Sustaining Lean Improvements

MASTER THESIS

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by

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Under lieu of oath

This master thesis was written solely by me and no other than the named sources have been used.

Worcester, December 2009 Christopher Schlichting

Preface

This master thesis was composed in the time between June and December 2009 at the Worcester Polytechnic Institute in Massachusetts in cooperation with a production plant of the MAHLE GmbH in Trumbull, Connecticut. It constitutes the completion of my master degree in manufacturing engineering.

At this point, I would like to thank all the employees at the Trumbull plant for the support and encouragement, which enabled me to add valuable practical insights to the theory of this thesis. My special thanks are directed at my advisor, Prof. Yiming Rong, for continuously questioning my ideas and thereby initiating new thoughts. Furthermore, I would like to thank Ed Jones and Pedro Fernandes at MAHLE for the chance to experiment with Lean ideas and the many informative discussions throughout the duration of the thesis. I'm also thankful to Prof. Richard Sisson, Prof. Christopher Brown and Walter Towner for volunteering to be on the advisory committee during the thesis defense.

Finally, I would like to thank my parents and my girlfriend for supporting all my decisions throughout the master degree.

Worcester, December 2009 Christopher Schlichting

Contents

Definitions

ABC	-	Activity-based cost accounting
Bottleneck	-	Production cell that is slower than the rest of the process
CMM	-	Coordinate-measuring machine
CNC	-	Computer numerical controlled
ERP	-	Enterprise resource planning (system)
FIFO	-	First In First Out
GM	-	General Motors
GPK	-	Grenzplankostenrechnung (German)
JIT	-	Just in Time
Lead-Time	-	time between initiation and completion of a process
Lean champion	-	individual at an organization, who promotes Lean changes
OP	-	Operation (as in OP10 or OP20)
PDCA	-	Plan Do Check Act
PM or TPM	-	Total Productive Maintenance
QC	-	Quality check
RCA	-	Resource consumption accounting
ROI	-	Return on Investment
TAKT	-	German for meter or pulse
TPS	-	Toyota Production System
TWI	-	Teaching Within Industries
WIP	-	Work in progress
5S	-	Toyota's standardized cleaning

Abstract

Starting in the 1980s with the first Toyota controlled production plant in the United States (NUMMI), the idea of Lean as derived from the Toyota Production System has become a popular method to improve production processes as well as any other procedure in organizations around the world. Over the last three decades a multitude of literature on Lean implementation and consulting companies offering help with the Lean transformation have emerged. The success rate of real Lean transformations however is often estimated to lie below 10% by experts such as Clifford Ransom or members of the Society of Manufacturing Engineers (SME). This leads to the question of why most companies fail to sustain the Lean improvements that most of them are able to initiate during the early implementation stages. This thesis will therefore investigate the root causes that lead to a time dependent loss of Lean improvements from three different perspectives. One standpoint is given by the TPS beliefs which are united in the House of Lean. The second angle on the topic is drawn from an online search of expert opinions and the final evaluation is taken from analyzing a real case scenario at a plant in Trumbull, CT. After this thorough analysis of possible root causes a set of countermeasures is presented that will support an organization in avoiding the major mistakes of a Lean implementation. The three countermeasures include standardization to build a base for Lean improvements, employee involvement to assure sustainability through conviction and continuous instead of rapid improvement. Every countermeasure will be described theoretically as well as with the help of examples from real life scenarios to enable the reader to apply the suggestions immediately. A final discussion will then examine the improvements that where reached at the production plant in Trumbull, CT and show how the combination of all three countermeasures ensures the sustainability of these improvements.

Keywords: Lean, Toyota Production System (TPS), House of Lean, Sustainability, Failure, Standard Work, Employee Involvement, Continuous Improvement

1 Introduction

In order to properly introduce the topic of this thesis, the following paragraphs will state the perceived problem as well as the resulting research objectives and the methodology which will be applied. The introduction will also provide information on the history of Lean and the MAHLE production plant, which provided practical examples of Lean implementation.

1.1 Problem Statement

During the last two decades, the notion of Lean has drastically changed the way organizations in the United States and around the world think about manufacturing their products or providing their services. The online book store Amazon lists over 66,000 titles on “Lean” and countless consulting firms that specialize on Lean have emerged. Still, the amount of organizations truly converted into a Lean state is estimated by experts to be less than 5% (Clifford Ransom number and SME online discussion). This disillusioning number leads to the question of why most organizations fail in sustaining the implemented Lean concepts and the resulting improvements.

1.2 Research Objectives and Methodology

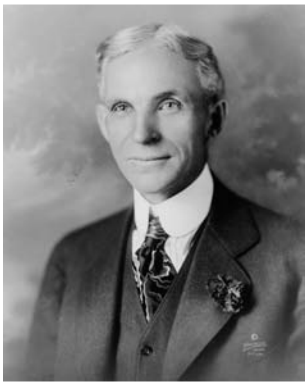
The objective of this master thesis is to analyze the main reasons that lead to Lean failures in today’s organizations. It will start by giving the necessary historical background information on Lean and the background needed to understand the practical examples taken from MAHLE, a manufacturing company in Connecticut, which will serve as an example throughout the thesis. To gain information on failure reasons, the thesis will then analyze three different sources: the Lean teachings of Toyota, the opinions of Lean experts and the real case scenario at MAHLE. The root causes identified from these sources will be matched with adequate countermeasures that help to ensure a successful and sustainable conversion to Lean. Every countermeasure will then be explained theoretically with supporting literature as well as exemplified on practical examples taken from an internship at MAHLE. Finally, the effectiveness of the proposed countermeasures will be assessed by analyzing the improvements made at MAHLE during the 2.5 months internship and a conclusion will be drawn on the issue of sustainable Lean improvements. Throughout this thesis, the focus will lie on the production environment, specifically, the Lean implementation on the shop floor. Although all Lean ideas are generally applicable to any process or procedure it is worth mentioning that the ideas and conclusions presented in this work where drawn from experiences in a manufacturing setting.

1.3 History of Lean

In order to get the right perspective of Lean, it is important to understand the history under which these ideas were formed. The next paragraphs will therefore start with some of the early ideas of mass production and end with Toyota's way of combining these ideas into their Production System.

In 1800, Eli Whitney Jr. (figure 1-1), who spent his life time in Massachusetts and Connecticut, started to promote interchangeability and by doing so revolutionized the way parts where manufactured. Up until then, a component was made to fit one product only, which involved a lot of rework. Whitney's idea to make a component fit, regardless of its future product, cleared the way for mass production as we know it today and he himself used this idea combined with his invention of the conveyor belt to produce muskets for the U.S. military. Due to the improved production methods, he was able to price his "standardized muskets" far below the competition at $13.40 per piece. Henceforth, interchangeability became the new standard in manufacturing and also influenced Henry Ford (figure 1-2) in 1913, when he started his "flow production" for the T-Model. This first case of true mass production is another mile stone in the Lean history, because it introduced the idea of flow in order to increase the throughput. Before, a car was completely built by a team of workers with no standard work procedures, which made it hard to improve on the individual process steps. The "flow production" (figure 1-3) used Whitney's idea of the conveyor belt and moved the car forward, while workers would do the exact same process step to every car that passed them by, like tightening the screws on the wheels for example. This way, Ford was able to do extensive time studies and improvement projects to increase the efficiency of every process step and by doing so, increase the throughput overall. In 1937 Toyota Industries Corporation, which was successful with its automatic looms for the textile industry, launched the Toyota Motor Corporation to start looking into the market of producing engines and cars. At this time, Toyoda Sakichi, the founder of Toyota Industries, had already developed the idea of Jidoka (built in quality) which became an important part of Lean later on.


1-1 Eli Whitney Jr.


1-2 Henry Ford

The following years were affected by the Second World War, where companies like Toyota and Ford were called on to supply war machinery in vast amounts for their government. The demand was steady and without any variability, so companies focused on improving the production speed. This was done through developing faster and more complex machines or increasing the workforce since the cost of the products was not the main concern at that time. The war therefore was the time when Training Within Industries (TWI) evolved in the United States which later on was modified and used in the TPS. After an involvement of the U.S. Army in the Second World War became inevitable, the goal was to rapidly ramp up the defense production. At this time, there were 8 million unemployed people in the United States that had never before worked in a factory or a shipyard. This meant that they had to receive training, but due to the shortage of time, this training would have to happen on the job. Since the government had a high interest in increasing the ability and the skill of the workers they supported the companies with advice on how to train employees most efficiently - this support became known as the TWI Service, whose methods are still in use today.

1-3 Ford's flow production

After the end of the Second World War the demand as mentioned earlier changed drastically. Companies like Toyota and Ford had to return to supplying to private customers who requested high variability at the lowest cost possible, two criteria that had been unimportant during the war. Toyota, who was close to bankruptcy after the war, looked towards production plants in the United States for helpful insights on how to deal with the new demand. In 1956, Eiji Toyoda, president of Toyota at that time, and Taiichi Ohno (figure 1-4), chief of production, traveled to Detroit to observe the plants of Ford and GM. Upon their return they realized that they could not use the ideas they had gathered one to one. The plants in the United States were supplying to a lot more customers than Toyota in post war Japan. In fact, only few people could afford a car, which made it difficult to gain the advantages of mass production used at Ford and GM. During the 1960s Taiichi Ohno and his colleague Shigeo Shingo therefore worked on adapting the tools and ideas they had seen in the United States to Toyota’s demand. The result became known as the Toyota Production System (TPS) which in the following years helped to turn Toyota from almost being bankrupt into a successful automobile manufacturer.

1-4 Taiichi Ohno

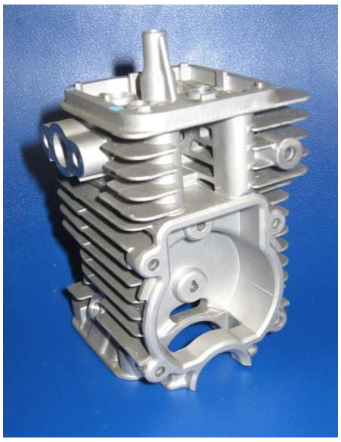
At this time other manufacturing companies of course took notice of Toyota’s success with TPS, but the common agreement was that the ideas of TPS would not work outside of Japan because of the differences in the employee’s mindset. This idea sustained until 1982, when Toyota started a joint venture plant with GM called New United Motor Manufacturing Inc. (NUMMI). It was Toyota’s first plant in the United States, which is why they had joined forces with GM to benefit from their supplier network, but the plant itself was run solely by Toyota using the TPS ideas. Soon after, it became apparent that TPS did work in the United States as well, since a plant that had been run by GM since 1962 was now winning awards and ranking among the most productive manufacturing operations in North America. Since then, the interest in TPS and “lean manufacturing”, as the ideas are often referred to since the term was coined by James P. Womack and his research team in 1990, has been growing immensely.

1.4 The MAHLE Trumbull plant

The MAHLE plant located in Trumbull, Connecticut, is one of over 80 manufacturing plants of MAHLE, Inc. The plant, run by 160 employees, has an annual output of 1,200,000 small engine cylinders which can be divided into three product lines and are used in lawn mowers, weed whackers, chainsaws and some all terrain vehicles.

One product line is the 2-stroke engine cylinder (figure 1-5), which is made from aluminum die casting and processed in three steps: machining (OP10), plating (OP20) and honing (OP30). MAHLE currently produces approximately 700,000 units of the 2-stroke engine cylinders per year with a capacity of 6 OP10 machines. In the following years they are expecting an increase in capacity which will demand increases in machining efficiency since money as well as space for new machines is not available. The second product is the 4-stroke engine cylinder, which contains valves to control the air flow, creating better emission rates but also making it a more complex product. The 4-stroke (figure 1-6) consequently needs more production steps: soft machining (OP10), plating (OP20), hard machining 1 (OP 30), honing (OP 40) and hard machining 2 (OP 50). The MAHLE plant in Trumbull currently produces between 400,000 and 450,000 of the 4-stroke family cylinders every year with a capacity of 4 OP10 machines. To keep up with this production volume, MAHLE has machines working on Saturdays and sometimes even Sundays which adds a lot of cost to the product. MAHLE Trumbull therefore currently looses $4 on every 4-stroke cylinder they sell. The product with the lowest magnitude but the highest profit is the big bore engine cylinder. Products from this family are used in All Terrain Vehicles (ATVs) and Jet skis.

1-6 2-stroke model



1-5 4-stroke model

1.4.1 Lean at MAHLE

After a change in leadership at MAHLE in Trumbull, CT, the new production manager decided to move the machinery into production cells starting February 2009, following the lean idea of reducing transportation but also to eliminate the waste of waiting, which most machine operators where bound to do while their machine was running. In the new cell design, an operator now runs 2 or 3 machines, which of course frees up manpower.

Especially for the 4-stroke production this decrease in manpower was necessary to reduce the cost and move towards the goal of regaining profitability. This workforce reduction at the beginning of the lean implementation is in line with the teachings of Womack and Jones (2003), who stated that in order to avoid demoralization by cutting jobs during the implementation, the company has to estimate how many employees it needs after all lean changes and adjust the workforce accordingly before starting the implementation. The two new OP10 cells in the 4-stroke production now incorporate two Brother CNC machining centers and one lathe and are dedicated to a certain product family within the 4-stroke. Running all three machines with just one operator was calculated to decrease the utilization of the two CNC machines to 1.5 instead of 2. This anticipated loss of 25% was accepted because the operator cost was cut by 66%. Due to the financial crisis, the demand had also gone down slightly and according to calculations the cells should be able to satisfy the current requirement of 1050 pieces per day for the 4180 family and 900 pieces for the 4282 family, with room for additional capacity once further lean projects where realized. The following months however showed that the cells did not perform as expected. Especially the 4180 cell didn't meet the expectations and averaged at 700 pieces per day.

At last, an important piece of information about MAHLE in Trumbull is that the workforce is not unionized, which arguably can ease the implementation of some Lean ideas, since there is no union to object changes in the job description of an employee if those become necessary. Although this circumstance can affect the speed at which changes are implemented on the shop floor, the content of the examples taken from MAHLE hold true for any Lean implementation.

2 Analysis

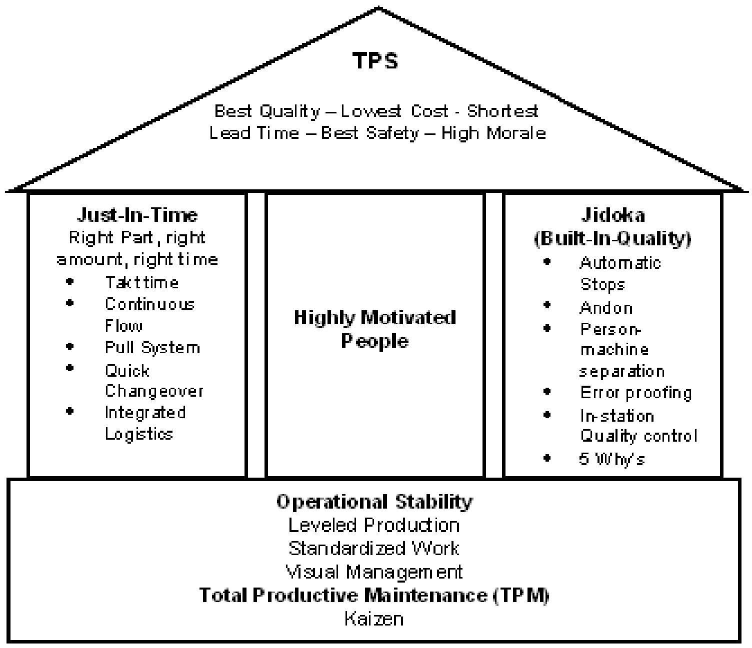
After introducing the problem of this thesis and providing the necessary background information, this chapter will analyze the sources of Lean implementation failures by approaching the problem in three different ways. The first approach will examine the Toyota ideas for possible reasons while the second approach will evaluate expert views on the topic of Lean failures. Finally, a study of the situation at MAHLE in Trumbull will offer reasons from a real case scenario and suitable countermeasures for the identified problems will be presented.

2.1 The House of Lean

The Toyota ideas can be graphically displayed in the “House of Lean”, which will be used in this chapter to search for possible weaknesses in today’s implementations.

2.1.1 Views of the Toyota Production System

The House of Lean, which is build up of a base, three pillars and a roof (see figure 2-1) is meant to resemble the dependence of the elements on each other. The base in this case is made up of Operational Stability through leveled production, standardized work and Total Productive Maintenance (TPM) which ensures that machines do not break down during the production process.



2-1 House of Lean (TPS)

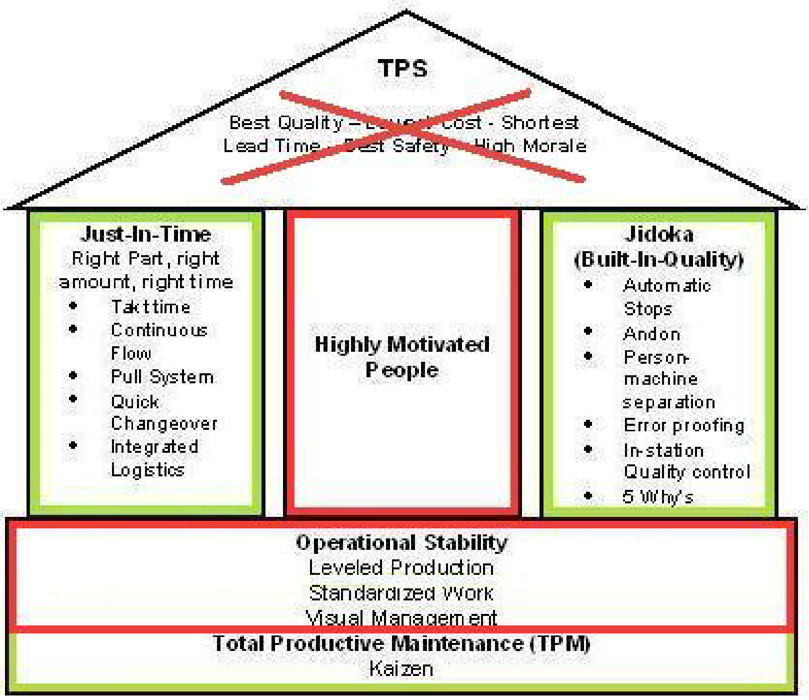
The pillars rest on the base to symbolize the need for Operational Stability in order to successfully implement lean. The first pillar is named “Just-In-Time”, which represents the customer orientation – producing the right part in the right amount and at the right time. This pillar contains tools to achieve this form of customer orientation. The second pillar stands for “employee motivation” and is intentionally placed in the middle of the house in order to symbolize that the employees are the core of Lean. The last pillar is “Jidoka” which has been mentioned earlier as an invention of Toyota founder Toyoda Sakichi and aims at improving the quality through tools like the Andon line, which allows employees to call for help if they notice a problem and even stop the production line if the problem can’t be solved in a given amount of time. Another tool is error proofing which Toyoda Sakichi already used to achieve person-machine-separation for his automated looms by implementing a mechanism that noticed if a thread broke and then stopped the machine. At last, the roof, which represents the achievements that can be reached by implementing Lean, rests on the three pillars to show that all three aspects have to be fulfilled. The achievements that can be reached are best quality, lowest cost, shortest lead time, best safety and highest moral. They are often mentioned with the following percentages (Jacobs, 2007):

- 80% lead-time reduction
- 50% inventory reduction
- 40% reduction in manufacturing and warehouse space requirements
- 70% reduction in set-up times
- 80% improvement in operating reliability
- 50% improvement in quality

Although these numbers seem farfetched, they can be reached in every company that is at the beginning of a Lean journey. A good example is the company VibCo in Wyoming, RI which reduced its lead time from 2 months to one week and thereby even exceeded the 80% goal. As with the lead time example, all of the above goals can be met by implementing Lean in a company.

2.1.2 Common view

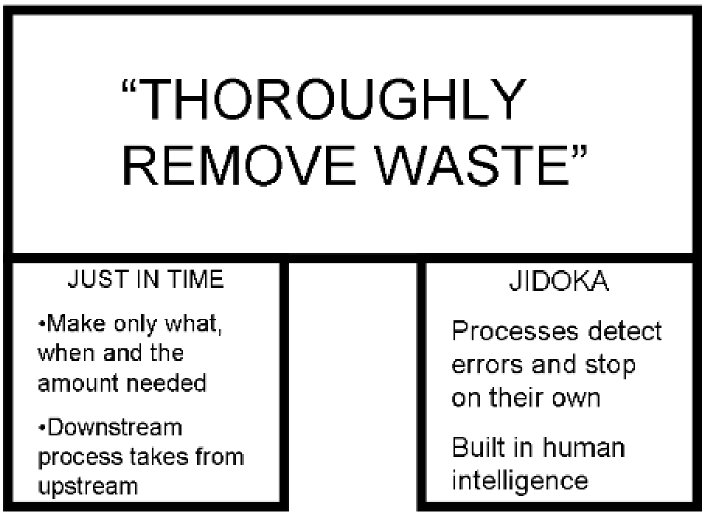
As stated earlier, Toyota's joint venture with GM started a Lean hype all over the United States in which many manufacturing companies tried to use Lean to gain the mentioned benefits. When comparing the focus of most Lean implementations then and today with the house of lean, it becomes apparent that not all sectors receive the same amount of attention. Most companies focus on the two pillars of Just-In-Time and Jidoka and parts of the base, where especially TPM has gained a lot of popularity. Other factors that also contribute to the base of Operational Stability like creating a leveled demand and standardizing the processes usually receive little to no attention. The same is true for the employee involvement, which is often neglected during Lean implementation. Without attending those aspects (marked red in figure 2-2) the goals of TPS can never be met.



2-2 House of Lean separated into guidance given and guidance needed

A reason why some aspects receive more attention than others lies in the amount of guidance given on the topics. Today, Amazon lists over 66,000 books on the topic of "Lean" associated with manufacturing. Most of the literature focuses on the explanation of tools, giving the reader the feeling that he/she can use them at any time to treat specific problems or gain certain improvements. The interaction between fulfilling base requirements and the success of the pillars is rarely clearly stated resulting in 75% of all companies that start an implementation failing within the first year (Rubrich, 2004). The aspect of employee involvement, though usually mentioned, also lacks concrete guidance in today's literature.

These two shortcomings are often expressed through “reduced” houses of lean, like the one in figure 2-3. They can be found in great numbers on the internet and very well express the focus of today’s Lean implementation.



2-3 Reduced House of Lean

The roof has been reduced to one single goal, in this case thoroughly removing waste. This goal is without doubt an important idea of Lean, but it should not be seen as the only goal. Furthermore, the roof now rests on two instead of three pillars, since the employee involvement has been eliminated. The company therefore focuses on using the tools of Just-In-Time and Jidoka to reach the goal. The second problem is caused by the missing base. Since it does not appear in most of the “reduced” houses of lean, companies do not worry about any prerequisites and think that any tool can be used at any time.

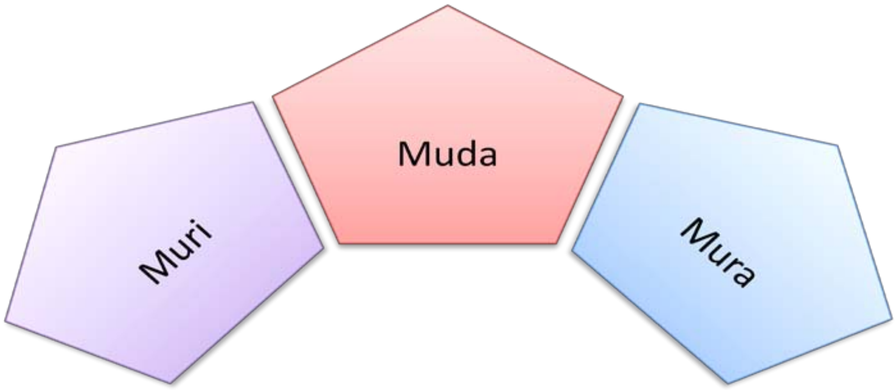
The most common goal, as shown in figure 2-3, is the reduction of “waste” in the production process. As mentioned earlier this idea of reducing the waste, which is often referred to by its Japanese translation “muda”, is heavily enmeshed with the overall Lean concept, but is not the only goal, as a comparison with the TPS focus will show. Muda is made up of seven specific kinds of wastes (figure 2-4) and the two pillars Just-In-Time and Jidoka offer tools to remove every one of these wastes. A Pull System like Kanban for example reacts to the customer demand and thereby reduces the waste #1 – over production. Implementing a one-piece-flow takes care of waste #2 – unnecessary stock; and putting the process steps into a cell design helps to reduce waste #3 – inefficient transportation. A very popular tool especially to start Lean implementations off with is 5S. It involves cleaning up the workspace and placing the tools needed close to their point of use. Doing so takes care of waste #4 – Unnecessary Motion.

2-4 The 7 Wastes (Muda)

Another tool that has enjoyed high popularity over the last years is Single Minute Exchange of Die (SMED), which aims at drastically reducing the set up time of any machine by taking as many set up steps out of the downtime of the machine and rather prepare more steps while the machine is still running. This approach reduces the waste #5 – waiting time. Built in Quality through error proofing and quality awareness of employees reduces waste #6 – rejects & defects. Finally standard work, where process steps are standardized to increase quality traceability and support continuous improvement, also reduces waste #7 – inappropriate processing.

When it comes to waste, the focus of TPS in contrast to the general focus of most companies also extends far beyond removing muda, but this fact is hardly found in the literature. In the teachings of TPS muda is only one of three categories (see figure 2-5). The other two are Overburdening, which carries the Japanese name “muri” and Unevenness, which TPS calls “mura”. One of the few books that refer to those categories is “The Toyota Way”, but even here this information is only revealed on the last couple of pages without any guidance on how to work with it.

Muri, “pushing a machine or person beyond natural limits”, can be perceived in different ways. From a technical standpoint it can be a cutting tool that is used to machine a steel alloy that it is not designed for, resulting in an increased abrasion and an early break down. Another way to interpret muri can be exploiting manpower, which can result in medical costs and labor shortage. In the same way the Lean tools can be overburdened by not sufficiently preparing the employees even though they are the heart of Lean or by not supporting the tools with the right preliminary actions (base) like demand leveling or standard work.



2-5 The categories of waste according to TPS

Mura then especially picks up the topic of unevenness in the demand as a key problem. In many companies it is common for the demand to be uneven, but since they are producing their products in batches, the irregularities are not apparent. When implementing continuous flow and pull systems though, the lack of preparation always shows since none of these tools work with an uneven demand. The literature offers some tools for theoretical demand leveling but there is little guidance on real case application. In reality a successful demand leveling usually includes involving the customer and a new approach to production scheduling.

Of course there are also companies that focus too heavily on the employee involvement or spend a lot of time creating the base for Lean and then fail in using the technical tools, which also makes a successful Lean implementation impossible, but those extremes are rather rare. The following work will therefore aim at the companies that employ the technical approach of using the tools without involving the employees or preparing the base and therefore fail with their Lean implementation.

2.2 Lean Failures

The theses that shortcomings in employee involvement and base preparation are major reasons for Lean implementation failures is not entirely new, being already mentioned in papers like “Usage and Promotion of Employee Potentials in Modern Production Systems” (Adami, Houben, 2007), who strongly recommended involving the employees in order to successfully implement any changes in production or “Beyond Partnerships: The Power of Lean Supply Chains” (Rivera et al, 2007) where it is said that a shortcoming in demand leveling will almost always make a Lean implementation impossible. A valuable addition to these views of experts would be a collection of failure reasons given by companies who attempted a Lean implementation.

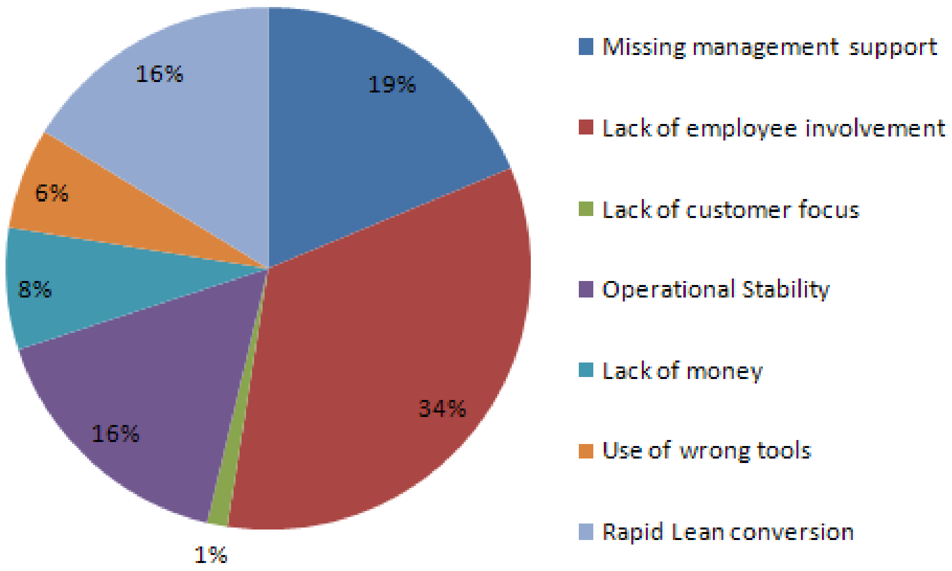
Gathering those reasons from companies however, proved to be an impossible task since the organizations are usually reluctant to even admit that the Lean implementation has failed, not to mention giving an exact reason for the failure, although this kind of exchange would help tremendously in improving the implementation strategies. In many cases, however, pointing out the real reasons might not even be possible because they will be perceived differently by various employees. Another reason for missing data on failure causes is often missing overview over the implementation process which makes a “lesson learned” impossible.

Therefore, instead of gathering data from companies, a representative number of expert views on the reasons for Lean implementation failures have been collected in order to show which reasons are broadly seen as important. The data was taken from 32 web sites (both English and German) which were found through a Google search. These pages were scanned for mentioned failure reasons, which were then recorded in a spreadsheet. The spreadsheet contained 8 categories into which the reasons were sorted:

1) Missing management support
2) Lack of employee involvement
3) Lack of customer focus
4) Operational Stability
5) Lack of Money
6) Use of wrong tools
7) Rapid Lean conversion

Missing Management support (1) refers to the situation that one person in the company is assigned with the task to implement Lean but gets no support from upper management who has to provide resources (people, money, machines, material) but also has to exemplify the

Lean ideas in order for them to be taken seriously by all employees and therefore create a culture change. Failure through lack of employee involvement (2) happens because the ideas, improvements and problems of the Lean implementation are not communicated within the organization. Employee involvement additionally includes employee training and involving all affected employees in the problem solving process, which is often lacked in the so called “top down” implementation, where the problems are solely solved by the engineering department and then forced onto the operators. The lack of customer focus (3) refers to the thought that all an organization does should be seen through the eyes of the customer and then reduced to those actions that the customer is actually willing to pay for. This idea is mentioned in almost every book on Lean and is a valuable proposal of Lean. Operational Stability (4) refers to the earlier explained base of the house of lean, which includes demand leveling and standard work to create a stable operation. The problem of lacking money (5) for the Lean implementation is usually due to the fact that the monetary value of lean improvements is not always immediately visible, which makes it difficult to get the needed resources from upper management. In this sense, it is connected to the first problem of management support. If the wrong tools (6) are used in a Lean implementation, the organizations took tools from the house of lean without considering the need of the situation, which can either be caused by insufficient understanding of the tools or by a wrong assessment of the problem. Lastly, a rapid Lean conversion (7) is often caused by short planning horizons of organizations who aim to retrieve the invested money in between 6 to 24 months. A real Lean conversion involves multiple cycles of continuous improvement which will not be accomplished in such a short time frame. In fact, it violates one of the main ideas of Lean that continuous improvement is never over and the company is therefore continually striving for perfection.



2-6 Reasons for Lean Implementation Failures

When converting the recordings into percentages of the total mentioned reasons, a distribution becomes visible, which shows the reasons that are mentioned most often by the experts (figure 2-6). Four of them are obviously at the forefront: Missing management support (19%), lack of employee involvement (34%), operational stability (16%) and rapid lean conversion (16%). Missing support by upper management will make the failure of a Lean implementation inevitable. This situation can be treated with training on the ideas of Lean and their advantages in order to convince upper management of the usefulness of Lean but this information is readily available and was mostly covered in the introduction. This work will therefore focus on the other three reasons, where the speed of lean conversions is added to the two previously discussed reasons which have now been approved through this analysis. The complete data table with a detailed breakdown of all the responses can be found in the appendix of this thesis.

2.3 Root Causes at MAHLE

A root cause analysis of why the Lean activities at MAHLE, Trumbull did not meet the expectations will show whether some of the above mentioned reasons can be identified as causes. They will then be used throughout the rest of the thesis as practical examples.

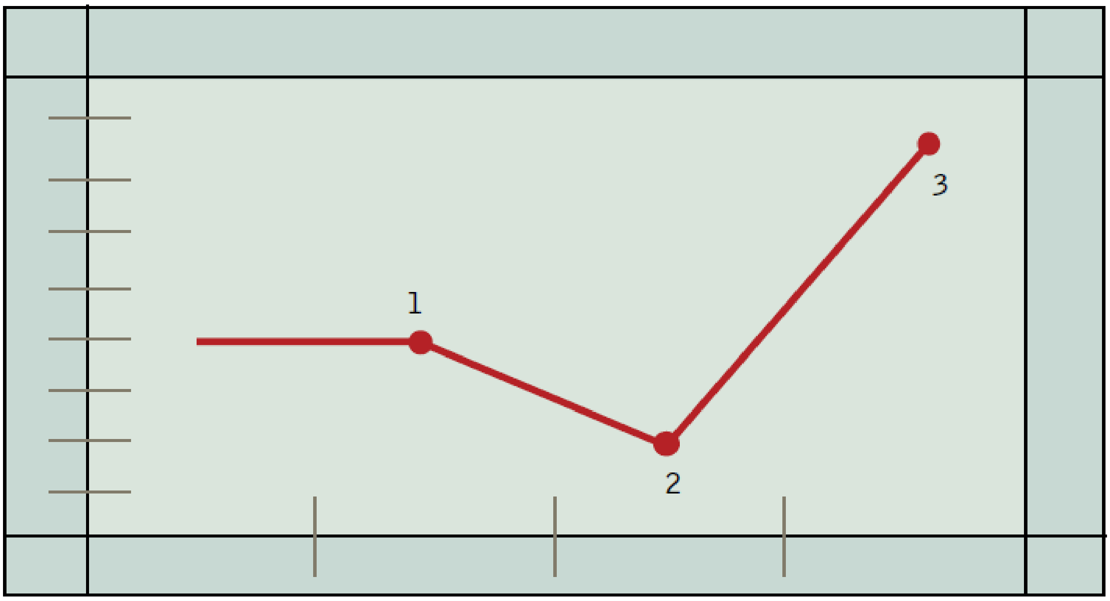
When looking at the situation of MAHLE, Trumbull with the four reasons of Lean implementation failure that were stated above in mind, lack of upper management support can be ruled out since the movement towards a Lean conversion was proposed by upper management. It could however be observed that a problem of middle management support was present, which showed through missing communication of the Lean principles to subordinates and the absence of proactive promotion of future Lean steps. This kind of behavior can either be linked to an antipathy towards Lean, in which case the organization has to part with these managers in order to make a successful Lean conversion possible., or it can be linked to missing training in which case it belongs to the second category of lacking employee involvement - with middle managers seen as subordinates of upper management, who also need to be trained in order to be able to support the Lean conversion. The lack of employee involvement was also apparent on the shop floor level. MAHLE, Trumbull made the right decision when ordering in a top-down style to move the machines into production cells, because the change had to occur quickly in order for the company to remain profitable. Afterwards though, employee involvement and training was keeping the cells from performing as planned. Right after the machine moves where finished, the employees should have been trained on how to work in the new surroundings. Instead, when the machines where combined into process cells, there was no operator training on how to work in this new environment. Since the operators knew how to run each machine separately, it was assumed that no additional training was necessary.

In reality, every shift came up with a unique work sequence which included material handling, quality checking and cleaning. This in turn obstructed all future improvement activities, caused by a missing base of standard work. MAHLE, Trumbull also lacked a leveled demand, which is the second part of the Lean base. Lastly, the effect of rapid versus continuous improvement cannot be judged on this example, since the company had just embarked on its Lean journey. In summary however, almost all the identified causes for Lean implementation failure can be observed at the MAHLE plant in Trumbull and it therefore serves as an excellent example to show how to counteract these implementation shortcomings.

2.4 Possible Countermeasures

This last section of the analysis chapter will summarize the identified reasons for Lean implementation failures and introduce the countermeasures that will be discussed in this thesis.

- The lack of management support scored high on the online search and also was apparent in the example organization. The reason for this problem can as mentioned either be linked to an antipathy towards Lean or to missing training. If an antipathy is existent which cannot be overcome by further information on Lean, the only solution is parting ways with this employee or starting a Lean project in another department.
  If training is needed, one big point that is often missed is the fear of change, which is mentioned in the article “All-out Kaizen” (Ortiz, 2006). Figure 2-7 shows the effect of an improvement activity on critical business metrics like productivity and quality. Point 1 in the graph represents the current state of the operation, while point 2 shows the drop that is likely to happen after an improvement is introduced. Point 3 then is the goal, which was targeted by the improvement. Chris Ortiz states that “in many cases, after an aggressive change in line layout, restructuring of work content, new standards, standards improvement and 5S, there is a dip in these business metrics”. Managers have to be aware of this fact and prepared to sacrifice some numbers shortly in order to gain improvements in the long run. Other than thoroughly educating all managers about Lean, there is not much else to do, which is why this thesis will not focus on this topic in more depth.

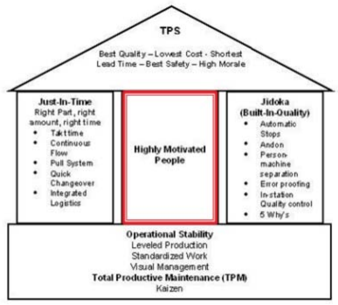


2-7 Effect of improvement on business metrics

- Operational Stability had been identified in the house of lean (figure 2-8) as being disregarded by many organizations when implementing Lean. Without a stable production, all further efforts of Lean tools will fail instantly or only last while no out of ordinary spikes disturb the production. Operational Stability also received numerous hits in the online search, affirming that many experts believe it to be an implementation mistake that is often made. However, there is little literature that focuses on this matter, which is why this thesis will investigate this topic further and introduce several tools that can be used to achieve stability in the early stages of a Lean implementation. The tools will be explained both theoretical and with actual examples from MAHLE, Trumbull.

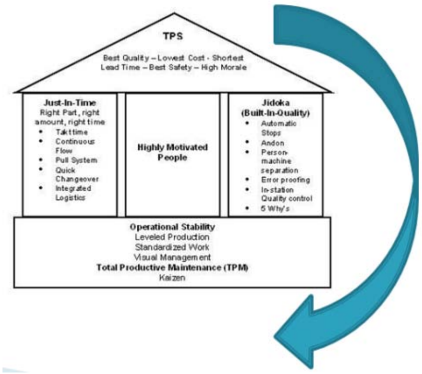
2-8 Operational stability

- Employee involvement received the highest rating in the online search, with almost every expert mentioning that involving all employees is crucial to an implementation success. The same is true for most books on Lean, but the topic is never investigated further and the Lean champion is trusted with making the right decisions to involve his or her employees during the implementation. The truth is, however, that most champions lose sight of the employees when starting to solve the Lean problems and implement the first countermeasures. This often results in missing acceptance by the employees who might adopt the changes for the supervisor’s sake but will drop them as soon as no one checks anymore. A sustainable implementation is therefore not possible and the goals of Lean as shown in the House of Lean (figure 2-9) cannot be met. This thesis will therefore highlight different steps in the implementation process where employees should be involved. It will then offer some tools for employee involvement which will again be supported by reports on the use of these tools at MAHLE, Trumbull.



2-9 Employee involvement

- The last implementation problem, which became obvious solely through the online search, is the rapid improvements with which the Lean ideas are implemented. Most manufacturing organizations plan in half-year or two-year cycles, because they focus on the return on their investment (ROI). This is fine for the acquisition of a machine, the plan to automate a production cell or the transition from one processing technology to another. In the case of a Lean transformation however, the perspective of ROI has to be redefined and continuous improvement trigger points have to be installed in order to allow for a thorough and sustainable implementation (figure 2-10). This thesis will offer management approaches that ensure sustainable continuous improvement and show the benefits of a slow Lean implementation, where continuous improvement cycles are used instead of rapid improvement actions.



2-10 Continuous Improvement

3 Countermeasures

This chapter will focus on providing countermeasures to the problems detected in the analysis chapter in order to ensure a sustainable implementation by offering theoretical knowledge on all of the identified areas as well as actual implementation examples from the MAHLE plant in Trumbull.

3.1 Operational Stability

The first problem identified in the analysis was operational stability. The following paragraphs will therefore offer ways to create a stable environment on the shop floor by applying Standard Work as well as some aspects of Visual Management, although this concept will mostly be covered when discussing employee involvement. The topic of Leveled Production has been deliberately left out of this thesis due to the lack of practical examples to support the theory. The importance of a Leveled Production however is undisputed and should always be considered when implementing Lean. Literature on this topic is readily available.

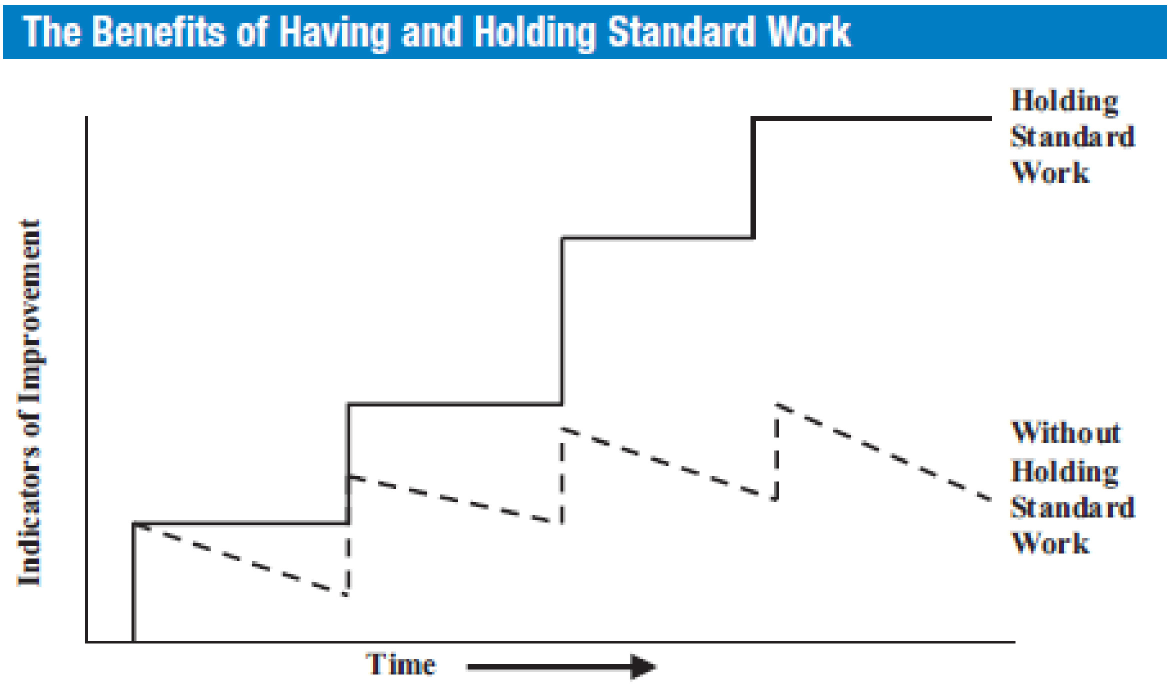
3.1.1 Standard Work

Taiichi Ohno is often quoted as declaring: "Without a standard, there can be no improvement". Tim Whitmore, Vice President of Consulting Services at Simpler Consulting, elaborates on this quote by saying “The principles of lean do not work well when everyone is allowed to choose their own work method or work sequence in which to do a job: the outcome is unpredictable; flow and pull are impossible” (Whitmore, 2008). The Lean tool “Standard Work” is therefore one of the first ideas that should be implemented in a company that is at the starting point of its Lean journey, because it provides the base for all improvement actions. Without a standard, there is nothing to improve upon, because the process is most likely performed in several ways by different employees.

Next to enabling the work team to continuously improve upon the process, Standard Work serves a couple of other practical uses:

- Understanding of process steps at all levels (operator & manager)
- Minimizing process variations
- Traceability of quality issues (man or machine)
- Elimination of unnecessary process steps (muda)
- Production to customer pull (due to set process times)
- Supporting sustainability of implemented changes (documentation)

Enabling everybody on the shop floor to quickly understand the process is a huge improvement by itself, since it serves the idea of transparency, which a Lean initiative always strives to create. It makes it easy for several entities of the production process to evaluate the process step. For the quality department, the root cause analysis of a problem becomes easier, because now an operator-caused problem is easily differentiated from a machine problem. If an operator does something to create a quality issue, it has to appear in every shift and on every machine. If this is the case, it can easily be counteracted through a change in the standard, which reaches all operators in all shifts. The production planning department on the other hand can benefit from Standard Work because the set process times enable them to plan production on the base of customer pull, which later on in a Lean implementation becomes more and more important. Finally, Standard Work supports the sustainability of process improvements because they are documented and collectively agreed on to be the best practice. As figure 3-1 shows, organizations usually fail to see continuous gains from their Lean improvements and the reason is missing standards.



3-1 Standard Work benefit

According to Jim Huntzinger, who in one of his articles showed that Standard Work is one of the tools Toyota learned from the TWI movement, the idea behind standardization is easy, “but developing team leaders and workers to actually standardize improvements and hold them takes time, probably 2-3 years to become accustomed to it. That’s why Toyota claims that coaching standardized work is the lengthiest step in a conversion to TPS." (Huntzinger, 2006).

The challenge therefore is to implement Standard Work from the very beginning of a Lean journey and introduce it in a way that all employees and managers will start to work with it and not against it. As Jim Huntzinger stated, both team leaders and workers have to be trained to use this tool, because they fulfill different responsibilities. The team leader on the hand needs maintain and document the standards, while the actual improvement is the responsibility of the work team.

Robert Hemmant of Celestica defines standard work as "establishing precise, efficient procedures for each task undertaken as part of any process or job […]. It starts with identifying the best way to perform a particular task, then developing methods and procedures" (Hemmant, 2008). This chapter will show how to identify the best practice and offer some tools to communicate the findings with everybody on the shop floor, while also highlighting opportunities to involve all affected employees in the implementation process.

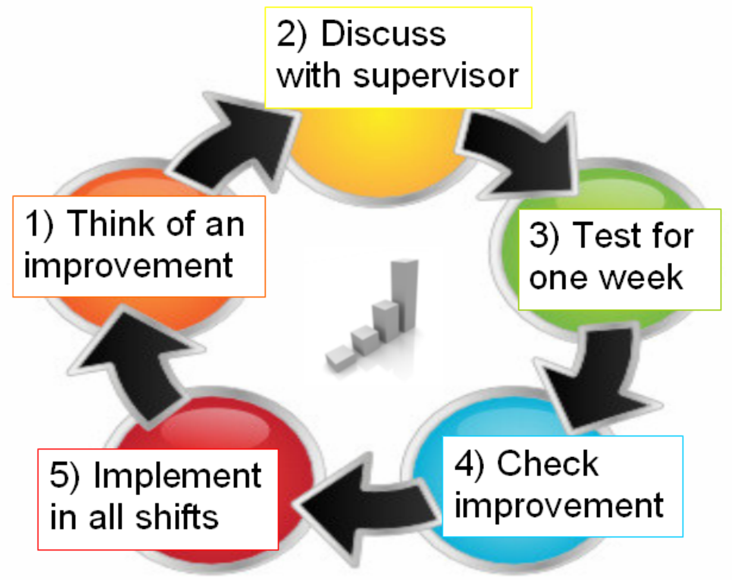
3.1.1.1 Creating a Standard Work Routine

In a company that has not yet mastered the transition to lean it is common for every employee to have his or her own way of doing the task at hand. From their point of view they have always done it this way and see no reason to change. This is true for the most part. Someone who has done the same processing work for years will know allot of little tricks and tweaks to make the work go easier, faster and safer, but usually one process step is done by several employees who will definitely differ in the way they go about their task. The difference might be minimal and not apparent at first glance but it will affect the output either in terms of quality or amount.

The first step of creating a Standard Work Routine is to thoroughly understand the process. All employees that work on the same process step should explain their way of accomplishing the task. It is vitally important to gather detailed information in order to find the small differences that exist between the ways two employees do the same task. It can be easy for employees to forget about some process steps that happen naturally for them, which is why it is helpful to have two or more employees observe each other at the work place. Acquiring knowledge of how operators in different shifts go through the process steps is a crucial part of creating a sustainable routine and it is not only necessary to find the best practice. In depth knowledge of the process will also help tremendously when implementing changes later on, since all participants will respect and acknowledge input of an expert much easier than that of someone who they feel has no understanding of the process.

After clarifying every uncertainty about the process steps, there should be enough trust between the participants to make initial time recordings. If times are recorded from the very beginning without the employees understanding of what is being analyzed, he or she will most likely perceive it as a benchmark of his or her effort, which will always distort the results. The time data collected in this first step can then be converted into flow charts in order to try different process sequences and find the most efficient solution. The flow charts also help to understand how many pieces are possible per shift, which allows the supervisor to set achievable but challenging goals for the operators. After this analysis, the work team has to agree on one routine, which all perceive as the best one possible at the moment. This is a critical part of making the Standard Work implementation sustainable. If the routine is forced upon the operators by the manager or if the operators cannot agree on one routine, the new routine might be followed for a while but eventually everybody will go back to what he or she believes to be the best routine. A discussion about the process being performed is not common in most companies but will be very helpful in making the implementation sustainable. All employees should be given the opportunity to explain why their way of doing the task is the best and the Lean champion can use the data he or she collected to involve all team members in productive discussion, in order to achieve an overall agreement. If needed, trial runs can be used to convince participants of the advantage of one routine over another by calculating the output per time, showing improvements in quality or ergonomic enhancement.

At the same time it is important to make clear that a change of the routine is possible at any time, but that it must follow a controlled procedure (figure 3-2) to ensure that the change is tested for its improvement capability and that, in case it does improve the process, it is introduced in all three shifts to maintain Standard Work. In order to do this, a 5 step circle was set up with the operators, which helps to control the improvement process. These five steps apply to anyone who wishes to make a change to the production cell, which could be the operator, the setup personnel, the supervisor or the plant manager. It starts with an idea that has to be shared with the supervisor and can then be tested for one week. At the end of the test an improvement has to be evident in order for the change to become part of the Standard Work and be implemented in all three shifts. This thesis will focus more on continuous improvement later on, but it is important to introduce this idea to the employees when talking about standards, because everybody should get the feeling that standards are a lively process that will always change once a better way of doing the work is found.



3-2 Standard improvement

In the case of MAHLE, Trumbull, it was necessary to spend three days observing all three shifts and clarifying all questions directly with the operators in order to gain understanding of the situation at the 4180 cell. The following list shows the machining data of this OP10 cell collected during these first three days.

Lathe

Lathe machining time: 21 sec.
Machined features:

- Base flange (3 mm material removal) to ensure flatness
- Fitting geometry for fixturing purpose in later processes

3-3 Lathe

Work sequence: 1) loading (part handling; cleaning collet; starting machine)
2) unloading (open door; part handling)

1) Loading times: 22.5;14.6;11.9;15.6;11.7;14.4;15.8;15.0;11.6;13.4 → Avg.: 14.6 sec.

2) Unloading times: 8.6;6.3;6.3;6.9;11.4;5.4;6.7;8.6;6.5 → Avg.: 7.4 sec.

Total times (for reassurance): 41.2;44.7;43.1;41.6;45.6;41.1 → Avg.: 42.9 sec.

Brother CNC machining center

Brother machining time: 3 min (4180 family) ; 4:12 min (4282 family)
Machined features:

- Bore diameter
- Mounting holes
- Spark plug thread
- Bearing and seal seats


3-4 CNC machining center

Work sequence: 1) unloading (+ cleaning parts)
2) cleaning fixture
3) loading parts (+ cleaning lathed parts) and starting machine

1) Unloading times: 20.3; 21.3 (cleaning for inspection); 15.4; 8.59; 10.8; 15.5; 11.9; 13.7; 13.1; 15.6; 10.0; 16.2; 11.9
→ Avg. (without first two readings): 12.9 sec.
Unloading times me (for reference): 52.4;49.0;42.8;50.6 → Avg.: 48.7 sec.

2) Cleaning fixture: 8.1; 8.0; 8.1; 8.1; 7.9 → Avg.: 8 sec.
Cleaning fixture me (for reference): 26.9;22.0;18.7;26.9;24.7;25.1 → Avg.: 24 sec.

3) Loading times (+ fixture cleaning): 20.8; 28.6; 16.2; 24.0; 29.9; 22 → Avg.: 23.6 sec.
Loading times me (- fixture cleaning): 32.9;32.6;25.7;29.8;24.4;28.6 → Avg.: 29 sec.

In-Process Quality Assurance

Log Sheet Quality Inspection (3 times a shift) : 1471sec.= 24.5min.
Every ½ hour inspection for perpendicularity: 100 sec.
Measured features:

- Bore diameter
- Base flange
- Spark plug thread
- Mounting holes
- Valve guide


3-5 Quality check station

Gauges and their use:

Big quality check:
- rocker arm gauge
- valve guide gauge
- air pressure gauge
- double gauge (probably dome height)
- thread measure gauge
- diameter measure sticks

½ hour check:
- air pressure gauge (perpendicularity)

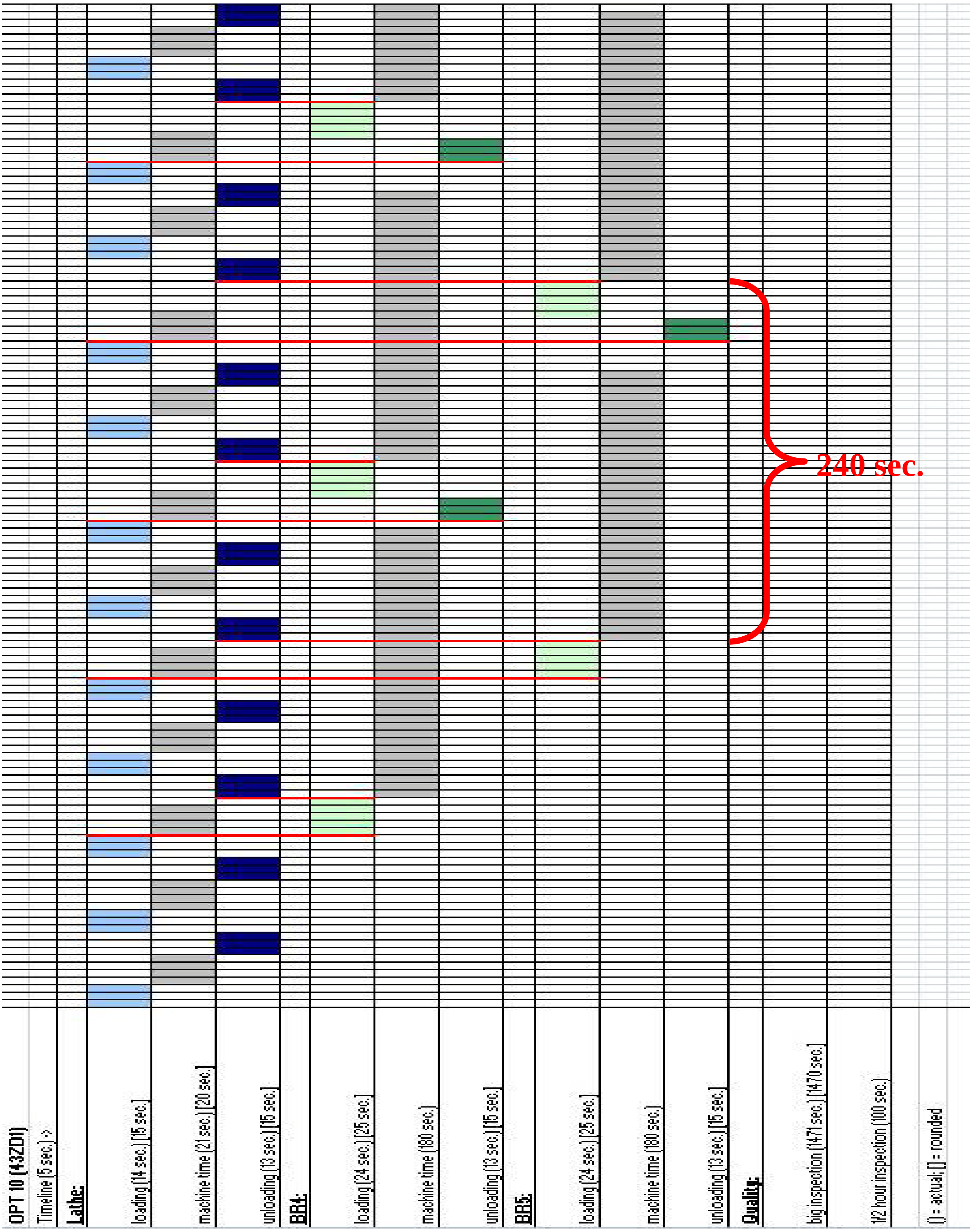
Lathe check (not on a certain time schedule):

- dome height
- caliper for fitting depth

Two major problems where observed in the production cell during the process study. One was the amount of non-productive (but necessary) actions such as quality checks, which consume a major amount of the operator’s time and often disturb his or her work cycle. Along with other observations made during the three days at the production cell, they were stored in a list of improvement opportunities, which will later be used in a Kaizen event to improve the cell. The other obvious problem was the absence of a standard work routine. As mentioned in the introduction, the machines had been moved together without training the employees. Every operator had therefore created a personal work routine, which resulted in a different output for every shift. There was also no possibility to introduce improvements, since the problems differed in every shift.

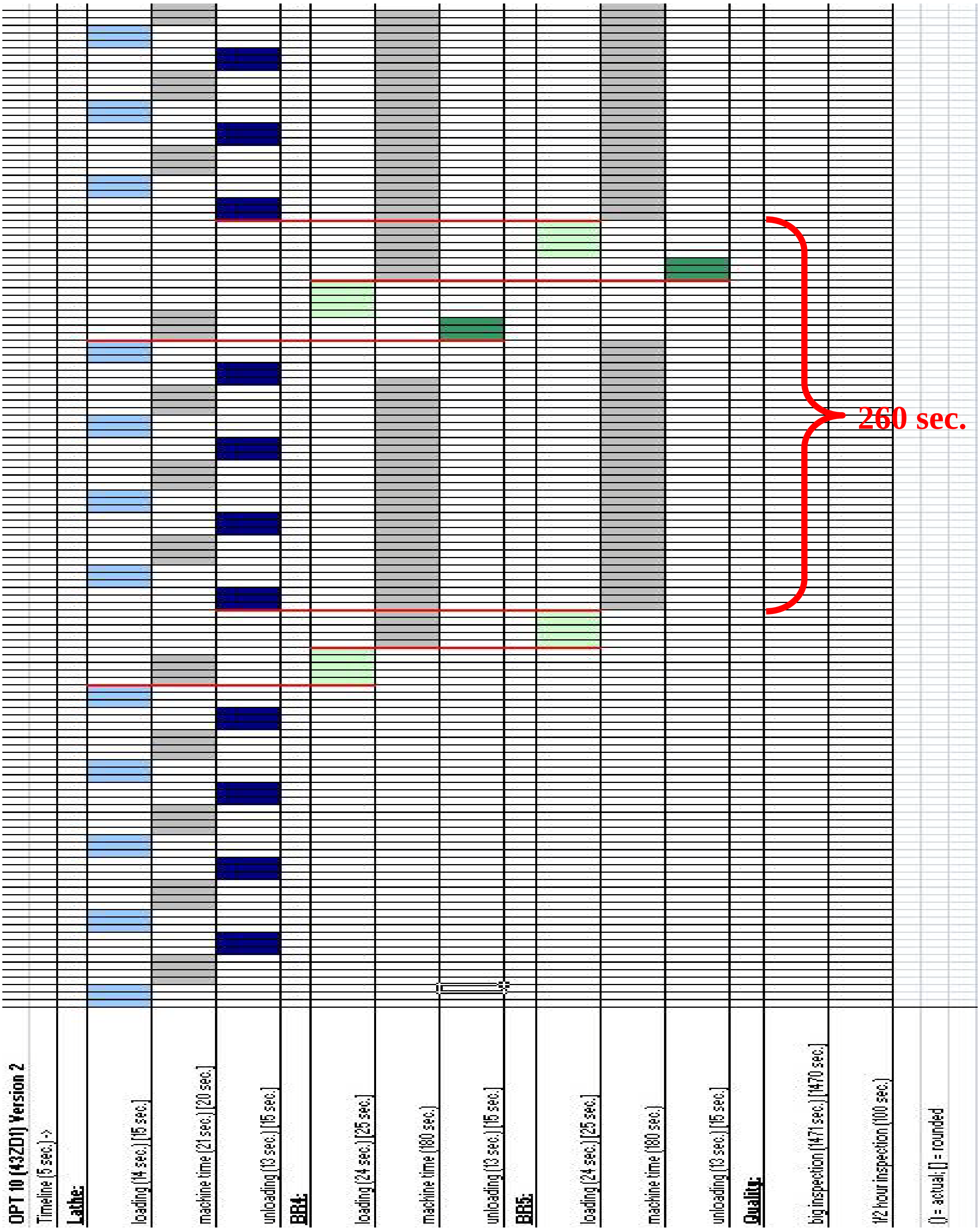
After the group agreed that a standard work routine was needed, they proceeded to the first step, which is putting the process into different sequences in order to decide which routine is the most efficient.

<u>Sequence 1</u>



3-6 Standard Work sequence 1

Sequence 2



3-7 Standard Work sequence 2

Sequence 1 is based on making only enough parts on the lathe to load one of the brother machines. Therefore the sequence starts off with loading and unloading the lathe two times. An important detail here is that the lathe is always loaded and started before the operator turns to one of the brother machines. This way the lathe is not idle for the whole time and a finished part is waiting when the operator gets back to the lathe. In order to use the flow chart to calculate the cycle time, the start-up phase has to be excluded, since the unloading times do not appear here. After a continuous cycle is established, a cycle time of 240 sec. can be identified.

Sequence 2 shows the scenario of machining 4 parts on the lathe and then unloading and loading both brother machines before returning to the lathe. Again, the first cycle does not show the true time, therefore the following cycle is used to determine a cycle time of 260 sec. for 4 parts. By comparing the two flow charts it is possible to determine that sequence 1 is more efficient, because a complete cycle (4 parts) takes 20 sec. less than it does when the process steps are done as shown in sequence 2. The flow chart also makes it easy to see how long the machines are idle (lathe: 30 – 50 sec.; brother: 60 sec.) and which measures can be taken to reduce the idle time. In this case reducing the unloading and loading times for both lathe and brother machine would have a positive effect as well as lowering the machining time on the lathe. These findings where again stored in the improvement opportunity list, for future reference at the first Kaizen meeting.

The ability to visually compare different routines played a big role in getting all operators to agree on one work routine because the difference in parts per shift was obvious. The operators were in fact very open to a standardization of their work, because they felt that a set of rules on how to do their job would give them the comfort that they are doing everything right and that quantity as well as quality issues would always concern the cell as a whole. Before, supervisors would target specific workers if a problem arose. Now, a man made quality issue would be solved through amendments to the Standard Work routine and the output per day would be set on the base of the time data collected earlier.

3.1.1.2 Calculating Standard Output

After a routine has been agreed on, the team can go ahead and calculate the standard output of the cell, which will give the operators and the supervisor a common base to rate the productivity of the shift or the day. If a negative deviation occurs, the cause will have to be questioned in order to assure that a similar cause will not affect the production again. Common causes are machine breakdowns (which can be counteracted by Total Productive Maintenance), material shortage (which is a planning issue) and quality problems. With a standard output in place, it is the supervisor's obligation to question every deviation and achieve a consistent productivity. If the deviation is positive for a longer period of time, new time studies will have to be taken to adjust the standard output.

In order to calculate the standard output, further information has to be gathered to determine the actual work time available, which is the productive time per shift after subtracting all personal allowance and non-productive time. At MAHLE, Trumbull, the available time per shift is 8 hours since the plant is run on a three shift model. Standard times for lunch and other breaks were easily obtained, all other non-productive times had to be measured or estimated. PM startup is a quick check of all machine functions that the operator performs at the beginning of the shift and it was for now estimated to take about 5 minutes to perform these actions. The same goes for cleaning the machines after the shift, which was estimated to take about 10 minutes. In the future these work contents will also have to be standardized, so that every operator spends the same time on it and produces the same result. In this first round of standardization, however, the team focused on creating a rough grid, which in future improvement cycles could then be refined.

4-stroke available time calculation

	Min
Total minutes per shift	480
Lunch	-30
Break	-10
PM startup	-5
Walking	-5
QC Log sheet	-108
QC code 21 check	-32
Cleaning	-10
Planned Production Time	280

table 3-1 available time calculation

Another estimate was the time given for walking to and from the machine at the beginning and at the end of the shift, since that was considered work time and was often used to interchange information between the shifts. The two measured non-productive times are the quality checks, which were taken from the process observation. All together, this amounts to 200 minutes or over 3 hours of non-productive time per shift, which is very alarming.

Table 3-11 then shows how this translates into 280 minutes of available time, which can be divided by the 240 seconds per cycle (4 parts) to obtain the possible amount of parts per shift. An operator under the given conditions can therefore produce 280 pieces per shift, which adds up to 840 pieces per day. While this number does not yet satisfy the goal that MAHLE, Trumbull had set for this production cell, it is higher than the average current production and with multiple improvement opportunities stored for the first Kaizen, which this thesis will touch on later, reaching the goal of 1050 parts per day will be reachable.

3.1.1.3 Making Standard Work visible

Once an agreement is reached, the final step is making the routine available on the shop floor. This serves three purposes. First of all, the participants of the work group have a daily reminder to follow the routine that they collectively agreed on. Secondly, the displays can be used to train new employees or temporary workers to follow the right procedure. Lastly, the visibility of the routine enables managers to understand the process quickly by making it more transparent.

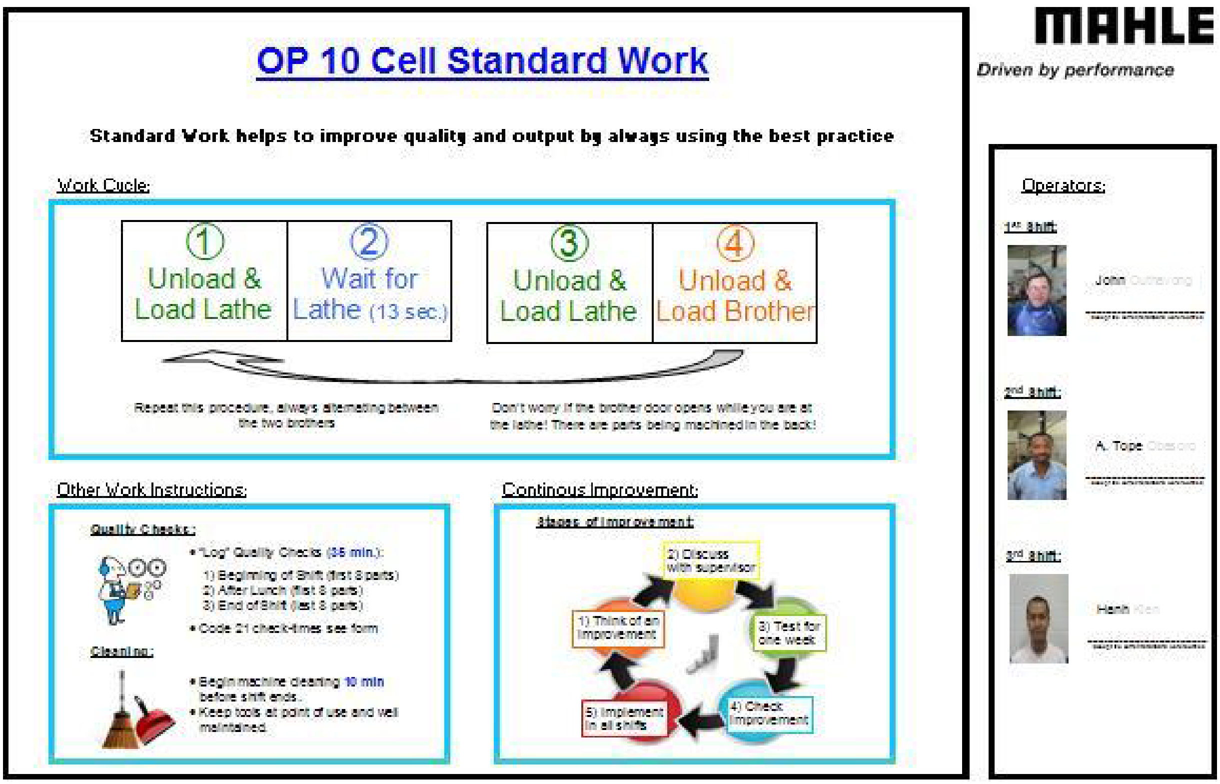
Making the routine available at the work station can be done in form of a work instruction, which is kept in a folder at the cell, but because one of the Lean efforts is to make everything transparent, the favored solution is an information board in front or above the cell. This board can then be divided up into several segments, conveying different information. One of these segments will show the work routine, divided up in easily comprehendible steps. The goal is to present the process in a way so that everybody can understand and perform the basic steps of the job by looking at the instructions. This can be achieved by using pictures and symbols rather than text to describe the process. A good test is always to get an employee from another work station to perform the task with just the guidance of the standard work instructions. The rest of the board can be used to display other content that is important for the work area. This can be break times, safety regulations or the names of all work team members. When creating the board, it should however be taken into account that the information has to be legible from afar and the board should therefore not be cramped with information. Another important aspect of making the implementation sustainable again is the involvement of the employees in the creation process. At Toyota, the operators therefore write the final documentation of the work standard themselves. They may be assisted by engineers and supervisors, but it is the aim of the company that every operator understands the working standard by involving them in the making.

At MAHLE, Trumbull, the standard work routine that was agreed on consists of 4 steps:

1) Unload a part from the lathe and load a new part
2) Wait for lathe to finish (13 sec.)
3) Unload a part from the lathe and load a new part
4) Unload two parts from the brother machine and load two new parts

Next to the standard work routine, the team decided to include some basic rules concerning quality checks and machine-cleaning on the board (figure 3-8), since those were the major time consumers according to the work studies. After being involved in the standard work initiative and knowing about the problems that are created by not having a standard, the employees themselves suggested posting these non-productive times on the board in order to keep them in an economically justifiable range. In addition, the team decided to include the five step improvement cycle on the board, so everybody would know how to handle changes to the standard. Finally, the names of the operators were posted on the board, since they were the ones who came up with the work routine. If the routine should be changed in any way, all of them would have to be notified and acknowledge their agreement with a signature below their name. This way, the board also serves as a link between all operators to recognize each other's input.

All the segments are made to be easily interchangeable by using Velcro® strips to fasten the laminated A4 sheets to the 6' 7'' x 3' 4'' hard plastic board. Therefore, if one area is subject to an improvement action, the supervisor can change just that segment by printing out the revised version and laminating it.



3-8 Standard Work poster

3.1.2 Standard Work for Supervisors

The past chapters focused on Standard Work to create a base for Lean improvement on the shop floor and therefore ensure the sustainability of the Lean implementation. Standard Work however can be used on any process or procedure and is therefore not at all limited to the shop floor. This chapter will look at the role of Standard Work in focusing the activities of the supervisor on Lean improvement, which completes the creation of a Lean base on the shop floor.

When implementing Lean on the shop floor, the focus is often set too narrow by only improving the work that is done inside the production cells. An important issue in making Lean improvements sustainable, however, is to include the leaders by introducing the process-focus in their daily work as well. The book “Creating a Lean culture” (Mann, 2005) is one of the few works in the Lean literature that devotes a whole chapter to Standard Work for managers and thereby acknowledges the importance of standards in the management of processes. He emphasizes on the leadership in order to make Lean conversions sustainable and early on in his book mentions that the “sole focus on results” that most leaders in today’s manufacturing environment are bound to, has to be transformed to a “dual focus on process and results”. By introducing Standard Work into the daily routine of a supervisor, the expectations of his or her superior are clearly stated and can be followed to ensure a smooth operation on all levels. When implemented even further up the command chain, Standard Work forms interlocking layers, which, according to David Mann, create a communication line within the company where every Standard Work task of one leader is periodically checked by the superior leader, which communicates problems in output or quality to the next level.

The Standard Work for leaders however differs from what is implemented in the production cells in a couple of points. First of all, the work of leaders becomes less and less structured the more it is detached from the shop floor. David Mann explains this with the following percentages of how much of one working day can be defined by Standard Work.

- Operator 98%
- Team leader 80%
- Supervisor 50%
- Production Manager 25%

Less structured work

More discretionary tasks

While the work of an operator can be mostly defined by Standard Work, only half of the tasks of a supervisor can be expressed in standards to leave room for discretionary tasks. Still, the introduction of standards for half of the daily responsibilities is a big step towards a successful Lean transformation on all levels. It enables every supervisor to continuously improve the daily routine by collecting data on the most common problems and therefore triggering improvement actions. According to David Mann, Standard Work on the management level is also a good method to expedite the identification of the leaders who are unable or unwilling to make the change to Lean and should therefore be removed from the process. In general, David Mann points out that about 10 – 20% of the leaders will indicate that they will not support the Lean conversion and it safes the company a lot of time to make these observations early on in the process. The other difference of Standard Work for leaders in comparison to operators is that the instructions should be presented in a working document, to allow the collection of data and the ticking off of completed tasks. This document can then serve as a communication between the superior and the supervisor as mentioned earlier.

When it comes to creating the content of a Standard Work for supervisors, the same rule applies as before. The processes have to be thoroughly understood and discussed before any standards can be created and the standards have to be commonly agreed on by the supervisors. Due to the more diverse tasks however, the time needed to fully understand all aspects of the job increases and can easily take up several weeks. At the end of the analysis, the team has to decide which tasks are discretionary and which can be structured to fit into a Standard Work routine. Some examples from David Mann's book for the supervisor include the following tasks.

- Gemba-walk with team leaders (weekly)
- Coordination of the shift change (daily)
- Attending a morning meeting (daily)
- Spot checking Standard Work (many times daily)
- Signing off quality checks (many times daily)
- Floor time (many times daily)

Often, the job of a supervisor is linked to constant firefighting of production issues, which takes the focus away from the necessary daily control that in turn would cause many of the problems to be caught before evolving to a "fire". In the cases presented in David Mann's book, the supervisors therefore perceived the Standard Work as a useful reminder of the tasks that need to be done on a regular basis. Otherwise the nature of production often leads the supervisor to lose the overview and focus on tasks that increase the short term results but do not fix the process problem itself. Standard Work for supervisors therefore is a necessary tool to enforce process-focused action that will support the sustainability of the Lean implementation.

At MAHLE in Trumbull this idea became apparent soon after starting the first Lean improvement event that included the supervisors. All of them stated to have no time for improvement activities because their daily workload would not permit it. The question of why quickly arose in upper management, since process observation and improvement was thought to be one of the main tasks of the supervisors. After consultation with the Lean governing committee, a list (figure 3-9) was issued to all supervisors with the request to track their workload during the following weeks.

Standard Work for Leaders

Name: ________________ Date: __________

Function: _______________

Action	Frequency & Time per day

3-9 Work log for leaders

The list is a simple log of the performed tasks and time they consumed. After a couple of weeks the first conclusion could be drawn. The supervisors spent major amounts of time chasing after parts and expediting them through the production process, never asking for the reason of the delay. At times when there was no emergency at hand, some of them supported the operators with simple fetch and carry jobs such as building cardboard boxes for the finished parts or moving empty conveyor baskets from the final inspection to the front of the production. Other supervisors used the free time to catch up on the paperwork that was often left undone in times of an emergency. None of them however showed a reasonable amount of time for process observation and improvement. The actions taken because of these results exceeded the time span of this thesis and could therefore not be included. However, an approach as suggested the Standard Work chapter of this thesis combined with the ideas presented in David Mann's book would offer a great starting point for a successful supervisor Standard Work implementation.

3.2 Employee Involvement

The lack of employee involvement received the highest rating in the online research on Lean implementation failure reasons and is also valued highly at Toyota, as one can see from the House of Lean. Still, most managers do not involve their employees enough during a Lean implementation and by doing so condemn the conversion to fail in an early state. Generally, a manager studies the problem at hand, which could be a low output in produced parts or quality problems. He or she then comes up with a solution to counteract the problem by looking at the process related data and matching it with the right Lean tool. The solution then most likely has to be defended against the superior after which the manager can proceed with the implementation. Here, two situations can occur. Either the employees oppose the changes right away because of errors that were not obvious to the manager before or they adapt the changes for the sake of the manager but will go back to the old process as soon as the compliance with the new rule is not controlled.

The first step in counteracting this situation, is understanding the reasons for not wanting to involve others or getting involved in improvement projects. When addressing this issue with managers and operators at MAHLE, two strong reasons for the lack of involvement became apparent.

1) From the manager's point of view, involving operators elongates the process of finding a solution, because different opinions have to be heard and a consensus has to be reached. For many managers it is also difficult to accept input from operators that will alter the solution they proposed. In many companies, managers perceive their operators as not intelligent enough to solve technical or organizational problems and, on top of everything, not interested in improving the process, which is definitely a core problem when trying to implement Lean. A Lean conversion, as mentioned earlier, cannot be implemented in a top-down manner. Managers therefore have to start recognizing the knowledge of their employees and accept their input in the problem solution process.

2) The employees on the other hand have learned from long term “bad supervision”, which was usually focused on product output and did not encourage the input of personal opinions. The introduction of a suggestion system, as it has been popular with many big organizations recently, gives proof to the habit of suppressing employee input. Once a suggestion system is introduced, the department is usually swamped with submissions of ideas that have been held back for years. This also shows that the general willingness to get involved in improvement activities is not low at all. Many of those suggestions in fact have a very high value because the operators have the inside knowledge of machines and processes and are therefore often able to see problems that are imperceptible to managers. This is the main reason why organizations are starting to change their way of thinking and implement suggestion systems. There is however one other reason why employees often refrain from making certain suggestions, even if they are asked to do so. The reason in this case is the misuse of their suggestions. As mentioned, most managers of course focus on increasing the product output while at the same time cutting as much of the manufacturing cost as possible. If an employee therefore suggests a method of increasing the output or even eliminating a certain process step, it could mean that the company fires one of the colleagues or even the employee himself.

Sources which were included in the online search confirm the existence of these problems. They are core issues which have to be resolved in order to start a sustainable Lean implementation. Discussing these issues openly with the affected groups can be the first step towards a solution. Managers have to understand that an improvement will only sustain if the operators understand the reasons behind it and achieving this understanding can only be done by involving them early on in the process. The managers also have to make sure that improvements do not lead to headcount reductions. The book “The Kaizen Revolution” (Regan, 2000), as well as many other books on Lean implementation, therefore suggests to evaluate the head count needed after a Lean conversion in advance and then to lay off the required amount of people before starting any Lean events. This way, operators do not have to fear that improvements will cost them their jobs and it also creates a sense of urgency to improve, since the lack of employees has to be absorbed. It also gives the manager the possibility to remove those from the work force that would hinder a Lean conversion because they will not agree with the ideas. In order to do so, however, the manager of course needs to have a good understanding of his or her workforce in order to predict who will be supportive and who won't. To predict the amount of employees needed after a Lean conversion, the manager can use the improvement percentages introduced in the analysis chapter.

The first step of employee involvement on the shop floor then has already been described in the analysis chapter as well. In order for the manager to understand the process, he or she needs to ask questions and spend enough time with the operators. This first encounter creates the base for all future collaboration between the Lean champion and the operators and should therefore be taken lightly. This chapter will now offer some more opportunities for employee involvement throughout the first steps of a Lean implementation. If applied, these methods will encourage motivated team work among managers and employees.

3.2.1 Visual Management

Making information visible to employees plays a key role in their involvement during a Lean conversion, because it will enable the operators to identify and understand problems that the shop floor is facing and therefore feel the need to improve. According to “Application of lean visual process management tools” (Parry and Turner, 2006), clear activators are required to motivate the work force. They follow the ABC communication model discussed in “Visual Factory: basic principles and the ‘zoning’ approach” (Bilalis, 2002), which states that communication is a key driver in behavior. Visual communication, respectively, is the most effective way to communicate information to a broad group of people and is therefore the best way to affect the behavior towards improvement actions. The following pages will offer two methods to involve employees by visually conveying information on the shop floor.

3.2.1.1 Info Boards

Info boards are used to present the daily data which will help the employees understand the situation on the shop floor. When designing an info board, the most important decision is which information has to be posted to support the employees in their improvement will. Every organization in this case, has to come up with individual metrics, but, according to operators at MAHLE in Trumbull, there are a couple of questions every operator on the shop floor has a daily interest in:

1) Does the product output meet the customer requirement?
2) What are the major quality defects?
3) What is the cost of a defect to the company?
4) How are the defects caused?
5) What are current and upcoming changes in the process?

It becomes obvious that there are three fields of interest for the operators, the product output, the quality of the product and changes in the process. The goal now is to present the required information in a way that is easy to read and can be quickly comprehended. The key here, as it was for the Standard Work board, is to use graphics instead of text, since they can convey a message more quickly and also across a farther distance. The product output has to show the requirement against the actual. The example at MAHLE will show a possible solution later on. Quality issues are best shown with pictures of defective parts to catch the attention combined with a short explanation of how the defect is caused, the defect rate per shift and a cost that is associated with the defect. This will make every operator aware of the problem and he or she can try to influence the quantity of defective parts by handling the part more careful, not passing defective parts further down the value stream or even finding the source of the problem in one of the machines. Lastly, once Lean has been introduced to the plant, an area of the info board should inform all employees about achievements that have been made in specific work cells and future projects that are planned. This way, employees can adapt improvements from other areas of the shop floor and are also in the picture of how Lean continuously improves the production process.

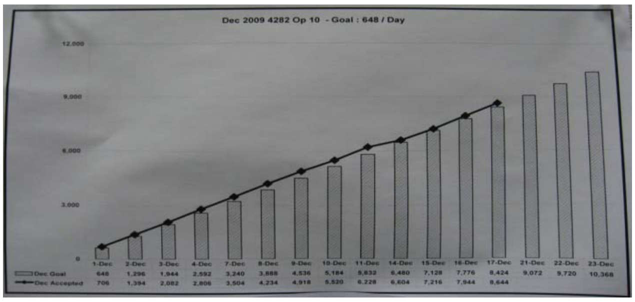
After the content of the board has been agreed on, the next important decision is the placement. The info board should be placed strategically so employees pass it at least once a day and cannot help but to absorb the presented information. The entrance to the shop floor is therefore a good place to position an info board. When deciding the placement, one should also think about leaving enough space for small group meetings. Once the info boards are set up, supervisors should use them once a week to gather their employees and go over the numbers. Especially during the first weeks and months, these meetings will help the operators to understand the figures and use them correctly to improve upon their work. Later on, the meeting can be a possibility to address specific problems or to compliment certain operators on their suggestions.

Lastly, one important issue is the maintenance of the info boards. An unmaintained board will quickly loose the interest of the employees and the implementation fails. Renewing the interest later on will require a lot more effort, which is why it is important to keep the boards up to date from the beginning of the implementation. The updating responsibilities in each case lie with the department that tracks the numbers. The product output, for instance, will be posted by the production planning department, or, if there is no such institution, by the supervisor of that area. The quality issues on the other hand will be posted by the quality department, since they have all the required data and knowledge to present the important facts about the issue. Lastly, the upcoming project section will be updated by the Lean champion and upper management. Together with the weekly shop floor meetings at the info boards, they create a culture of information exchange that is crucial to a sustainable Lean implementation. It works, however, only if all participants take their responsibilities seriously and continuously provide current information.

At MAHLE in Trumbull, the info boards where implemented in the form of two info towers (figure 3-12), one for the two stroke process and one for the four stroke. They are positioned at the front of each production line and offer four sides to present information. The information that is supplied follows the structure explained above. Product output per day is shown in a diagram (figure 3-10), where the customer requirement is shown as a line and the output of the previous days is represented by columns which either exceed the requirement line or stay below, in which case the left over requirement is added to the next day. The quality department maintains another area of the tower where it posts current quality issues with pictures and explanations. The Lean initiative currently does not inform about past results and upcoming projects but would have a space do to so. The maintenance department however uses part of the tower to inform about upcoming Productive Maintenance (PM) actions (figure 3-11), so operators and especially the setup personnel can plan ahead.

Where MAHLE, Trumbull does not fulfill the requirements is in using the boards on a day to day basis. The supervisors currently do not have the habit of holding weekly meetings with their operators and the most operators are therefore not completely familiar with the meaning of the boards and the information presented on them. Currently mostly the managers use the board to inform themselves about how the processes are doing, but the goal of establishing a bridge between management and employees in order to foster employee involvement in Lean improvement projects is not helped this way.

3-11 Info Tower



3-10 Production volume per day

3-12 Preventive Maintenance board

3.2.1.2 Production Boards

Another visual tool that should be introduced on the shop floor early on in a Lean conversion is the production board, which shows the parts produced per cell and per shift. Next to serving the basic purpose of making the production numbers transparent to everybody in the plant, the production board serves three functions that stimulate the employee involvement in the Lean implementation.

1) For once, the board is another opportunity for the supervisor to hold short weekly meetings with the operators of just that cell to discuss current problems or upcoming changeovers.

2) Public posted numbers also challenge operators from different shifts to achieve an equal amount of work, so the best operator defines the standard to a certain extend.

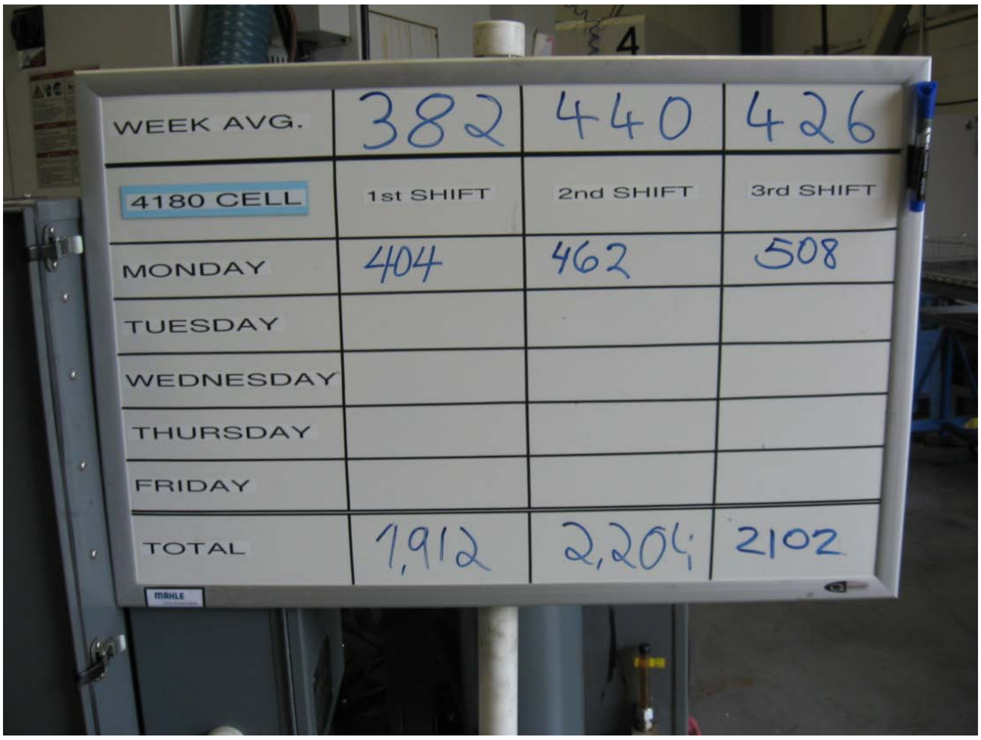
3) Another effect of the production board has been documented as the Hawthorne effect by Henry A. Landsberger (1955), which suggested that a gain in motivation can be reached by observing the work of a human, which then translates into higher product output.

The design of a production board depends on the point of use and can range from very complex to very simple. For a first implementation the design should follow the spirit of Lean, which always prefers the simple solution that is not cost intensive. The design should also be easy to adapt if requirements change. A whiteboard with a predefined table (figure 3-13) for weekdays and shifts is an easy solution, where operators can fill in production numbers with a dry-erase board marker and remove the past input at the beginning of every week.

Week Average			
	1st Shift	2nd Shift	3rd Shift
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Total			

3-13 Production Board

At the end of a week, the supervisor can then sum up the total per shift and calculate a week average, which will be a lead for the following week, while of course the previously in the Standard Work implementation agreed requirement per day is the most important mark to be met.



3-14 Production Board at MAHLE

At MAHLE in Trumbull the shift requirement resulting from the Standard Work implementation was 280 pieces. The board was implemented to assure that this number is continuously met in production. The design was a simple white board with a couple of lines to divide the board up into the table shown in figure 3-14. Soon, however, it became obvious that the motivational effect of publicly posting the output numbers together with the Kaizen improvements, which will be explained in the next chapter, increased the output far beyond the calculated requirement. The team will therefore soon have to re-asses the process and create a new standard output. Especially at the beginning of a Lean implementation, the standards will be subjected to frequent changes.

The production boards were placed in front of every production cell, with the operators filling in the numbers at the end of each shift. For the supervisors, the boards present a way to quickly assess the situation and ask further questions if the output deviates from the standard. To draw even bigger gains out of the production boards, they should be included in so called Gemba Walks, where management walks the shop floor frequently to inform themselves about the current situation.

3.2.2 Kaizen Event

A Continuous Improvement process is the next step in the Lean transformation after Standard Work has successfully been implemented. Again, this step of the Lean implementation needs the involvement of all affected employees to ensure a sustainable result. This chapter will therefore explain how to plan a kaizen event that allows for a high rate of employee involvement and will show the theories at work on a Kaizen event at MAHLE in Trumbull.

Kaizen is the Japanese expression for “improvement”, which has been made famous through the book “Kaizen: The key to Japan’s competitive success” (Imai, 1986). In Kaizen, Toyota unites the use of all TPS tools as well as the philosophy of Lean. It is the philosophy side of Kaizen that advocates the involvement of all employees, which makes Kaizen events a perfect tool to spread this mind set and take the first steps towards a culture change. Kaizen events are also a great opportunity to teach the employees about the Lean tools in order to endorse their use in all future problem solutions. The execution of a successful Kaizen event with sustainable gains however requires detailed planning. This thesis will focus on the aspects of Kaizen that encourage the interaction between different groups of employees. For more information on the tool oriented side of Kaizen, readers can refer to literature such as “The Kaizen revolution” (Regan, 2000).

The first two crucial decisions of a sustainable Kaizen event are appointing a Lean champion and selecting a first Lean project. The Lean champion should be someone who has a good rapport with both the management and the operators. He or she needs a strong believe in the Lean techniques, but at the same time cannot be a maverick. The position of a Lean champion has to be understood as a service to the organization and its employees. He or she therefore needs to do everything to support the employees in finding the right solutions (training, data collection, intervention) instead of forcing personal ideas onto the team. The selection of the first project is critical because a project failure could possibly undermine the whole Lean conversion by leading to distrust in the Lean ideas. According to “Kaizen Event Implementation Manual” (Geoffrey and Mika 2002), it is therefore important to choose a high potential success as a first project. In a next step, the Lean champion has to collect some preliminary data on the process, similar to the data collected during the Standard Work project. He or she will also have to plan the first Kaizen meeting, an important incident in the employee involvement, which is why the following paragraph will offer some ideas on the content of the first meeting.

At the same time as the appointment of a Lean champion, a governing committee has to be set up that schedules and watches over all Lean events. This committee, as mentioned in “All-out Kaizen” (Ortiz, 2002), usually includes the Lean champion, the plant manager, the production manager and leading employees from quality, maintenance and engineering. Together they monitor the progress of the Lean projects and decide on new areas that need improvement. The first Kaizen meeting, as stated earlier, needs to be accurately planned to ensure a sustainable start. Before deciding on the content of the meeting however, time and duration have to be set. Assuming a three shift operation, a meeting in between two shifts is advisable in order to involve as many line operators as possible. The third shift operator can be asked to come in as well, as long as it does not affect his or her required resting time. Giving everybody the opportunity to participate is crucial but often neglected. Duration wise, two factors have to be taken into account. Most companies cannot afford to have their operators away from the machine for hours or even days, as it is often recommended in Lean literature. Due to this fact, many organizations refrain from involving important line operators and adhere to the conventional one week Kaizen event, promoted in most of the Lean literature, thereby, however, creating a highly possible failure reason as we now know. Instead, the Kaizen meetings should be planned as short trainings, not exceeding one hour in total length and divided into blocks of no more than 20 minutes, since this is the average receptiveness for the new information according to “The Change-Up in Lectures” (Middendorf and Kalish, 1996).

Once time and the duration are set, the Lean champion can focus on getting all employees the right information while at the same time encouraging everybody to participate. In order to incorporate all these features into the meeting, it can be divided up into four segments.

1) The first segment of the meeting can be summarized as “Introduction”. The Lean champion can use the meeting to introduce the term “Lean” and afterwards start an introduction round where every team member introduces him or herself and also lets the team know whether any previous exposure to Lean is present. The introduction of all team members is important even though they work together on a day to day basis. The team environment is a completely different setting from the shop floor, which is why it is important to renew the connections among the employees and possibly add to them.

2) After the introduction round, the Kaizen meeting can be used as a Lean training session to familiarize the employees with the Lean tools and ideas. It is advisable to start with the basics such as the idea of waste, what is understood as the value stream and the benefits of standards, if does have not already been introduced during the Standard Work project. This thesis contains some presentation slides used at MAHLE to introduce these basic ideas in the appendix. They can be referred to, for questions on how to present the material to the employees. According to “Training Within Industry: The Foundation of Lean” (Dinero, 2005), information has to be repeated at least five times in order to ensure a thorough understanding of a topic. It is therefore not sufficient to introduce the issue of waste and waste reduction just once in this meeting. The following meetings have to repeat the information and build on it, so everybody becomes thoroughly familiar with the terms and ideas and at some point uses them naturally when thinking about problems. The information presented in every Kaizen event should also be linked to action item of this meeting.

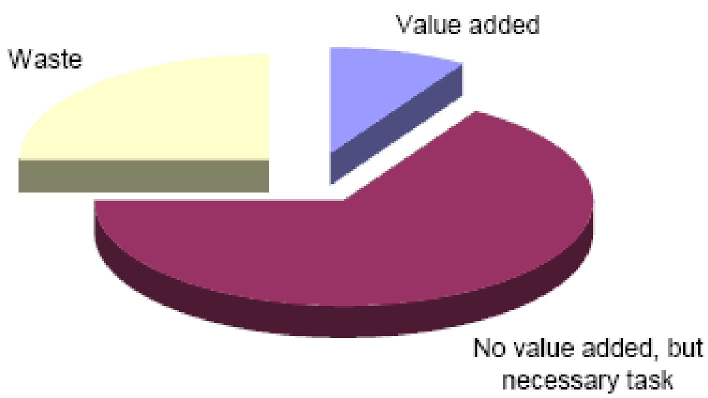
3) The third segment of the meeting can be called the “action item”. It usually contains floor time, where, as mentioned before, the teachings of the meeting can be used hands on. In the case of the first Kaizen meeting, the floor time should be used to identify the value stream of the project sight and use the newly acquired knowledge of waste to identify problems. Each team member should carry a notepad and record his or her ideas for improvements.

4) To conclude the meeting, the team should reconvene in the meeting room and compare their notes. The Lean champion at this point has to act as a moderator, to make sure all ideas are heard and stored in a list for use in future meetings and as a feedback for the governing committee. The employees can then be released to the daily work with a reminder to constantly view their daily tasks with the received Lean information in mind, in order to see the waste and improvement opportunities everywhere.

Meetings such as this should henceforth be held in a continuous matter, such as every one or two weeks. In the following meetings further Lean ideas can be introduced and the team can agree on tackling a couple of improvements from the list. The Lean champion will constantly offer all the information and knowledge needed to solve the problems in a Lean fashion and lead the first improvements projects by himself. Later on, it is the duty of the

Lean champion in conjunction with the governing committee to pick the most involved employees and release some of the responsibility of leading improvement projects onto them. Once the Lean ideas spread, the Lean champion cannot get involved in all improvement projects and therefore needs to enable other employees to take on leadership roles. At some point along the Lean implementation time line, when the champion feels that the group has developed enough momentum, he or she can stop attending the meetings of this group but must assign a new team leader to carry on. This new leader should then periodically report to the Lean champion about current improvement projects and future plans. Through employee involvement the Lean conversion eventually becomes a self directed "living" project, which needs no outside action by the Lean champion other than always making information and resources available to all teams. Information at this stage is often made available through a space on the info board or a Lean newsletter that informs about recent improvements and introduces new ideas to the employees.

At MAHLE, Trumbull, the one hour Kaizen meeting was scheduled at 2:30 pm every Tuesday, with the second shift operator coming half an hour early and the first shift operator staying half an hour longer. Furthermore, the team consisted of the setup personnel from first and second shift, who generally arrived earlier and stayed longer respectively. Lastly, the supervisor of the four stroke area attended, because the 4180 cell, which the Kaizen meeting focused on, was part of the four stroke process. The presence of the supervisor served as a hint for the employees that the activities where backed by upper management and encouraged the operators to get involved. After a round of introduction, in which only the supervisor pointed out some prior knowledge about Lean, a first Lean training was held with slides that can be found in the appendix of this thesis. This first session started by introducing the Lean attitude of creating value for the customer while always considering the whole value stream. After comparing the normal ratio of value to waste in a non Lean process (figure 3-15), the 7 Wastes where defined with examples of possible occurrences on the shop floor and ways of dealing with identified waste.



3-15 Waste to value added ratio

In addition the team was reminded of the importance of Standard Work in a process. They had already had some exposure to the topic during the Standard Work project, but as mentioned earlier, repetition of all Lean ideas is necessary to create a change in how people think about problems. Following the Lean training, the group moved to the shop floor to examine the process at the 4180 cell. The operators showed the rest of the team the new standard procedures and how the material moves through the cell. They also pointed out all the ancillary activities like checking the quality, replenishing the raw material stock or machine maintenance related work. The whole group then spent 20 minutes around the cell taking notes on possible improvements, while the operators took turns in running the process. After returning to the meeting room, every team member got the opportunity to propose some improvement ideas, which were stored in a list that had already been started during the Standard Work project. The last action of this meeting was for every team member to rate the improvements on their importance before leaving the meeting room.
The following list shows the opportunities ranked after improvement amplitude, stating with the most important improvements:

1) ½ h quality check (base flatness and perpendicularity) keeps the worker from getting into a productive flow.
    - Is the quality check necessary?
    - Can the frequency be reduced?
    - Can somebody else do it?

2) 3x big quality check has the same effect + it takes time to bring the cylinders down to inspection
    - Is the quality check necessary?
    - Can somebody else do it?
    - Can somebody else take the cylinders down to inspection?

→ The measurement requirements have to be redefined

3) The lathe machining time is too short to do something else but too long to just wait next to the machine.
    - Can the operation be shortened?
    - Can the door open automatically?
    - Can the lathe work without coolant to reduce the cleaning time afterwards?

4) The setup time for OP 10 is currently at 2h (10 min for Lathe and the rest for setting up the two brothers e.g. making locator fit and measuring parts on CMM).
    - Can the setup time be reduced?
    - How can the logistic help by giving advance notice about which bore core will be next

5) Restocking and marking of cylinders with a color that indicates the shift consumes a lot of time
    - Increase the length of the conveyor band to hold more raw cylinders
    - Have somebody else restock and mark the cylinders whenever OPT 10 runs low
    - Use a visual cue to remind of restocking

6) The same thing goes for the empty baskets at the end of OP 10. The worker should stock enough baskets at the beginning of the shift to work for one shift without needing any new baskets. He should NOT move baskets from incoming to outgoing while he is working.
    - Should be included in a standard work instruction

7) The loading\unloading of the Brother machines takes a long time. This is mainly due to cleaning the part and the fixture
    - Can we clean more efficient with a flat nozzle?
    - Can we clean automated after the part is removed?
    - Can the clamp be lifted with a spring?
    - What is the cost of repairing the broken sliding door on BR4?

8) The workers use the baskets to elevate the one basket actually holding cylinders. This results in a lot of basket handling which costs time. It also makes the workplace less transparent and destroys the flow thinking.
    - Can we get tables with a height equivalent to the conveyor bands?

9) Cleaning the cylinder is done repetitively, after the lathe and before the brother.
    - Can cleaning be reduced to after lathe or before brother?
    - Which is preferred?

10) When the door of a brother machine opens, it does not indicate that the machine is waiting since a part is still being machined in the back.
    - Can an additional cue (timer or sound) be installed to let the worker know that there are 20 sec. left in the cycle and that he should load the parts?

11) Some workers use sandpaper once in a while to remove chips from the fixture.
    - Can this be avoided?

These opportunities where then discussed in the governing committee, where it was decided to split the group into two teams, one tackling the time consumption of the quality checks (opportunities 1 & 2) and one addressing the material flow issues within the cell as well as the raw material supply (opportunities 5,6,8,9). The issue of reducing the lathe time (opportunity 3) was given to the engineering department, to propose some solutions to the team in one of the future meetings.

The following group meeting started off with another Lean instruction on 5S and point of use storage, which can again be found in the appendix. Afterwards, the team was divided up into two groups, splitting the expertise as even as possible. Group 1, which was assigned to opportunities 1 & 2, also received assistance by an engineer from the quality department, who would be able to explain any questions about history and necessity of certain quality checks. Group 2 on the other hand received the supervisor, since many material flow issues could be addressed by him personally. In the following weeks the Lean champion has the duty to regularly check on the team's advancements, where he or she sometimes has to encourage the teams to follow the Lean spirit and make drastic changes just to see what the results are. He or she also needs to ensure that needed resources are available to the teams. The group meetings are continued with Lean teachings in the beginning and separate team work for the rest of the hour. The slides of the third meeting are also attached in the appendix and show a possible Lean game to demonstrate the advantages of One Piece Flow and Pull, which will only be believed by employees if it is experienced.

The results of the team projects will be presented in the conclusion of this thesis along with the improvements in output per shift. The job of the Lean champion after the two projects where finished was, as mentioned earlier, to find the most capable members of the group and develop them towards leading their own Lean improvement meetings in another cell. In the case of MAHLE, Trumbull, two individuals, an operator and one employee from the setup personnel, showed a far greater understanding and passion for Lean than the rest of the group. By reporting them to the governing committee, the Lean champion achieved to free up some of their time to get further involved in Lean activities. Lastly the Lean champion continuously used the info board to notify all other employees in the plant about the improvements made in the 4180 cell, which soon created a demand for Lean activities in other areas.

3.2.3 Job Rotation

The last method to encourage employee involvement that will be presented in this chapter is Job Rotation, which promotes operators to be “cross-trained” to work in more than one cell. According to Allwood and Lee, who investigated the impact of job rotations on problem solving skills, “Operators will increase their knowledge and feel focused, involved and motivated” (Allwood and Lee, 2004) when cross-trained on different machines. The idea is to extricate the operator from the daily routine of running the same machines every day. This can potentially improve the problem solving skills of the operators, but it can also cause insecurity in many cases. Many operators feel that their worth to the company is the ability to run a machine that no one else is able to run in the same manner. In the Standard Work chapter however, it already became apparent that it is not favorable to have specialists in a company, when continuous improvement is intended. The first hurdle in implementing Job Rotation is therefore to convince the specialists that a broader qualification is beneficial, without fueling the fear of becoming exchangeable in this new scenario.

- Cross-training allows the operator to help out, if there is a bottleneck.
- Cross-training enables the operator to switch to another process if the former process becomes obsolete.
- Cross-training helps to improve the process, because different views are acquired.
- Cross-training prevents injuries caused by reiteration.

These are all possible reasons to convince a reluctant employee to give cross-training a fair chance and see it as an opportunity. The real gain of cross-training however is, to get all employees more involved in the daily production problems. Cross-training reduces the boundaries that naturally exist between two cells by exchanging their operators. Future problems between those two cells will in most cases be handled entirely by the two operators without needing the supervisor as a middleman. As Ebeling and Lee stated, “Job rotation not only enables operators to learn a different task, but also gives them an overview of the production process” (Ebeling and Lee, 1994), which is crucial for continuous improvement as it is supposed to happen in a Lean conversion.

The design of a cross-training scheme however requires some detailed planning, which should be discussed in the governing committee. According to Park, who investigated different labor efficiency matrices, every operator should only be rotated to one additional task (Park, 1991). Further rotation will have little impact on the system performance while it definitely decreases the receptiveness of the employee and might lead to incomplete understanding of some of the processes. The important decision is which cells to cross-train in order to gain the highest benefits on the shop floor. In order to make these decisions, the governing committee should look at which cells are dependent on each other and often create material build up in between (bottlenecks). Cross-trained employees could help to reduce the build up by filling in for the other operator while he or she is taking a break or making quality inspections. Another way to look at the cross-training scheme is to match cells that do not have to necessarily run at the same time and/or are down a lot because of missing operators. Either way, once a cross-training plan has been set up, it is again important to communicate this visually on the info board. A matrix of all processes for example could be used to show which operators are capable to run which cells. This helps the supervisor in allocating operators when needed and increases the employee motivation, because their qualifications are visually displayed.

The 2.5 months at MAHLE in Trumbull were not sufficient to implement Job Rotation. The need was however acknowledged and some natural forms of cross-training could already be identified. In these cases, supervisors had trained certain operators in another cell in order to run it in case of sickness or material build up. This situation however clearly showed that a visual representation is necessary in order to inform everybody about the skills of each employee, because currently only the supervisor who administered the training knew about the new skills of some of the operators.

3.3 Continuous Improvement

According to “Implementing Lean Principles Kaizen and Kaikaku” (Bicheno, 1999), Kaikaku, the Japanese term for rapid improvement, has caught the attention of mangers due to its high gains in short time periods. The online search in the analysis part of this thesis however showed that this trend towards rapid improvement actions and away from continuous improvement cycles causes many Lean conversions to fail in creating a sustainable progress. There are, without a doubt, situations where a quick and drastic improvement is needed to either fix a critical problem or to demonstrate to the employees that nothing is set in stone but that everything can be changed if it improves the process. For long term sustainability, however, continuous improvement cycles are indispensible. The question therefore is how to ensure continuous improvement in an organization, so that it never stops to question its processes. Taiichi Ohno is often quoted stating that “every improvement start from the needs […] without people feeling the need for it, an improvement will not take its full effect nor be sustainable.” (1978). Creating the need for improvements is therefore a key element in a successful Lean transformation. This chapter will offer two methods of making the need for improvement visible and consequently ensuring continuous focus on improving processes.

3.3.1 Lean Accounting Approach

Among the Lean community, the idea of real Lean accounting is a controversially discussed topic. The beliefs differ on what Lean accounting involves. The tenor however is that conventional accounting methods as they are used in all common enterprise resource planning (ERP) systems do not offer the right data to make informed decisions on which processes to improve next. The first question to answer therefore is which roles accounting information plays in an organization and how this affects the implementation of Lean ideas. According to Grasso (2005), cost accounting information has three basic roles.

1) Financial reporting

2) Operational control and improvement

3) Decision making and planning

The financial reporting side of cost accounting focuses on providing auditable inventory valuations and income measurements for external financial reporting (Grasso, 2005). Operational control and improvement as well as decision making and planning on the other hand are internally focused roles of cost accounting that influence improvement activities like the ones proposed by Lean. Currently, conventional accounting methods focus mostly satisfy the financial reporting role, leaving managers with data that does not support their decisions on how and which processes to improve. A good example of this is Orest Fiume's description of a typical management meeting at The Wiremold Company, a manufacturer of cable and wiring, based in West Hartford, Connecticut. Fiume, at that time vice president of finance, who would lead Wiremold's conversion to Lean accounting in the 1990's (Cable, 2009), recalls that "after about 30 seconds, you could see everybody else's eyes glaze over […] because when you look at those statements, they're just unintelligible to anybody that doesn't have a degree in accounting.". He realized that the data he was feeding the managers did not allow them to think creatively about improvements. In fact the data actually hid most of the problems. The next question therefore is, what information cost accounting needs to offer managers to effectively satisfy part two and three of Grasso's list. The following adapted list from "Are ABC and RCA accounting systems compatible with Lean Management?" (Grasso, 2005) therefore compares the needs of Lean accounting to the standard accounting.

Lean Accounting	Standard Accounting
• Focus on cost reduction	• Focus on cost maintenance (actual = standard)
• Create new targets monthly	• Set standards annually
• Propose improvements to satisfy targets	• Variance analysis to eliminate the source of deviation
• Track target achievements	• Track standard achievement
• Investigations when target reductions are not achieved	• Investigations when standards are not achieved

table 3-2 Lean vs. standard accounting

The table shows the current focus of cost accounting on standards compared to the Lean focus on targeted change. A Lean accounting approach therefore has to offer data that enables the managers to create targets on the base of eliminating costs, track target achievement by comparing the data from previous months to the current and, if necessary, investigate on the reasons why the improvements did not meet the target.

When Lean became popular in the United States in the 1980s, the answer to many of these problems was found in activity-based costing (ABC), which greatly improves cost accuracy and precision (Schonberger, 2008). These ideas are still valid today, but have lost a lot of attention after the first hype passed.

ABC identifies activities in an organization, similar to value stream mapping in Lean. It then assigns costs to every activity and links the activities to certain products. By doing this, it turns a lot of costs which were previously allocated as overhead into direct costs that are linked to a specific product. This way, a manger can see a more realistic cost of each individual product and therefore identify areas of improvement, by looking for the most cost intensive activities. According to Grasso, after Robin Cooper and Robert Kaplan had introduced ABC, "case studies reported astonishing differences in reported product costs, […] which led to dramatic improvements in profitability and competitiveness for some U.S. firms.".

The procedure however also has some valid points of criticism. Once several products use common resources to different extends a weighting method needs to be used to allocate the costs properly. This weighting method is commonly referred to as "cost driver", for which the accountant has to make certain assumptions about the use of the activity by each product. The methods used to allocate the activity costs to the products over time became very complex and created a lot of extra work for the accounting departments. In addition, even ABC is not able to assign every cost to an activity and therefore has to collect some overhead costs in a central account that is not assigned to any products but nevertheless has to be settled with income from all the products. In this case many argue that these costs need to be in some way allocated to the products, but they fail to see that the idea of ABC is to provide information to management (Wikipedia, 2009), which makes it unnecessary to forcefully assign costs to products that do not add any valuable information. Another reason why ABC started to get a bad repetition is because of how managers made use of the data. The allocation of fixed and variable costs to activities can foster the thought that by eliminating a product that is not profitable, the costs are eliminated as well. In reality however, fixed costs such as the rent for the plant or the cost of equipment and "sticky" variable costs that do not decrease one-to-one with the reduction in product such as the number of employees, are now spread over the remaining products, making them more expensive and therefore less profitable. This starts, what is often referred to as the "death spiral" in which managers remove or outsource one product after another, trying to get more profitable overall but in reality running the plant out of business.

Since the 1980s, the methods of ABC have evolved, while at the same time other cost accounting methods emerged, such as the flexible margin costing, which was adapted from a German method called Grenzplankostenrechnung (GPK) or resource consumption accounting (RCA), which tried to combine the best aspects of ABC and GPK. In the long run, however, studies show that 80% of all organizations in the United States are still using traditional cost allocation systems (Grasso, 2005). This is mostly due to the influence of major ERP suppliers such as SAP, whose systems use those traditional allocation systems and the mentioned extra work for accountants created by producing the ABC reports. The Lean champion therefore has to request the fabrication of these reports in order for the governing committee to make the right decisions. Without the information that ABC or any other shop floor oriented accounting method offers, improvement decisions will focus on the wrong processes or topics and therefore lead to a failure of the Lean implementation as a whole. ABC helps in finding the real waste and starting improvements projects that eliminate it. It also offers the possibility to follow up on implemented changes and asses the improvements. Activity based costing can therefore be seen as the motor that continuously drives improvement by showing wasteful expenditures.

For more information on ABC and how the accounting system affects the decisions on the shop floor please refer to the works by Paul A. Sharman or Robin Cooper and Robert Kaplan, since the magnitude of explaining the accounting details would go beyond the scope of this work.

At MAHLE, Trumbull the accounting department was involved as soon as the governing committee formed, because for the reasons mentioned earlier, the current financial information did not support the decisions that the governing committee was planning to make. After discussing these needs with the accounting department, a cost structure was created that used the ideas of activity based costing by allocating the expenses to different processes in the plant. Due to current lack of information and because a true ABC cost structure takes a lot of time to assemble, the rules of ABC where not followed closely. The result (figure 3-16) however offered a lot more insight into the costs of production and where to start improvement projects. From this list, two areas of improvement where identified. The use of chemicals and oils, which generate costs twice because their disposal is expensive as well and therefore account for about $125,000 per month, where to be analyzed and reduced as much as possible. The same was decided for operating supplies such as tools and oil filters, which account for about $60,000 per month but where currently replaced at random with no standard lifetime. Both projects will analyze the standard lifetime of the oil, the tool or the filter and create a routine that regulates the exchange of these resources. In a couple of months these changes should become evident in the cost structure. Currently, the governing committee is planning on a 30% decrease in both expenses, which would translate into savings of about $650,000 per year. Once these goals are met, the committee can analyze the cost structure again and focus on a new issue, while going from large costs towards the smaller expenses as the Lean efforts progress. One issue the new cost structure does not help to address yet is the cost of each production step. This would make the design of specific Lean projects possible which target the most cost intensive process cell. Over time, the governing committee together with the accounting department should work towards such a cost structure, which separates the costs of each process step and preferably allows the viewer to differentiate between products.

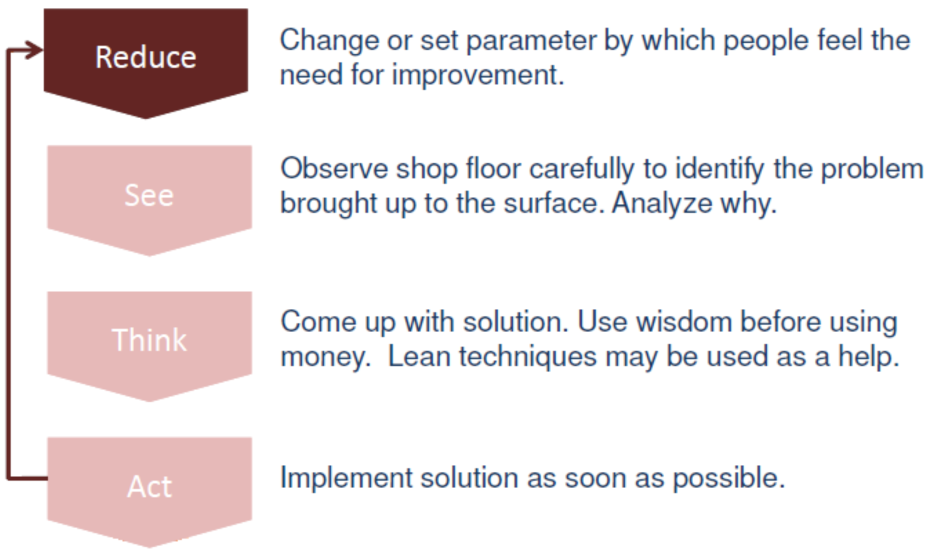
Good Pieces
Scrap
Total Pieces

	2008	2008	2008	2008	2009	2009	2009	2009	2009	2009	2009
Cost Elements	Sept Act.	Oct Act.	Nov Act.	Dec Act.	Jan Act.	Feb Act.	Mar Act.	April Act.	May Act.	June Act.	July Act.
420000 Production Labor											
421200 Overtime Wages											
417000 Temporary Labor											
Total Hourly Labor											
430000 Salaries											
405200 Fixtures & Tools											
405220 InspectionInstrumen											
405230 Chemical & Oils	96,665.52	107,382.35	86,656.12	89,258.47	77,738.54	55,123.02	71,085.37	67,695.19	74,575.79	57,806.77	60,501.23
Chemicals & Oils	23,094.40	24,696.71	31,575.99	44,631.69	50,618.40	31,629.97	41,305.59	30,514.96	50,295.36	43,711.68	28,718.99
Nickel @ std + PPV	74,661.73	84,476.19	56,197.76	45,515.63	28,189.00	23,907.44	30,311.22	38,594.74	25,784.22	14,905.91	31,782.24
Nickel Recovery	1,090.61-	1,790.55-	1,117.63-	888.85-	1,068.86-	414.39-	531.44-	1,414.51-	-1,503.79	810.80-	
405240 Prot. & Safe Device											
405245 Unif. & Safety Clot											
405290 O. Operat. Supplies	68,163.84	46,084.25	47,435.44	39,765.92	56,054.02	65,018.82	53,277.57	66,252.30	58,233.99	59,826.06	35,895.18
Diamonds	33,290.87	25,751.33	21,238.93	19,924.06	25,615.02	32,279.00	22,404.48	17,472.16	30,670.26	31,079.61	14,829.35
Other Operating Supplies	34,872.97	20,332.92	26,196.51	19,841.86	30,439.00	32,739.82	30,873.09	48,780.14	27,563.73	28,746.45	21,065.83
405500 Office Supplies											
405520 Computer Supplies											
417010 Environmental Charg	29,017.79	26,736.34	20,647.02	25,182.68	13,415.97	18,626.66	14,853.63	21,586.23	14,219.82	11,828.88	9,249.04
Waste Oil and Coolant disposl.	14,620.55	16,570.66	9,404.58	14,363.25	6,019.77	9,763.10	11,207.85	14,513.31	7,935.83	6,035.67	7,584.86
W Water testing and sludge removal	14,397.24	10,165.68	10,165.68	10,819.43	7,396.20	8,862.58	3,645.68	7,072.92	6,283.99	5,793.21	1,664.18
417095 Training, Seminars											
Sewer Taxes											
417130 Incoming Frght Land											
[illegible]00 Outbound LandFreigh											
[illegible]010 Outbound Air Freigh											
473000 Postage											
474100 Travel & Entertainm											
474210 Non Deduct. Travel											
452010 Maint. Machines Ext											
451010 Maint. Building Ext											
451100 Maint. Admin. Ext.											
452020 Rep. Parts Machines											
452120 Maint. Mold Build											
416100 Utilities Electric											
416300 Utilities - Water											
416400 Utilities - Gas											
* Debit											
*Total											

3-16 Activity Based Costing at MAHLE

3.3.2 Contingency Approach

Another method of making the need for an improvement visible when it does not become apparent during regular production is to intentionally create an emergency. Crises in the past decades have proven to help companies evolve in a way that would not have happened otherwise. The idea of Lean would have never evolved if Toyota was not forced to adapt to a new market situation. “Implementing Lean during a Crisis” (Lewis and Pinette, 2006) therefore suggests that a crisis is a great accelerator in Lean conversions. Womack and Jones mention this approach already in Lean Thinking (Womack and Jones, 2003) and suggested the creation of small emergencies to create the need for improvement on the shop floor level. They however did not offer any ideas on how to create and handle such “management-made” emergencies. Yuji Yamamoto expanded on this thought by creating a circular approach to creating improvement through contingency (figure 3-17), similar to the Plan Do Check Act (PDCA) cycle of Deming. Yamamoto’s ideas resulted from direct observation of two small companies (130 – 150 employees) during their Lean transformation by a TPS consultant. His objective was to identify a “red thread” that the consultant follows throughout the transformation (Yamamoto, 2009). What he found was a cycle based on four steps, where the reduction of an important process parameter always triggers a new improvement project.



3-17 Contingency approach

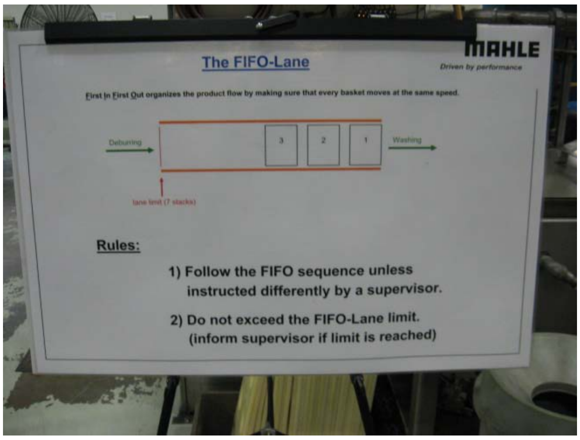
The steps that follow the reduction of the process parameter are the ideas that have already been discussed during the discussion of Kaizen in this thesis. The choice of the process parameter however is the important issue of this approach to continuous improvement. It depends on the need of the production cell, but usually is either related to a decrease in the work in process (WIP) or the TAKT time in which a part has to be produced. A third approach that is often facilitated is the focus on defect detection after every process step, thereby creating a visual indication for the source of the quality problems. All these situations create a tactile sense of urgency on the shop floor where “people have no choice (or little choice) but to feel the need for improvement” (Yamamoto, 2009). Decreasing the TAKT time translates into increasing the required output, which does not need extensive prearrangements. Decreasing WIP however needs to be planned more carefully in order to assure enough transparency to catch problems early. An efficient method of making WIP visible is the First In First Out (FIFO) line. Originally a technique to organize data in the field of computer science, TPS applied the idea to the shop floor in order to create a self-controlled product queue. By putting a FIFO line in front of every process cell, the product flows continuously through the value stream, which offers several benefits. Defective products can be traced back more easily because sequence which has been created in the first process step is still intact and, if some cells in the value stream are shared among different products, the supervisor does not need to specify which product to run, since the natural sequence controls the flow. In regard to increasing the transparency, FIFO creates a universal order throughout the shop floor and does not allow for any “hidden” WIP.

During the implementation phase of FIFO, movable dividers can be used to mark the lines until their final position and length is determined. The dividers should however be physical in nature and not just painted on the ground since the painted version usually calls for a lot more supervisor intervention. Before setting up the FIFO lines, a team consisting of the Lean champion, a representative from the production planning department and the supervisor should estimate the needed length of the line by taking into account how many parts the subsequent cell processes per hour and how many hours of work should be allowed to stack up before an intervention of the supervisor is necessary. The result defines the length of the FIFO line, which should not be exceeded. While at the production cell, the team should also include the operator in order to carry on the idea of employee involvement. Once the FIFO line is set up, training for all the affected employees needs to be held to explain the idea and the rules of FIFO. For further reference these ideas and rules should in addition be posted close to the FIFO line.

Unorganized WIP often hides bottlenecks or slow setup procedures. In the effort of making these problems visible and thereby creating a sense of urgency to improve, FIFO helps to organize the existing WIP. In a next step, the governing committee can decide to reduce the process parameter WIP, as suggested by Yuji Yamamoto. Because every cell now has a dedicated area for its production queue it is fairly easy for the supervisor to identify which cell runs low on material and which cell cannot keep up with the pace. On the base of these observations the need for improvement becomes visible for both the supervisor as well as the operators. New Lean projects can be created to examine the process steps and identify the reasons that cause one cell to be slower than the other. In this manner the contingency approach ensures a continuous source of improvement possibilities and in the case of WIP reduction also creates major cost reductions since the company is no longer capturing its money in large amounts of unfinished products.

At MAHLE in Trumbull the search for the next Lean project facilitated the ideas of the contingency approach as well. In a first step, FIFO lines where set up along the 4-stroke value stream. Yellow dividers where used (figure 3-18) to establish the provisional FIFO lines and all operators where informed about the advantages of FIFO and its rules. The rules were also visually displayed at the FIFO line for future trainings (figure 3-19). Through the implementation of FIFO lanes, the dimensions of the current WIP became visible. Before, the amount of WIP was only evident in the production data but not on the shop floor. During the following weeks, the supervisors reduced the WIP by not running some of the machines full time until every FIFO line was within its predetermined boundaries. Afterwards the value stream was observed closely for increases or decreases in the FIFO lines. Soon, the first bottlenecks arose, most of which were pointed out directly by the operators. The governing committee now had evident data on where to start the next improvement projects and at the same time had preset employee involvement in the problem since it was evident on the shop floor.

3-18 FIFO lane at MAHLE



3-19 Visual display of FIFO rules

4 Discussion and Conclusion

This thesis proposed that a set of reasons are responsible for the high failure rate in sustaining Lean improvements among manufacturing organizations. Through the analysis of the TPS teachings, an online search of expert views and the study of a manufacturing plant in Trumbull, the reasons identified where missing standards, a lack of employee involvement and rapid instead of continuous improvement. Following the analysis, countermeasures to address each one of the failure reasons were offered, proposing that incorporating these countermeasures into a Lean implementation will improve its sustainability considerably. The conclusion will now assess the effectiveness of the proposed countermeasures on the MAHLE production plant in Trumbull as well as summarize the findings of this thesis on how to sustain Lean improvements.

4.1 Results at MAHLE

The 2.5 months internship at MAHLE presented the opportunity to offer real life examples of the countermeasures for this thesis but the question remains whether the proposed countermeasures actually affected the sustainability of the improvements made during this time.

After introducing Standard Work to the 4180 cell and running the first Kaizen event with the group of operators and setup personnel, the output per day increased by over 70% from 700 to 1200 cylinders per day, thereby exceeding the requirement of 1050 pieces, which had been calculated by management when planning the layout changes. At the end of the internship, after running further Kaizen events and introducing activity based costing, the accounting department was able to evaluate the cost per cylinder with and without Lean improvements (figure 4-1) by comparing the current cost with data from before the Lean implementation.

4-1 Influence of Lean on cost per part

Although the real cost data cannot be revealed in this work, the graph shows that the cost after Lean improvements (red) is consistently below the corresponding value for non Lean production (blue), independent of the units per month, which naturally have an even greater influence on the cost.

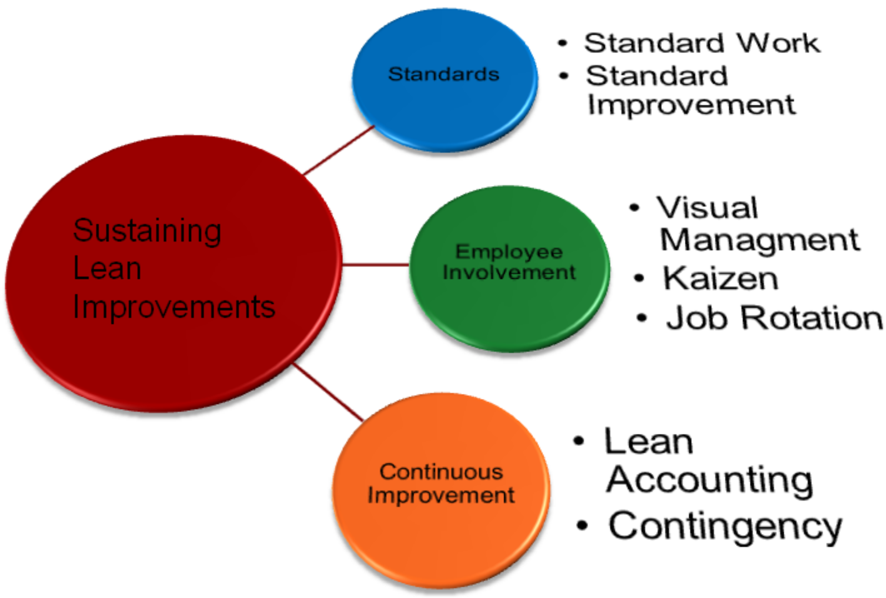
These improvements were achieved in just 2.5 months, although or distinctly because a lot of time was devoted to base creation and employee involvement. The effect of investing the time to create standards and discussing the Lean improvements with all affected employees resulted in a high employee buy-in into the Lean ideas and created an environment where improvements could easily be implemented and sustained, since all operators worked according to standards that they believed in. At the same time, the continuity of improvements was supported by creating a demand through WIP reduction and the introduction of activity based costing as well as through a motivated governing committee. While benefits like these are difficult to express in numbers, the positive feedback of operators, supervisors and upper management expressed during the internship suggests that the implementation was run in a way that served the needs of the shop floor as well as the management level.

When returning to Trumbull about 4 months after the end of the internship, the feelings towards Lean had not changed and all the implemented changes where still intact or even improved, which, when compared to other Lean implementations is an obvious step towards sustainability of these improvements. Since the thesis ends at this point, there is no long term data on the sustainability of the improvements at MAHLE. However, the indications above prove that the advocated approach is able to create improvements in a relative short period of time and simultaneously ensures the sustainability through standardization, involving employees and continuity.

4.2 Sustaining Lean Improvements

This thesis focused on three aspects during a Lean implementation which, due to a lack of literature on these topics, are often disregarded, leading to short term improvements that cannot be sustained over a longer period of time. As figure 4-2 shows, the thesis proposed that sustaining Lean improvements depends on three aspects: standards, employee involvement and continuous improvement. Figure 4-2 also shows the basic tools that this thesis linked to the individual aspect.

In order to create standards, one should implement Standard Work all across the shop floor and in addition use Standard Improvement to ensure that further development will not distort the standards. In order to achieve employee involvement, the thesis suggested visual management tools to empower every employee by making information available as well as Kaizen events to teach employees about Lean and train their problem solving skills. In conjunction with Job Rotation, which enables the employees to cooperate on problem solutions, these tools ensure thorough employee involvement which will increase the buy-in into the Lean improvement ideas and thereby make them more sustainable. At last, continuous improvement supports the sustainability of Lean implementations by constantly challenging the current state process, thereby not allowing for a loss of focus on the already implemented changes. The two tools that this thesis offered to create a constant focus on new improvement possibilities are Lean Accounting and the contingency approach.



4-2 Key elements to sustain Lean improvements

A Lean implementation that includes these key issues will not automatically succeed in creating sustainable Lean improvements, but following these ideas and making sure that all three aspects are attended will ensure a more stable implementation with higher chances of sustainability. The time it takes to implement each one of these tools depends on various factors and will most likely not be same in any two companies. The current level of employee motivation which is often influenced by previous attempts to implement similar ideas, affects the implementation speed significantly. As can the fact that a plant is unionized or not as mentioned in the introduction. The idea of this thesis however is that the three key elements need to be thoroughly introduced before any other Lean tools can be successfully implemented. A Lean champion should therefore constantly keep these elements in mind and check the progress in those areas. When struggling with one of the elements, the Lean champion should know that skipping one element is not an option, since it endangers the sustainability of the whole Lean implementation. Instead, he or she can resort to the ideas offered in this thesis on how to successfully implement the particular element. Pointed in the right direction, the literature offers a vast amount of information on all three elements for the Lean champion to read. Their relationship in ensuring sustainable Lean improvements however, has never been stated as clearly as in this thesis.

5 Table of figures

6 Table of tables

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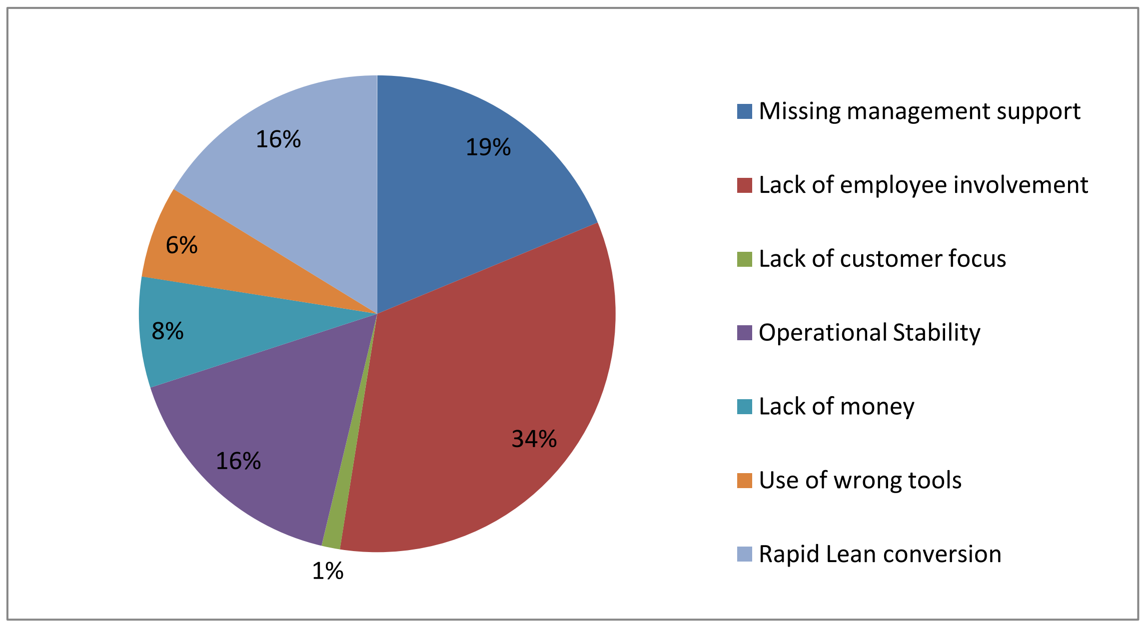
8 Appendix

- Online Search Results
- Online Search References
- PPT slides of 1st Kaizen event at MAHLE
- PPT slides of 2nd Kaizen event at MAHLE
- PPT slides of 3rd Kaizen event at MAHLE

Online Search Results:

Reasons / Sources	perc	total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Missing management support	19%	15	1	1			1			1		1	1	1			1	1		1	1		1						1			1		1
Lack of employee involvement	**34%**	27	**1**	**1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**1**	**1**	**1**	**1**			**1**	**1**	**1**	**1**	
Lack of customer focus	1%	1	1																															
Operational Stability	**16%**	13		**1**			**1**	**1**			**1**				**1**	**1**			**1**					**1**			**1**	**1**			**1**		**1**	**1**
Lack of money	8%	6	1									1	1								1						1		1					
Use of wrong tools	6%	5			1												1				1		1					1						
Rapid Lean conversion	**16%**	13								**1**	**1**						**1**	**1**	**1**		**1**	**1**	**1**	**1**		**1**				**1**			**1**	**1**
	100%	80																																

Search input: reasons, lean, failure | lean, implementation, problems | lean, mistakes | gründe, lean, scheitern



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(accessed between Aug. 3rd and Dec. 8th 2009)

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PPT slides of 1st Kaizen event at MAHLE:

MAHLE
Driven by performance

Learning about Lean - part 1
July 14, 2009

Christopher Schlichting

Objectives

MAHLE
Driven by performance

- Round of Introductions (+ Lean experience)
- The Lean attitude
- The 7 Wastes
- Standard Work
- Review of implemented changes

Thinking Lean

MAHLE
Driven by performance

- Difficult times ask for new approaches.
- We redesigned the shop floor after the lean ideas (cell design).
- In a second stage all employees need to understand the ideas behind Lean:
  - Value added vs. Waste
  - See the process through the customers' eyes
  - Actively take responsibility for results
- We chose the 4180 cell because
  - It serves our highest demand from STIHL.
  - We believe that the operators in this cell will make good use of the Lean ideas.

Lean attitude

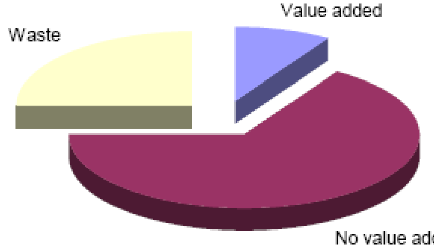
MAHLE
Driven by performance

- Create **value** for the customer.
- Always consider the whole **value stream.**
- Implement **flow** into the processes.
- Striving for **continuous improvement.**
- Control processes with a **PULL** system based on customer Takt.

Waste

Driven by performance

- Anything that consumes value, without creating value:



The 7 types of waste (cont.)

Driven by performance

5) Inventory
   - Between lathe and brothers

6) Motion
   - Work routine

7) Defects
   - Quality checks

The 7 types of waste

Driven by performance

1) Overproduction
   - Late change over

2) Extra Processing
   - Register depth

3) Transport
   - Cell design

4) Waiting
   - Cell design

Getting rid of Waste

Driven by performance

- See waste wherever it occurs.
- Identify it as a problem, do not accept waste as a given!
- Creativity for problem solutions.
- Best practice solutions (standard work).

Standard Work

MAHLE
Driven by performance

- Ensures that everybody is working in the most efficient way known today.
- Permits improvement through all shifts and cells.
- Eases the search for quality problems caused by the operator. (either everybody is doing it wrong or nobody)
- Enables untrained personnel to understand the process quickly. (engineering or substitution during sickness)

Standard Work Board (cont.)

MAHLE
Driven by performance

- Continuous Improvement
  1) Think of an improvement
  2) Discuss with supervisor
  3) Test for one week
  4) Check improvement
  5) Implement in all shifts through Standard Work board

Standard Work Board

MAHLE
Driven by performance

- Work Cycle
  - Different Work Routines in comparison
  - Most efficient routine was chosen
- Other Work Instructions
  - Quality Checks
  - Cleaning

Review of implemented changes

MAHLE
Driven by performance

- Floor Mats (operator)
- Lathe time reduction (operator / engineering)
- Tables and board instead of baskets (engineering)
- New entrance / exit (operator / engineering)
- Reduction of non value added time
  - Quality checks (operator / engineering)
  - Raw cylinder supply (engineering)

PPT slides of 2nd Kaizen event at MAHLE:

MAHLE
Driven by performance

Learning about Lean - part 2
July 21, 2009

Christopher Schlichting

MAHLE
Driven by performance

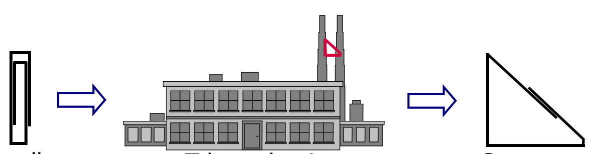
Objectives

- Round 1 of the paperclip game
- Review of the 7 wastes and standard work
- Introduction of one piece flow and pull
- Round 2 of the paperclip game

MAHLE
Driven by performance

Triangular, Inc.

- Manufactures metal triangles in two sizes.
- 8 employees are needed to run production
  - 5 operators
  - 1 quality inspector
  - 1 carrier
  - 1 warehouse



MAHLE
Driven by performance

Role distribution

- Raw material supplier
- OPT 10 operator
- OPT 20 operator
- OPT 30 operator
- OPT 40 operator
- OPT 50 operator
- Quality inspector
- Carrier
- Warehouse
- Customer

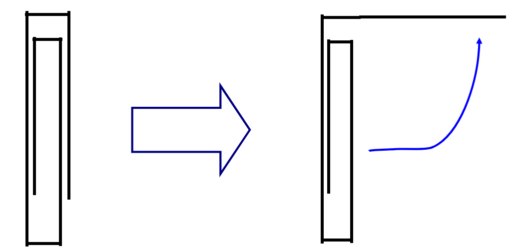
Rules of Round 1

Driven by performance

- Customer orders in lots of 4 per size
- Customer orders every minute
- Manufacturing lot size is 5
- Supplier ships bulks of 11 per size
- Parts can only be moved by carrier
- The Round will run for 10 min.

OPT 10 Standard Work Chart

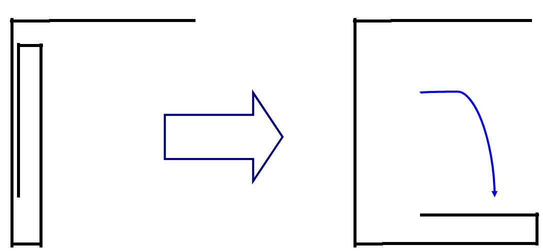
Driven by performance



Lot size is 5

OPT 20 Standard Work Chart

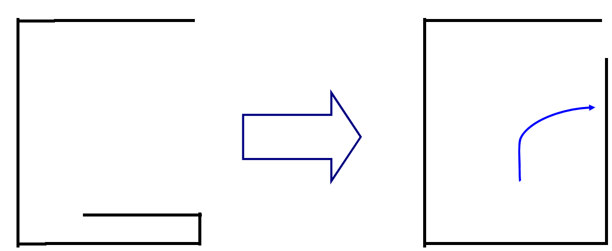
Driven by performance



Lot size is 5

OPT 30 Standard Work Chart

Driven by performance



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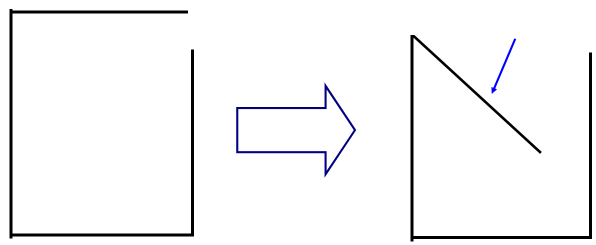
OPT 40 Standard Work Chart

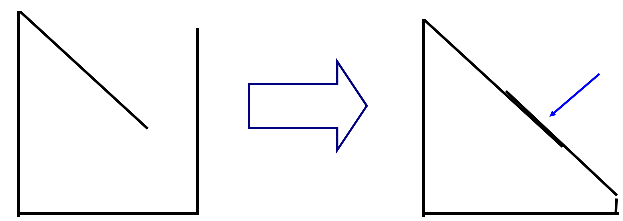
MAHLE
Driven by performance



Lot size is 5

OPT 50 Standard Work Chart

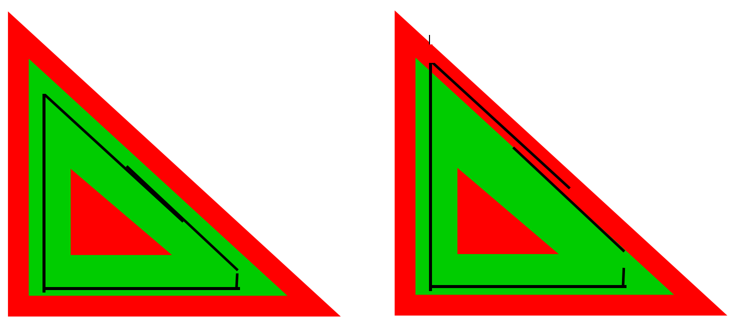
MAHLE
Driven by performance



Lot size is 5

QC Standard Work Chart

MAHLE
Driven by performance

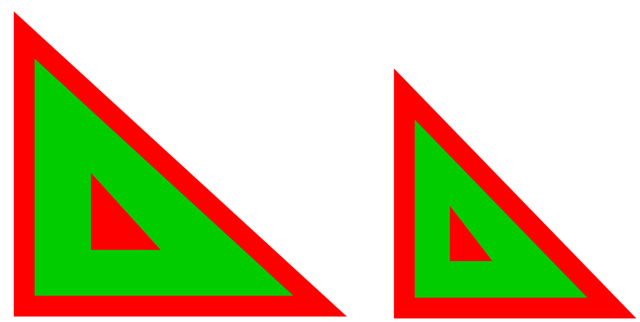


OK

not OK

QC Check

MAHLE
Driven by performance



big triangle

Small triangle

Results

MAHLE *Driven by performance*

Round	1	2
Raw material		
WIP		
Finished goods		
Total inventory		
Parts sold		

Improvements

MAHLE *Driven by performance*

- ____________________________
- ____________________________
- ____________________________
- ____________________________
- ____________________________

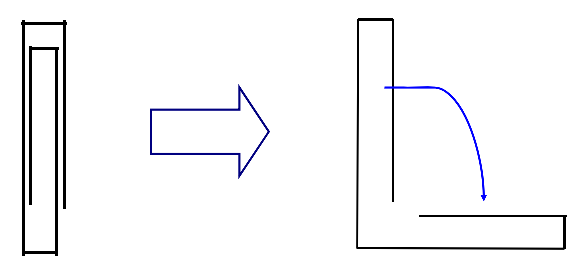
Rules of Round 2

MAHLE *Driven by performance*

- Customer orders in lots of 1 per size
- Customer orders every 15 sec. (4 per minute)
- Manufacturing lot size is 1
- Supplier agrees to ship just in time (1 part per shipment)
- Machines are close together so carrier is only needed at the beginning and at the end of the production line.
- The Round will run for 10 min.

OPT 10 Standard Work Chart

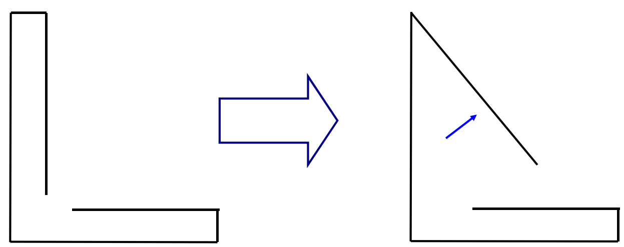
MAHLE *Driven by performance*



one piece flow

OPT 20 Standard Work Chart

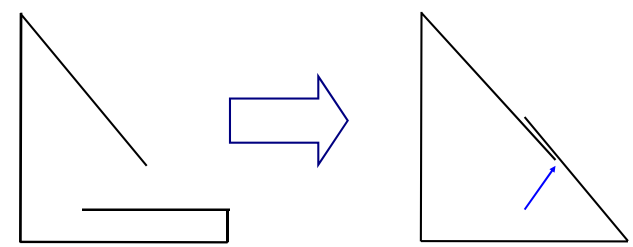
Driven by performance



one piece flow

OPT 20 Standard Work Chart

Driven by performance



one piece flow

PPT slides of 3rd Kaizen event at MAHLE:

MAHLE
Driven by performance

Learning about Lean - part 3
August 6, 2009

Christopher Schlichting

© MAHLE

MAHLE
Driven by performance

Objectives

- Repeating the 7 Wastes
- Introducing 5S and point of use storage
- Walking the floor (around OP 10) to observe the flow

MAHLE
Driven by performance

The 7 types of waste

1) Overproduction

2) Extra Processing

3) Transport

4) Waiting

5) Inventory

6) Motion

7) Defects

MAHLE
Driven by performance

5S

- **Sort -** All unneeded tools, parts and supplies are removed from the area
- **Set in Order -** A place for everything and everything is in its place
- **Shine -** The area is clean before work is performed
- **Standardize -** Cleaning and identification methods are consistently applied
- **Sustain -** 5S is a habit and is continually improved

- Setting everything in order is one thing, but it also has to be close to where you use it:

Let's walk the value stream!

Comments: