Implementation methods of Lean Management with practical exercises in automotive factory

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
Ing. Pavol Strýček, PhD, MBA

Ing. Norbert Zimerman

1227690

Vienna, 18.09.2014

Affidavit

I, **NORBERT ZIMERMAN, Ing.**, hereby declare

1. that I am the sole author of the present Master's Thesis, "IMPLEMENTATION METHODS OF LEAN MANAGEMENT WITH PRACTICAL EXERCISES IN AUTOMOTIVE FACTORY", 88 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 18.09.2014

Signature

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I would also like to thank the participants in my survey for their time for filling in the questionnaires, as well as to the people participating in my Lean game trainings and for their support during trainings.

Last but not least, I want to thank my family: my wife Jana for supporting me spiritually throughout my whole MBA studies and my children who helped me to prepare and test lean games for my practical part.

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List of abbreviations

AM: Autonomous maintenance

BC: Brace Control

CIP: Continuous Improvement Process

HR: Human Resource

KB: Knorr Bremse

KMS: Knowledge Management System

KPI: Key Performance Indicator

KPS: Knorr Production System

LM: Lean Management

LT: Lead Time

MBA: Master of Business Administration

MTM: Methods-Time Measurement

PDCA: Plan Do Check Act

PI: Process Improvement

OEE: Overall Equipment Efficiency

OEM: Original Equipment Manufacturer

OPF: One Piece Flow

QM: Quality Management

JIS: Just In Sequence

JIT: Just In Time

SMED: Single Minute Exchange of Die

TPM: Total Productive Maintenance

TPS: Toyota Production System

VSD: Value Stream Design

VSM: Value Stream Mapping

Abstract

The fastest and most effective way of training employees in the method of lean production is to create your own image from the experience obtained during the training. In the current turbulent times it is not possible for a worker to participate in the implementation of lean manufacturing to obtain a perfect practical knowledge and on the other hand, only a theoretical training without practical implementation is often not effective. Therefore, a combination of theoretical knowledge of lean methods with a practical training using simulation games on created model situations came into existence. Based on practical simulation exercises a lean game training (also called as an experiential method) results in a better learning of theoretical knowledge.

The aim of this Master's Thesis is to propose and create simulation exercises i.e. lean game trainings for selected methods of lean manufacturing in automotive companies; to examine the effectiveness of trainings and lean methods and implement them into practice by training employees using lean games. In the theoretical part, selected methods of lean production and lean administration are described. Forms of learning within the enterprise and training methods for employees by implementing Lean Management and Lean tools are also pointed out.

The practical part of this Master's Thesis is focused on finding the current status of Lean tools used in the selected company, to find out the knowledge level of employees about Lean tools and Lean Management. Based on the current state, a methodically specific training plan for employees using simulation lean games have been created. In the practical part, simulation lean games suitable for a particular type of production within the enterprise have been also created.

Created lean simulation games help employees to learn the practices and methodology of Lean tools in a short time, as well as their use by implementation in the processes. These simulation games can be helpful for all similar production companies or suppliers who want to implement and maintain lean manufacturing processes in the company.

Keywords: Lean Management, Lean Methods, Lean games, Trainings within the company, One Piece Flow, Lean Production, training modules

1. Introduction

Market behavior, customer requirements and competitiveness compared to the situation several years ago have changed dramatically. Today, sudden changes on the market and in business conditions are characterized by the rapid dissemination of information that brings chaos into traditional management methods. Traditional production planning and control is based on a detailed planning for several periods in advance, which is not possible nowadays.

A strong competition and efforts to dominate the market prevail between companies. To maintain leadership and market position the companies must have high-quality products at a competitive price. A satisfied customer is another important factor. No matter what type of organization or production you work for, there are always three important things that you need to fulfill to get a ticket in today's global competitive environment. Needs as well as customer satisfaction can be measured using three variables - Quality, Cost and Delivery time.

Figure 1.1 Three key factors for a customer (Northgrant Scaffolding: 2012, www.scaffoldingbristol.com/)

Quality means satisfying the requirements of customers, whether by manufacturing a product or providing services for the customer. If the quality is bad, the customer may complain about it or he can return the product back. For the manufacturer, this means additional costs, bad name or even loss of the customer. In today's supply chain, a bad product or semi product can cause a number of problems in the production process, stops in the line, additional repair costs, etc...

Cost – It is important to deliver affordable and high quality products to the customer. One of the preconditions to success is the optimization of costs. Companies are

trying to analyze their costs in manufacturing and non-manufacturing processes and optimize them so that they bring the greatest additional value. Elimination of waste is an important factor. It is one of potentials to reduce the cost of the product. Lean manufacturing is a good way to optimize costs. Lean manufacturing philosophy promotes the idea that all company activities bring value to the customer.

Delivery time - The customer requires the production and the delivery of products in the shortest possible time. Therefore, to reduce production costs, more and more companies start to implement the philosophy of Just in Time. Stocks are minimized to create flexible production and reduce costs during manufacturing of the product. Today's forecast is not accurate for a longer time period as customer requirements are changing in short periods of time.

Companies start to implement Lean Management and lean production elements into their processes to stay competitive on the market and be able to meet all customer requirements in a short time. If the implementation and use of these methods are to be effective we need to have a qualified staff at all levels in the company. Nowadays, companies are starting to realize that human resources are the most valuable element on which the business can be built. Continuous improvement of the potential of its own employees and at the same time quick training of new employees in production processes and corporate culture are the new conditions for staying competitive on the market. During implementation of Lean tools, a conflict between department leaders and employees arises. Superiors would like to see their subordinates to adapt immediately to changes in the company, because they have to meet customer requirements. Employees feel the need to undergo more training to be able to work efficiently using lean methods. One of the possible solutions for this situation is the creation of training methods for efficient training and education of employees using practical exercises.

1.1. Motivation

As mentioned in the previous section, production companies are subject to constant pressure for improvement, they are looking for new ways of how to improve their processes, shorten production and delivery time in order to be able to compete and become a market leader in the field.

For more than 10 years, I have been working for automotive companies and during this period, customer requirements as well as the market have changed completely. The customer wants to buy quality products at a lower price. Changes must be implemented into process in the shortest possible time. Global market players are expanding their production to other countries abroad to reach new markets and to fulfill new customer requirements.

During my career, I have been working for both OEM and tear 1 supplier. Mutual cooperation between OEMs and Tier 1 and 2 is so closely connected that now it is necessary to think and act globally, not just within the company.

Daily implementation of new Lean tools and improvement of Lean Management in the company become a more and more important factor in the company. I have attended a number of courses related to Lean tools as well as their implementation. During implementation, it is necessary to inform and train each worker of the team in the meaning of Lean Management, benefits and the reason why are these methods are implemented in the production. Mostly, I only met with theoretical training or short oral transfer of information.

During my MBA studies, we had lectures and workshops about Lean Management. Here, I met with lean game training. During the Six Sigma lecture with Mr. Strycek we played lean games to simulate Lean tools in practice. During the PPC Production Planning and Control lecture with Mr. Lölmann we simulated a work flow and work process of production using a lean game.

Then I started to think about a way how to apply the above-mentioned trainings in the company I work for now and how to inform and train people effectively in implementation of these methods into production. During an excursion in VW Bratislava, we visited an internal training center, where they had created various games to simulate production processes. We were shown and got acquainted with the training center and then we took part in practical exercises. After the workshop, there was a free discussion where we discussed various issues identified during these practical exercises.

Then I got the idea to create trainings using simulation exercises designed for production processes in the company I work for. This would be a good way to acquaint employees with Lean Management and to show them how lean methods work in practice.

1.2. Research focus and problem

The research focus of my Master's Thesis is the implementation of Lean Management system and Lean tools using lean game trainings in automotive company. The research problem of the thesis derives from the fact that company does not have a lot of time to organize trainings in Lean tools for their employees. On the other hand, it is very important to have Lean Management and use lean methods in the company. Therefore this Master´s Thesis is focusing on research of effectiveness of trainings in lean games on implementation of Lean Management and tools in the company.

1.3. Research questions

For research the following research questions have been developed:

- Which tools of Lean Management are the most important for the company?
- What is the task of each Lean Management tool?
- What methods there are to train or re-train workers and management by implementing Lean Management and tools?
- What are the benefits of using training in lean games and how it is implemented into practice?

1.4. Hypotheses statement

From my work and study experience and after reviewing the literature, the following hypotheses are identified:

- *Many companies are trying to implement or have already implemented tools for Lean Management, but it is difficult to use them or develop them further in practice.*
- *Many employees are not trained in Lean tools and methods. They do not understand why they have to use them.*
- *The fluctuation of employees and new employees being hired in the company is another problem. These people often do not get the lean production training and are not able to use Lean tools in practice.*
- *Nowadays, short and effective trainings for all employees are required. On the other hand, management does not want to release staff for a few days to attend trainings.*

- *In the literature, there are no precisely described procedures how to train staff in Lean Management and how to get the people familiar with these methods in practice.*

1.5. Research aim

Based on the hypothesis, I decided to focus in my research on the lean game trainings for employees in the company. I will research the effectiveness of these trainings for further implementation of Lean Management and Lean tools into company´s processes.

The research aim of my Master's Thesis is to analyze the current state of the company in the field of Lean Management and Lean tools and to develop lean games suitable for the company to help the management to implement Lean tools and train new staff and workers regularly or retrain them after a specified time period. This research is divided into 2 parts. In the first part, the information about actual state of the implementation and trainings in the company is reviewed. Using a survey in the form of short questionnaire I will try to find out the knowledge level of employees about Lean tools after evaluation of the current state, I have prepared suitable lean game trainings for the production and non-production departments in the company. The second part concerns the execution of lean game trainings with selected employees and subsequent evaluation of the success of these trainings. Created lean games help to get employees familiar with various methods of Lean Management and help them to use or implement these methods in practice or into production processes. In the last part of my thesis, I am proposing a training plan for the management and employees in order to implement lean methods properly as well as keep them in practice.

1.6. Structure of the Master's Thesis

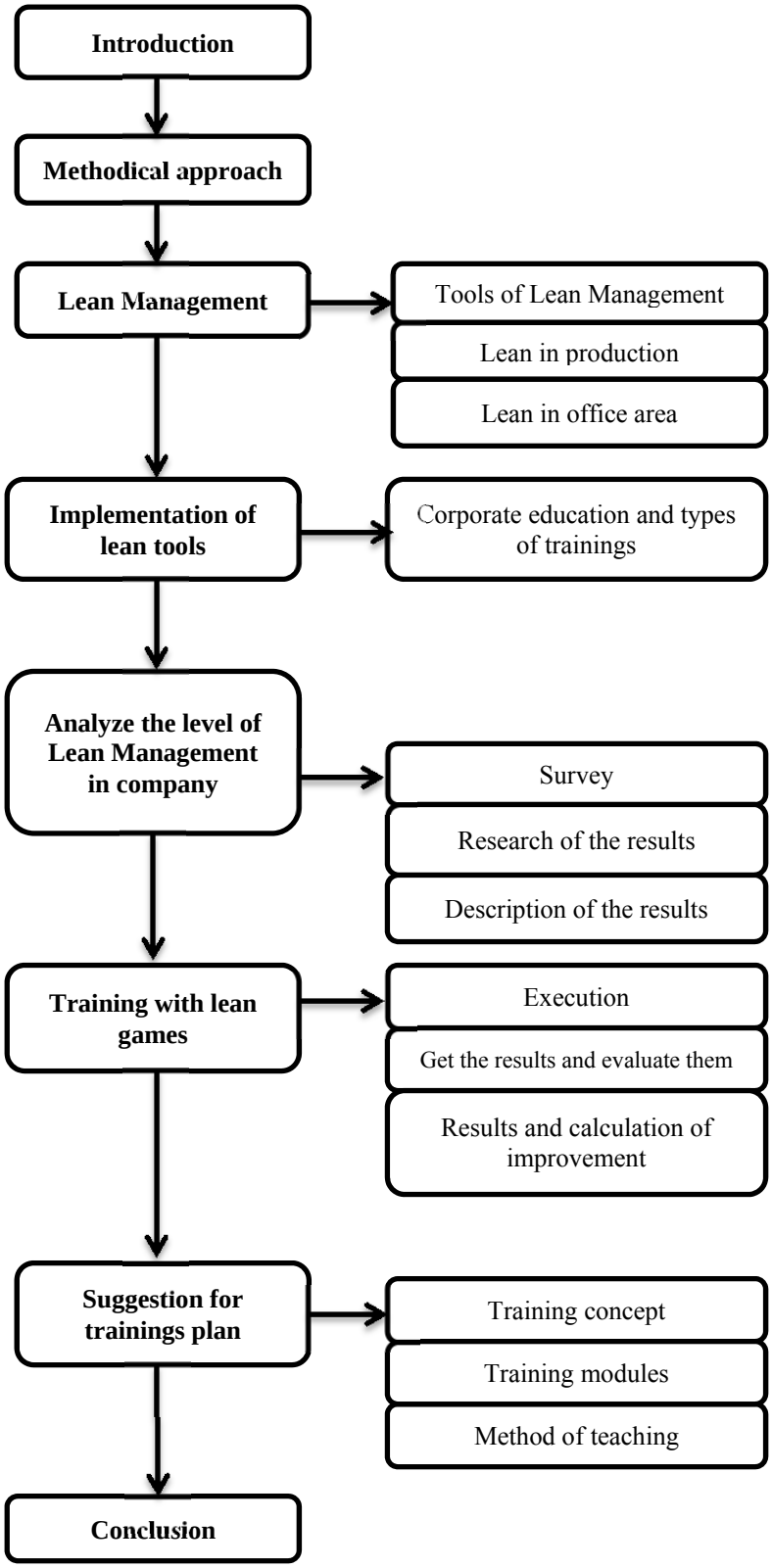

Figure 1.2 Structure of the Master´s Thesis

2. Methodical approach

2.1. Description of the methodical approach

In my Master's Thesis, I am using different research methods based on a theoretical method, descriptive method, analytical method and an analysis.

In the theoretical part of the research, I am mainly using descriptive and abstraction method. I am picking out the important Lean tools for the company and using a descriptive method to describe the meaning of each lean tool as well as the meaning in practice.

In the second part, I am using an experimental method. With empirical method, I have created a questionnaire to find out the current state of lean production (tools) in the company. Based on the result of the survey I have tried to create trainings using lean games. With questionnaires before and after executing lean games, I am using a comparative method to compare improvement of workers participating in training.

A more detailed description of this method is in the chapter 8.

2.2. Literature study and Information retrieval

I have gained a lot of information about Lean Management from my MBA Studies and from my work experience. A deeper knowledge of this topic was obtained from literature study. I have found a lot of discussions, articles, books and other literature in English, German and Slovak language in the library or on the internet. At the beginning, I did a research and collected a list of relevant literature. All literature and articles used in my Master's thesis can be found in the Bibliography section.

3. Lean Management

Lean Management (LM) deals with creation, implementation and improvement of an integrated system of people, materials and equipment for the benefit of humankind. Lean Management and Lean tools play a major role in increasing the efficiency, productivity and improvement of the quality and work processes in the organization.

The main objective of Lean Management is to increase productivity by eliminating waste, reducing or removing operations, which do not bring value, and to improve the efficient usage of resources.

Lean Management is derived from the Toyota Production System (TPS). TPS is still improving after a period of forty years. It began with efforts to reduce the time for the exchange of tools for stamping presses, consequently reducing stocks and finally passed to the philosophy of inventory management called Just-In-Time (JIT). This led to a lower need for warehouse space, fewer forklifts, eliminating wasted space, etc. Lean is the elimination of waste. But more importantly, Lean is a continuous improvement at all levels of work processes.

Lean can be defined as a target moving ahead, because it is its heart. Lean is a process of learning and improvement. Lean Management cannot be defined as something that is permanent or fixed. It is continuously improving process.

- *Lean is a culture of continuous improvement practiced at every level of the organization and by every team.*
- *Lean is respect for people. It is respect for the voice of the customer and it is respect for those who do the work, who are "on-the-spot" and are, therefore, the "world's greatest experts" in their work.*
- *Lean is the elimination of waste in all its forms. Lean is the ability to distinguish between work that actually adds value to your customers and work that does not. By eliminating waste, you have free resources to devote value-adding activity that serves your customers.*
- *Lean is a work environment that assures the quality and safety of all work for both customers and staff.*
- *Lean is a focus on improving the work process and not on blaming people or creating fear.*

(Lawrence M. Miller, 2014: www.lmmiller.com)

3.1. Tools of Lean Management

It is a comprehensive set of techniques that, when combined and matured, will allow you to reduce and then eliminate the seven wastes. This system not only will make your company leaner, but subsequently it will make you more flexible and more effective when reducing waste. (Wilson 2010: 9)

All activities in LM are oriented to reduce costs and improve production processes. A typical procedure for cost reduction is the reduction of personnel, personnel costs, work space and inventory. Without knowledge of the practice lean can lead to local optimization, what on the other side can often lead to an increase of the total cost of the company.

J. Košturiak wrote that "during cost reduction it is necessary to monitor the impact on the whole company, and also to deal with the cause and not with the consequence. The cost reduction should not be turned against the quality and should focus on customer satisfaction." (Kosturiak 2006: 36)

The starting point of lean practice is to eliminate those factors that are clearly detrimental to the economy of the company. In the first place, it is necessary to avoid cases of fines or damages. Furthermore, we need to focus on those cases, which cause the biggest losses:

On MBA lectures we have been told that waste is everything that increases the cost of the product or service without increasing its value. In the MBA scripts, there are 7 + 1 kinds of waste defined there: *Overproduction, Waiting times, unnecessary transport, Production of defective parts, Excessive stores, inefficient movements, inappropriate production process, Scrap and rework.* (Lidauer: MBA Handouts)

Concept of lean manufacturing advises on strategic management tools. We can use its potential fully only using the correct way of implementation. This can bring the company a competitive advantage in different areas. A key part is the company management. When they are not very much aware of all the risks and do not proceed systematically by implementing LM, a whole concept is perceived as a couple of unrelated methods.

3.2. Lean Production

The term „lean production“ was used by James Womack and Daniel Jones in their books to describe the Production System, which is referred to a TPS and is the basis for many production systems in the world.

“TPS is the next major evolution in efficient business processes after the mass production system invented by Henri Ford, and it has been documented, analyzed, and exported to companies across industries throughout the world. Outside of Toyota, TPS is often known as lean or Lean production“. (Jeffrey K.Liker 2004, 14)

At the beginning, this system was known as Just in Time (JIT) for continuous improvement and forced problem solving via a focus on throughput time and reduction of inventory. The TPS emphasizes on continuous improvement, respect of people and standard work and it is particularly suitable for assembly lines. Lean production supplies the customer with exactly what the customer wants, when the customer wants it and without waste. Lean operation is driven by workflow initiated by the „pull „ of the customer´s orders.

There is a distinction between JIT, TPS, and lean operations. (Jay Heizer 2010: 654)

- *JIT emphasizes forcing problem solving*
- *TPS emphasizes employee learning and empowerment in an assembly-line environment*
- *Lean operation emphasizes understanding the customer*

Production system can be understood as a set of methods and tools that lead to the achievement of business strategy. Lean production system cannot be built on lean manufacturing, it is also necessary to focus its efforts to optimize logistics, develop administrative processes. (Dlabač 2010: www.e-api.cz/article/69775)

3.3. Lean Productions 5 Principles

In In the book The Machine that Changed the World (Womack et al. 1990), there are described five lean principles that literally mean life or death for a company. These principles have been described newly in the book Lean Thinking (Womack & Jones, 1996) and they focused more on how to add value to processes not just on reduction of waste. The five principles are:

1. Specify value from the point of view of the customer. The customer when purchasing a product sees it as a final output of the company. It is easy to say “give

the customer what they want", but difficult to realize. Therefore, the company needs to eliminate waste at the beginning of the creation of a product design and during its production.

2. Value Stream is a method that draws and describes processes of a product in the company. The principle is to focus on the whole supply chain, from customers' orders, through all involved processes and departments, up to delivery of the product to the customer. For example we can quickly recognize the following: value added to a product means assembling parts together, non-value adding is the waiting time of the product in batches or stocks, which is waste.

3. Flow This principle shows how important is manufacturing of products in one flow through one value adding step to the next. This principle is based on the movement of the product from one station to another in constant one piece flow. Company should to try to eliminate queues or production in batches, because these steps are non-value adding.

4. Pull means meeting consumer's rates of demand with production but not over producing. The idea with Lean is to push this point as far upstream in the product manufacturing process as possible, wait for a demand and then manufacture the product fast and with high quality.

5. Perfection The last principle is possible after fulfilling the other four principles. Perfection is not only producing a quality product. It is also hearing the customer's voice and producing exactly what the customer wants, when they want it, for an acceptable price and with minimum non value adding operations.

(Bicheno 2008: 12-13)

3.4. Tools in Lean Production

We must realize that Lean Production itself is not a tool that will be implemented into work processes in the company and will bring immediate success. It is a way of thinking. It is important to understand the thinking and the concept and create a common way in the company with employees, suppliers and customers, to make it work. Concept of Lean Manufacturing includes many tools that could be used in the company to become Lean. The idea is to monitor the entire supply chain from material input to the final product. So far, there is no other philosophy that made these aspects so effective as lean. The basic pillars of modern production systems are

the identification and elimination of waste, visual management, standardization, maximum utilization of production facilities OEE, mutual synergy between the development - production - logistics, flexible layout in manufacturing and many others. During MBA lectures, we discussed the following elements of Lean Manufacturing shown in Figure 3-1: (Sihn 2013: MBA Handouts)

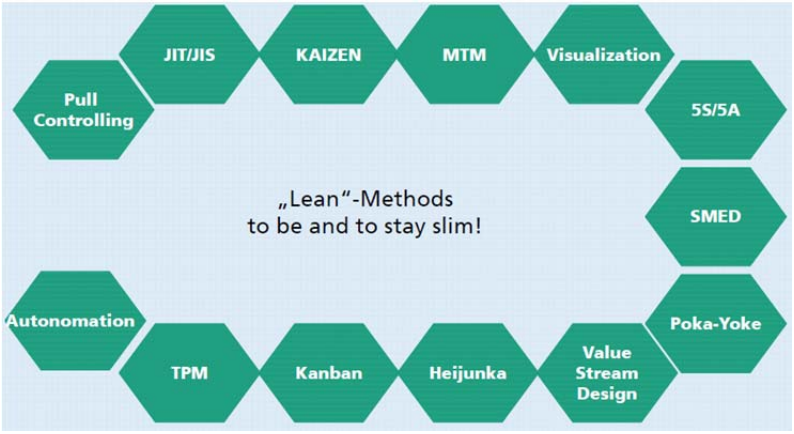

Figure 3.1 Selected "lean" tools/methods and concepts for lean manufacturing (Sihn 2013: Operations Management - MBA Handouts)

In the following section, I am describing in detail the selected elements of Lean Management, which I will then use for creation of Lean games for employees' trainings in the company.

3.4.1. 5S / 5A Method

5S method (5A in German) comes from Japan. Its contribution is the clarification and simplification of work. Initially, it was created for the production line work, later it has been used in offices and now it can be used anywhere. Arranged workplace affects positively an employee's performance, eliminating potential injury and it helps to organize thoughts.

The real objectives of a 5S program are: (Bicheno 2008: 12-78)

- reduction of all types of waste
- elimination of variation
- productivity improvement

5S is a system of steps and procedures that can be used by individuals and teams to arrange work areas in the best manner to optimize performance, comfort, safety and cleanliness. (Peterson 1998: 59)

There are plenty of specialized books describing 5S. 5S utilization improves internal processes and enhances overall performance. In 5S method there the original words in Japanese are used and in Figure 3-3 you can see the original name, translation into English and the meaning. (E-Crane 2014: www.e-crane.com)

Figure 3.2 Five steps in 5S Method (E-Crane Worldwide 2014: www.e-crane.com)

Japanese	**English**	**Explanation**
Seiri	Sorting	- Separate items that have to be in the workplace and that have to be removed - Keep only what is necessary and remove everything else from the workspace. - Define and label the item non-value ad and remove them. The removal of these items makes the workspace available and improves workflow
Seition	Simplify	- Clean workplace - Arrange and deploy analytical methods to improve workflow and eliminate lengthy and unnecessary movements. - Do assessment and evaluate the ergonomic on workplace. - With label visualize and identify only those tools that are necessary for work performance.
Seiso	Shine	- Do cleaning every day, identify abnormalities or potential problems. - Identify and visualize cleaning tasks and check the tools in place.
Seiketsu	Standardise	- Remove deviations from the processes, standardize work procedures, tasks and create checklists. - Visualize the standards so that deviations are immediately recognized. - Standardize similar equipment and tools for possible cross-check - Train and re-train employees in work team
Shitsuke	Sustain / Self-discipline	- Do regularly checks - Check the list where the staff sign or write all activities with signature - Regularly motivate and support effort to sustain the progress. Don´t give it up

Figure 3.3 5S Method in practice (Jay Heizer 2010: 654-655)

We should not forget and support the additional „S-Activities" during the execution of 5S method in practice. The additional activities are: (Jay Heizer 2010: 654-655)

- *Safety: Build safety by using 5S on the workplace*
- *Support/maintain: Reduce variability, unplanned downtime and cost.*

5S shows and reduces waste. With this method the following can be achieved: improvement and simplification of material flow, equipment layout, material placement and inventories. Furthermore, the quality, productivity and safety will be improved. (BURIETA 2013: www.ipaslovakia.sk)

3.4.2. Standards and Visual Management

Standard simply explains process activities, their parameters, time and order. Visualization is used for quick and easy understanding of the situation, for rapid discovery of abnormalities, deviations, or some problems in the process. Especially standards make problems visible and we can quickly react to it. Also it helps the worker not to waste time and it makes immediately clear whether the process is according to the standard or not. (Košturiak 2010: 205-206)

"To standardize a method is to choose out of many methods the best one, and use it. What is the best way to do a thing? It is the sum of all the good ways we have discovered up to the present. It therefore becomes the standard. Today´s standardization is the necessary foundation on which tomorrow's improvement will be based. If you think of standardizations the best we know today, but which is to be improved tomorrow – you get somewhere. But if you think of standards as confirming then progress stops." (Henry Ford, Today and Tomorrow: 1926)

Each standard has the following features:

- Individual responsibility and authorization
- Transfer personal experience and know-how to the organization
- Transfer personal experience to the next generation of operators
- Collection of experiences and lessons learn from mistakes within the organization
- Implementation of know-how gained from a particular workplace into workplaces across the company
- Discipline

The role of management is to create and implement standards, consequently to support their keeping in practice and creation of working discipline. Later the implemented standards can be again revised and improved.

3.4.3. Kaizen

Kaizen means continuous improvement of processes, activities, people and their collaboration in the company in the form of the PDCA cycle. The cornerstone of this system is called culture improvement, dissatisfaction with the current state, constantly finding and eliminating waste. It is important to view the problems as opportunities. Basic principles are:

- It focuses on improvements that are based on knowledge of people in production area, which are usually far away for the people in management. Company management practically does not know about 99% of problems in the manufacturing area. More than half of these problems can be solved without costs or at a min. costs.

- Involving employees in the improvement brings a sense of higher satisfaction and self-fulfillment, contributes to the improvement of corporate culture and the development of employee skills. Kaizen is the form in which people are spontaneously coming up with ideas and participate in their implementation.

- Kaizen is the philosophy of internal dissatisfaction with the current state. It is a controlled process, because the improvement from the perspective of one department may not be an improvement for whole company. (Košturiak 2010: 3-9)

System with improvement ideas is an important part of Kaizen focused on the individual. The main improvement ideas are

- improve own work
- save materials, energy and other resources
- improve the working environment, machinery and processes
- improve equipment and tools
- improve product quality
- new product ideas
- customer service and customer relations
- Improvements in office work, etc..

(Masaaki Imai 2011, 124-126)

3.4.4. Kanban

Kanban is a communication tool in production and control system for inventory. It was designed by Taiichi Ohno in the Toyota. The word Kanban comes from Japanese and means a label or a card.

The card is the authorization for the next container of material to be produced or transported (Sihn 2013: MBA Handouts)

This card is attached to a specific part in the production line, which refers to the delivery of certain amount of parts or materials. When all parts are consumed, the same card that returns to the original position, where it serves as a further order for the given amount of parts or material. (Imai 2011: 102-103)

3.4.5. One Piece Flow

OPF - One Piece Flow is a method used for production in the cellular environment. The cell is a space where there is everything you need for the process, and it is also easy to reach it. At the same time product shall not pass to the next operation until the previous operation is completed. The aim of this method is processing the product one by one on time and correctly throughout the whole production without unplanned interruptions and long waiting times.

If you try to attain one-piece-flow, you are also setting in motion numerous activities to eliminate all *muda* waste. Using OPF you will get few of the benefits of flow.

1. *Build in Quality* – every operator is an inspector and works to fix any problem in the station
2. *Creates Real Flexibility* – Instead of putting a new order into the system and waiting weeks, we can fill a new order in few hours.
3. *Creating higher Productivity and reducing cost of inventory*

(Jeffrey K.Liker 2004: 95-96)

3.4.6. SMED - Single Minute Exchange Die

SMED is a system for reducing dramatically the time it takes to complete equipment changeovers. The essence of the SMED system is to convert as many changeover steps as possible to “external” (performed while the equipment is running), and to simplify and streamline the remaining steps. The name Single-Minute Exchange of Dies comes from the goal of reducing changeover times to the “single” digits (i.e. less than 10 minutes).

A successful SMED program will have the following benefits:

- *Lower manufacturing cost (faster changeovers mean less equipment down time)*
- *Smaller lot sizes (faster changeovers enable more frequent product changes)*
- *Improved responsiveness to customer demand (smaller lot sizes enable more flexible scheduling)*
- *Lower inventory levels (smaller lot sizes result in lower inventory levels)*
- *Smoother startups (standardized changeover processes improve consistency and quality)*

(Vorne Industries 2013: www.leanproduction.com/smed)

The methodology was developed in Japan by Mr. Shigeo Shingo. System SMED has demonstrated effectiveness in many different industrial sectors. The method can be described in three steps.

1. *Analysis* - description of the current state, time recording of individual actions and evaluation of waste for each operation
2. *Solution proposal* - the definition of actions to eliminate waste
3. *Implementation measures for improving* - process optimization and change of internal activities to external activities
4. *Standardization of processes* means to create or edit existing work instructions for tools exchange and parameter settings on the machine. Some mature companies enter and record the instructions and standards into an internal database called KMS - Knowledge Management System.

(Levay 2013: www.ikvalita.cz)

3.4.7. TPM – Total Productive Maintenance

The Aim of Total Productive Maintenance (TPM) is to maximize the efficiency of production machines using a system of prevention, which covers the total life cycle of the equipment. An important part of TPM is the training. It explains how machines work and how they should be maintained in the production. It touches all staff in all departments at all levels and motivate them through teams and voluntary activities to maintain the equipment.

(Imai 2011: 170-173)

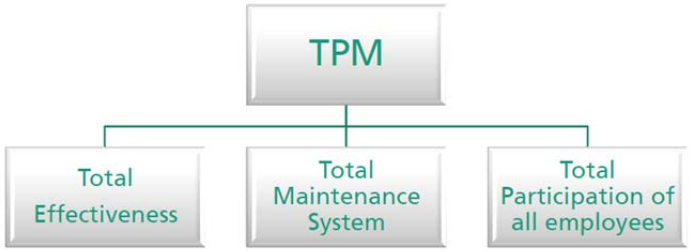

Figure 3.4 TPM – Total Productive Maintenance (Sihn 2013: MBA Handouts)

Implementation of TPM in the enterprise can detect and remove errors and weaknesses of the machines and equipment much earlier. One of the goals is to pass simple maintenance operations directly onto the operators who work on the machine. Before implementation of corrective and preventive TPM, it is important to define the task for corrective and preventive maintenance and employees have to assign responsibility for performing the tasks.

The aim of TPM is to achieve Zero Defect, Zero Breakdowns and Zero Accident on workplace and work equipment. Everything what is away from prescribed target brings us additional costs.

Figure 3.5 TPM – Zero Defect, Zero Breakdowns and Zero Accident ((Ruzga 2014: www. leanvisualblog.bradyid.com)

It´s important also to see these 3 key points before implementation of TPM:

1. Autonomous maintenance [AM]
2. Preventive and predictive maintenance [PM]
3. Early equipment maintenance [EM]

(Ruzga 2014: www. leanvisualblog.bradyid.com)

3.4.8. Value stream mapping

We learnt at the MBA lecture with DI Jürgen Minichmayr how to gain a holistic overview about the status in an organization from the supplier to the customer in a simple way and with a very effective method of value streams. "*Value stream mapping is target oriented and concentrating on the essentials, it represents a common language to communicate weak points and solutions within a company." (Minichmayr 2013: MBA Handouts)*

Value stream mapping captures the whole process on the gross level of processed details. It captures the essential elements of the process flow and their relationship. The role of the process mapping is to show how the different activities contribute to value creation, which processes create a product. It also allows you to see wasting and bottlenecks. Current workflow view is called a value stream mapping. It is a proposal for the process optimization. Value stream design is a better future (ideal) state of processes, what a company wants to achieve. It drafts a future state with ideal processes that a company is trying to achieve.

In the Picture bellow you see an example for Value stream mapping of a workflow.

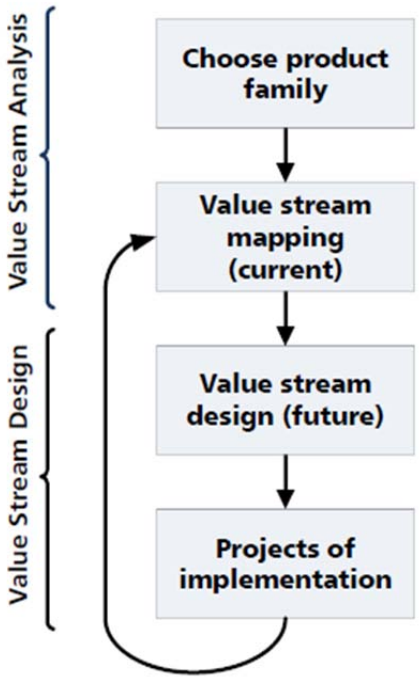

Figure 3.6 Process steps by Value Stream mapping and design (Minichmayr 2013: MBA Handouts - J 10_ValueStreamDesign)

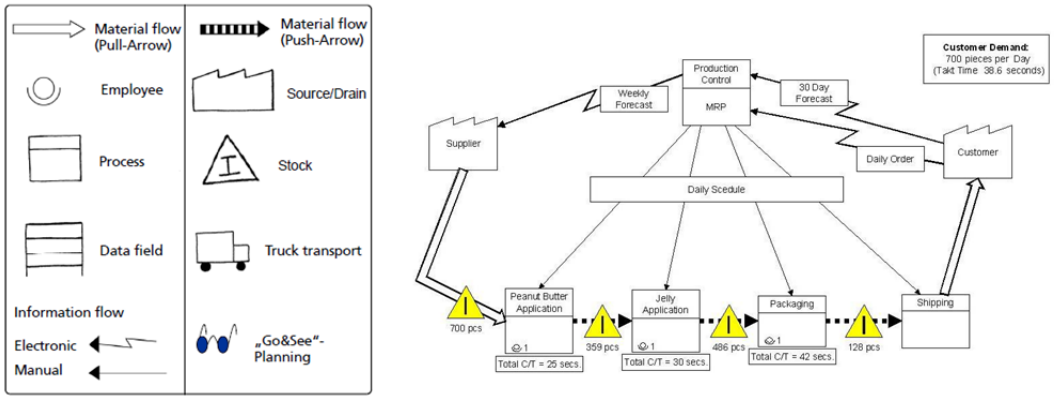

Figure 3.7 VSM symbols and simple example of VSM
(Gemba Academy 2014: http://blog.gembaacademy.com)

According to (Košturiak et al. 2006: 46) typical value adding operation of VSM are:

- *reduction of production lead times by 20-50% in a few days*
- *reduction of areas*
- *better understanding the process of operation and the links between them*
- *simplification of the management system*
- *reduction of batches and synchronization of processes*
- *elimination of waste from processes*

3.5. Supporting lean methods for errors detecting and quality improvement

Production processes should be arranged so that if a possible error occurs, it is immediately revealed and the problem can be solved immediately. For the above-mentioned process we use the following elements or methods:

3.5.1. Poka – Yoke

Poka Yoke or "mistake-proofing," means providing a visual or other signal to indicate a characteristic state. It is often referring to as "error-proofing". Poka-Yoke is actually the first step in a truly error-proofing system. Error-proofing is a manufacturing technique of preventing errors by designing the manufacturing process, equipment and tools so that an operation literally cannot be performed incorrectly. (iSixSigma 2014: www. isixsigma.com)

If an error or a defective product occurs, Poka Yoke does not allow production to continue. This idea can be applied to products or systems where the parts must fit

together (see Figure 3-9). If they do not fit into each other, it means an error is occurring and must be solved immediately.

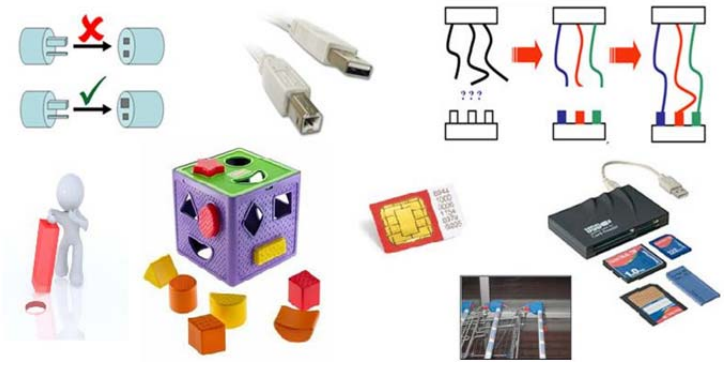

Figure 3.8 Examples for Poka-Yoke (Martisovic 2013: www.produktivne.sk)

The system will relieve workers from basic checks of products or systems and give them more space to dedicate to their work.

3.5.2. JIT – Just in Time

It is a philosophy for complete elimination of waste and it brings a big flexibility in production. "Just-in-Time" means making "only what is needed, when it is needed, and in the amount needed." For example, to produce efficiently a large number of automobiles, which can consist of around 30,000 parts, it is necessary to create a detailed production plan that includes orders of parts. Supplying "what is needed, when it is needed, and in the amount needed" according to this production plan can eliminate waste, inconsistencies, and unreasonable requirements, resulting in improved productivity. (Toyota Motor Corporation 2014: www.toyota-global.com)

3.5.3. Pull system

A pull system is process based on customer demand. It is based on a concept that each process is manufacturing each component of a product in line with other departments to build a final product to the exact expectation of the customer.

If your production processes are designed to produce only what is deliverable, your business becomes leaner as a result of not holding excessive stock levels of raw, partly finished and finished materials.

One of the main identifiers of pull system comes in the form of having Kanban methods in your production cycle. In essence, a Kanban can be described as a visual aid, which is used to show that either you have finished a process or you require

more materials. Kanban is a concept that lends itself to high turnaround industries, but it can be applied to other environments. Unfortunately, pull systems do not lend themselves to all business types, because it cannot be used for different types of product, different lead times and different types of stock holding. However, by having pull systems in some of your production processes, you will be able to reduce your lead times, and perhaps associated costs. (Smith 2013: www.elsmar.com)

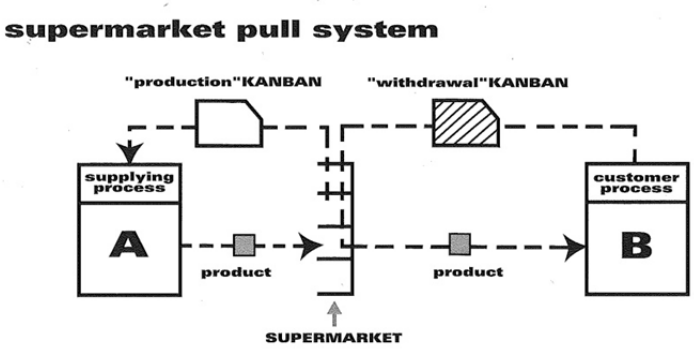

Figure 3.9 Example of a Pull System by using Supermarket with Kanban (Today´s Lena manufacturing 2011, www.todaysleanmanufacturing.com)

4. Lean in Office – Methods of Lean Management in office area

Many companies have already implemented and used lean principles in production. Implementation of Lean principles for administrative processes is the next step how to make processes effective across the company.

Organizations realize now that many processes that slow down production and cause wasting are administrative processes. Therefore, companies give greater importance to solving this problem.

As one lean office expert, who works for TechHelp, explained: "*Too often we look at how to get things done better or faster in the office instead of examining what things we really ought to be doing.*"

(Process Excellence Network 2014: www.processexcellencenetwork.com)

4.1. 8 Types of waste in the administrative process

It is difficult to get data about how many administrative processes according to lean principles are classified as waste and provide no added value to the end user. Some experts are still attempting to estimate that. It is about 80% or more. Therefore, this area requires clearly an attention.

Figure 4.1 8 common wastes in administrative processes
(Experiencesolutions 2009: http://www.experiencesolutions.com.au)

To identify and eliminate bad processes in office, you need to learn how to identify waste in this area. There are 8 common wastes known in administrative processes.

Defects & Inspection

Due to defects in your administrative work, for example you did not meet the customer needs; you have to open this case again. An additional inspection and rework has to be done and this leads to more time being spent on this case. We should notice and eliminate these defects to produce a good product at first time. *Examples:* (errors in order, errors in Invoice, lost files or records, bad or missing information)

Over Production

This this is the act where the employee produces more than what the customer wants. Employee has to know the need of the customer and give him what he actually needs and paid for.

Examples: (Producing reports that no one reads, print information that is not needed, print files just-in-case, Memos or email to everyone).

Waiting

Waiting is an idle time e.g. waiting for material, information, people or equipment that is not ready. This time we do not bring a value ad into the company.

Examples: (Waiting for approvals or signatures, Delays in receiving information, Attendees not all on time for meeting, slow system response time, Printer or computer break-down).

Non-Utilized People or Knowledge

A company does not know the abilities and knowledge of all employees. Therefore, this human potential is not appropriately used. This happens in most large companies where it is difficult to know all abilities of all employees.

Examples: (Implement and use some methods without training, Limited authority and responsibility for basic tasks, inadequate business tools / training available).

Transportation

This is the act when you move the product you are working on somewhere to other department, place or storage. Transportation is an additional time and it does not bring us a value.

Examples: (moving product in and out of storage, no signs identifying areas or departments, multiple hand-offs or approvals, bad area layout, excessive filing of documents).

Inventory

Inventory is a common result of multi-tasking and otherwise un-balanced workloads. It can be found in e-mail or work order in-boxes, to-do lists, product development pipelines, and resource assignment charts. If a person has three tasks to complete, it is guaranteed that two of them are waiting (in inventory) while that person performs the third

Examples: (files piled up between desks, batch processing transaction & reports, obsolete files or office equipment, no sufficient cross-training)

Motion

Employees in the office walk in the office or outside to reach the office equipment or even walk more to meet people. Meetings are a motion in the sense that employees are working without producing, unless a decision is made or information is produced during the meeting. Examples: (Looking for items without a defined place, searching for files on computer).

Excess Processing

Employees often create a multiple version of documents. Excess processing is an additional work to put the paper, files, tabulators, etc. into the right version. Examples: (multiple signatures collect a lot of information that are unused, multiple working on document with different software versions, unnecessary reports).

(A Lean Journey Blog 2014: www.aleanjourney.com)

5. Concept for implementation of lean production

Lean production belongs to the strategic management tools. Its potential is fully established only by properly chosen mode of implementation and it can bring a competitive advantage in different areas for the company. Management plays a key part of business. People in management are not very much aware of all risks. They do not precede the implementation systematically as a whole concept and they perceive lean tools as a couple of unrelated methods.

Although individual methods are based on relatively simple principles related to lean manufacturing, the concept as a whole represents a complex system. Underestimating this complexity may lead to a wrong choice of procedure. For example, links to other business processes and activities are often neglected. It is important to understand and accept the principles on which lean production is built. It is also important to take to awareness the links between the different methods.

For implementation of lean production in the company it is necessary to have a coordinator or a specialist. They are responsible for effective implementation of lean production. The main task of the coordinator is to have a methodical character – consulting activity, assuring, using standard tools and procedures, planning and coordination of various activities with employees.

To have several of these coordinators within the company is very effective. One option is to use the potential of line managers who become coaches for individual sections or departments.

Coaching is an extended form in the organization for training, leadership and implementation of lean methodology into company processes.

5.1. Engage employees in the process of Lean Management

To implement lean management rules and lean tools into processes is not enough. The company management has to involve all employees in this process. Here are 2 reasons why to do it.

Reason 1: A large part of lean activities is associated with the work of ordinary employees. Whether, it is a setting up and maintenance of machinery or detection of unnecessary movement at the workplace.

Reason 2: Ordinary employees often know about small problems, the management does not. When you give employees an opportunity to propose improvements

concerning these problems and motivate them to do it, it can lead to quite significant cost savings.

A specific feature of Japanese companies, which has recently been expanded to America and Europe, is teamwork. Japanese companies rate the teamwork for several decades as the basis of success. Teamwork is essential for proper use of lean management and lean tools. The company may, however, plan better their production process, organize the layout and design substantially production cells. If you cannot engage properly employees, you have no chance to succeed. The transition to the concept of lean management is not just about changing the production process; it is necessary first to change people's minds. For an employee, who had always worked under the old methods, it is not easy from day-to-day to start working completely differently. There are the following three reasons why to create teamwork:

The first reason is the delegation of certain tasks on the teams. This frees the manager from solving operational problems: Most managers spend much of their time solving problems that cannot be postponed. This does not lead to solving the cause. This problem appears again after a period of time and the manager is trapped in a cycle of small daily decisions and he has no time for long-term strategies. Such companies operate, but do not develop in the long term and cannot be competitive in the future. Creating teams and transferring the responsibility to them releases the time for managers and they can focus on long-term strategies to develop the company.

The second reason why to implement teams is that one feels greater work satisfaction in a team. The teams themselves determine how to achieve their targets. This gives people an opportunity to participate on decision making. Employees get the sense of greater importance and their ideas contribute to the company's success. Of course, these are the people who prefer to work. According to the old model the commands coming from management are executed and employees feel happy that they do not have to think about anything. The team work is better for most people. It gives workers the opportunity for self-realization.

The third reason is efficiency. It increases the work efficiency. This follows up on the previous two reasons. Better management and more satisfied employees do their job obviously better. Moreover, team has power to solve problems using the best possible solution.

In one team should have about ten people, depending on the company and area of work of the team. At the beginning, it is better to set up smaller teams and gradually increase the number of people in a team together with new functions and tasks. Constant training of its members is an important element that ensures the proper function of the team. As mentioned above, the team members must manage different kinds of work. Therefore, it is necessary, especially at the beginning, to teach an employee how to perform new tasks. But learning never stops. It is necessary to improve constantly the communication between members and develop their personalities in order to improve relationships within the team.

Building a team is currently considered as an element, which increases significantly productivity and improves the working environment. Here are several limitations and risks that need attention. For teams to work correctly, it is necessary to organize their work properly. Rapid creation of teams can lead to confusion in competencies, poorly defined objectives or communication problems between team members.

5.2. Continuous Improvement – driving for Innovation and Kaizen

Many large and medium-sized companies in America and in Europe have already implemented lean tools in the production and also in office processes. But as Masaaki Imai writes in his book Kaizen, according to one of Parkinson's laws, "the organization, as soon as it is built, will start to crumble. In other words, there must be a constant effort to improve and maintain the status quo. If this effort is lacking, the regression is inevitable". This means, in the case when company runs with no other changes till innovation, the quality of production start to decrease and after some time the company loses the competitiveness on the market. Therefore, it is important for something to happen at a time, when no innovations are introduced. Kaizen starts at this moment. Kaizen can improve company production processes through small continuous changes in the period between innovations. Thus company gains a huge market advantage in comparison to companies where an improvement does not occur. (Imai 2004: 43)

6. Corporate education and trainings

At the time of high competition, when firms have identical or similar technologies, the success of the company determines mainly processes where a person is active. These are innovation, customers, manufacturing as well as sales effectiveness and more. That is the reason why companies should invest into development of their employees. Investing in human resources leads to their overall development. This is specifically reflected through increased employee performance and service level. It also increases the company's competitiveness, possibility of using its own resources to cover the needs of employees, loyalty to the company, self-fulfillment and employee satisfaction. Therefore, training and forming working knowledge have to be considered in the current time as a lifelong process and as an important part of personnel management. (Hudáková 2013: http://fsi.uniza.sk)

Nowadays, the companies avoid directive approach or this approach is only used in crisis situations. There is no universal method how to manage and motivate employees. New or young companies use consultative or participative style of management. Probably the easiest way is to listen to their employees. They often tell their manager about goals and they themselves clarify their motivation. Manager ascertains regularly the view of employees and only after consideration of comments he decides. This procedure also breaks down the pressure on him. He tries to obtain the accordance of the team with the implemented changes. Open and constructive discussions run in the teams, where all have an opportunity to give a comment. The manager will not only hear the ideas but he also requires a logical reason. However, the manager must consider the simplicity and flexibility of solutions and the time consumption. He must also clarify the result, low investment requirements and technical equipment in the company. (Inventic 2014: www.podnikajte.sk)

According to (Tureckiova 2004: 89), there are three approaches of how to train staff:

1) *Organization of various trainings activities* - reaction on the immediate needs of individuals or company. For its randomness and without orderliness it cannot really bring an educational effect.

2) *Systematic approach* - connects corporate and personnel strategies with the company education system to one system of personnel work.

3) *Concept of the learning organization* - comprehensive approaches of how to develop people in the organization. Employees learn continuously and from daily experience in particular.

6.1. Current educational methods within the company:

Nowadays, the company uses modern teaching methods - so-called experiential learning pedagogy. These methods include:

Team learning - on one side the lecturers on the others side the groups of employees. Teamwork usually leads to higher performance comparison to a work of individual.

Action learning - employees organize themselves and create teams. Here the participants gather knowledge from different groups. Group itself creates its own structures and modes of social behavior,

Situation and story drama - an employee or group of employees are conducted to situations, stories and events, where they are forced to act.

Cooperative learning – is a positive interdependence of employees by performing the tasks. It is a collaboration of small groups with an emphasis on personal responsibility and personal accountability when performing sequential tasks. (STÖHR 2012: 6-9)

Employees verify the theoretical part of the training by practical experience and so they are ready to deal with the situation on their workplace in practice.

Nowadays, a company puts emphasis on natural methods for improving skills and innate disposition of each participant on the educational training. It is important to think about the right choice of education, as well as right selection of educational organization.

There are two forms of employee training:

Training out of the job - participate on external training in the form of informal training or conference

Training on the job - within the company, or training directly on the workplace

Figure 6.1 Two forms of corporate education

The main trend in today´s education system is going away from the classic classroom. More and more emphasis is put on line managers. Managers are in direct

contact with employees, influence the productivity and success of an individual or a team. Line managers are expected to overtake an activity in company education.

6.2. Forms of training of Lean Management

A company needs to develop and improve not only their products but also their employees to stay competitive or become a market leader. Employees are the basic unit of a production system. They are key persons for the continuous improvement of business production processes and they help to shift the company to a higher level. Companies that want to implement and use lean manufacturing system, must motivate their employees and give them necessary training and tools. Only this way a Lean manufacturing system can work properly. Employee training for lean manufacturing is not just for workers on the production line, but also for human resource department, director of the plant, an industrial engineer, coordinators of lean activities in the company and also for other groups involved in this process. (HARRIS et al. 2007: 1-17)

As mentioned before, different forms of training within the company or outside are used for workers:

- *Formal training or seminars* - here are generally represented principles of lean manufacturing and lean management. The main task of this training is the presentation of different methods of lean management and all possible alternatives, principles and ways for implementation of this method in practice. Seminars are often linked to practical examples with multimedia demonstrations, case studies and workshops.
- *Simulation Games* are one of the best tools to bridge the theoretical principles with practice. The biggest advantage is the ability to apply this principle on real model. The game simulates similar criteria as in a real process in the company.
- *Practical training* - one of the most common types of training in the company. The training is performed at the workplace, where the participants become familiar with the real problems. During the training the worker proposes changes for improvement, which may be immediately or shortly realized.

6.3. Training for employees using lean games

For simulation games and practical trainings it is very useful to have a training center or a training room within the company. Using a simulation game is an effective way of passing the basic methodology of lean production to the workers in the company. Lean Game is prepared according to the processes in the company. Each employee cannot directly participate in the implementation of lean tools into production processes and on the other hand theoretical training is often short and ineffective.

6.3.1. Seven Benefits of teaching Lean with simulations

1 *Simulation demonstrates Lean principles in action*.

The main reasons for using a simulation as a teaching tool, is to demonstrate Lean methods. The common training may not be interesting or can be hard to understand. Therefore, lean methods are illustrated with a simulation using a lean game.

For example, the participant does a simulation of a 5S method and this way he will never forget it. Simulations let people play with this method and make people think about their own processes.

2 Games involve your audience

Maintaining your audience's interest is one of the hardest things to do during training sessions. Especially when they do not want to be there! By involving the participants, you will pique their interest. People learn by doing.

3 Games are perfect team building activities

Training sessions done at your workplace will typically involve people of different departments and management levels. A mandate from the top: Everyone needs to know Lean!

These workshops are excellent opportunities to foster team building. Games can be used to break the ice and get your audience to participate, but they are also great for getting people to work together.

When you design your workshop with multiple sessions and divide your group into teams they will compete against each other. Once the teams see the simulation results, they immediately become more competitive and try to improve by working together!

4 Simulations are small and flexible

Manufacturing and business processes are large and complex. Providing real-world improvement solutions within the current business is difficult within a two-day training session. Simulations are small and compact. They fit into a room. They can be performed in a quiet training room environment, rather than a noisy shop floor. They do not interrupt normal business. They are short. They are expandable.

5 Games are confidence builders

The audience consists of many types of people. Shy, introverted thinkers mix it up with overbearing loudmouths. By placing people in roles they are not familiar with, you can empower them. A shop floor employee can shine while directing the divisional manager, who is struggling with the bottleneck process. When roles are switched in such a way, managers can see what it is like to be in the trenches, while others can become confident with their new responsibilities. This is also a good opportunity to identify problem solvers and leaders.

6 Test real processes with simulations first

Sometimes simulations are used to simulate actual processes in your business, for example implementation of Kanban system. Kanban card calculations can become pretty confusing once all the factors such as lead times and signal stagnation are considered. Simulating this with pieces of paper or on a spread sheet will make things a lot clearer and highlight potential issues before implementing into the real world.

7 Teacher train yourself

By training and executing lean games you train your presentation style. A simulation allows you to break away from teacher-mode and interact with individuals one on one. You can relax, joke around, answer questions and have a breather while the teams are interacting with each other.

(Boersema 2012: www.leansimulations.org)

7. Analysis of the current state in the company

7.1. Analysis and evaluation of the implementation of Lean Management

In this part of my Master's Thesis I am analyzing the current level of implementation of Lean Management and Lean tools in the company. In the first part of the analysis, I am describing how employees are trained, what types of training they attended and how new employees are trained at the beginning of employment. I am also analyzing which lean methods are already used in the company. Furthermore, I am going to verify using a survey how detailed is the training in Lean Management and which of selected methods are used in practice. I am going to execute the analytical as well as the practical part of my Master's Thesis in the company Knorr Bremse Austria, specifically in production area of brake valves and their supporting office departments.

7.2. Trainings for employees within the company

At the beginning of employment, every employee passes a course on topics required by law (safety, internal guidelines of company, etc.). They are informed further about the specific processes needed for his work. These are for example quality management guidelines, IT guidelines, etc. In the production area, new employees are trained in specific works, for example for bonding and adhesive processes to assembly some parts together. These specific trainings are needed for the work in the company. The trainings are different depending on the department and the area where the worker starts to work.

A guideline specifying how frequently should employees be trained or retrained in Lean Management and Lean tools does not exist in the company. Management of the company attended several types of external as well as internal trainings in lean philosophy and methods of Lean Management. Management is also trained in how to implement and use selected lean methods in practice. The trainings are led via KPS expert. KPS expert from Knorr Bremse Group leads and shows how to use a specific method in practice. Knorr Bremse Group has its own production system KPS (Knorr Production System). It consists of 4 pillars including the lean philosophy and selected Lean tools. Management in each company within the group is responsible for implementation and using selected lean methods in practice.

Employees in the production are not regularly trained in how to implement and use Lean tools on the workspace and in the processes. New employees receive only oral information about KPS and lean methods that are included in the KPS. Some employees that are selected as future team leaders receive internal trainings for Lean Management. Here, they are trained more in detail in Lean Management and philosophy, Lean tools and how to use them in practice. This form of training is theoretical as well as practical, executed directly on a selected workplace.

Other employees get only short information about selected basic lean methods (5S, One Piece Flow, 8 Types of waste.) on the team meetings or during auditing their work and workplace. Last year, the company created short presentations for selected basic lean methods as training materials. The worker has to read and sign the understanding of the content. Trainings in the lean production in the company are not systematically planned and performed.

7.3. Lean tools in the company

The company has already implemented several methods of lean production and also developed its own KPS system. The main pillars and the Lean tools that have to be used in processes are defined in this KPS System. Standardization is implemented into some processes. These processes are described with instructions in the guidelines.

Process improvement is one part of KPS production systems. This process improvement uses Kaizen Cards (PI Card). The company uses PDCA Cycle to execute and implement new ideas of Kaizen. KPS has an audit plan to check the implementation and utilization of lean methods in practice. KPS Expert carries out an audit every year and using an audit plan he examines the degree of implementation and development of lean methods in production processes in the company. The company has already implemented 5S Method to all production departments.

Management in the company organizes Zero Defect Projects for selected products from the production area. Project leader with his team analyze, improve and verify whole production process using selected Lean tools. (Value Stream Mapping, Spaghetti diagram, Time Analysis, Flow Diagram, and Value stream design).

5S Method was also implemented in the office area for a few years. This method was not evaluated in past years, as well as it was not audited. This led to a stop in using

this method in the office area. The company has started a new project LEO - *Lean in Office* last year. The company tries again to start the 5S method and to implement Lean Management and Lean tools into office processes to improve whole work process using this project.

The company Knorr Bremse implemented some Lean tools for improving production processes and uses them in practice. It does not mean that there is nothing to improve. Management is aware of continuous improvement as a fundamental criterion for an effective and competitive enterprise. Therefore, management in the company still evolves activity for using lean methods in all manufacturing and non-manufacturing processes.

7.4. Analysis of Lean Management using Survey

The aim of the survey is to investigate employees' knowledge level about Lean Management and Lean tools. Using a survey I will try to find out if they know what it means, which trainings they attended, where the training was done, if they use these methods in practice. The questions are created and construed to find out the position of an employee in the company, knowledge, trainings and corporate educations for lean philosophy. Furthermore, I try to obtain, by means of questionnaires, further information about the utilization of lean methods in their work, the need for training and interest in extension of their knowledge in this area.

I have created the questions and possible answers for the survey based on the information and analysis in the company. I have decided to create only 10 questions to avoid spending too much time when filling it. The template of the questionnaire in German and English is attached in Annex 1.1. In order not to interrupt the whole production, I distributed the questionnaires only in production area BC (brake control) and their supporting departments. I have chosen an anonymous form for filling in the questionnaire to preserve the anonymity of personal data. The anonymous form was positively evaluated by employees as well as by the company's union. Survey was distributed to 85 employees, of which 78 returned back.

7.4.1. Survey results from questions 1 to 10

Individual results from Survey are evaluated according to the questions from 1 to 10. I have written down comments concerning each question as well as for evaluation of

results. You will find the summary comments on the total evaluation of results and information gained from the Survey at end of this chapter.

Question Nr. 1: ***Please indicate your work position***

The first question finds out the work position of a participant and his job title. This information is important for further evaluation of the job position comparing it to level of knowledge about the lean philosophy and Lean tools. Optionally, we can find out if an employee on a certain work position attended some training, or if they use lean methods in practice.

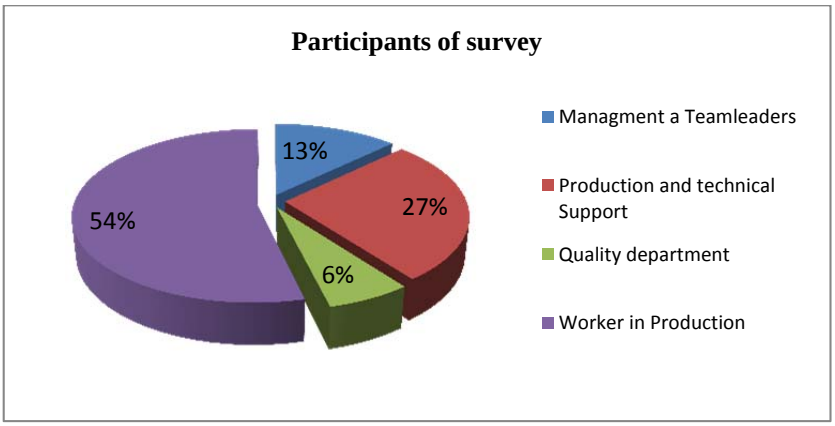

Figure 7.1 Segmentation the participants in survey into groups

The staff of BC production took part in this survey. They are people from production line and offices departments supporting this production. I have sorted all participants into 4 main groups by work position, department and people that manage their workers.

Question Nr. 2: ***How long do you work for the company***

The next question is focused on the time the employee works for the company. This information is important for further mapping of the time period after which the company gives employee training in the lean production.

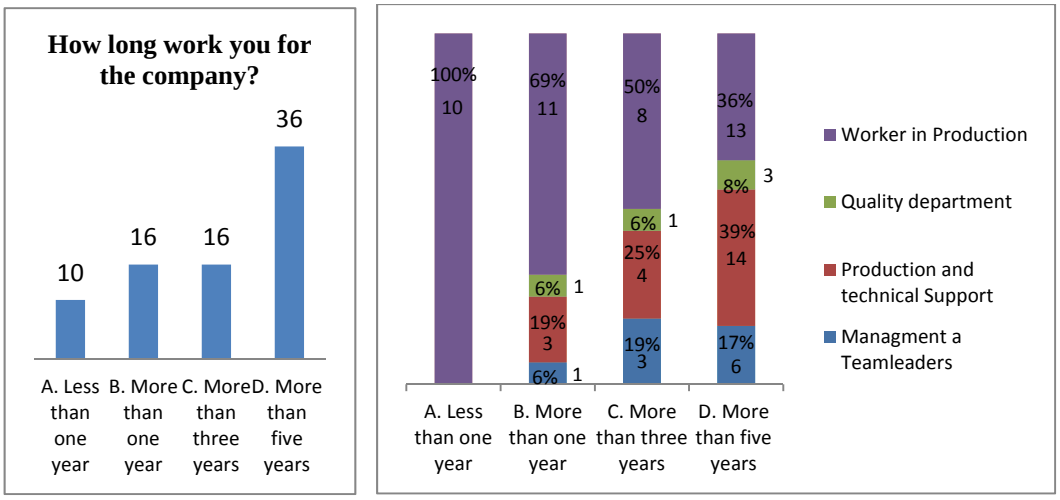

Figure 7.2 Graph – How long do workers work for the company

From the results we can see that many workers are employed in the company for more than 5 years. This means there is no high staff turnover and the most changes are in the production.

Question Nr. 3: **Did you hear about the following terminology in your company? (Lean Management, lean production system, Lean tools)**

Purpose of this question is to determine, whether workers hear or work with this terminology in the company, how widespread is the propagation of this methodology in the company and in the individual departments.

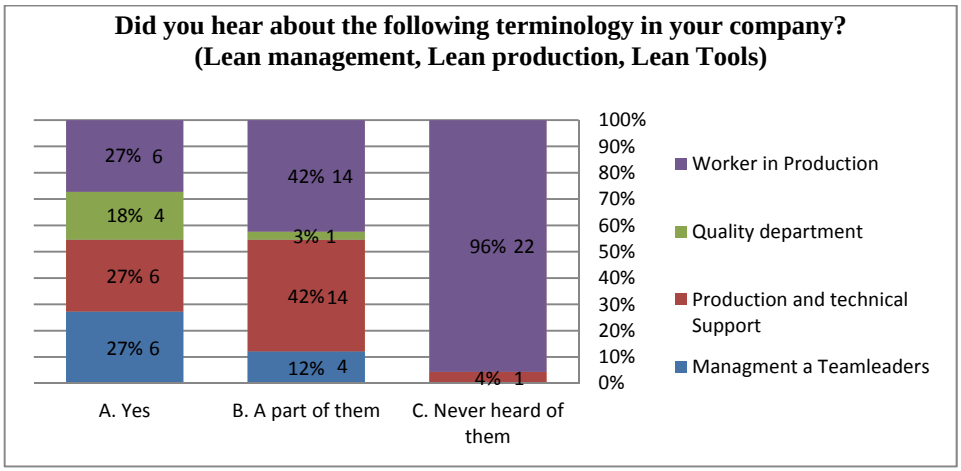

Figure 7.3 Graph – How many workers heard about Lean Management

We can see on the graph that in each department there are some employees who know about lean methodology or have already been informed about this topic. They got the knowledge or information either through training or propagation of lean methods in the company. In comparison to the second question, there is a visible

effect. Employees that work for company for less than three years are not intensively informed about lean and they did not get training in Lean Management. The evaluation clearly shows that new workers in the company do not get or have not received any basic training in Lean Management.

Question Nr. 4: ***When did the last training for lean principles and methods in general in the company take place?***

This question will tell us when was the last training in Lean Management and Lean tools organized for employees.

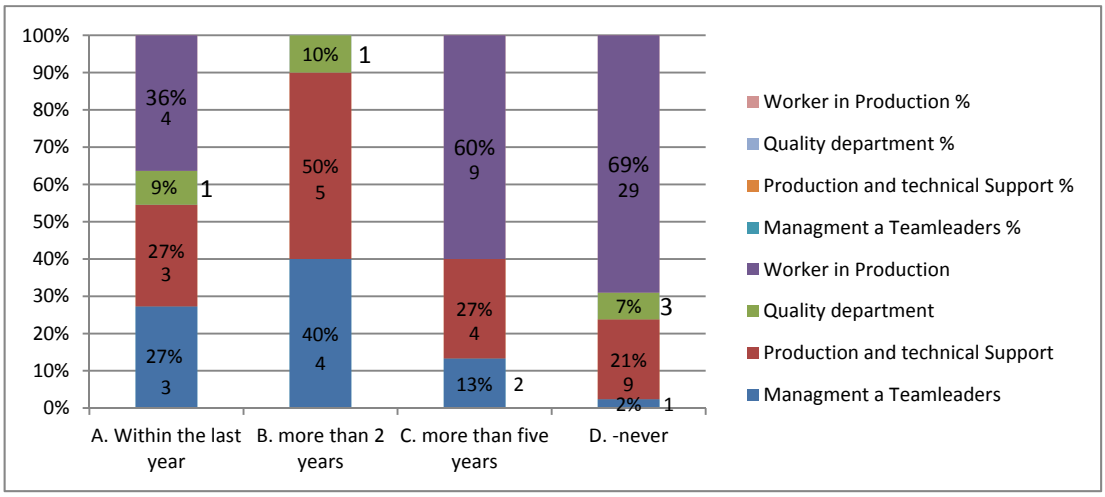

Figure 7.4 Graph – How many workers have got trainig for lean principles

Systematically planned trainings in lean principles and Lean Management do not exist in the company. There is a mixture. People are trained in different methods regardless the department.

Question Nr. 5: **When you attended trainings, was it done within the company or externally?**

This question gathers information on how the company provides lean trainings for their employees. The aim of this question is also to determine in general whether the employees get trainings and where are these trainings in lean methods executed (externally or internally).

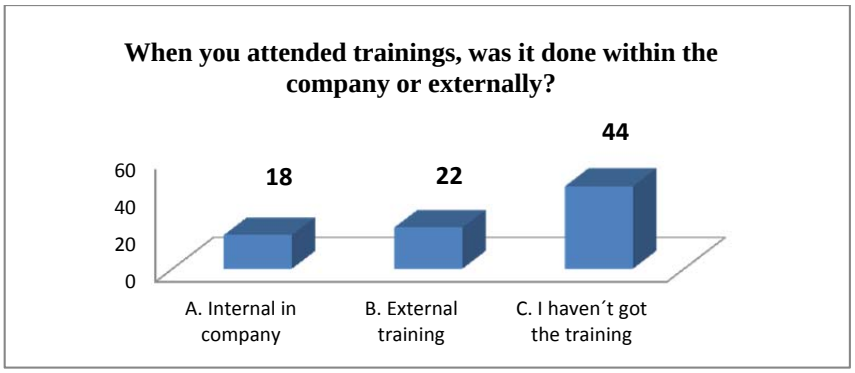

Figure 7.5 Graph – Evaluation for the type of training

We see from the results that people are trained internally and externally in equal measure. More than half of participants have not received any training in Lean Management.

Question Nr. 6: ***In which Lean tools and methods have you got the training?***

The question maps the level of training in production, as well as in office and in management. We want to find out in which lean method they are trained for further implementation in the practice.

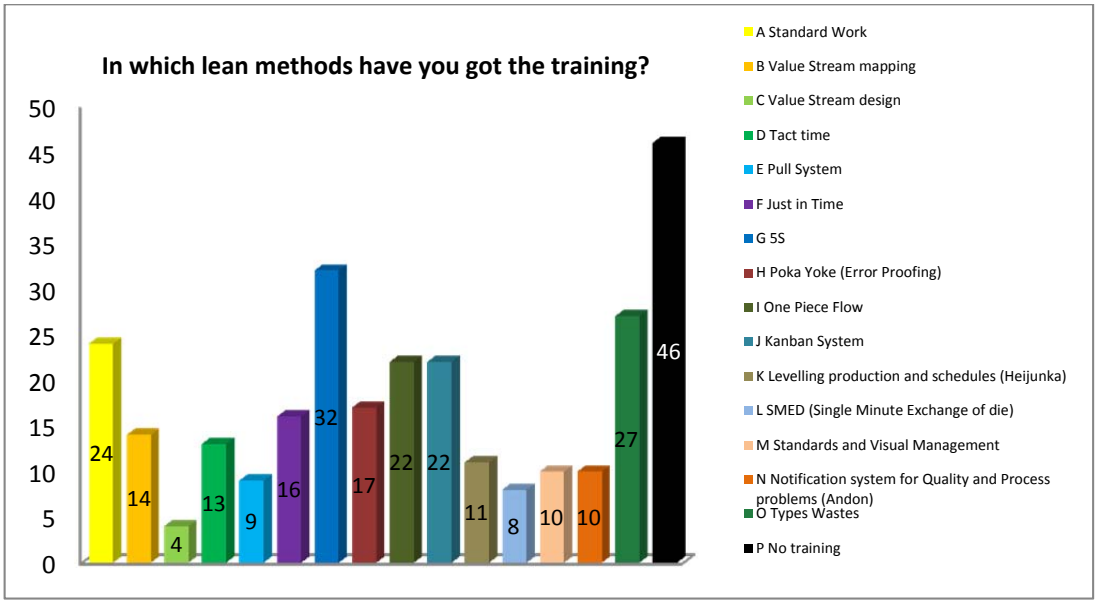

Figure 7.6 Graph – Evaluation of type of trainings

Results show that more than half of employees have no training in Lean tools. Those are particularly new workers in the production and some employees from various departments. Management and team leaders are trained, as the analysis shows, externally as well as internally. They received a broad range of trainings. The chart shows all types of trainings and the number of employees that got these trainings. Most participants have got the training for 5S, Standard Work and 8 Types of waste.

It was a few years ago, when the company implemented these methods into practice and organized training for employees.

Question Nr. 7 ***Do you use following Problem solving methods in the company?***

The question finds out which methods of Lean Management employees use to solve problems in their work.

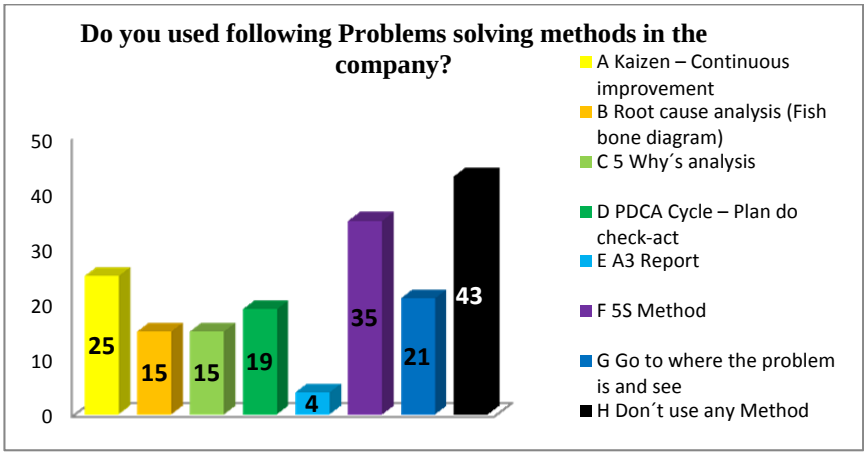

Figure 7.7 Graph – Evaluation of Problem solving Methods used in the company

Employees use, to some extent, all selected methods for solving their work problems. 5S method is already implemented in the company, therefore most people use it. It is also noteworthy that some people use lean methods even though they did not attend trainings or did not get any internal instructions. More than half of respondents' do not use lean methods in their work.

Question Nr. 8 Have you been evaluated or surveyed in Lean tools or Lean Management within the company in the last 2 years?

This question maps whether the company has already investigated the knowledge level of employees, level of implementation and the use of Lean Management, lean philosophy and lean methods in the company in the last 2 years.

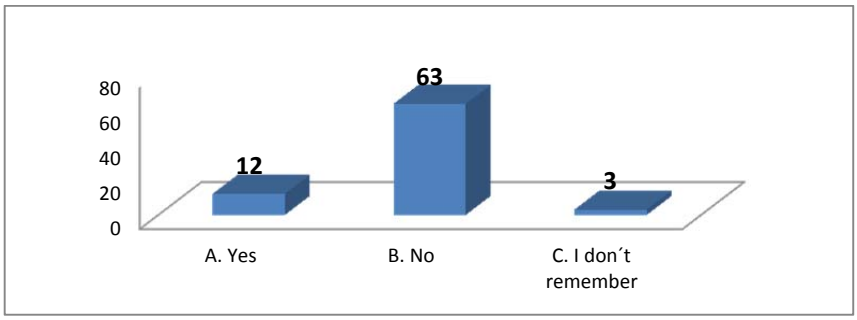

Figure 7.8 Graph – Number of employees being surveyed in Lean Management

The question also confirmed previous analysis of observations in the company. The company has not done any survey yet to obtain information about the knowledge level of Lean Management and their use in practice. 12 respondents participated in a similar survey on Lean Management before they attended a training performed by an external training company.

Question Nr. 9 ***Do you consider the use of Lean tools and Lean Management important for the company and for your work?***

Purpose of this question is to determine how important is using Lean Management and Lean tools for them and for their work. Furthermore, the question determines if the workers know the aim of Lean Management, that it is an improvement for their work, processes and overall business in the company.

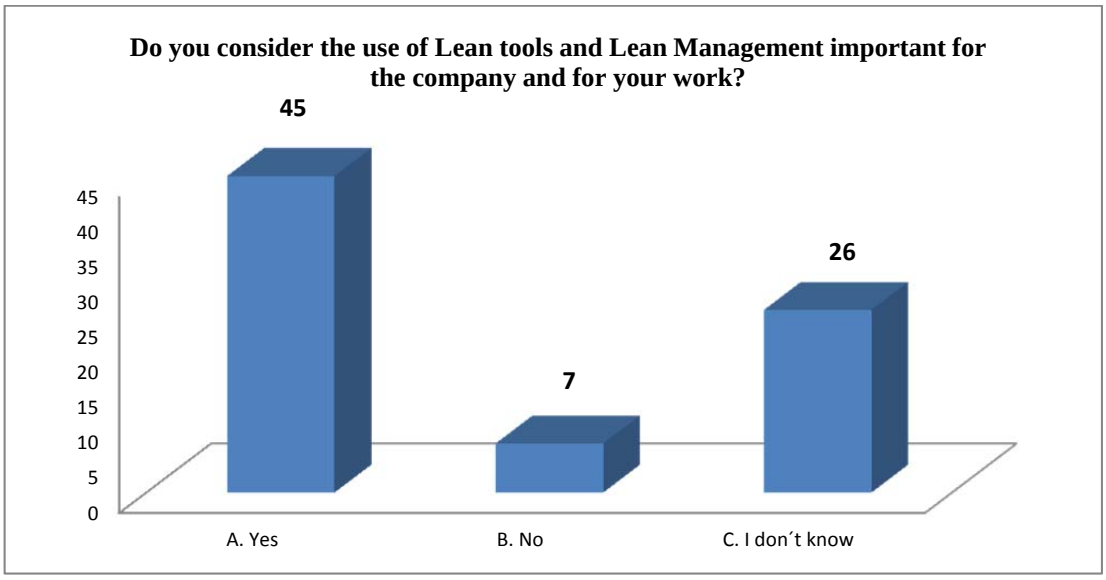

Figure 7.9 Graph – Evaluation of importance of Lean Management

More than half of participants realize, that Lean Management is required in the company for better managing of processes and they also know about its benefits for their work. On the other hand, we have some participants that do not know what Lean Management brings them. We can see from the survey that this group of employees has no experience or knowledge about lean methods. Some participants gave negative answer. It may express their dissatisfaction with the company.

Question Nr. 10 ***Do you feel that you need more training in Lean tools and lean practices?***

The question maps the interest of employees in Lean Management and Lean tools training, implementation and use of Lean Management in practice.

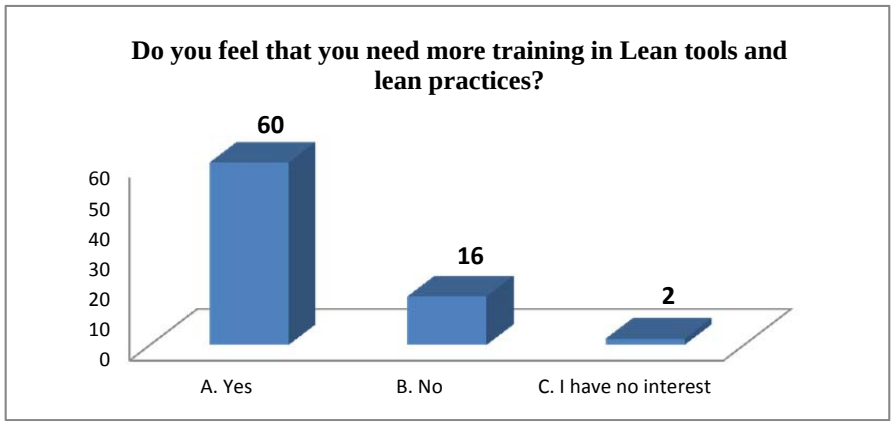

Figure 7.10 Graph – Evaluation of interest in futher traning in Lean Management

These results follow up on results from question no. 9. Most people expressed positive interest in more training in Lean Management and lean methods. They also expressed positive attitude to implementation and development of Lean Management and Lean tools in the company.

7.4.2. Summary of findings from the survey

Analysis as well as results from the Survey confirms, that only a third of respondents have knowledge about Lean Management and lean methods. Another third of respondents have heard about these methods in the company or gained the knowledge from previous employment. The Knorr Bremse Company has already implemented and uses some of lean methods in the processes. Some employees got various trainings during the implementation of Lean Management. This implementation has been done some years ago. Since then there are not any regular educations or trainings organized to refresh or to pass new knowledge about Lean Management to employees. When new workers start to work for the company, they are not train or informed about lean in the company in their first year of employment. Employees that got trainings have been trained internally and externally equally. More than half of respondents do not have any trainings in this methodology.

Participants in the survey have attended different types of lean trainings in the company not just those needed for their work. As mentioned before, few years ago

the company started with implementation of the following Lean tools: 5S, 8 Types of waste and standard work in the production. These methods are now used in the production; they were used in the office but are no longer used there. That is why the largest share of training falls on these three Lean tools.

Most participants that passed trainings in the company are managers, team leaders and employees from quality department. They also use this method in practice and for solving problems in their work. However, there are some employees in the company that have to use lean methods without having passed training. It may be the fact that some employees have already come with the knowledge from previous employment. Dangerous is the fact that these workers have to use 5S and Standard Work on the workplace, but have no training and enough knowledge about it. This fact can lead to incorrect use of these methods in practice.

The company has not been interested yet in feedback about the Lean Management through any questionnaire or survey, from employees in the company. Yearly audits to monitor implementation and using of Lean Management and selected lean methods in practice are conducted in the company. KPS Expert uses a form of questionnaire to evaluate, with manager of department, the level of implementation of Lean Management in the production area. Some respondents have already participated in a similar survey on external trainings. It is a formal way of getting information about employee knowledge for better planning and execution of Lean Management training.

More than half of respondents realize, that implementation and use of Lean Management is a benefit to the whole company, as well as for their work. On the other hand, a third of respondents do not know the meaning of Lean Management, what its content is and how to use it in practice. As a consequence, employees that are not trained cannot see the sense and benefit of Lean Management in the company.

Most of the respondents realize the need of implementation of more lean methods into processes, as well as their use for daily work. They are willing to participate in training in implementation and development of Lean Management in the company. This finding is very positive for the company. Employees are willing to take part in the improvement of company's processes, as well as in their personal development.

7.5. The findings resulting from the analysis

After the analysis and evaluation of results from the survey, the following facts are drafted:

- Creation of systematic trainings in Lean Management and implemented lean methods in the production (theoretical education, training with simulation game, training directly on the workplace)
- Retraining employees in already implemented methods (5S, Standardization and 8-Types of Waste)
- Renewal of regular audits to check the utilization of implemented methods in office and in production area.
- Cooperation of managers with HR Department to propose and select which trainings have to be executed internally and externally
- Creation of new work positions or extends a work content of selected employee to overtake the responsibility for creation, preparation and organization of internal trainings of Lean Management for employees.
- Creating an area or room for lean trainings, maybe for the future plan a trainings room
- Creating groups and time plan for executing the trainings with new employees, as well as retrain the old employees.
- Visualization and promotion of Lean Management and selected Lean tools within the company in production and office areas.
- Motivate employees on all levels in the company to cooperate more in implementation of Lean Management and Lean tools.

8. Creation of simulation games for lean production trainings

The aim of this Master's Thesis is to create and execute specific trainings using lean games for production workers, as well as for employees in the office area. The analysis confirmed the need of training and retraining of employees in lean production systems. Created simulation games practically supplement the proposal for trainings concept. Created lean games in this Master's Thesis are based on knowledge gained from literature, MBA study and analysis carried out in the company. Before executing lean simulation games, I have created a short presentation about lean methods used in the game. The purpose of presentation is a theoretical explanation about selected lean methods and shows their use in practice. For smooth running of the simulation game I have explained the rules of the game before the start. Furthermore, I created training content, instructions for simulation games, working documents used during the simulation game and documents for registration the time from individual rounds.

Lean game training consists of the following:

1. Short entry test with a few targeted questions about lean methods
2. Short presentation about Lean Management and selected lean methods used in the game. It explains the basic principles and application in practice
3. Process simulation –participants play lean simulation game to demonstrate selected methods in practice. These way participants get the practical experience of implementing this method into practice.
4. Discussion about gained knowledge from training, answering open questions
5. Validation of acquired knowledge by answering questions in the final test

Entrance and final evaluation test

I created entrance and final tests with short and targeted questions to verify knowledge of participants before and after the training. A participant receives an entrance test at the beginning of the training. This test serves for verification of the initial knowledge of the participant about this lean method before the training starts. Final test is handed out after the training to verify if the training was successful. Both tests have same questions, but the final test also contains questions about participant's satisfaction with the training form and to gain some comments for

further improvement of the training. You will find templates of both tests with right answers in annex Nr. 2.1; 2.2; 3.1; 3.2

Before execution of the training with lean game

Trainer performs the following points before the start of lean game training.

- Introduction of participants,
- Narrative description of the simulation game and its aim,
- Explanations what will be done, simulation or assembly during the simulation game, what are the key points of selected lean method in the game.

It depends on the trainer and participants of the training if all above described points are necessary.

8.1. Lean Game 1 - Training for 5S Method

This simple game with letters demonstrates 5 Steps of 5S used in practice in office as well in manufacturing area.

The main task of this game is to show how the basic principles of 5S method work in practice. In addition to this game, the player can remember individual steps of this 5S Method. Therefore, this game uses letters from which a player composes individual words of 5S methodology *"SORT, SET IN ORDER, SHINE, STANDARDISE, SUSTAIN"*. In German language these are *„Sortieren, Sichtbare Ordnung, Sauberkeit, Standardisieren und Selbstdisziplin"*.

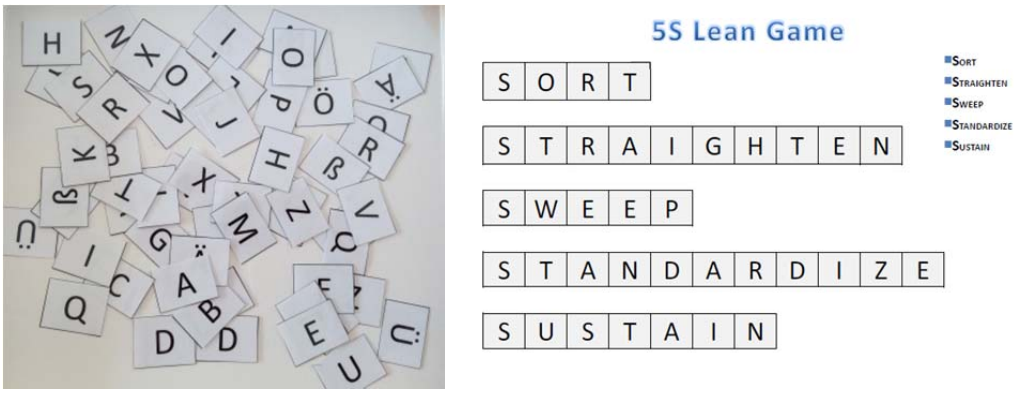

Figure 8.1 5S Cards with letters and the model of 5S for final round

Key points of this game are: 5S Method, Waste, Cleaning the Workplace, Productivity, Reduction of Variation and Standards in the Office and Work area.

The task is to create 5 words in order from 1 to 5 from given letters. The words are keywords of 5S Method. This game has 4 rounds. The players measure their time spent in each round. The trainer writes the time results of each player on the board

after each round. This game can be played by any number of players and we can play several rounds in a row. The time for assembling the words should be shorter after each round of the game, the productivity increases, variation and errors are reduced. All these aspects can be easily recognized and detected already during the simulation.

8.1.1. Summary of learning point from this 5S game

- The participant learns to understand how the productivity is measured
- What is a waste time and how long does it take to find the right letters
- Learning the wording of 5S Method - SORT, SET IN ORDER, SHINE, STANDARDISE, SUSTAIN

8.1.2. Steps for the simulation of 5S Lean Games

1. Material preparation according to the attached copies in the annex
2. Moderator (trainer) explains the 5S method with a short presentation and he points out the main principles of this method. Trainer also explains with the help of images in the presentation how the method is used in practice. After the presentation, he asks participants, if they have understood the principles of this lean method. Only when all participants agree, he starts to explain the rules of this lean game step by step as is described below.
3. Start of the first round of this lean game. The letters are prepared in the small box without any order. Create 5 words of 5S methodology (SORT, SET IN ORDER, SHINE, STANDARDISE, SUSTAIN) from the letters. Begin from the first word to the last one. Check the correct order of words and letters. Measure the time with a stopwatch and record the final time into a table. The trainer displays these 5 words on the board during the game.
4. After the first round, the trainer opens the discussion and explains the principle of the first step SORT in 5S method. After the discussion, players pick up only those letters they need for this game. They put other letters away from the table.
5. Return the remaining letters into the box and start a second round. Repeat the game as given in the first round. Measure the time of assembling all 5 words

in the correct order of words and letters. The trainer writes the time results of each player on the board.

6. Again, he opens the discussion and explains the principle of the second step STREIGHTEN.
7. The players arrange letters in the box so that all letters are visible and in order.
8. Run the third round of simulation game. Measure the time of assembling all 5 words in the correct order of words and letters again. The trainer writes the time results of each player on the board.
9. Again, he opens the discussion and explains the principle of the third step SHINE. In this case, it is not necessary to don the cleaning of the workplace. The trainer just mentions the theory to explain this step. (for example cleaning of the workplace and tools).
10. Go to the fourth round of the simulation game. The trainer explains the fourth principle of the 5S method STANDARDISE. In this round the trainer gives a model assembly for players to put the letters in. Start the last round of simulation game. Put the letters onto the model and assembly all 5 words in the correct order of words and letters. The trainer writes the time results of each player on the board.
11. At the end of the lean game, the trainer evaluates all the times from each round. He explains the progress from first to last run and opens a discussion and answers any question of players. At the end, he gives some recommendations for the practice.

The lean game is divided into four rounds. The third round, due to the fact that there is no need for cleaning in the game, is not practically executed. Trainer gives only a brief theoretical explanation. You have to measure time in each round and write it on the board for further comparison of the measured time between players and rounds and for final evaluation of the measured time.

8.1.3. Execution of the 5S Lean Game training

All trainings using lean games were executed with the employees from Brake Control assembly area in the company Knorr Bremse Mödling. This 5S Lean Game training was executed with 10 participants divided into 2 groups. Knorr Bremse

Company does not have its own training rooms; the training took place in one of the meeting rooms in the company. I prepared and distributed training material on workplaces in the meeting room in advance (see the Figure 8-2).

Figure 8.2 Preparation of training material

After welcoming the participants, I explained how this training will run. I handed out the entry test to get knowledge about this 5S lean method before the start of the training. Before filling in of this entry test I also informed participants, that they would be filling in the same test at the end of the training to compare the effectiveness of the training. I also informed them, that they would get the right answers during the training and by active participation in the training. After the entry test, I explained to participants using a short presentation the 5S method the individual steps, where the method is used and how it is implemented in practice. In the presentation I pointed out the advantages of 5S method and benefits for workers and for the whole company.

The lean game was started by distribution of the materials to participants and explanation of rules for the each individual run. The aim of the lean game was to create 5 words of 5S method from letters. The entire game consisted of 4 rounds where in each round one step of 5S method was simulated. Participants measured their own time using a stopwatch in each run. After each round I wrote the measured time on the board.

5S Lean Game 1	Round 1 (Min)	Round 2 (Min)	Round 3 (Min)
Participant Nr. 1	5:17	3:11	1:30
Participant Nr. 2	5:21	3:52	1:30
Participant Nr. 3	5:40	3:32	1:27
Participant Nr. 4	4:55	3:42	1:15
Participant Nr. 5	5:35	3:48	1:55

Figure 8.3 Execution of one 5S game and the resulting time for each run

After execution of one step of the 5S Method I emphasized the main points from the round for better understanding of this 5S step and responded open questions being asked during the individual rounds of the game. As you can see in table Figure 8-3, the measured time was shorter from round to round. In the final discussion, I mentioned benefits and savings brought by using this method. I also asked participants where they would implement this 5S method in the company. Participants would be implementing the 5S on their workplaces and especially in the offices. The answers to my question as well as the proposals were very positive. Participants wanted to know when next trainings would take part; they would also like to participate in the project of implementation of 5S methods in the department or on workplace.

The last step before the end of the training was to answer questions in the final test. The final questionnaire was enriched with two questions concerning the ability the implementation of this method at their workplace as well as satisfaction with the quality and execution of the training. At the end of the training participants had the possibility to write some comments or ideas for further improvement of this training.

After answering the question in the final test, I thanked participants for the cooperation on this training 5S and terminated the training.

8.1.4. Final evaluation of knowledge from 5S Lean Game

Entrance and final questions were created for getting the feedback from participants in the training. The graph in figure 8-4 shows the evaluation and comparison of the right answers before and after the training. I have compared the number of correct answers before and after the training.

We can see that this type of training is very effective and participants gained new knowledge in the field of Lean Management in the 5S method.

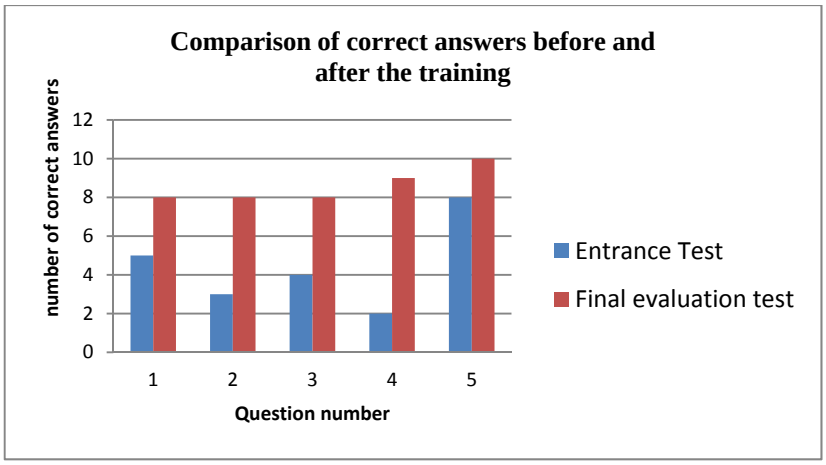

Figure 8.4 Comparison of correct answers before and after 5S Lean game training

As I informed participants that they would be answering the same questions at the end of the training, they concentrated more during the training and they asked and discussed the correct answers for questions during the training. Some questions concerned more meanings. It was difficult for some participants to choose the right answer. I noticed this so in the future I will choose the questions as well as the answers more precisely.

8.2. Lean Games 2 – Single Piece Flow vs. Batch Production – Assembly the parts in one cell production

The current demand of Knorr Bremse was to create and execute specific training for employees for the currently implemented method - One Piece Flow - in the assembly process. The analysis also confirmed the need for an employee training for this method of lean manufacturing.

In this game, we tried to simulate the working process with one person in one work cell. The training shows the difference between production in batch mode and production in one piece flow in the assembly process. This Lean Game was created using building kit called MERKUR. Furthermore, for the smooth running of this Lean Game I created training content, work procedure with assembly steps, work instructions for the assembly process and documents for noting the time of each player and runs for further time analysis.

Key points of this game are: One Piece Flow Method, Batch production, time measurement, productivity, delivery time, throughput time and quality assurance.

8.2.1. Product description of the simulation game 2

In this simulation game I used the construction set shown in the figure 8-5, where we screw the parts together and finally we assembled a small simple car. This simple car contains some subcomponents, which can be used for further developing of the lean game or for adding more parts into the training process to train more lean methods.

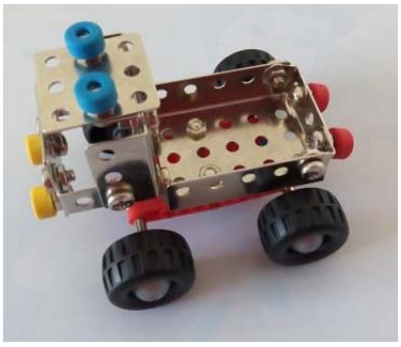

Figure 8.5 Building kit MERKUR-Car

8.2.2. Description for execution of lean simulation game 2

The workers training contains following points:

1. Presentation in PowerPoint, explanation of the OPF method, pointing out the advantages of this method and showing the concrete examples with pictures.
2. Practical exercises with participant of the training using lean game. During the lean game the difference between one-piece flow and batch production is shown. The employees will learn the advantages of the One Piece Flow method in manufacturing.
3. 3. Discussion, answers to participants' questions and filling in of the final test to compare the knowledge gained during the training.

8.2.3. Steps for training Lean Game 2 - Single Piece Flow vs Batch Production

The trainer explains to participants' both methods Batch and One Piece Flow before the start of the lean game. He also explains the advantages of OPF and where and when each method is used. After a presentation, the trainer explains the rules of the lean game, assembly instruction and working tools used in the game. Lean game is divided into 2 runs. Workers will choose their job position in the lean game (assembly worker, material preparation, time measurement, product transport and customer). The role of the customer is played by one of participants in the training. After the first round, a discussion takes place to explain into depth the main points of these methods used in this round. Customer requires production, testing and delivery

of 5 pieces of one product. The task is to produce products of the required quality in the shortest possible time and delivery them to the customer.
In a simple way we simulate the assembly of a product in an assembly cell with one worker, like it is in the real assembly process in the production area.

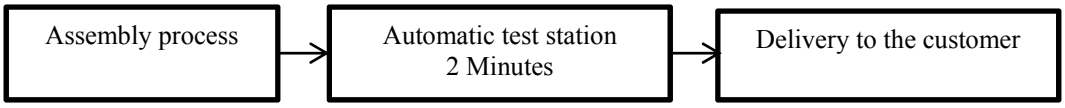

Figure 8.6 Simulation process in lean game 2

I. Run - Batch production

Participants of the training take their places. The workplace for assembly is marked as on the figure 8-6 as one cell production, where the assembly and testing process is executed from the beginning to the end in one cell. The material is already prepared and delivered into the work cell. The worker assembles all 5 products simultaneously using prepared parts. According to working instructions all 5 products assembled in Batch are subsequently tested on test station for 2 minutes one by one.
Another worker measures the time of the assembly, testing and delivery to the customer. The total time of finished and delivered products to the customer is written into a prepared table on the board. The final time is presented by the trainer to participants of the training at the end of the round. He shows how long it takes to deliver products to the customer. In this round, the time for delivering one product equals to the total time for delivering all products to the customer.
Subsequently, the trainer opens discussion and explains the disadvantages of batch production. He also asks the participants for suggestion of changes to improve the process and shorten the delivery time to the customer. The trainer also develops discussion and explains the rules of One Piece Flow for the second round.

II. Run: One Piece Flow Production

Participants take again their places. The same assembly and testing processes will be done. In this round, the products will be assembled in One Piece Flow method. The material is already prepared and delivered on the workplace. Assembly worker in the cell assembles 5 products one by one using prepared parts according to working instructions using One Piece Flow method. Another participant measures the time of assembly, testing and delivery of the product to the customer. The trainer writes

down the time of the production and delivery to customer into the prepared table on the board. In this case, each time need for finishing a product is a delivery time to the customer.

At the end the measured times are presented to all participants of the lean game. The time needed to deliver each product to the customer is discussed. The trainer compares the time differences needed for delivery of products to the customer in Batch and in One Piece Flow production mode. Subsequently, he opens discussion where participants can discuss the assembly process and compare the processes in One Piece Flow and Batch production.

8.2.4. Summary of learning point from lean game 2

- The participant understand difference between batch and OPF production
- It is shown how to shorten lead time to quicker the delivery of the product to the customer
- Reduction in storage, no storage in production area
- Elimination of mistakes in assembly process
- Increase Flexibility - One piece flow is faster than batch production
- Improves Productivity – with reducing the waste

8.2.5. Execution of training Lean Game 2 - Single Piece Flow vs. Batch Production

Training for One Piece Flow versus Batch production was realized as other trainings used in this Master's Thesis in the Knorr Bremse Company. 2 trainings groups with 5 participants took part in the training. Participants in groups were from both production and offices area. In the figure 8-7 you can see an example of training material preparation for this lean game training.

Figure 8.7 Material for Lean Game OPF versus Batch Production

This training had the same structure As the previous Lean game trainings also this training had the same structure. After welcoming the participants and explanation of objectives, they filled out in the entry entrance test. After answering the question in entry test, I as a trainer introduced and explained with prepared presentation the theory for of method One Piece Flow and Production in Batch methods. I showed them where we use these methods in production, explained their use in practice and consequently I pointed out the benefits of One Piece Flow production.

Before starting, the Lean game participants were divided in appointed to work positions (production worker, logistics, time measurement and customer). The fifth person has had the task to monitor this process to find some improvements to optimize the process. This lean simulation game had 2 rounds – assembly in batch mode in the first round and assembly in One Piece Flow in second round. In each round the one worker of time measurement measured the time needed for assembly and delivery and the time results I were entered into the table in annex 3.6.

Figure 8.8 Course of Lean Game Training OPF versus Batch Production

8.2.6. Research and evaluation of results of Lean Game 2

After evaluation of results from questionnaires, we can see positive facts again. Using this type of training participants gained new knowledge about a part of Lean Management. The total time for all 5 products was a little shorter in Batch mode in comparison to OPF Mode. At the beginning, participants saw only this total time. I had to explain again and show in the table that this time is not so important for the customer as the time needed for the delivery of the product, like it is in OPF. I also explained the other disadvantages of Batch mode in comparison to OPF. Some Lean expressions in this training were used in their original language or in English.

Training was executed with German speaking employees. Therefore, participants in trainings did not know or understand some lean words. So, I had to find out equivalent expressions during the presentation. In the final discussion, I had to explain the meaning of these lean words and methods using other words in German language.

The aim of the training was to present and demonstrate particular methods of production and also to show the fact that using One Piece Flow method in assembly process the customer gets ordered products continually and in shorter time in comparison to Batch production.

Participants expressed great satisfaction with this type of training and they demanded other trainings in lean methods in this form.

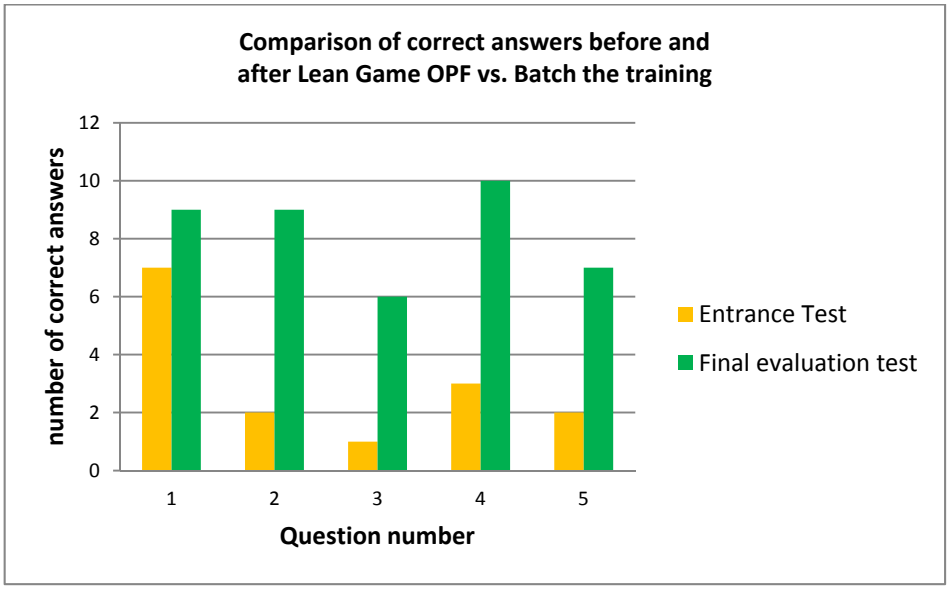

Figure 8.9 Comparison of correct answers before and after Lean game training 2

8.3. Lean Games 3 - Single piece Flow in cell with line production

In this game, participants get training in One Piece Flow Production in one cell and subsequently a training how to divide the assembly steps to create a line production with more than one operator. The main task is to show and practice how to divide assembly steps in workstation in line production, how to use Kanban system, how to do line balancing and calculation of tact time using a lean game.

Key points of this game are One Piece Flow method, Line production, time measurement, productivity, delivery time, tack time, line balancing, Kanban system.

8.3.1. Product description for the simulation game 3

As mentioned before, I also used the assembly kit MERKUR for this simulation game. I use this type of kit because it is the most similar to the real assembly processes in the company. In the assembly cell there are parts assembled and screwed together, which can be simulated using this kit. As an example we will use a component that is assembled in an assembly cell, the Driver's brake valve. Using this Merkur kit I have created an assembly block which represents a part of Driver´s brake valve (see in the Figure 8-10).

The worker assembles and screws the parts together during the working process. The individual parts in the building kit represent this process.

Later for an advanced lean game training MERKUR add-block can be used which will bring the training closer to the real product. The other possibility is to use the real parts from assembly line. It is also possible to create and simulate a lean game using real parts.

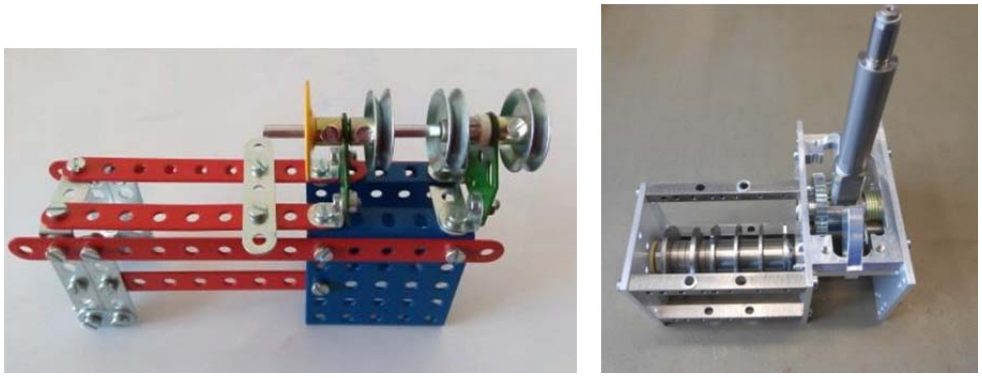

Figure 8.10 Building kit MERKUR Machine and Base Part of Driver´s Brake Valve

8.3.2. Description for an execution of the lean simulation game 3

At the beginning of training the trainer explains to participants, how to implement One Piece Flow in line manufacturing, how to document the current process, how to draw current layout, measure the time for each operation and calculate the tact time. In the next step, employees get a short overview of how to create a new layout and which steps are necessary to do to create line manufacturing within the work cell. In the last step, they get information about line balancing and creation of a continual flow.

Then the trainer explains rules of the lean game. Lean game is divided into several rounds. Afterwards, the trainer presents working instructions, assembly materials and

tools that are to be used in the. Work tasks in lean game are assigned to workers and they are given some time to review the product, job, tools, and workflow.

The following rules are applied:

The game has three rounds. After each round, a discussion is opened and after each round there is a possibility to change the rules. The task is to produce 3 pieces of product in the working cells and delivery them to a customer in the shortest possible time. In each round, we measure the time of assembly operation and finally the time of production. The time is written on the board for further comparison of rounds and for final evaluation.

The first run - Lean Game One Piece Flow and Line Production

In a simplified method we will simulate assembly process of the base part of Driver's brake valve. A similar product is produced in the real work cell. In the first run, we will simulate the same assembly process as in the real assembly cell. That means; the whole product is assembled from the start to the end in the cell by one person. After the assembly process, the product is checked for functionality on a test bench. When the product is fully checked with an OK result, it is sent via transport to the customer.

To simplify the whole process, in this game we will simulate only the assembly process. You can see an example of the assembly process in Figure 8-11.

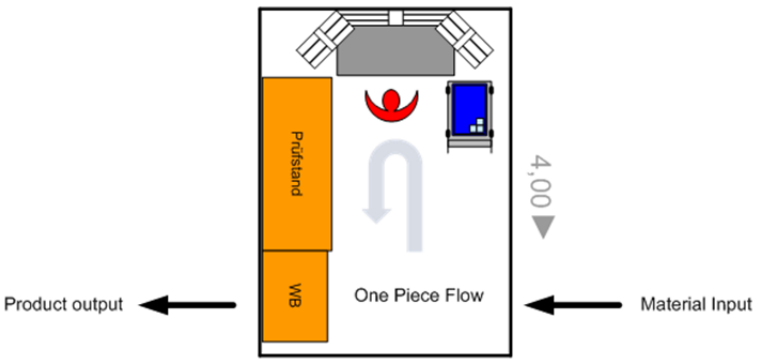

Figure 8.11 U-Cell with one Person

Jobs - material preparation, transport, assembly worker, time measurement and customer – are assigned to participants. The worker responsible for time measurement measures the time of each assembly operation and writes it down into the table. At the end, he calculates the total time of a finished product. You will find

the formula for calculation with an explanation in the presentation attached in the annex 4.1.

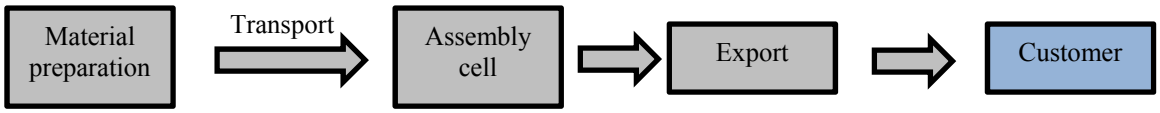

Figure 8.12 Simulation process in lean game 3

The worker in the warehouse prepares parts for each product and sends them into production. Production worker assembles the products together one by one using One Piece Flow. He also does tests of functionality. After the functionality test on a testing bench, the finished product is transported to warehouse for further delivery to a customer.

The worker has to produce 3 products in One Piece Flow according to working instructions. Another participant measures the time of material preparation, production, functional testing. The trainer writes the time into the table.

The measured time is presented to all participants at the end of the first round.. The trainer shows the time needed for assembly of each part of a product and he calculates the total time needed for assembly of the whole product. Based on this, the trainer opens a discussion and he asks participants what is wrong in this process, which changes would they suggest to shorten the production and delivery time. The trainer also asks what waste the participants see in the process and how it can be removed. In the next point trainer explains which tasks are necessary to do to create a line within this work cell. Together they propose and agree to new modifications of process. These modifications will be applied in the second round.

The second run - Lean Game 2 - U-Cell with 3 Workstation and Kanban system

Trainer proposes a new concept of assembly line divided into 3 workplaces within the cell. Two workers will assembly the subcomponents and third worker will assembly these subcomponents together to finalize the product. If it hasn´t been proposed by participants yet, the trainer also proposes an implementation of a Kanban system. The Kanban system serves for better organization of material in the assembly process. The trainer also proposes a new layout for better organization of the transport and assembly of material in order to reduce the working area. In the new layout we should consider conditions for ergonomics of the workplace and

organization of material. To control quality in assembly process a self-check of operations have to be implemented. The trainer draws the new layout for assembly line on the board. Employees get new working instructions and some time to read instructions and some time needed for answering few open questions.

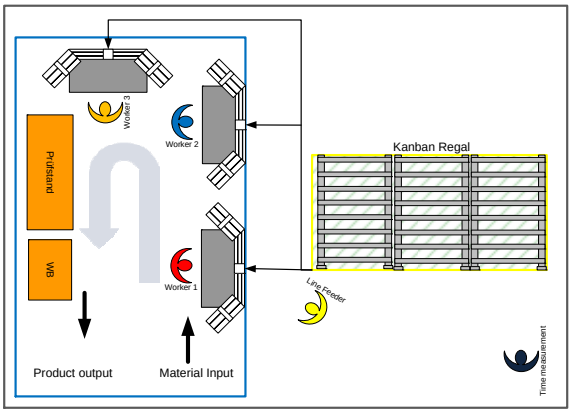

Figure 8.13 U-Cell with 3 Workstation and Kanban system

Material is distributed from Kanban to each workstation into a Mini-Kanban system. The Mini-Kanban is material in shelves in the workstation. In this round, the worker responsible for material transport delivers material to Mini-Kanban for each workplace. He is responsible for transport of finished products from the production area to the export. Pre-assembly worker (in these round 2 workers) produces subcomponents in One Piece Flow and passes the finished subcomponents to the next work station. The third worker receives the subcomponents from worker 1 and worker 2. He does the quality self-check of components and assembles them together to create the final product. Each worker produces 3 components, so at the end of the line there will be 3 finished products. In the assembly process, the Pull system is used . Fifth worker measures the time for material preparation, assembly operations at individual workplaces. To get the right time data from all workstations, the workers 1, 2 and 3 measure the time themselves and report it to the worker responsible for measurement. He writes the time in the table. The final time is written into the same table used in the first round of this lean game.

After mounting all 3 products, the trainer presents the measured time of each process in the second round. The trainer compares the differences of measured time between the first and second round. He shows and discusses individual progress of implemented changes that bring us success. Subsequently, the trainer shows and

calculates the tact time for the product. He discusses the results and improvements in this round with participants. He tries to explain and discusses with participants how to apply this system in the real assembly cell in the company.

The third Run Lean Game 2 - Line Balancing

In the third round, the trainer explains the issue of line balancing. Together with the participants they find out idle times in the process and explain why they occur. Trainer draws a graph on the board with assembly times for each assembly operation and he shows the inequalities in assembly times between workstations.

Subsequently, he tries to change the assembly operations together with the participants in order to get better line balancing to create continuous manufacturing flow. After approval of this assembly process, they start the production of 3 pieces again. The worker measures the time and calculates the tact time.

8.3.3. Course of the training Lean Game 3 - One Piece Flow and Line Balancing

This training had the same structure as the previous Lean game trainings. The training follows the methodology of One Piece Flow, which is a major theme in the assembly process in the company. The target of this lean game was to show and train how to create an assembly process on a small production line, as well as how to balance the work operations on the line and calculate the tact time. The participants received the entrance test to answer questions about lean methods used in this training. After the entrance test, I explained the aim of the training, the method which will be used in this training and rules of the lean game. Before the start, I explained all 3 rounds of the lean game in details. This training and the method used in this training were completely new for participants. Therefore, they asked me a lot of questions and I had to explain some terminology and methods more widely. The formulas for calculation of the tact time and throughput time were also new; therefore I had to help them with calculation of this time data.

After the first round, participants proposed some improvements and changes in the assembly process. The next step was the implementation of the Kanban system to demonstrate how the Kanban works. Before the third round we did the line balancing, which was very interesting for participants. They had a lot of questions and at the end they proposed new ideas for improvement.

Participants practiced various lean methods due to this game. This training was executed with 5 participants in the mixed group - people from production and office area.

In each round, the worker responsible for time measurement measured time and the time results were entered into the table. The participant also calculated the tact and throughput time. You can find all results from this game in annex 4.6.

8.3.4. Research and evaluation of results of Lean Game 3

Based on this training and execution of lean game, participants gained essential knowledge for creation of an assembly line and the information about a new production system. Participants were very active during the training. They themselves suggested improvements for the creation of continual run of the assembly process and compared them with the real cell on their working places. They also proposed ideas to use a real product for this training. I promised to them, that real product would be used when they start a project on the workplace. This will be the next necessary step to deepen their knowledge gained during this training.

The comparison of answers from the entrance and final tests are evaluated in the figure 8-16. Here we can also see a positive evaluation of trainings.

8.4. Analysis and research of all executed lean games trainings

As mentioned before, for measuring the success and meeting the objectives of the training, I have created an entrance and final questionnaire to get the information about the knowledge level of participants. Number of correct responses from the entrance and final tests are evaluated and shown in the Figure 8-16. Here, we can see the difference of the knowledge level before and after trainings.

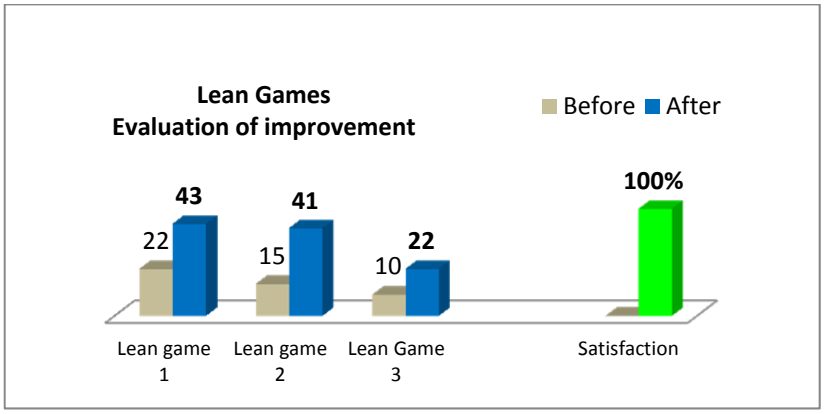

Figure 8.14 Evaluation of the correct answers before and after each lean game

On the graph, we see an increase in the correct answers and thus increase in knowledge of participants inn trainings. After the execution of all three trainings, we can say that this type of training was fully successful. Subsequently, the graph also shows evaluation of satisfaction of participants with this type of trainings. This type of training was fully new for employees in the company. They found the training very interesting, paid attention during the whole training and participated actively during the execution of lean games.

Evaluations of Lean game – 5S

Participants in this training were from different departments. Some participants already had knowledge about this method. However, during training, they clarified the individual steps of this method that were previously understood otherwise. Some participants heard about this method for first time. We can see this in the results of correct answers before training. Everyone had clarified the steps of this method during the practical part of the lean game. The number of correct answers increased rapidly after the training. Participants were motivated, discussed questions from the entrance test and asked which the correct answers were.

Evaluation of the Lean game – One Piece Flow versus Batch Production

The theme One Piece Flow is an actual theme for production in the Knorr Bremse company. The company presents this method to employees and tries to implement it into work process. However, the outcome of the entrance test showed us, that employees do not understand this method much. In particular, they do not know why they have to use it in practice. In addition, the word "Batch" was a foreign word for some participants. Therefore, some participants only guessed the right answer in entrance test. Participants do not recognize what exactly is wasting on their workplaces. The company presents 8 types of waste; the employees only memorize the correct answer. The effect is that they know the 8 types of waste but they are not able to see it in practice. Using this method I saw that participants have significant gaps in knowledge. Therefore, during the theoretical part I tried more to explain the answers to questions for better understanding of the differences, advantages and disadvantages of both of these lean methods.

Evaluation Lean game - One piece Flow and Line Balancing

Creating a line and balancing the work operations within the line was something new for participant in the training. The working process in BC production department is designed for a working cell with one person inside. In this cell, the product is produced from the beginning to the end. Therefore, participants had a problem in the entrance test to define correctly what tact and a cycle time is. I have explained this terminology to them in the presentation and on practical examples. After presentation, I have explained and showed how to calculate tact and cycle time. In the second round and the third round of this lean game, they used the acquired knowledge to calculate the times by themselves. In the second and third rounds, they realized how relevant is line balancing and continual flow for the production.

From correct responses after the training we can see that participants understand these methods now and subsequently will be able to use them in practice.

8.5. Results and calculation of improvement

The mounting knowledge level of employees is very difficult to measure, good qualified staff may bring the company incalculable value. With new trainings and also retraining of employees the company can await increase in productivity, reduction in waste and at the end cost savings. On the other hand, we reduce errors in the production and thus we increase the quality of our products. Today, these points are one of the key factors for success.

According to the evaluation of the correct answers after the performed trainings, we can conclude that trainings with the use of lean games performed very well. This form of training was new to employees in the company. Therefore, participants were interested in and focused on the training for the whole time. Another successful factor was that participants did not attend the offered training only passively but in an active form. Each participant was productive during execution of this training.

It was harder to keep the full attention of participants during the OPF and Line balancing lean game. Here, a specific product for assembly and only for one assembly worker was used. In this case, only one worker assembled parts together and the others watched him. An additional time was necessary for disassembling the product after the first run. In the future, it is necessary to deal with these observations and improve them. It will be better to have more groups or assembly workers with

more parts to assembly more products at the same time. We can also put more parts into the process to engage more participants during the lean game.
Here are some comments and proposals from participants of the trainings:

- *The training was very interesting in particular this practical part*
- *It is better to use more parts or products and more assembly workers to bring more dynamic into the game.*
- *Training should be done directly in the production area on the selected workplace or for selected products.*
- *I have never passed training in OPF before. With the gained knowledge I can now imagine better these methods in the real work process and also use it on my workplace.*
- *Training should be defined as a standard for all employees concerned.*
- *The times differences between the first, second and the third rounds are huge. I have realized it only after the lean game.*

Beside these positive impacts of trainings, the knowledge level of employees concerning Lean Management and Lean tools has improved. For example, the training in OPF method gives employees the ability to adapt to this method more quickly in real production. A Lean game is a good tool how to explain and train the use of Lean Management in the production area as well as in the office area. The content or rules of the lean game can be edited or expanded according to the needs of the staff training.
The individual remarks and deficiencies found during the training should be implemented into improvement process of internal trainings as well as a better quality of trainings in the future.

9. Proposal for training of the management and working employees

Through a systematic training plan for Lean Management and Lean tools, it is possible to achieve a higher level of implementation of these methods across the whole company.
Before the creating a systematic plan we have to focus on the following points:

- Retrain employees, who attended training a long time ago

- Train employees, who never attended the training in the company
- Train new employees and prepare them for their work position
- Plan the trainings across the whole structure of the company
- Promote better Lean Management and Lean methods in visualization form in the company and in departments or in work teams
- Select an internal trainer or trainers responsible for the lean trainings in the company

To fulfill the above described points, it is necessary that the company sets the targets for realization of these points in practice. Fulfillment of the above described objectives will have a positive impact on the training process that will be faster and more effective and on the increase of the productivity of the company. On the other hand, production time will be shorter; the waste in processes and production costs will be reduced, etc. The company will have a well-trained and satisfied staff. At the end, having satisfied employees the company can earn more money. After the training, it is very important to motivate employees to use the gained knowledge in practice. One of the indicators for measuring the use of lean methods in practice is an increasing number of new ideas for improvement (Kaizen) and also their implementation in processes.

9.1. Training concept

If training is to be effective and performed throughout the enterprise, it is important to define the target group and select lean methods for training. Target skills needed for their work should be planed for these target groups, as well as for particular employees. Target skills should be agreed on in advance with the company management. The depth of the knowledge gained during trainings should be planned for each target group and particular employees according to departments they work in.

Lean Tools \ Department or work position	Management a Team leaders	Production and technical Support	Quality department	Worker in Production	Human Resource	Information Technologies	Logistic and material management
Standard Work	x	x	x	x	x	x	x
8 Types of Wastes	x	x	x	x	x	x	x
SMED (Single Minute Exchange of die)	x						
5S	x	x	x	x	x	x	x
One Piece Flow, Pull System, Tact time	x	x	x	x			x
Kanban System	x	x		x			x
Kaizen – Continuous improvement, PDCA Cycle	x	x	x	x	x	x	x
Value Stream mapping	x	x	x	x	x	x	x
Value Stream design	x	x					
Andon-Notification for Quality and Process problems	x	x	x	x			x
Production leveling and schedules (Heijunka)	x	x					x
Standards and Visual Management	x	x	x	x	x	x	x

Figure 9.1 Selected Lean tools and departments for a training concept

In figure 9-1 I have selected methods for the company and defined trainings in lean methods for the departments in the company. For each department in the company I have defined methods which are necessary for the efficient execution of their work.

9.2. Key person for training concept

If trainings are to be well planned and efficiently and effectively performed, it is also essential to have a person responsible for trainings in the company. Key person for training of Lean Management is a trainer or coach. The trainer can be selected from employees within the company, who already has experience in Lean Management and in training of people. He has to have an acquired knowledge from Lean Management at an expert level. If the company does not have such a person, it is necessary to prepare a person within the company to an expert level or take one from outside the company before planning and running a training process in the company. His role in the organizational structure will be to be a link between the departments in the company for implementation of Lean Management. His main activities will be the implementation of Lean Management in the company, leading or coaching the process improvement in production and in the offices and training of employees in the company in Lean Management. He will consult the training plan for employees with the company's management, HR department and leader of each department.

The main activities for trainer of Lean Management and Lean tools trainings are:

- Creation the plan for training or retraining of employees
- Connection of the training content with work process on the workplace
- Preparation of training content and materials for each training
- Creation and update of training modules according to company needs
- Execution of trainings for lean methods and lean production in the company
- Verification of the efficiency of trainings directly on workplaces
- Presentation of the result of trainings, status of the Lean Management implementation in the working process, etc., to the management of the company

9.3. Trainings modules and groups

The analysis of the questionnaires showed that employees after a specified period do not remember not only the content of the training, but the whole training where they have participated. The second main point from the analysis is that workers are using lean methods, for which they are not trained. On the other hand, there are some employees that passed trainings, but they never used the gained experience in practice. To have effective trainings and use the gained knowledge in practice effectively, it is necessary to devide individual types of lean methods into groups. Furthermore, it is necessary to put employees into groups for a particular training. You can see specific examples of training modules that I am proposing in the following paragraph

9.3.1. 5S Module and Lean in Office

5S Module and Lean in Office	Management a Team leaders	Production and technical Support	Quality department	Worker in Production	Human Resource	Information Technologies	Logistic and material management
Explanation of 5S method 8 Types of Waste	●	●	●	●	●	●	●
Methodology for implementing 5S in practice	●	●	●	●	●	●	●
Explanation of the concepts of Lean in office	●	●	●	●	●	●	●
Identifying waste in administrative processes	●	●	●		●	●	●
Lean game for 5S method	●	●	●	●	●	●	●
Verification of getting knowledge	●	●	●	●	●	●	●
Implementing 5S in the workplace	●	●	●	●	●	●	●

Figure 9.2 Trainigs of 5S module and Lean in Office

The aim of the 5S module and Lean in office is to give employees a training, after which they will be able to use the method in practice and to identify waste in manufacturing as well in administration processes. In addition, they gain knowledge and practical experience in how to start 5S on workplace and in offices.

9.3.2. Value stream mapping and Value Stream design module

Value Stream mapping and Value Stream Design module	Management a Team leaders	Production and technical Support	Quality department	Worker in Production	Human Resource	Information Technologies	Logistic and material management
Explanations of these methods	●	●	●	●	●	●	●
Practical examples in practice with comments	●	●	●	●	●	●	●
Explanation of signs and process mapping	●	●	●	●	●	●	●
Steps for implementing in practice	●	●	●	●	●	●	●
Lean Game for Value Stream mapping	●	●					
Lean game with Value stream design	●	●		●			
Verification of gained knowledge	●	●	●	●	●	●	●
Mapping concrete processes in the company	●	●					
Designing concrete process in the company		●					

Figure 9.3 Trainings of Value stream mapping and Value Stream design modules

This module is designed for all departments in the company. The aim of these trainings is to explain the methodology of how to read and draw the scheme of the process maps and their symbols.

Furthermore, this module is extended with Lean Game. This game demonstrates this process in practice. Participation in this training is necessary for the people from the management, team leaders and employees from departments supporting production processes.

9.3.3. One Piece Flow und Pull System module

One Piece Flow und Pull System module	Management a Team leaders	Production and technical Support	Quality department	Worker in Production	Logistic and material management
Method of Pull System and One Piece Flow	●	●	●	●	●
Explanation of the OPF method	●	●	●	●	●
Explanation of the principle of Pull	●	●	●	●	●
Show practical examples in practice	●	●	●	●	●
Lean Game for One Piece Flow	●			●	
Implementing OPF on the workplace				●	
Verification of gained knowledge	●	●	●	●	●

Figure 9.4 Trainigs of OPF und Pull System module

As mentioned in previous chapters, the current demand of company's management is the implementation of One Piece flow into the production process. OPF training module is created for 5 different departments (see Figure 9-3). Detailed description of this training and its execution is described in the practical part of my Master's Thesis.

9.4. Trainings for new employees

The analysis shows the need for training of new employees in Lean manufacturing and Lean tools implemented in the company. Of course, a new employee must at first be informed about safety and internal company directives. Then the employee must be fully trained in their work. Therefore, I propose an example of timeline for the training of new employees in the company.

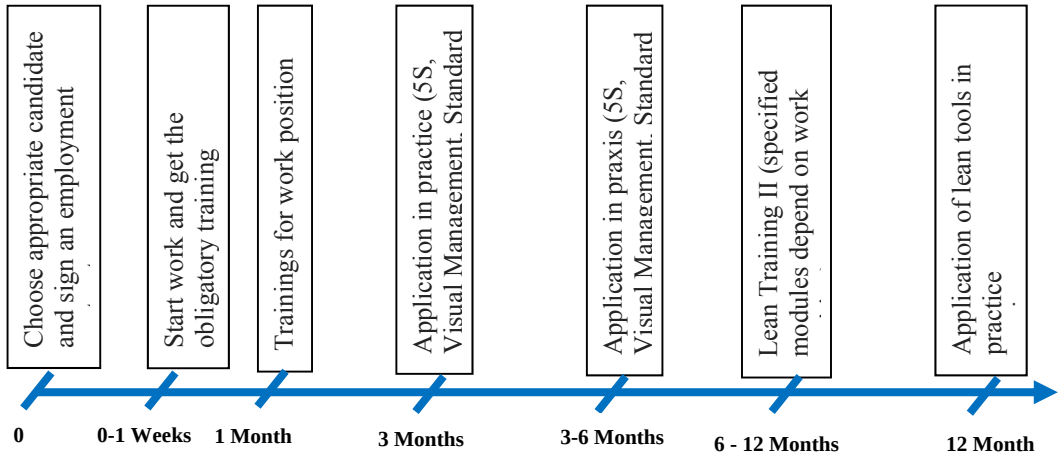

Figure 9.5 The timeline for training a new employee

A job interview with potential employees is already an important factor. Here, HR department together with the manager of department have to emphasize and give requirements for used lean methods in the company. When workers starts to work for the company they must complete all required trainings for their job within 3 months and only when they are well trained for their job, they can get the first basic Lean Management training. These trainings have to be mandatory for all employees. After trainings, the new employee must apply these methods in practice. When they get familiar with these methods, they can start with lean training II in Lean Management and concrete Lean tools necessary for their job and work position.

9.5. A teaching Method

As a basic Lean Management training I chose the most important lean methods, which the company just wants to implement or is already using in practice.

The form of trainings can change. It depends on the trainer and the company management which form for which training will be used. The best combination is hearing and seeing with a deeper explanation by the trainer. I am proposing the following form and order of trainings. *Power Point presentations* – followed by the *lean game* to practice the knowledge gained during the training – *verification of the knowledge* from training by answering questions in a test or questionnaire – subsequently *implementing and using the acquired knowledge in practice*.

10. Measure indicators for continuous improvement

To quantify effectiveness and efficiency of implementing Lean Management and Lean tools in the company it is necessary to create some KPI Indicators. For defining key performance indicators we can use PDCA cycle like on the Figure 10-1.

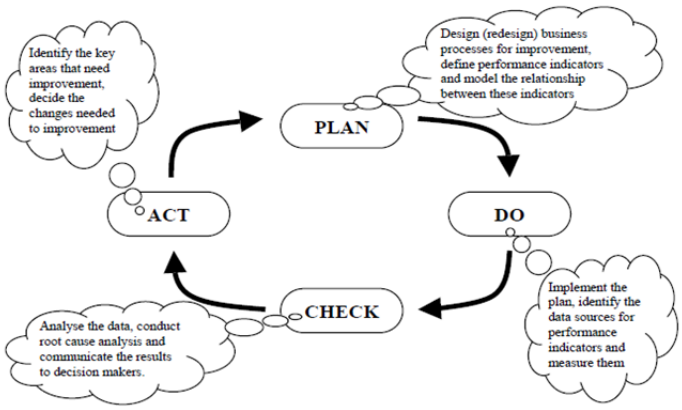

Figure 10.1 PDCA Cycle for KPI Indicators (Umit S. Bititci at al.2000: 692-704)

For implementing Lean tools and creating lean processes I selected these most important KPIs.

- **Indicator for number of employees trained in basic Lean tools** (select the basic Lean tools that are necessary for each department and employees in the company)

$$\textbf{\textit{People trained in basic Lean tools}} = \frac{\textit{Number of trained people in company}}{\textit{Number of employee in the company}} \quad (\%)$$

- **Indicator for implementation of selected method in the department or in processes** (select Lean tools that we have to implement in departments or processes and number of all selected departments)

$$\textbf{\textit{Implementation of selected Lean method}} = \frac{\textit{Nr. of departments using this lean method}}{\textit{Number of Departments}} \quad (\%)$$

- **Indicator for Number of KAIZEN (improvement ideas)** We can measure this KPI the number of proposed KAIZEN´s on each department. The first Kaizen or ideas for improvement can be gained during trainings)

- **Indicator for Number of implemented KAIZEN´s** (This indicator shows the number of implementations of ideas in practice. It is also a motivation factor, when the employees see, that their ideas were implemented and used in practice.)

$$\textbf{Number of implemented KAIZEN´s} = \frac{\textit{Number of realized KAIZEN´s}}{\textit{Number of proposed KAIZEN´s}} \quad (\%)$$

Beside the above-mentioned indicators, the indicators for measuring *productivity*, *FTQ* and *delivery reliability* are also used. These indicators are already implemented and used in the company.

For example, when we change an assembly process in cell to OPF, we can see the increase in the productivity and quality. Another example is in the office. When we optimize the processes for ordering the material internally and externally, we can measure and see how our LT (Lead time) is shortened and the material is received faster and in a shorter time. This improvement has positive impact not only on ordering the material, but also on the whole production chain.

To facilitate continuous improvement, these indicators need to be deployed right down to operational teams who use them to monitor, control and improve daily activities. These indicators should be:

- *Simple to understand and use*
- *Relevant*
- *Visual*
- *Accurate and reliable*

11. Hypothesis evaluation

After taking into account the results of the research, the final evaluation of the hypotheses are:

- *Many companies are trying to implement or have already implemented tools for Lean Management, but it is difficult to use them or develop them further in practice.*

The first hypothesis could be confirmed. From the analysis and from the survey can be seen, that the company has implemented the lean management in production area, but further development is missing. Some Lean tools were implemented, but they are not checked if they are used and after some time employees stop using them.

- *Many employees are not trained in Lean tools and methods. They do not understand why they have to use them.*

This hypothesis can be confirmed as well. People that work for the company for long time have some training in lean production. The trainings were done differently externally or internally and using various methods. A structure and a training plan for training employees do not exist in the company. There is a phenomena, some employees have passed trainings but they do not use the gained knowledge in the practice and some employees have not passed trainings and use lean methods. A situation arises here showing that people do not use the methods correctly, they do not understand the reasons for using them and after a time they stop using them completely.

- *The fluctuation of employees and new employees being hired in the company is another problem. These people often do not get the lean production training and are not able to use Lean tools in practice.*

Results of my research show that this hypothesis is also correct. In each company there is fluctuation. Some people leave the company and new people are being hired. The results show us, that new people are not trained in Lean tools and get some information about Lean tools in the company from their colleagues or they do not get any information at all. They are using some basic methods like 5S, Standard work, Kaizen but they do not have the training.

- *Nowadays short and effective trainings for all employees are required. On the other hand, management does not want to release staff for a few days to attend trainings.*

This hypothesis is correct. During the analysis, I have asked the management why all people do not get trainings in basic methods of lean production. The answer was that they do not need it, or they do not have time to attend trainings. Before executing the training with lean games the manager of the department asked me how much time will the training take, because the productivity and delivery time are at the first place. Therefore, I tried to prepare very short trainings using lean games and only with necessary practical information.

- *In the literature, there are no precisely described procedures how to train staff in Lean Management and how to get the people familiar with these methods in practice.*

This hypothesis is not correct. After literature study and retrieval of information on internet, I have found some ways how to implement Lean tools in the company and train the people. Each company has to select the most effective and the most suitable method for company processes. The way of implementing the lean in the company depends on the type of company, type of production and decision of the management.

The most of the above-mentioned hypotheses can be confirmed; one of them cannot be confirmed. After a final summary of the above, it can be noted, that for implementation of the Lean Management in the company, training of all employees is necessary. It is also very important to have training modules and training plans. When using Lean game trainings, the implementation of Lean Management in the company can be quicker and more effective.

12. CONCLUSION

In this Master's Thesis, I investigated the ways of training people were investigated in order to implement Lean Management and Lean tools in the company. The main aim of the Master's Thesis was to create Lean games, examine the improvement of training methods and at the same time point out new ways of training of employees for the lean production in the company.

As we all know, training means additional costs for the company. However, a lot of companies support these trainings for employees. They are aware that an improvement in the company can be achieved only when the people work in this new way.

Only when using Lean Management, lean tools and lean processes can we can achieve a continual work flow without interruptions and idle times. For example, when 5S is well implemented, we achieve an order, cleanliness and transparency on the workplaces. This will automatically lead to quality improvement of our products as well as to shorter LT (lead time). A quicker process also means decrease in costs; increase in satisfaction of our customers and finally higher profit for the company.

Master's Thesis is divided into more chapters. In theoretical part, the main methods of Lean Management and the ways how to train people using these methods in automotive company are pointed out. The theoretical research consists of introduction of the main methods of Lean, their detailed description and tasks for implementation of lean processes in the production and office area.

When implementing Lean, we must not forget to concentrate also on administrative processes. Many companies do not have continual flow due to non-functioning supportive or administrative processes. Therefore, trainings for employees as well as projects for improving administrative processes are also very important.

I have done a research, using references stated below, of the corporate method, types and forms of education of lean management. Here, I have focused further on training form using Lean games, where I have described the advantages and benefits of trainings with lean games for the implementation of lean processes in the company.

Before creating suitably designed games with training instructions, I did an analysis of the company in order to get the information about the degree of implementation and the use of Lean tools in the company. To obtain a comprehensive view I did the observation of the processes and consequently I created a survey to obtain

information about the employees' knowledge of lean methods and passed trainings in the company. Results of the analysis demonstrated the need for implementation of systematic and targeted trainings in lean methods across the company.

In practical part, I have proposed and created three different types of lean games where I have described in detail the procedure for each lean game as well as their preparation and training processes. For each game, I have created a short teaching material in the form of presentation, entrance and final questionnaires to compare improvements of employees' knowledge and benefits of trainings.

After the evaluation of results, I have obtained positive information about improvement of the knowledge level of employees when lean games are used during the training.

However, training employees is not enough. Many companies organize trainings for employees but they do not need it or they do not use it for their work. To avoid these mistakes, I have recommended preparation of an effective training system for the company. Firstly, I have recommended having an internal coach in the company for preparation and execution of trainings. Afterwards, I have proposed some examples of creation of training modules for the target groups of employees, as well as systems and timelines for employee trainings in lean management. This brings all companies an order and system into planning and executing of targeted trainings as well as using gained knowledge in practice.

The practical part of my Master's Thesis was carried out in the Knorr Bremse Austria Company, but the Master's Thesis has been written in such a form that the methodology can be used in any automotive company, which deals with the issue of lean implementation and trainings in the company.

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Lean Management and Lean tools Survey

Company name

……..

This Survey serves for getting information about the knowledge of working people in the field of lean management and lean tools. Please complete the following Lean Management Survey. The results from this survey will be used in Master Thesis of Mr. Norbert Zimerman. The survey is anonymous.

Thank you for your time.

Customer Name:
Knorr Bremse Mödling

Date: ……..

1. *Please indicate your work position?*

- ☐ Upper management
- ☐ Lower management,
- ☐ Purchasing and Ordering the material
- ☐ Team Leader
- ☐ Worker in Production
- ☐ Quality
- ☐ Production
- ☐ Other department

2. *How long do you work for the company?*

- ☐ Less than one year
- ☐ More than one year
- ☐ More than three years
- ☐ More than five years

3. *Did you hear about the following terminology in your company? (Lean management, lean production system, lean tools)*

- ☐ -Yes
- ☐ -A part of them
- ☐ -Never heard of them

4. *When did the last training for lean principles and methods in general in the company take place?*

- ☐ -Within the last year
- ☐ -more than 2 years
- ☐ -more than five years
- ☐ -never

5. *When you attended trainings, was it done within the company or externally?*

- ☐ Internal in company
- ☐ External training
- ☐ I haven´t got the training

6. In which of lean tools and methods have you got the training?

- ☐ Standard Work
- ☐ Value Stream mapping
- ☐ Value Stream design
- ☐ Tact time
- ☐ Pull System
- ☐ Just in Time
- ☐ 5S
- ☐ Poka Yoke (Error Proofing)
- ☐ One Piece Flow
- ☐ Kanban System
- ☐ Levelling production and schedules (Heijunka)
- ☐ SMED (Single Minute Exchange of die)
- ☐ Standards and Visual Management
- ☐ Notification system for Quality and Process problems (Andon)
- ☐ 8 Types Wastes
- ☐ **No from upper written methods, no training**

7. Do you use the following Problem solving methods in the company?

Kaizen – Continuous improvement	☐ Yes	☐ No, never
Root cause analysis (Fish bone diagram)	☐ Yes	☐ No, never
5 Why´s analysis	☐ Yes	☐ No, never
PDCA Cycle – Plan do check-act	☐ Yes	☐ No, never
A3 Report	☐ Yes	☐ No, never
5S Method	☐ Yes	☐ No, never
Go to where the problem is and see (Genchi genbutsu)	☐ Yes	☐ No, never

8. Have you been evaluated or surveyed in Lean tools or Lean Management within the company in the last 2 years?

☐ Yes ☐ No ☐ I don´t remember

9. Do you consider the use of Lean tools and Lean Management important for the company and for your work?

☐ Yes ☐ No ☐ I don´t know

10. Do you feel that you need more training in Lean tools and lean practices?

☐ Yes ☐ No ☐ -I have no interest

Thanks for your time and answers.

LEAN MANAGEMENT SURVEY **ANSWERS IN SURVEY**

1	Please indicate your work position	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	Managment |X|			|X|																									|X| |X|																				|X|																										
	Purchasing and Ordering the material																												X											X		X																			X	X	X	X																		
	Team Leader																	X		X		X		X																																			X																							
	Worker in Production					X		X	X				X	X	X	X	X		X		X						X			X	X	X			X		X	X	X		X		X	X		X	X		X	X	X	X		X										X	X	X	X			X	X	X	X	X	X	X	X	X	X
	Quality department		X																						X	X							X																																					X											
	Technical Support for Production																											X																									X															X												
	Other department			X	X					X	X	X											X																							X			X							X	X	X																								

2	How long work you for the company	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Less thanone year																										X			X								X								X			X		X	X												X		X	X												
	B. More than one year		C							B			X	X														B											X		X		X											X				A			B				X									X	X		X			X
	C. More than three years	A						X	X							X																				A								X	B					X					B				A				B					B	C						X		X	X	
	D. More than five years			B	B	X	A				B	B			X		X	A	X	A	X	A	B	A	C	C			B		X	X	C	A	X		X			B		B					X	B					B			B	B			B		B								X	X	X							

3	3. Did you hear about the following terminology in your company? (Lean management, Lean production system, Lean Tools)	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Yes	A	C	B	B	X	A		X		B	B	X				X	A	X	A	X			A	C	C			B				C																								B	A																					
	B. A part of them									B				X	X	X						A	B					B		X		X		A		A	X			B		B	X	X			X	B					B	X	B	B			A	B	B	B	B					B	C	X	X			X		X			
	C. Never heard of them							X																			X				X				X			X	X		X				B	X			X	X	X	X												X	X	X	X					X	X		X		X	X	X

4	4. When did the last training for lean principles and methods in general in the company take place?	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Within the last year	A		B	B				X				X				X				X		B	A		C																																A																							
	B. more than 2 years										B	B						A		A		A			C				B							A																	B															B											
	C. more than five years						A	X						X					X											X				A			X	X		B		B		X				B														B			X						X								
	D. -never		C			X				B					X	X											X	B			X	X	C		X				X		X		X		B	X	X		X	X	X	X		X	B	B	B		A	B	B		B	X		X	X		C	X	X	X	X	X	X	X	X	X

5	When you attended trainings, was it done within the company or externally?	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Internal in company	A			B		A		X				X					A	X	A	X		B	A								X												X									B					A					B			X			B											
	B. External training	A		B			A				B	B				X	X			A	X	A			C	C			B			X		A		A				B		B						B								B		A														X								
	C. I haven´t got the training		C			X		X		B				X	X												X	B		X	X		C		X		X	X	X		X		X		B	X	X		X	X	X	X		X	B		B		A	B	B		B	X		X	X		C	X		X	X	X	X	X	X	X	X

6	In which of lean tools and methods have you got the training?	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A Standard Work	X		X		X	X		X			X	X			X	X	X	X	X	X	X	X	X	X	X			X		X	X										X																X										X											
	B Value Stream mapping	X		X							X							X		X	X	X		X	X	X			X			X																										X										X											
	C Value Stream design																			X	X			X					X																																																		
	D Tact time	X		X								X	X				X		X	X	X	X	X	X	X	X																																																					
	E Pull System	X											X				X		X	X	X			X	X	X																																																					
	F Just in Time	X		X								X	X				X	X	X	X	X	X	X	X	X	X			X																												X																					
	G 5S	X		X		X	X		X		X	X	X			X	X	X	X	X	X	X	X	X	X	X			X		X	X	X	X		X				X		X						X					X			X		X				X																	
	H Poka Yoke (Error Proofing)	X		X								X					X	X		X		X	X	X	X	X			X		X		X	X		X				X																																								
	I One Piece Flow	X		X		X	X		X			X				X	X	X	X	X	X	X	X	X	X	X			X		X	X				X																					X																					
	J Kanban System	X		X		X			X			X	X			X	X	X	X	X	X	X		X	X	X			X		X	X																X									X				X																	
	K Levelling production and schedules (Heijunka)			X									X					X	X	X		X		X	X	X														X																X																							
	L SMED (Single Minute Exchange of die)	X		X									X						X	X				X	X	X																																																				
	M Standards and Visual Management	X											X							X	X	X	X	X	X	X																															X																					
	N Notification system for Quality and Process problems (Andon)								X				X			X			X	X	X		X	X	X	X																																																			
	O Types Wastes			X		X	X					X	X			X	X	X	X	X	X	X	X	X	X	X			X			X		X	X	X				X		X						X					X					X										X											
	P No from upper written methods, no training		X					X		X				X	X												X	X		X							X	X	X		X		X	X	X	X	X	X	X	X	X	X		X	X		X		X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

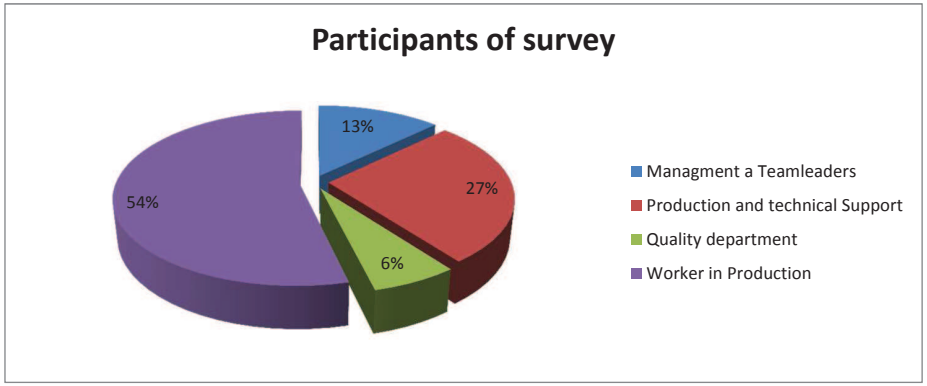
7	Do you use the following Problem solving methods in the company?	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A Kaizen – Continuous improvement	X	X			X	X				X	X	X		X		X	X	X	X	X	X	X	X	X	X			X			X	X																				X						X										X	X										
	B Root cause analysis (Fish bone diagram)	X	X												X		X			X	X	X	X	X	X	X		X	X				X																																					X										
	C 5 Why´s analysis	X					X					X					X	X	X	X	X	X	X	X	X	X			X				X																																														
	D PDCA Cycle – Plan do check-act	X	X				X										X		X	X	X	X		X	X	X						X	X																				X					X	X	X									X	X										
	E A3 Report																			X			X	X					X																																																		
	F 5S Method	X	X	X		X	X		X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X							X					X	X			X			X					X	X										X										
	G Go to where the problem is and see (Genchi genbutsu)	X	X										X		X	X	X	X	X	X	X		X	X	X	X		X	X							X	X		X	X																													X										
	H I am not use any Method				X			X		X				X													X			X					X			X				X	X	X	X			X	X		X	X		X	X	X	X				X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X

8	Have you been evaluated or surveyed in Lean tools or Lean Management within the company in the last 2 years?	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Yes	X	X										X					X	X	X	X		X					X				X				X			X																																										
	B. No			X	x	X	X	X	X		X	X		X	X							X		X	X	X	X		X	X	X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	C. I don´t remember									X						X	X																																																														

9	Do you consider the use of Lean tools and Lean Management important for the company and for your work?	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	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Yes	X	X	X	X		X	X	X			X	X	X					X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X						X			X	X			X		X			X		X	X			X			X	X		X	X	X	X		X		X	X			
	B. No									X																									X		X		X						X																											X							X
	C. I don´t know					X					X				X	X	X	X									X													X	X	X	X			X			X	X		X		X	X		X			X	X		X	X			X								X			X	X	

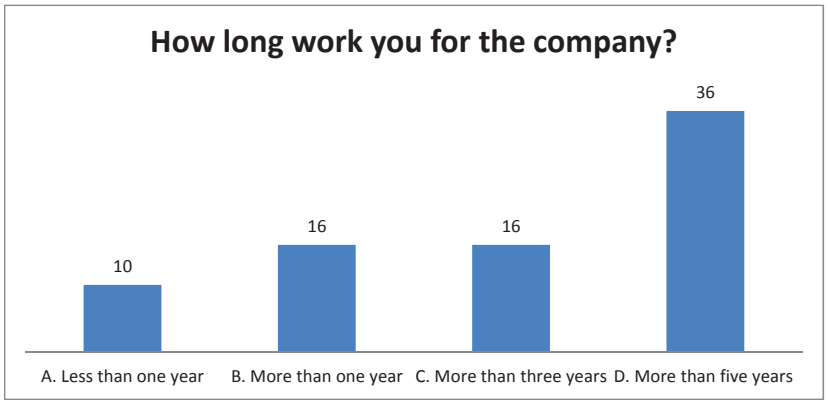
10	Do you feel that you need more training in Lean tools and lean practices?	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	A. Yes		X		x		X	X	X	X			X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X		X	X	X		X			X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
	B. No	X		X							X	X										X			X						X				X		X			X	X				X															X	X										X	X							
	C. I have no interest					X																															X																																									

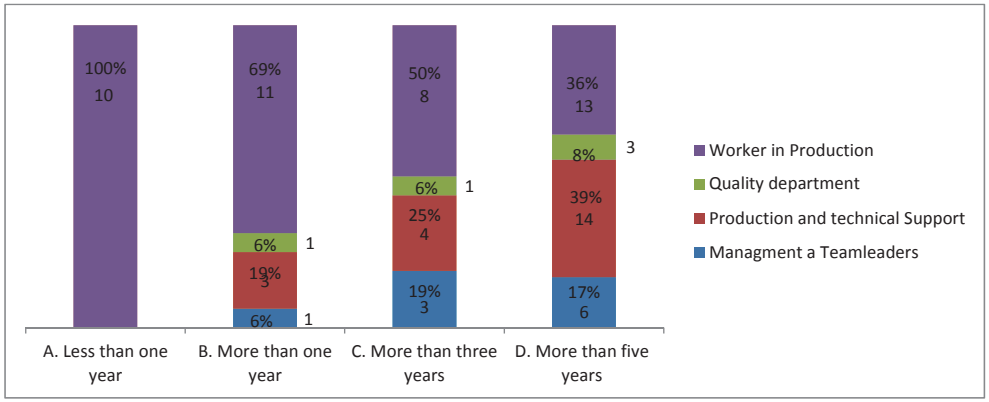
1	Please indicate your work position	
	Managment a Teamleaders	*10*
	Production and technical Support	*21*
	Quality department	*5*
	Worker in Production	*42*
		78



2	How long work you for the company	
	A. Less than one year	*10*
	B. More than one year	*16*
	C. More than three years	*16*
	D. More than five years	*36*

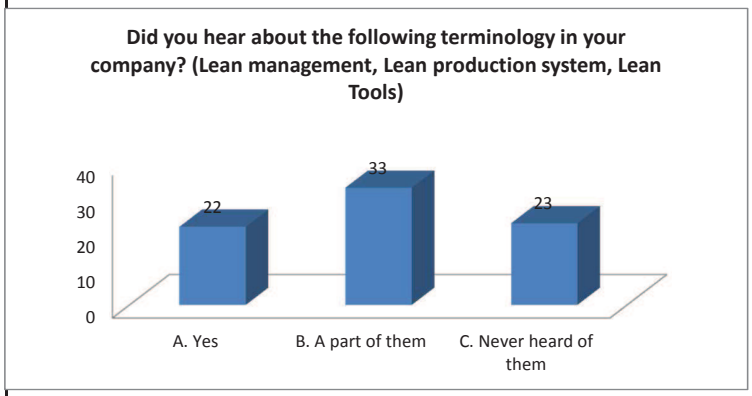
	Managment a Teamleaders	*Production and technical Support*	*Quality department*	*Worker in Production*	Managment a Teamleaders %	Production and technical Support %	Quality department %	Worker in Production %	
A. Less than one year	0	0	0	10	0%	0%	0%	100%	100%
B. More than one year	1	3	1	11	6%	19%	6%	69%	100%
C. More than three years	3	4	1	8	19%	25%	6%	50%	100%
D. More than five years	6	14	3	13	17%	39%	8%	36%	100%
	10	**21**	**5**	**42**					**78**

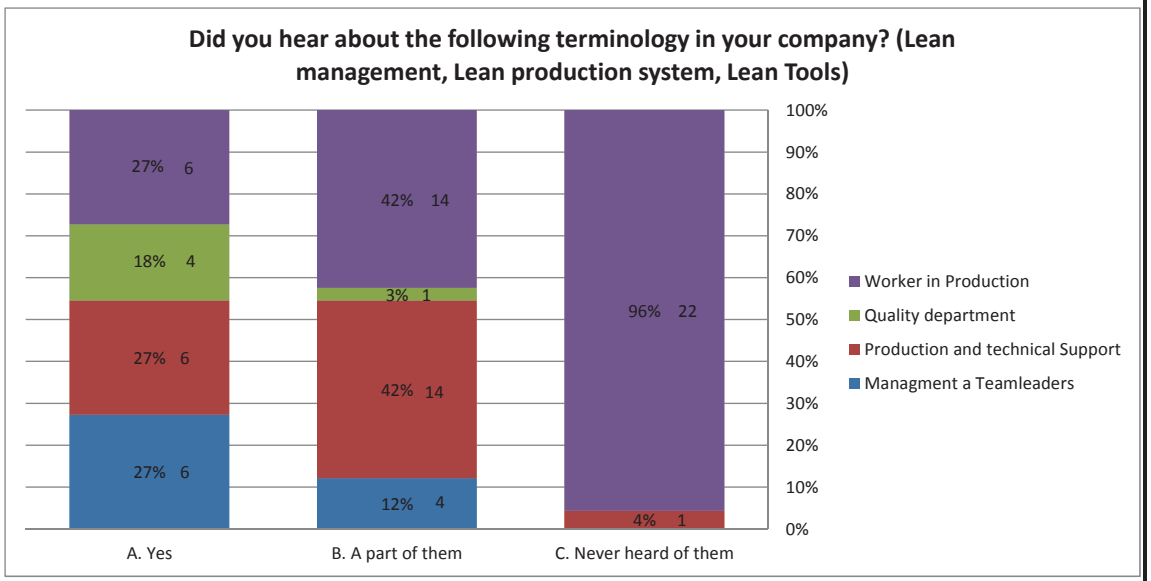




3	Did you hear about the following terminology in your company? (Lean management, Lean production system, Lean Tools)	
	A. Yes	*22*
	B. A part of them	*33*
	C. Never heard of them	*23*
		78

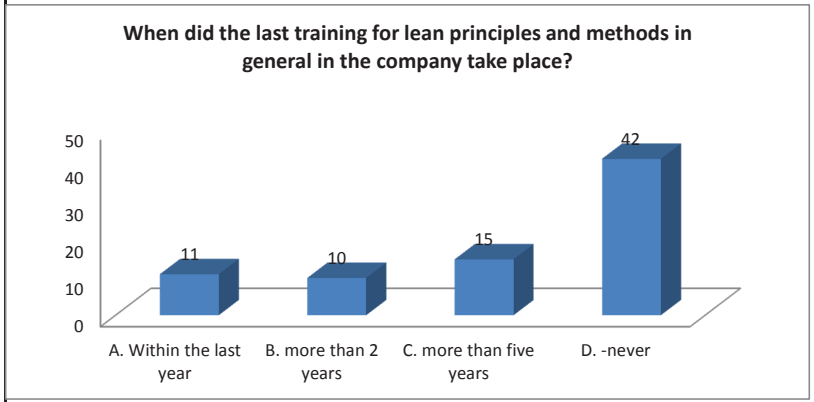
	Managment a Teamleaders	*Production and technical Support*	*Quality department*	*Worker in Production*	Managment a Teamleaders %	Production and technical Support %	Quality department %	Worker in Production %	
A. Yes	6	6	4	6	27%	27%	18%	27%	100%
B. A part of them	4	14	1	14	12%	42%	3%	42%	100%
C. Never heard of them	0	1	0	22	0%	4%	0%	96%	100%
	10	**21**	**5**	**42**					**78**

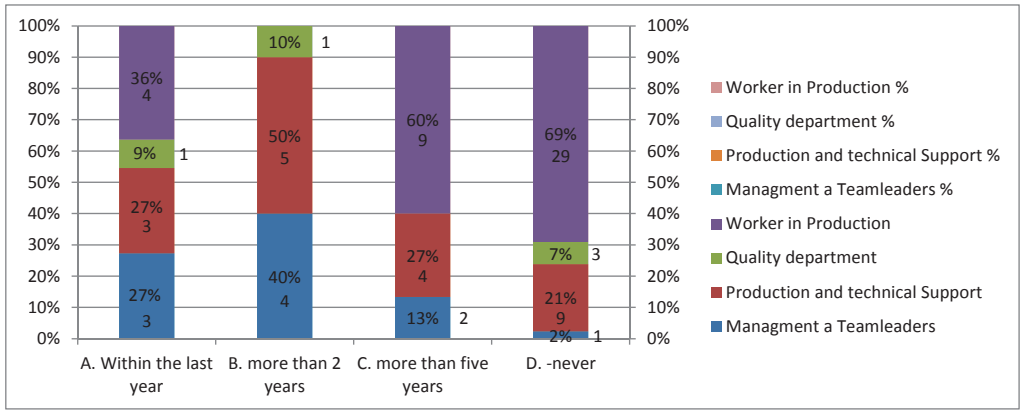




4	When did the last training for lean principles and methods in general in the company take place?	
	A. Within the last year	*11*
	B. more than 2 years	*10*
	C. more than five years	*15*
	D. -never	*42*
		78

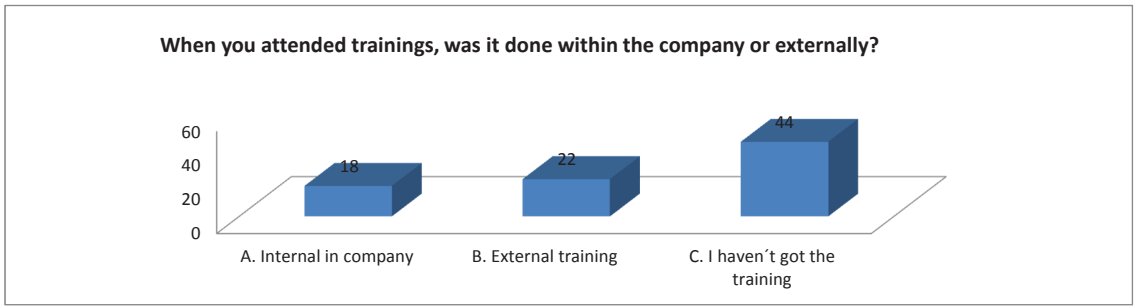
	Managment a Teamleaders	*Production and technical Support*	*Quality department*	*Worker in Production*	Managment a Teamleaders %	Production and technical Support %	Quality department %	Worker in Production %	
A. Within the last year	3	3	1	4	27%	27%	9%	36%	100%
B. more than 2 years	4	5	1	0	40%	50%	10%	0%	100%
C. more than five years	2	4	0	9	13%	27%	0%	60%	100%
D. -never	1	9	3	29	2%	21%	7%	69%	100%
	10	**21**	**5**	**42**					**78**



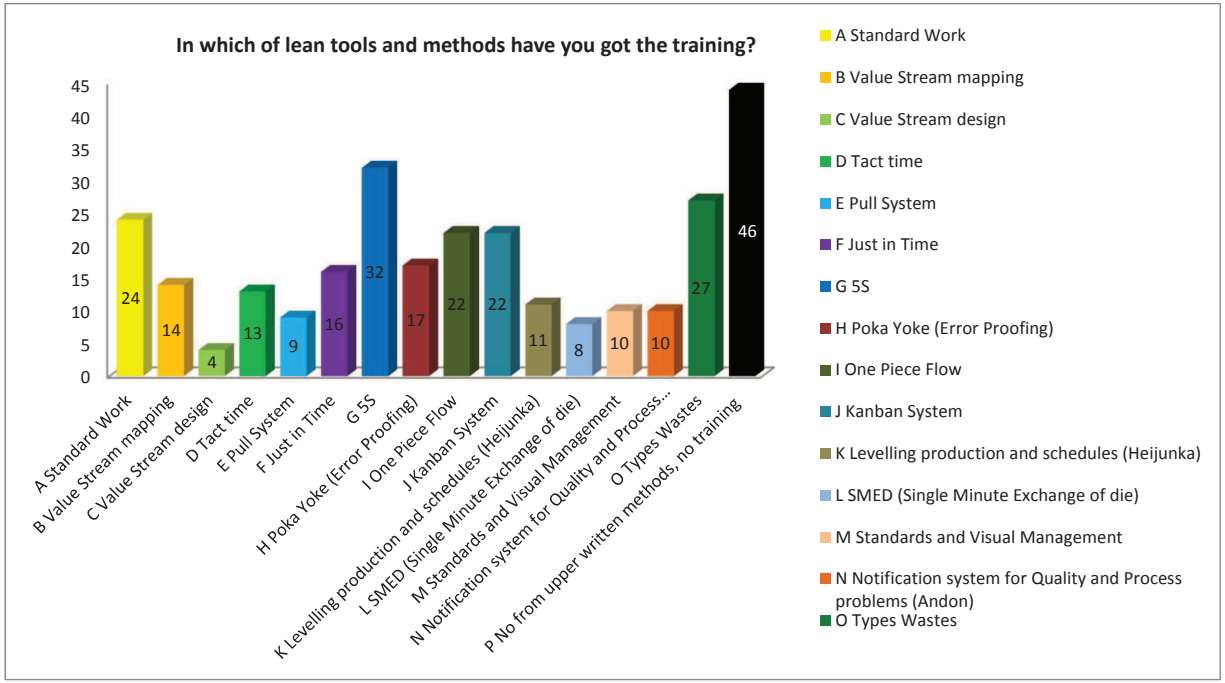


5	When you attended trainings, was it done within the company or externally?	
	A. Internal in company	*18*
	B. External training	*22*
	C. I haven´t got the training	*44*
		84

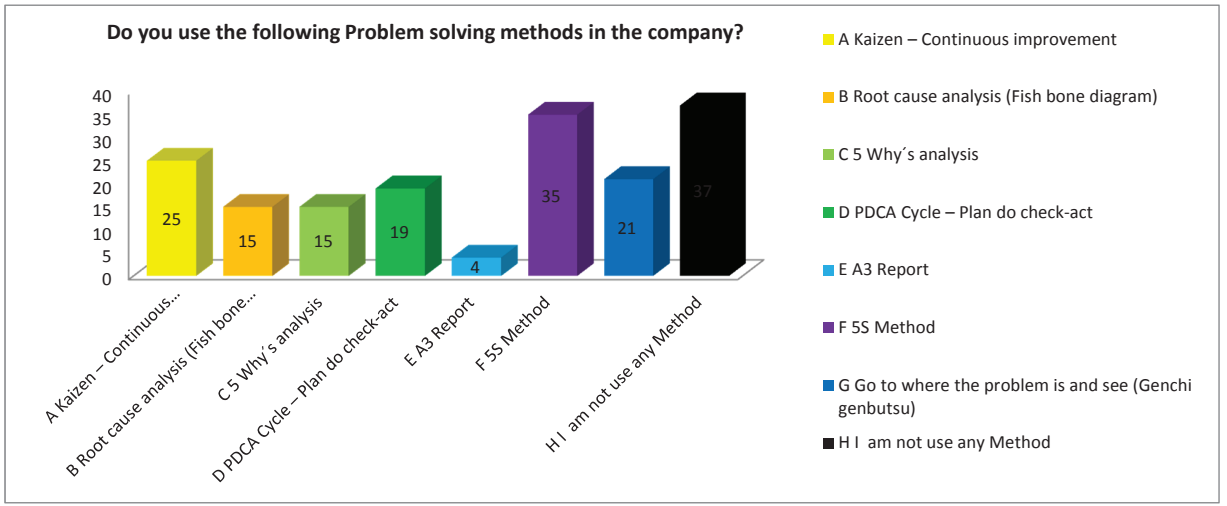
	Managment a Teamleaders	*Production and technical Support*	*Quality department*	*Worker in Production*	Managment a Teamleaders %	Production and technical Support %	Quality department %	Worker in Production %	
A. Internal in company	6	5	0	7	33%	28%	0%	39%	100%
B. External training	7	8	2	5	32%	36%	9%	23%	100%
C. I haven´t got the training	1	8	3	32	2%	18%	7%	73%	100%
	14	**21**	**5**	**44**					**84**



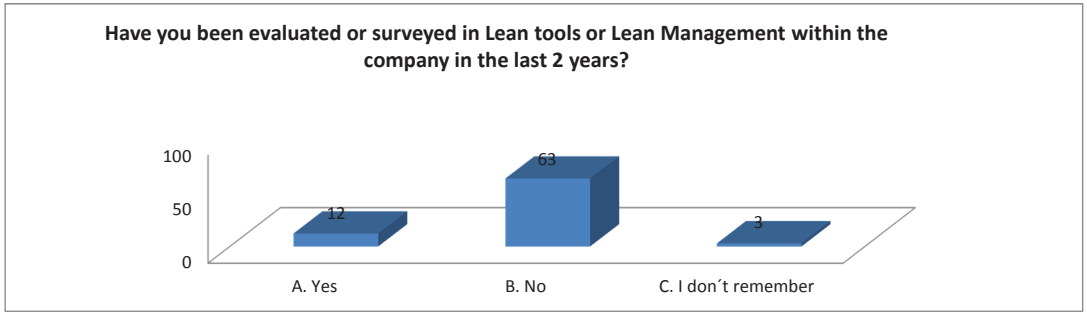
6	In which of lean tools and methods have you got the training?	
	A Standard Work	*24*
	B Value Stream mapping	*14*
	C Value Stream design	*4*
	D Tact time	*13*
	E Pull System	*9*
	F Just in Time	*16*
	G 5S	*32*
	H Poka Yoke (Error Proofing)	*17*
	I One Piece Flow	*22*
	J Kanban System	*22*
	K Levelling production and schedules (Heijunka)	*11*
	L SMED (Single Minute Exchange of die)	*8*
	M Standards and Visual Management	*10*
	N Notification system for Quality and Process problems (A	*10*
	O Types Wastes	*27*
	P No from upper written methods, no training	*44*



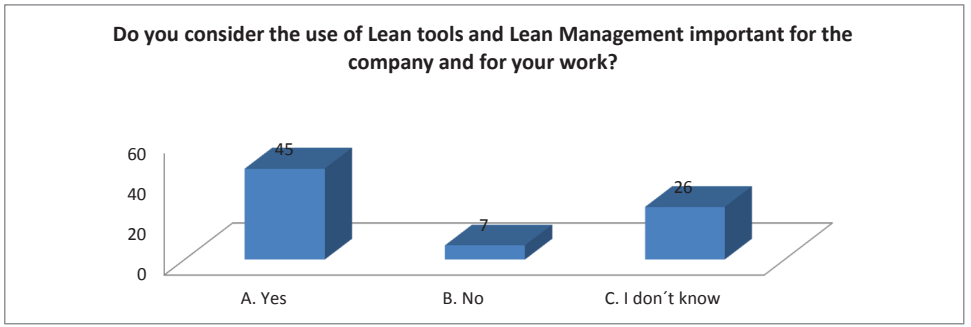
7	Do you use the following Problem solving methods in the company?	
	A Kaizen – Continuous improvement	*25*
	B Root cause analysis (Fish bone diagram)	*15*
	C 5 Why´s analysis	*15*
	D PDCA Cycle – Plan do check-act	*19*
	E A3 Report	*4*
	F 5S Method	*35*
	G Go to where the problem is and see (Genchi genbutsu)	*21*
	H I am not use any Method	*37*
		171



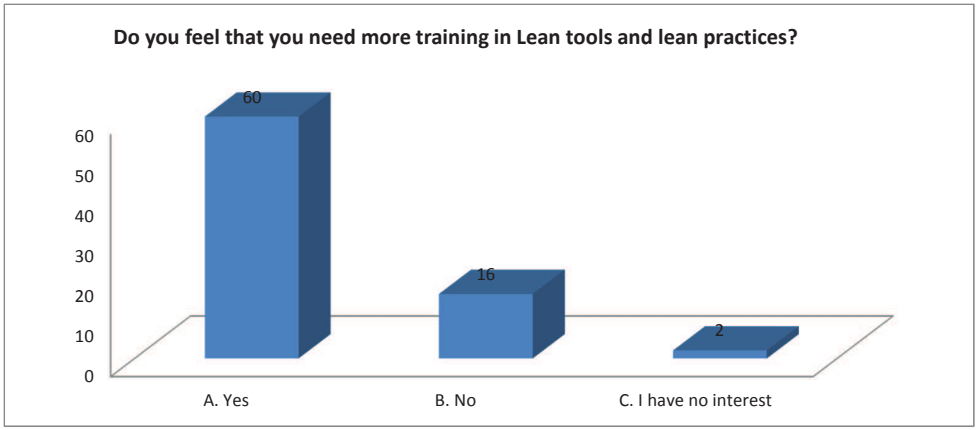
8	Have you been evaluated or surveyed in Lean tools or Lean Management within the company in the last 2 years?	
	A. Yes	*12*
	B. No	*63*
	C. I don´t remember	*3*
		78



9	Do you consider the use of Lean tools and Lean Management important for the company and for your work?	
	A. Yes	*45*
	B. No	*7*
	C. I don´t know	*26*
		78



10	Do you feel that you need more training in Lean tools and lean practices?	
	A. Yes	*60*
	B. No	*16*
	C. I have no interest	*2*
		78



Entrance Test

This test contains questions about the methodology used in the following training. It serves for getting information about knowledge level of participants about this lean method. Please fill in the following questionnaire before the start of the training. The results will be used only in Master Thesis of Mr. Norbert Zimerman. The questionnaire is anonymous.Thank you for your time.

Customer Name: **Date:** .....

1. What is lean Manufacturing?

A. ☐ Manufacturing quick as possible

B. ☑ **Way for company how reduces the waste and produce better quality**

C. ☐ Reducing or limited production for period time

D. ☐ New product is produce on the line for first time

E. ☐ No answer is right

2. The definition of "KAIZEN" is

A. ☐ I have never heard about KAIZEN

B. ☑ **Change to better**

C. ☐ Better quality

D. ☑ **New idea for improvement**

E. ☐ Higher employee bonus

3. In 5S, the term "Sorting" means to

A. ☑ **Only have the needed tools and resources in working area**

B. ☐ Everything has a place

C. ☐ Keep the working place empty

D. ☐ All no needed tools put to the selves or boxes

E. ☐ I don´t know

4. In 5S, what is "Standardizing"?

A. ☐ Only one type of product is produce on workplace

B. ☑ **Ensure everyone is doing it the same way**

C. ☐ Clean all workplaces at the same time

D. ☐ All tools and workplaces are marked

E. ☐ I don´t know

5. 5S Method we can use?

A. ☐ Only for manufacturing in production area

B. ☐ In Office area

C. ☐ In customer and service area

D. ☐ At home

E. ☑ **Everywhere**

Thank you very much and I wish you a pleasant training

Professional MBA
Automotive Industry
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5S Lean Game Training

PRESENTATION FOR 5S BASIC TRAINING

Mobility Cluster Vienna
EUROPEAN UNION European Regional Development Fund
MINISTRY of AGRICULTURE and RURAL DEVELOPMENT of the SLOVAK REPUBLIC
bmwfj
creating the future

Why 5S and why do we want to use 5S Method?

5S represents 5 steps how to standardize the workplace:

5S provides five steps for maintaining a visualized workplace (visual controls and information systems).

5S is the fundamental for the elimination of waste, a manufacturing strategy based on "Lean Manufacturing" and a concept for the waste to see and remove it.

1.S – SORT

- Sorting out unnecessary or broken things in the workplace (e.g. with using Red Cards)
- Remove unnecessary things and stuff

By sorting out save or eliminate we reduce:

- Surface, shelves, cabinets, which are used for the storage of unnecessary things
- Transport (cars) that are blocked by unnecessary things
- Potential errors due to incorrect materials
- Unnecessary movements

Who: staff
Where: shop or office
How: with prepared Red Cards

1.S – SORT

Areas and examples where we can perform it

Production area

stocks:
Raw materials, purchased parts, work in process, inventories, semi-finished products, finished products

Facilities
Machinery, equipment, devices , tools, measuring instruments, transportation equipment, Workstations, cabinets, chairs

Surfaces
Ground, free up roads, shelves, storage places))

Offices

Documentation
Notes, protocols, old work orders, contracts, reports, Company rules, invoices

Equipment
(Copiers, computers, fax machines, old and unnecessary equipment, Schneider, Printers, electric fans)

Storage
(Folders, binders, cabinets, shelves, chairs, tables, replacement print cartridges)

Office supplies
(Pencils, rulers, highlighters, erasers, scissors, ...)

Other
(Business cards, books, magazines, newspapers, drawings, brochures, ...)

2. S – STRAIGHTEN (Seiton)
Sort and order what is left!

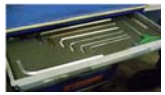
- Required things arranged according to frequency of use in the right place so that they are easy to find and use.
- Everything has its own place and after using put it on the same place

Straighten prevents wasting of time , material and energy through:

- unnecessary Search
- Unnecessary activities
- wasting of parts
- Stoppage of machines and their equipment
- Order supports the work safety

Aussortieren

Anordnen



Richtigen Platz definieren

3.S – SWEEP (Seiso)
Clean working place and area thoroughly

Clean entire workplace and environment

Cleaning supports:

- having a clean workplace
- detecting and correcting errors
- work safety in the workplace
- feeling comfortable in the workplace
- winning the trust of customers

Define and carry out regular cleaning of the workplace so that the work is easier and safer

Method:
Systematic cleaning of the workplace, where cleaning is also used as a check!

tools:

- Cleaning schedule and cleaning tools
- Defined locations for cleaning tools

4. S – STANDARDIZE
Set, define and document the standards

Standardization means:

- Selecting the best (safest, most ergonomic, fast and therefore economical) method.
- Standards make it possible to quickly identify problems (deviations from standard).

Examples of standards:

- cleaning standards
- tool stands
- standardized workplaces
- material on the workbench
- Job Description
- description and sorting out the folders for the files on the server, PC or in the cabinet

vorher

nachher

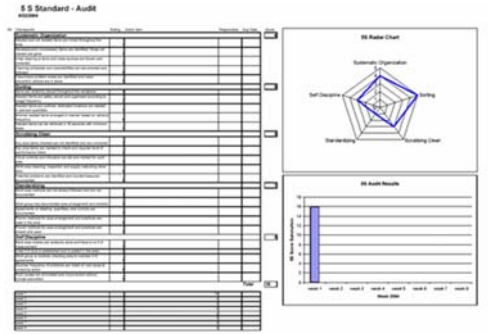
5. S – SUSTEIN
Comply and improve standards (shitsuke)

Complying and improving standards means:

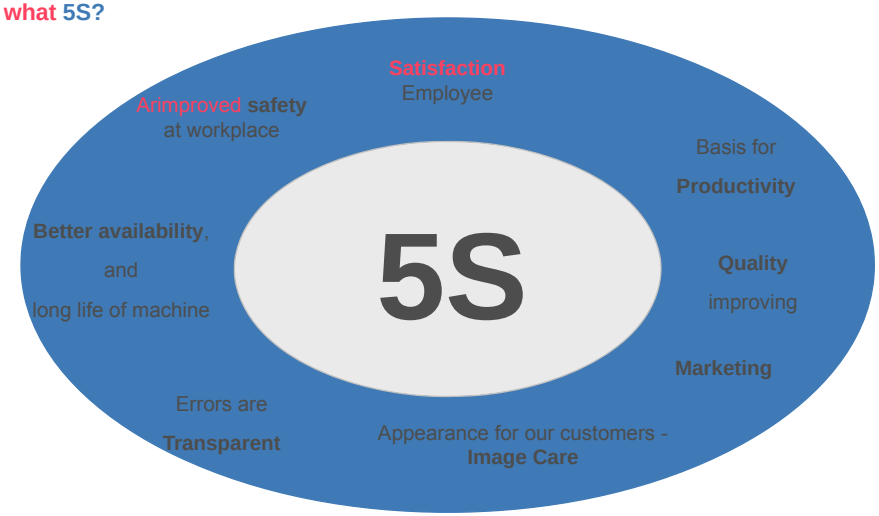
- The permanent applying and observing rules, agreements and standards by all employees completely independent of their level in the hierarchy.
- It also includes the independent act without direct instruction.

This is supported by:

- Agreement of all and exemplary behavior of superiors
- Personal Responsibility
- Identification with their own workplace
- Compliance with agreed responsibilities
- teamwork
- Audits can be understood as a tool for identification of improvement potential
- Permanent reduction of the effort to comply with the state reached



To what 5S?



5S – METHOD - RECAPITULATION

5SLEAN GAME WITH LETTERS

5S – Lean Game with letters

FIRST RUN

- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN

On the pad, letters are prepared in chaotic order.

- Assemble 5 words of 5S methodology (**STREIGHTEN, SHINE, STANDARDISE, SUSTAIN**) using these letters. Begin from the first word to the last, in the correct order of words and letters.
- Measure time using the stopwatch and write down the final time in the table.

SECOND RUN

- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN

Discussion ?

- Sort out letters and put away those you don´t need.
- Put the letters you need into the box again.
- Again assemble these 5 words of 5S methodology (**SORT, SET IN ORDER, SHINE, STANDARDISE, SUSTAIN**) using these letters . Begin from the first word to the last, in the correct order of words and letters.
- Measure time using the stopwatch and write down the final time in the table.

THIRD RUN

- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN

Discussion ?

- Prepare the letters on the table so that all letters are placed visibly in the box
- Again assemble these 5 words of 5S methodology (**STRAIGHTEN, SHINE, STANDARDISE, SUSTAIN**) using these letters . Begin from the first word to the last, in the correct order of words and letters.
- Measure time using the stopwatch and write down the final time in the table.

FOURTH RUN

- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN

Discussion ?

If it is necessary you can clean your workplace

- Go to the next run

FIFTH RUN

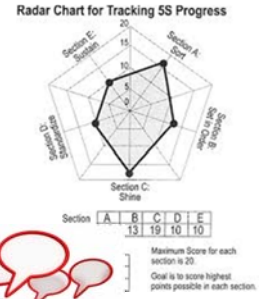
- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN

Discussion ?

- Prepare the letters on the table so that all letters are visible and in the correct order and wording and place them in the box
- Use the model assembly that you get from the trainer
- Again assemble these 5 words of 5S methodology (**STRAIGHTEN, SHINE, STANDARDISE, SUSTAIN**) using these letters . Begin from the first word to the last, in the correct order of words and letters according to the model assembly.
- Measure time using the stopwatch and write down the final time in the table.

CONCLUSION

- SORT
- STRAIGHTEN
- SWEEP
- STANDARDIZE
- SUSTAIN



Section	A	B	C	D	E
	13	19	10	10	10

Maximum Score for each section is 20.
Goal is to score highest points possible in each section.

Discussion and remarks from players

THANK YOU FOR YOUR TIME

5S Game Card with letters

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z	Ä	Ö	Ü	ß

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z	Ä	Ö	Ü	ß

5S Lean Game

S	O	R	T

S	T	R	A	I	G	H	T	E	N

S	W	E	E	P

S	T	A	N	D	A	R	D	I	Z	E

S	U	S	T	A	I	N

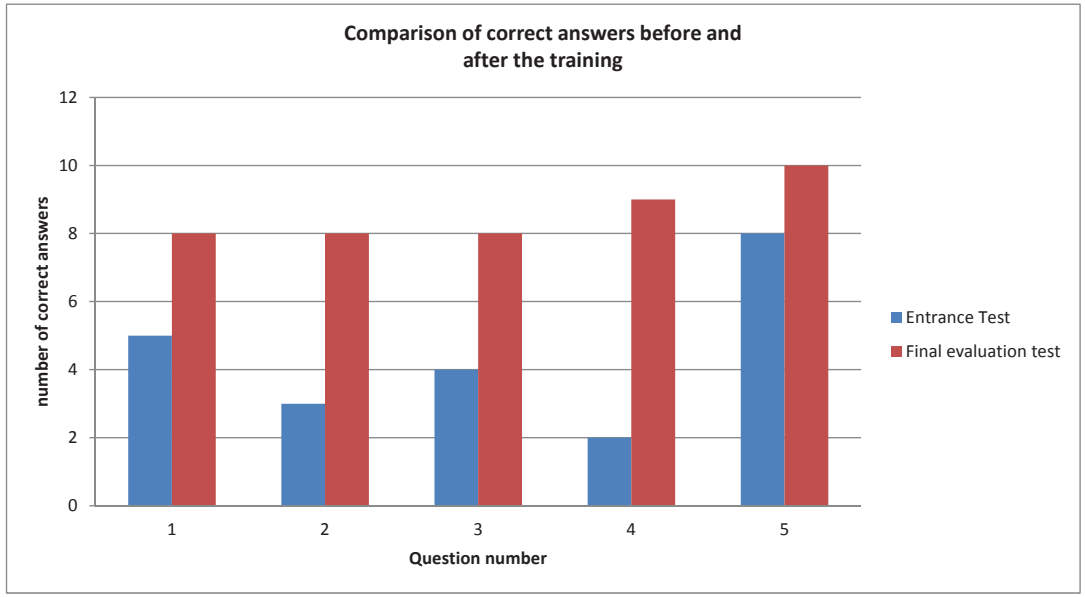
- **SORT**
- **STRAIGHTEN**
- **SWEEP**
- **STANDARDIZE**
- **SUSTAIN**

	5S Methode	Participant Nr. 1	Participant Nr. 2	Participant Nr. 3	Participant Nr. 4	Participant Nr. 5	Participant Nr. 6	Participant Nr. 7	Participant Nr. 8	Participant Nr. 9	Participant Nr. 10	Right answers
Entrance Test	*1. What is lean Manufacturing?*	1	0	1	0	1	1	0	1	0	0	5
	2. The definition of "KAIZEN" is	0	1	0	1	0	0	0	0	1	0	3
	3. In 5S, the term "Sorting" means to	1	0	1	0	1	0	0	0	0	1	4
	4. In 5S, what is "Standardizing"?	0	0	1	1	0	0	0	0	0	0	2
	5. We can use the 5S Method?	1	1	1	1	1	1	1	0	0	1	8

Final evaluation test	*1.What is lean Manufacturing?*	1	0	0	1	1	1	1	1	1	1	8
	2. The definition of "KAIZEN" is	0	1	1	1	1	1	1	0	1	1	8
	3. In 5S, the term "Sorting" means to	0	1	1	1	1	1	0	1	1	1	8
	4. In 5S, what is "Standardizing"?	1	1	1	1	1	1	1	1	1	0	9
	5. 5S Method we can use?	1	1	1	1	1	1	1	1	1	1	10
	6. How are you satisfied with the training?	100	100	100	100	100	100	100	100	100	100	10
	7. Would you be able to apply the acquired knowledge in practice?	100	100	100	100	100	100	100	100	100	100	10
	8. If you have any remarks or suggestions how to make the training better, please write it down.	Comments	xx	xx	Comments	xx	xx	xx	xx	xx	xx	

5S Lean Game 1	Round 1 (Min)	Round 2 (Min)	Round 3 (Min)
Participant Nr. 1	5:17	3:11	1:30
Participant Nr. 2	5:21	3:52	1:30
Participant Nr. 3	5:40	3:32	1:27
Participant Nr. 4	4:55	3:42	1:15
Participant Nr. 5	5:35	3:48	1:55

5S Lean Game 2	Round 1 (Min)	Round 2 (Min)	Round 3 (Min)
Participant Nr. 1	4:48	3:01	1:22
Participant Nr. 2	5:11	3:11	1:30
Participant Nr. 3	5:00	3:22	1:30
Participant Nr. 4	4:59	3:15	1:15
Participant Nr. 5	5:05	3:26	1:25



Final evaluation test

This test contains the same questions as the entry test. It serves for getting the information about knowledge level gained during this lean game traning. Please fill in the following questionnaire after the training. The results will be used only in Master Thesis of Mr. Norbert Zimerman. The questionnaire is anonymous. Thank you for your time.

Company Name: **Date:** .....

1. What is lean Manufacturing?

A. ☐ Manufacturing as quickly as possible

B. ☐ Way for company how to reduce the waste and produce better quality

C. ☐ Reducing or limiting production for a certain time period

D. ☐ New product is produced on the line for the first time

E. ☐ No answer is correct

2. The definition of "KAIZEN" is

A. ☐ I have never heard about KAIZEN

B. ☐ Change to better

C. ☐ Better quality

D. ☐ New idea for improvement

F. ☐ Higher employee bonus

3. In 5S, the term "Sorting" means to

A. ☐ Have only the needed tools and resources in the working area

B. ☐ Everything has a place

C. ☐ Keep the working place empty

D. ☐ All not needed tools should be put to the shelves or boxes

G. ☐ I don´t know

4. In 5S, what is "Standardizing"?

E. ☐ Only one type of product is produced on the workplace

F. ☐ Ensure that everyone is doing it the same way

G. ☐ Clean all workplaces at the same time

H. ☐ All tools and workplaces are marked

H. ☐ I don´t know

5. We can use the 5S Method?

A. ☐ Only for manufacturing in production area

B. ☐ In the office area

C. ☐ In the customer and service area

D. ☐ At home

E. ☐ Everywhere

TURN THE PAGE

Final evaluation test

6. How are you satisfied with the training?

F. ☐ Very satisfied

G. ☐ Satisfied

H. ☐ Normal, like other trainings

I. ☐ Not satisfied, loss of time

7. Would you be able to apply the acquired knowledge in practice?

J. ☐ Yes

K. ☐ No

L. ☐ I need more training

8. If you have any remarks or suggestions how to make the training better, please write it down.

ENTRY TEST

LEAN GAMES ONE PIECE FLOW AND LINE BALANCING

This test contains questions about the methodology used in the following training. It serves for getting information about knowledge level of participants about this lean method. Please fill in the following questionnaire before the start of the training. The results will be used only in Master Thesis of Mr. Norbert Zimerman. The questionnaire is anonymous.Thank you for your time.

Customer Name: **Date:** .....

1. Prepare a good organized work area is?

A. ☑ **Safer and more efficient**

B. ☐ Waste of time

C. ☐ OK, but there is more important work to do

D. ☐ I will do it because my boss wants it

E. ☐ I organize my work area my way

2. Batch production is characterized by

A. ☐ Grouping the same machine and skilled people in one place

B. ☐ Continuous material flow through the manufacturing

C. ☑ **High WIP (Work in Process)**

D. ☐ Manufacture of special products

F. ☐ I don't know

3. Which of this activities are wasting

E. ☑ **Repair of defective products**

F. ☑ **Produce more products than necessary at the same time**

G. ☑ **Waiting for material**

H. ☐ Assembling the various parts on the product

I. ☑ **Excess consumption of material**

J. ☑ **Create reserves of material on the workplace**

G. ☐ All the above activities are wasting

4. One Piece Flow Production means,

A. ☐ A worker produces all products at once on the workstation

B. ☑ **Through the production goes the product, where the workers shift it without storage**

H. ☐ I do not know, I never heard about this

5. Tact time of workstation is

A. ☐ Total time from order to finish one product

B. ☑ **Total Time of all operations on the product within the workstation**

C. ☐ Sum of times waiting for the next order

D. ☐ Time for employee where must perform all operations on products

E. ☐ I don´t know

Thank you very much and I wish you a pleasant training

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OPF Lean Game Training

PRESENTATION FOR LEAN GAME TRAINING

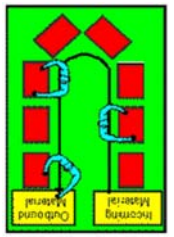
Single Piece Flow vs Batch Production
Parts assembled in one cell production

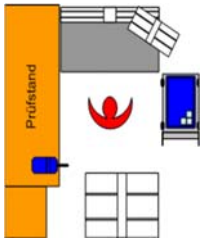
One Piece Flow

is a condition that exists when moving through a manufacturing process one unit at a time, at a rate determined by the needs of the customer

The opposite of one piece flow is a mass production with batches and queues

We use One Piece Flow Production:
- In cellular manufacturing
- On the line manufacturing





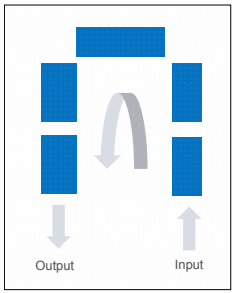
One piece flow manufacturing approach helps companies to produce a variety of products for the customer with as little waste as possible.

Layout design for One Piece Flow production

All machines, Workbenches (Workstations) and equipment are arranged in a sequence that supports a smooth flow of materials and components through the process with minimal transport, movement and delay.

Production line

OPF conditions for a U shaped cell
- Start from right to left
- One Piece produce from beginning to the end in the cell
- Balanced operation for each station to create flow in tact time
- Trained operators for the One Piece Flow method



U-Shaped Cell from right to left

Advantages of One Piece Flow

- Short lead time, quicker delivery to the customer
- Reduction in storage, no storage in production area
- Fewer mistakes during assembly
- Builds in quality – when we produce „one by one“ defects are detected immediately and corrective actions are used at once
- Improves safety – one piece flow limits the need to lift heavy boxes or pallets of material
- Flexibility - One piece flow is faster than batch production
- Improves Productivity – by reducing the waste (e.g. motion, transport, waiting) as a result the productivity increases

One piece flow manufacturing approach helps companies to produce a variety of products for the customer with as little waste as possible.

LEAN GAME OPF – ASSEMBLY INSTRUCTION

Working Instruction

Montage Teile

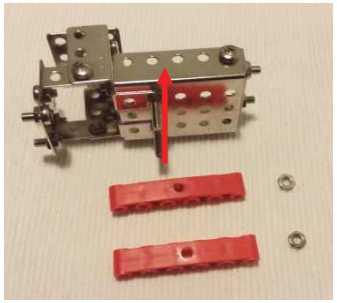
Wagenhaube (1)

Wagenkasten (2)

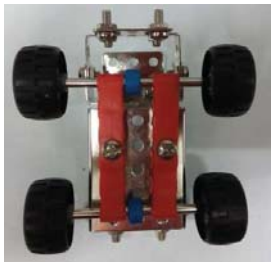
Zusammenbau von Wagen
Vormontierte Baugruppen: Wagenhaube (1) und der Wagenkasten (2)

Montage Schritt 1:
Wagenhaube (1) und der Wagenkasten (2) mit 2x kürzen Schrauben und 2x Mutter zusammenschrauben

Montage Schritt 2:
2x rote Chassis vom unten mit 2x längen Schrauben und 2x Mutter vom unten am Wagenkasten (2) befestigen

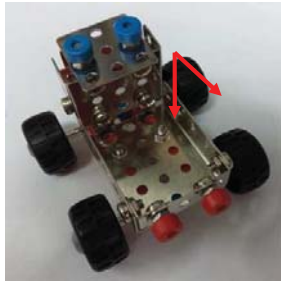


Montage Schritt 3:
4x Räder und 4x Felgen zusammenstecken. 2x Achse durch Chassis durchstecken, blaue Zentrierungsdisk einsetzen. Zusammenfertigte Räder auf Achse einstecken

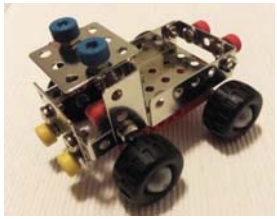


Montage Schritt 4:
2x gelbe Scheinwerfer vorne einsetzen
2x blaue Leuchttürme oben einsetzen

Montage Schritt 5:
2x rote Bremslichter hinten einsetzen

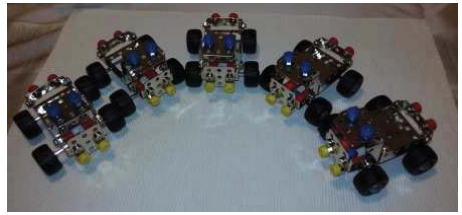


Test Probe:
Lassen Sie den Wagen mit automatischem Prüfrack für 2 Minute testen.



TESTLAUF

Produkt Lieferung:
Schicken Sie das Produkt zur Kunde



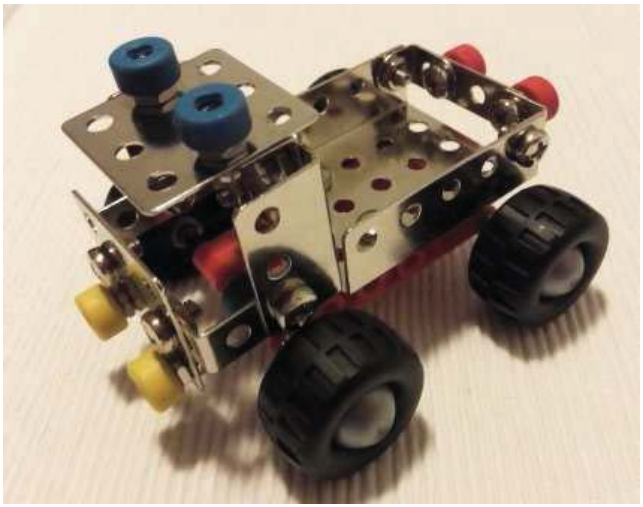
LIEFERUNG

Erstellung:	Norbert Zimerman	Datum:	1.7.2014	ÄI:	Änderungsindex	Seite 1	von 1

LEAN GAME OPF – ASSEMBLY INSTRUCTION

Working Instruction

Test Probe:
Lassen Sie den Wagen mit automatischem Prüfrack für 2 Minute testen.



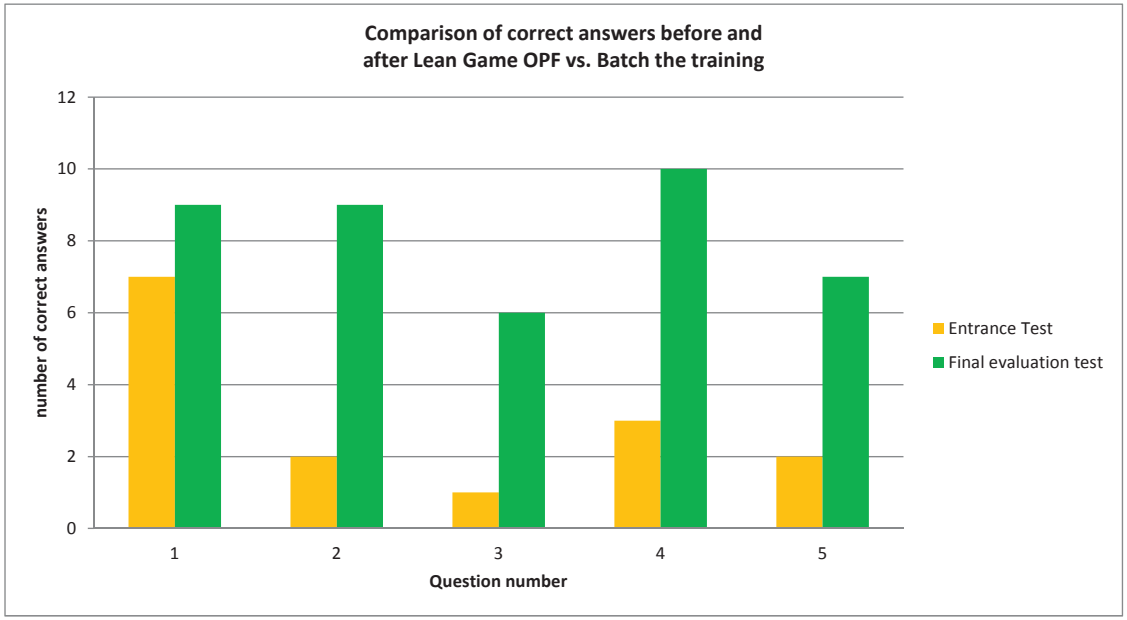
TESTLAUF 2 Minuten

Erstellung:	Norbert Zimerman	Datum:	1.7.2014	ÄI:	Änderungsindex	Doku-Nr.:	Doku-Nr.:
Prüfer:		Datum:		00		Seite 2	von 2
Freigabe:		Datum:					

	ONE PIECE FLOW vs. BATCH PRODUCTION	Participant Nr. 1	Participant Nr. 2	Participant Nr. 3	Participant Nr. 4	Participant Nr. 5	Participant Nr. 6	Participant Nr. 7	Participant Nr. 8	Participant Nr. 9	Participant Nr. 10	Right answers
Entrance Test	*1. Prepare a good organized work area is?*	1	1	1	1	1	0	0	1	1	0	7
	2. Batch production is characterized by	0	0	0	1	1	0	0	0	0	0	2
	3. Which of this activities are wasting	0	0	0	0	1	0	0	0	0	0	1
	4. One Piece Flow Production means,	1	0	0	0	1	1	0	0	0	0	3
	5. Tact time of workstation is	0	1	0	0	1	0	0	0	0	0	2
Final evaluation test	*1. Prepare a good organized work area is?*	0	1	1	1	1	1	1	1	1	1	9
	2. Batch production is characterized by	1	0	1	1	1	1	1	1	1	1	9
	3. Which of this activities are wasting	1	1	0	1	1	0	1	0	0	1	6
	4. One Piece Flow Production means,	1	1	1	1	1	1	1	1	1	1	10
	5. Tact time of workstation is	0	0	1	1	1	1	1	0	1	1	7
	6. How are you satisfied with the training?	100	100	100	100	100	100	100	100	100	100	10
	7. Could you apply the acquired knowledge in practice?	100	100	100	100	100	100	100	100	100	100	10
	8. If you have same remarks or suggestion how to make the training better, please write it down.	Comments	xx	xx	Comments	xx	Comments	xx	Comments	xx	xx	

OPF vs. Batch 1	1 Piece	2 Piece	3 Piece	4 Piece	5 Piece	Summary (Min)
Round 1 Batch Production	x	x	x	x	x	20:10
Time to delivery to customer	x	x	x	x	x	**20:10**
Round 2 OPF Production	4:12	4:08	4:12	4:17	4:00	20:49
Time to delivery to customer	4:12	4:08	4:12	4:17	4:00	X

OPF vs. Batch 2	1 Piece	2 Piece	3 Piece	4 Piece	5 Piece	Summary (Min)
Round 1 Batch Production	x	x	x	x	x	23:05
Time to delivery to customer	x	x	x	x	x	23:05
Round 2 OPF Production	4:33	4:38	4:32	4:22	4:32	22:37
Time to delivery to customer	4:12	4:08	4:12	4:17	4:00	x



OUTGOING TEST

LEAN GAMES ONE PIECE FLOW AND LINE BALANCING

This test contains the same questions as the entry test. It serves for getting the information about knowledge level gained during this lean game traning. Please fill in the following questionnaire after the training. The results will be used only in Master Thesis of Mr. Norbert Zimerman. The questionnaire is anonymous. Thank you for your time..

Customer Name: Knorr Bremse Mödling **Date:** ……

1. *One Piece Flow Production means,*

A. ☐ A worker produces all products at once on the workstation

B. ☐ Through the production goes the product, where the workers shift it without storage

C. ☐ I do not know, I never heard about this

2. *In line production,*

A. ☐ all workstation work at similar times

B. ☐ It is right when work differently long

C. ☐ It is right if work differently long but it is possibility for improve

D. ☐ I don't know

3. *Cycle time is*

A. ☐ Total Time to finish the product completely

B. ☐ Total Time of all operations on the product within the workstation

C. ☐ Time for waiting on material

D. ☐ Total Time of all operations on the product within the line

E. ☐ I don't know

4. *Which of this activities are wasting*

A. ☐ Repair of defective products

B. ☐ Produce more products than necessary at the same time

C. ☐ Waiting for material

D. ☐ Assembly the various parts on the product

E. ☐ Excess consumption of material

F. ☐ Create reserves of material on the workplace

G. ☐ All the above activities are wasting

5. *Tact time of workstation is*

A. ☐ total time from order to finish one product

B. ☐ Time to finish all operations on the product within the workstation

C. ☐ Sum of times waiting for the next order

D. ☐ Time for employee where must perform all operations on products

E. ☐ I don´t know

TURN THE PAGE

OUTGOING TEST

LEAN GAMES ONE PIECE FLOW AND LINE BALANCING

6. *How are you satisfied with the training?*

A. ☐ Very satisfied

B. ☐ Satisfied

C. ☐ Normal, like other trainings

D. ☐ Not satisfied, loss of time

7. *Would you be able to apply the acquired knowledge in practice?*

E. ☐ Yes

F. ☐ No

G. ☐ I need more training

8. *If you have any remarks or suggestions how to make the training better, please write it down.*

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OPF Lean Game Training III

PRESENTATION FOR LEAN GAME TRAINING

One Piece Flow in cell production and in line production
Product assembled in one cell and on the line

KEY POINTS OF THE TRAINING

- ONE PIECE FLOW PRODUCTION
- KANBAN AND MINI-KANBAN SYSTEM
- LINE BALANCING
- WASTE SEE AND RECOGNIZE
- TIME MEASUREMENT

Implementing one Piece Flow in line manufacturing

One Piece Flow refers to the concept of moving one work piece at a time between operations within a work cell or production line

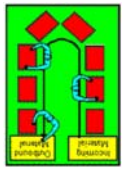
As an opposite extreme, we can process an entire batch or lot at each operation before moving it to the next operation.

We use 3 types of production with one piece flow

line manufacturing

On the line or cellular manufacturing one product is assembled with more than one person on the line.
The product is assembled one by one and moved to the next station within an assembly line.

Cellular manufacturing with min. 2 people



U-Cell with one person

In U-Shaped cellular manufacturing one product is assembled with one or more than one person within the work cell using small and flexible machines. The operators are skilled for diverse operations within the cell.
The product is assembled one by one and moved to the next station within the cell.

Steps for implementing one Piece Flow in line manufacturing

Documenting the current process

- Collect product and production data
- Document the current process, draw the current layout and flow
- Measure the time for each work operation
- Calculate process capacity and Tact time

$$\text{Takt Time} = \frac{\text{Daily Work Time}}{\text{Daily Required Quantity}}$$

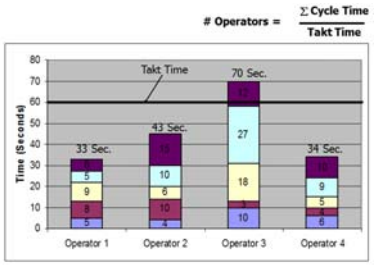
Steps for line Design

- Define the product family and calculate the tact time
- Balance the work within the work cell to create a flow
- Design and organize stations in a cell ergonomically
- Make a test run before implementation

Steps for implementing one Piece Flow in line manufacturing

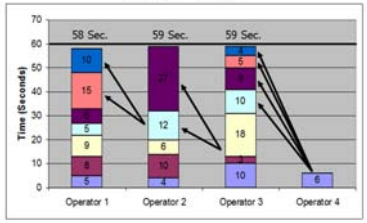
Cycle Time / Tact time Bar Chart → **Line balancing Bar Chart**

$$\text{\# Operators} = \frac{\sum \text{Cycle Time}}{\text{Takt Time}}$$



Define the product family and calculate work time. Draw the time of each operator on the standard work bar chart.

$$\text{\# Operators} = \frac{\sum \text{Cycle Time}}{\text{Takt Time}} = \frac{182 \text{ Sec.}}{60 \text{ Sec.}} = 3.03 \text{ Operators}$$

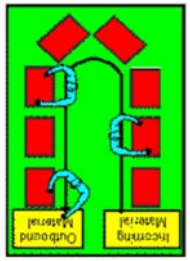


Balance the work to create flow.
Use the operator balance Chart and standard work combination chart

Steps for implementing one Piece Flow in line manufacturing

Design the cell to ensure flow and ergonomics

- Use a team brainstorming to improve **Method, Machine, Material and People**
- Plan possible layouts and select the configuration for U, C or Straight line
- Make a test run through the cell, observe operation steps and measure time
- If necessary redesign the work cell anew and repeat the test run
- Create a standardized work layout

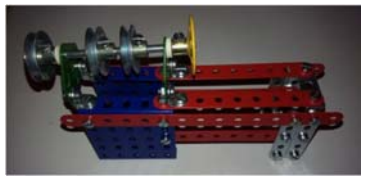


Documenting the new process

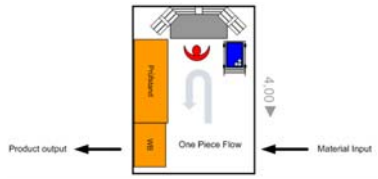
- Revise the standard work combination
- Draft new standards for operating procedures
- Measure and document work time for each operation in work station

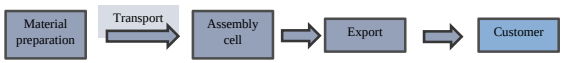
Thank you for your attention

OPF LEAN GAME and Line production



FIRST RUN

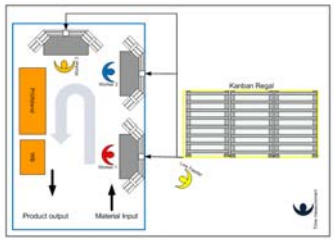




Prepare material and assembly in One Piece Flow 3 products according to working instructions. Another participant measures the time of material preparation, production, functional testing. The trainer writes the time into the table.

SECOND RUN

Create U-Cell with 3 Workstations and Kanban system

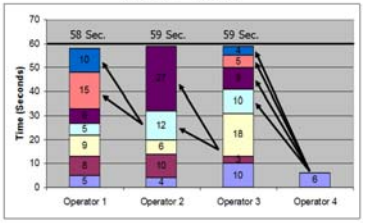


Create new concept of assembly line divided into 3 workplaces within the cell. Two workers will assembly the sub-components and third worker will assembly these sub-components together to finalize the product.
Implement a Kanban system. The Kanban system serves for better organization of material in the assembly process.
Another participant measures the time of material preparation, production, functional testing.
The trainer writes the time into the table.

THIRD RUN

Line Balancing

$$\text{\# Operators} = \frac{\sum \text{Cycle Time}}{\text{Takt Time}} = \frac{182 \text{ Sec.}}{60 \text{ Sec.}} = 3.03 \text{ Operators}$$



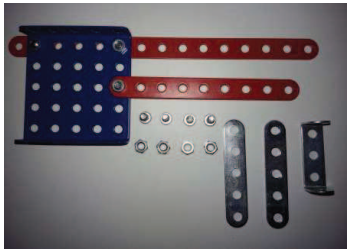
Trainer tries to change the assembly operations together with participants in order to get better line balancing to create continuous manufacturing flow. After approval of this assembly process, they start the production of 3 pieces again. The worker measures the time and calculates the tact time.

LEAN GAME OPF and creation of assembly line

Working Instruction for first run

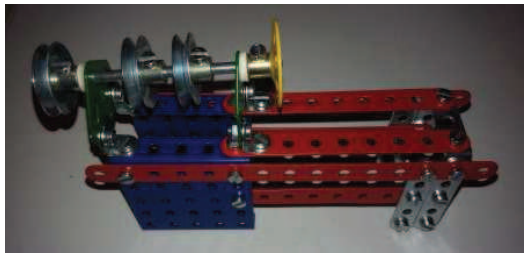
Zusammenbau von Maschinery Set Basic in One Piece Flow

Montage Teile – Gruppe 1

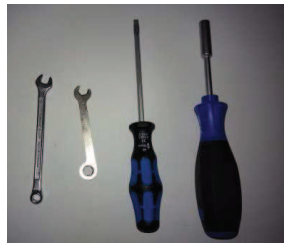


Montage Teile – Gruppe 2

Montage Teile – Gruppe 3



Endprodukt

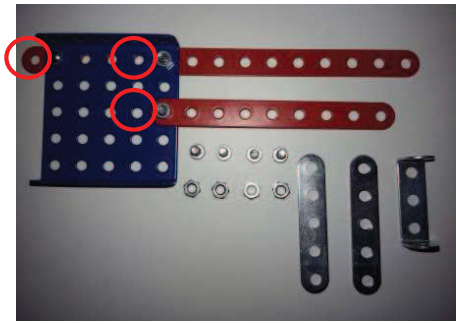


Werkzeug

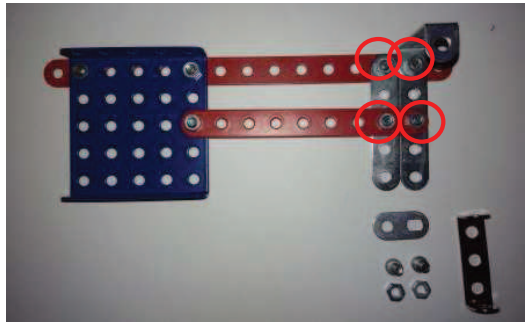
Montage Schritt 1 – Linke Wand zusammen montieren:

1.1 Teile, 10x Schrauben und 10x Mutter vorbereiten

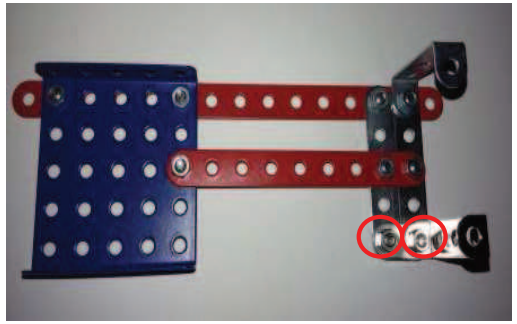
1.2. mit 3x Schrauben und 3x zusammen montieren



1.3 mit 4x Schrauben und 4x zusammen montieren

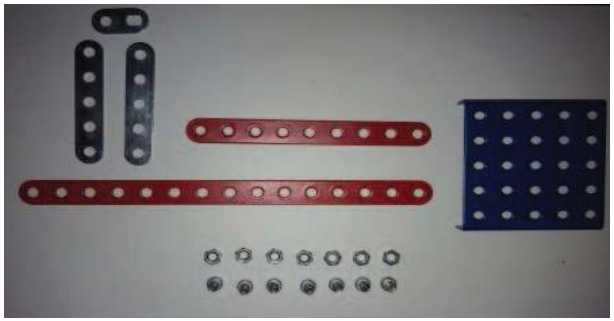


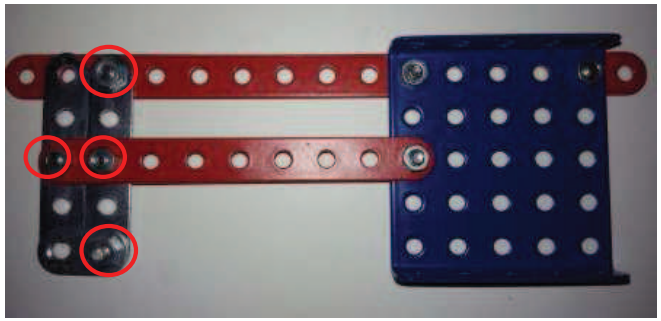
1.4 Teil mit 4x Schrauben und 4x zusammen montieren



Montage Schritt 2 – Rechte Wand montieren:

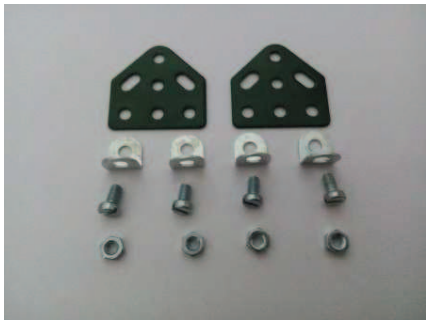
Wagenhaube (1) und der Wagenkasten (2) mit 2x kürzen Schrauben und 2x Mutter zusammenschrauben

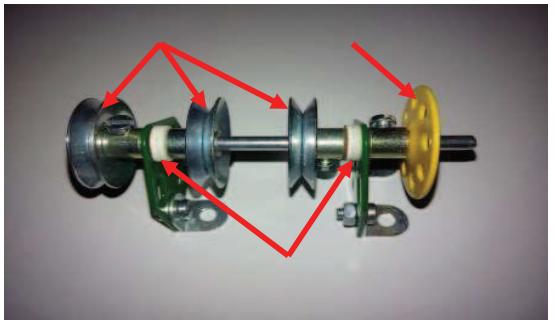




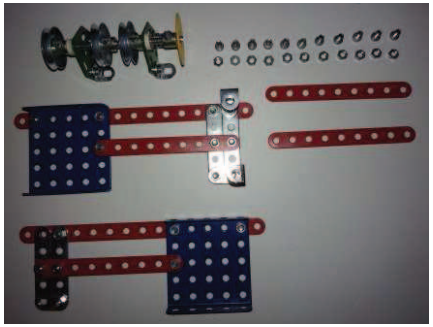
Erstellung:	Norbert Zimerman	Datum:	1.7.2014	ÄI:	Änderungsindex	Seite 1	von 1

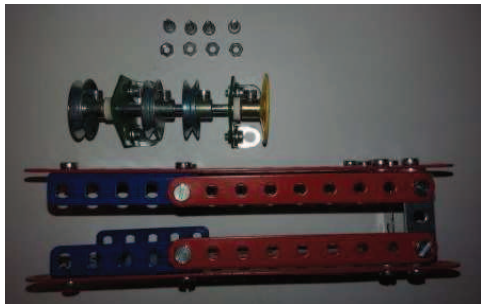
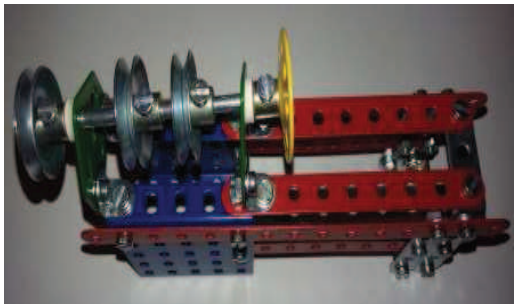
Montage Schritt 3 – obere Teil zusammenbauen:
Die Teile zusammen schrauben und bauen



Montage Schritt 4 – Zusammenbau des Endproduktes:
Die einzelnen Gruppen zusammen bauen



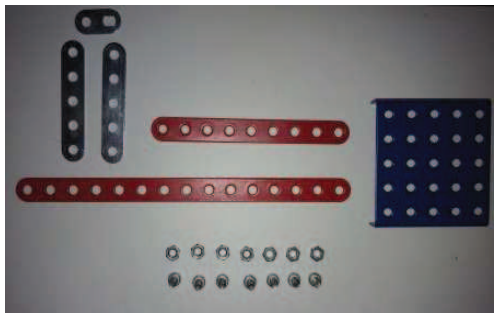
LEAN GAME OPF and creation of assembly line

Working Instruction for second run – Workplace 1 in Line production

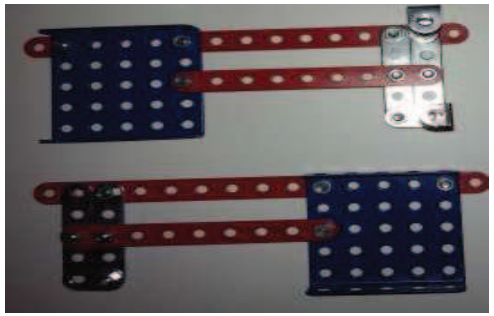
Zusammenbau von Maschinery Set Basic in One Piece Flow

Arbeitsplatz 1: Vormontieren die Linke und Rechte Wand

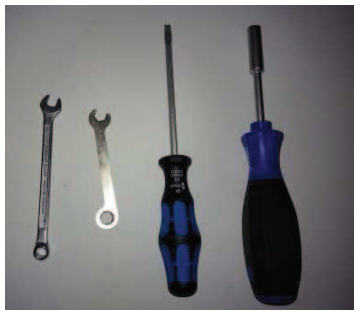
Montage Teile – rechte Wand



Montage Teile – linke Wand



Endprodukt von Arbeitsplatz 1

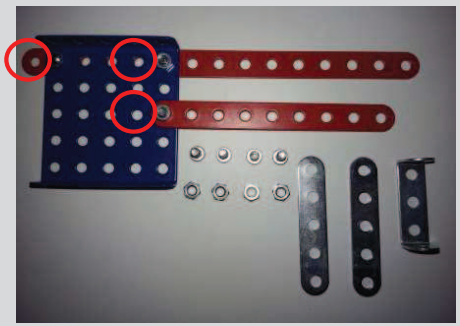


Werkzeug

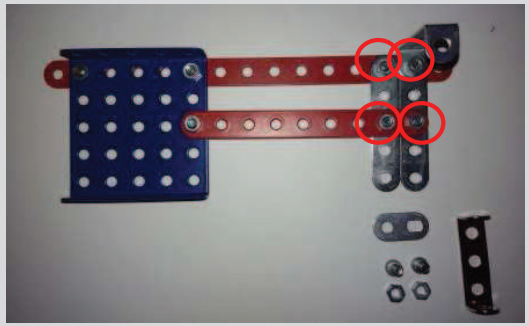
Montage Schritt 1 – Linke Wand zusammen montieren:

1.1 Teile, 10x Schrauben und 10x Mutter vorbereiten

1.2. mit 3x Schrauben und 3x zusammen montieren



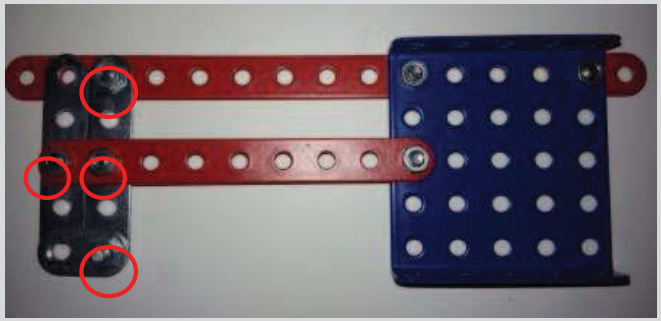
1.3 mit 4x Schrauben und 4x zusammen montieren



1.4 Teil mit 4x Schrauben und 4x zusammen montieren

Montage Schritt 2 – Rechte Wand montieren:

Wagenhaube (1) und der Wagenkasten (2) mit 2x kürzen Schrauben und 2x Mutter zusammenschrauben

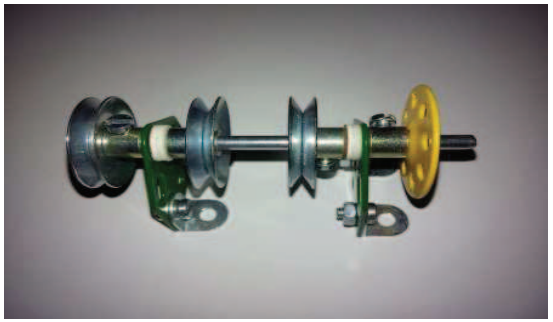


Erstellung:	Norbert Zimerman	Datum:	1.7.2014	ÄI:	Änderungsindex	Seite 1	von 1

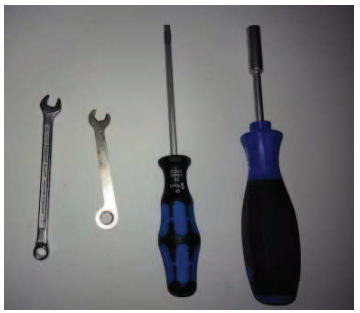
Zusammenbau von Maschinery Set Basic in One Piece Flow

Montage Teile – obere Teil

Arbeitsplatz 2: Oberer Teil - Zusammenbau



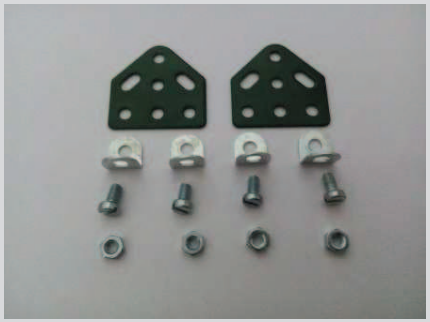
Endprodukt von Arbeitsplatz ´2



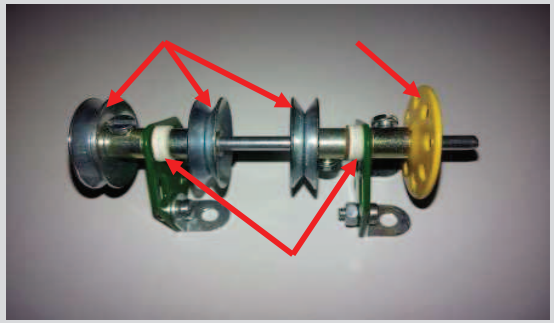
Werkzeug

Montage Schritt 1 – obere Teil zusammenbauen:
Die Teile zusammen schrauben und bauen

2.1 Teile zusammenschrauben

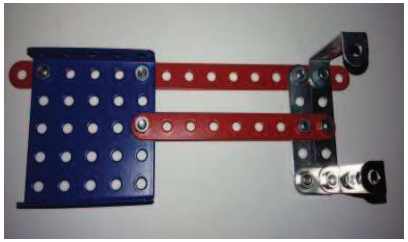


2.2 Alle Teile zusammenbauen

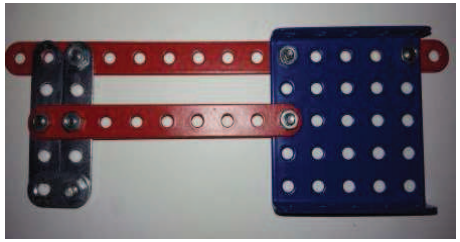


Zusammenbau von Maschinery Set Basic in One Piece Flow

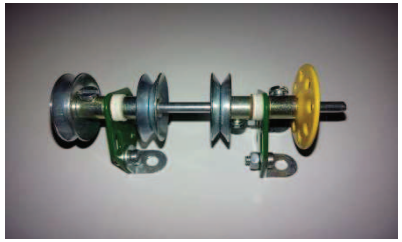
Arbeitsplatz 3: Zusammenbau



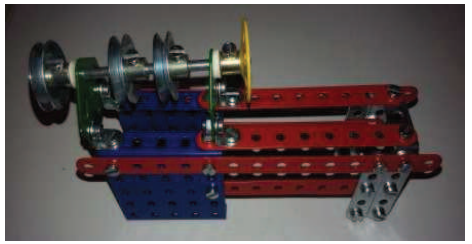
Montage Teile – Linke Wand



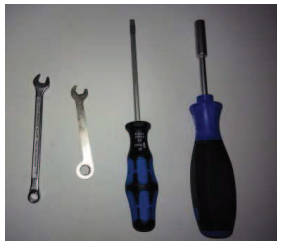
Montage Teile – rechte Wand



Montage Teile – obere Teil

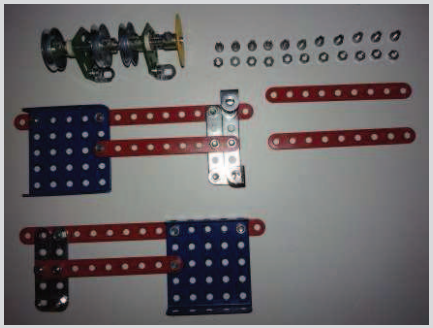


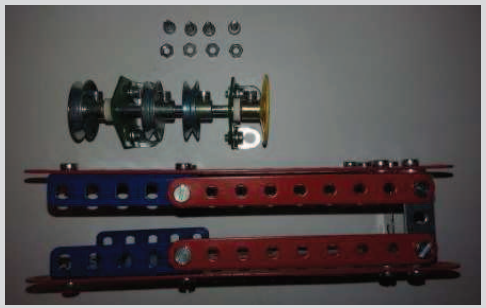
Endprodukt von Arbeitsplatz ´3

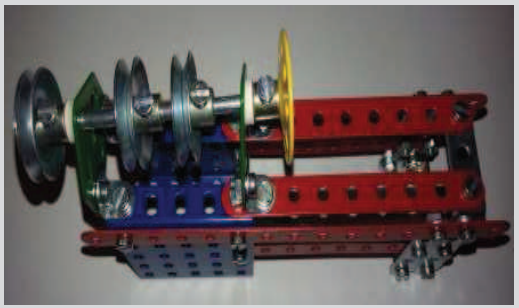


Werkzeug

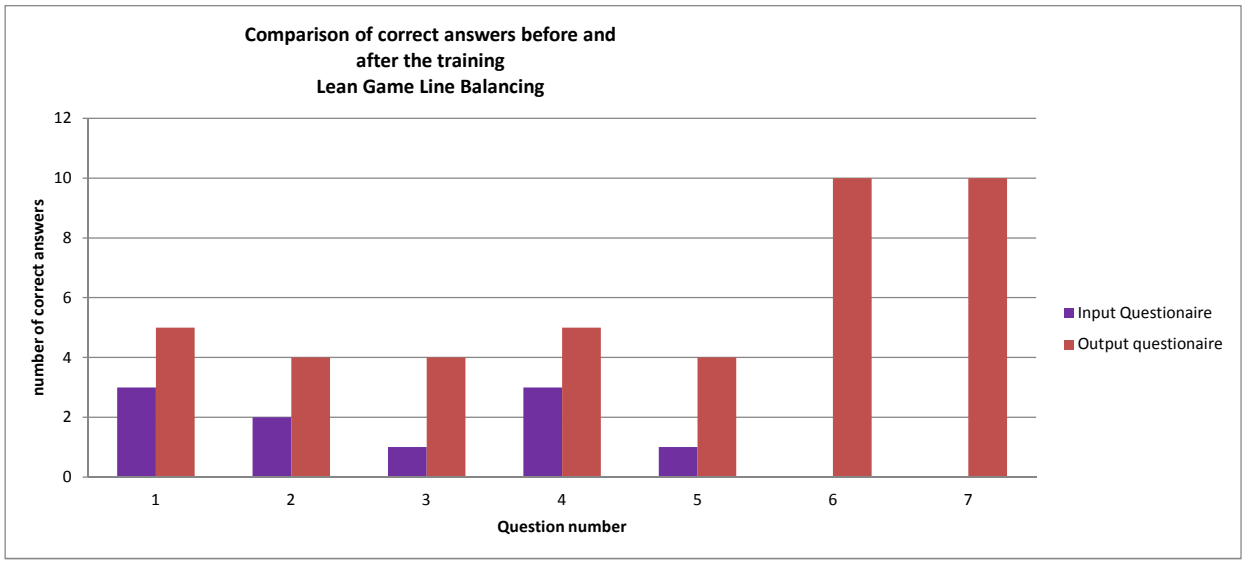
Montage Schritt 3.1 – Zusammenbau des Endproduktes:
Die einzelnen Gruppen zusammen bauen







ONE PIECE FLOW and Line Balancing	Participant Nr. 1	Participant Nr. 2	Participant Nr. 3	Participant Nr. 4	Participant Nr. 5	Right answers
1. One Piece Flow Production means?	1	1	0	0	1	3
2. In line production means,	0	1	0	0	1	2
3. Cycle time is	0	1	0	0	0	1
4. Which of this activities are wasting	1	1	0	0	1	3
5. Tact time of workstation is	0	0	0	0	1	1
6. How are you satisfied with the training?	100	100	100	100	100	0
7. Could you apply the acquired knowledge in practice?	100	100	100	100	100	0
8. If you have same remarks or suggestion how to make the training better, please write it down.	Comments			Comments		
1. One Piece Flow Production means?	1	1	1	1	1	5
2. In line production means,	0	1	1	1	1	4
3. Cycle time is	1	1	0	1	1	4
4. Which of this activities are wasting	1	1	1	1	1	5
5. Tact time of workstation is	1	1	0	1	1	4
6. How are you satisfied with the training?	100	100	100	100	100	10
7. Could you apply the acquired knowledge in practice?	100	100	100	100	100	10
8. If you have same remarks or suggestion how to make the training better, please write it down.	Comments			Comments		



	Lean Game 3 Round 1	1 Piece (Min)	2 Piece (Min)	3 Piece (Min)
Worker 1	Material preparation	06:25	05:50	05:45
Worker 2	Operation 1.1	02:10	02:01	01:58
	Operation 1.2	02:25	02:11	02:30
	Operation 1.3	01:30	01:15	01:22
	Operation 1.4	00:55	01:05	01:00
	Operation 2.1	01:25	01:16	01:25
	Operation 2.2	01:20	01:10	01:10
	Operation 2.3	01:45	01:55	01:52
	Operation 3.1	00:55	00:58	00:53
	Operation 3.2	01:10	01:05	01:05
	Operation 3.3	02:05	01:55	02:00
	Operation 4.1	02:00	01:55	01:50
	Operation 4.2	02:30	02:15	02:22
	Functionality check	02:00	02:00	02:00
	Time to delivery	22:10	21:01	21:27

	Lean Game 3 Round 2	1 Piece (Min)	2 Piece (Min)	3 Piece (Min)	Avege Time
Worker 1	Material preparation	12:25	x	x	12:25
Worker 2	Operation 1.1	02:00	01:55	01:52	01:56
	Operation 1.2	02:15	02:12	02:10	02:12
	Operation 1.3	01:25	01:23	01:28	01:25
	Operation 1.4	01:05	01:00	01:00	01:02
	Operation 2.1	01:12	01:22	01:23	01:19
	Operation 2.2	01:10	01:05	01:08	01:08
	Operation 2.3	01:35	01:52	01:45	01:44
Worker 3	Operation 3.1	01:00	00:55	00:50	00:55
	Operation 3.2	01:20	01:25	01:00	01:15
	Operation 3.3	02:00	02:05	02:05	02:03
Worker 4	Operation 4.1	02:03	02:05	01:55	02:01
	Operation 4.2	02:40	02:35	02:25	02:33
	Functionality check	02:00	02:00	02:00	02:00
	Time to delivery	21:45	21:54	21:01	21:33

	Lean Game 3 Round 3	1 Piece (Min)	2 Piece (Min)	3 Piece (Min)	Avege Time
Worker 1	Material preparatio	12:25	x	x	12:25
Worker 2	Operation 1.1	02:05	01:45	01:45	01:52
	Operation 1.2	02:05	02:05	02:00	02:03
	Operation 1.3	01:15	01:15	01:20	01:17
	Operation 1.4	01:00	01:05	01:00	01:02
	Operation 2.1	01:05	01:20	01:15	01:13
Worker 3	Operation 2.2	01:05	01:00	01:10	01:05
	Operation 2.3	01:15	01:34	01:35	01:28
	Operation 3.1	01:05	01:00	00:45	00:57
	Operation 3.2	01:10	01:05	01:05	01:07
	Operation 3.3	01:50	01:55	02:00	01:55
Worker 4	Operation 4.1	02:10	02:14	02:05	02:10
	Operation 4.2	02:45	02:45	02:35	02:42
	Functionality check	02:00	02:00	02:00	02:00
	Time to delivery	20:50	21:03	20:35	20:49

Time to delivery to customer				
Lean Game 3	1 Piece	2 Piece	3 Piece	Summary (Min)
Round 1	22:10	21:01	21:27	**1:04:38**
Round 2	21:45	21:54	21:01	**1:04:40**
Round 3	20:50	21:03	20:35	**1:02:28**

Line Balancing	Round 2	Round 3
Werker 1	12:25	00:00
Werker 2	10:46	06:13
Werker 3	04:13	06:31
Werker 4	06:34	06:51