Lean Manufacturing

Eeva Järvenpää & Minna Lanz
Tampere University of Technology, Laboratory of Mechanical Engineering and Industrial Systems, Tampere, Finland
eeva.jarvenpaa@tut.fi, minna.lanz@tut.fi

Synonyms

Lean production, Toyota Production System (TPS)

Definition

Lean manufacturing is a production philosophy, which concentrates on the customer value, and targets to serve the customer as efficiently as possible by eliminating all unnecessary waste from the operations. Waste means all the actions that do not add value to the customer, and value is something that the customer is willing to pay for. Lean emphasises efficient flow of products over the maximum utilization of resources.

1. Introduction

Today's manufacturing companies operate in an environment, which is characterised by rapidly changing customer requirements and ever increasing global competition. Companies need to be able to produce high-quality, highly variable products, with fast and reliable delivery time, and with a competitive price tag. Thus, rapid responsiveness and agility has become a new strategic goal for the manufacturing enterprises alongside with high quality and cost reduction. Lean manufacturing can help the companies to improve in regard with all of these goals.

Lean is a famous production philosophy originating from the Japanese car manufacturer Toyota Motor Company and their well known production system, Toyota Production System (TPS). TPS traces back after the World War II and recession, when the directors of Toyota noted that the old mass production methods were less profitable than before, and decided to redesign their production system. They wanted to offer their customers a wide variety of car models and to produce them in low quantities. (Ohno 1988; Hobbs 2004) Founding on that idea, Toyota started to design a new system, with the priority to cut costs by removing all unnecessary cost factors. At the same time, they wanted the system to have flexibility, which would enable it to react to changes in the market environment faster than the old production models. (Hobbs 2004) Toyota's methods turned out to be very advantageous, which made other companies and American researchers interested in their approaches. James Womack and Daniel Jones studied

Toyota for years, and finally in 1990 they published their bestseller *The Machine That Changed the World*. The book described the story behind the success of Toyota: How they created value for the customer by performing a series of actions in the correct sequence and at the right time and by doing them properly the first time (Womack et al. 1990).

This new type of production philosophy became known in the 1990's as "Lean production". The word "lean", meaning "thin" or "slender" is very fitting since the basic idea is to trim the process from all unnecessary factors. According to Womack and Jones (2003), Lean provides a way to do more with less – less human effort, material, equipment, time and space – while simultaneously being better at providing customers exactly what they want. Modig and Åhlström (2013) describe lean as an action strategy, which aims towards an efficient material flow and improved use of resources through elimination, reduction and control of waste. Lean shifts the focus from optimizing the efficiency of individual resources in production to optimizing the flow of the total production process (Liker 2004).

The literature review by Bhamu and Singh Sangwan (2014) discussed various definitions of Lean manufacturing, and concluded that there is no one definition. Some authors view Lean manufacturing more from philosophical perspective related to the guiding principles and underlying goals, while some view it from practical perspective with a set of management practices, tools and techniques. Principles define what should be done, while tools define how it should be done. It has been recognized that many Lean initiatives fail, or doesn't bring the expected benefits, due to too much focus on the tools rather than the philosophy and principles behind (e.g. Rother and Shook 1999; Spear and Bowen 1999). Thus, as the principles form the backbone of Lean, they will be in the focus of this chapter. In addition, the connection between Lean and sustainability will be highlighted.

2. Lean Principles and Philosophy

The base of Lean manufacturing is built upon a set of Lean principles. The core principles are: value, value stream, flow, pull, and perfection (Womack and Jones 2003). In the following sub-sections, these are discussed in further details.

2.1. Value and Value stream

The guiding principle when eliminating waste from operations is value. Value is always defined from the customer's perspective. Therefore the fundamental basis is to understand what the customers want and what brings value to them. Value stream is the set of all activities needed to transform a product from an idea all the way to the hands of the customer. It includes the product design activities, management of all the information needed from the order to the delivery, and the physical transformation of the raw materials into the finished product. (Rother and Shook 1999; Womack and Jones 2003)

Work consist of three components. First is the actual work, which adds value to the product or service from the customer's point of view. Second component is auxiliary work, which does not add value to the product or service, but is necessary. The third is activity that does not add value to the product or service and is unnecessary. (Manos and Vincent 2012). When the whole value stream is analysed, many non-value adding activities are usually detected. A core of Lean manufacturing is to eliminate everything that adds cost without adding value. Such activities or processes are called wastes. Waste can be reduced by eliminating the non-value adding steps, if possible, and if not, minimizing the time and resource spent on them. (Liker 2004)

Taiichi Ohno (1988) originally defined the seven wastes as: Overproduction, Waiting, Motion, Transportation, Overprocessing, Inventory, and Defects and Re-work. The most fundamental waste is overproduction. It means producing an item before there is an actual need (e.g. an order) for it. Waiting refers to standing idle while waiting for the next processing step, part, tool or information. Unnecessary transportation means moving materials and parts to and from storage or carrying work in progress (WIP) long distances. Over processing or incorrect processing refers to producing higher quality than the customer requires, or performing unnecessary steps to process the parts. Excess inventory refers to excess work in progress, raw material, or finished goods. Excess inventories hide problems, cause longer lead times, take physical space and may cause the parts to become obsolete before they get used. Unnecessary movement means any unnecessary motion the worker needs to perform during the work, e.g. to pick up tools from other workstations. Defects refer to producing or repairing defective parts. Later on, eighth waste type – Unused employee creativity – was added to the list (Liker 2004; Tapping and Smith 2008). It means that if the company does not engage or listen to its employees, it may waste time, ideas, improvements, or skills.

Overproduction is usually considered as the fundamental waste because it often causes most of the other types of wastes. Producing more than is really needed causes a build-up of unnecessary inventory. As inventories tend to hide underlying problems, the motivation to continuously improve operations will most likely decrease. For example, if buffers are held between the stations, machine shutdowns do not immediately disturb the whole production line. Thus, there is no need to fix the root cause, which caused the machine shutdown, and the same problem may repeat later. (Liker 2004)

These above discussed wastes are called in Japanese as *Muda*. In addition, there are two other types of waste, *Muri* and *Mura*, that are equally important to take into account. *Muri* is the waste of overburden, which means pushing a resource, whether a worker or a machine, beyond its natural limits. This can lead to quality and safety issues. *Mura* refers to the waste of unevenness or irregularity. It results from an irregular production schedule or fluctuating production volumes. The fluctuation can also be caused by defects, missing parts, machine downtime etc. The unevenness presumes that there are always resources available for the highest level of production, even though less is required on average. When *mura* is eliminated the process becomes easier to control and manage. *Mura* is the root cause for *muda* type of waste, i.e. the non-value adding activities. Thus, the elimination of waste should start from *mura*. (Liker 2004)

Value stream mapping (VSM) is a method in which the value stream is identified and visualized in a single canvas, in order to detect the wastes in the process. The conventional VSM examines the economics of the production line, mainly regarding time-related metrics, such as cycle time, lead time, changeover time, etc. (Rother and Shook 1999) Value stream mapping forms the basis for improving the flow. Thus, it is often considered as one of the most essential tools of Lean. In the exhaustive literature review by Jasti and Kodali (2015) Value Stream Mapping was the most popular element of Lean in the reviewed articles.

Value Stream Mapping must always start from defining the customer value. Otherwise, there is a risk of improving a value stream that efficiently produces something the customer does not really want. Taking a value stream perspective considers the "big picture" of operations, instead of concentrating on just improving individual processes. Often the companies target their Lean efforts to removing waste from isolated areas, which of course does not lead to success when considering the whole. Thus, value stream mapping is an invaluable tool to understand the whole value stream and to identify the correct targets where the elimination of waste can bring benefit for the whole. "The whole" in this case can mean the operations in single company, i.e. from door-to-door, or in extreme cases it may concern the whole supply chain. (Rother and Shook 1999)

2.2. Flow

The flow principle means that the product flows through the manufacturing process without interruptions and waiting. Flow production can be seen as an opposite of the traditional batch production, in which the products have to wait between the phases for the whole batch to be completed. The batching approach is widely exploited because it seems intuitively very efficient as it keeps the machines and employees busy. However, in the flow system it is important to focus on the object that is moving through the process, instead of the resources that are acting on these objects. (Womack and Jones 2003) Traditional production management approaches often puts their emphasis on maximising the resource utilization and efficiency, instead of flow efficiency. Resource efficiency is the time a resource is used for adding value in relation to its available capacity. This means that in a resource efficient process the resource has all the time something to work with. Flow efficiency, in contrary, is the value-adding time in relation to the throughput time. Flow efficiency presumes there is always a resource available for the flow unit to be processed. The flow unit can be material, information or people. (Modig and Åhlström 2013)

A major issue when focusing on resource efficiency is that it often leads to sub-optimization. This means that the individual resources are efficient, but a large amount of their time is actually used on secondary activities. For example, if there are many flow units simultaneously in the process, it generates the secondary need of managing higher inventory and WIP levels. This again makes it difficult to have an overview of the situation and can lead e.g. to the need of unnecessary transporting or looking for materials. Such secondary needs commonly propagate even more secondary needs, and the secondary activities start to seem like value-adding activities even they are not. This leads to efficiency paradox: the resources are constantly busy, but value is not added effectively. The efficiency paradox can be solved by removing the need for the secondary activities. This entails making the process to flow more efficiently. It is very difficult to reach simultaneously high resource efficiency and high flow efficiency. The main reason for this is high variation in the process, which requires some level of buffers if resources should be always kept busy. Buffers in turn increase the throughput time, decreasing the flow efficiency. (Modig and Åhlström 2013)

In order to make the flow system to work, it is essential that the parts are of good quality and that the resources are always available when needed. Otherwise, it would cause serious interruptions to the flow. The workers need to be multi-skilled, so that they can move between stations to balance the workload and to help each other in unexpected situations. (Manos and Vincent 2012; Petersson et al. 2010)

In a flow system, it is crucial that defective parts or products are not sent further downstream on the production line. This relates to another important pillar of Lean, *Jidoka*, which sometimes translates to “autonomation”. It means automation that can stop itself when defects occur. *Jidoka* has two principles: built in quality and stopping production if defects are detected. Built in quality means that quality is built in during the production process, by utilising mistake-proofing often called by the Japanese term *poka-yoke*. The target is to prevent mistakes from happening in the first place, or at least to notice them before sending the part ahead. Built in quality can be implemented e.g. with visual controls. (Liker 2004; Manos and Vincent 2012) Stopping the whole production line when a problem is detected may seem like a drastic action. However, it makes the problems visible, and everyone has the common goal to fix them fast. Furthermore, it encourages to fix the root cause, not just the symptom, so that the problem won’t repeat. From individual worker’s viewpoint it may feel intimidating to stop the whole production. Thus, it is very important that the management strongly encourages for actively detecting issues and halting the production when issues are faced. (Petersson et al. 2010)

Lean emphasises visual control and visual management as part of implementing *Jidoka*. Visual control and management exploits different kinds of visual tools, which help everyone to understand the status of the process easily, at a single glance. In addition, they help the managers to estimate whether or not the process is functioning normally. Examples of such visual tools are: lines, labels, signs, pictures, painted floors, kanbans, production boards, shadow boards (a board painted with figures of the tools that belong there), andon lights (light indicating there is an issue on some workstation), or many other things. The goal is to achieve a visual work environment, which is self-ordering, self-explaining, self-regulating, and self-improving. (Manos and Vincent 2012)

2.3. Just-in-time and Pull control

Just in time (JIT) is a method for achieving flow production. The basic idea of JIT is to ship items in the right amount at the right time. This is attained by producing small lots with short throughput times. JIT targets to a process in which small amount of products flows smoothly through the production, arriving in each destination exactly when it is needed. In order to ensure efficient flow, JIT has to be applied to the whole value chain. (Womack and Jones 2003) With JIT principle it is possible to get rid of the worst of the 7 wastes which was overproduction (Manos and Vincent 2012).

The pull principle refers to a process in which the customer "pulls" the product from the process, and nothing is produced before there is a customer order. Customer may be either external or internal (e.g. next process station) customer. The underlying idea is to not make anything until it is needed by the customer, and when the need occurs, then make it quickly. This is enabled by the throughput time reduction achieved with the flow production. After successfully implementing the pull principle, there is no more need for demand estimates. The pull principle and short throughput times allow the companies to always deliver the products to their customers in a reasonable time without the need to keep excess inventories that can eventually end up unsold. (Womack and Jones 2003) Pull control is the ideal state in just-in-time manufacturing. The leanest example of this kind of pull would be one-piece flow where only one product flows through the process based on the customer order. That way there is zero inventory and 100% on-demand. (Liker 2004)

JIT can be achieved by exploiting some common Lean methods, such as *kanban* (signboard scheduling system) and *heijunka* (production leveling). *Kanban* is a Japanese term for a sign or signboard. In Lean it refers to a signalling method which, in a pull system, gives a trigger and directions for the production or replenishment of items. In simple case, Kanban can be just an empty bin or empty storage place, which triggers the production of the diminishing part, or it can be a card, which is sent upstream when new parts are needed. In the era of digitalization, the Kanban cards are being transformed into electronic versions as well. (Manos and Vincent 2012)

Heijunka is a Japanise term referring to production levelling. Contrary to the mass production, where big lot sizes are preferred, *heijunka* targets to reduce the lot sizes to a minimum. This means that the processes of the whole value stream have to adapt to a schedule, which requires many changeovers. Therefore, the changeovers have to be executed very quickly in order to keep the whole process flexible and production levelled. (Manos and Vincent 2012) Furthermore, *heijunka* aims to level out the workload, meaning eliminating significant peaks and valleys. This will reduce the strain of all the involved parties whether it be equipment or the employees of a production company or its suppliers. However, sometimes this levelling contradicts with the JIT principle, as it may require frontloading or postponing deliveries and keeping an inventory. Customer orders are not always predictable, which means that, if the workload and orders are levelled, the customer will not get their products exactly when they want them. Then again, this is acceptable, as levelling production schedule can reduce much more waste by supporting evenness of production and consequently minimizing the over- and underutilization of resources. As discussed earlier, eliminating mura, the waste of unevenness, plays an essential role in eliminating the other types of waste, muri and muda. (Liker 2004;

Petersson et al. 2010)

2.4. Kaizen – Seeking for perfection

Following the earlier discussed principles can lead the company to a positive cycle of finding more and more opportunities for improvement. One of the Lean core principles is seeking for perfection, which is approached through continuous improvement. Continuous improvement is translated from the Japanese term *Kaizen*. It refers to a total philosophy, which aims towards perfection through the process of incremental improvements. Pre-requisite and foundation for continuous improvement are stable and standardized processes, which make waste, variation and inefficiencies visible. Such visibility again enhances learning from improvements and empowers the employees. (Liker 2004; Petersson et al. 2010)

The starting point for a kaizen process is to establish a plan-do-check-act (PDCA) cycle to ensure the continuation of sustaining and improving standards. *Plan* refers to defining the target situation. (Tapping and Smith 2008; Imai 2012) This can be presented for instance in the form of future state map (Rother and Shook 1999). *Do* refers to implementing the improvement plan. *Check* entails evaluating if the improvement plan stays on track and if the targeted goals are met. *Act* refers to the standardization of the new procedures in order to prevent the original problem repeating, and to allow detection of the variation (Tapping and Smith 2008; Imai 2012). Kaizen highlights problem-awareness and offers ways to identify problems. Recognizing these problems, and consequently the need for the improvement, is the starting point for any improvement process. Lean stresses the thorough analysis and understanding of the root cause of the problem as an imperial for making sustainable improvements. (Liker 2004)

Imai (2012) differentiated between innovation and *kaizen* by highlighting that innovation is a technology-oriented improvement, which calls for large investment, whereas *kaizen* requires more continuous effort and commitment from people. In order to make *Kaizen* to work, everyone involved in the process have to be dedicated and committed to the improvement. Both managers and workers need to be on board, and committed to the *kaizen* philosophy. Implementation of kaizen process does not usually require large monetary investments. Instead, the change comes from within the company and its people, their behaviour and attitude. (Imai 2012) Involving operators and team members to the problem solving can boost employee confidence and skills to face the future challenges (Bhamu and Singh Sangwan 2014).

The indispensable basis of inherent strive to perfection is a Lean culture within the organization. Lean is a people-centric production philosophy, and human factors and top management support play a big role in a successful Lean culture. Continuous improvement and learning require an attitude of self-reflection, even self-criticism, and a great desire to improve things. The top managers and leaders must be strongly committed to making the Lean transformation and steering the organization forward consistently. In order for the employees to adopt the Lean culture in their everyday work and actions, it is essential that the vision and mission are clearly elaborated and communicated to everyone in the organization. (Liker 2004; Manos and Vincent 2012)

3. Connection between Lean and Sustainability

"Economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs", by the World Commission on Environment and Development (WCED 1987), is the most well-established definition of sustainable development. Sustainable development is typically further divided into three pillars: environmental, social and economic sustainability. The economic aspect focuses on securing both short- and long-range profitability and economic viability. Social sustainability entails promoting social development and improved quality of life in terms of wealth, safety, well-being and influence. Environmental sustainability seeks to minimise the negative impacts of human actions to the environment and to conserve the natural resources. (Jovane et al. 2009)

Manufacturing industry has a strong influence on the sustainability of economies, from all the three viewpoints. Sustainable production has been defined by the Lowell Centre for Sustainable Production as *"the creation of goods and services using processes and systems which are non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for employees, communities and consumers, and socially and creatively rewarding for all working people"* (Lowell Center for Sustainable Production 1998).

Lean contributes towards sustainability from many perspectives. Cherrafi et al. (2016) studied the literature around integration of Lean and sustainability approaches. Their study revealed that after year 2010 the amount of publications combining Lean with sustainability has increased. Many researchers have concluded that Lean and sustainability are tightly interconnected and share many similar goals and support each other. Faulkner and Badurdeen (2014) stated that some authors see the Sustainable manufacturing as some sort of evolution from Lean manufacturing, which extends from waste reduction to closed loop utilization of the materials. They also stated that Lean manufacturing practices and tools have been utilized as a catalyst to develop better strategies for green and sustainable manufacturing (Faulkner and Badurdeen 2014). Verrer et al. (2014) identified clear correlation between the Lean maturity and the success with green initiatives in companies.

Many researchers have utilized Value Stream Mapping as a basis for sustainability evaluation and identification of improvement targets. E.g. Faulkner and Baburdeen (2014) presented a Sustainable Value Stream Mapping to evaluate the sustainability performance of a manufacturing company. They extended the traditional VSM, familiar from Lean manufacturing, by environmental and social metrics. Verrier et al. (2014) proposed a framework for Lean and Green management, which considers simultaneously the Lean and Green indicators. They approach the Green indicators through seven types of wastes of Green, originally defined by (Hines 2009): excessive water usage, excessive power usage, excessive resource usage, pollution, rubbish, greenhouse effects, and poor health and safety.

Figure 1 illustrates examples on how Lean can positively contribute to the three pillars of sustainability. For instance, the reduction of waste has a positive effect on both economic and environmental sustainability. Levelling of production reduces the stress of employees and other stakeholders, which has positive effects on social, and eventually on economic sustainability. As discussed earlier, Lean is highly people centric management philosophy. Employees should be strongly involved in the improvement activities, which gives them a good possibility to influence on the working conditions, and ways of working. This should have positive effect on the social aspect of sustainability. Furthermore, creating visual workplaces where every tool and material has its dedicated spot, and where no excessive work in progress is lying on the floor, makes the workplace safer for the people.

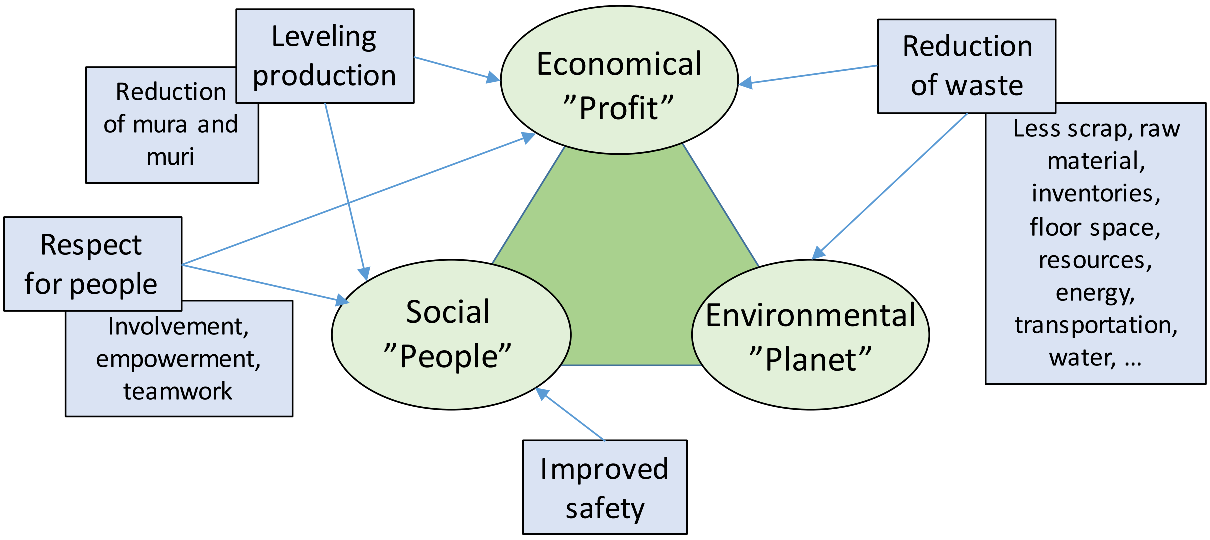

Figure 1. Support of Lean to Sustainable Development.

However, there are also some topics, which make Lean and sustainability a bit contradicting. For instance, Lean overlooks the sustainability in favour of customer demand and value. In addition, the definition of waste differs. (Cherrafi et al. 2016) While Lean aims to improve operations and cut waste from the customer's perspective, Green initiatives focus on environmental perspective (Verrier et al. 2014). In Lean thinking, if something does not cause cost (directly or indirectly) it is not considered as waste. Sometimes following the values of environmental and social sustainability can lead to more expensive ways to produce and to bring the product to the market. This can be considered as waste, unless it brings value to the customer. On the other hand, the environmental and ethical consciousness of consumers is continuously growing. Thus, it may actually add value to the product from the customer perspective, and provide a competitive advantage for the company.

There has been a lot of debate whether Lean has negative or positive effects on the employee well-being, job autonomy and satisfaction. Based on the literature review by Hasle et al. (2012) both positive and negative effects have been reported. For instance, Lean practices that increase work intensity and load affect negatively, while practices increasing employee influence and support affect positively. There is also strong evidence that in cases of manual work with low complexity, Lean can have negative impact on both the working environment and employee health and well-being. However, Hasle et al. concluded that it is not possible to establish an unambiguous negative or positive causal effect of Lean to the work environment. Lean takes so many different forms, for instance regarding context, implementation and practice. These will have different effects on workers' working environment, health and well-being. (Hasle et al. 2012) Yang et al. (2012) brought up that most of the companies that adopt Lean production concentrate more on techniques rather than human resource practices, which can affect lean implementation and how it is perceived.

Rodríguez et al. (2016) argue that human resource practices, such as teamwork, participation to the implementation of lean tools, influence on group decisions, influence on the determination of norms, participation in continuous improvements, praise for higher performance, regular feedback, training, focus on customer value, empowerment, and better understanding of individual tasks and the customers' needs, can positively change the perceived job autonomy and how employees evaluate their jobs. On the other hand, as highlighted by Shah and Ward (2007), employee involvement is one of the core aspects of a Lean system. After studying the effects of Lean on employee well-being and satisfaction, Hasle et al. (2012) pointed out that the results suggest that some of the issues with Lean may decrease with a more comprehensive implementation of Lean. Rodríguez et al. (2016) suggest that practitioners should understand Lean manufacturing as an integrated socio-technical system, and balance their attention between Lean techniques and human elements.

4. Discussion

Even though Lean was born in automotive industry, it has been successfully applied in different types of industries changing the way how the business and operations are run. Based on the extensive literature review articles of Bhamu and Singh Sangwan (2014) and Jasti and Kodali (2015) Lean has found applications from manufacturing to service sector; mass production to high variety and small volumes production; labor-intensive industries to technology-intensive industries; construction industry to assembly industry; and from medical health care to communication industry. According to the review by Bhamu and Singh Sangwan (2014) various authors have documented quantitative benefits of Lean implementation, such as reduced production lead time, processing time, cycle time, set up time, inventory, defects and scrap, as well as improved overall equipment effectiveness. The various qualitative benefits that have been reported include, for instance, improved employee morale, effective communication, job satisfaction, standardized housekeeping, and team decision making.

The literature reviews by Bhamu and Singh Sangwan (2014) and Jasti and Kodali (2015) show that Lean Manufacturing is studied and implemented all over the world. Majority of the articles come from the developed countries, the most dominant countries when measuring by the amount of scientific publications produced, are US and UK and other European countries. However, in recent years the developing countries such as India, Malaysia and Brazil have started to produce more publications on Lean Manufacturing. In the developing countries, the publications are mainly related to the implementation of Lean in companies, while the developed countries produce publications that concern about combining Lean with some other approaches and paradigms, such as Green, or applying Lean in new contexts such as education. Even though Lean manufacturing has started to raise awareness in developing and underdeveloped countries, the study by Cherrafi et al. (2016) revealed that the studies from these countries do not combine Lean with sustainability. However, they emphasized that these countries could often benefit from such combination, especially because according to OECD (2012), the potential economic and social impacts of environmental degradation are particularly significant for them. This is because the economic growth of the developing countries is usually dependent on their natural resources, and at the same time, these countries are very vulnerable to risks related to energy, food, water security, climate change and extreme weather conditions.

Lean manufacturing is not just about optimizing the flow of material, but the information flow is equally important (Rother and Shook 1999). Lack of information or wrong information can cause delay, mistakes and hassle during the production execution. This was highlighted by the study, which analysed the manufacturing operations management practices and challenges in Finnish manufacturing companies (Järvenpää et al. 2016). The study revealed that utilisation of improper tools for production planning and control (e.g. spreadsheets, pen and paper) caused a lot of waste and bad transparency to the operations. The production plans were maintained in several spreadsheets, which were not integrated together, nor with the Enterprise Resource Planning (ERP) system. Due to the scattered information and lack of integration a lot of wasteful activities, such as manual typing of information to multiple files and systems, and searching for information from diverse places, had to be continuously performed. This lead to low quality and obsolete information as well as weak visibility and access to the information, which again caused a lot of hassle, and bad levelling of the production load. The information was not flowing efficiently, causing bad decisions and inefficient execution of operations. Resources were efficiently used, but for doing wrong things. (Järvenpää et al. 2016)

The same study pointed out that lack of information transparency in the production network decreased companies' possibilities to react timely on disturbances, such as delays in component deliveries from their suppliers. Inventories and buffers were maintained to compensate these issues. On the other hand, lack of transparency within the company meant that it was really difficult to understand the "big picture" or to learn from the effects of one's own actions. (Järvenpää et al. 2016) The study indicated that even though Lean is not often connected with IT-system implementation, proper manufacturing IT-systems can definitely contribute towards Lean by providing better visibility to the production status, and more accurate information to support decision making and continuous improvement.

5. Cross references

Material flow analysis

Top management involvement
Deduction of waste generation

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