generalizations. Looking at the LE0 start-up case study, there are some aspects that have to be considered:

- The case study was performed at Heineken, a company with a lot of departments with different interest in EEM. This was also one of the things that influenced setting good requirements for EEM. Therefore outcomes might only be generalized to large manufacturing organizations like Heineken.
- The packaging department of Heineken is a department that works with advanced technologies, which also influence setting good EEM requirements. Advanced technologies are decisive in this case, so outcomes might only be generalized to manufacturing organizations that work with advanced technologies. This statement is strengthened by the fact that in this case study a lot of start-up problems were found that were mentioned in literature on start-ups in advanced manufacturing organizations in the automotive industry (Almgren, 2000).
- In the case study at Heineken, looking at EEM, outsourcing played a central and very important role. Outsourcing seems inextricably connected to EEM, since manufacturing companies do not build equipment their selves. This does mean that the outcomes are only
applicable to organization that use EEM in cooperation with external suppliers, looking at EEM this means almost every organization that uses EEM.

- The final factor that really influenced the outcomes of this research was time pressure (production pressure). The LE0 project was under a lot of time pressure which resulted for instance (together with outsourcing) in too little focus on design reviews, which really influenced EEM success. According to literature time pressure seems very prevalent in organizations that introduce new products to the market and start up new production lines (Terwiesch & Xu, 2004). Therefore again the outcomes of this research seem applicable to a wide range of manufacturing organization that introduce new products and start up new production lines (still there has to be some kind of time/production pressure).

9.2 AM

Question rises if the AM outcomes of this case study can be generalized to settings beyond the sampled one. Generally speaking can the outcomes be generalized to a lot of organizations that have the same structure as the packaging department as Heineken (machine bureaucracy). It is expected that operators at for instance Unilever are not varying very much in skills and ways of working. However, looking at the LE0 case study, there are some characteristics that have to be taken into account when applying inferential generalizations on what influences a quick and successful implementation of AM step three in the start-up of a new production line. Looking at the LE0 start-up case study, there are some aspects that have to be considered:

- In the case study operators were familiar with AM for more than six years, which influenced the outcomes of this research. This research would not even be possible in organizations not familiar with AM looking at the investigated factors. Therefore the outcomes might only be applicable to organizations that are sufficiently familiar with AM. This does not mean that some factors could also be present in companies that are not very familiar with AM.
- The operators in the case study had different (AM) knowledge levels, which was an important factor and influenced the outcomes of this research. Looking at the characteristic of a machine bureaucracy, this phenomena seems very prevalent in most manufacturing organizations. Therefore the outcomes seem to be broadly applicable to manufacturing organization that works with AM.
- The case study was performed in a manufacturing company located in Western Europe. This aspect may come as a surprise, but through the extensive conversation done during the case study; Western habits really seem to determine the attitude of operators (also towards AM). Operators in Eastern Europe might for instance have a totally different attitude towards AM, which, if this research was to be performed there, could give totally different outcomes. Therefore the outcomes of this research are applicable to Western (European) manufacturing organizations.
- Finally again time pressure (production pressure) played an important role, also in the AM process. The whole start-up was under a lot of time pressure, which had major influence on the outcomes and the presence of certain factors. Again time pressure seems prevalent in such circumstances and the outcomes on this point seem applicable to a wide range of manufacturing organizations (again there has to be some kind of time/production pressure).
9.3 T&E

Question rises if the T&E outcomes of this case study can be generalized to settings beyond the sampled one. Again like with AM it is expected that the outcomes can be generalized to a lot of organizations that have the same structure as the packaging department as Heineken (machine bureaucracy). It is expected that operators at for instance Unilever are not varying very much in skills and the way they interpret trainings and knowledge gaining when starting up a new production line. However, looking at the LE0 case study there are some characteristics that have to be taken into account when applying inferential generalizations about what operators find important in T&E in the start-up of a new production line. Looking at the LE0 start-up case study, there are some aspects that have to be considered:

- In the case study an extensive T&E program with multiple trainings was set out, in which not all the operators got training, but only the most skilled. If every operator had got trainings the outcomes of this reach would really change. Therefore the outcomes and recommendation might only be applicable to organizations that choice to give only a few operators very extensive trainings.
- As described in the inferential generalization of AM, the fact that there are different skilled operators involved really influenced the outcomes of this research. Again looking at the characteristic of a machine bureaucracy, this phenomena seems very prevalent in most manufacturing organizations. Therefore the outcomes seem to be broadly applicable to manufacturing organizations that apply T&E in start-ups.
- The packaging department of Heineken works with shift programs, which influences T&E and therefore also the outcomes of this reach. Mutual knowledge sharing and communication becomes very important, but also how knowledge is divided of the shifts. Therefore the recommendations might only be applicable to manufacturing organizations that work with shifts. Again this seems a very prevalent aspect of manufacturing organizations and therefore widely applicable.
- Looking at T&E also the Western habits of operators seem to be important for the T&E outcomes of this research. Operators in Eastern Europe might for instance have a totally different attitude towards T&E, which, if this research was to be performed there, could give totally different outcomes. Therefore the outcomes of this research are applicable to Western (European) manufacturing organizations.
- Finally also in T&E time and production pressure were very prevalent. The whole start-up and preliminary T&E phases were under a lot of time pressure which influenced the outcomes and recommendation on T&E. Again time pressure seems prevalent in the circumstances like LE0 and the outcomes on this point seem applicable to a wide range of manufacturing organizations (again there has to be some kind of time/production pressure).
10. Conclusions & Recommendations

This chapter is meant to answer the main research question of his research. To do so, every sub question will be answered briefly. The figure below shows the progress of this research.

The main research question was:

*What factors have to be considered making the TPM elements EEM, AM and T&E in new production start-ups successful, what theories give more insight in this and how to manage all this?*

The following answers to the sub questions will together provide the answer to the main research question.

1. What does the literature say about TPM and in particular EEM, AM and T&E and what factors derive from this?

Total Productive Maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce. TPM management brings everyone, from machine operator, equipment designer to manager together to work in small autonomous groups to improve quality, reduce waste, reduce manufacturing costs, increase equipment availability and improve the overall state of maintenance. Especially the cooperation between maintenance and operations is very important, since operators shift from pure operational tasks to a more all-round shop floor management role. Implementation of TPM requires a lot of afford and a real organizational culture change. Many companies struggle to implement and maintain TPM. TPM is aiming at continuous improvement and consists of eight pillars that rest on the basis of 5s. Three of them are important in a start-up and are investigated during this research; EEM, AM and T&E.

EEM is about designing new equipment with lessons learned from the use of old equipment. It also aims at a vertical start-up. These are also the two goals that are investigated during this research to determine EEM success. To find factors that could influence EEM success, two important parts of EEM are investigated: the design, manufacture and installation (DMI) part and the start-up part, the influence of this choice will be elaborated answering sub question 6 and further on in the discussion. For each part factors that could occur and influence EEM success are identified. In TPM literature only factors that could occur in the DMI part are identified. The factors that derived from TPM literature can be seen in the final factor list in table 6 of chapter 6.4.

AM is more or less self-management of the shop floor by operators. The main idea of AM is that operators perform routine maintenance tasks and keep improving their system. These tasks include daily cleaning, inspecting, lubricating and the tightening that equipment requires. To perform good AM, operators have to gain full ownership over their equipment. Complete implementation of AM consists of seven steps, in this case study only the first three steps are investigated. This research
looks for factors that could influence a quick and successful implementation of AM step three in the start-up of a new production line. AM success in this research is therefore not the result of AM (more efficiency), but the implementation success. The AM factors that derived from TPM literature can also been seen in the final factor list in table 6 of chapter 6.4.

Last T&E fosters employee’s skills and tries to close knowledge gaps. This research focuses on what operators find important looking at a T&E program in the start-up of a new production line. As base, this research is therefore looking for factors that could be important in a start-up, so that operators can elaborate on these. Unfortunately TPM literature lack factors that could give insight in this, only training is mentioned.

2. **What does the literature say about production start-ups, the possible problems and what factors derive from this?**

When a new production line starts producing, the efficiency rate (OEE) has to ramp up. Organizations aim at vertical start-ups, also one of the goals of EEM. During the start-up the equipment supplier is present to commission the system and support the client organization if needed. There are however a few problems that could hamper efficiency (OEE) during start-up and could therefore hamper the degree of vertical start-up. Vertical start-up is a goal of EEM; this research therefore assumes that the problems that production start-up theory mentions have to be considered managing successful EEM. This research will therefore investigate if factors from start-up theory are present in the EEM start-up part and influence EEM success (equipment satisfaction and vertical start-up). Factors that are derived from production start-up theory can again be seen in the final factor list in table 6 of chapter 6.4.

3. **What supporting theories could be used to create insight in what influences the success of EEM, AM and T&E in production start-ups and what factor derive from this?**

To find supporting theories EEM, AM and T&E at Heineken were observed to find links to theories beyond TPM. The most important findings/observations to suggest supporting theories will be discussed per element.

EEM in Heineken consist of a project route with four major steps: Scenarios Development & Conceptualization Engineering, Basic Engineering, Detailed Engineering and Installation. The start-up part is however underexposed in this route. If one looks at the structured EEM project route of Heineken similarities with Systems Engineering could be recognized. Similarities are for instance: conceptual engineering and detailed engineering. Since Heinekens EEM project route almost only resembles the DMI part of EEM, systems engineering will be explored to find factors that could be added to the EEM DMI part and might influence the success of EEM. Like stated, the start-up part is underexposed in Heinekens EEM route. How to handle start-up problems for instance, was arranged just before the start-up. Heinekens focus is therefore largely on the EEM DMI part and the vertical start-up gets less attention, or is assumed to be realized when the DMI part is managed well. This research tries to show that both the EEM DMI and start-up part influence the goals of EEM. To find proper theories for the start-up part, the start-up process and problems handling of LE0 was observed closely by participating in every operational start-up meeting. Observations showed that there were a lot of unforeseen problems that had to be solved on short notice. Also differences of opinion between project parties were observed. These are typically problems that are mentioned in theory on project & process management. Therefore to add more factors to the EEM start-up part (apart from factors that were already added from start-up theory) these supporting theories will be used.

Concluding, this research assumes that factors from systems engineering are present in the EEM DMI part and influence EEM success and assumes that factors from project & process management are
present in the EEM start-up part and influence EEM success. The factors that were found in theory on systems engineering and project & process management can again be seen in the final factor list in table 6 of chapter 6.4.

AM in Heineken resembles a lot of how TPM literature describes AM. Heineken adopts the AM steps and the purpose of AM that literature describes. Of course Heineken has its own tools to perform AM, but the general idea is the same as in literature. AM was observed in LE0, but also in other production lines. It became clear that this process, although being implemented six years ago, still encounters problems. Also the early implementation of AM in LE0 encountered problems, especially the knowledge difference between operators became very evident and the large workload of operators was often blamed for bad AM results.

What is very interesting here is that some barrier were observed that are described in TPM literature as being general TPM implementations barriers. Therefore this research assumes that general TPM implementation barriers also influence a quick and successful implementation of AM step three in the start-up of a new production line. Dominant TPM implementation barriers are added to the AM factors and can be seen in the final factor list in table 6 of chapter 6.4.

For LE0 a very extensive T&E program was set up. The idea of this program is that a selection of high skilled operators gets an extensive trainings program and that they have to teach other operators when they enter the shifts. If one looks for supporting theories to find what operator might value important in T&E, there is not really one specific theory that could support the T&E thinking in the start-up of a new line. This research is really searching for the experiences that operators had in the T&E program of LE0 and what they find important to improve learning. Therefore theory on what might improve learning could provide useful factors as a base for conversations with operators. This is why theory on learning improvement points was used to derive factors that could give more insight in what operators find important about T&E in start-ups. This research therefore assumes that theory on learning improvement could give more insight in what operators find important in T&E during the start-up of a new production line. On top of that did observations suggest that tacit knowledge is also a factor to keep in mind. The factors derived from learning improvement and tacit knowledge can again be seen in the final factor list in table 6 of chapter 6.4.

4. To what extend are the assumed factors present in the Heineken case, are there additional factors and do they have to be considered for EEM, AM and T&E success in start-ups?

To answer this question different important respondents per element were questioned in extensive interviews/discussions and on top of that important observations were done. Respondents stated if factors were present, and if so, how they influence the predetermined success of EEM, AM and T&E. For this research only factors that were present were taken into further analysis to get a robust view if there is influence to success of the elements. These way respondents could give examples to strengthen their answers. The most important findings will be stated per element.

EEM DMI part

Factors that were present and showed influence on equipment satisfaction in the LE0 case are: too little focus on design reviews (TPM and SE), poor selection of construction materials (TPM), wrong fabrication of equipment (TPM), outsourcing (SE) and too much focus on systems instead of subsystems and interfaces (SE). Factors that were present and showed influence on vertical start-up in the LE0 case are: too little focus on design reviews (TPM and SE), wrong fabrication of equipment (TPM), outsourcing (SE) and too much focus on systems instead of subsystems and interfaces (SE). This shows that during the EEM DMI part both factors from TPM theory as well as systems
engineering theory have to be considered for EEM success (both equipment satisfaction and vertical start-up).

**EEM start-up part**

Factors that were present and showed influence on equipment satisfaction in the LE0 case are: *late engineering changes (start-up), adversarial relation with supplier (project & process management) and too much focus on production (additional).* Factors that were present and showed influence on vertical start-up in the LE0 case are: *inappropriate management decisions (start-up), lack of materials (start-up), lack of materials quality (start-up), late engineering changes (start-up) and too much focus on production (additional).* Two important things are noticed. First, factors during the start-up influence both the equipment satisfaction and the vertical start-up. Remark is that only two factors during the start-up influence the equipment satisfaction and most of the equipment satisfaction seems to be determined in the DMI part. Secondly looking at the equipment satisfaction both theory on start-up and project & process management provide influential factors (only one from project & process management) and looking at the vertical start-up, no factors from project and process management and only factors from start-up theory seem to influence this goal. The respondents were not capable of indicated the influence of these factors to the vertical start-up. Possible reasons for this will be discussed in the discussion in the next chapter.

All in all theory on production start-up (problems) certainly has to be considered for EEM success and theory on project & process management is assumed to be also important for EEM success.

**AM**

Factors that were present and showed influence on a quick and successful implementation of AM step three in the LE0 case are: *low knowledge level of operators (AM), low level of 5s (AM and TPM), waiting for support (AM, amount of implementation (TPM), lack of communication (TPM), large workload (TPM), too much focus on production (TPM), lack of understanding importance (TPM) and lack of management support (TPM).* These results show that apart from AM barriers, general TPM implementation barriers have to be considered when successfully implementing AM in a new production line (in an organization familiar with AM).

**T&E**

Factors that were present and confirmed to be suitable as a base to see what operators find important in T&E during a start-up are: *proper selection of workers (learning), trainings (learning), motivation (learning), use tools that support performance (learning), support (learning), tacit knowledge (tacit knowledge), mutual knowledge sharing (additional), shift scaling (additional), early involvement of operators (additional) and too much focus on production (additional).* Learning improvement theory was useful to see what operators find important, but looking at T&E in a start-up, extra factors have to be considered like: *mutual knowledge sharing, shift scaling, early involvement of operators and too much focus on production.*

5. **What recommendations should Heineken consider making the TPM elements EEM, AM and T&E in start-ups successful?**

Looking at the descriptions of all the present and influencing factors, some relations between them can be noticed. One of the most obvious reasons for this is that some factors were stated on a higher aggregation level or are higher in hierarchy as others. The descriptions respondents gave, together with observations done during the case study made it possible that relations between factors could be drawn. These relations are very valuable, because some factors that did not seem to influence EEM and AM success (T&E has different success analysis) according to the respondents seem to effect
other factors that do influence EEM and AM success. This suggests that some factors are indirectly influencing EEM and AM success. Next to that do the relations, together with the factor descriptions, give more insight in recommendations for more success in EEM, AM and T&E. A simplified overview of the most important recommendations for Heineken will be given. The full descriptions can be seen in chapter eight.

Most important recommendations for EEM are:

- Create a more transparent and mutual relationship with the supplier about EEM
  - Perform design reviews with supplier
  - More cooperation in managing the integration of the total system
- Create more understanding and commitment towards EEM within the company Heineken
- Create more alignment, cooperation and commitment between project members

Most important recommendations for AM are:

- Ensure more management support looking at the following:
  - Initiating 5s
  - Creating an environment for communication and initiate this
  - Steer on using AM system to solve problems from the early start
  - Provide enough AM knowledge within every AM responsibility
  - Every step and associated step is thoroughly analysed
  - Clear objective on production vs. AM

Most important recommendations for T&E are:

- Make sure the trainings contribute most to operator learning by:
  - Choosing trainers that can motivate operators
  - Ensuring that practical trainings should immediately follow theoretical trainings
  - Making the circumstance of practical trainings as optimal as possible (small groups, quite environment and running machines)
- Make sure the knowledge distribution is equal in each shift when scaling up
- Supporting tools or documents should be available and easy accessible from the early start
- Make sure every operator interacts with support
- Beware that T&E does not suffer too much from the focus on production

6. What is the added value of the findings in this research to the existing knowledge on TPM?
First of all this research made a better understanding of EEM, to show what factors influence EEM success (equipment satisfaction and a vertical start-up). Literature only states a few factors that could influence EEM success, looking at these factors, these only appear during the design, manufacture or installation of equipment. This research wanted to demonstrate that there are factors that could occur in the DMI part, but that there are also factors that could particularly occur during a start-up that influence EEM success. This is information lacking in TPM literature. Therefore the choice was made to divide EEM in two important parts: the design, manufacture and installation part (DMI) and the start-up part. This research showed that EEM success (equipment satisfaction and a vertical start-up) is depending on factors in both parts. To show this, supporting theories beyond TPM literature were used.

Theory on systems engineering was used to create a better view on factors in the DMI part of EEM. Factors that Blanchard (2008) mentions like the difficulty of defining requirements, outsourcing and
focus on systems instead of subsystems and interfaces seem present in the LE0 case and have influence on EEM success. Therefore a big step is made in a better understanding of what to consider when designing, manufacturing and installing new equipment using EEM.

Theories on production start-ups and project & process management theory were used to create a better view on factors in the start-up part of EEM. First looking at factors from production start-up theory (Almgren, 2000), (Almgren, 1999), (Baloff, 1970) and (Terwiesch & Xu, 2004) a lot of factors were present in the LE0 case and some of them influenced a vertical start-up and even equipment satisfaction, like late engineering changes. Start-up problems are significantly influencing EEM success and should therefore be considered managing EEM.

Secondly if one looks at the theory on project & process management (Meredith & Mantel, 2010) and (Bruijn & Heuvelhof, 2008), almost all derived factors were present. Unfortunately their influence to EEM success did not really come forward during this research. In the relation between factors, described in chapter eight one could see that especially the factors from project & process management are influencing inappropriate management decisions, which plays a central role in EEM success. Therefore these factors cannot be neglected looking at EEM success.

Also looking at AM this research provided added value to the existing knowledge on TPM. The most important finding of this research was that being familiar with AM for more than six years, does not automatically mean that AM step three can be quickly and successfully implemented in the start-up of a new production line. The most important link between theory and practice is that apart from some AM barriers mentioned in literature, also general TPM implementation barriers mentioned by Ahuja & Khamba (2008a), Rodrigues & Hatakeyama (2006), Cooke (2000), Ben-Daya et al. (2006) and Bamber et al. (1999) are applicable when implementing AM step three in the start-up of a new production line. Both AM and general TPM implementation barriers created a very complete view one what could hamper a quick and successful implementation of AM step three in the start-up of a new production line.

T&E success was investigated a little different as EEM and AM, but created a very useful overview on what operators find important in T&E during a new production start-up. Setting a base of factors that might improve the learning of operators and let operators elaborate on these is a first step in understanding what operators really find important in T&E during a start-up. To set this base theory on learning improvement from Chase et al. (2006) was very useful. This research showed very tangible examples of what operators find important in T&E, which creates new insights in TPM.

Looking at the answers to all the sub questions, the content seems to deliver a very extensive answer to the main research question. A very brief answer could be that for EEM success, factors from theory on TPM, SE, production start-up and project & process management have to be considered. For AM success, both factors from theory on AM and theory on general TPM implementation have to be considered. Finally give factors from theory on learning improvement and tacit knowledge better insight in what operators find important for successful T&E in start-ups.

Looking at the whole research process (approach/methodology, data gathering and results) there are some points for discussion, some of these points already came forward in this conclusion or the latter chapter on generalizations. The next chapter will elaborate on this and will come up with avenues for future research. On top of that, a personal reflection on the whole research will be given.
11. Discussion & Reflection

This chapter will discuss the approach/methodology, the data gathering and the results of this research. This discussion results in avenues for future research. In the end of this chapter a personal reflection on this research will be given. The figure below shows the progress of this research.

11.1 Discussion

The discussion consists of a discussion on the approach/methodology, data gathering and result of this research. This will in the end result in avenues for future research.

11.1.1 Discussion on approach/methodology

This research may not have to most natural structure, because one not exactly knew what to look for in advance. This research tried to find factors that could influence the success of EEM, AM and T&E and create better insight in these elements during a start-up, but where to find factors that could realize this was uncertain. EEM, AM and T&E are totally different in content and requires different research views to investigate success, which made it challenging to clearly present all this in a research report with this kind of scope.

The first step in this research to find factors was to extensively look at TPM literature and especially EEM, AM and T&E topics. Looking at the to be investigated success; equipment satisfaction, vertical start-up (EEM), quick and successful implementation of AM step three (AM) and what operators find important for a successful T&E program (T&E), there was not elaborated very much in TPM literature. Especially the vertical start-up that EEM should realize intrigued the researcher, because how to reach this, or what could influence this was nowhere to be found. Only some factors were found that could be present in the design, manufacture and installation of new equipment. The start-up part was not elaborated in literature, therefore the first important choice of this research was made to look at EEM from a two-part perspective. This choice really showed that particular factors are present during the design, manufacture or install part and other factors are present in the start-up part. This research demonstrated that factors from both parts could influence the EEM goals. Therefore successful EEM depends on serious management of both parts.

Looking at the insufficient literature on EEM, AM and T&E success in start-up, additional literature was needed to add factors to the elements to create a better view on success. From this point on the second important choice was made to critically look at EEM, AM and T&E in Heineken and LE0 and use this information to find supporting theories that are somehow related to the EEM, AM and T&E, to provide factors. Of course this is a really open approach that could be criticized, because personal or subjective findings and perspectives play an important role. Eventually the choice to look at the EEM DMI part from a systems engineering perspective was influenced by the fact that I as an inexperienced researcher, have quite some experience and knowledge in this field. Also the choice for
project & process management was influenced by the researchers foreknowledge. However theory on production start-ups, AM/TPM barriers and learning were totally new for the researcher. Looking at AM and the investigated barriers, this research goes quite into depth. Seeing similarities between AM barriers and general TPM barriers made it possible that an extensive amount of factors could be investigated to look at AM implementation success. T&E was however harder to investigate since the initial goal was to investigate what was closing knowledge gaps of operators. To find a way to investigate these goals became harder when this research progressed. Therefore a slightly different approach was chosen and the scope of T&E success changes from what is closing operators knowledge gaps (in a start-up), to what do operators find important looking at a T&E program (in a start-up). Factors from learning improvement theory seemed very useful to discuss with operators and created more insight in what they find important in T&E during a start-up. This research assumes that if a T&E program fit operator’s needs, that this will contribute to more success and thus also to closing operators knowledge gaps. *However this research does not prove this and future research on points that came to the surface is needed to see if these contribute to closing operators knowledge gaps.*

### 11.1.2 Discussion on data gathering

The most important sources of data gathering was desk research, interviewing and performing observations. Desk research was particular important to gain insight in how Heineken was performing TPM and what theories could be added to the existing TPM theory to gain more insight in what is influencing success. Interviews and observations were important for the conclusions of this research and provided the real added value of this research.

The final interviews that were performed were not always easy. This could maybe inextricably be linked to the fact that semi structured interviews, without specific questions were used. Only factors were mentioned and used as starting points for respondent’s answers and even discussions. To make good accessible interviews, the interviews (for every element separately) were first performed with an average respondent representative for the other respondents. These respondents were asked if the interview was understandable and if other respondents would feel the same way. In these first interviews it became clear that some things needed more clarification and that other things could be left out. Nevertheless were the follow up interviews not always easy. Sometimes respondents really stray away from the topic and the influence of the factor on the predetermined success became not very clear. Sometimes even after repeating the question, if the factor had influence on success, the real influence was still omitted. This sometimes resulted in the fact that if it was very obvious, looking at the respondents answer, the influence to success was assumed (these assumptions were however exceptional in this research). For some factors one had to admit that stating the real influence was sometimes hard. Especially the factors from project & process management were very broad and asked on a high aggregation level. Fortunately the researcher was able to perform a lot of observations, which really strengthened the answers of the respondents and created a total view with as minimal subjective conclusions as possible.

For EEM, AM and T&E different interviews were composed, with different factors and different dependent success. To get valid and useful answers respondents were selected carefully looking at the content and the purposed result of the interviews. Of course when performing interviews in a single case study, triangulation of sources is important, which was more or less secured in every element. If one looks at the EEM respondents, one could state no comments. Seven skilled respondents all very related to the subject were questioned. The interests of these respondents vary very much so this really strengthened the answers. One could of course argue that seven respondents is still a low
number, but looking at their expertise and the very extensive answers (also the similarity in the answers) validity of the results is expected.

For AM eight respondents were questioned of which seven skilled operators closely involved with the AM implementation in LE0 and an AM expert with a lot of AM knowledge and also closely involved in the start-up of LE0. There was the possibility of operators giving strategic answers, since they could easily state that the workload was too much, to explain disappointing AM results. The confirmation of the independent AM specialist dealt with this and created more validity of the results.

In the T&E interviews also only skilled operators were questioned, because they got training and are able to really understand questions and give proper answers. Fact remains that also questions on the start-up learning process itself were asked, for instance on how the mutual knowledge sharing went. Triangulation of sources is not totally secured here. This means that the answers to these questions are stated from the perspective of high skilled operators. The perspective of less skilled operator might be different. High skilled operators state often that less skilled operators were not pulling enough information; it could very well be that less skilled operators state that high skilled operators are pushing not enough information. **Less skilled operators could not elaborate on the trainings, but they could state how they experienced the start-up, this is food for future research.**

### 11.1.3 Discussion on results

Per element a short discussion on the results will be elaborated beginning with EEM. The purpose of this research was to create more understanding about the concept EEM by demonstrating what could affect the success of EEM. Therefore the concept was split in two parts, the design, construct and installation (DMI) part and the start-up part to see if both parts influence the predetermined goals of EEM (equipment satisfaction and vertical start-up). This research showed that factors from both parts influence equipment satisfaction and a vertical start-up. However the equipment satisfaction is mostly determined in the DMI part, which was also expected. The separation of two parts made it easier to look at EEM and created a better understanding on EEM by showing when certain factors could occur.

If one looks critically at the present factors, one could see that some are assumed not to be present. This research sometimes draws a hard line between which factors were present and which not. A majority of the respondents was the criterion to determine whether a factor was present or not. A weakness of this is that sometimes if three respondents state that a factor was present, this factor was not taking into further analysis. **Especially the factors on which a minority of the respondents stated their presence must be investigated in future research; because it could very well be that these factors are also important for EEM success.** Examples of these factors are: little MP data used, incorrect requirements, installation errors and high frequency of minor stoppages.

Apart from the factors that were not present, the factors that were present did not always showed influence. For some of these factors influence was expected, but this case study did not demonstrate so. The criterion here to assume influence was that more than one respondent who thought the factor was present stated that the factor influenced success. There were some present factors for which only one respondent stated influence. Examples are: **poor selection of construction materials, corners cut in the optimization of processes, adversarial relation with supplier (to vertical start-up), different goals and expectation among project members (to vertical start-up) and different perceptions on problems and solutions by project members (to vertical start-up).** If one looks at chapter eight on relations between factors, one could see that some factors, for which no influence was demonstrated, influence other factors (which do influence success). **This could mean that the present factors for which no influence was demonstrated are still important for success and have to be considered. Also these factors deserve attention in future research.**
A reason that respondents could not always exactly state the influence of present factors could be that some factors (from project & process management) were questioned on a high aggregation level, which made it hard to investigate the influence on EEM. *Future research has to derive more factors from project and process management, so that it is maybe easier for respondents to demonstrate the effect to EEM.*

Looking at AM, the purpose of this research was to give insight in what is influencing a quick and successful implementation of AM step three in the start-up of a new production line. If one looks at the posed factors they are all stated in a negative form. This was done so that it is easier for respondents to visualize the effect. If one used general factors like ‘‘level of 5s’’ the influence might become less evident than if one asks ‘‘low level of 5s’’. If one looks at the presence of factors, some factors were not present like ‘‘lack of training’’ or ‘‘lack of moral’’, but these factors are assumed to have influence on a quick and successful implementation of AM if they were present. Again some of the respondents (a minority) stated that factors were present like: lack of training and lack of moral. *These factors, like in the EEM analysis, also deserve future research to look at their influence.* The present factors all seem to influence the success of AM, the reason for this could be that the border between a factor being present and having influence might be small, in comparison to EEM factors.

If one looks at the theories on general TPM implementation barriers that were added to AM, these really seem to reflect when applying AM in a new production line. *However, in this research only a few general TPM implementation barriers were taken into further research (only those that were dominantly present), but it could very well be that more apply, again an opportunity for future research.*

Last looking at T&E, the purpose of this research was to create insight in what operators find important in a T&E program during the start-up of a new production line. The analysis of T&E was done differently in comparison with EEM and AM. In this analysis, factors from Chase et al. (2006) were used as a base to find points that operators find important in T&E. One has to admit that the factors used from chase et al. (2006) are quite general, especially the present factors. The less general factors like *work specialization, do very few jobs at a time and allow worker to redesign their tasks,* unfortunately did not seem to be present in the LE0 case. These factors are really hard to investigate (with operators) and prove to be not very suitable in a complex start-up in which a lot of processes have to be mastered.

Looking at the present factors, operators could perfectly state what their thoughts one these factors were. This research assumes that if the points mentioned by operators are taken into account that this contributes to more success in T&E programs and eventually to more successfully closing knowledge gap of operators. *However this is a very risky statement and future research on the points that operators mention is necessary.*

### 11.1.4 Avenues for future research

Discussion on the approach/methodology, data gathering and results of this research, results in some avenues for future research. Before these are stated the fact that the outcomes of this research are based on a single case study makes future research necessary to strengthen the conclusions this research did on EEM, AM and T&E. Looking at the discussions above some avenues for future research can be distinguished. First of all looking at the respondent of the T&E interviews, only skilled operators were questioned. Answers like ‘‘less skilled operators are not always pulling enough information’’ could be biased. This suggests the following avenue for future research:
• Investigate the opinion of less skilled operators to create a more thorough and complete overview of what operators find important during T&E. Secondly this research only took factors into future analysis if a majority of the respondent stated these factors were present. Some factors were stated present by a minority of respondent, it could very well be that these factors are also important for EEM, AM and T&E success. This suggests the following avenue for future research:
  • Take factors that were only stated present by a minority of respondents into future research, to investigate if they influence EEM, AM or T&E success anyway.
Thirdly looking at the factors that were present, some did not seem to influence EEM, AM or T&E success. However for some of these factors, influence was assumed. Sometimes one respondent shared this vision, which was not enough to draw conclusions. These factors also deserve future research to investigate if they influence EEM, AM or T&E success. This suggests the following avenue for future research:
  • Take factors that were present, but showed no influence to EEM, AM or T&E success into future research if there are reasons for this (influence is assumed and one respondents agrees).
Fourthly for some factors respondents really struggled demonstrating their influence. This especially counts for factors from project & process management. The high aggregation level of these factors might be the reason for this. In the analysis on the relation between factors, factors from project and process management show influence to management decisions; this assumes that they also influence EEM success. To prove this, future research is needed. This suggests the following avenue for future research:
  • Investigate the role of project & process management on the success of EEM by stating factors from a lower aggregation level.
Fifthly, this research showed via a base of factors what operators find important in a T&E program. This research suggests that if these points are considered, this could contribute to more successful T&E and to more minimization of operator’s knowledge gaps (in start-ups). However this is a risky statement and needs more research to be proven, this leads to the following avenue for future research:
  • Investigate if the points that operators find important for T&E contribute to more minimization of operator’s knowledge gaps.
Last, in this research only a selection of dominant general TPM implementation barriers were investigated on their influence on AM. This already resulted in an extensive overview of what factors could influence AM implementation in a start-up. However to make this overview even more complete, more general TPM implementation barriers could be investigated. However this is optional and not necessary to strengthen the conclusions of AM. A suggestion for future research could be:
  • Add more general TPM implementation barriers to investigate their influence on a quick and successful implementation of AM step three in the start-up of a new production line.

11.2 Personal reflection
I would like to begin this personal reflection on my research with my employment procedure at Heineken, which was rather quick and unusual. After having everything arranged with another company, all of a sudden Heineken gives me a call five weeks after applying. After almost forgetting the application and a little bit overwhelmed by a flattered feeling, I decided to have a quick visit. I must admit that my gut feeling told me that Heineken would be the right company for my internship and maybe even for my further career. After an interview at Heineken both parties were enthusiastic and Heineken would do their best to fix an assignment for me on short notice. A week after my interview an assignment was fixed and I could start almost right away. This meant that I had to cancel
the company for which everything was arranged. Cancelling a company that was also very
evergetic and putted some afford in me is not easy, but on the other hand a nice lesson to deal with
such situation in the future.

The assignment that I got from Heineken was rather short and vague, maybe because the assignment
had to be made rather quick. The assignment description that I received from Heineken was the
following:

‘‘Execute and support TPM step 1 to 3 of Early Equipment Management (EEM) for Autonomous
Maintenance (AM)’’

Looking at the assignment, a lot of own interpretation was possible and this could be seen both as an
advantage and a disadvantage. The advantage was that I could dive into literature and make sure that
the theoretical part of my research was secured. This research linked additional theories to TPM
theory and thereby created new insight in TPM success in start-ups. The observations and desk
research, together with my technology, policy and management background made it possible that I
quickly noticed patterns between Heinekens organizational process (TPM) and additional theories.
Linking theories and seeing pattern between them, means being busy on a really academic level,
which is quite nice and satisfying when one succeeds. The danger of this process is however that it is
sometimes hard to stop searching for literature, patterns and relations. There comes a moment that
you have to feel saturated and scope your research, but this can be quite tricky
with this kind of research approach. Also my inexperience as a research influences this. Most of the theories that I
linked to TPM like: Systems Engineering and Project & Process Management were treated during my
study at the TU Delft. Theory in TPM and production start-ups was however totally new and also big
educational experience. Graduating in a domain that goes beyond your specialties requires some extra
work, but is a great opportunity to gain knowledge in other technological fields. So, all in all offers a
somewhat vague assignment description the opportunity to dive in different literature right away, but
it also has its downside.

A vague assignment could also be a disadvantage, because I was not really sure what Heineken was
expecting from me and I was floating around with different ideas for quite a long time. I came to
notice that I had to shape my assignment and the added value of my assignment on my own. This was
a very useful and educational experience, but also very time consuming, because I changed the scope
and approach of my research quite often. In the end I agreed with Heineken to support the AM
implementation process quite intensive and that I would provide lessons in the field of EEM, AM and
T&E. Especially supporting and guiding the AM implementation process was very practically and
time consuming, but on the other hand a very educational experience in which I gained my first
functional leadership and persuasive skills. I really noticed that working and cooperating within
different layers of the organizations suits me well.

Next to all my practical activities there was also the need to do research. A real benefit for me was
that, because I was so engaged in this start-up process, a lot of data and confirmation of literature
came my way. The intensive AM process, all the start-up morning meetings, the endless small
conversations, general observations, the extensive interviews/discussions and so on, really created an
overflow of data and information, to derive really nice conclusions. The overload of information’s
does mean that the one really has to filter all the information and try to adopt the useful information as
much as possible. Sometimes you have to make sure that some information goes in one ear and leaves
the other right away, otherwise one could easily be distracted form the core of the research.
During all my conversations and interviews I noticed that within an organization like Heineken there are a lot of personal interest, which I had to deal with. It is very important to piece through some biased information and come to the objective core of problems. It really helps to have some social skills to overcome these problems and get most honest answers from people. One has to gain trust with people and make sure that they understand that this research will not be hold against them. Finding the right balance between being an independent researcher and a dependent trainee or temporary employee is the key to success. Using the strength of not being bound to the organization or to other people’s interests, makes it possible to get information from people that permanent employees might not get. This all made it possible that enough in depth data was gained during my case study at Heineken.

Final challenge was to process all the data into a presentation that was short, value adding and understandable for higher management of Heineken. Shortly after all my data gathering Heineken requested me to present my results. Presenting results based on scientific research to a company like Heineken is something that one has to transfer with some kind of nuance and intelligence. Making pure scientific recommendations is not the way to go and companies are also not very interested in this. The practical implication is what matters. To give proper recommendations to Heineken, some shortcuts had to be made and the thorough data analysis started after my internship. Fortunately were the main conclusions on the basis of my data already quite visible on forehand. The final conclusions of my research divided very little from my conclusions to Heineken. Fortunately Heineken was very pleased with my findings and way of working.

My internship at Heineken was very challenging and therefore a great learning experience for me, in which I gained skills that I could not have gained at the university. That is why this internship was the best way for me to finish my study and prepare myself for my future career.

Green Horizons,

Derk Querido
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APPENDICES
## Appendices

### I. Outcomes Interviews & Observations EEM

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<td>Yes this was present, but this is more a continuous process of situations. It started with the floor; the heights were not matching with the drawings. This project was a real snowball effect with a lot of different options that were weighed. Reuse of machines, partly reuse of machines etc. So the design of the line constantly changed. A lot of options were tackled so and the management decisions took very long (too long) this means that there was not very much time for design reviews.</td>
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<td><strong>Baal, Member of the project team; planned maintenance (8-05-13)</strong></td>
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### Table 12 Outcomes interviews and observations EEM

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**Design, Manufacture & Install part**

Too little focus design review

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- What one afterwards has to do is take the Heineken specification/requirements and looks how much really was delivered and explain why certain things were not delivered. That is really learning lessons.
| Little MP data used | No | Not really, but there was not really a vision from the EEM pillar towards this project. Pillars worked together to give input to the design, but because the structure of the pillars is not mature enough it is really hard to use pillar standards for the design of a new line. | Yes too little data from the pillars. Most data came from Den Bosch and the other pillar data we really had to gather ourselves at the pillars. In the end I think everybody is happy, but the gathering of all the data took a lot of effort, and this is a pity. You should have a database with all the AM, PM Safety etc. data. | Data from the pillars was partly used. The main reason for this was that the supplier KHS thought they already knew the Heineken specification because they also do a lot of business with other Heineken breweries. Unfortunately breweries in different countries have different specifications and the specification that Heineken cooperate for Heineken Zoeterwoude does not use instance uses. Especially the breweries in Africa have different specification for production lines. Also the pillars data is not easy accessible and this should be stated in EEM standards. | What I really noticed was that this was the first time that we did it like this and that everybody was really finding a way how to gather all the needed information to feed the EEM design. In the safety pillars there are not really standards specifications for safety that can be used for a new line. The PvE was good, but one must realize that this can be better. We should review have we asked the right things, did the supplier understand us and did we get what we wanted? I think there was more to realize than we did. For most people it was a lot of extra work on top of their daily work and this reflects the completeness. Maybe a different approach to come to the PvE. | There was enough data gathered, but the supplier translated not everything. The idea is that we want to start with a certain level of machines (from supplier’s side) and build on and use EEM from this point on. Unfortunately this level was too low at KHS. The Heineken standard is also to low. If one builds a line this line has to be ready for the coming 10 years. Heineken global/corporate is not at the level we are and this is strange (they build the lines in the rest of the world). | Yes there was too little MP data because everything went to fast. PvE had to be made in a real hurry. Input from Heineken Global was not used and they have a lot of experience. Another reason is that we have too little standards. This all influenced the satisfaction. |

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### Poor selection of construction materials

Yes. Wrongly interpreted requirements for the bottle and crate conveyors. Because of wrong material there were a lot of stoppages, which impacts the OEE and satisfaction about the system. (Talk to the right people, not KHS managers because the translation to construction or programmers is not good). Conclusion the lines had to be closer with Heineken design and KHS design and construction people.

Yes. Palletizer for instance; the design is not very hygienic. There was no RVS but another type of steel that is really unhygienic if it gets in contact with moisture. It has influenced on the lifetime of the machines, so the system satisfaction, but not really on the production.

We don’t have mechanical specifications in the Heineken project bureau. The cable ducts were carried out in carbon steel, this was because we did not specifically request other steel. There were some other minor things, but it never influenced the start-up.

Not really the material, but more the design, what is a clean design. The supplier could have different visions on this because it does not look at the machine from a user’s eye.

No I could not figure something

Yes again the examples of the palletizer. There was not RVS delivered. This all had to be replaced. Maybe it is not directly visible for us but KHS has to make extra costs and has to earn this in some way. How KHS is earning this back is not directly visible for us. (Maybe the next line is more expensive)

Yes especially poor steel choices. The supplier sometimes interpreted this wrongly. For instance in the filler Heineken demanded stainless steel, but the legs of the machine were from poor steel and will rust quickly in the future, this is not desirable. The question is how to specify if Heineken requests the filler to be made of stainless steel, KHS states that the legs are not part of the filler.

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### Wrong fabrication of equipment

Yes. Heineken saw the drawing for the GNIF in the filler rejected it and still does it get delivered by KHS. (More intensive consultation is needed or the right location). Impacts client satisfaction.

Not really

Yes the stairs or the GNIF for the filler and this has influenced to the production and satisfaction.

Yes look at the large LOI list. This has a lot of impact on the start-up process. Because of all the adjustment that has to be done a vertical start-up is only a dream. Production sometimes has the idea (partly caused by inexperience) that

In Germany we found out that a lot of things were interpreted different than we thought. Maybe influenced by the sub braches of KHS, who all have their own engineering department. All these branches interpret the

During the MI 200 points came up and these were almost all (90%) shipped to Zoeterwoude. Correcting all these points is causing stops. Still there are some points that are not tackled.

Can be better but was not bad. But often we accepted certain standard KHS things because the fabrication process was too far on the way.
| Difficulty of defining requirements | Not really difficult, but what is realistic to ask? EEM in Heineken must capture quick wins. (laag hangende fruit). Examples maintenance free bearings, stainless steel, more safety. Not really the control in inner technology of the machine. So there was not really difficulty in defining requirements. | Not really, but the Heineken specification for certain things were not really available. It should be that if you buy a bottle line or a can line that for all the machines the standard specs are already available. Technology is future than the Heineken specification and therefore their must always be an interaction between suppliers and client to keep EEM up to date. EEM requires close cooperation with the supplier. | It is getting better in the organization, but it was still a difficult process. It was hard to find out the right requirements and especially with the time pressure we experienced. We had to order really fast and this puts a lot of pressure on a robust design. It was all just in time but the production or the satisfaction was not harmed. In May we order the specifications were ready in April. | We have the Heineken RFQ were a lot of standards are already stated; this RFQ is the basis of the PvE. Stating good requirements was a tough job and there are also some minor faults in this document. Technology goes forward so the requirements also have to be updated. PvE was quite good, however there are some minor mistakes in it; It is not only asking requirements in a PvE it is also ensure that is it understood and respected. Yes this was difficult. This is influenced because within Heineken we have 2 steams one that says you have to design from a user perspective and the other (top management) say you have to let the design over to the supplier. New techniques are good, but one does not want to lose certain basal techniques. The focus should be on easy maintainable machines and very smart new machines are not always easy maintainable. Because top management sees maintenance as evil and leaves the design rather to suppliers, EEM can be contrary with the current Heineken business. It is not so easy to It is not so difficult, but the Heineken specification for certain things were not really available. It should be that if you buy a bottle line or a can line that for all the machines the standard specs are already available. Technology is future than the Heineken specification and therefore their must always be an interaction between suppliers and client to keep EEM up to date. EEM requires close cooperation with the supplier. | HeiQ sates the minimal requirements, but are these also enough to make our current processes as optimal as possible. Not really difficult, but one has to state requirements so that in 5 years we are still satisfied with the system. What one should do is building this line looking at the vision of 2020 and not the vision of 2013 with build on options. It can be difficult to realize this because a lot of people think in the here and now and do not look in the future. PvE does not deserve any prizes. This was not specified enough. If one describes something there are always different ways to interpret this. It went to fast, we had to make this in one week. We are not yet in an EEM mode. We do not record our learning’s in such a way that we get easily access to it in the future. The process of designing and implementing new equipment, that requires for instance different operator handlings and cleaning methods, can be difficult because technology is getting more sophisticated, but Heineken still has to comply with Heineken standards. Moreover, advanced sophisticated technology demands Heineken to grow in their technological in-house knowledge, otherwise Heineken gets more and more dependent on the knowledge of suppliers, which gives Heineken less power in negotiation processes. Vink (2013) foresees that Heineken will become more and more dependent on
say this because every manufacturing company what machines that have the latest technology. You want machines that have the highest output against the lowest costs. If EEM is only fed by the shop floor you will always hear ‘we used to do it like this and we used to do it like that’. Technique goes forward and therefore setting requirements from an EEM perspective is not an easy task. EEM should be on a high abstraction levels and not on a very detailed one, this is not possible. On top of that, a supplier cannot satisfy all the things that operators used to do. EEM should really look at functional requirements.

Outsourcing

Outsourcing was not good. There was no sparring time with the supplier. That was the risk of this turnkey project. Did the supplier read the requirements thoroughly? There was never a call from KHS that they did not understand some requirements. This resulted again in expectations that were not met, so this Marketing was really pushing on this project and if the TPM standards are not easy accessible and it costs a lot of time to make requirements for the new line the sparring time with the supplier is also under pressure. Framework contract could help. Yes this was a problem because KHS also has to order certain things. If Heineken wants to have the machines in October, KHS has to order in June. So there was also not much time for KHS to really look at the requirements. KHS has a delivery time of six months for the machines, but Outsourcing makes it hard to really get what one want, this is partly the fault of KHS, but Heineken is also to blame. You have to realize that the requirements were stated to commercial persons. Who were giving it to others and this process repeated it a few times. The fact that KHS has I think the outsourcing procedure was good and the relation between KHS and Heineken was good. But because of the time pressure some giving in on requirements is done and the effect will last years. For instance the whole dry part, all the machines are to close The discussions with supplier about the details were too late. And the time for this was too short. We could not explain enough what we really wanted to have. Stated and delivering it on paper versus actually discussing it, makes a huge difference. Examples are hygienic design of fillers. There was hygienic design One should really make a waterproof PV and then go to the supplier to talk what is possible. Also priorities can be made in requirements. But one always has to be clear in requirements and requirements have to be SMART. EEM was not sufficient, but the overall project went very well.

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The fact that KHS also outsourced certain machines or conveyor parts made the integration harder. If the expertise of the third parties was not available, sometimes problems raised.
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<td>Too much focus on systems instead of subsystems and interfaces</td>
<td>Yes. Heineken is not capable of defining all the small interface requirements. Also KHS has 4 or 5 locations and the communication between these can also be a problem. One location makes this machines the other that machine and the other the link between the machines. Example of the dry part: communication between conveyors and machines does not work well. Operators have to reset machines and conveyors in.</td>
<td>Yes this is true. For example the integration of the old machines with the new ones; the labelers with the new bottle conveyors. Also because the labelers were from another supplier, a lot more tension came to the start-up. It really hampered the production and it creates irritation, which is not desirable in a project like this.</td>
<td>Yes. KHS was responsible for the total line and had to integrate all the machines together. Some machines were older and not from KHS. Therefore there was not really a focus on interfaces. This really influenced the production. If you really want to secure things you have to make a functional design of the whole system. We asked for a function design from KHS, but we never got it. Learning point is that there has to be some kind of functional design. On this area improvement are needed. For instance the beer supply to the filler, KHS thought that the beer supply came from the roof; while in Zoeterwoude the beer pipes push through the ground. Again the GNIF is mentioned. But also the integration of third party machines gave problems. The communication with the third parties was always indirect via KHS. An example is the foil machine directly after the palletizer. This is no I think this was sufficient. One doesn’t want to go too deep, this is more for the supplier. We have one main contractor KHS, so this means that KHS is responsible for the machines in LE0. If we had the choice one machine level, we might sometimes choose for different machines from different suppliers. We used to compose production lines our self’s. Heineken is then integrating the line itself we machines from maybe 20 different suppliers, this all we went in depth, but rather late. Example is the inspection for empty crates. There was not in depth specification of how this machine should perform. A good example is the beer supply to the filler. The thought beer came from the roof and at Zoeterwoude beer comes from the floor. We discussed this and they changed their designs and we made interface requirements so that their system makes a good connection to ours. Feedback and discussion was good here.</td>
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Different ways. This is very irritating for operators and this is at the expense of the client satisfaction. Solution is more total integration plan.

Machine does not have adjustable heights, which are needed, because the crate stacks are not always at the same height and this should be known by KHS, but this was not communicated to the third party. Dissatisfaction about the machines.

Changes and outsourcing plays a more important role. Bad example was the GNIF schakelaar 3. Drawing was made, we said it was not good and they did not change it. I can accept a no, but communicate, and then we can search for solutions.

Between old and new, one can always expect problems, for instance: Conveyor and labeler. Labeler and labels. Conveyor and EBI.

Incorrectness of requirements

- The requirements for lubrication were not correct. The PvE stated that lubrication points had to be centralized as much as possible, but the RFQ did not. The RFQ is higher in rank than the PvE so the desired centralized lubrication points were not delivered. The lubrication on some point will take a very long time, but this does not directly influence the start-up, but of course there is dissatisfaction about it.

- You always have to deal with design from the supplier. You can only change some minor technical things.

- There is no clarity to me which document are leading. What do we have to state in PvE, what do I use from HeiQ and what do I state in RFQ? I see a lot of double things in those docs, but this has to become one doc. They you have minimal standard and one can state that certain standards have to be higher because the process is different for instance. Now was it so that one moment we looked at this doc and the other moment we looked at that doc.

- No most of the time correct but not delivered.

Looking at the PvE, requirements could be sharper, for instance:

All machine books should be delivered as soon as possible. It is acceptable that the machine books are not “as built” yet. As built documentation should be delivered as soon as possible. Better: Determine together with supplier an appropriate time because this gives too much slack.

All machines must be accessible in an optimal safe way to do activities like cleaning, maintaining and producing. Platforms, stairs etc must be realized in this project.
<table>
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<th>Lack of stakeholders approval of requirements and validation</th>
<th>AM was not very satisfied. Layout of the machines is not good. AM people came together and sketched their requirements, but technology is further. Therefore expectations are sometimes different from the deliverables. This influences the system satisfaction of some stakeholders.</th>
<th>The collaboration between the pillars was really smooth and good. Adjustment by different stakeholders (pillars) was always substantiated and everything was open for discussion. Most adjustment that the pillars wanted was actually approved.</th>
<th>For every pillar there were a few representatives in the project team. This process was very difficult there was not a lot attention from the pillars towards this project. There was a real lack of data sharing from the pillars.</th>
<th>In principal the requirements is a collection of the input from all the stakeholders. In the project team everybody had his focus area. How this process really went is not clear to me.</th>
<th>I think there was enough approval of all the stakeholders.</th>
<th>Approval yes. But some stakeholders did not listen enough to the experts. There have been choices made for which specialist say that these were not the right choices. Some un satisfaction on choices for no sort machine for strange bottles. This problem will increase a lot over time and take this into the design was cheap, but to do it now costs a lot more.</th>
<th>No we were really in line with each other, but this was basically because our requirements were not SMART enough and then one easily agrees with each other.</th>
<th>Better: Every point on all the machines that affect cleaning, maintaining and producing must be safely accessible for operators with a height of 1.70 meter. If necessary platforms, stairs etc must be realized.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation errors</td>
<td>No large wrong installed parts, some minor things.</td>
<td>Not really wrong, but rather inconvenient from Heineken point of view. We have two toplayers and if one does not work the line stops from there, while one of the two toplayers is perfectly capable of serving the palletizer. The same story for the crate washers. This influenced the start-up OEE. Another example</td>
<td>There were some installation errors. We tough KHS was very capable of installing a line, but we discovered that KHS was also outsourcing installation works and then you really have to depend on the quality of other firms. There were no big errors, some things were a little unlogic, but it did not really influence the start-up.</td>
<td>Because there was no time to make adjustments to the machines in Germany (because of time pressure) the wrong management decision was taken to ship the machines anyway. There was more focus on delivery on time as there was on delivery quality. Therefore there had to be an enormous afford on site, which also resulted in wrongly</td>
<td>There was a time during the installation that 150 men were working on the project and KHS did sometimes not precisely know what one was doing anymore. There was only one foreman who could not manage all this. This resulted in installation errors which again resulted in a lot of rework. The construction of all the electro cables</td>
<td>Not really only details.</td>
<td>Not really. For the time that was available KHS really did a wonderful job.</td>
<td>Lot of small parts were wrongly installed, examples are bearing that were installed upside down, reset buttons that were not on very logic places, supporting poles under conveyor that were in the way for shop floor transportation etc. Not immediate impact on the production, but the LOI lists keeps growing and</td>
</tr>
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</table>
are the light signals that the machines have, they were not Heineken standards so operators were sometimes confused and this had also impact on the production. Other clients from KHS have different EU standards that are different from Heineken standard, KHS practiced this at Heineken. All the installed parts. This influences the start-up. It is way easier to make adjustment at the manufacturer because the machines are still “naked” here on site a lot of other things are attached to the machines, which also make adjustments harder. It took three times more work than planned and on top of that a lot has to be corrected because the people working on this did not knew what the Heineken installation specifications were. If this really influences the start-up is uncertain but I assume the start-up curve could be more vertical if all the installation mistakes were not present. All the rework will definitely hamper production in later stages. Lot of LOI points have to do with cables and pipes. Fencing around the toplayers was installed wrong and this made it very difficult to operate the machines. This has to be adjusted. Because the machines are difficult to reach and operate, production will suffer a bit. Heineken has to realize that not all the points will be tackled, so prioritizing is important.

| Start-up part |
|---------------|---------------|
| **Inappropriate management actions** | Problems with the labeler. Operational Management pushes on production and must sometimes also consider quality. Problems that were known from the | Wrong management decisions on the labelers. The different labels that were required must have been available quicker or at least | There was a real pressure on production from management and then it is really difficult to resistance this. First you have to have everything in | I cannot comment on wrong management decisions during the start-up, but managerial decisions before the start-up were not good or at least took too long. | Decisions have to be made that are not optimal, but one has to make decisions. One can only say that a decision was not optimal a priori. Wrong decisions were | No view. | It is hard to discover them because what is inappropriate and what would have happened if other decisions had been taken? |


The possible problems should have better be mapped. The order and then you must start production. This which also influenced the start-up. Processes sometimes intertwined with each other. The main reason for this was the problem with the labelers. 

made, but on the moment the decisions were made these were the right one. Example: late involvement of specialists in certain areas. In the labelers for instance. Make specialists dedicated to start-up the labeler. We knew from experience that Krones is not very good at commissioning a label machine with plastic label, Heineken is way better at this. Make specialists available for this. The problems with the labeler would have been noticed earlier and this could have saved two days of production. In start-up things go wrong that for sure, the only question is; where will it happen. If one has risky areas like the labelers specialist have to be available. Make a good planning for the availability of specialists.

<p>| Use of not-yet-verified technologies | No this could harm quality and production. | Not really, but KHS had a lot of struggle with the plastic bottle conveyors. This was not proven technology. It is not so that it does not work but we really had to convince the | The filler has double filing valves; this is no proven technology and gave some problems. This did not really hamper the production, but it requires some extra attention from technical project members. | The wash off of the labels by the bottle washer. It seemed proven technology, but it is not as proven as it seems. It does not seem to be the machine, but the technology and quality of the labels. The plastic labels are | I’m not really sure, but I guess not. | The plastic bottle conveyors are not very common, but it is not not verified technology. | Maybe only the wash-off of the labels. |</p>
<table>
<thead>
<tr>
<th>Corners cut in optimization of processes</th>
<th>supplier to use this, because they had not experience with this (looking at warranty etc.). No delay in start-up, but in prior negotiation processes.</th>
<th>designed in a way that they curl of the bottle in the bottle washer and take the glue with them. But this process does not seem to work well. The bottle conveyors are from plastic, which is new and never done, till now there are no problems with this, but the future will tell if these decisions were right. These decisions are always risky.</th>
<th></th>
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<tbody>
<tr>
<td>High frequency of minor stoppages</td>
<td>Corner to use this, because they had not experience with this (looking at warranty etc.). No delay in start-up, but in prior negotiation processes.</td>
<td>designed in a way that they curl of the bottle in the bottle washer and take the glue with them. But this process does not seem to work well. The bottle conveyors are from plastic, which is new and never done, till now there are no problems with this, but the future will tell if these decisions were right. These decisions are always risky.</td>
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</table>

**Corners cut in optimization of processes**

Yes. Controlling the bottle conveyors and setting the optimal pasteurizer settings. It helps production for now but it costs a lot of extra water. This is really a deviation from what is designed for. Another example is the inverters to steer the conveyors. This influences the production.

Again the example of the pasteurizer. The original idea is that the pasteurizer is always full and delivers in batches, this also to save water and energy. However this caused a lot of failures in the startup because the pasteurizer stops and resets a lot. Therefore is decided to have a constant throughput of the pasteurizer. This has not influence on the OEE, but only on energy inefficiency (client satisfaction).

Yes the inverters. It is decided to not burden the conveyors too much so the inverters do not go into failure modes. In two months there will be new inverters. This means that the buffer of crates is less and this influences the production a bit. Now it is not really recognized because the line done produce on full speed, but if the line goes to full speed the inverters are a problem. This short cut is a choice between a little production loss or an unmanageable situation for operators.

There was some corners cut in the design process. Some options were not taken into account so that there could be better design reviews.

Not in my field of operation, but I can imagine that the whole project can be seen as a shortcut. I’m not enough involved to state something on this. However I’m aware that there are some problems present at LE0 and probably they could have been prevented if there was more attention in the design phase. For example the toplayer and the crate washer.

Brackets for the GNIF. The double packer, I really think that this machine is needed in the future and then it will cost a lot of extra money. This is not really a start-up shortcut, but more a shortcut in the design.

Replacing Teflon on the labelers every shift seems not very efficient, but it is done for the moment to make sure that this cannot be the problem.

**High frequency of minor stoppages**

Yes definitely, one can see this in the production data. Costs OEE.

Yes. And this influenced the OEE. Short stops go hand in hand

It is not bad, there are some minor stoppages because the lines has to be

- -

Needed for commissioning. But should be minimized.

More in the EEM design process.

- There are some machines that have a very high frequency of minor stoppages.
with commissioning of the system. It influences the start-up (OEE), but is on the other hand needed to have a good running system in the end, tough the negative influence has to be minimized. Comissioned. The line does not operate at full speeds so things could change. For instance the bottle washer is giving a lot of small failures. In the P&V is stated that this machines should run without operators interfering. After a few weeks, because of all the failures, is decided that there will be a temporary employees operating this machine constantly. No doubt this problem will be solved, but production does suffer from it during the start-up.

Lack of materials

Sometimes waiting for spare parts, but no OEE loss. No really lack of production materials. Requested spare parts take very long. This long arrival time of extra part influences the start-up. If something does not work well and had to be substituted (because it hampers operators or machines to work sufficient) and this takes very long, it has influence on the production.

In the beginning there was a lack of labels and bottles, but this did not really influence the start-up. Ordering spare parts takes very long time, but till now the production did not suffered from it.

The spare parts plan always goes wrong, but this is in the beginning not so important. In the beginning the supplier is still responsible that the spare parts are available. I don’t know if the lack of spare parts influenced the start-up.

Especially cables and this influenced the start-up. Communication cables were the biggest problems.

Especially in the beginning there were some problems with CL&L when it came to providing production with enough bottles at the right time. This influenced the start-up, but it does not differ from the performance of other lines.

Lack of material quality/status

Yes quality of the labels, influenced start-up. No there was lack of quality of material. One could have prevented the problems with the labelers. This all cost lot of OEE.

The quality of the labels was not good, but there was not enough research on what was needed. This really influenced the start-up. Greece did it so.

Quality of materials was not sufficient

Quality failures cannot always be seen in advance. But in the risky areas we must have more specialists.

Labels were not suited for the labeler, but one cannot say that this was due to bad quality of the labels. The quality of the crown corks was not very well and
Zouterwoude can also do it, but what the quality specs are in Greece could be really different. It was not recognized as being a risk. The wash ability of the labels was identified as being a risk, but most of the time risks that are being recognized in advance do not occur in reality. Huge influence on start-up and overall production pressure.

### Breakdowns

| Breakdowns | Not significantly from a technical point of view. But more breakdown in new technology because operators do not yet understand the system. | Toplayers, palletizer, bottle washer and filler had a few breakdowns. Maybe there are a few more breakdowns in a new line than an existing line. Not more breakdown in new technology as in proven technology. | Yes but not significant, normal for a start-up. | - | - | - | - |

### Personnel performance

<p>| Personnel performance | Really big difference in dry and wet area. Dry area people are really reticent to talk to KHS people and on the wet part operators take matters into their own hands. This influences OEE and closing the knowledge gaps of operators. You really need someone who facilitates the knowledge level could be higher, but the big advantage is that it is really a team. Maybe this is more important than knowledge. KHS is sometimes complaining that they notice that some operators did not have education and that the knowledge level is sometimes really to low. | - | - | - | Better than it was. | Line of demarcation between the skilled and less skilled operators is sometimes very big. Skilled really interfere with KHS. Less skilled are more individually and hesitate to connect to KHS, they also sometimes walk away from problems. |
| Late engineering changes | Modifications for the toplayer, so one toplayer can serve the palletizer, this also counts for the crate washers. This influenced the start-up (OEE). | Toplayers, glass crushers (outside of the scope), create washers, adjustments of the bottle conveyors after the labelers. But these things did not really influence the start-up because the big modifications are done outside operating hours. | There are a lot of technical changes in a start-up. Some things are even still in order processes. Some things are not thought of in advance, because they come to the surface by using the system. Most of the time operators identify these problems by using the system. Then they notice that buttons are not in the right position of there are parts were a lot of bottles are being emitted and glass crushers have to be placed so that the operator does not have to walk constantly. | I think it is important that we look back at the LOI list and see if these could be things prevented in advance. My experience is that LE0 does not deviate from earlier projects if one looks at the process. Overall I think this line is the best performing (production wise) new line looking back at earlier lines. Maybe modifications are unavoidable, but the amount can be reduced. One has to look at all the modification from a higher perspective and could then maybe see that some subjects could get more attention in the future. An example is safety system in the machine. Machine safety systems were now separated from the machine system and you want this more integrated. Not really sure if this influences the start-up, but we made it ourselves extremely complicated and this is not desirable. It could have been way simpler. | Only 400, big influence to the start-up, especially when time became more precious. | Yes, but no very big ones like repositioning of machines. | There was a lot of frustration on what engineering changes KHS was performing and when. The communication on the shop floor was not good and Heineken people could not adjust their planning to the activities KHS was performing. KHS was sometimes stopping the production without saying. Heineken can also do engineering stuff KHS must really do what Heineken cannot do because the amount of work is too much to do it all. |</p>
<table>
<thead>
<tr>
<th><strong>Adversarial relation between client and contractor</strong></th>
<th>Yes and this can influence the process, not sure if this really influences OEE.</th>
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<tbody>
<tr>
<td>The TPM though is really different with KHS. They just construct and install a new line and want to produce as quickly as possible. This all does not really hampers production.</td>
<td>KHS often states, that they also have their own specifications. KHS also tries to standardize and Heineken makes it difficult for KHS, because they often have to deviate from their standards. If clients often ask for certain specifications KHS makes it their standard and assumes that this is also the most suitable solution for Heineken. There was never a good look into the requirements of Heineken. This influenced the start-up and created a very long LOI.</td>
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<tr>
<td>Political games are always present and sometimes we have to consult the higher management of the supplier. Sometimes the supplier does not build things the way we want it or that the quality is not good enough. If we want changes, mostly the employees from the supplier on site understand it, but they sometimes have to get permissions by the company and this process again has to pass different layers. This can delay the start-up, but not very severely.</td>
<td>Not really, but I rather see that suppliers are more client orientated. This means that they design and build the machine more from an operator or maintenance perspective. Also the intelligent in machines is really lacking. The machines do not build up historical data to see how the performance was over the last few months. This could make maintenance for instance much easier, cause one get focus on the weak points and sees areas where a lot of failures occur.</td>
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<tr>
<td>Not really during the start-up. But the vision of the supplier is to build a machine against the lowest costs. Then one can see solutions that are easy during fabrication, which decreases their costs, but these solutions can be extra expensive looking at maintenance costs (for Heineken). Example; engines that are not easy accessible and take half an hour to check them. They don’t use the strategy to use more expensive materials and that make the life cycle costs less, which is far more important that production costs for Heineken. Purchase prize should be subordinated, but top managers often don’t see it this way, because they life now.</td>
<td>Yes but in the design phase, with pressure specifications for instance.</td>
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<td>Political games; The bandwidth in which machines operate is sometimes set very sensitive. The means that for instance machines stop when the process or material deviates a little bit from what the machines defines as good. This ensures a lot of short stops, some machines have to be adjusted to a wider bandwidth so that they do not stop for every little deviation, the problem then is that Heineken is losing the warranty over the machines. To make EEM really successful, the relation with supplier has to change from pure client-contractor to a more partnership relation. There must be a mutual understanding in the desired equipment need and the LOI adjustment during start-up have to be finished in a partnership relation, political games between client and contractor seem to damage EEM success.</td>
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<tr>
<td>Difference of goals and expectation among project parties</td>
<td>Yes. Production has a real deadline looking at the market. Project also considers this deadline, but is really interested in the overall quality of the production line. In previous start-up did the project get more attention, in LE0 was a real emphasis on production. Different goals delay the project because of more negotiation.</td>
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<tr>
<td>Uncertainty who has authority to make decisions</td>
<td>No.</td>
</tr>
<tr>
<td>Different perceptions on problems and solutions by involved parties</td>
<td>something that goes wrong and they act themselves and don’t realize that this can harm the project budget for instance. You cannot monitor everything. This does not hamper production, sometimes only my satisfaction.</td>
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<tr>
<td>Yes there were often different thoughts on problems and solutions, but it is hard to say if this really influenced the start-up. To see if this influenced the process one has to go back to see if there was wrong management decisions.</td>
<td>In particular with quality. Quality has a totally different view on how things should go during the start-up. Quality mostly sees one solution and not a wider range of solutions. This has minor influence on the production. Sometime the line had to stop because some quality checks had to be done. The planning for these activities can be way better. The responsibilities have to be clear.</td>
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<tr>
<td>Yes there were different perceptions on problems and solutions. An example is the dosage of chemical in the bottle washer. The quality pillars thought that an external firm would arrange this and proceed with arranging this. This is logical because under pressure people start with certain procedures, the question is if this is always the right procedure. Things that were arranged had to be reversed.</td>
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<tr>
<td>There were sometimes different perceptions on how to solve things. This does not really influence the start-up, but is does influence the optimization of the process. I have the opinion that one should not run fillers at high speed when all the problems that one has on lower speed are not solved.</td>
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<tr>
<td>If problems are stated by operators and discussed without operators being present in the morning meetings, management can interpret problems differently. Management neglects sometimes problems because they don’t seem important, for instance the HDI of the filler. Also some problems are very irritating or frustrating for operators, which could really demotivate them, while management finds these problems less important and gives less priority.</td>
<td>-</td>
</tr>
<tr>
<td>Sometimes the basic logic in the system was not good. These are really things that have to be captured</td>
<td>More in house expertise on the right places so abnormalities can be discovered</td>
</tr>
<tr>
<td>Other</td>
<td>Managing a good project and make sure everything is delivered on time, both machines and documentation is</td>
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</table>
in EEM. Example there are two toplayer and if one goes into failure the pallitizer stops. (Again interface requirements) more discussion the processes in advance. quicker.

not seen in advance (during manufacturing inspections) like fences around machine has to be monitored quite well. Supplier doesn’t think about usability for operators and if one does not monitor this closely the result can be very disappointing. Lot of last minute decisions from the supplier’s site. EEM management also covers additional things like fences and stairs. We saw 3D drawings of some machines, but KHS has the software to guide us through the line in 3D, this did not happen and could also be an eye opener.

future.

something that can be arranged without EEM through project management. This was very well arranged in LE0 especially if one looks back on past projects. LE0 made use improvements. But if one looks at the learning’s that were translated in LE0 a lot of improvements can be made. Budget cannot be leading because then too often (also by Heineken) the choice goes out to standard machines. The benefits of EEM on the long term can be immense, but management often does not see this. To what extend does Heineken really want EEM and to what extend is it seen as a burden (by top management)

Suppliers don’t know EEM and build in standard, because it is easier to buy and produce.

The purchase departments really steers on suppliers standards, because one can bargain a lot and not discuss own EEM requirements. We have to bargain with global on their standards and
state our experience and make the standards better (with good arguments; LCC). There is not enough ‘keten denken’ purchase want something completely different. Targets are not met if expensive production lines are bought that are way cheaper on the long run (missed opportunity for Heineken!)
### II. Outcomes Interviews & Observations AM

**Table 13 Outcomes interviews and observations AM**

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Factor</th>
<th>Observations</th>
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</thead>
<tbody>
<tr>
<td>Wesselink; PCO operator (part of the startup team) (11-04-13)</td>
<td>Low Level of 5s</td>
<td>Has influence because it cannot be seen separated from AM. More 5s must be arranged in advance, it also require close cooperation from operators. Because 5s makes AM easier, it also creates more commitment towards AM.</td>
</tr>
<tr>
<td>Velzen; PCO operator (part of the startup team) (11-04-13)</td>
<td>Low Level of 5s</td>
<td>It is not at the level that it should be and this influences the success of AM.</td>
</tr>
<tr>
<td>Gelderen; SO operator (part of the startup team and also writer of manuals) (16-04-13)</td>
<td>Low Level of 5s</td>
<td>Yes good 5s is needed to achieve AM. There are poor signals; the optimal walking routes have to be discovered.</td>
</tr>
<tr>
<td>Kins; SO operator (part of the startup team and also writer of manuals) (19-04-13)</td>
<td>Low Level of 5s</td>
<td>It is part of AM. 5s is an important issue because it ensures a neat work place. It is part of AM so it has to be good to have AM success. There are still not enough fixed places for closets and materials, which does not contribute to our standard systems and therefore not to successful AM.</td>
</tr>
<tr>
<td>Rijsdam; SO operator (part of the startup team) (29-04-13)</td>
<td>Low Level of 5s</td>
<td>If 5s is not good it does not directly influence AM. But if 5s is really bad then AM is also not possible.</td>
</tr>
<tr>
<td>Anderson; SO operator (part of the startup team) (19-04-13)</td>
<td>Low Level of 5s</td>
<td>5s is not so bad. We know how we want things and only some visualization is missing, like predetermined locations. It has influence on AM and the commitment towards AM.</td>
</tr>
<tr>
<td>Bennis; PCO operator (part of the startup team) (29-04-13)</td>
<td>Low Level of 5s</td>
<td>5s is the basis of AM and it is also a part of AM. It is part of the circle of continuous improvement and contains working arrangements. Managing the shop floor has to become easier and AM becomes more accepted by operators. The machine can be in good AM status, but if there are no arrangements on material stocks, working arrangements, fixed places for materials and a clean environment, the machine will also deteriorate.</td>
</tr>
<tr>
<td>Ipskamp; TPM facilitator AM (7-05-13)</td>
<td>Low Level of 5s</td>
<td>There was some resistance against the fact to determine fixed locations for materials, because these could changes. I suggested to marked temporary locations with duct tape for instance. One could really see that all lot of determined locations do not change and that operators (through all their experience) pretty well know where the best locations for tools and materials are. One could really see that if the workplace is more in order there is also more commitment towards AM. If cleaning materials are well within reach there are...</td>
</tr>
<tr>
<td>Low Knowledge level of operators</td>
<td>It is quite high. Of course one has very high skilled and very low skilled, but the average is good. I think that there are enough operators per shift that are skilled in AM. The higher skilled get more AM roles than the less skilled.</td>
<td>Is not sufficient. If one really wants LE0 to start off in AM step 3, the operators have to have more AM skills. The idea to start off in step 3 is not good. You first have to explicitly do step 1 and check or audit this. Then step 2 etc.; people forget the basics of AM if the line has to start in step 3. One constantly has to coach operators in AM; this coaching is currently done insufficient. Basic computer knowledge is sometimes also lacking, which hampers AM.</td>
</tr>
<tr>
<td>Waiting for support to do repairs</td>
<td>Yes a lot of things are being blamed on KHS. Some operators are waiting for other to do things. Not really the support but just the skilled operators.</td>
<td>Yes some don’t pick up the system and push a lot of things to the supplier; this really hampers the AM process.</td>
</tr>
</tbody>
</table>

| more used then when they are not within reach or operators have to more afford.
| Lack of moral | There was not enough ownership and commitment. So enough moral especially from the startup team. | Yes this has influence because ownership means having knowledge. | Is sufficient. This is reinforced by WPO. | Not everyone has enough feeling of ownership. One have this or not and the people who do not have it need extra coaching from team leaders. Some people act on their own and others do as they are told, the difference is hard to see from the outside. | There is enough ownership and commitment. If I am busy with a machine I do this with 100% commitment. | There was enough commitment and ownership. There is more commitment and ownership if one has more knowledge. | - | This is enough in LE0. This cannot be the problem. | - |
| Amount of implementation (too much) | Yes it was too much at ones. People forget the basic AM things like step 1 or 3. AM only works if the keep repeating the basics. So A new line should start in AM step 1. | Yes dealing with AM implementation next to startup operations is tough. The additional work that is required looking at a line that is already in step 3 is much. | It was too much at ones. I have the opinion that you cannot quickly pass step 1 and 2. You really have to go into depth in these steps in a new line. If you everything at ones the risk arises that you do some things only for 20%. One can maybe do the step quick, but you should not do them interchangeable. You should audit the step individually, but now one does the audit and the steps are all done a bit. | What is too much? I think that starting up in AM step 3 (after 7 weeks of production) is crazy fast. It is better to do things right instead of doing everything together with the risk of doings things not thorough enough. It was not only AM that was too much at one, but everything seems important during a startup; production, quality, AM. It would be better the set certain priorities. | If it is really too much I don’t know. We are executing AM long enough. The AM things do not change in a new line, the tasks are a little different but the system does not change. | Yes it is too much. We are still busy with a lot of other things and we are still in a learning process. Start with AM step 1 is better. | - | Cannot answer this question | AM step 1 and 2 are being underestimated. One easily thinks that new machines do not require AM step 1 and 2. But step 1 and 2 are the basis. Maybe first do step 1 then 2 and then 3 would be better, but steps are always intertwined. | - |
| Lack of Training | Yes there should have been some basic AM trainings. | Maybe not training, but you have to keep repeating the AM basics. If you now perform a measure | There was lack of training. The core and purpose of AM should be repeated frequently. Some operators started | No. WPO should be enough, but you have to repeat the basic of the WPO roles (AM roles) that operators | An AM training could not hurt when starting up a new line. There are always things | Maybe a small refresher, but no more than that. WPO should be enough. | - | No I do think there needs to be AM training on top of the other trainings because one another | - |
to see the AM step 3 level of operators, I think 50% will fail. Few people really pull AM. The skilled core will again really implement AM.

with AM in 2006 and the basic AM knowledge sunk a lot. have. that one forgets and one goes to an AM trainings things become clear again.

Few people really pull AM. The skilled core will again really implement AM.

have. that one forgets and one goes to an AM trainings things become clear again.

Lack of Communication

Communication was bad. And if you ask one about his AM role most of the time people cannot explain what his role really means. This also hampers efficient communication about current AM affairs.

This is lacking. Especially the communication between the wet and dry part is bad. Influences AM. There have to be a central person who guide and steer this communication. I think that management is responsible for this.

This was good. I never had a problem with this. I have to say there are a lot of operators who are willing to push and receive information, but there are also operators that only receive information and are not willing to push information. In general it is good and the critical things get communicated, but if one really focuses on individuals, the information communication is sometimes lacking.

In the real beginning a lot of things past each other, but things are starting to run now. Communication play important role in AM everybody has to know what is going on.

In the real beginning a lot of things past each other, but things are starting to run now. Communication play important role in AM everybody has to know what is going on.

- Hard in the seven shift program and no early involvement in WPO. One has to start as soon as possible with TPM structures in startups; support has a role in this.

- Hard in the seven shift program and no early involvement in WPO. One has to start as soon as possible with TPM structures in startups; support has a role in this.

Yes this was lacking and seems vital to get everybody on the right AM level. There is also an important factors which I observed and that is that people tend to forget to communicate things because the large amount of things that have to be implemented.

Amount of new technologies

No AM does not change by this

Yes and this is not only technique in machines, but also other tools w use like monitoring the machine performances. The way operators have to process information

No the basic technology does not change very much and if it does one has to rely on old AM knowledge and apply it to the new machine, this can be a problem. It does influence AM because the cleaning approach to machines is different and one has to learn this. This is also a learning experience.

The AM system stays the same, it is only a new learning process. Therefore new technologies might have influence on the implementation

Should not affect the AM process. AM stays the same, it only has to be executed in a new environment.

Of course the CILT changes and also the

Should not change AM.
Large workload

| Large workload | Yes. Operations take all your time. This has to with the new technologies and understanding operations. | It now really hampers the AM process, but it is all additional work. Time is too short to really start off in AM step 3. | You only have 8 hours a day and the occupation of operators is declining. More and more is expected from operators the preparations for the WPO take quite some afford if one wants to do this right. If you are with more people you once in a while could find some time to do administrative things, but this is not possible anymore. What one now can see is that operators are coming earlier to work to do these things. | Running the line with this amount of operator’s makes it hard to put everything in order concerning AM. | In a startup one has little time to perform other tasks except operating and getting to know the machines. Especially with the operator occupation that we now have the workload is pretty high. Time to really prepare for the WPO is too little. My role is safety and I don’t have a lot of time to really perform my role well. | Especially in a new line. Too busy with the startup process; getting to know the machines. | Yes look at focus on production | Yes look at focus on production | Yes of course. | This also created annoyance and unpleasant working environment. There were no clear goals and it seemed that everything had to be fixed (AM production etc.), this really created a huge workload and sometimes operators even took their job home (mentally) |

| Large workload | Yes. Operations take all your time. This has to with the new technologies and understanding operations. | It now really hampers the AM process, but it is all additional work. Time is too short to really start off in AM step 3. | You only have 8 hours a day and the occupation of operators is declining. More and more is expected from operators the preparations for the WPO take quite some afford if one wants to do this right. If you are with more people you once in a while could find some time to do administrative things, but this is not possible anymore. What one now can see is that operators are coming earlier to work to do these things. | Running the line with this amount of operator’s makes it hard to put everything in order concerning AM. | In a startup one has little time to perform other tasks except operating and getting to know the machines. Especially with the operator occupation that we now have the workload is pretty high. Time to really prepare for the WPO is too little. My role is safety and I don’t have a lot of time to really perform my role well. | Especially in a new line. Too busy with the startup process; getting to know the machines. | Yes look at focus on production | Yes look at focus on production | Yes of course. | This also created annoyance and unpleasant working environment. There were no clear goals and it seemed that everything had to be fixed (AM production etc.), this really created a huge workload and sometimes operators even took their job home (mentally) |

Too much Focus on productio

| Too much Focus on production | Yes but it has to do with new technologies, workload and focus on production. | Yes. A lot of operators find AM more important than production, because they think that this is the vision of Heineken. The older operators think more in amount of crates leaving the line. In my opinion this is the right vision, but AM could support this by making shop floor work easier. Unfortunately this is not seen by many operators. Team leaders are | Everybody gives his own priorities, but I think that production has the highest priority and not AM. | Yes look at the workload. | Not purely production but getting to know the machine. If do not really feel pressure from production, this is more for the team leaders. | Yes and this is a barrier for AM implementation, management has to be more clear on how much time we have for AM things. They must set target for production and give us slack for AM related things. If you ask an operator, production always has priority over AM, so management must | Look at workload | Yes clearly present. One could also see if (operational) management is focusing very much on production that operators could always use this as an excuse to not perform AM related things. | Yes clearly present. One could also see if (operational) management is focusing very much on production that operators could always use this as an excuse to not perform AM related things. | Yes clearly present. One could also see if (operational) management is focusing very much on production that operators could always use this as an excuse to not perform AM related things. | Yes clearly present. One could also see if (operational) management is focusing very much on production that operators could always use this as an excuse to not perform AM related things.
It is not really resistance, people see that AM has its advantage. Having everything in your own hand is its advantage.

There is not really resistance, people do not really following the right AM route and take shortcuts. This is not the idea of AM. One has to eliminate contamination as much as possible and thereby reduce the cleaning time. If one really cannot solve the contamination things will end up in a cleaning list. Therefore again step 1 and 2 of AM are very important and if one wants to be in step 3 immediately, step 1 and 2 sometimes get too little attention. It is not resistance but more ignorance and one has to reinvigorate the process again.

It is a method for which we have been working for years now and there are good things about it and less good thing about it. I don’t think there is a real resistance against it.

This can be present but that is one reason why we have team leaders. This process won’t start itself. It has to be initiated by management. AM is still seen as something on top of operational activities and this has to change. AM is your work and it helps you to make your work easier and have a higher efficiency rate.

Yes operations go first.

Like I said, it is too often seen as something on top of normal activities.

Yes operators could not understand the pressure on a quick implementation of AM if operational processes were not understood properly. This was sometimes that
| **Lack of (Management) support** | **Management really failed in this. They were too busy with other things. Some people just have to be guided. The must be the leaders when it comes to AM and make themselves and us more dedicated to AM in the startup. There was not enough sense of urgency from their side.** | **Most AM analyses were not properly done and management had to steer this into better directions.** | **Yes this is always needed and especially when AM has to be implemented all over again.** | **There had to be better support for AM from the TPM office and operational management. There was support for quality, safety, production, but maybe not enough for AM. There were audits (done by TPM office) and there were some lessons, but there was not really close guidance. More proactive AM support could be useful. It was considered too easy that the AM knowledge was sufficient.** | **Yes management really has to support the process especially in the beginning.** | **Most of the things we can do on our own, because we also have a lot of knowledge. The stronger operators pull the rest. Maybe management support would be nice, but not crucial.** | **Yes this is needed.** | **I said it before there is an important role for management in this process. The situation will always stay the same looking at operators, one is stronger as the other and this has to be managed. If we choose for the AM system as we have it now, with WPO, management plays an important role and without management the whole systems does not work. When starting up a new line there is a very important role for management.** | **Yes everything has to be steered in the right direction and targets have to be set.** |

| **Other** | **Forgetting step 1 and 2. Implemented AM with a small group of people that really know the drill. Some operators are just not AM educated enough. Later on lower educated operators can get their AM role, because it is not more than keeping lists etc.** | **Getting everybody on track. Check off a cleaning list is not the problem, but explaining what one really did is something else. AM step 1 and 2 can be really tough for people, give more focus to this and give better support.** | **I keep saying that immediately going to step 3 is not the right way. Step by step implementation is to way to go. AM step one for instance could already start when KHS was installing the line. More involvement of operators is needed in these phases. If one buy and installs a new window, the window is new, but one still has to clean it, because the installation made it dirty. One can start mapping hard.** | **The process was too messy, there must be better goals regarding AM. What was really expected was not clear enough. The AM audits that were done were not communicated etc.** | **Quicker start with 5s and more guidance in the whole AM route.** | **Implementing AM things proper takes a longer time then just a month. Cleanings list have to evolve from long term operations, it is not something you make quickly. Cleanings times will change the methods can maybe change, etc.** | **Management must be clearer on what they expect from us looking at AM. Make a clear vision on production and AM and guide operators better.** | **Tight team has huge influence to the success of quick AM implementation. Operators know each other and know the competences of each other. If one first has to get to know each other AM is already one step behind.** | **-** |
accessible places for instance in the beginning, also machines were way easier accessible. Start earlier with AM! If one sees things that are not logic adjustments can be made.
### III. Outcomes Interviews & Observations T&E

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Velzen; PCO operator (part of the start-up team) (11-04-13)</th>
<th>Wesselink; PCO operator (part of the start-up team) (11-04-13)</th>
<th>Gelderen; SO operator (part of the start-up team and also writer of manuals) (16-04-13)</th>
<th>Kins; SO operator (part of the start-up team and also writer of manuals) (17-04-13)</th>
<th>Rijsdam; SO operator (part of the start-up team) (19-04-13)</th>
<th>Anderson; SO operator (part of the start-up team) (19-04-13)</th>
<th>Bennis; PCO operator (part of the start-up team) (29-04-13)</th>
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<tbody>
<tr>
<td>Proper selection of workers</td>
<td>This was done of course and there was no other option looking at the occupation of rayon 1. We really learned a lot and also learned others, but I’m not sure that this influence the success of T&amp;E.</td>
<td>There was no other option, but I’m not sure if this contributed to the success, I guess so. Still one has to teach other we operate LE0 with 30 operators and in the start-up team only 13 are present.</td>
<td>Looking at budget and time this was the way to do it. We (start-up team) are capable of teaching others, so this is the way to do it.</td>
<td>This made the trainings successful. One don’t want to put less skilled operators into trainings, this would not work. Giving everybody training is not an option and simply won’t work.</td>
<td>For me the trainings were sometimes hard (German and English) I can imagine that for even less skilled operators the trainings are too difficult.</td>
<td>Others would not appreciate the theoretical trainings and they are not capable of teaching other, so this was good and contributed to success.</td>
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<tr>
<td>Machine trainings</td>
<td>Theoretical: filler, pasteurizer, labeler, bottle washer. Almost no practical training, which is bad.</td>
<td>Theoretical filler, Pasteur, Labeler, bottle washer Practical: packer, unpacker, bottle washer</td>
<td>Theoretical; filler pasteurizer. Practical bottle washer, crate buffer, palletizer, depalletizer.</td>
<td>All; both theoretical and practical.</td>
<td>Theoretical: pallitizer, depallitizer, crate storage, packer and unpacker. Practical: pallitizer, depallitizer, crate storage, packer, unpacker, bottle washer, pasteurizer and filler.</td>
<td>Theoretical: filler pasteurizer, bottle washer, toplayer, packer unpacker. Practical: filler, pasteurizer, bottle washer, toplayer, packer.</td>
<td>All, but I had the shorter versions of the operator training, because I also had mechanical trainings.</td>
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<tr>
<td>Opinion theoretical</td>
<td>Not useful. Because there was no related</td>
<td>Useful, but could have more depth. Would have made a</td>
<td>Not very useful, but this was merely because I am the</td>
<td>There was a real difference between trainers and their</td>
<td>Very difficult because it was in English or</td>
<td>Good. Sometimes you forget things</td>
<td>Good, instructive and nice. The trainers were very good and</td>
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<td>Observations</td>
<td>A proper selection showed Advantages and disadvantages. The advantage was that skilled operators were learning a lot in a short time period, but this meant that the knowledge gap between skilled and less skilled became very big. It is not easy for operators to teach other all this knowledge. Apart from this did some operators felt a little discriminated by the solution of selecting only the high skilled for the T&amp;E program and the early start-up.</td>
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<td>Timeframe</td>
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<td>trainings</td>
<td>Theoretical trainings were given when the machines were not ready. No positive points. Trainer for the bottle washer was not aware that the labels (that have to be washed off) are from plastic.</td>
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<td>difference if there were no theoretical training.</td>
<td>The writer for the manuals and already saw a lot of documentation. Educational quality. The study material was very good. I found the theoretical trainings useful.</td>
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<td>educational quality.</td>
<td>German and I don’t master these languages. I understand some things, but not much. Some things I asked others who speak better English as I do. Overall I was not so amused by the theoretical trainings.</td>
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<td>Opinion practical trainings</td>
<td>The solution is a headset. The practical training for the filler was useful, but we really had to ask the things that were interesting for us, like: how to start up, how to empty the machine and how to clean the machine. KHS was really focused in how to use the touch screens. The really practical things were forgotten, but we asked for it. For the pasteurizer not really because this is an unmanned machine. The practical trainings on the dry part were completely useless because when we had practical training the machines were not working yet. The machines that did work were not working well. The practical trainings were a little chaotic and the wet part was far better than the dry part. In the dry part a lot of machines were not running and then the practical trainings is quite useless. Of course the software interface is being discussed, but we could not see the machines work. One could now see that there is a lack of practical knowledge on certain machines in the dry part.</td>
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<td>Motivation during training</td>
<td>No not really. They give some practical examples which is nice and Operators were motivated. Trainers try to tell everything as nice as possible, again example with the it was not boring, it was brought it interesting. It was not tedious. Things that were not interesting for us. Motivation was that it was very interesting; at least if one has interest in his job. In the start- Again because the language barrier there was little motivation for me. No not specifically.</td>
<td>Because you’re not directly try it on the machines. But a lot of stuff was useful. If you really start with the machines a lot of things from the theoretical trainings pop up. They performed well. We had theoretical trainings before and often they were very somnolent. There was time for jokes, lifetime experiences and it was very alternately, which was nice.</td>
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<td>Practical trainings were good, but the group must be smaller. If you are with a group of six, four people are not paying attention. There cannot hear it or see it. Operators are not asking: ‘sorry what were you saying’ they wander off because they cannot follow it. Solution is headset.</td>
<td>90% of learning is doing, but one needs the theoretical training to execute the practical training. Good was that one could learn by playing with the machines. Lot of operators now are afraid of really using the machines, because they don’t know what is going to happen. If one has more practical training this fear would be less. They just have to try, there is hardly anything that you can do wrong (very buffer proof). Language was sometimes a problem; sometimes you miss the real finesse. The practical training was very good. I found the theoretical trainings useful. More or less the same story, the language was a barrier. The noise together with the language problem, made it very difficult for me. Also the groups were too big, we were with 7 to 8 operators on 1 square meter. These were good.</td>
<td>Basically good, but the disadvantage was that the groups were too big. This means that some cannot hear or see what is happening. One often has to push buttons and everybody wants to push the button, so large groups are not ok. One could see that always the same operators are standing in front.</td>
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<td>Motivation during start-up</td>
<td>Yes. Every time you want to make that extra step and not fall behind. Experience everything. I missed one week because of my holiday and really missed a lot of knowledge. In one week a lot of things happen during a start-up.</td>
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<td>Work specialization (one or multiple machines)</td>
<td>Worked on multiple machines. But that really depend on the person.</td>
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<td>Operator experience with machines</td>
<td>The relation between operator and trainer became more reciprocal this was and that really motivated. Also the personal twist by really getting to know each other and the trainer (personally) created a good learning ambiance.</td>
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<td>Tacit knowledge</td>
<td>During a start-up one does a lot of things</td>
<td>When one does something the next things calls, this is typical for a start-up</td>
<td>We did a lot of things</td>
<td>No</td>
<td>Multiple things, sometimes too much, look at all the long days</td>
<td>We did a lot, to many things to remember</td>
<td>not interviewed.</td>
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<td>Support KHS</td>
<td>Ok. They were not always available. They trainers who one can appeal very easy left after training and it could be very useful if they stayed a little longer.</td>
<td>Was good, you can ask everything. They are not somewhere in the back but they are really approachable. If they detect a failure themselves to go and fix it.</td>
<td>There were always enough KHS people and they were always willing to help. Now only programmers are present, but they are also very willing to help. Of course one German guy is nicer than the other, but in general the relation was pleasant.</td>
<td>The people that were responsible for the training were very pleasant. The relation on the line with KHS is also depending on operators, some asks KHS everything and learn a lot, while other are really shy and remain a large knowledge gap.</td>
<td>If you ask them something they are willing to answer, but the relation was not good, ‘good morning’ was too much.</td>
<td>If you ask them something they were always willing to help. They don’t talk a lot, but the overall relation was good.</td>
<td>This was good, but it could be better the first weeks. When I introduced myself as being technical operators they were far more open and also wanted to learn from me. They involved me way more in optimizing and solving problems on the machines. Sometimes if they were really focused they didn’t have time, but this is logic.</td>
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<td>Allow workers to redesign their task</td>
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<td>Very few jobs at a time</td>
<td>During a start-up one does a lot of things</td>
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<td>When one does something the next things calls, this is typical for a start-up</td>
<td>We did a lot of things</td>
<td>No</td>
<td>Multiple things, sometimes too much, look at all the long days</td>
<td>We did a lot, to many things to remember</td>
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<tr>
<td>Tools or equipment that support performance</td>
<td>This is needed, especially for some people, but these were often lacking. Examples are machine manuals.</td>
<td>There were some vital documents missing and I made quite lot instructions during the start-up. These are needed for operators else some don’t know what to do in certain situations.</td>
<td>One learn more by doing, not by using tools</td>
<td>Tools are essential to learn, especially when KHS is not available.</td>
<td>Tool are needed and they must be quick and easy accessible.</td>
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<tr>
<td>Tacit knowledge</td>
<td>Yes really. And operators that need training and education most were attached far too late. The strategy of teaching the best and let them</td>
<td>Still there is sometimes crucial knowledge for one operator, the bottle washer for instance. Also with the filler there are two persons who really know a lot. I am really specialized in the labeler.</td>
<td>On can now see (in the seven shift program) that there are really strong teams and more weak teams. The educated start-up team is not equally divided over all the teams. This means that sometimes</td>
<td>Yes especially the bottle washer. We now solve this by making a lot of standard operating procedures and one point lessons, but only one person really knows the ins and outsides of this</td>
<td>Not really, I think the knowledge is quite well spread. On the other hand there are two guys from the start-up team that really know everything.</td>
<td>Especially in the beginning. This process goes automatically. If the machines really start to run people automatically move to a machine and get</td>
<td>Yes one could really see this in the separation of dry and wet. In the wet area the borders of tacit knowledge become vague and also in the dry part, but if one compares the dry and the wet part there is</td>
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</tbody>
</table>

D.J.W. QUERIDO

TU Delft

Delft University of Technology
<table>
<thead>
<tr>
<th>Distribution of Tacit Knowledge</th>
<th>Mutual Knowledge Sharing (also with Operators Outside the Start-up Team)</th>
<th>Shift Scaling</th>
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<tbody>
<tr>
<td><strong>128</strong> D.J.W. QUERIDO distribute it does not really work. Because of tacit knowledge are taking things for granted (by skilled operators) the strategy does not really work.</td>
<td><strong>Moderate.</strong> Some operators hesitate to ask things. They are afraid to ask the same things multiple times. There is a real gap between operators.</td>
<td>From 1 to 2 and 3 was not really a problem. But to the 7 shift program rally makes a difference. In the 7 shift program you end up in new teams and work together with different people.</td>
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<td>the knowledge really has to come from one person and this is hard for the team, but also for the one having all the knowledge. On weekdays LE0 and line 12 run together so you can share a lot of knowledge together with the occupation of LE0 and the 12. During the weeks the team that operates LE0 is on its own and that can be tough.</td>
<td><strong>You must share knowledge. But it depends really on the type of operator how well the knowledge sharing is. Some are really reluctant, sometimes also the skilled operators from the start-up team. But mostly the operators from outside the start-up team can be reluctant in asking information.</strong></td>
<td>1 to 2 to 3 was not the problem, in this system one knows what to expect from each other. But when scaling up to a seven shift program this changed. Then you work with operators you don’t know and then you really have to get a sense of what somebody is capable of.</td>
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<td>Machine.</td>
<td><strong>The knowledge sharing was good, but again one can see a difference between dry and wet. This was again caused by the fact that the wet part was running better (after the problems with the labeler).</strong></td>
<td>Scaling from 1 to 2 to 3 went very smoothly. How things will turn out with the 7-shift program is uncertain. When we had the 3-shift program in every shift there were enough well educated operators to pull the rest.</td>
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<td>Specialized in this machine. The knowledge occupation over the machines is sufficient.</td>
<td><strong>Things I know I share with others. I think this process went pretty smooth, but still it has to come from two sides.</strong></td>
<td><strong>KHS is told me they recognized a very large knowledge differences when the shifts scaled up.</strong></td>
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<td>Still a lot of tacit knowledge and there are only a few knowing a lot about both areas.</td>
<td><strong>Not good. You’re in a learning route yourself and at the same time you have to teach others, this is difficult. On top of this other operators have to show their good will and ask things, this also does not happen enough. Self-initiative was not sufficient.</strong></td>
<td>Knowledge differences will always be present. Scaling up the teams will have influence on the production, but I think the influence is minimal. This minimal influence is</td>
</tr>
<tr>
<td>Specialist for the bottle washer.</td>
<td><strong>I like to teach others and I involve others, but after having said it three times one has to do it on his own. If somebody still is refusing things or does not come to me then I stop. Knowledge sharing comes from two sides especially during a start-up.</strong></td>
<td>Only when we went to the 7 shift program, there were some knowledge differences between the shifts.</td>
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<td><strong>I cannot really answer this question. But I know that the knowledge distribution in the 7 shifts is not equally divided.</strong></td>
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</table>
You are no not always with the same people. What one can expect from each other is really uncertain and brings extra difficulties. Production and OEE could be way higher if the team were more of the same strength.

| Learned most from | Practical trainings and lot of sparring with colleagues on the shop floor. And mutual conversations with the support KHS is giving. | I learned most from the things that not went well. Scaling up to seven shifts was not worked out well. The knowledge diffusion that we had envisioned was not going as it supposed to go, because some team had more educated operators in them as other teams. The seven shifts were not planned in advance. | During practical trainings and test runs. In the test runs especially, a lot of things go wrong, this are the moments when you learn most. Together with KHS you fix problems, this are the real learning moments. Remark is that the collaboration between operators and KHS on the wet part was far better than on the dry part. On the dry part KHS people were far busier troubleshooting, sometimes at the expense of having eye for operators. | Failures, because one has to fix them. In first instance one fixes problems in cooperation with the supplier and after a while you try it yourself. The palletizer was mostly operated by KHS in the beginning because this machine required extra attention. We were not very involved in this process because KHS was constantly optimizing this process with laptops etc. We didn’t want to interfere a lot and build a real knowledge gap on this machine. A lot of palletizer failures cannot be fixed by us. | By doing. Observing a lot how machines experts from the supplier do things. This was my first start-up and I noticed that if one observes from the very first start one learns a lot. | Lot of practical doing. Sparring with KHS. I asked a lot of questions to KHS. |
What if support leaves

You really are going to miss it. Because there still is a large competence gap, which we create ourselves.

Know they are really needed; it is very unsure what will happen if they will leave. I think we will need them for quite a while, especially on the dry part. Now there are still things that do not work proper, you need KHS for those things. A lot of processes still have to be optimized. If all the machines work the way they were designed to then KHS can leave, Heineken can also do the real fine-tuning.

The support from KHS will stay for a long time. The mechanics from KHS already left. I don’t know what will happen, but you need them till the SAT.

If the support leaves, some teams will not be able to run. If KHS will leave after a few weeks we are able to run I think, but some teams will perform better than others.

If the support leaves right now we have a problem. The knowledge level of the operators is not at it desired level. Also the technical engineers do not have enough knowledge.

There will be a lot of trouble. I think that a lot of big problems will come to the surface along the way. Similar problems like with the labelers or the bottle washer will return.

I think we will manage, but some things will take a long time to fix.

Other important things.

Do not mix people from line 12 and the new line. Really old people that will only work one more year for Heineken have to stay in their old habits; do not engage them in the new line. The occupation has to be calculated way earlier. And six operators including one temporary operator is too less to really control LE0.

Overview over the whole line! What is happening where and when in the process. I think this can be managed better. More mutual contact about current affairs. Sometimes the dry part is really busy and there are only 2 operators, while there are 4 on the wet part looking at the filler, the communication has to be better (EEM start-up). Wet-dry communication can be better. But also what management decides with KHS in the morning meetings. Only in the beginning there were operators present in the morning meetings, this was meant to stay, but it did not.

Make sure in all the teams (shifts) is enough knowledge. Not everybody has to know everything, but you need one high skilled operator on the dry part and one on the wet part in every shift. This went well until we went to the 7-shift program. It is hard to see if knowledge influences the production because if the line runs well there is not much knowledge required. You need knowledge when things go wrong.

We started with educating even before the floor was constructed and this was a real plus.

Language. Also some training were supposed to take 3 day and were reduced to 1 day because of time problems, this is really sin. There was a lot of knowledge thrown away because of this.

The KHS trainings were really good, next time do it again like this.

The early start the strategy of the start-up team was good, but later on there had to be more rotation and more involvement of operators from outside the start-up team. (before scaling up the shifts)

KHS could not see by our uniforms which gradations one has. For instance I’m a technical operators and have more knowledge about technique then other operators. Often KHS needs someone like me. They found it really annoying not to know what kind of skills different operators have. We had a face book with all the KHS people and expertise, but they did not have ours expertise’s and faces.
IV. Results AM audits wet area LE0

7 weeks after start-up
Table 15 Outcomes first AM audit LE0

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Most striking things that can be pointed here are the following:

- WPO does not work proper. The line is not fully adopted in the ‘werk plek organiatie’ which means that the border between LE0 being a project and LE0 fully integrated in AM is too vague. Problems are easy pushed to the supplier and the communication to all operators what their (AM) responsibilities are lacking.
- AM step 3 is better implemented as step 1 and 2. Operators are forgetting the basis and jump to conclusions (standards like CILT)

11 weeks after start-up
Table 16 Outcomes second AM audit LE0

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Most striking things that can be pointed here are the following:

- WPO works better and operators took decisions by determining what is in their responsibility (AM) and what is not. A lot more problems were tacked via AM routes.
- One went back to the basics and AM step 1 and 2 were more thoroughly passed. This needed close support and guidance from management.