The Toyota Production System

The Key Elements and the Role of Kaizen within the System

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1. Introduction

The oil crises in autumn 1973 as well as the following global recession had a huge impact on the global economy and its companies. Even the economy of Japan broke down in 1974 and decreased to a zero growth. However, the Toyota Motor Company had higher profits compared to other companies in the following years of the recession, although they also experienced a nominal shrink. This increasing gap in between Toyota and the other companies made managers and market expert curious of what Toyota was actually doing different compared to them (Ohno, 2013).

Before the oil crisis and the following recession other companies and market experts were barely interested in Toyotas production technology and their production system. This interest changed with the end of the economy growth and many companies were unable to make profits as long as they continued to use the American mass production system. It was obvious that the time on the automotive market had changed (Ohno, 2013).

The question is now, what did the Toyota Motor Company different compared to its competitors? Taiichi Ohno is well known as the founder of the Toyota Production System (TPS) and also the founder of lean management. However, Toyotas way to performance excellence and being the world market leader in the automotive industry has been long and actually started with a simple thread.

Nowadays, the Toyota Production System contains and combines a huge variety of lean management elements in the so called TPS-House. One of the key elements of the TPS-House is the Kaizen method which ensures a continuous process improvement within the production system.

The purpose of this paper is to give the reader a deeper understanding of the roots and the development of the Toyota Production System. Furthermore, it will introduce the concept of the TPS-House with its key elements whereby there is a focus on the continuous process element – Kaizen. Therefore, this paper is divided into five sections. In the next section it starts with a historical background of the Toyota Motor Company and the roots of the production system. It also gives an idea of Toyotas thinking. Section number 3, represents the concept of the TPS-House. The following section number 4 describes the key elements within the TPS-House and the Toyota Production System. Afterwards, a discussion about the role of continuous process improvement – Kaizen – within this concept is given. Finally, a summary of the paper is presented.

2. Historical Background

2.1. The origins of the Toyota Motor Corporation

The history of the Toyota Motor Corporation actually started before the company was founded. Sakichi Toyoda was born in Kosai, Japan near Nagoya on 14th February 1867. He learned craft of the carpenter from his father and used this skill to manufacture weaving looms out of wood. In 1894 he started to manufacture looms which were cheaper and better than the common ones on the market. The special feature of his weaving loom was that they stopped automatically as soon as a thread tore (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

However, he still was not satisfied with his innovation because he realized that his mother and his grandmother and their female friends still had to work too much. Due to that reason, he

developed an electric weaving loom. But there was a serious problem with the electric loom because there was no electricity in his area. Hence he started to experiment with steam engines until his electric loom worked (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

With this new machine he founded the Toyoda Automatic Loom Works, Ltd. in 1926. A few years later in 1929 he sent his son Kiichiro Toyoda to England to sell the patent rights to the Platt Brothers who were the most important manufacturer of spinning and loom machines on the market. Kiichiro Toyoda negotiated £100,000 for the patent rights. There was actually no reason for Sakichi Toyoda to sell the patent rights of his electric loom but in his opinion should everyone create something great in his life. Hence he gave this money to his son to found his own company. Thus Kiichiro Toyoda founded the Toyota Motor Corporation in 1930 (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

Due to rather bad production conditions in the company, it took until Toyota a few years until they produced their first vehicles. In the beginning the production was more on trucks than on cars. In 1935 the first truck was produced – the Toyota G1 (see figure 1). Also, the first car was produced in the same year – Toyota A1 (see figure 2) (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

Figure 1: Toyota G1

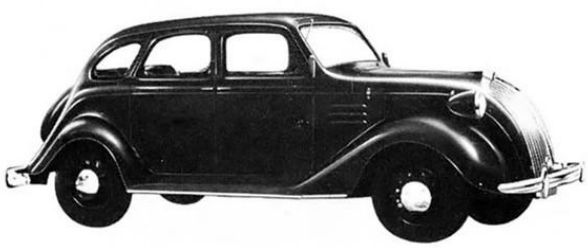


Figure 2: Toyota A1

2.2. The birth of the Toyota Production System (TPS)

In 1950 Toyotas Chief Executive Officer (CEO) Eiji Toyoda – a cousin of Kiichiro Toyoda – did a research trip to the United States with his managers. The purpose of this trip was to visit and analyze the production sites of Ford and General Motors (GM) to gather ideas of the market leaders of how they could improve their production system. However, he and his managers experienced an unexpected surprise. The production systems were still at the state of the 1930s. For instance, the production of Ford and GM operated with many different machines and a huge amount of intermediate products which had to be stored in certain ways. Additionally, there were many interruptions within the whole production processes, thus a huge amount of materials were stacked in intermediate storages. Moreover, due to the overproduction that Ford and GM carried on, defects on the intermediate products were not identified. Hence, Eiji Toyoda and his managers experienced an enormous waste of resources (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

Due to this experience, Eiji Toyoda saw a chance for the Toyota Motor Corporation on the global automotive market. Thus, he gave his plant manager Taiichi Ohno the commission to improve the Toyota production process in that way, that the productivity can compete with Ford. Fortunately, Ohno's task was not to reach the production level of Ford and to step into direct completion with Ford (Ohno, 2013) (Liker, Der Toyota Weg, 2014).

On the basis of this task, Ohno and his engineers started to experiment in the Toyota production plant. The result was the TPS-House.

3. TPS House

The TPS-House is structured in three parts and shows the elements of a lean system. It displays the foundations on the bottom, the pillars – which represent the core activities - in the middle and the as usual for a house the roof on top which shows the goals of the Toyota Production System (see figure 3).

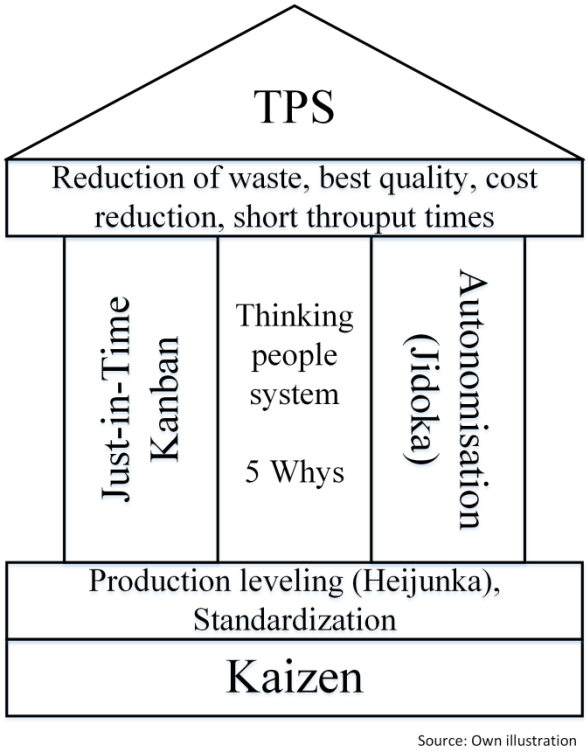


Figure 3: TPS-House

Following, this paper describes some of the key elements of the TPS-House that are used within the Toyota Production System.

4. Toyota Production System Elements

The easiest way to understand the concept of the Toyota Production System is to start with the roof of the TPS-House because it represents the goals of the system.

4.1 TPS goals

One of the main goals within the TPS is the avoidance and reduction of waste (Ohno, 2013) (Thun, Drüke, & Grübner, 2009). The elimination of waste bases on Taiichi Ohno's approach that any activity has to generate an added value and that unnecessary activities needs to be abolished. The Japanese word for the elimination of waste is *muda* (Liker, Der Toyota Weg, 2014). There are two aspects which have to be taken in consideration in sense of elimination of waste. First of all, an improvement makes only sense if it has a reduction of costs as result. That means that only things are allowed to be produced which are really needed. This production has to be accomplished with the minimum of workforce. Secondly, the efficiency of all workers that are involved in the production system as well as every assembly line needs

to be analyzed to find potential aspects of waste reduction. That means, if only actual work is considered as work and everything else is considered as waste, the result would be the following equation:

$$Current\ Capacity\ = Work + Waste$$

Thus, there is only a real improvement within the system if there is no waste and the work is increased to 100 per cent. Therefore, any type of waste within the system needs to be identified (Ohno, 2013). There are seven main types of waste: waste of overproduction, waste of waiting, waste of transportation, waste of processing, waste of inventory, waste of motion and waste of defects (Chakravorty, Atwater, & Herbert, 2008) (Ohno, 2013).

Waste through overproduction is considered as the worst type of wastes. Overproduction is the process of creating a huge amount of products before they actually are needed. It also leads to excessive amounts of inventory. Furthermore, overproduction hides other problems within the process because it makes it impossible to identify other problems and defects which would occur under normal production circumstances (Liker, Der Toyota Weg, 2014) (Lean Manufacturing Tools, 2015).

The main causes of waste of waiting are unbalanced processes. That means if one process takes longer than the next the workers have to wait until they can fulfill their tasks. For instance, the workers have nothing to do because they have to wait for the right tools, materials or parts to continue the production process. Thus the waste of waiting leads to delays within the whole production process. Even the wastes of transportation can be the cause of waste of waiting due to longer leading times (Liker, Der Toyota Weg, 2014) (Lean Manufacturing Tools, 2015).

Waste of transportation usually occurs while the product is in process. During this process the materials and even the final product needs to be transported over great distances for the finishing process or in between the different warehouses. This leads to long and inefficient transportation paths (Liker, Der Toyota Weg, 2014).

Waste of processing is a result of unnecessary process step in the processing. This type of waste occurs through the use of unsuitable tools or poor product design. Even the production of products of higher quality than needed is a type of waste (Liker, Der Toyota Weg, 2014).

A high amount of inventory in sense of raw materials, products in progress and final products are considered as a waste of inventory. This high amount of inventory leads to higher throughput times, old or defected parts and products, high transportation and storage costs and to delays. Furthermore, too much inventory also hides problems within the system like unbalanced production capacity, delays of deliveries, unused machine capacities, long changeover time and all kinds of defects (Liker, Der Toyota Weg, 2014).

Any kind of unnecessary motion that a worker needs to do during the finishing process is a waste of motion. For instance, any type of motion that a worker needs to do to find the right tool or part is a waste of motion as well as a waste of the workers time (Liker, Der Toyota Weg, 2014).

Wastes of defects occur through the production of products and parts with defects as well as their rework. All repairs, any garbage, reproduction and inspection are all activities which do not add any value to the final product. Thus all of these activities are a waste of motion, time and energy (Liker, Der Toyota Weg, 2014).

Hence, the total avoidance of waste can shorten the throughput times and thus improve the process quality. Furthermore, by reducing the costs the profitability and competitiveness of any organization can be increased. Therefore, only the right quantity is allowed to be produced while the workers have to be implemented effectively or sometimes even have to be released (Li, 2012) (Ohno, 2013).

4.2 TPS foundations

The foundation of the Toyota Production System contains three main elements: *Kaizen*, production leveling (*Heijunka*) and standardization. While the elements of production leveling and standardization will be described in this section, the role and importance of *Kaizen* will be discussed in section number five.

With the methodology of production leveling (*Heijunka*) production areas and their logistics is smoothed and the demand for sub-assemblies and components from the supplier are the same every day (Black, 2007) (Ohno, 2013). This methodology helps to master the increasing product diversification and is a requirement for a successful introduction of *Kanban*. The advantage of production leveling is the prompt visualization of production orders and leads to soothe production processes. Variations that occur through internal and external influences are reduced step by step and eliminated in the end (Dickmann, 2015).

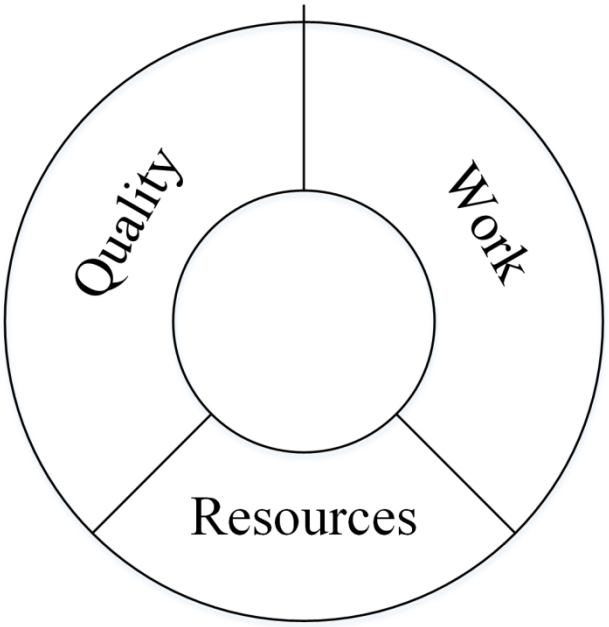
Thus, the goals of the production leveling are:

- Creation of constant material and information streams to achieve a higher possibility of planning
- Ensure a smooth production rhythm through decoupling of the customers' production orders
- Creation of standardized working processes as a basis of efficient and stabile continuous improvement process (*Kaizen*)
- Creation of a continuous and plan able workload for workers and machines
- Visualization of Kaizen to create a deviation transparency of the target state to work them off with the involved staff step by step
- Minimization of inventory alongside the whole value stream as well as decreasing of throughput times
- Creation of customer effective flexibility while continuous reduction of the total costs (Dickmann, 2015)

The concept of standardized work processes is effectively implemented within the car manufacturing industry and enters particularly in context of holistic production systems in focus. The standardization of mounting forms the main focus of standardization. This standardization is partly achieved by documentation in so called standard operations through the employees. These standard operations contain out of three components:

- The work sequence explains the content and the sequence describes the build upon each other steps which are necessary for the fulfillment of the tasks
- The cycle time describes the maximum amount of time to create a product. The cycle time depends on the production quantity and results out of the available working time and the number of units that needs to produced
- The standard inventory is the lowest necessary amount of materials to maintain the working process. Usually corresponds this amount the minimum inventory

Toyota realized already early the potential of its employees' knowledge of their individual working area and achieves great process improvements through the documentation of workflows. These improvements can be proven by shorter throughput times, lower need of materials or space, or higher quality. Thereby, the shown in figure 4 assumptions for determining are used in the Toyota Production System (Carell & Herrmann, 2007).



Work
- Repeatable manual processes

Resources
- Reliable with a minimum amount of disorders

Quality
- standardized

Source: Based on Carell, A. & Herrmann, T. (2007): Innovationen an der Schnittstelle zwischen technischer Dienstleistung und Kunden - Konzeptionelle Grundlagen., p. 171

Figure 4: Assumptions for determining

4.3 TPS pillars

As the foundation of the Toyota Production System is elimination of waste the two pillars to utilize these foundations are Just-in-Time and autonomation (see figure 3). The pillars represent the core of the Toyota Production System. The first pillar contains beside the Just-in-Time concept also the *Kanban* concept.

The basic goal of Just-in-Time is that the right materials/parts are available in the right quantity at the right time (Ohno, 2013). Just-in-Time is an organizational principle that has the goal of on-demand implementations of organization internal and cross-organizational processes for the exchange of goods. The Just-in-Time production and its supply aims through a continuous material and information flow to a high market and customer orientation while simultaneous inventory reduction in the value chain. Elements of the Just-in-Time concept are the integrated information processing (e.g. introduction of the pick-up principle, IT-based communication for the production and procurement, combination of several planning and control methods), the production segmentation (creation of product and technology oriented production units, group organization, flow optimization) and the production synchronous procurement. The realization of Just-in-Time concepts leads to the reduction of current assets and changes thus the vertical and horizontal balance sheet structure (Gabler Wirtschaftslexikon, 2015) (Ohno, 2013) (Thun, Drüke, & Grübner, 2009).

The *Kanban* idea was originally adapted from U.S. American supermarkets in which products got refilled in the same amount as they were taken by the customers. In a *Kanban* system the

type and quantity of needed units are written on a tag like card – the so called "Kanban". This card is sent from a worker of one process to another worker of the preceding process. Thus, the Kanban card is used as an order card. If a part is consumed in a production stage, the upstream production stage is induced to produce a new one. Hence, the *Kanban* system is based on the pick-up principle and two adjacent stages of production are connected to a control loop (Ohno, 2013). The connection of processes allows a better control of quantities needed for various products. In the Toyota Production System, the Kanban concept is supported by smoothing of production, standardization of jobs, reduction of setup times, improvement activities, design of machine layout and autonomation (Monden, 1993). As a result of the *Kanban* system there is no overproduction with the system (Ohno, 2013).

The second pillar of the Toyota Production System contains the concept of autonomation (*Jidoka*). The autonomation stops the production process immediately when a problem first occurs and highlights the causes of the problems (Lean Enterprise Institute, 2015). Due to this automatic stop of the production process the machines within the Toyota Production System can be considered as intelligent machines (Ohno, 2013). This approach leads to quality improvements by eliminating the root causes of defects (Lean Enterprise Institute, 2015). Interestingly, the idea of *Jidoka* has its origins in Sakichi Toyodas' weaving looms. As described in the historical background section, these weaving looms also stopped automatically as soon as a thread tore. Thus, through this concept there is a quality control since no defective parts can pass to the next work station. If the line stops, an immediate investigation to its root causes gets initiated to prevent similar defects from occurring again. Additionally, this approach is also more cost-effective than inspections on a regular time basis subsequent repairs or reworks within the system (Monden, 1993) (Ohno, 2013).

However, the Toyota Production System does not only rely on the autonomation to identify defects within the system. There are also various visual controls to monitor the state of the line as well as the production flow. The most common visual control system within the Toyota Production System is *Andon* and call lights.

Each line within the system is equipped with a call light and an *Andon* board. The call light is used to call a supervisor, maintenance worker or general worker according to the assembly or machining lines problem. The light usually has different colors. Any color represents a different type of needed assistance. To make the lights most visible to the staff they are generally suspended from the ceiling or if impossible in any other most visible location (Monden, 1993) (Ohno, 2013).

Andon is the name of the indicator board that shows when a worker stopped the line. Each worker involved in the production process has a switch that enables him to stop the line in case of a breakdown, delay or defect at his station. In such situation, a red light over the line turns on and the Andon will indicate which process is responsible for the stop of the line. Then the supervisor will immediately go to the workstation to investigate the problem and take the necessary actions to solve the problem (Monden, 1993) (Ohno, 2013). Each light color indicates a different condition or problem with the work station. There are usually five colors with the following meanings:

- Red Machine trouble
- White End of a production run; the required quantity has been produced
- Green No work due to shortage of materials
- Blue Defective unit
- Yellow Setup required (includes also tool changes, etc.)

All types of Andons are turned off when the responsible supervisor or maintenance person arrives at the work station (Monden, 1993).

The use of Andon and call lights shall also create a division of man and machine to create higher humanity on each work station. Furthermore, by taking more attention of each worker on every work station to its process there is an additional visual quality control implemented in the production process (Ohno, 2013).

To determine the root cause of a breakdown, delay or defect on a work station the technique of the 5 Whys is used in the Toyota Production System. Asking "Why?" seems like a quite childish approach but it was one of the favorite techniques of Taiichi Ohno because for him it was important always to understand the context of the problems. Thus this approach became part of the Toyota mentality (iSixSigma, 2015) (Ohno, 2013). The 5 Whys technique is also used in the Analyze phase of the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology. By asking the question "Why?" five time it is possible to peel away the layers of symptoms and can lead to the root cause of the problem. The answer of each question often leads to another question. That is also the reason that the question needs to be asked five or even more times so that really the root cause of the problem can be identified (iSixSigma, 2015).

Thus, the 5 Whys technique is most useful to help to identify the root cause of a problem and also to determine the context between different root causes. It is also considered as the "Thinking people system" within the Toyota Production System. Furthermore, it is one of the easiest tools to use in any process and it does not need any statistical analysis (iSixSigma, 2015).

All elements of the Toyota Production System are somehow related to each other. That means that there is potential of process improvement in each element. Thus, the following section will describe and discuss the methodology of continuous process improvement (*Kaizen*) within the system.

5. Discussion

Kaizen is originally a Japanese life and work philosophy which is nowadays better known as a methodological concept (Ohno, 2013). *Kaizen* is a continuous improvement process that tries to improve product as well as internal processes (e.g. Development, Production, Distribution, Sales, etc.) The goals of *Kaizen* are to create quality from the beginning and standardization of operations in accordance with the considerations of the involved employees by identification with the task and correctly follow the self-imposed standards. Furthermore, it is Kaizen' goal to achieve a conscious and responsible avoidance of waste of resources (e.g. time, materials, etc.) and the workers encouragement of independent detection and elimination of vulnerabilities within the system (Gabler Wirtschaftslexikon, 2015).

There are two different types of *Kaizen*. Both of them need daily activity. The first type is maintenance *Kaizen*. The task of this *Kaizen* type is to deal and react to unpredictable events like mistakes, breakdowns, changes or variations that can occur every day in order to meet the expected standard. The goal is to bring the system back to the standard. The TPS is designed to identify problems quickly to eliminate them. As explained earlier, due to visual controls it is even possible that the whole process will closed down. Maintenance *Kaizen* is an urgent and immediate approach in which the work group in charge is expected to select the right

measurements to make sure that this event will not recur (Liker & Convis, The Toyota Way to Lean Leadership, 2012).

The second type of Kaizen is improvement Kaizen. This type is usually simply called *Kaizen* and it represents the real goal of the Toyota Production System. It does not only maintain the standards within the whole system like the maintenance *Kaizen* it rather tries to improve the standards and bring them to the next level. It does not matter of how many improvements were already done within the system because every process contains waste at any stage which leads to the opportunity of continuous improvement (Liker & Convis, The Toyota Way to Lean Leadership, 2012). Following, the improvement *Kaizen* is simply called *Kaizen*.

Kaizen requires a cooperative management style. This management style demands various principles of work organization. A principle of that work organization is that cross-functional and interdisciplinary collaboration in groups are needed. Furthermore, consensus decisions instead of individual decisions by superiors as well as common formulations of goals are required. Moreover, the information transfer from top to the bottom of the organization and vice versa is another important aspect of the concept (Gabler Wirtschaftslexikon, 2015).

By using techniques and tools – such as 5 Whys - of continuous process improvement any types of waste can be reduced to achieve the goals of the Toyota Production System. The foundations of the TPS represent the basis for successful daily *Kaizen* by creating smooth and standardized processes which help to eliminate internal and external variations.

Additionally, the pillars of the TPS make it breakdowns, delays and defects more visible by reducing the inventory and lead times as well as the opportunity of stopping the whole process. That means, this concept makes it possible to identify and eliminate problems within the system and to implement process improvement solutions.

The biggest misunderstanding of *Kaizen* within the Toyota Production System is that there is no more need of it due to its application over decades (Liker & Convis, The Toyota Way to Lean Leadership, 2012). However, especially due to the fast developing information technology, there are continuously new potentials of improvements within the system.

6. Summary

This paper describes the key elements of the Toyota Production System and it gives an idea of its complexity. It shows that the concept of *Kaizen* within this system represents a major key role which has an impact on every other element from the bottom to the top of the TPS-House.

Kaizen is without any doubts a core value of Toyota and the company is famous for making several hundred thousand Kaizen proposals every year as well as their implementation. (Fujimoto, 2012). It is impossible to maintain the gains from a lean approach unless there is a focus on continuous process improvement. That means that Kaizen is daily business within the Toyota Production System and also needs continuously new inputs. Without new inputs there would not be any improvements within system and Toyota would lose its core value. Many improvements of Toyotas processes are based on small and incremental changes which are created and implemented by the lowest management level (Liker & Convis, The Toyota Way to Lean Leadership, 2012). This excellence of processes and added value by workers of any level within the system shows the power of simple techniques of *Kaizen*.

However, it does not mean that Toyota is only implementing small changes and improvements to its system. Kaizen is used at different levels and by different functions. For instance, senior managers are expected to lead process improvement activities which have huge impacts across many different functions up to major changes to the whole system (e.g. production control transforming the entire logistics and delivery system to a higher performance level) (Liker & Convis, The Toyota Way to Lean Leadership, 2012).

Thus, the concept of continuous process improvement (*Kaizen*) can be implemented in any level of an organization as well as in any type of industry. There are processes in every task which have potential for improvement, especially through the continuous increasing use of information technology and digitalization.

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