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Lean Management
Practice in Production and Management

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supervised by
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Affidavit:

I, Andreas Rezanka hereby declare

1) that I am the sole author of the present Master's Thesis "Lean Management - Practice in Production and Management", 75 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.

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Abstract:

This Thesis deals with the term Lean and its related terminology Lean Production and Lean Management. Considering that the term Lean has successively developed since its first appearance there are various definitions together with different ways of comprehension.

The objective is to compile a theoretical definition respectively to establish a state-of-the-art approach towards the principles of Lean especially compared to more traditional and different types of management based on the research question.

Particular focus is put on avoiding waste in any form as well as the complexity of the term Lean and its methods concerning an implementation in existing organization structures.

Keywords:
Lean – Lean Management – Lean Production – Six Sigma – Kaizen – Kanban – 5-S

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1 Introduction

1.1 Background/Problem Discussion

There are a lot of possible effects that can be seen if a management is challenging to change to a Lean Production and Management. These effects can not only be seen inside the organization but also from the customers' point of view. In an environment where the company has to satisfy the demands of the customers it is necessary to work in the most effective way. This can induce a lot of different activities as well as that it puts pressure on the product realization process to be not only flexible but also efficient. It can be seen as one of the purposes of this thesis to identify possibilities to make the production in a company as effective and flexible as possible, in the meaning of a Lean Production.

Due to the fact that a Lean Production is avoiding any waste, specifically that topic is very crucial for this thesis. Waste in a lean meaning is meaning any resource that is not absolutely necessary for the production of the product. This means both, time as well as parts.

1.2 Research Question

With the goal to take a look on possibilities to make a company leaner in the meaning of being more effective and flexible, the following research question was defined:

"How can organizations make their production more effective and flexible in the meaning of being leaner?"

1.3 Methodology

To answer the research question that is mentioned above there was a literature research following a hermeneutical approach. This means that relevant literature was searched and analyzed to answer the research question above. Only literature that was seen as important was used in this thesis.

2 Definition „Lean“

2.1 Definition

The prevailing opinion that the concept of lean originally emerged from Toyota stable is only partially true. The phrase “ Lean manufacturing” rather became really popular in 1990 when James P. Womack, Daniel Jones and Daniel Roos published their book “The Machine That Changed the World”, which was a pioneering success. In their book the authors suggested a new system in which less capacities of everything were used compared to mass production. This applied to the investment in tools, the manufacturing space and the engineering hours, hence it was “lean” (Sakar 2012: 2).

Lean Management can be seen as a revolution in management as it promises a lot of great benefits to organizations like shorter product lead time due to reduced manufacturing efforts in a dramatically degree. Further higher labor efficiency as well as quality and an increasing in the market flexibility.

According to the logic of mass production it can be said that the market rules had changed in the last years and that there is a relation between quality and price in the meaning that better quality justifies a higher price of a product. In Lean Production systems can be produced with high quality and lower cost than in traditional manufacturing. So it can be mentioned that with applying lean manufacturing methods it can be demonstrated that high quality standard is not necessarily demanding higher costs for the company, because it is possible to reduce overall costs. A nearer look shows that especially the indirect costs can be reduced while upholding the reduced manufacturing time as well as the quality standards. (Jackson 1996: 4)

To work with Lean Management it is necessary for managers to understand the concept of Lean Management. Only a few organizations have been able to truly achieve being so-called lean and this is caused by the factor that lean is a never ending journey for the organization. There are a lot of different pictures of lean perspectives of lean. A nearer look to lean thinking the main point is seeking of eliminating waste to specify value and line up value- creating actions in the best possible sequence. Lean activities should be conducted without any interruption whenever a person is requesting them. Another factor of lean thinking is the performing of these actions into a more and more effective way. A near a look to the different definitions of lean indicates that it is a philosophy of possibilities to shorten the time in between orders of the customers and the shipment to

the customers. Most of the time the elimination of waste is of high importance.(Trent 2008: 4).

To take e closer look to the different types of waste that should be avoided in Lean Production and management there can be mentioned overproduction, transportation, waiting, inventory, motion, defects, Over-processing and improper use of human resources. (O.A. Value stream maps 2010: 4)

In the case of lean manufacturing it can be said that this initiatives focuses on eliminating all of the waste that is produced by manufacturing processes. And in the mean of lean it is necessary to mention that this is simply a thought process. Regarding to one of the possible definitions of lean it can be said that is not a tool and it is used to look at the business of the organization whether it's meant for the service, the manufacturing or any other activity in the organization where there is a customer and supplier. The mean side processes within lean are focused on identifying waste not only from the perspective of the organization but also from the perspective of the customer. In the end there are possibly as much definitions of lean as there are people that try to define the term itself. (Trent 2008: 4). The following figure 1 shows the lean concepts and lean levels (Hines, Holwe and Rich 2004):

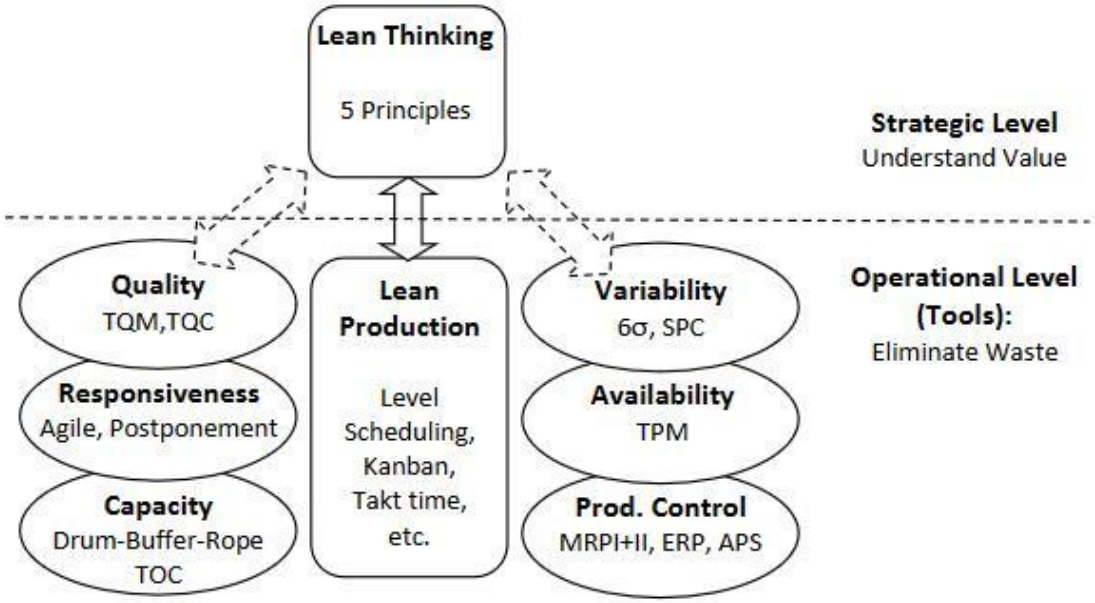

Figure 1: The lean concepts and the levels of lean

2.2 Lean vs. Traditional Management

It is necessary to mention that a functioning lean manufacturing requires Lean Management in the organization. Still the majority of organizations is working in the traditional way, because they are not thinking long-term and therefor don't have the necessary patience to persevere until the traditional system has changed into a lean system. Another point is that it needs a lot of physical procedural changes to transform a company from mass to lean. Mostly this is accompanied by significant changes in the currently prevalent structure as well as the processes of the corporation and therefore requires a lot of courage not only from the management but from the personal too (Jackson 1996: 5). The following figure 2 presents an overview of the differences between traditional and Lean Management (https://www.slideshare.net/KarenMartinGroup/lean-leadership-7123809/16-Traditional_vs_Lean_ThinkingTraditionalLeanRevenuefocusedMarginfocusedImprovement_focus)

Traditional vs. Lean Thinking

Traditional	Lean
Revenue-focused	Margin-focused
Improvement focus: optimizing value-added work	Improvement focus: eliminating non-value-added work
Fire fighting is rewarded	Fire prevention is rewarded
Focus on financial metrics & lagging indicators	Focus on operational metrics & leading indicators
Suboptimization is rewarded	Value stream performance is rewarded
Specialized workers organized by function	Cross-trained workers organized by value streams
Complexity is the norm	Simplicity is the norm
Inspect in quality	Build in quality
Non-visual workplace / management	Visual workplace / management
Dynamic schedule and priorities	Static priorities and schedule
Unclear ownership & accountability	Clear ownership & accountability
Excessive reviews and approvals by leadership	Decisions are made by those closest to the work
Improvements identified by management	Improvements identified by workers

Figure 2: Traditional vs. lean thinking

Performance Management Systems

To begin with Performance management according to the United States Office of Personnel Management is “the systematic process by which an agency involves its employees, as individuals and members of a group, in improving organizational effectiveness in the accomplishment of agency mission and goals” (United States Office of Personnel Management, http://www.opm.gov/perform/overview.asp.)

Going further it includes activities such as planning work and setting expectations, continually monitoring performance, developing the capacity to perform, periodically rating performance in a summary fashion and rewarding good performance (Broadbent & Laughlin 2009: 284)

De Toni and Tonchia (1996) referred to performance management as management by process. They argued that for the company to have a unified goal centered on all aspect of customer satisfaction and the overall performance in terms of quality timeliness, efficiency, flexibility, management should endeavor to link all the activities together.

In the light of the above definitions and Bhasin (2008) stated that the management process becomes useless when the information collected is not properly utilized or that organizations lack the effective system required to translate the feedback into an effective strategy for action. (Bhasin 2008)

Through feedback from measurement outcome implemented, performance management offer organizations the chance to refine and make better their processes (Amaratunga & Baldry 2002).

Hoque (2008) clearly highlights the importance of aligning performance management systems with the strategic goals of the organization which in relation to Cheng (2006) is the key to success of the organization. He stated that

“... ensuring congruence between all operational elements, encompassing employees at all levels in all departments, requiring total management commitment to teamwork, and information systems integrate with those of the customers and the suppliers.” (Cheng 2006: 765)

De Waal (2006) stressed that for the PMS to be successful there must be mechanism in place that would ascertain if the organization is functioning at its optimum. He went further to say it should be adopted across the organization and managers should consistently use it and its outcome should lead to improved organizational performance. To this end the

PMS and the attitude of staff within the organization needs to be of extremely high standard.

“The performance management systems are seen as a closed loop control system which deploys policy and strategy, and obtains feedback from various levels in order to manage the performance of the business” (Bititci et al 1997: 524).

Ferreira and Otley (2009) asserts that it has to do with the defining, controlling and managing both the accomplishment of results as well as the process employed to attain these results from a societal and organizational perspective rather than individual level. They assumed this name so as to reflect a shift to a wider perspective of the role of control in managing organizational performance from the usual compartmentalized ways. It also gives a managerial emphasis, by integrating various dimensions of managerial activity with the control system (Ferreira & Otley 2009: 266).

Ferreira and Otley (2009) suggested twelve key areas that should be taken into consideration in developing the structure for performance management systems. Similar to Otley (1999) five main steps regarding issues that should be considered when developing a system for managing organization performance. Joyce et al. (2003a) cited in Grønholdt and Martensen (2009) identified eight management practices and divided them into ‘‘primary management practices’’ representing the fundamentals of business, and the last four being ‘‘secondary management practices’’ (Grønholdt & Martensen 2009: 48).

Ferreira and Otley’s (2009) twelve key areas are discussed below.

Vision and Mission

There cannot be control without objectives on which evaluation of performance is based. Thus it will be appropriate to say objectives are the starting point of performance management. The general direction an organization wishes to pursue is expressed in its vision and mission. The vision states the future position the organizations aspires to attain while the mission outlines the overriding purpose of the organization in relation to the values of stakeholders. Vision and mission statement serves as pointers that direct the process of deciding changes that should be made or not in strategies and activities in the face of ever changing environment.

Key success factors

Key success factors are those factors, activities, attributes, competencies, and capabilities that are seen as critical prerequisites for the success of an organization in its industry at a certain point in time. For an organization to move its vision forward these factors must be achieved and their identification and monitoring is important for the accomplishment of strategic goals.

Organizational structure

The organizational structure spells out the responsibilities and accountabilities of the participants in the organization by specifying the roles individuals should not pay attention to.

There are multiple types of organizational structure depending on the choice regarding decentralization/centralization of authority, differentiation/standardization, and the level of formalization of rules and procedures.

There is a connection between organizational structure decisions, key success factors and strategic decisions. The identification of key success factors requires organizations to assess the suitability of existing structures.

Strategies and plans

As a way of accomplishing the organizational objectives, chosen strategy points towards the direction an organization decides to follow and to achieve its objectives over a period of time. As argued by the authors' organization needs to develop the strengths that correspond to its key success factors so as to accomplish the goals set before them. An important aspect of this requires a translation of strategic goals to operational goals to realize alignment. Accordingly, researchers also propose matching the environment; strategy and internal structures together would result to higher performance.

Lack of direction is one of the key control problems observed in practice as well as failure to communicate strategies and plans to organizational members may result in a lack of understanding of how individual actions contribute to the overall strategy.

Key performance measures

These are financial and non-financial measures used to assess the success of the organization in achieving its objectives, key success factors, strategies, and plans at different levels and simultaneously satisfying stakeholder's expectations. Key performance measures in performance management frameworks are specifically highlighted. It reflects its importance and influence on individual behavior within the organization. There is evidence that alignment between performance measures and strategy affect performance in particular, the pairing of quality-based manufacturing strategies with the extensive use of subjective non-financial performance measures was found to have a positive performance effect. Attention should be paid to consider both area that measures are absent and area where they are in use.

Target setting

This forms an important aspect of the performance management framework because the set targets are used as a basis on which performance of the organization is evaluated. Research shows that when targets levels are set it has a positive effect on performance with about 80 to 90 percent chance to success. Consequently, some authors' opinion is that when there is need for cooperation between units, target setting is not related to higher performance.

Performance evaluation

This is the evaluation of performance of the organization as a whole in general and groups of individuals in particular. Performance evaluations can either be objective, subjective or in between both extremes. In the former there is no scope for ambiguity in the weightings assessment is based only on the actual results and, typically, they do not allow for adjustments to the agreed standards of performance nor to their weightings. Subjective on the other hand, the person in charge of the evaluation knows and determines the specific weightings assigned on different dimensions of performance. Its importance is that it detects error in performance measurement and corrects them.

Reward systems

When performance is evaluated the result is the reward that could include expressions of approval and recognition by senior management, financial rewards, long-term progression

and promotion. Non-financial reward could be in form of subtle attributes and behavior. The workings of performance management system could be affected in a situation where subordinates receive a positive or negative comment with regards to their work progress and will influence their behavior. The relationship between rewards, motivation and performance is complex, perhaps more so than it appears at first sight. Reward as a way of motivating subordinates would enable them to align their personal goals with those of the organization. By so doing unwanted behaviors are put aside. Group reward although have attracted increased attention, it is however faced with difficulty of a situation where individuals see themselves as not part of the group, potentials for free riders. (Ferreira & Otley 2009: 275)

Information flows, systems and networks

Information flows, system and networks are the nervous system that hold together the whole system and is an important facilitator to any performance management system. Through system accounting and control, information can be managed and they form a part of the information system. Networks are also another part of the information system.

In traditional organization performance management revolved around budgeting system, however recent trends now see organization embracing broader performance management systems like production, quality control, logistics systems etc.

Performance management systems use

The use made of information and controls is a corner- stone of the performance management system. Evidence from case study suggests that the use of control information can be more significant than the formal design of the control system. There is considerable scope for the development and operationalization of the concept of use, and for research to ascertain the effects of different types of use of control systems.

Performance management systems change

Owing to environmental and organizational change, performance management systems change was included in the framework as they are also requires change. This change is imminent so as to keep their importance and usefulness. Talking about performance management change, it relates to the design infrastructure that strengthens the performance management systems as well as the way performance management

information is utilized. Strategies are an important factor when mention is made about performance management systems as a result it is vital for organizations to consider the scope of strategic change in an ever competitive environment. The extent to which strategies have changed is an issue of interest for understanding the functioning of the performance management system. Thus when change is considered it is the extent and type of change that have resulted that focus should be on rather than the process of the change itself.

Strength and coherence

In a bid to understand the operation of the performance management system, the strength and coherence between the links within the performance management system is important. The performance management system as a whole is greater than any individual part, thus it is paramount for all the different parts to be aligned and organized so as to meet its purpose. In speaking of strength and coherence, all the components that have been discussed so far are connected.

The authors' provides hints as to what to look for when examining the strength and coherence of the performance management systems. They suggested that judgments should be made about the extent to which the control system "consider(s) multiple stakeholders, measure(s) efficiency, effectiveness and equity; capture(s) financial and non-financial outcomes, provide(s) vertical links between strategy and operations and horizontal links across the value chain, provide(s) information on how the organization relates to its external environment and its ability to adapt" (Ferreira & Otley 2009: 276).

2.3 Lean Management/Six Sigma

2.3.1 Description

It is possible to trace the roots of Six Sigma to two primary sources: first there is the total quality management to mention and as second the Six Sigma statistical metric originating at Motorola corporation. It can be said that nowadays Six Sigma can be seen as a broad long term strategy for decision making rather than a quality management program that is narrowly focused on total quality management. Six Sigma preserved the overall concept that every person working in an organization is responsible for the quality not only of the goods but also of the services that are produced by a company.

The following figure 3 shows an overview of the six sigma model (http://www.sixsigma-institute.org/What_Is_Six_Sigma.php)

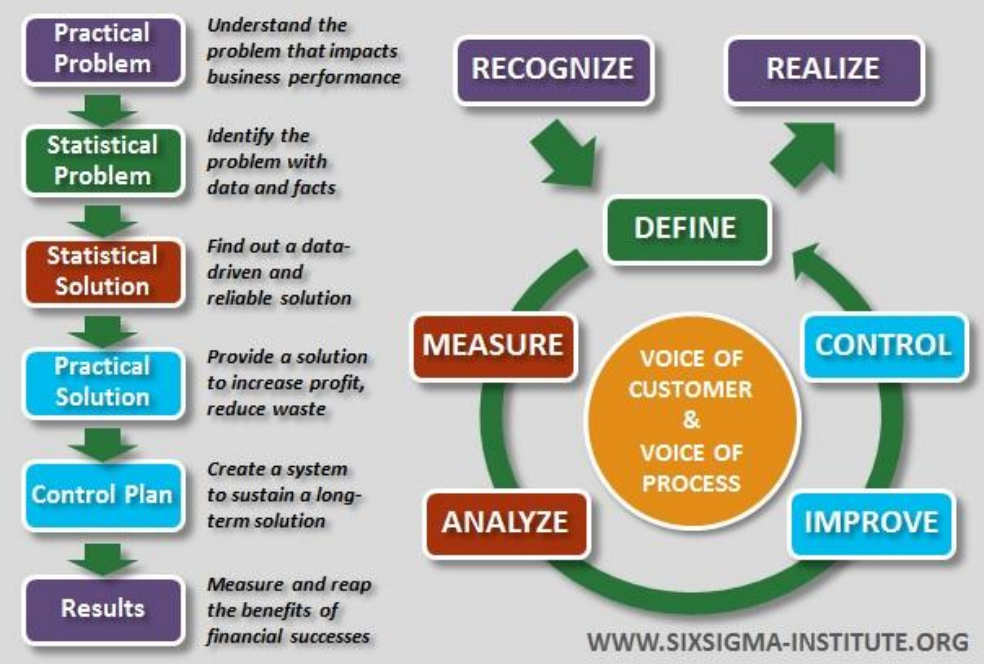

Figure 3: Six Sigma model

Another important component of Six Sigma is that it is possible to trace it to total quality management that includes the focus on the satisfaction of the customers when it is necessary for the management to make decision .Other important points are a significant investment in education and training in statistics are as well as in route cause analysis or other methodologies that help to solve problems with the help of total quality management. In the sense of total quality management the first priority was quality. A nearer look to total quality management and its main tools shows that there are seven tools of quality are included, namely control charts, histograms check sheets, scatterplots, cause and effect diagrams, flow charts and Pareto charts. In addition in total quality management there also seven tools of quality for the management like affinity diagrams, interrelationship digraphs, tree diagrams, Matrix diagrams, prioritization matrices as well as process decision program charts and diagrams for the activity of the network (Sower et al. 1999).

Regarding the development of the Six Sigma metric it can be said that is based on Motorola in 1987 as a response to the product quality that was substandard. In many

cases this substandard product quality could be traced to decisions that were made by engineers in the case they had to design component parts. Regarding the traditional way there was used the three sigma rule from design engineers if it was necessary to evaluate if there is an acceptable proportion of manufactured components in the expected tolerances. In the case of consistent components tolerance this was the spread of six standard deviation units of process variation about 99.7% of the components in a given centered process necessary to conform to tolerances. This means that only 0.3% of the produced parts would be non-conforming to tolerances and about 3000 non-conforming parts per million (CPPM) that are produced in a given company. If the products of the company become more complex there is a higher rate of defective products that are becoming commonplace. At the same time the customers demand a higher quality of the products of a company. For example it can be said that a cell phone includes hundreds of different components. Typically every single component includes numerous of different but very important characteristics of quality. So it is not uncommon that a product includes thousands of different opportunities for defect in every product that it is selling.

In the traditional thinking of three sigma quality for each opportunity for defect this was not acceptable for the future and a newer look to the formula that was used to determine the probability of defect free products provides an approximate guideline for only two important reasons. Since the Three Sigma Standard can be seen as the minimum it can be expected that a lot of product that are produced in a given company are able to surpass the three sigma standard. On the other hand with the 0.997 conformance probability it can assumed in centered process. It would be an expectation that a lot of processes would not be centered every time when a component is produced in a company. However the calculation illustrates the challenge that is inherent in the production of defect free products. If a company is assuming thousand opportunities for defects, the calculation says that only 37% of the produced products will be defect free if the level of the quality at each opportunity for defect averaged 99.9% and 90% of the products can be seen or expected as free of defects, if the level of the quality at each opportunity for defect averaged 99. 99%. (Arnheiter & Maleyeff 2005: 4)

In other industries there a similar challenges if they have to achieve superior quality. A lot of industries where the products are not as complex as in the cell Mobile or computer industry the companies face similar challenges. This companies that manufacture less complex products but have to sell them in a very high number are also in the need to achieve superior quality. At Motorola the relationship between component quality and the

final product quality was studied. The company was able to discover that from lot-to-lot a given process tended to shift a maximum of 1.5 Sigma units (McFadden 1993).

The first company that adopted a six sigma strategy was the Ford motor company in the late 1999. For this company it can be said every car that was pulled out had approximately 20.000 OFDs. If Ford could attain a Six Sigma quality then approximately one car in every 15 cars that are produced by the company would contain a defect. It is necessary to mention that if Ford operated at a 5.5 Sigma level it is about 50% of the produced cars that would include at least one defect.

Nowadays Six Sigma stands for a combination of the Six Sigma statistical metric and the total quality management most of the time. There are additional innovations that make it possible to enhance the effectiveness of the program at the same time while it is expanding the focus. It is important to mention that the main components of Six Sigma retained from total quality management and that includes a focus on the customer as well as a recognition that a high-quality is not only the responsibility of one person but of all employees and the emphasis on a training for the employees as well. The Six Sigma metric is used, too but in the widely expanded form. With the help of Six Sigma the value of the output of a company includes not only quality but availability, reliability as well as delivery performance and a high service in the aftermarket. This is why superior should be a performance within each of the different complements of the customer's value equation. Hence the Six Sigma metric is applied in a very broad fashion. It is striving for a nearly perfect performance but with the lowest level of activity in the company. In addition it must added that Six Sigma programs aim to create a structure and under this structure it is generally possible to decide which training of employees is formalized and it's possible to support the training to ensure its effectiveness .In the Six Sigma metric it is necessary that every single employee is involved in the activities of the company that have an impact of the customer satisfaction. It is necessary to train the employees to solve the basic problems. They have to learn to get the necessary solving skills. If it is necessary employees can be provided advanced training and required to act like mentors to other employees in the means of supporting the quality improvement projects (Arnheiter & Maleyeff 2005: 5).

2.3.2 Misconceptions regarding Lean Management and Six Sigma

If there is taken and nearer look to the definition of Lean Management and description of Six Sigma it can be said that they were derived from two very different points of view. In this sense Lean Production was derived from the needs of the companies to increase the

flow velocity of the products. This should possible because of an elimination of all activities that are called non-value added. On the other hand Six Sigma was developed because of the need to ensure the quality of the final products. This was made by focusing on obtaining a very high conformance at the OFD level. In order for proponents of one program to learn from the other program there can be mentioned some misconceptions. The most important misconceptions are described below.

Misconceptions regarding Lean Management

It can be mentioned that one of most common misconception of Lean Management is that the term lean means lay-offs. This may be due to the term lean, but it is a key misinterpretation of lean. If an employee is called performing non-value-added activities in Lean Management within their job it is necessary for both, the employee and the management, to find a way that the employee can better perform the job with the aim to eliminate the non-value added activity activities. Laying-off the employee would be counterproductive because it is no longer possible for the company to work with the knowledge of the person. Further the remaining employees would maybe be reluctant to take part in the waste elimination project in the future.

Further it is necessary to mention that lay-offs are not possible to take place in the context of Lean Management unless it becomes a necessity and every effort of the firm to retrieve or to reassign the Employee from the side of the company is failing. It is necessary to mention another misconception of Lean Management and Six Sigma. Lean is not only working in Japan because of the unique culture in the country. It can be seen as a fact that Lean Management is not only a universal system in Japan. The most successful Lean Management implementation shows that these companies are not in Japan. Maybe the source of this misconception is the belief of the people that the employees in Japan are more frugal than their counterparts in other countries. But it must be mentioned that even if this were true there is often a conflict between eliminating waste and being frugal, for example if an engineer designs an inferior part to save money for the company.

But that can be mentioned another key misconception regarding Lean Management. It says that lean is only designed for manufacturing. But even in the manufacturing environment, Lean Management is able to view every step in the whole process as a service step. In this process that value of the customer is added with minimal waste. This can be seen as a framework in which the processing claims in insurance industry for example of evaluating loan application to the bank and treating patients in the hospital. This all involves performing activities that are synonymous with the viewpoint of Lean Management. So it can be said that in every business where customers exist and a

company must make activities to satisfy the customer it is possible to practice Lean Management in a successful way (Arnheiter & Maleyeff 2005: 7).

The last misconception mentioned here is that it is only possible to work lean within certain environments. Often this opinion comes from managers in operations that are large batch operations in the traditional way as well as from managers of different job-shop operations. Lean Management encompasses much more into the side of the manufacturing, while these types of operations are never being able to conform to the "lot size of one" principle. If these companies would make attempts to identify and eliminate all activities that are non-value added throughout the company these organizations would be able to practice important aspects of Lean Management. It would also be able for these organizations to pursue other different elements of Lean Management if they are continuously attempting to follow the principles of Lean Management when they adopt new manufacturing technologies in the company (Arnheiter & Maleyeff 2005: 12).

Key misconceptions regarding Six Sigma

In the case of six Sigma it can be said that the most common misconception is that Six Sigma is the new flavor of the month and is only pushed by quality consultants in a similar way total quality management, Deming management, business process reengineering and ISO 9000 where pushed in the last years. It is necessary to mention that there will always be some consultants that love new ways to live in management and take every seminar to proclaim themselves as experts in a given program. Six Sigma is no exception in this, but however it is state of the art when it is seen in terms of quality management because it borrows from previous programs, especially from the total quality management focus on the customer and the Deming management philosophy, but at the same time it adds new features like the comprehensive training structure to these philosophies.

This new features are for example a comprehensive training structure and further a broad definition of the value that is made from the perspective of the costumer. It does not only include the quality but also delivery and service. It can be mentioned that while the name of Six Sigma maybe is changing in the following years the main features of the program will be carried over to other subsequent programs and there will be new and improved versions.

There is another misconception of Six Sigma that is important to mention, namely that the goal of 3.4 NCPPM is an absolute factor that should be applied to every opportunity tolerance as well as specification, although it is not of ultimatum importance and

expression of the costumers value. The 3.4 NCPPM was derived at Motorola and based on the characteristics of the project of this company. It is necessary to mention that other firms doesn't use this metric in the sense of absolute goal in every given case. The Pareto principle is an important part of Six Sigma. With the help of the Pareto principle it is possible to make improvement of projects that will focus on the" lowest hanging apple".

It is a given fact that a company business is not static for a very long time. New services or products will generally provide a never ending source of low hanging apples. As in alternative it is necessary to find examples where a goal of 3.4 NCPPM isn't good enough and it is necessary to set the target at a higher Sigma level. For example the pursuit of exceptional quality is required especially in nuclear power or medical device with the aim to prevent a catastrophic loss of human life (Arnheiter & Maleyeff 2005: 12).

Another important point to mention is that Six Sigma is not a program for quality only. This is not the right way to see Six Sigma. The concept of quality in Six Sigma relates to the equation to the entire customer value. The applicability of Six Sigma is very broad and it includes delivery, manufacturing, service and other maintenance components (Arnheiter & Maleyeff 2005: 13).

2.3.3 Integrating Lean Management and Six Sigma

The following figure 4 shows an overview to Lean-Six-Sigma (https://www.slideshare.net/GhineaRodica/improve-performance-through-lean-six-sigma-management):

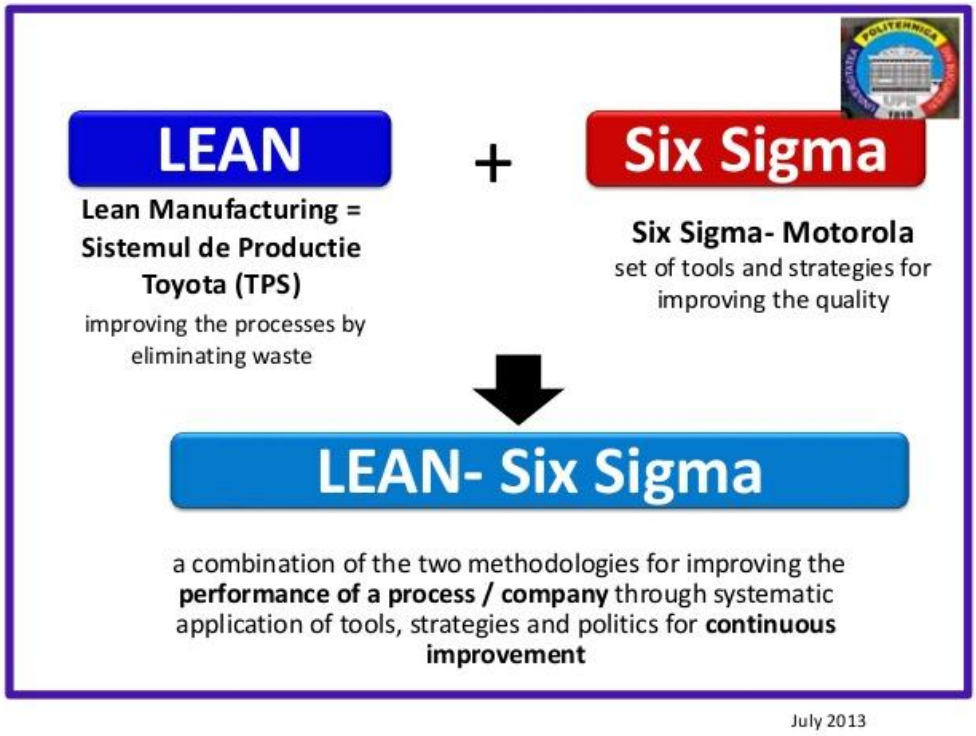

Figure 4: Lean Six Sigma

As it was mentioned above it is possible for organizations to reach a point of diminishing returns with the help of only one form, either Lean Management or Six Sigma alone. But there can be received benefits if both programs are used simultaneously.

Lean organizations can gain some important points from the Six Sigma program. For example it can be mentioned that lean organizations should learn to make a better use of their data if it is necessary for them to make decisions. Further they should use different methodologies that allow a more scientific approach to quality.

In case of occurring quality problems within a Lean Management system, defects are likely to be identified internally via the ZQC system. When this occurs, waste is incurred in a number of ways. First, there is a loss of opportunity for the production of that component since operation times are synchronized with demand via the pull system of production control. Second, cost is added through rework or scrap. Third, indirect personnel and

other overhead must be available to handle the scrap and rework, such as a repair department.

As an example there can be considered a manufacturing cell with a two-minute cycle time. The cell operates for two eight-hour shifts, with a target production as result of 480 units per day. Work in the cell consists of 20 individual tasks and each unit of product possesses a total of 100 OFDs. In this cell, when the 480-unit daily target is not met due to system variations (e.g. defects, machine downtime, power failures), overtime must be utilized. For example, if component quality at the OFD level were 1,000 NCPPM (0.1 percent), then on average 1.5 hours of overtime would be required per day.

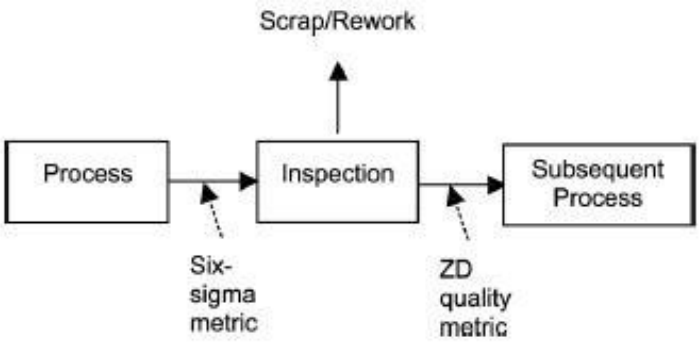

Figure 5: Typical measure points in ZQC and Six Sigma philosophies)

If this were the case, the company could allow for buffer quantities to be pre-produced, but this practice also creates waste and is undesirable. The ZQC system also has the potential to cause reliability and quality problems due to the interaction of tolerances in complex products. An example involving Ford transmissions illustrates the problem caused by relying on tolerance-based pass/fail criteria during inspections. Ford had a problem with warranty claims for automatic transmissions. The transmissions were made at both the Ford Batavia (Ohio, USA) facility and at a Mazda facility in Japan. Data showed that customer satisfaction was higher for the Mazda-built transmissions. Subsequently, samples of both Ford and Mazda transmissions were disassembled and each component part was measured (Gunter, 1987). The Ford transmissions all conformed to tolerances, but exhibited a much higher level of dimensional variation than the Mazda transmissions. With a product as complex as a transmission, the interaction of the parts caused more failures in the Ford transmissions. In order for a lean producer to ensure that this problem is not repeated, less dependence would need to be placed on pass/fail attribute inspections and more on keeping processes on target. The Ford

transmission example illustrates a phenomenon that is likely to occur whenever attribute, or go/no go, inspections are used to judge quality, as is often the case in ZQC systems. By collecting and analyzing variable measurements using control charting methods, processes can be effectively kept on target. In cases where variable measurements are costly or time consuming, narrow limit gauging may be used to keep processes on target (Ott & Schilling: 1990). Alternatively, pre-control, also known as stoplight control may be used within the context of ZQC (Salvia, 1988). A comparison of control charts and pre-control shows that under most conditions, control charts are better suited for keeping processes on target (Maleyeff & Lewis 1993).

Further there are a lot of different factors that six sigma companies can gain from Lean Management.

A competitive company must have both high quality goods and provide a high quality of service. For example, a company that operates in a batch-and-queue mode runs the risk of providing poor service to customers even if quality is at Six Sigma levels. By reducing manufacturing lead times, a company that is producing to order will enhance competitiveness by achieving faster deliveries or by meeting promised due dates a higher proportion of the time. An organization that is producing to stock will gain from a reduced lead times by decreasing the horizon of their forecasts as well as by replenishing stocks more often and thereby increasing the firms revenues and inventory turnover rate. Organizations that use Six Sigma should include training for all persons in the firm in Lean Management methods that eliminate every form of waste, such as it is described in Kaizen, reducing setup times, and mapping the whole value stream. Two examples will be used to show how Six Sigma organizations may get to a point of diminishing returns, due to the non-use of certain Lean Management methodologies.

Consider the following scenario that is adapted from a Harvard Business School case study (Wong & Hammond 1991). A manufacturing company that includes a children's knitwear division is using a process-oriented layout (for example the plant is organized by machine type). For this product, the average number of operations can be seen as ten and the average processing time per operation is one minute. Like many organizations run in this traditional batch-and-queue mode, the processing is done in batches since machine setup times and the reluctance to risk idle machinery cause the company to accumulate large WIP inventories on the shop floor. In the case, it is noted that an average of 30,000 garments of work-in-process inventory exists on the shop floor and the average manufacturing lead time is 15 days. The 15-day lead time results in a percent value added time of 0.14 percent.

Consider an alternative example (as second example) involving a typical Six Sigma improvement project in which an organization is experiencing too many missed due dates. Efforts to address the problem might begin with the “Five whys” root causing analysis, an approach also often practiced in a lean organization. The result of the “Five whys” series of questions are:

1) Problem is missing due dates – why?
2) Lead time is long – why?
3) Not enough capacity – why?
4) Long setup times – why?
5) Die adjustment is time consuming.

At this point, two types of decisions are possible:

1) Increase capacity by purchasing additional machinery, and
2) Increase capacity by reducing the setup times.

The latter alternative is preferable in terms of cost and would be the obvious choice in a lean organization. In this case, the real root cause in this situation may be that the lack of knowledge in Lean Production within the firm has perpetuated and institutionalized long setup times.

The intersection of Lean Management and Six Sigma

The performance of a business is determined by the complex interactions of people, materials, equipment, and resources in the context of the program that manages these interactions. It is fair to say that management theory regarding operating systems is still evolving. While both Six Sigma and Lean Management represent the state-of-the art, each system gives priority to certain facets of organizational performance.

Therefore, in a highly competitive environment, diminishing returns may result when either program is implemented in isolation. A thorough analysis of the two programs provides some likely reasons why the programs alone may fail to achieve absolute perfection.

Figure 6 summarizes the nature of improvements that may occur in firms that practice Lean Management or Six Sigma and the corresponding improvements that an integrated program could offer. The horizontal axis represents the customer’s perspective of value, including quality and delivery performance. The vertical axis represents the producer’s cost to provide the product or service to the customer. Under either system, improvements will be made, but these improvements will begin to level off at a certain point in time. With

Six Sigma alone, the leveling off of improvements may be due to the emphasis on optimizing measurable quality and delivery metrics, but ignoring changes in the basic operating systems to remove wasteful activities.

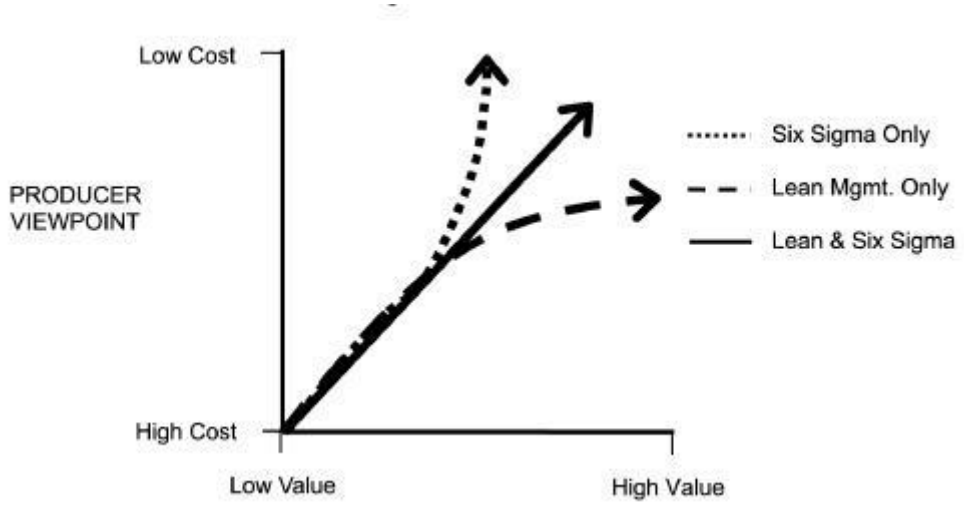

Figure 6: Improvement

With Lean Management only, the leveling off of improvements may be due to the emphasis on streamlining product flow, but doing so in a less than scientific manner relating to the use of data and statistical quality control methods.

3 Key Principles of Lean Management

According to Emiliani (1998) specifying value is the first principle of Lean Production is customer-based; the customer to a large extent determines what should be produced. In the same vein, Julien and Tjahjono (2009) simply see it as what makes the customer satisfied.

Identifying the value stream is the next step and is about identifying the processes involved in the production of a specific product from the point of view of the end-customer. In this way the production unit can identify processes that add value, eliminate those that do not add value and lastly are those that cannot add value and cannot be avoided (Emiliani 1998). The third principle which is Creating flow, Julien & Tjahjono, 2009; Emiliani 1998) suggested that the value should continuously flow and never should a

value-adding activity be delayed. This they pointed out would reduce the cost of the product by eliminating lengthy queue times and large quantities of expensive inventory that would have been the case of batch and queue production methods. The fourth principle relates to the production of only the products that are required by the customer are known as Pull. This principle holds that production must be just-in-time (JIT) both internally and externally. The last is Perfection, which is all about perfecting every process in the production by the reduction of waste thereby focus only on activities that create value. In Lean Production, perfection cannot be attained however it facilitates the endless utilization of opportunities of all types of assets (Emiliani 1998; Julien & Tjahjono 2009;

Engelund et al, 2009). Below are identified the five principles of Lean Production:

3.1 Visual Management (Control)

Mann (2005) argued for visual management in this way “If tact time is the heart of Lean Production, visual management and the process surrounding them represent the nervous system in Lean Management” (Martin 2010: 39).

Henderson and Larco (2003) refer to visual management as management by sight, not by computer whose purpose is to “see” the factory, its performance, its problems and its opportunities for improvement. As the authors pointed out, visual management plays an important role if employees are to be empowered. According to them there is no employee empowerment if there is no available information, which is derived from visual management (Henderson & Larco, 2003). One of the many principles suggested by the authors is 5S, which they say is a critical foundation of visual management-a safe, orderly, and completely clean work area. Visual management entails that a factory should be structured in such a way that there is flow from incoming receiving through fabrication/subassembly operation onward to the final assembly as illustrated in the figure below

Information displays forms another crucial piece in visual management. Information should be shown at two levels: individual work area performance and overall plant performance according to Henderson and Larco, (2003).

Mann (2005) suggested that visual control if not properly used would amount to wallpaper. Thus management must ensure total adherence so as to achieve its objective of establishing and maintaining a Lean Management system.

3.2 PDCA (Plan, Do, Check and Act)

This concept forms the basis for continuous improvement and it's all about planning, evaluating, and the identification of problems and its causes. It is made up of four stages according to Bergman et al, (2001).

Plan is the first stage in the cycle and it's about identification of problems and its root cause.

Do is the second stage and involves the execution of the decision made in the first stage.

Check is carried out to evaluate the how effectively the first two stages have been implemented. It is also known as the follow-up stage (Bergman et al, 2001).

Act is the last stage of the cycle and it is where the improved changes are introduced into the current processes of the organization.

It is a continuous improvement process in the sense that when gaps occur due to movement from one stage to another, steps are taken to correct these gaps. The cycle thus begins all over again from the planning stage (Oakland 1999).

3.3 Standardized Work

Henderson and Larco (2003) defined standardized work as a repetitive process through which work in an assembly line is carried out. The work methods and motions have to be properly studied and understood so as to determine the best possible way in which standardized work can be executed. It not enough to only study the work methods but the people that are to use should be trained in executing the process. An illustration was given by the authors of united parcel service where they have guidelines on steps a delivery person should follow in leaving the truck, and which hands a parcel should be held so as to maximize efficiency (Henderson & Larco, 2003). Martin (2010) stated that immediately a product and all its production work activities have been made simpler, the next appropriate step is to standardize work so as to reduce work variation. According to the author this method reduces the overall cycle time and the rate of recurrence of processing errors required producing products.

Martin (2010) suggests a 5S approach in standardizing work process activities as illustrated in the figure below

Sorting entails removing unnecessary materials and information not required to execute the current work task from a work area. Setting in order involves arranging the needed materials and information for easy reach and usage. Shining the work area as the third 5S approach in standardizing work activities includes keeping the work area clean always. This enables the employees to easily detect abnormal processing conditions so as to improve their work areas. Standardization ensures that everyone does work tasks exactly the same way every day. Sustain develop controls to make sure work improvement are maintained the same way all the time irrespective of the person in charge (Martin 2010).

3.4 Teamwork Empowerment

The idea behind teamwork empowerment is based on the tenet that decision with regards to what should be done should be left to those who are directly involved in the situation. It is made up of individuals from different disciplines that are assigned specific task and are given room to make decision as they deem necessary. They are obligated to think outside the box if processes are to be improved and thus implement any change they think is vital towards improving output quality. However it is important to note that teamwork without cooperation and esprit d´corps (morale) will obviously hinder the success of such teams. Henderson and Larco, (2003) came up with four stages through which teams advance: forming “acquaintance stage”, norming “settling down stage”, storming “conflict resolution stage”, and performing “tried and tested stage”. Going through the above-mentioned stages as suggested by the authors creates a sort of experience that its members will always remember thus forming a very strong bond.

In the formation of people that make up these teams, it is important to include personnel from different department (finance, quality assurance, materials supply) of the company. In a typical Lean Production environment teams are made in groups of production cell, which have meetings at regular intervals so as to discuss and solve problems peculiar to them. These meetings should last 10-15 minutes between operators and leaders preferably at the beginning of each shift. During such meetings performance from previous day is assessed, and a production goal for the day ahead is set.

Aside the daily short meetings held, there should be a half hour meeting every week where crucial issues such as performance, quality, production and overtime schedules are tackled and decision is reached and implementation is affected. This is continuous improvement in action (Henderson & Larco, 2003). This will no doubt require the

consistent and systematic training of the company employees so as to ensure a successful culture change.

As one CEO quoted

"No vision, no strategy can be achieved without able and empowered employees" (Ahlstrom 1998).

Through teamwork empowerment they are able to take responsibility in some certain indirect task such as maintenance, procurement, quality, and material handling and control (Ahlstrom 1998).

3.5 Training

Training is another important tool that is sometimes not paid adequate attention to, however it is found that training is required in the following areas: overall lean concepts, team empowerment, change management, specific lean tools, and lean accounting.

Cross training of operators simply means training every member of the team on the line to be able to perform the all jobs on the line. Cross training enables the members of the teams to be multi-skilled that affords tremendous benefits such as job rotation, which reduces fatigue, and increases the output quality. In as much as management oversee such training program, it is important to allow some form of organization and coordination by the group itself, and for the most part, done on the job (Henderson & Larco, 2003).

3.6 Motivation

Motivation in the standpoint of Robbins (2005) is seen as the processes that make up for an individual's painstaking effort towards achieving a goal in an organizational context. In their definition they stressed on the intensity, direction and persistence and argued that having high intensity without proper channeling of effort in the right direction will not be beneficial to the organization. Thus consideration must be given to the quality of effort and its intensity simultaneously so as to achieve the organization's goals. Persistency on the other hand according to them is a measure of how long an individual can keep up with their effort. Motivation can be of two type's namely intrinsic and extrinsic motivation.

According to Kohn (1999) intrinsic motivation are factors that stern from within personal interest, desire and fulfillment.

From the author viewpoint, a manager should consider the three C's of motivation:

Collaboration (an environment that encourages team spirit thereby leading to cooperation through assisting one another), content (employees knowledge that their little contribution adds value to the organization overall goals makes them take pride in their work) and choice (employees ability to make decisions in relation to their work creates a feeling of empowerment). Extrinsic motivation is as a result of external factors that are outside of the organization which influences internal needs, wants and/or subsequent behavior. This type of motivation causes employees to perform a task based on the anticipated reward (Kohn, 1999).

3.7 Communication

Simply defined according to Robbins and Coulter (2007), communication is the transfer and understanding of meaning. From this definition the transfer of meaning has been highlighted that is to say communication is incomplete when information and ideas have not been conveyed. In the same vein, for communication to be considered complete its intended meaning must be imparted and understood. Robbins (2005) suggested communication includes both transference and the understanding of meaning. Effective communication between management and employees is of great importance because it provides the information that enables work to be done efficiently. Thus there is a connection between communication and managerial performance (Robbins & Coulter, 2007).

Communication could be downstream or upstream, the former is flow of information that is from the top to bottom example is from managers to employees in an organization in the form of assigning of goal, provision of job instruction, enlighten employees about policies and procedures. While the latter is bottom-top kind of information flow in the form of feedback to top management, update on progress towards goals and convey current problems. A third type of communication per se could be said to lateral or horizontal. It exists between employees who are of the same work group, among managers at the same levels.

Communication can be oral (speeches, formal one-to-one and group discussion, informal rumor mill or grapevine), written (memos, letters, fax transmissions, electronic mail instant

messaging, bulletin boards) and non-verbal (body movements, intonations or emphasizing of words, facial expression, physical distance between sender and receiver) (Robbins, 2005).

Within a group or organization, communication plays four important role namely control, motivation, emotional expression, and information. Communication as a control tool forms guidelines employees are expected to follow. Through communication, employees are motivated to know what they have to do, how well it should be done and ways to improve it. Communication with regards to emotional expression enables employees to express their feelings of satisfaction and resentment in their work group (Robbins 2005).

3.8 Kanban

According to the Institute for manufacturing a Kanban system is a system that works on the basis that each process on a production line pulls just the number and type of components the process requires, at the right time. There are two types of Kanban system namely a withdrawal and production-ordering Kanban systems, the former indicates the type and quantity of a product that should be withdrawn form a preceding process by a manufacturing process while the later spells out the type and quantity of product that should be produced by the preceding

Kumar and Panneerselvam (2006) suggests that the Kanban system operating with a single card is known as the production-order Kanban and where there is short distance between workstations only buffer is placed in-between that functions as both an inbound and out bound buffer. On the other hand in a two-card system where the distance between the workstation is more there will be separate inbound and outbound buffers serving each workstation. The cards are referred to as production order and withdrawal Kanban correspondingly.

4 Tools and Methods of Lean Management

4.1 Value Stream Mapping (VSM)

In most companies it is not possible for the management to describe the complete series of events in every detail that are required to bring a product or a service to the customer after his request. Often this means that an improvement in one area of the company leads

to other, new problems in another area of the firm. Without understanding every detail of the production it is not possible to solve true problems with root causes that reside upstream. Sometimes expensive changes are made that do not improve the customers experience nor addresses the true problem. The point of interest in improving is analyzing the conflicting priorities and interdepartmental tensions (Martin & Osterling 2013: 1)

To define “value stream” in the sense it is used in Lean Production it can be mentioned that it includes all actions, value added as well as not valued added ones, that are currently required if a company want to bring a product through the main flow, necessary for every product. That means the production flow from the raw material to the complete product that is given to the customer and the design flow started from concept to launch.

If an organization is taking a value stream perspective it means working not just on individual processes but on the big picture. It doesn’t mean an optimization for parts but for the whole process. It is necessary to follow the main stream for a product to have a real good look at the whole from the raw material to the ready product that is given to the customer. That also implies following the main stream across a lot of firms and facilities (Rother & Shook 2003: 3)

Value Stream Mapping can be seen as a pencil and paper tool that helps not only to see but also to understand the flow of material as well as information as a product is making its way through the value stream. In other words this means to follow the path of a products production from customer to supplier. Further it draws a visual representation of every given process in the flow of material and information in a careful way. After that it is necessary to ask a set of key questions to draw a map of the future state of the desired way the value should flow. In doing this over and over it is possible to see in an easy way, maybe the simplest way, the value and the sources of waste which can be seen as the most important factor in Value Stream Mapping (Rother & Shook 2003: 4).

An optimal practice in drawing value stream maps makes it possible to support lean manufacturing in a great way. At this point it is important to mention that the point of getting lean is not mapping which is only a helpful technique, but to implement a value-adding flow. But it is necessary to have a vision of this flow to create it and with the aid of mapping it is much easier to focus on the flow with the vision or the desired, most of the times improved, state of it. To use mapping in an optimal way if an organization is planning changes in the value stream or the production it is important to draw a map of the future-state first (Rother & Shook 2003: 5).

The mentioned future-state map is generated with the final aim to improve the value-adding steps as well as eliminate the steps that are not value adding and so called waste in the actual system of the company. Rother/Shook provide in their work seven different guidelines to follow which are based on the concepts of thinking in a lean way and should be followed when a future state map for an improved manufacturing system is generated.

1. “Produce to tact time
2. Develop continuous flow
3. Use supermarkets to control production where continuous flow does not extend up stream
4. Schedule based on the pacemaker operation
5. Produce different products at a uniform rate (Level the production mix)
6. Level the production load on the pacemaker process (Level the production volume)
7. Develop the capability to make “every part every - period time”
   (Rother & Shook 1999: 44)

There can be mentioned pros and cons Value Stream Mapping. To take a nearer look to the pros it can be said that Value Stream Mapping relates three different factors of the manufacturing process namely to the supply chains, distribution channels and the flow of information. Further Value Stream Mapping integrates not only the flow of materials but also of information.

Another positive factor of Value Stream Mapping is the possibility to link scheduling functions and production control, for example production planning and demand forecasting to production scheduling and shop floor control with the help of operating parameters for the manufacturing system exact time. This determines the rate of production at which every single processing state in the manufacturing system should operate (Irani & Zhou: 2). There are a lot of symbols used in Value Stream Mapping. Some of them are showed in the following figure 7: (http://www.conceptdraw.com/examples/value-stream-mapping-symbols):

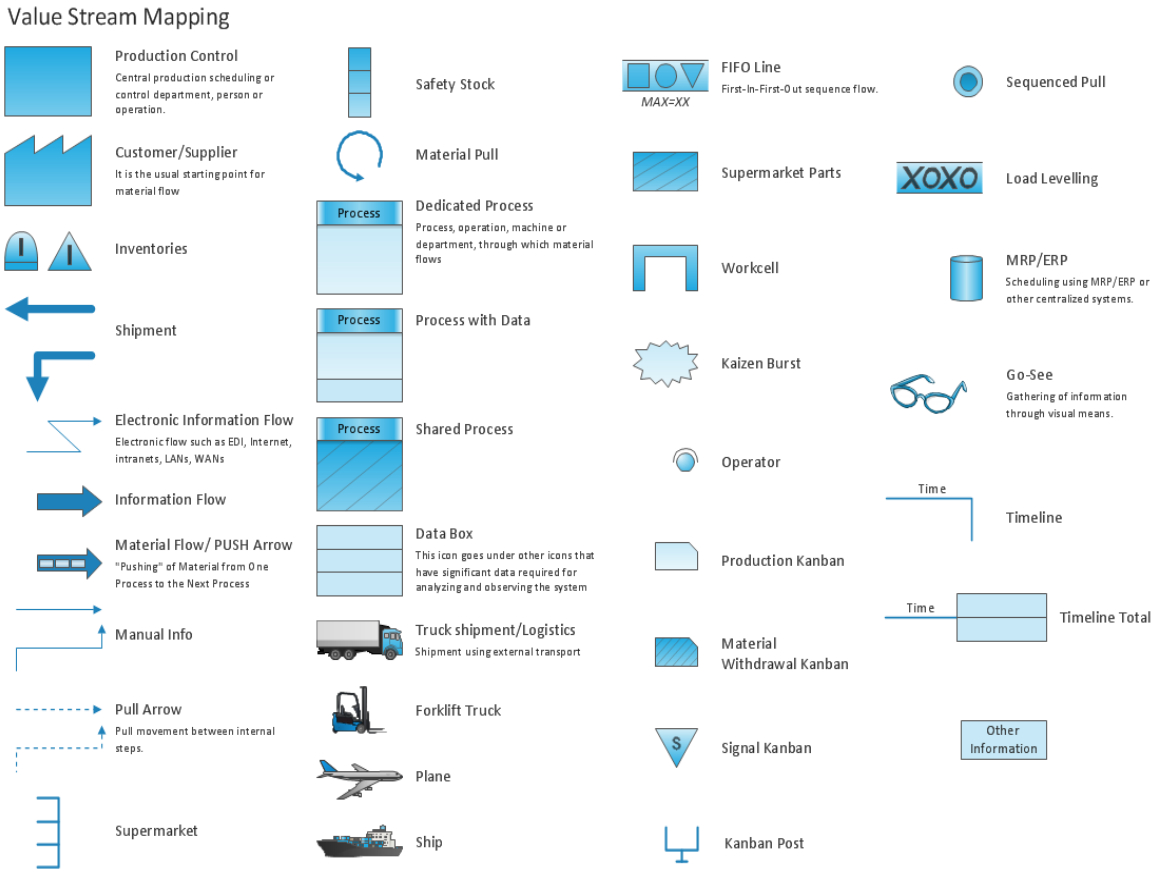

Figure 7: Value Stream Mapping

Because of the fact that for example Production Flow analysis as well as process analysis and improvement is taught and implemented in isolation of each other there are often problems so see the possible steps in relation to each other. Value Stream Mapping helps to unify these IE techniques as well as it provides important descriptive information for the Icons (Operation and storage) used in the standard Flow process Charts in IE.

Further it is possible to form the basis for the implementation of lean manufacturing with the help of value steam mapping. This is made by designing a manufacturing system that is based on the complete dock-to-dock flow time for a family of products.

Value Stream Mapping also provides a firm with a form of “blueprint” for their planning in a strategic way with the aim of deploying principles of lean thinking to make the transformation into a lean organization easier.

Besides this positive factors of Value Stream Mapping there can also be presented some disadvantages of this tool.

Most of the time Value Stream Mapping fails in the case of mapping multiple products that are not produced in identical manufacturing processes or assembly process flow. Further Value Stream Mapping fails if there is a relation between transportation and queuing delays necessary, and also in the case that operating parameters and measures of performance of the manufacturing system are necessary to know. Value Stream Mapping lacks an economic measure for value for example for factors like profit, throughput the operating costs, the expenses for inventory and other factors like this. Regarding the cons of Value Stream Mapping it can be said that this tool also lacks the spatial Structure of the layout of the facility. And there is no information about the way in the spatial structure of the facility layout impacts the inter-operation material handling delays as well as the sequence in which different batches enter the queue that is formed with every step in the process as well as in the manufacturing routings, the container sizes. Further it is necessary to say that Value Stream Mapping pants tends to bias the factory designer so that he is only considering this sort of strategies such as continuous flow or other tools that are suitable for a high volume low variety manufacturing facilities. So that it can be said that Value Stream Mapping is also failing in considering the allocations are as well as the utilization of the factory floor space that is a very important resource for production support or material handling aisles. Another failing of the Value Stream Mapping is that it is not able to show the impact of inefficient material that flows in the facility for example backtracking and crisscross flows. It also fails to handle the complete bill of materials of a given product since that usually results in a value stream that is branched and multi-level. Another important point to mention is that Value Stream Mapping is not able to factor queuing delays or sequencing rules for multiple orders or capacity constraints or other factors like that in any map.

Last not least if it is necessary to mention, regarding the Value Stream Mapping, that it doesn't have the capability to show a rapid development as well as the evaluation of multiple analyses in the sense of “what if” which are required to prioritize a different alternatives for improving the map in a current state when there is a constraint of time and/or budget. (Irani & Zhou: 3).

4.2 Kanban

4.2.1 Description

Kanban is a method for defining, managing, and improving services that deliver knowledge work, such as professional services, creative endeavors, and the design of both physical and software products. It may be characterized as a “start from what you do now” method. A catalyst for rapid and focused change within organizations that reduces resistance to beneficial change in line with the organization’s goals. The Kanban Method is based on making visible what is otherwise intangible knowledge work, to ensure that the service works on the right amount of work that is requested and needed by the customer and that the service has the capability to deliver. To do this, we use a Kanban system, a delivery flow system that limits the amount of work in progress (WiP) by using visual signals. The signaling mechanisms, sometimes referred to as Kanban’s, are displayed on Kanban boards and represent WiP limits, which prevent too much or too little work entering the system, thereby improving the flow of value to customers. The WiP Limit policies create a pull system: Work is “pulled” into the system when other work is completed and capacity becomes available, rather than “pushed” into it when new work is demanded.

Kanban focuses on the delivery of services by an organization. One or more people collaborate to produce (usually intangible) work products. A service has a customer, who requests the work or whose needs are identified, and who accepts or acknowledges delivery of the completed work. Even where there is a physical product from services, value resides less in the item itself and more in its informational content (software, in the most general sense). (http://Kanbantool.com/5-Kanban-board-principles, pp3)

4.2.2 Kanban Values

The Kanban Method is motivated by the belief that respecting all individuals that contribute to a collaborative organization is necessary, not only for the success of the firm, but also for it to be worthwhile at all. Kanban’s values can be summed up in one word, namely “respect.” However, it is useful to expand this into a set of nine different values (including respect) that show for what reason the principles and practices of Kanban exist. (http://Kanbantool.com/5-Kanban-board-principles, pp3)

Transparency

This means the thinking that sharing information in an open way improves the flow of business value (Rossi & Lödding 2012: 197). Using a clear and straightforward vocabulary is an important part of this value.

Balance

The understanding that different aspects, as well as viewpoints and capabilities have to be balanced reaching maximum effectiveness. Some aspects (for example demand and capability) will cause breakdown in the firm if they are out of balance for a longer period.

Collaboration

This means working together. The Kanban Method was formulated to improve the way people work together, so collaboration is at heart of this method (Tendon & Muller 2014 : 113)

Customer Focus

Knowing the goal for the system. Every sort of Kanban system flows to a point of realizing value when customers receive a required item or service. Customers in this context are external to the service of the firm, but may be internal or external to the organization if they are seen in every possible way. The customers and the value they receive is the important in Kanban.

Flow

The process of realization that work is a permanent flow of value, whether it is continuous or episodic. Seeing flow can be mentioned as an essential starting point in using Kanban as a method

Leadership

The ability to inspire other people to take action through their example, as well as their words and reflections. Most organizations have a hierarchical structure to some degree, but in Kanban leadership is needed at all levels to make value delivery and improvement possible.

Understanding

Primarily understanding means self-knowledge (as well of the individual as of the organization) in order to move forward. Kanban is a kind of improvement method, where knowing the starting point can be seen as foundational.

Agreement

The commitment to move together toward goals and respecting differences of opinion or approach. This does not mean management by consensus, but it means a dynamic co-commitment to improvement.

Respect

Valuing, understanding and showing consideration for people. Appropriately at the foot of this list, it is the basis on which the other values of Kanban rest.

These values show the different motivations of Kanban in seeking to improve services that are delivered by collaborating teams. The method cannot be applied in a faithful way without embracing them (Reddy 2015: 64).

Figure 8: Kanban Values

4.2.3 Kanban Pros vs. Cons

In this chapter, the pros and cons of Kanban are described.

Advantages:

- Reduces waste and scrap: products are manufactured only then when they are needed. In this way overproduction is eliminated
- Inventory level management: Kanban has great inventory practices which smoothens out inventory levels and eliminates carrying costs
- Flexibility in production: Kanban ensures you are not stuck with excess inventory if there is a sudden drop in demand for a product
- Increases productivity and efficiency: Kanban helps to eliminate the time waste and people are able to focus on current work. For this reason, making supplies is more accessible and productivity increases

Disadvantages:

- Less effective in shared-resource situations: suppose that upward production line is made of several parts. Downstream line requires make more parts, but it requires a buffer to ensure that downstream station does not run out. System becomes more complex because each part needs a separate signaling card
- Inflexible in demand changes and product mix: Kanban system assumes there is a stable production plan, where supplier always delivers components for production when it is needed. Therefore, the system is not suitable for industries where volumes and mixes of production fluctuate
- Variability elimination: system can be disrupted by unpredictable and lengthy down times and any variability may affect system's functions
- Production flow: because of the fact that Kanban requires planned weekly and monthly schedules linked with day-to-day flexibility, it may not be possible in an environment where multiple or short length product types are manufactured

The following figure 9 shows the five Kanban board principles (http://Kanbantool.com/5-Kanban-board-principles)

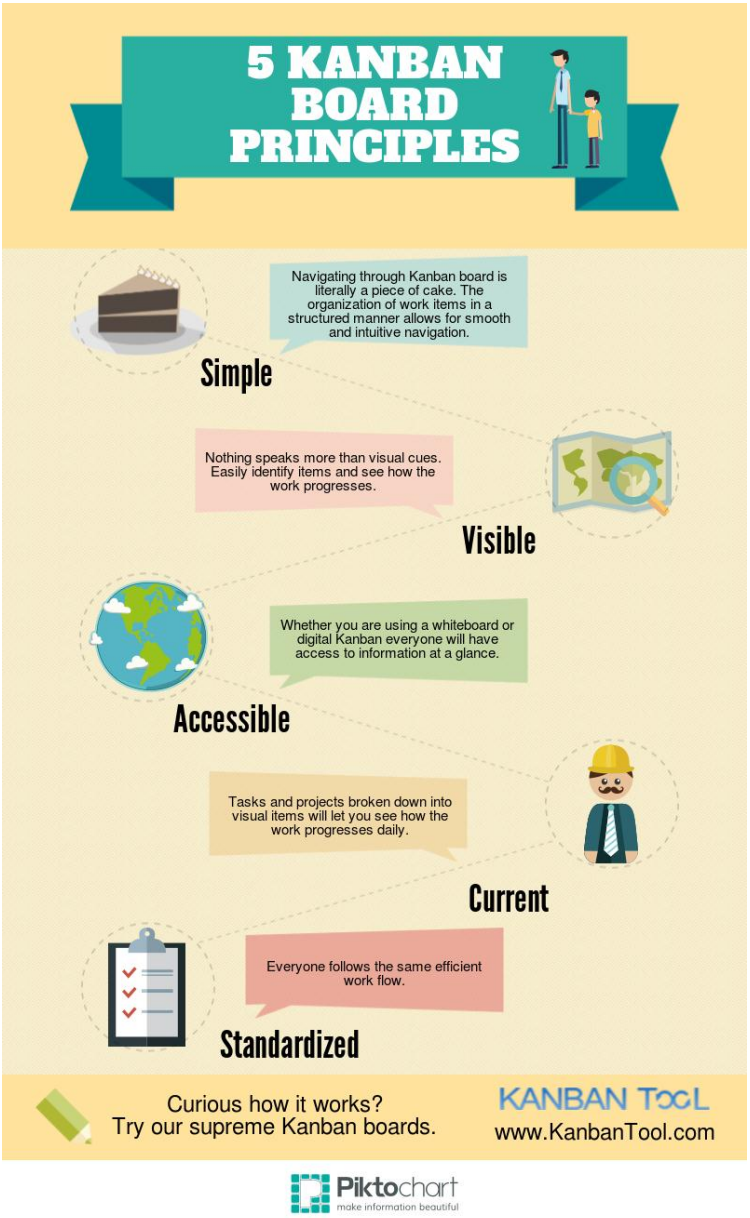

Figure 9: Kanban board principles

4.2.4 Scrum

Scrum is one of the dominant agile frameworks which has a set of guidelines that manage the development of product (McKenna 2016: 27). The methodology of Scrum is iterative, measurable and incremental, since it focuses on really tightening up development cycles, which are based on scope that is divided into smaller tasks amounts of effort called sprints, rather than extensive planning, building, testing or deployment. So it brings higher productivity and lower costs to the firm (Cohn 2009: 11)

Advantages:

- Iterative and incremental method: allows tracking of a project workflow and provides intermediate results
- Adaptability for product development: Scrum allows you to change priorities and requirements. Also, add modifications or features quickly
- Participation and enhancing communication: all team members are involved into process and motivated to express their opinion and contribute to all decisions. Team is able to easily communicate and eliminate obstacles as soon as possible
- Cooperation: enhanced customer and client relationships by daily communication
- Increasing productivity: it allows to deliver products more quickly by determining an estimation and comparing the performance of team productivity

Disadvantages:

- Requires experienced team: usually, Scrum methodology is applied for small 5-8 people teams. Team members must be committed to the project, as this framework requires experienced team. If a team consists of novices in this area, there might be a risk of not to completing the project on time. Moreover, strict control over the team might put a lot of pressure on them which may also lead to failure
- Time expenses: after each sprint a new sprint planning needs to be done, which may consume a lot of time if a longer sprint is planned. Unexpected issues may also hinder the process of completing a sprint on time, thus more time will be needed to remove those issues
- Scope creep: Scrum doesn't have a defined end date. For this reason, a released work may not have everything that the stakeholders want and new features are needed to be released
- Iteration definition: the Scrum estimation is one of the hardest and wasteful parts, as tasks must be well defined, otherwise estimated project costs and time will not be precise (http://www.solutionsiq.com/what-is-Scrumban/).

The following figure 10 shows the Scrum principals as an overview (https://www.slideshare.net/chdessus/Scrum-book-of-knowledge-reading-notes-part1-57789552)

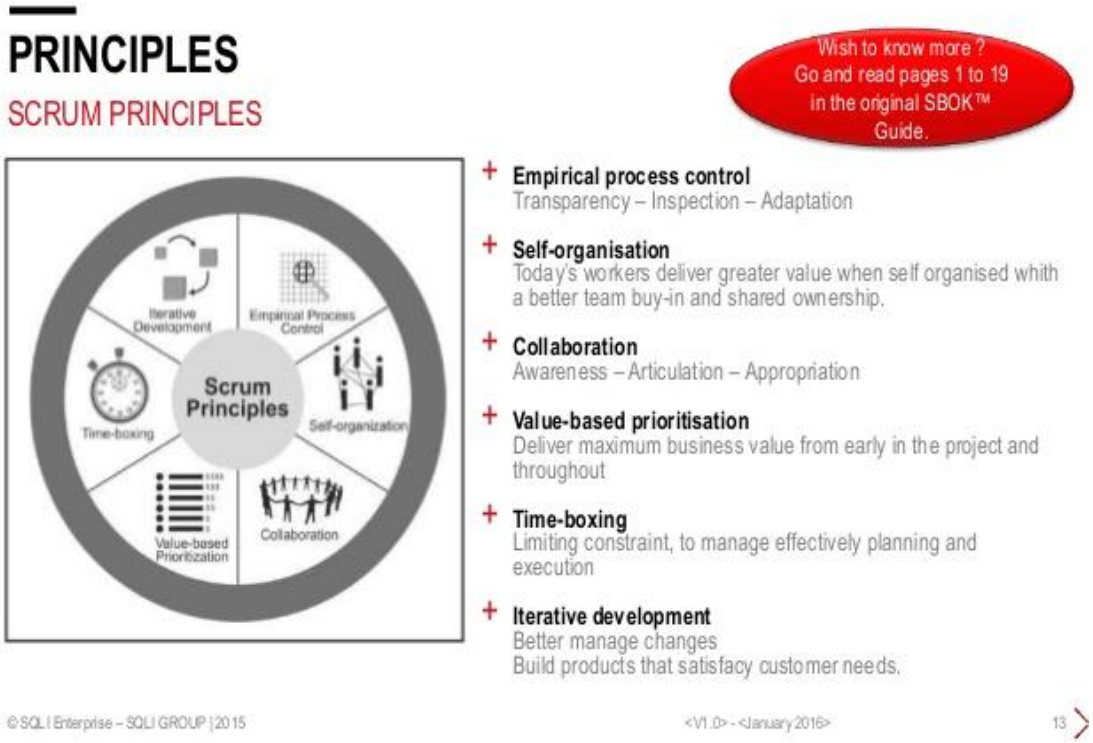

Figure 10: Scrum principles

4.2.5 Scrumban

Scrumban is a mixed methodology of both Scrum and Kanban which increases adaptability and universality for product manufacturing and support focused companies, because no single tool is perfect (Kniberg & Skarin 2010: 8)

Advantages:

- Saving time: Scrumban uses planning on demand technique so there is no need to do estimating or sprint planning. Team plans only when there is a demand. For this reason team members get extra day of work
- Quality: saved time on planning allows to focus on quality control and to verify if work item is ill-formed. Saved time allows to control a manufacturing process and to inspect if work is promoted to the ready queue. If something ill-formed is found, then it gets bounced and troubles are eliminated, then process is repeated once again

- Waste minimization: Scrumban uses inter-process buffers and flow diagrams to show weaknesses and opportunities of the process. This gives an opportunity to eliminate everything that is not adding value to the customer

The following figure 11 shows a comparison between Scrum and Scrumban (http://www.solutionsiq.com/what-is-Scrumban/):

	Scrum	Scrumban
Board / Artifacts	board, backlogs, burn-downs	board only
Ceremonies	daily scrum, sprint planning, sprint review, sprint retrospective	daily scrum (planning, review and retrospective as needed)
Iterations	yes (sprints)	no (continuous flow)
Estimation	yes	no (similar size)
Teams	must be cross-functional	can be specialized
Roles	Product Owner, Scrum Master, Team	Team + needed roles
Teamwork	collaborative as needed by task	swarming to achieve goals
WIP	controlled by sprint content	controlled by workflow state
Changes	should wait for the next sprint	added as needed on the board (to do)
Product Backlog	list of prioritized and estimated stories	just in time cards
Impediments	dealt with immediately	avoided

Figure 11: Scrum vs. Scrumban

4.3 Kaizen

4.3.1 Introduction

Kaizen first appeared in Japan during the 1950s. Taiich Ohno, the inventor of Toyotism, which means a sort of work organization to reduce costs and improve productivity and the quality of the products as well.

Toyota was the first organization to practice this new idea that gave rise to TPS (Toyota Production System) with the help of different tools. Among these tools the Kaizen concepts are very popular (Delers 2015: 5).

A nearer look to Kaizen in the sense of a model shows that it consists of continuous improvement that is practicable to a given production line. Kaizen originally comes from

the Japanese words “Kai” (change) and “zen” that means good or better. It is important to mention that Kaizen adopts existing tools as well as procedures to improve the final product. As in every tool of Lean Management it is necessary for the success of Kaizen that everyone in the company is participating in the changes.

Further it can be said that Kaizen includes a large number of other tools which are used together, for example the PDCA cycle, TQM and the SMED method. Because of its oriental origin, Kaizen can be seen as a break from the systems that are common in western. This is meant in the sense that Kaizen stands for small improvement instead of profound innovations. Because of the fact that the changes are small but continuous it does not require big money resources. (Delers 2015: 6)

Kaizen can also be seen as a tool of growth of an organization. It is not necessary to redeploy personnel, but it should be made known to everyone in the organization that the situation at the moment is not acceptable. It must not be forgotten that every change in the company is personal for the workers because they own their own ideas and have the chance to benefit from the improvement in a direct way. Managers of companies want to grow their employees in experience and skills because this increases the human resources of the firm.

In this sense Kaizen removes barriers in an organization that are causes not only by bureaucracy but also by politics. With the aid of Kaizen it is possible for the company to focus on priorities for progress (Mika 2006: 31)

The five principles of Kaizen are presented in the following figure 12 (http://www.1000ventures.com/business_guide/mgmt_Kaizen_main.html):

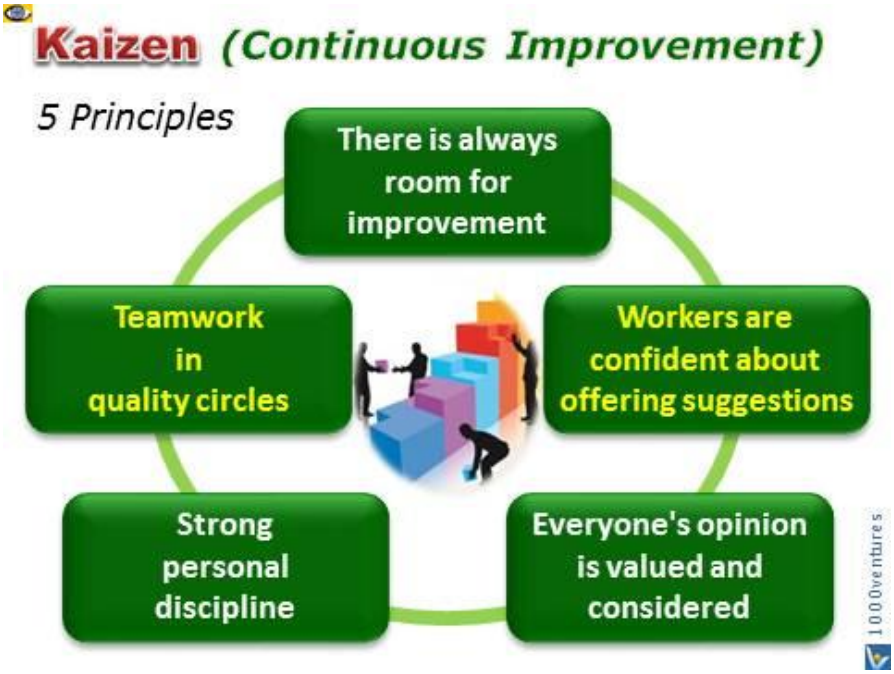

Figure 12: Kaizen principles

4.3.2 Kaizen Events

It must be mentioned that Kaizen events can be seen as very important because they provide not only a big return on investment of financial resources but also on human resources. Kaizen never ends, it is a continuous method for improvements that will compound the return. It is important to explore every idea that needs little no investment to be successful.

By resolving a bottleneck sometimes it is possible for a Kaizen event to eliminate the need for capital equipment expenditure. At the moment this bottleneck occurs the Kaizen event should be done in an automatically way instead of considering a new machine purchase, because often there is no new equipment necessary and so no further costs for the company.

Sometimes Kaizen events eliminate the need for costly overtime because it is improving processes and at the same time collapses lead times as well as it reduces work- in – process. Further there can be mentioned other results of Kaizen events that are seen immediately like the reduction in the floor space as well as in labor or a faster service for the customers of the firm. It can also improve profits.

A great advantage of Kaizen events is the flexibility of them which makes it possible to applicate them everywhere in the organization, where waste must be eliminated.

Every time Kaizen is performed there is an increase of training and education of the different members of the company that comes with an increase of value to the organization. Not only the quality of the products but also the moral in the firm improves at the same time as trust and respect (Mika 2006: 32)

4.4 One Piece Flow

One piece flow describes a concept that was criticized by Toyota for a long time. It means producing in batches. It can be said that organizations that produce in batches often only increase the size of their buffers if a problem arises due to unevenness in production. The goal behind this is to create facilitate high machine utilization.

The effect of increasing the size of buffers is that the problem that caused the unevenness is hidden by increased buffer levels wherein this cannot be seen as a solving of the problem. Often this is illustrated by the Japanese lake, like it is shown in the following figure 13 (https://www.slideshare.net/swatiluthra5/just-in-time-manufacturing-ppt-31477037)

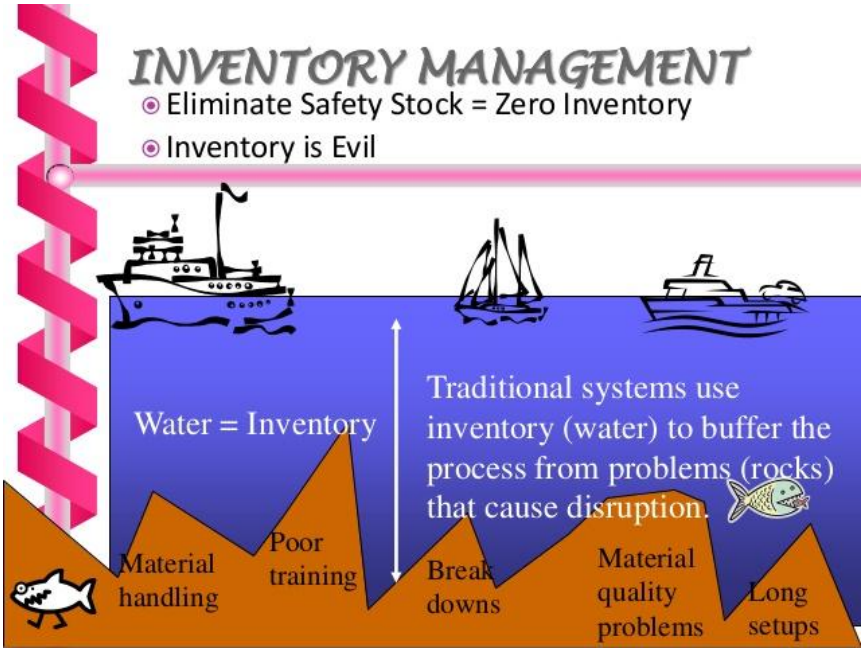

Figure 13: Japanese lake

In figure 13 the surface stands for the buffer level, while the shallows are a symbol for the problems in the production of an organization. To bring the problems to the surface it is necessary for the organization to bring the surface level down, which means to minimize the buffers. This can be done by reduced batch sizes.

In achieving one-piece-flow can be seen the ultimate goal of reducing the batches, because there the pieces or products flow in a separate way, just as one, throughout the whole process of production. It must be mentioned at this point that one-piece-flow cannot used in every type of manufacturing. For example it is not useful in heat treatment.

Aiming at one-piece-flow by reducing the size of the batches the problems will come to the surface and it is possible not only to see them but also solve them. All this must be done in accordance to the elimination of waste and therefore becoming more and more lean (Gornicki 2014).

4.5 5-S-Systematics

The 5S method is a tool for continuous improving Lean Management processes, whose task is to create a highly efficient, clean, and ergonomic working environment. It is a collection of 5 simple rules and at the same time it is a tool that allows you to control the workplace visually. The 5S tool originates from Japanese philosophy, namely from the five basic elements of the system: Seiri (selection), Seiton (systematization), Seiso (cleaning), Seiketsu (standardization) and Shitsuke (self-discipline).

The 5S is a collection of techniques aimed at creating and maintaining clean and high-performance workstations. The 5S as a name refers to the five steps required to fully implement all the assumptions of the method:

SELECTION

Is the basis for the standard that follows the principle: Just what is needed, in the quantities needed only, and only when needed". That is removing from the workplace any items unnecessary to perform the current operation.

SYSTEMATICS

Is a means by which you keep all your equipment in order and label both the equipment and all the items stored so that everyone can easily find what is needed. The effectiveness of the systematics depends on proper selection.

The Systematics will be ineffective if there are too many items organized and labeled unnecessarily. Speed identification of objects, can be obtained by labeling, drawing lines and outlining the highlight/shadow areas.

CLEANING

Tasks in the workplace include washing, vacuuming, renovation and dirt/dust/waste removal. The 5S method procedure should be implemented as a necessary and routine task performed by each employee to create a friendly and safe working environment. Regular cleaning improves the feeling of comfort, and reduces the risk of equipment failure. An important element at this stage is the responsibility and common involvement of all the team members participating in the process.

STANDARDIZATION

Implementation and maintenance of the previous three stages of the 5S, is a time when it is possible to begin standardizing the company processes with the use of this method. The introduction of a set of rules resulting from the three steps of selection, systematics, and cleaning will help employees to understand their tasks and the aims to be achieved by the introduction of the 5S method. At this stage it is possible to implement mandatory instructions at the workstation.

SELF DISCIPLINE

Is continuous acting in compliance with given procedures. In accordance with the concept of Kaizen, the previously started tasks should constantly be improved. To maintain the introduced policy, we can enter internal audits and bonus schemes for employees. Applying checklists at various positions allows to check on the present degree of compliance with earlier assumptions (Falkowski & Kitowski 2012: 127).

5 Lean Production

5.1 Definition „Lean Production“

As the base ground of Lean Production can the mentioned TPS tools as well as other techniques. Like it is told in the original concept of lean the aim behind every principle in Lean Production is to minimize not only the resources but also the waste that can never be completely avoided. Another main point in this context is like it is mentioned in Lean Management less effort in human resources as well as less necessary space for production, a higher quality in production in the sense of fewer defects in the manufactured products and less inventory (NSPR 2004). Further, Lean Production should in every point meet the customers' expectations not only by delivering high quality in service and product but also in doing so at the right time and at the right costs. (Roos & Associates Environmental Consulting 2004: 1).

While in the traditional mass production there is a lot of conventional “batch and queue”, in lean manufacturing the processes of the production are organized in e quite different way. The necessary steps in production ad joint each other in a one-piece, continuous flow, which can be seen as the principles and the methods of Lean Production. It is necessary to closely control such production processes in a clean operational, ordered and well maintained environment like it is told in JIT principles. If an organization want to shift to a Lean Production instead of traditional production a system wide and continual improvement is necessary and there must be the support of all the employees of the organization to change the way of production in the best way (Roos & Associates Environmental Consulting 2004: 2).

Regarding to Lean Production there can be mentioned several principles that are important and further some tactical methods for achieving them. The key principles include the following strategies:

- Giving the customers the possibility to pull value through the enterprise in the way that the company analyzes not only the demands of the costumers but also by producing in a way that meet the real demands of the costumers.
- By working in a way that as well identifies as eliminates non-value added activity that can be called as waste in every step of the production-process.
- Because of the continual improvement and the never ending problem-solving activities employees must be involved in every step of the process

- Further it is necessary to implement an improvement framework in the sense of plan-do-check-act in a rapid way to build momentum and achieve results as fast as possible.
- To improve a fast problem-solving and decision –making a metrics a fast performance feedback is of great importance
- Last not least there can be mentioned the necessity of approaching improvement activities not only from a part of the organization but from the whole company or system perspective (Roos & Associates Environmental Consulting 2004: 2).

The differences between traditional and lean approaches of production are illustrated in the figure 14 below (Roos & Associates Environmental Consulting 2004: 2):

Figure 1: How Craft, Mass Production, and Lean Thinking Compare[3]

	Craft Production	*Mass Production*	*Lean Production*
Focus	Task	Product	Customer
Operations	Single items	Batch and queue	Synchronized flow and pull
Overall Aim	Mastery of craft	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Integration (part of the craft)	Inspection (a second stage, after production)	Prevention (built in by design and methods)
Business Strategy	Customization	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

Figure 14: Mass production/lean thinking

5.2 Lean Manufacturing

5.2.1 Definition

The term Lean Manufacturing means the production of goods in which less of everything is used if it is compared to mass production, like it is mentioned above. It is a matter of a generic process management philosophy. Lean manufacturing has renewed its focus from the seven wastes of Toyota, where it was first implemented to improve an overall customer value by adding some new key perspectives. In many cases Lean is linked with Six Sigma, hence the methodology of Six Sigma emphasis on reduction of the variation of the process of production and the way Toyota uses it in a combined way.

For many managers lean is a possibility to identify and eliminate waste as well as a help to improve the quality of production time and make a reduction of costs possible. Lean manufacturing can be done in different problem-solving ways. This includes a continuous process improvement (Kaizen) and the five whys as well as mistake proofing.

It can be mentioned a second approach to lean manufacturing. In this approach the focus is upon improving the smoothness in the sense of a flow of work through the whole system and not upon the reduction of waste. There can be mentioned different techniques to improve the flow. They include production leveling as well as pull productions (in the sense of Kanban) and the Heijunka box.

5.2.2 Types of Waste in Lean Manufacturing

The overall goal of lean is to eliminate waste. Toyota defines three different types of waste: the non-value added work, overburden and unevenness.

It is possible to identify the seven wastes and classify resources which are commonly wasted on companies. The following seven wastes were identified by the chief engineer of Toyota:

Defects

It is necessary to mention that quality defects prevent customers from excepting a product that is produced by the company. The effort to create this defect product is wasted. It is necessary to add new waste management processes in an effort to reclaim some value for the products that include quality defects.

Overproduction

The term overproduction can be defined as the production or acquisition of items before they really requires. Overproduction can be seen as the most dangerous waste in a given organization because overproduction is hiding the problems in the production itself. Because of this it is necessary to store overproduction as well as manage and protect it.

Transportation

Each time a product is moved there is a big risk that the product is damaged, delayed or lost and the risk transportation is possibly a cost for non-added value. There is no transformation made in transportation that the customer is disposed to pay for.

Waiting

To take a look at the time that is spent by the workers because they have to wait for resources to arrive can be seen as waste too. This waiting time for the employees can be seen as empty and the capital sunk in goods and services. These costs are not delivered to the customer. In some case there are processes in the company to manage his times of waiting.

Inventory

As examples for inventory there can be mentioned raw materials or finished goods. The inventory represents a capital outlay that hasn't produced an income yet for the company either for the customer or by the producer of the inventory. Raw materials as well as work in progress or finished products that are actively processed without adding value is waste.

Motion

If motion is compared to transportation it can be said that motion refers to the worker or to the producer or the equipment. This is of great significance not only for the damage but also for safety. Motion also includes fixed assets and expenses that incurred in the process of production.

Over-processing

If a company is using a more expansive or otherwise valuable resource than is necessarily needed for a task or is adding features that are designed but not needed by the customer, this can be called over processing. Some people need to perform tasks to show that they are overqualified or to maintain their competency. The training for these employees is indispensable and can be used to offset the waste associated with over processing.

Further unevenness can be avoided if the company uses just in time systems that are based on little or no inventory or by supplying the process of production with not only the right part but also the right time and the right amount of resources (Alabay 2008: 7).

5.3 Nine Principles of Lean Manufacturing

In the environment of manufacturing especially assembly work is mostly characterized not only by short transportation circles but also by a constant try to diminish the sizes of the batch. At the same time there is an increasing of the variations and models of the produced products.

It can mention a constant pressure to shorten the lead times inside the organization and this makes manufacturing in the meaning of lean manufacturing very challenging even if the firms are very innovative.

Further it is necessary to respond to the rapidly changing customers in a very quick way which makes it necessary to use manufacturing systems that are easy to reconfigure as well as expanded to react quickly to changes without a high investment.

It can be said that lean manufacturing as an approach depends highly on workplace organization and flexibility. Lean techniques are also interesting for organizations to eliminate large outlays for a dedicated machine. In an assembly work until it is necessary to start automation. The concept of Lean Manufacturing can be described with the help of the following phrase: “less is better”. This leads to a simplified and uncluttered work environment that is in every point answering the demands of the workers. The goal of producing one piece at a point instead of batch manufactured for a stock can be seen as a reaction to the customer’s needs and as a possibility to produce only the momentarily needed quantity.

Because of the fact that there is a limited numbers of products is produced it is sometimes necessary to make a change in manufacturing processes during the day in order to accommodate various parts and to establish maximum use not only of equipment but also of personnel and floor space. The requirement of being flexible creates unique demands on the work cell and the components of it (Bosch 2009:2).

The following figure 15 shows a typical u-shaped cell for lean manufacturing. The numbers in the figure refer to the chapters below (Bosch 2009: 3):

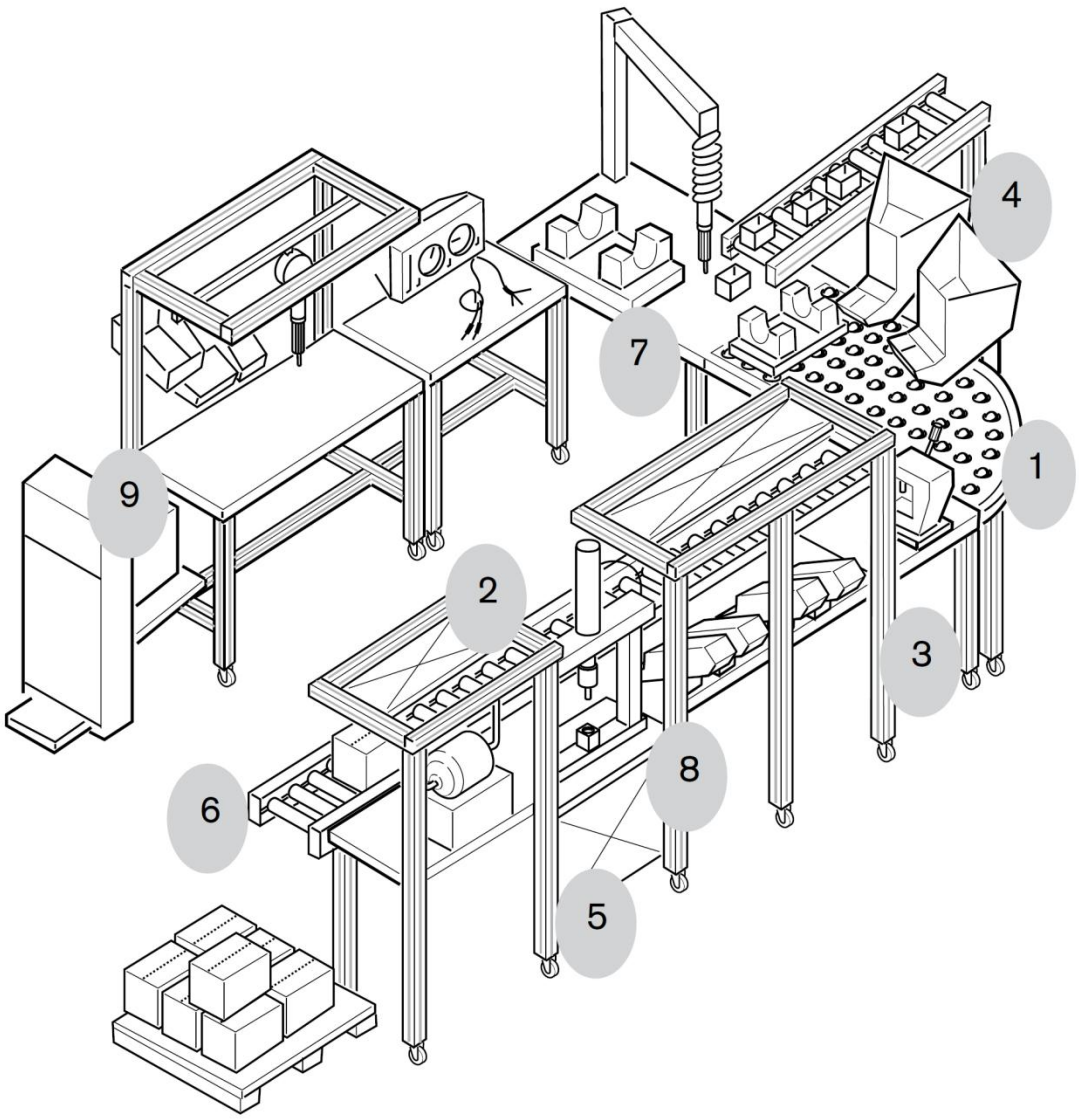

Figure 15: Lean working cell

In the following chapters the nine most important principles to make a workspace lean are being discussed (Bosch 2009: 2)

5.3.1 Continuous Flow

A nearer look to a lean work cell shows that it is u-shaped as the preferred shape. Further there is a connection between each of the sub processes in order of the manufacturing process. There is a minimum movement required for the worker to move from one piece of work to another as well as from getting from one workstation to another.

It can be seen as one of the ultimate goals of a lean work cell that there is no non-value-added movement for the worker because of the shape of the given work cell. Every time a worker is finished with a given process it is only necessary to turn around to start with the first step of the next process.

Further it is possible to carry the work piece from one operation that is value-added to the next if this is necessary. In times when the work piece or the fixture holding the work piece are too heavy to move it is not only necessary but also easily possible to transfer it mechanically between different workstations, although sometimes especially heavy parts must be transported on belt conveyors. For moving parts between lean workstations it is often ideal to manually push or use gravity conveyors instead of the traditional way to move them. Because of the low complexity they are easy to service and the downtime is minimized. Additionally it can be mentioned that it is easy in lean work cells to connect the different stations end-to-end which makes it possible to easily move the single stations inside the work cell. Figure 16 gives an example:

Figure 16: continuous flow

Sometimes the curved end (“corners”) of a work cell that is u-shaped is a problem for workers, because they are sensed as potential dead space. Sometimes they are used as mini storage area and because of that a return to batch processing can be encouraged. To solve this problem there should be used a ball roller transfer to make the movements of the parts easier through the corners of the u-shape of the work cell.

The following figure 17 presents a ball roller transfer:

Figure 17: ball roller transfer

All in all it can be said that for a work cell in the meaning of a lean manufacturing it is best if the work cell is u-shaped and makes it possible to connect sub-processes. There is a Value-add-to-value-add operation possible and the machines in the work cell are typically in the order of the process. Further the parts arrive as needed which brings a counterclockwise flow to the production as well as a one-piece-flow. Every necessary work that is necessary for the production of the product is done outside by support people, not by the owner of the work cell.

The overall benefits from a work cell like it is described above is the elimination of non-value added movements as well as work in process and inventory (Bosch 2009: 4)

5.3.2 Simplicity

Since one-at-a-time manufacturing as well as continuous flow is another important goal of lean manufacturing is can be seen as important that each machine or workstation is designed to fit within a minimal envelope. This ensures that excess flat space at the workstation is eliminated. The best possibility to do this is the avoiding of possibilities to store parts or subassemblies at the machine, because storing parts brings an increase of the work in process and often, batch processing is the result of this. It must be mentioned at this point that an increasing of work in process as well as batch processing defeats the purpose of lean manufacturing subsequently. In addition it can be said that smaller workstations and machines that are designed in minimal size can eliminate step between the sub processes from the worker that are unnecessary.

Additionally it is possible to save significant floor space by a proper sizing not only of workstations but also of machines. In the meaning of conformity and standardization it can be tempting to avoid the deployment of standardized workstation or machine basis for every necessary process. In contrary every workstation or machine should be designed in a way that it is possible to optimize assembly sub processes. It must be mentioned that in most cases this will be different from one workstation to another. Achieving this customization is possible with virtually every structural material.

Further it is possible to save costs and minimize the environmental considerations that are in relation to disposing inflexible welded steel structures if there is a preference for reusable and reconfigurable materials. To take a look to extruded aluminum this material is suitable because of its modular characteristics for bolt-together systems in the case of implementing the concepts of lean manufacturing.

Because of the fact that organizations have to deal with an environment that is continuous improving it is absolutely necessary for all work cells and workstations to be easily modified in the case that a change is needed at improvements are identified. It must be mentioned that lightweight aluminum structures are very easy to move in the case of reconfiguration of the workplace. This is because of their superior flexibility not only in layout but also in design. It is possible to mount casters in a very quick way to the T-slotted profiles which allows moving them without any lifting equipment.

The following figure 18 shows an example for the fact that in a lean work cell any necessary processes should take place in a minimal work envelope:

Figure 18: Simplicity

All in all it can be said that the lean machine basics are continuous flow and the saving of factory floor space. Further an elimination of excess production as well as preventing extra space on the drawers or shelves. The benefits of the simplicity of lean machines are a one-at-a time manufacture as well as quick production changeover and further a production that is not only customizable but also easy to modify. (Bosch 2009: 5)

5.3.3 Workplace Organization

Regarding the organization of the workplace there are two important factors to mention, namely tool holders and information boards.

The desired result of properly design lean work cell is a not only smooth, but uninterrupted flow of competed work pieces. A loss or misplacement of tools can slow down this flow very fast. Because of this every tool that is used in the workstation should have its own holder. It can be seen as the best way to deal with tool holders if there are as many holders as tools, thus it is quickly noticed by the worker if one specific tool is missing. A specific holder for each tool enables the worker to easily add or take away a holder from the workstation if the tool that it is holding is not needed anymore. This adds not only to the flexibility of the workstation but also enables an increasing of the usefulness of the

whole lean process. The following figure 19 presents a modular tool holder in a lean work cell:

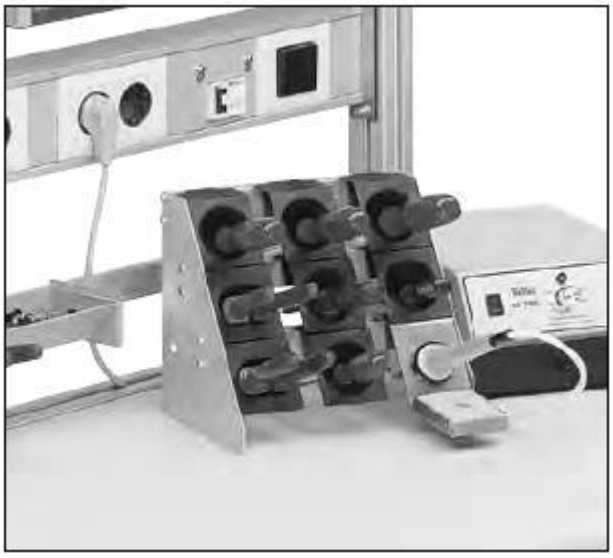

Figure 19: modular tool holder

Further there should be backup tools be available at any automated workstation, but it must be mentioned that these backup tools should not be in the workers way. They should only be here if a failure occurs at the automated workstation. It can be said that these tool holder structures are of maximum benefit in a lean workstation that allow tools to be slid or swung into the workspace and could be as easily returned if they are not needed anymore.

Regarding information boards it is necessary to mention that a ready availability of information that can be seen as work-critical also adds to efficiency in a given work cell. With the help of important information the worker is able to make the right decisions and act on them on the spot. As examples for important information can be mentioned work instructions or repair procedures as well as assembly processes. The information mentioned above enables the worker to limit downtime that is often spent in asking a supervisor.

Regarding the following figure 20 it can be said that it presents an example for an information board:

Figure 20: information board

All in all it can be said that workplace organization basics enable the worker to organize tools with specific tool holders and provide them backup tools in automated workstations. Another important factor is insisting on flexible tool mounting structures as well as the possibility to get important information in an easy way. As benefits there can be mentioned a much lower downtime and a reducing of wasted motion as well as uninterrupted work piece flow and an improving of the product (Bosch 2009: 6)

5.3.4 Parts Presentation

In production there are additional parts required during an average shift that are needed in the work cell. In lean work cells traditional methods of resupplying workstation cannot be seen as useful, because it should be possible for every worker to do his work with as less interruptions as possible. Because of this every needed part should be supplied to every possible workstation from the outside of the work cell. The simplicity of lean work cells is fit by bins or the use of gravity feed conveyors.

At this point it is important to mention that it should be possible to load part bins from behind which means from outside of the work cell. Only in this case the worker is able to continue his production without being interrupted. The parts can be carried by gravity to the area of the worker. Further it is necessary that bins are also designed in a reconfigurable way. One possibility to do this is the using of a key stud which locks them in position. It is easily possible to stack the bins. With the help of this the flexibility of the work cell can be increased.

It must be mentioned at this point that many assemblies require larger parts than bin although they are the perfect solution for small part that are necessary in production. Again it must be the goal that it is possible to deliver the single parts to the work cell without them entering the workplace and interrupting the work of the manufacturer. This is easily done with the help of gravity feed conveyors. If it is necessary to remove the scrap or containers from the cell it can be necessary to add a second gravity conveyor that mounted in the reverse direction.

Sometimes it is necessary to move parts that are very heavy. This can be a special problem in designing a lean work cell. In the sense of a lean work cells lift assist devices can be of great help in this circumstances. It is possible load heavy single parts or boxes of parts onto a case lifter (fig.21) After that the loaded parts can be raised to the needed work high with the help of hydraulic, pneumatic or electric power.

Figure 21: case lifter

All in all it can be mentioned that parts presentation basics include supplying the parts as needed and that it is possible to load necessary parts from outside to the work cell with the help of gravity as the preferred method. As benefits there can be mentioned the easy

reconfiguration as well as reduced motion from the worker that is wasted. It enables an uninterrupted production and a quick changeover (Bosch 2009: 7).

5.3.5 Reconfigurability

Especially the re-configurability of a work cell that is designed as lean is very important. It enables the manufacturer not only to change the process but to go from one good part to another without wasting time which means as quick as possible. If it is possible to make the changeover faster, there is less production time lost.

One way to enable a fast changeover are quick-change fixtures that can make a changeover possible within seconds. At the workstation there can be stored a different number of fixtures that will be swapped when the situation requires it. An example for this would be an assembly fixture that is locked to the t-slot at the front of the workbench with the aid of a star knob and a quarter turn connector.

Sometimes it is necessary because of changes in the process or other factors to reconfigure the work cell in very short time or it is necessary to move it to accommodate assembly of a new product. These circumstances make it necessary to move every component of the workstation quickly. The mobility that is necessary for a rapid and efficient changeover can be getting real with the help of lockable casters on the machines or on the workstations (Bosch 2009: 8)

The following figure 22 shows casters on a machine stand:

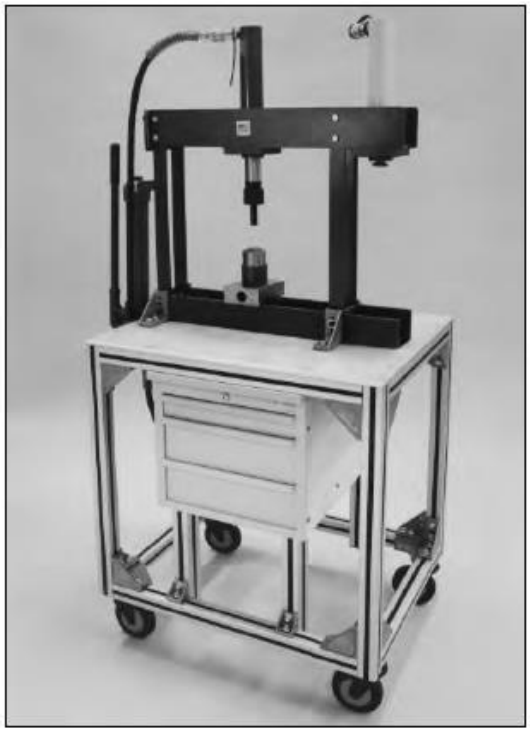

Figure 22: casters

5.3.6 Product Quality

The decrease of quality problems is one of the most important results of a one-at-a-time-manufacturing. So it is necessary for the manufacturer that every produced piece that is produced is verified by visual inspection. If through the gages verification is required they should be mounted to the machine or to the workstation to replace them quickly. It can be seen as a necessity that star knobs or locking levers enables a quick release of fixtures.

Sometimes it is not possible to fix a quality problem in an easy way, for example if a malfunctioning machine or a flawed process is the source for the quality problem. If the problem is caused by a malfunctioning machine it is possible to change the structural framing system although it is maybe a great problem that must be solved in minimum time. Once again a construction that is designed in a bolt-together style can be able to solve the problem in less time.

If on the other hand a malfunctioning machine is the cause of the problems it may also be possible to replace it easily particularly if there are provided quick disconnects for not only all electric but also all pneumatic lines at the time the work cell is designed. Further it is important to mention that there should be not visible pneumatic or electric connection inside the lean work cell. If they are present it would slow down the possibility to change

the machines within a cell. It is important that a machine that has been disconnected from all power sources can be easily transported if they are mounted on casters that a lockable.

Another important result of a design that makes it easy to reconfigurate or to do a changeover eliminates any reluctance on the part of the management as well as on the worker to use machines that are “almost” right and “will do”. This means a change of attitude that can contribute greatly to a production of high quality products

All in all there can be visual inspection as primary mean of quality assurance. Further it is necessary to test that fixtures and gages are easy to replace or if necessary to change out and an easy reconfiguration encourages changes for quality’s sake. The benefits in this are an immediate feedback on quality because of the manufacturers that inspect single parts and platforms for continuous improvement as well as the elimination of rework areas. By giving the responsibility to the assembler there is a greater product quality assurance (Bosch 2009: 9).

5.3.7 Maintainability

Another requirement of lean cells is the ease of service. In a pull-through system there must not be long down times because the product must be produced when the customer demands it. The ultimate in maintainability is provided by a modular structural framing system.

It is possible in just a few minutes to replace or reconfigure components. It is ensured by the bolt-together construction that it is possible to service not only machine stands but also workstations and parts presentation equipment in a few minutes. It is possible to even rebuild entire machine bases in a minimum time.

Because of the structural framing system it is easy to get different and necessary components for all guards, machine bases and workstations. So there are a minimum different number of tools required to maintain a structure if standardized components are used. If a structural framing system is used there are three or four simple hand tools sufficient if it is necessary to build or repair any structure. There can be mentioned another benefit of maintainability namely that there is no need for a large inventory of spare parts. It is possible to create virtually any structure with a few accessories, no matter if it is necessary to standardize on one size of aluminum or maybe one or two connectors.

Further it is necessary to mention that a structure that is designed in aluminum requires no finish work as well as no welding or painting. Additionally any form of necessary repair can be accomplished in very little time.

All in all it can be said maintainability basics in a lean work cell enables working with ease of service and a manual back-up. Another point is to put the operator manual on the given machine and standardize as many components as possible. It is better to use common tools for the different machines that are needed than specific tools because they are easier to get and it is not necessary to store a lot of different tools. Further there is no finish work required on the different system components and there is only a little amount of different spare parts necessary in the case of a failure.

The benefits of this are a minimum down time as well as easy to source replacement parts and a quick service (Bosch 2009: 10)

5.3.8 Ease of Access

Because of the fact that if an aluminum framing system is the foundation of a cell that is designed lean it is possible to mount all necessary components to easily accessible locations every surface of the cell can be seen as a potential mounting surface. It is possible to position not only parts bins but also different tools, shelves and fixtures that are necessary for an efficient work in an easy way. Further because of the T-slot on the surface of the framing system pneumatic or hydraulic components can be repositioned in a minimum of time if clearance space is critical.

Additionally different components can be added to any workstation in a quick way and further repositioned if this is necessary to insure accessibility for every manufacturer. This can be done without any great afford. It is important to mention that it is the same with individual panels or entire guards. They can also be removed quickly with simple hand tools by service technicians, so that maintenance can be performed again by the workers in very little time.

Comprehensively it can be said that the basics for accessibility in a lean work cell include that all controls as well as fixtures are positioned in an ergonomic design. It is further necessary that every component that is serviceable is at rear of machine or workstation in order to eliminate an interference of maintenance personnel with production. There must be a clearance for all tools for ease to use and all guards have to be easy to remove with an aid of a simple hand tool. Then there can be mentioned different benefits like a

minimum downtime or an easy serviceability as well as an optimum on ergonomic design (Bosch 2009:11).

The following figure 23 presents accessibility in a workstation design

Figure 23: Accessibility

(Bosch 2009: 11)

5.3.9 Ergonomics

Regarding ergonomics there can be mentioned two different factors namely height and lifting.

About height is can be said that it is necessary to protect the manufacturer from ergonomic problems. By definition it is necessary that every workstation that is designed as lean has to be also designed in an ergonomic way. It is always important that the work can be maintained at the ergonomically correct height. Although it is not frequently considerated designing for the average worker height has to be a necessity. It is necessary to mention at this point that the average heights vary in different countries so it must be possible to easily change the high of the workstation as well as of a single machine if there is a change that a lean work cell may be shipped from one country to another.

Regarding the factor “lifting” it is necessary to mention that it is necessary to consider lift assist devices whenever the weight of boxes or parts as well as single parts exceeds lifting. There can be used electric, hydraulic or pneumatic devices, but one important factor must not be forgotten: Like every device that is used in a lean work cell, it must be as easy as possible as it is said in the definition of lean manufacturing cells. A powerful

tool in this case can be a software package that allows to test the ergonomics of a work cell before it is constructed. This can help to prevent delays in the manufacturing that are caused by a faulty design. With the help of such a software package it is possible to settle ergonomic issues in the state of design rather than on the factory floor. This provides time as well as money. (Bosch 2009: 12)

6 Discussion

Based on the research question that was the defined in the introduction there was made a nearer look to Lean Management as well as Lean Production. Both are possibilities that work together and make it possible for a company to work in a more effective and flexible way. In other words working lean means working as simple as possible and avoid waste in any sense. Like mentioned above this is the biggest difference between traditional management (production) and Lean Management (production).

To practice a lean way there exist a lot of tools and methods that can be of big help for companies like Value Stream Mapping, Kanban or Kaizen and the mix of this tools and methods, especially Kanban and Scrum.

Regarding Lean Production/lean manufacturing it can be said that the most important factor to work lean is to avoid waste. If Lean Production is compared to mass production there are fewer resources needed in any meaning of the word. There is less time needed for the manufacturer and less tools and parts to produce a given product. Further Lean Production is much more flexible than mass production which is very important because every company has to deal with a changing environment. To be able to live in the economic market an organization has to fulfill the desires of the customers that are changing as fast as the environment.

Nevertheless it can be mentioned that Lean Production is a branch of Lean Management with the primary goal to avoid waste, like mentioned above. This can be practiced in avoiding overproduction as well as waiting times and buffer stock. Further the production must be returned to its core elements and errors should be avoided. Another important factor is the pursuing of continuous improvement like it is described in methods like Kaizen.

The nine principles of Lean Production (chapter 5.3) show that is very important to ensure that adequate technical equipment is available for the worker to do his job. So the theoretical background of Lean Production is shown in practice with the help of the principles mentioned above.

Last not least is can be mentioned that a Lean Production as a branch of Lean Management brings a better use of resources to the company which is an important factor to stay alive in a fast changing economic environment.

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