Professional MBA

Automotive Industry

Production system for component manufacturer

A Master's Thesis submitted for the degree of

"Master of Business Administration"

supervised by

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I dedicate my master thesis to all those companies in the automotive industry which do not fear changes and which passion for further progress and perfection is unlimited.

Affidavit

I, **Barbara Strašek**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Production system for component manufacturer", 92 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 23.01.2012

Barbara Strašek

Signature

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List of abbreviations

APS: Audi Production System

CIP: Continuous Improvement Process

FPS: Ford Production System

FTPM: Ford Total Productive Maintenance

JIS: Just in sequence

JIT: Just in time

MBA: Master of Business Administration

MPS: Mercedes- Benz Production System

NPW: Nissan Production Way

OEE: Overall Equipment Efficiency

OEM: Original Equipment Manufacturer

PDCA: Plan Do Check Act

PPM: Parts Per Million

PPS: Porsche Production System

PS: Production System

QM: Quality Management

ROI: Return on Investment

RPS: Renault Production system

SMED: Single Minute Exchange of Die

SPS: Synchronized Production System

SQC: Statistic Quality Control

TQM: Total Quality Management

TPM: Total Productive Maintenance

TPS (SPT): Toyota Production System

TUW: Technische Universität Wien (Technical University Vienna)

VPS: Volvo Production System

WCM: World Class Manufacturing

WIP: Work in Progress

VW: Volkswagen

Abstract

In the fast changing environment companies have to be more and more flexible, agile and lean in order to keep the current position on the market, to stay competitive or to become even bigger and to grow market share. The challenges and the cost pressures are very high in the automotive industry and with the globalization and new markets suppliers are facing not only tough customer requirements but also tough competition. In order to improve the most important three focuses of each company: quality, delivery time and costs in constantly changing and very unpredictable times, it is necessary that companies form their own production system.

As there is no concrete information in the literature how to build an effective production system, the main objective is to develop the production system for the component manufacturer in the automotive industry.

With different research methods: inductive and deductive method, comparative method, descriptive method, analytical method, compilation method, analysis and synthesis; and various literature studies and sources the main research questions were analyzed and answered.

The result is developed effective production system model with specific design and 10 elements for the component manufacturer in the automotive industry. The elements are divided into three groups: basics elements (5 elements), pillar elements (4 elements) and roof element (1 element).

The developed production system model can be a helpful tool for all those companies or suppliers which would like to progress even faster and manage all the market and customer challenges without much stress and risks.

keywords: production system, elements of the production system, design of the production system, OEMs, component manufacturer, basics elements, pillar elements, roof elements.

1 Introduction

Customer is the king! This is not only the sentence that you say to your customers, but it should be the way of life for the entire company. Sooner all employees at all levels in the organization will start working as their main focus is satisfaction of the customer needs, sooner the company will have better results and their customers will be happy.

Customer needs are mainly focused on three things:

- **Quality**: Customer wants to receive quality according to their requirements and expectations. Non quality products present trouble to our customer such as bad final product, additional costs, additional time spent resolving the claims (waste), production stops, checking of the corrective actions at the supplier… In our company we say that the quality, not the price, is the argument in sales. You can have the lowest price on the market, but if you have quality problems, then in the long term, your lower price is not the competitive advantage anymore. Customers should take the whole picture into the account when discussing about the competitiveness of the suppliers.

- **Delivery**: With introducing lean manufacturing the delivery has become more important for the customer and for the supplier as well. Reducing inventories at companies has brought good financial results to the companies, but more responsibility and dependence on the material planning and logistic departments. Especially after 2008, because of the financial crisis, the higher flexibility is demanded on the market. Suppliers receive no more trustable long term forecast for the production planning, material ordering or production itself. The orders are fixed in most of the cases for maximum one week and then it depends on the supplier how good he is in delivering to the customers exactly according to their requests. By introducing JIT and JIS customers and suppliers have become more and more connected and dependent on each other. If a customer has an unreliable JIS supplier he risks that because of the non delivery the whole production or assembly line stops. So it is really important that the reliable suppliers are chosen and that the

trustful relationship with the on time right information exchange is built between customers and suppliers.

- **Costs**: Costs pressure is with the quality and delivery the only constant point at the today changing automotive world. On one hand we have customers' demands that down the supply chain require cost decreases each year, while on the other hand we have more and more unpredictable market situation with very volatile risks and prices at the black metallurgy markets / materials. As the pressure for the cost reductions from the customer is constant from year to year it is also constant the pressure for the costs increase. Despite the material prices, there are many costs that are increasing in the companies: salaries and wages, electricity, taxes, inflation, interest rates… The company has to find right answers for the both challenges.

If we look at all three above described important components in reality, we find out that the today problem of the OEMs and big automotive suppliers is in their organization. They are organized so, that purchasing has its own goals and it is measured by the savings they are able to achieve each year. Quality department is focused on the quality of the products and wants to have only suppliers with no bad quality parts and no claims, as by this they will have no problem in the production or assembly. Logistic department wants to receive the right parts in the right quantity at the right time. They want to have reliable suppliers which are flexible enough to except everyday changes in the schedules without any problems. At the end of the day it is always purchasing department who takes the decision which supplier will get new or additional orders and sadly it is true that in most of the cases the supplier which has the lowest price is chosen, even though his quality and/ or delivery performance is poor. Such decisions are definitely not in favour of the customer company as they create a lot of indirect costs and different kinds of waste in the company. For the right decisions the companies should always look at the whole picture.

Anyway it is not the suppliers' role to take care of the organization of the customer or to try to change them, but to develop the most efficient way how to meet their

requirements and expectation in the most quality, delivery, cost efficient and satisfactory way.

One important and historically proven way of creating a system that will help the organization to cope with all the increased demand and requirements from the customers and markets is to create a production system.

1.1 Motivation

It is said many times that in the today global world the only constant is change. The companies have to be more and more flexible, agile and lean in order to keep the current position on the market, to stay competitive or to become even bigger and to grow market share. The challenges and the cost pressures are very high in the automotive industry and with the globalization and new markets we are facing not only tough customer requirements but also tough competition.

I am working for an automotive tier 2 component supplier. When I was thinking and choosing the topic for my master thesis I always had in mind the practical application of it. What added value will it bring to my work and my company? How can I help our company to progress even faster?

I got the idea for my master thesis during the MBA excursion to VW Slovakia in Bratislava, when they presented us new VW production system with which VW wants to become by 2018 number one OEM in the world. During the MBA lectures when we learned more about the production system I realized that having its own specific production system could be one way how to reduce the negative market influences and risks.

It is also for component manufactures important to think in the same way as OEMs think. Our company is already achieving extremely good results in terms of quality (achieved 2,5 PPM and less then 1,8 claims per million supplied parts in 2010) and delivery (100% delivery in 2010). By that we are also A suppliers for all of our customers and for some of them we became even S (strategic) suppliers. Even though our customers are satisfied with us they are setting each year higher requirements and targets. In order that our company will be able to meet all the requirements of the customers on one side and to achieve that as smoothly as

possible and with the minimum costs on the other side, it is necessary to introduce and implement a production system. To put on the right position and fine tune already existing elements in the company and to introduce the new elements, which have to be implemented.

1.2 Research focus and problem

The research topic of my master thesis is the automotive production system. The research problem of the thesis derives from the fact that there is no concrete information in the literature how to build an effective production system for neither OEM neither tier 1-n suppliers. That is why it is difficult for the automotive companies to start developing their own production system.

1.3 Research questions

From the research focus and research problem I have developed following research questions:

- Which OEMs have developed and are using their own production systems?
- What is the structure and design of each of the existing OEM production systems? How do they look like?
- How many and what elements contain analyzed OEM production systems?
- Are there any elements that are common in all of the analyzed OEM production systems?
- What are the main features of the common elements in the production system?

1.4 Research aim

The research aim of the master thesis is to develop a production system design with selected elements for the component manufacturer. The clear distinction of the two stages of the development and implementation of the production system has to be defined: the short term (the basics of the production system) and the long term (elements which can be implemented only when the basic elements already exist in

the company – pillars and roof). The suggested production system has to help the company to be even more lean, flexible and agile.

1.5 Structure of the thesis

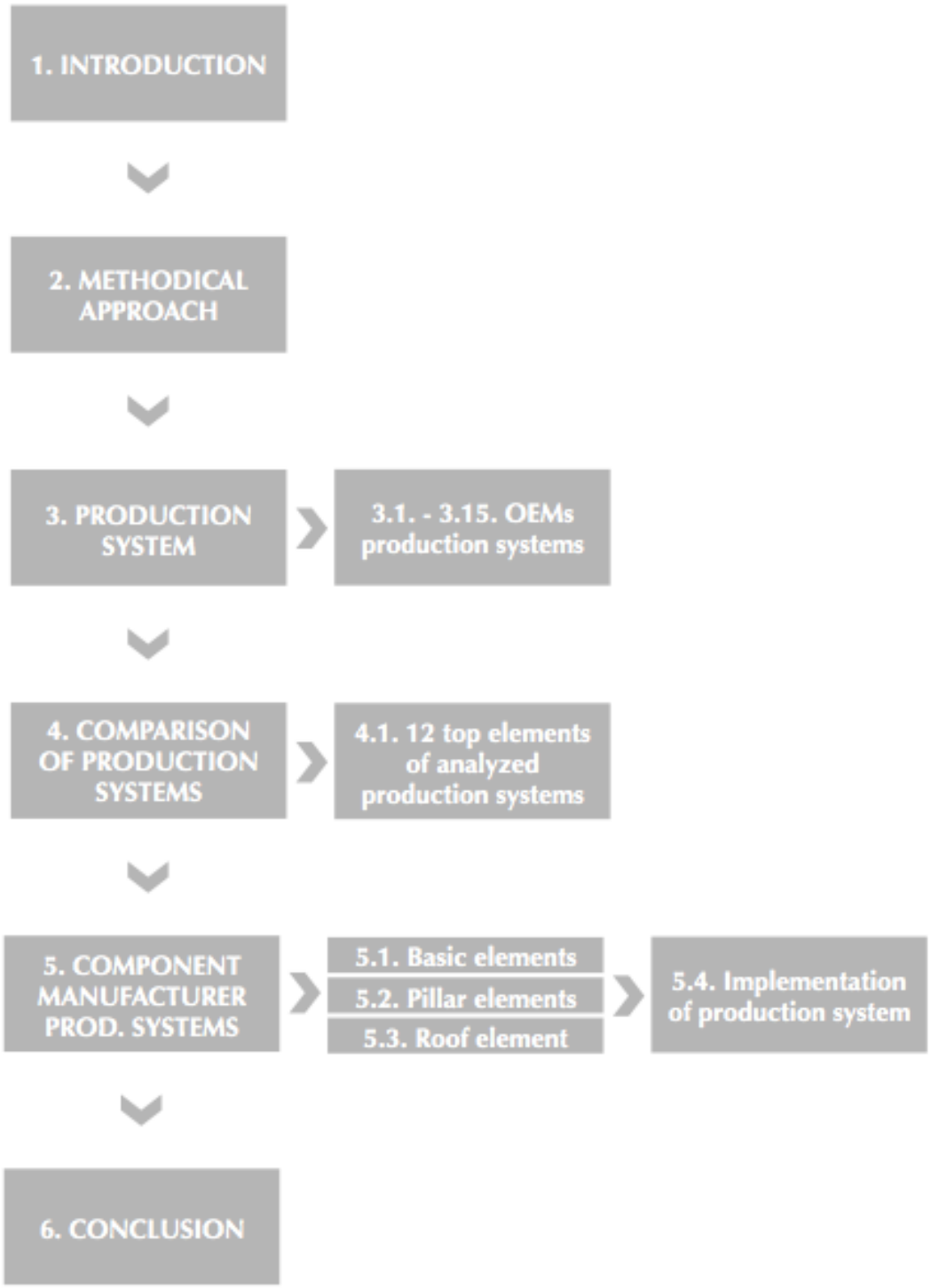


Figure 1-1: Structure of the thesis

2 Methodical approach

In my master thesis I have been using different research methods: inductive and deductive method, comparative method, descriptive method, analytical method, compilation method, analysis and synthesis.

At the theoretical part of the research I have mainly used the compilation and inductive-deductive method by which I was able, based on the different literature, thoroughly and systematically show the meaning of the production system for a company.

Method of qualitative and also quantitative analysis was used in the master thesis where different OEM production systems were compared (comparative method) and the most important elements of the production systems were defined and described (descriptive method). For the practical part of forming the production system for the component manufacturer the synthesis method was used.

2.1 Literature study

Quality literature study is important for both theoretical and practical part of the master thesis. It is important to find updated relevant information. On production system topic it exist a lot of literature in English and also in German language, which presented an additional challenge for me. It is important to create in the beginning a critical list of all relevant literature according to the research problems, questions and aims.

2.2 Information retrieval

I have been gathering the information from the different sources: TUW On line library, National University Library in Ljubljana, already existing and new bought personal books, internet sites of the OEMs, available industry data, articles from conferences and different business magazines and presentations. It was necessary to sort out from the huge number of all information only the relevant ones. All literature details are shown at the end of the master thesis under the section Bibliography.

3 Production system

In order to improve the most important three focuses of each company: quality, delivery time and costs in constantly changing and very unpredictable times, it is necessary that companies form their own production system. The production system has to be in line with company vision and long term strategy.

Let us first look what is a production system and what different definitions of the production system say.

According to Abele et al (Abele et al. 2008: 313) production system it is a set of principles and methods that are integrated for achieving long term improvements in efficiency and quality.

Encyclopaedia Britannica says that production system is "*any of the methods used in industry to create goods and services from various resources. It is a transformation process transforming resources into useful goods and services. When view as a process it consists from two flows: physical flow of materials, work in progress and finished goods; and the flow of information and the inevitable paperwork that carries and accompanies the physical flow*" (www.britannica.com)

According to Production and operation management (Kumar, S. Anil, N. Suresh) (Kumar & Suresh 2007: 3) definition of the production system of the organization is that part of the organization that produces products of an organization. "*It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management.*"

At the lecture of professor dr. Vera Hummel we learned that the production system covers, describes and quantifies all those processes, methods and rules with a company that are connected to production. (Humel: MBA handouts)

To sum up: the production system includes all elements and all connections between these elements that are required for the complete manufacturing of the product/ goods/ services. It is necessary to see the connection and compliance of the

production tasks, which can be characterized through type, quantity and sequence to create the production program.

Why do we need a production system?

Besides the before mentioned improvement of the quality and delivery time, there are two drivers that support the need for the production system: increased complexity and increased cost pressure.

Increased complexity on the market can be seen through increased number of variants, product specialization, increased dynamic and time pressure on the market and through the increased networking and chaining of the business. Cost pressure has always been an important factor, especially in the automotive industry that companies have to fight against and find answers to the increased competitive pressure from the low costs countries, progressive market consolidation, integration of the niche markets through mass production and declining of the quality and productivity benefits as the resources are cheaper in low cost countries.

What are the effects of the production system (Humel: MBA handouts)?

- Transparency and stability of the processes;
- Comprehensive examination of all processes that appear through the life span of a product;
- Company specific selection and best possible application of successive methods;
- Standards that are being continuously improved;
- Concentration of innovative resources;
- Basis for target oriented decisions;
- Guaranteed staff motivation by proactive integration;
- Measurable success and comparability of individual sections independent of business location and function;

- Correspondence between the company's vision and the objectives of the individual sections.

We can say that the production system bundles different production (company) strategies, gives order to the variety of methods and gives standards for processing operational tasks.

The production system originated in automotive industry and it is also nowadays still very important in the automotive industry. The most known production system in the automotive industry is Toyota Production System and because of its success it is nowdays adopted in many other industries. Let us now look at the selected existing production systems of 15 different OEMs.

3.1 Toyota Production System

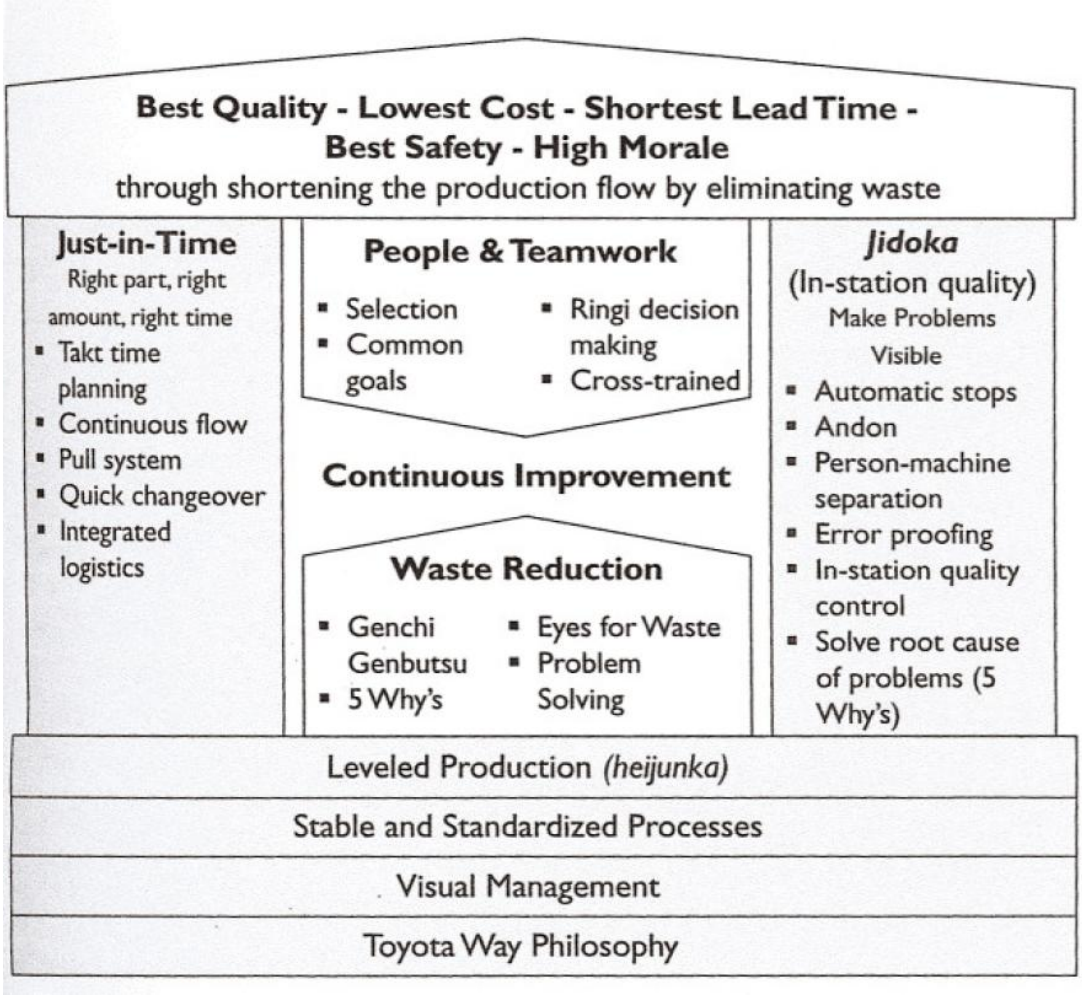


Figure 3-1: Toyota Production System (www.toyota-global.com)

Toyota was not the first OEM who designed their own production system, but it was also the most successful one and is nowdays the base and benchmark for other automotive production systems. The TPS base is the philosophy of the complete elimination of all waste taking into the account all aspects of production in order to use the most efficient methods. By that Toyota is able to increase the quality of the products on one hand and reducing the costs on the other.

TPS was established based on two concepts: JIT and jidoka (automation with a human touch). JIT means that each process produces only what is needed by the next process in a continuous (one piece) flow. The ideal of one piece flow is to make one unit at the time at the rate of the customer demand or takt. Jidoka means that equipment is immediately stopped, when a problem occurs, and by that it is prevented that defective products are produced. (www.toyota-global.com)

TPS house (Figure 3-1) has become one of the most recognizable and used structures for the production systems, not only automotive, in the world. The structure of the house is easy to understand and to follow its philosophy: the house is complete and strong only if the basis, pillars and roof are strong. That means that each element and the process in the TPS structure is important and has to be strong. Even more important is how the elements are connected and the way the elements reinforce each other.

The heart of the TPS is eliminating waste. The first step at applying TPS is examining the manufacturing process from the customer's perspective. Both, the internal and external customers. Looking at the processes through the customer's eyes it is possible to identify value and non value added steps and using KAIZEN to help to eliminate waste from the processes. (Liker 2004:32-33)

Today it is possible to find different versions of the TPS house, but the core principles remain the same. It starts with the goals of best quality, lower costs and shortest lead time as the roof. There are then two strong outer pillars – JIT, probably the most used element of TPS, and jidoka – automation with a human touch. In the centre of the system are people. There are also various foundational elements, which include the need for standardization, stable, reliable processes, and also heijunka, which means levelling out the production schedule in both volume and variety. A

levelled schedule is necessary to keep the system stable and to allow for minimum inventory. (Liker 2004: 32)

Toyota often present the TPS house model with the goals of costs, quality and timely delivery, which actually in their plants follow common Japanese practice of focusing on QCDSM (quality, costs, delivery, safety and morale). *"Toyota with its culture and policy will never sacrifice the safety and health of their workers for production. And they do not need to, as elimination waste does not mean creating stressful and unsafe work practices."* (Liker 2004: 34).

The TPS is not simple a toolkit that consists of different elements. It is not just a set of techniques, but a system based on a structure. It only works as a whole structure with its root focus on supporting and encouraging people to continually improve the processes they are working on. If you simply copy individual elements of the TPS in a new structure and you do not include the important element of people, the purpose is lost. (Liker 2004: 34) Toyota people are empowered, empowered to make improvements. TPS respects employees by giving them the opportunity to enrich their jobs and their life. (Heizer Render 2011: 667)

3.2 Ford Production System

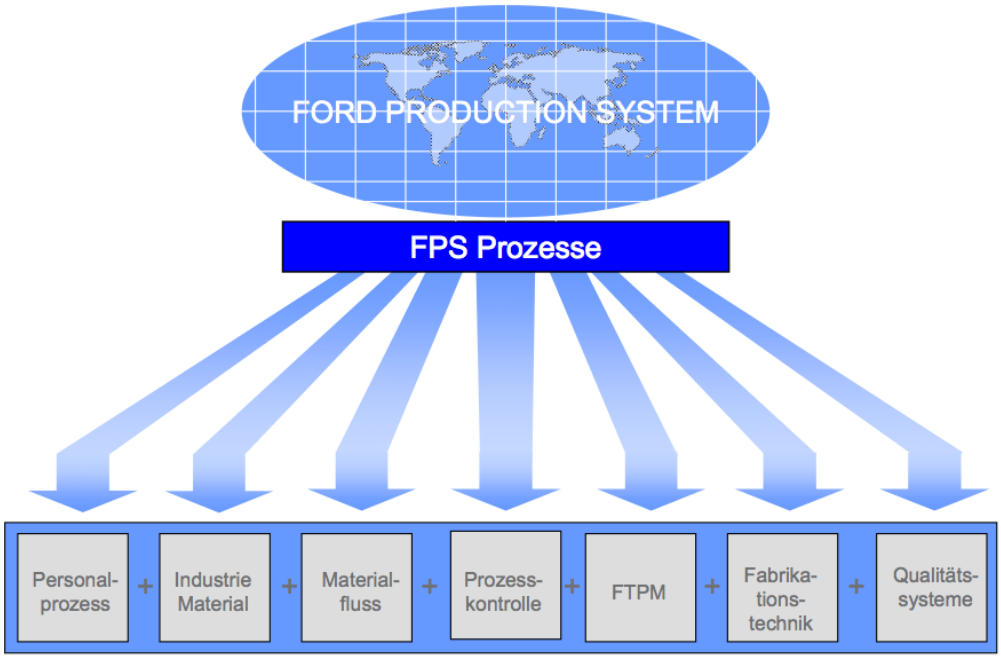


Figure 3-2: Ford Production System (Humel: Automotive MBA handouts)

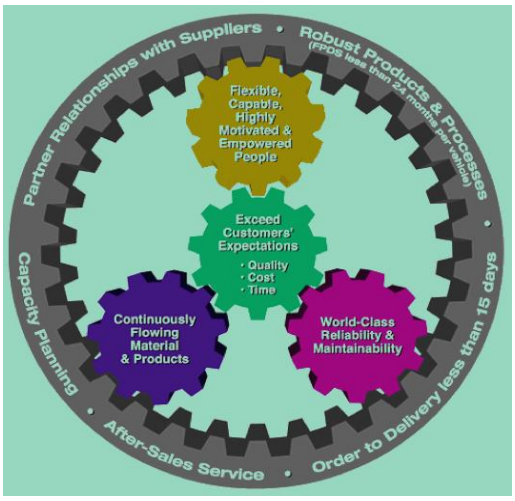


Figure 3-3: FPS Gear Model (www.fordmotorcompany.com)

Figure 3-4: FPS Tree Model (www.fordmotorcompany.com)

It was Henry Ford who was actually the first who already in 1913 in Highland Park created flow production by moving assembly belts which increased the productivity of the plants enormously and by that created the base for the TPS and other production systems. It was Henry Ford book Today and Tomorrow, who astonished several Toyota managers and among other practices from US helped to form today TPS. (Liker 2004: 20)

Ford has later in the mid 1990s developed his production system and incorporated also the key components of other production systems (Toyota, Volvo, Mazda and Nissan) to create new Ford Production System. FPS in nowdays defined by 11 elements: sharp (safety and ergonomics), work groups, managing, materials management, FTPM, industrial materials management, manufacturing engineering, environment, visual factory, quality and training. (Fowler 2001)

They are graphically shown in two ways: as FPS Tree Model (Figure 3-4) which shows that elements need to function together as a system and FPS Gear Model (Figure 3-3) which looks apart from the importance of the system also at the processes driving improvements and the ultimate goal of producing customer value. Three pinion gears (world class reliability and maintainability; continuously flowing material and products; flexible, capable, highly motivated and empowered people) are linked to the central gear that operates the system. The central gear is the gear of exceeding customers expectations in quality, cost and time. (Fowler 2001)

In Ford lean transformational journey one of the key steps was to change to a lean organizational infrastructure that supports the front line workforce – in the shop floor and in the engineering design studio. (www.fordmotorcompany.com)

3.3 Mercedes – Benz Production System (MPS)

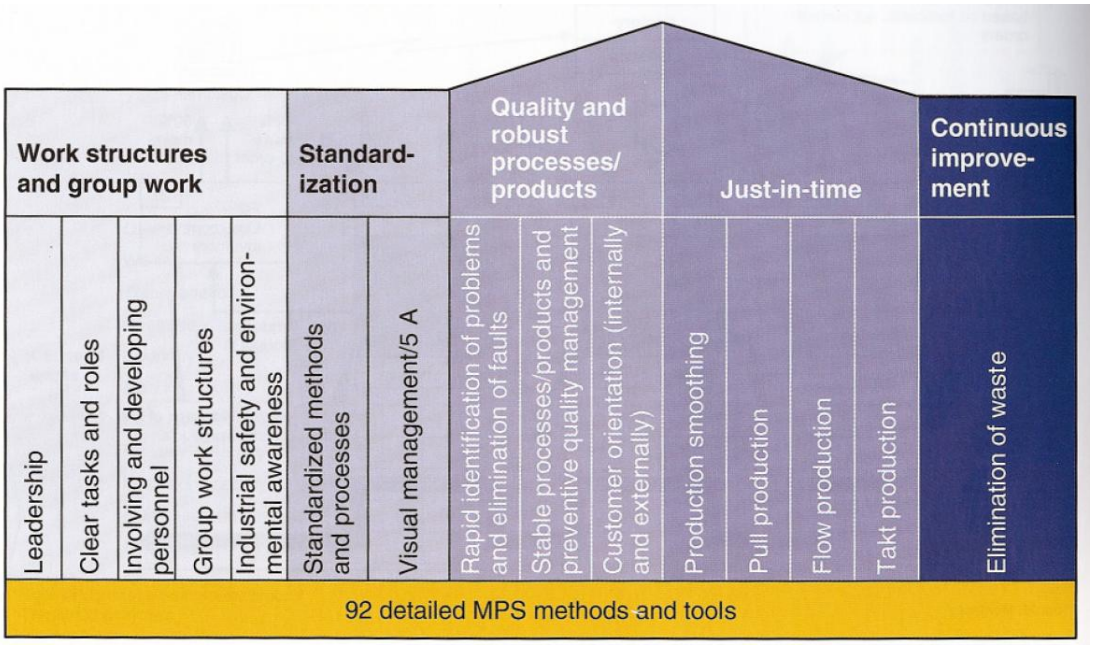


Figure 3-5: Mercedes – Benz Production System (Abele et al. 2008: 316)

Mercedes-Benz developed its production system already in the mid 1990s in order to pursue lean production principles. It consists of 5 subsystems, 15 production principles and 92 methods and tools.

The subsystems represent the main themes in production, whereas the operating principles serve to differentiate between the different aspects of these themes. At the third level are tools. They describe the main methods, the best practice routines used in the production organization throughout the Mercedes-Benz passenger car plants.

MPS is like a toolbox consisting of a clearly identifiable set of tools. The clear structure of the MPS and the listing of MPS methods according to the paragraphs allows users to quickly get an overview of the topics and to find the necessary answers in the tools provided (Haller et al. 2000).

"Guided by production principles shown in Figure 3-5, the underlying processes are foundation for applying lean production methods and striving for continuous improvement – in line with the principles Operational excellence. Improve and carry on improving forever." (Abele et al. 2008: 316-317)

3.4 Opel Production System

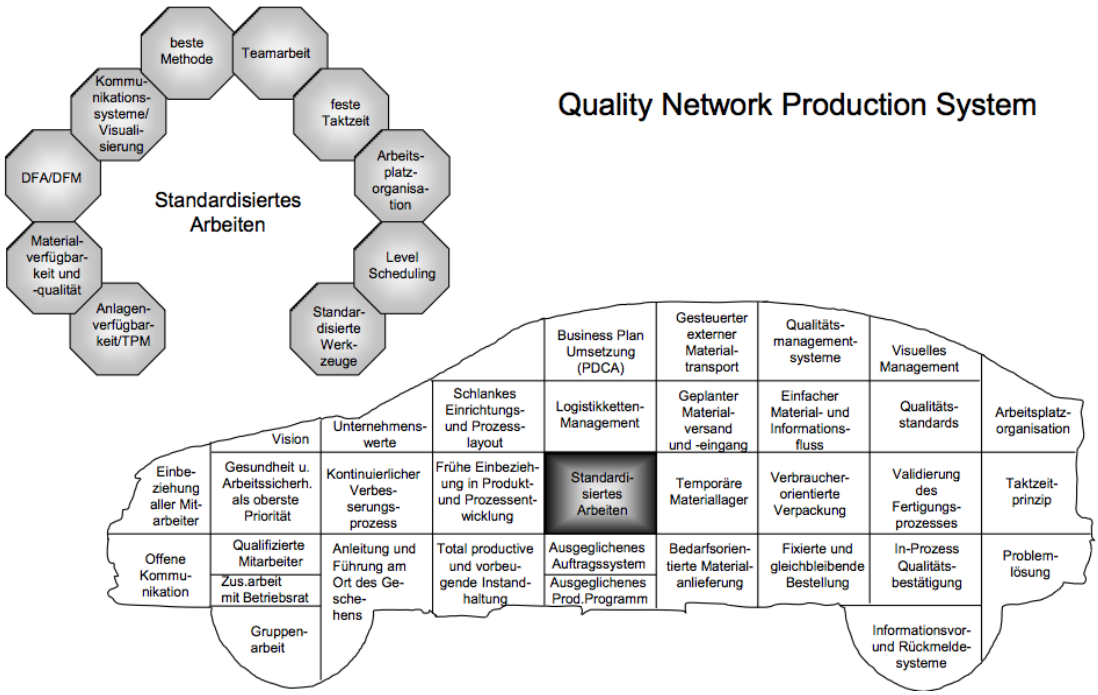


Figure 3-6: Opel Production System (Hoffmeyer 2000: 50)

Looking only at the Figure 3-6 of the Opel Production System it can be easily told that it is so far different from the other OEM production system by 2 things: design and complexity. It is not designed in a house shape but as a car, which make sense in the automotive industry. On the other hand it has by far the biggest numbers of elements presented among all OEM production systems.

With the built production system the main objectives of the Opel are that with the mix of methods, strategies and requirements they increase the productivity, increase the quality, minimize costs, include workers, improve work by continuous improvement process, shorten the throughput times, strong leadership, and standardization. (Hoffmeyer 2000: 50)

3.5 Volvo Production System (VPS)

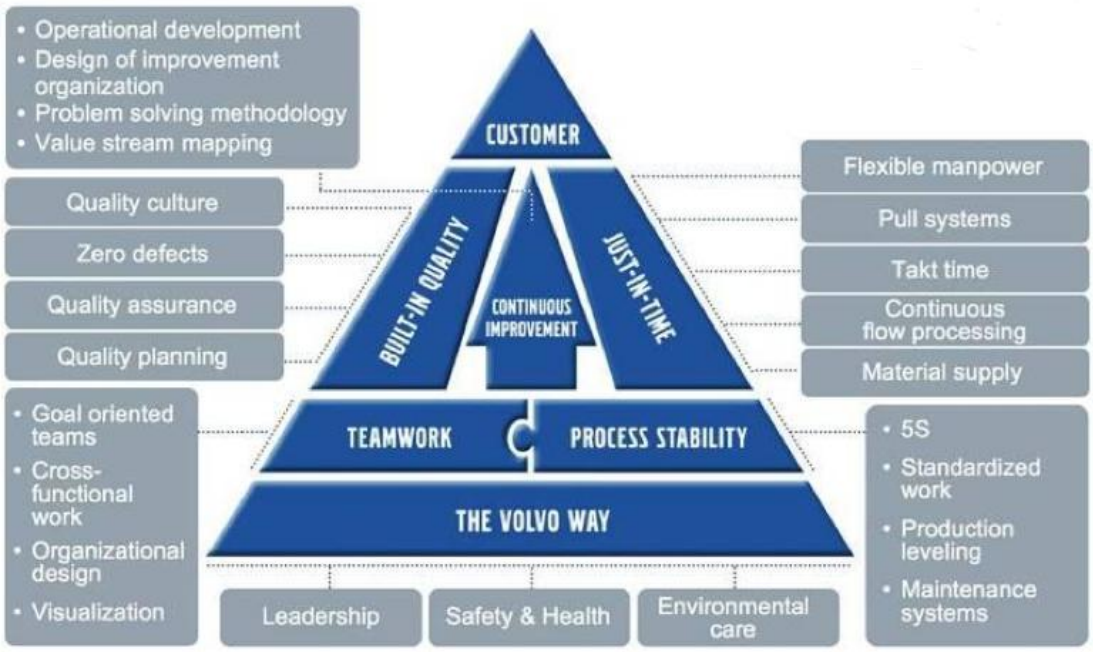


Figure 3-7: Volvo Production System (www.volvogroup.com)

The new Volvo pyramid structure of the production system was established at the end of 2008, so it is pretty new.

The main objective for Volvo in forming the VPS was to achieve world class performance, by three ways of creating value:

- To create value for their customers through securing the quality and delivery times and to lower the costs.
- To create value for their employees through safe and environmentally sound workplace. To realize full potential of employees by focusing on continuous improvement and value added activities.
- To create value for their owners by reducing waste, reducing costs of poor quality, drive and support commonality and to reuse the best practices across business units.

VPS covers three important dimensions: Vision, 5 principles and Modules with tools and techniques.

VPS vision is the organization where quality, delivery and productivity are continuously improved. Everything is done in The Volvo Way – including Volvo values, Culture and Leadership.

VPS 5 principles are: teamwork, process stability, continuous improvement, JIT, built in quality. They guide Volvo to reach their vision of continuously improved quality, delivery and productivity. They also help and support the implementation of the vision and daily maintenance of the production system.

24 VPS modules are building the knowledge how to use a tool and what should be the ideal state. The modules have different tools and techniques that once, they are applied they focus on the material and information flow and through that they drive continuous improvement activities and behaviours. (www.volvogroup.com)

3.6 Volkswagen Production System

Volkswagen built its production system because of 10 reasons: utilization of resources, quality improvement, cost reduction, consistent appearance, customer satisfaction, risk reduction, complexity, market share, continuous growth and financial stability. (VW MBA lecture 2010)

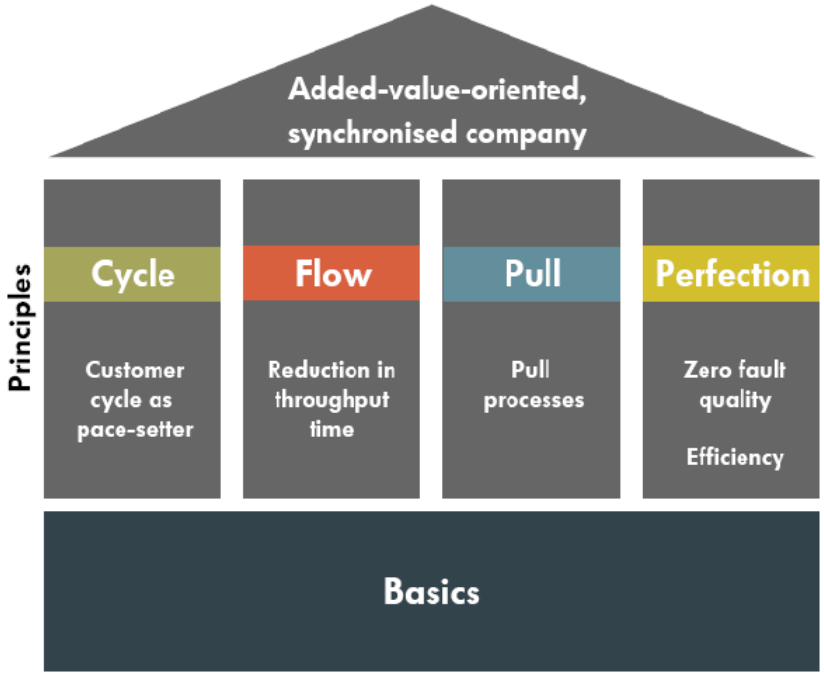


Figure 3-8: VW Production System (VW MBA lecture 2010)

VW designed its production system in a shape of the house with the basic elements which main objectives are systematic and sustained elimination of any waste, standardized working practice and visual management, smooth and even production and employee oriented labour organization.

On the basics stand 4 pillars: tact, flow, pull and perfection (VW MBA lecture 2010).

The objectives of the tact pillar are that customer cycles create lean production system's pulse, fixed customer cycle are the basis for eliminating waste, harmonization of all working processes, cyclical, standardized and non waste working practice.

The objectives of the flow principles are: continuous production by coupling and aligning all processes, reduction of through put time by reduction of floating stock, continuous piece production.

The objectives of the pull principles are: the downstream process only collects parts/ information required from the previous process, keeping stocks at minimum and reducing the throughput time.

And the objectives of the perfection principle are: stabilization and constant improvement (optimization) of all processes within the company (zero-fault strategy), safeguarding quality through processes and product efficiency and fault prevention, fault detection, fault feedback and permanent fault rectification.

By the basics and 4 principles VW wants to achieve its vision to become in 2018 added value oriented, synchronized company based on the best production system.

3.7 Audi Production System (APS)

APS as Opel Production System has a shape of a car, but compared to Opel with less, 10, elements: group work, CIP, TPM, visual management, standardized work, standardized quality, work organization, material system, environment and MBO.

The main objectives of APS are easier communication, less waste, stabile processes and stabile quality.

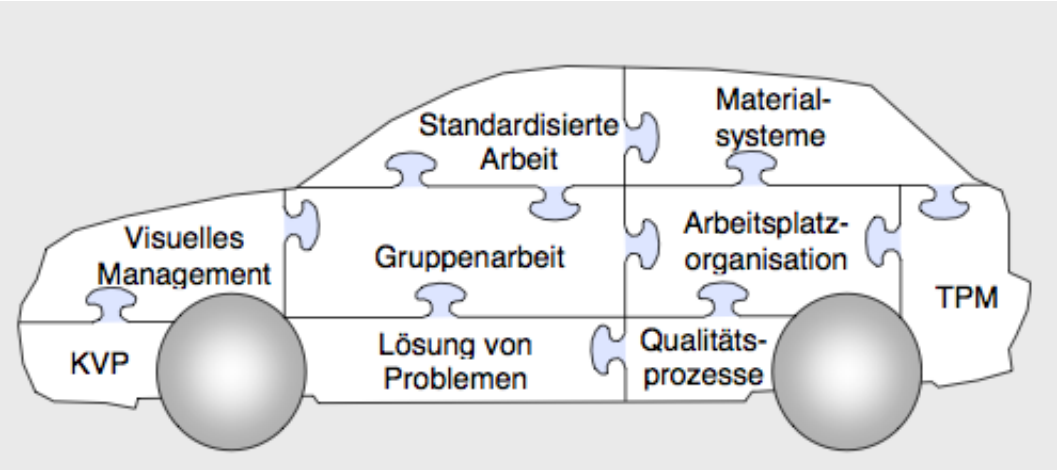


Figure 3-9: Audi Production System (Spanner & Ulmer 2000: 60)

Interestingly Audi has also continuous improvement of APS that enables Audi to have always updated APS according to their needs.

They have learned through the past many important lessons that they are now using when implementing APS: to give more emphasis on learning to see waste, easier and flexible implementation, flexible standards, training and motivation of the employees, consequences of the implementation, long-term strategy.(Spanner-Ulmer 2000: 60).

3.8 Porsche Production System

Figure 3-10: Porsche Production System (www.porsche.com/international)

Porsche has developed its production system based on lean management and principles in order to achieve 3 goals (www.porsche.com/international):

- Improve quality, deliveries and costs;
- Increase the productivity
- To give creativity more space.

The Porsche house stands on four principles (www.porsche.com/international):

- Flow principle has the goal to realize flow production through coupling and alignment of the processes.
- The goal of tact principle is to achieve rhythm through harmonization of the labour content.
- Pull principle's goal is that the following process gets only the parts that it needs for the production.
- The goal of zero defects principle is to improve and stabilize all processes.

All 12 elements of the PPS are presented also in the Figure 3-11, which are all pointing to the central PDCA circle.

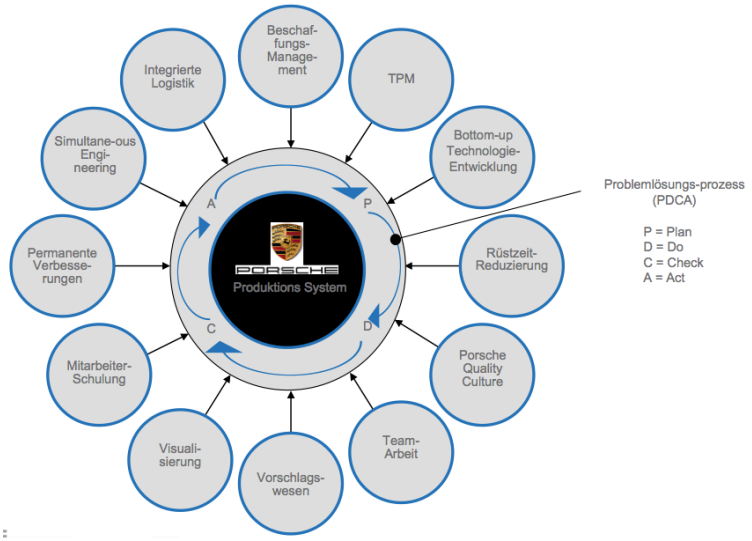


Figure 3-11: Porsche Production System elements (Humel: MBA handouts)

3.9 BMW Production System

BMW Production System consists of two parts: 3 core elements CIP, integration of the task and cooperation form (i.e. group work) and 10 basics elements.

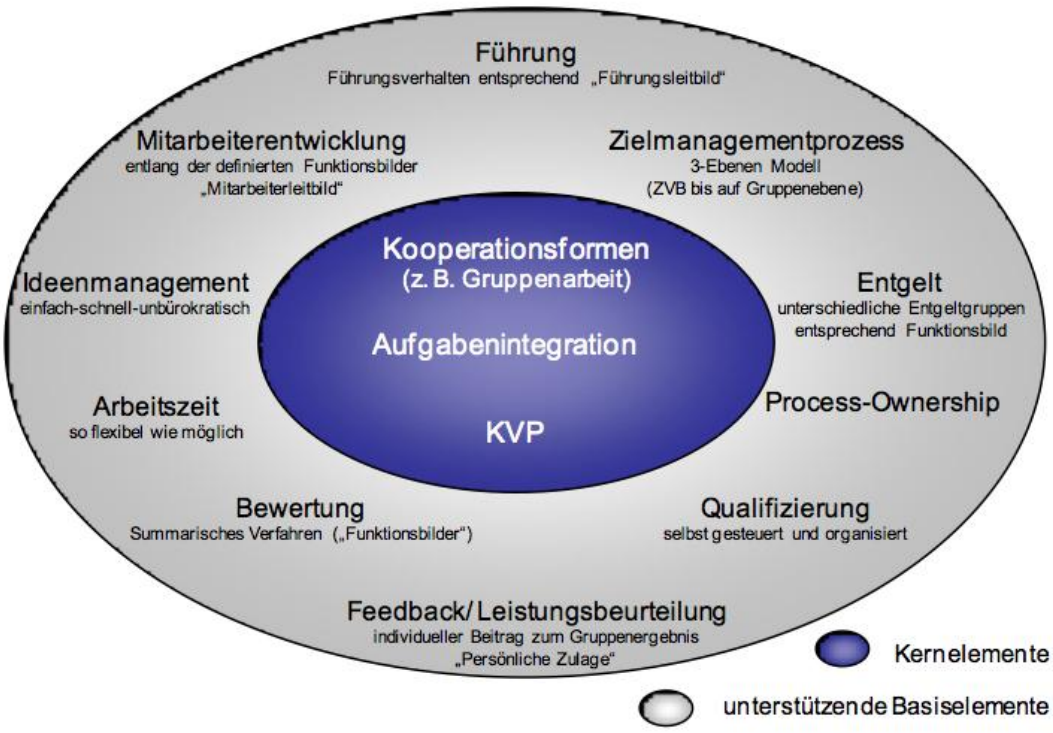


Figure 3-12: BMW Production System (Humel: MBA handouts)

BMW has introduced in the past highly flexible production system and manufacturing planning, by which they were able to fully utilize their plants and to reduce overall costs.

BMW core competence is flexibility. They are able to react quickly and flexibly to the fluctuations on the market and to the individual wishes of their customers. Flexibility for BMW means the ability to shift production of different models among different plants and demand shift in different global markets. (www.bmwusfactory.com)

3.10 Nissan Production System

Is also known as Nissan Production Way and has two features (www.nissan.com):

- Never ending synchronization (Douki) of manufacturing with the customers with two objectives: on time deliveries of the products and services to the customers and reduction of lead times for production and development to synchronize the production with customers as closely as possible.
- Never ending quests to identify problems and put in place solutions.

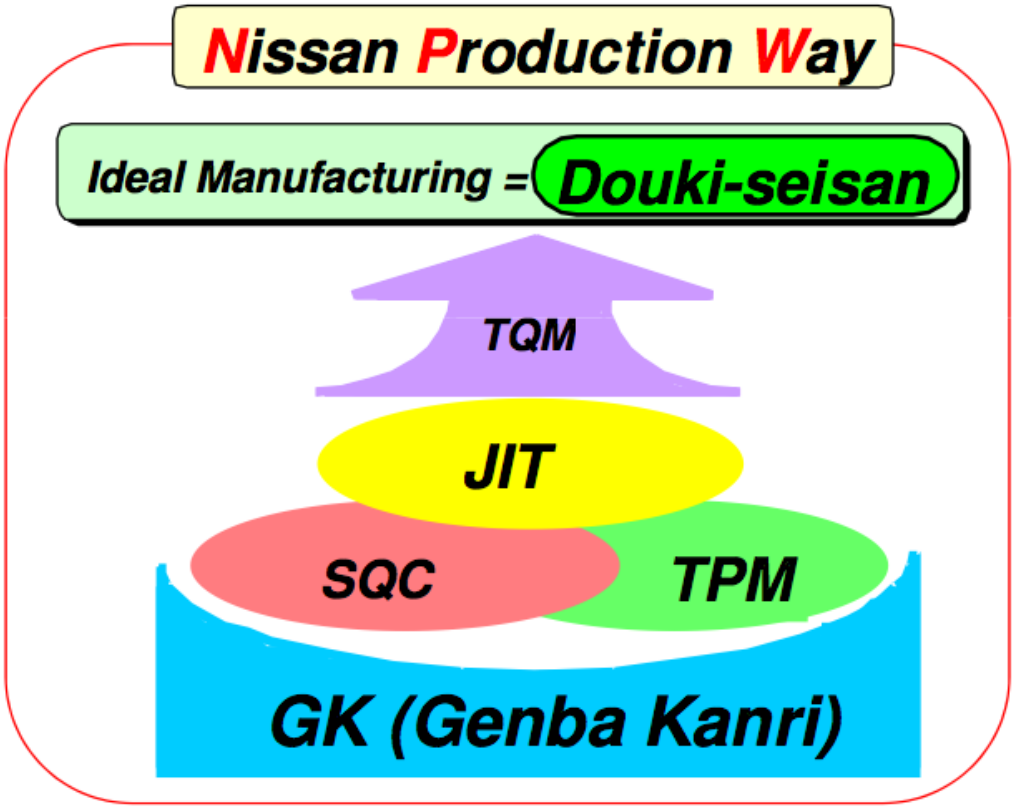


Figure 3-13: Production System (www.nissan.com)

As it is seen from design of the NPW the basis is Genba Kanri – shop floor management which with the help of four elements (SQC, TPM, JIT and TQM) brings to Douki seisan (Ideal manufacturing).

3.11 Renault Production System

RPS has some of its elements adopted from the NPW and by implementing it according to the Renault-Nissan alliance annual report from 2009 increased the productivity by 15%.

RPS is based on two fundamental principles: coordinates quality control and lean production. One of the important objectives of the RPS is also customer satisfaction by achieving expected quality for internal and external customers, reduction of production costs, manufacturing of the right products at the right time and promotion of personal accountability and mutual respect. (www.renault.com)

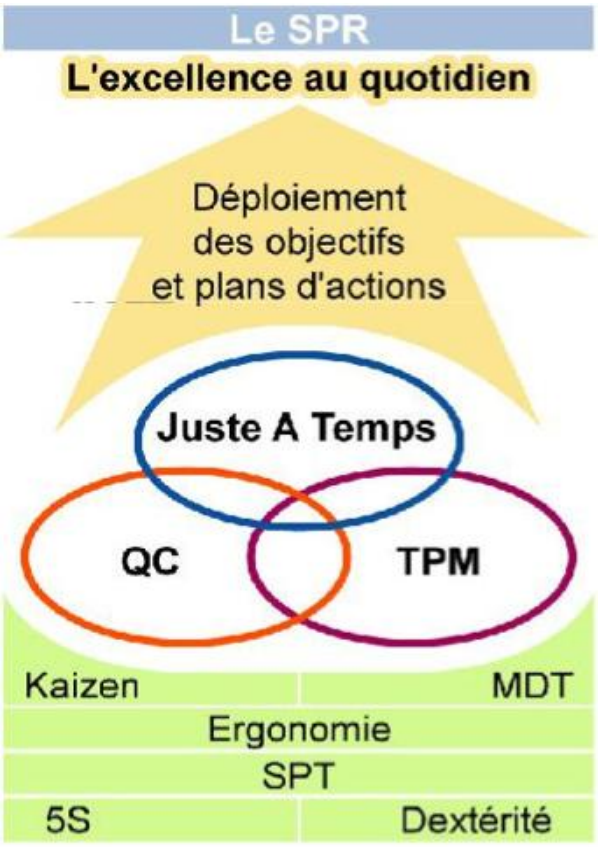


Figure 3-14: Renault Production System (www.renault.com)

The 6 basic elements of RPS are 5S, dexterity, TPS, ergonomics, MDT and Kaizen. It is especially interesting that Renault is the only OEM that has in its production system as one of the basic element TPS.

With 6 basic elements and 3 core elements (QC, JIT and TPM) Renault target is to achieve objectives and plans on a daily level. (www.renault.com)

3.12 GM Production System

GM developed its production system which is called Global Manufacturing System in order to implement lean thinking leadership, to achieve exceptional business

results, to sustain performance improvement and to fight the competition. (www.gm.com)

Figure 3-15: GM Production System (www.gm.com)

Figure 3-16: GM Production System elements (www.gm.com)

GM Production system consists of 5 principles which are forming 5 orbits:

- Continuous improvement – GM fosters attitude which nurtures change and supports all employees in improving their own jobs and environment for the continuous improvement of the company.
- People involvement – GM recognizes its employees as the most valuable resources and provides support to allow employees to work in a motivated, empowered and particular way.
- Standardization – A dynamic process by which GM documents, follows and performs work according to the core standards, terminology, principles, methods and processes to achieve a common base from which to improve.
- Built in quality - Quality expectations are achieved in each process to ensure defects are not passes on to the next processes.
- Short lead time – GM target is reducing the time from the placement of the order by the final customers to the delivery of the product and receipt of the payment. There are three types of lead time: Total Lead Time, Product Development Lead Time and Process Lead Time.

Within each of these principles are several elements (33 in total) which are together answering the questions what, why and how to organize manufacturing operations in order to eliminate waste. (www.gm.com). They are graphically shown in Figure 3-16 in the shape of the truck.

3.13 Suzuki Production System

SPS is a system of concepts, philosophies and rules how to run a business (Chacon, Hawkins 2004: 9.162). As many other production system was also developed from TPS. The base of SPS is standardized work on which five equally important pillars are built: 5S, Kaizen, Level Production, JIT and Quality in station (www.globalsuzuki.com).

SPS has three main objectives:

• Ensures a safe working environment when producing high quality, low-cost products.

• Lowering the unit costs by continually identifying and eliminating waste.

• High flexibility that allows quick reaction to changes in the market or product. This offers a competitive edge of Suzuki in the global marketplace.

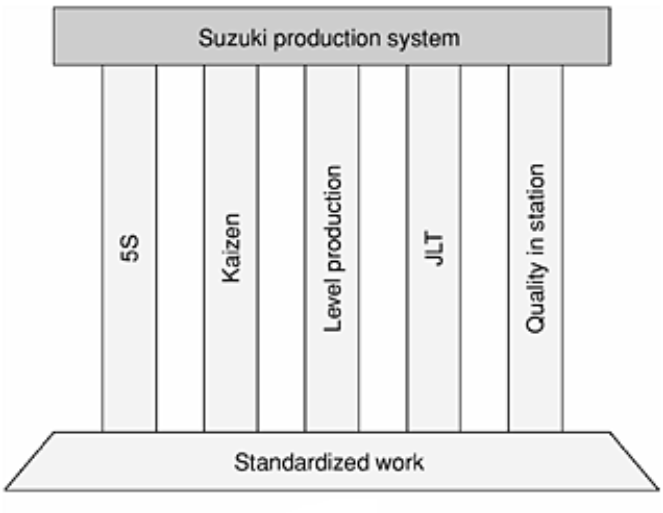


Figure 3-17: Suzuki Production System (Chacon & Hawkins 2004: 9.162)

3.14 Fiat Production System

Fiat PS pyramid consists of 5 basic pillars: Leadership, Involvement Safety Standardization, Audit, Standards and Tools and Methods and 4 roof elements: Workplace Organization, Quality System, Maintenance System and Logistic System.

All activities behind Fiat PS are oriented to the 4 goals: zero accidents, zero waste, zero breakdowns and zero inventories. (www.fiatspa.com)

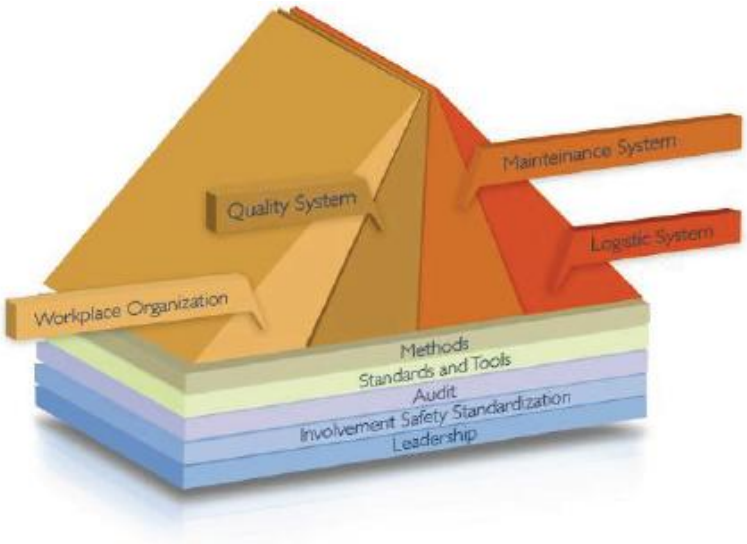


Figure 3-18: Fiat Production System (www.fiatspa.com)

To improve PS Fiat has also developed its own WCM (world class manufacturing) system. Fiat WCM consists of 10 technical and 10 managerial pillars shown in the figure 3-19. Each of 20 pillars brings company incremental levels of improvement and results that can be clearly seen and measurable. The objective of the Fiat WCM is continuously improvement of the production performance and empowering the Fiat PS. (www.fiatspa.com).

Figure 3-19: Fiat world class manufacturing (www.fiat.com)

3.15 FAW Production System

The third most productive Chinese automaker FAW has also formed its own production system in 2007. It is design as a stock market symbol – the bull. It consists of 10 elements: process quality control, objective management, standard operation, well balanced production, on time logistics, efficiency, team management, and improvement of all personnel, 6S and talent training.

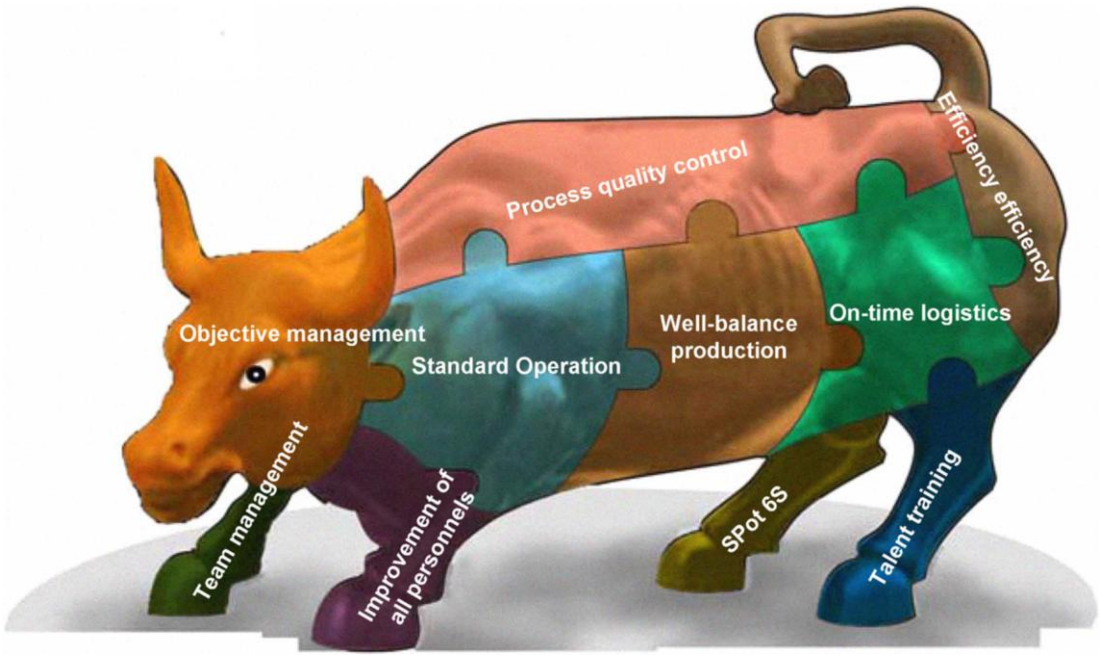


Figure 3-20: FAW Production System (Wang et al. 2010: 576)

In the building process of independent lean production management mode FAW quality control improving activities are regarded as the carrier to learn production pattern of VW and Toyota, through three processes of point-to-surface study, integrated improvement and management innovation. (Wang et al. 2010: 576)

4 Comparison of the production systems

In the previous chapter we have seen the description and the design of each of the 15 OEM production systems. Now let us look at all the elements of each production system gathered and compared together in the Figure 4-1, where different OEMs are listed in the horizontal level and different elements of the production system in a vertical level. The 62 production system elements are listed by the decreasing number of points.

There are 12 out of 62 elements that have 7 or more points and are present in the 47% of analyzed production systems: quality, standardization, work structure- group work, CIP, TPM, 5S, visual management, KAIZEN, JIT, flow, tact times and leadership.

On the other hand we have surprisingly big percentage: 40% of all elements (25 elements) that are present only in one of the production system of the analyzed OEMs.

The structure and the number of elements are really different among all analyzed OEMs. The highest number of production system elements has Opel, with its 21 elements. And it is Nissan who has the lowest number, only 6 elements, creating a production system.

The element with the highest number of points, 13, is quality. Quality is one of the core elements in most of the production systems. We can find quality element specified as TQM, total quality control, built in quality, quality in processes, quality in stations, quality management, stabile quality and standardized quality processes.

It is also interesting that some of the OEM's production systems have been updated in the recent years, especially after the 2008 economic crisis, when new strategies were formed. The two elements that have been added recently to the production systems are work safety and environmental awareness.

no.	element	Toyota	Ford	Mercedes Benz	Opel	Volvo	VW	Audi	Porsche	BMW	Nissan	Renault	GM	Suzuki	Fiat	FAW	Total
1	quality	●	●	●	●	●	●	●	●		●	●	●	●	●	●	14
2	standardization	●		●	●	●	●	●			●	●	●	●	●	●	12
3	work structure and group work	●	●	●	●	●		●	●	●		●	●		●	●	12
4	CIP	●		●	●		●	●	●	●	●	●	●			●	11
5	TPM	●	●		●	●	●	●	●		●	●	●				10
6	visualization (visual managemnet)	●		●	●	●	●	●	●			●	●				9
7	KAIZEN	●		●			●	●			●	●	●	●			8
8	JIT	●		●			●				●	●	●	●			7
9	flow	●	●	●	●		●					●	●				7
10	takt times	●		●	●	●	●					●	●				7
11	leadership	●		●		●				●		●	●		●		7
12	5S	●				●	●					●	●	●		●	7
13	process stability	●		●			●	●				●	●				6
14	pull	●		●		●	●					●	●				6
15	logistic system/management	●			●		●		●						●	●	6
16	training /development of the employees		●						●	●	●					●	5
17	Kanban	●					●					●	●				4
18	Automation	●					●					●	●				4
19	problem solving			●	●	●	●										4
20	work safety		●	●		●									●		4
21	environmntal awareness		●	●		●		●									4
22	level production	●				●								●		●	4
23	participation of all employees			●	●					●							3
24	ergonomics		●				●					●					3
25	OEE										●	●				●	3
26	quick set ups and layouts	●			●		●										3
27	customer orientation			●	●												2
28	process control (statistical)		●								●						2
29	management of ideas/ proposals								●	●							2
30	process ownership		●							●							2
31	assesment/ analysis									●	●						2
32	flexible production	●											●				2
33	qualified employees				●					●							2
34	MBO									●						●	2
35	clear objectives							●							●		2
36	material system					●		●									2
37	value stream mapping						●						●				2
38	poka yoke						●										1
39	level scheduling				●												1
40	professional maintainance														●		1
41	flexible work time									●							1
42	flexible manpower					●											1
43	task intergration									●							1
44	manufacturing technology		●														1
45	technology developmnet								●								1
46	reducing set up times								●								1
47	simultanious engineering								●								1
48	procurement management								●								1
49	shopfloor management										●						1
50	dexterity											●					1
51	smooth production			●													1
52	information system				●												1
53	material planning				●												1
54	corporate values				●												1
55	open communication				●												1
56	easier communiaction							●									1
57	vision				●												1
58	early participation of development				●												1
59	salary system									●							1
60	industry, material		●														1
61	audits														●		1
62	methods														●		1

Figure 4-1: Comparison of production systems

4.1 12 top elements of the analyzed production systems

4.1.1 Quality

Quality of the products and services as meeting customer's requirements is an important competitive advantage that makes a company successful in the long term if

the company quality is also reliable. There are many different aspects of the quality in a company and there is so much literature about quality that I could write a separate paper about this element. It is important that quality is not only task of the management of the production process, but it has to be adopted by all employees in all company processes.

When we look at the quality in the company in a systematic and profound way, aiming at the long term success, benefits and prosperity of all members of an organization, the most appropriate approach is TQM.

TQM is a comprehensive approach to improving competitiveness, effectiveness and flexibility through planning, organizing and understanding each activity, and involving each individual at each level. It is useful in all types of organization. (Oakland 2009: 30)

TQM has been developed through the past decades and it is still developing. There are many quality management gurus whose ideas, principles, tools and approaches are used in TQM. One of the most famous is Mr. W. Edwards Deming, who has introduced 14 core points to help companies increase their quality and productivity and implement TQM:

1. Create consistency of purpose toward improvement of product and service.
2. Adopt new philosophy. Lead to promote change.
3. Build quality in the product: stop depending on inspection to catch problems and achieve quality.
4. Build long term relationships of loyalty and trust, based on performance instead of awarding business on the base of price.
5. Improve continuously and forever every process to improve product, quality and service.
6. Institute training on the job.
7. Adopt and institute leadership.

8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations and targets for the workforce.
11. Eliminate numerical quotas for the workforce and numerical goals for management.
12. Remove barriers that rob people of pride in work.
13. Institute a vigorous program of education and self-improvement for everyone.
14. Put everybody in the company to work to accomplish the transformation.

(Deming 2000: 23-24).

There have been defined also 7 concepts of the effective TQM: continuous improvement, six sigma, employee empowerment, benchmarking, JIT, Taguchi Concepts and Knowledge of QM tools. Additionally to the 7 concepts exist also 7 tools for TQM, which can be divided into 3 groups: Tools for generating the ideas (Check Sheet, Scatter Diagram and Case and Effect – Fishbone or Ishikawa Diagram), Tools for organizing the data (Pareto chart, Flowchart) and Tools for Identifying Problems (Histogram, Statistical Process Control Chart). (Heizer & Render 2011: 232-236)

4.1.2 Standardization

Is the element that reached the second place by being part of the 11 OEMs production systems.

Encyclopaedia Britannica explains that standardization in *"the industry is the development and application of the standards that permits large production runs of components that can be readily fitted to other parts without adjustments."* (www.britannica.com)

Standardization is very much linked to the quality and continuous improvement process. The work has to be first standardized in order that continuous improvement

can be made, otherwise continuous improvement would mean just another way that can be used when performing the work.

Standardization was very effectively used element in the past mainly at Japanese OEMs, but nowdays it is becoming more and more important all over the world, as it is an important tool for fighting the increased complexity and costs in the automotive market.

Standardization is also one of the 14 Toyota Way Principles. It is important to use stable and repeatable methods everywhere in order to maintain regular timing and output at the processes, which is the foundation for the flow and pull principle. (Liker 2004: 140)

4.1.3 Work structure – group work

The same number of points as standardization reached also group work. Group work exists when a number of people are completing the task of the work system and it is contrary to the individual work.

Many companies are realizing that having good work groups (including teams) is more important than having only good individuals. Especially if companies form right work groups, empower people and give them more responsibility, employees will be more motivated and successful in performing good work, eliminating waste and non quality. This is also the right approach as people at the workplace, performing the work every day will have the most ideas how to successfully improve the work and processes.

How important are the right work groups it is also emphasised in the following paragraph: "*The development of effective work groups (including teams) is very important. Group affect individual behaviour, motivation and performance just as individuals can affect the way groups function. Moreover, group behaviour is partly a function of organizational culture, climate, leadership style and other aspects of the organization's environment. The extent to which group goals are consistent with organizational goals is a key factor in the overall success of an organization.*"(French 2007: 95).

4.1.4 CIP

Interestingly it was American W.E. Deming who was teaching and implementing the system of continuous improvement in Japan after the 2nd World War. Deming formed so called PDCA (plan – do – check – act) cycle of continuous improvement in the company. PDCA cycle forms four key stages of managing and continuous improvement of all processes:

- Plan – What to do? How to do it?
- Do – Perform the task/ work as it was planned.
- Check – Has the task/ work been performed or done according to the plan?
- Act – How to improve the task/ work the next time.

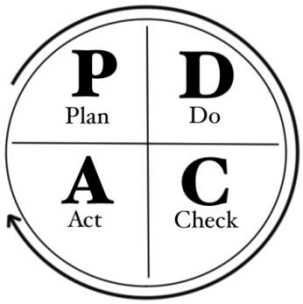


Figure 4-2: PDCA cycle 1

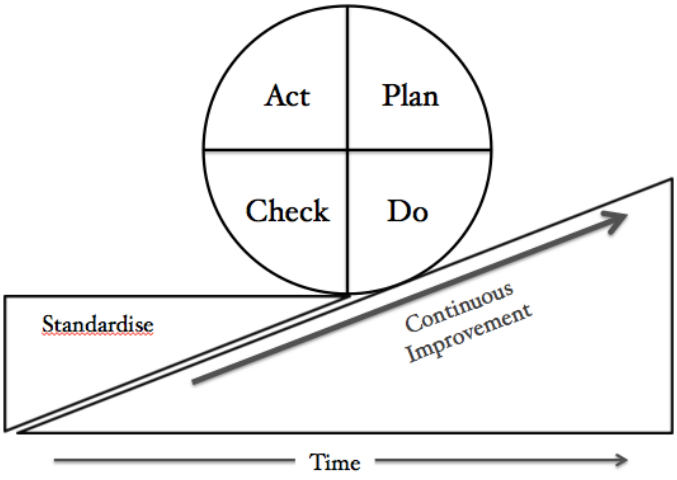


Figure 4-3: PDCA cycle 2

The use of PDCA cycle presents constant search of more efficient methods for improvement of the processes. It allows two types of corrective actions: temporary and permanent. Temporary corrective actions are achieved as a result of practical analysis and correction of the defects/ failures. Permanent corrective actions are composed from the research and elimination of the main reason for the defect/ failure.

PDCA cycle is more than just a tool. It is a basis for the continuous improvements of the procedures and processes that are build in the company's culture and brings important competitive advantages for the long term existence of the company.

4.1.5 TPM and 5S

Maintenance is a very important process in the company in order to achieve high production with minimum cost, optimal quality and avoidance of environmental and safety risks.

TPM is a combination of TQM with the strategic view of the maintenance from processes and equipment design to preventive maintenance. It includes:

- Designing of reliable, easy to operate and easy to maintain machines;
- When Purchasing machine total costs of ownership (including service and maintenance costs) have to be looked at;
- Good preventive maintenance plans have to utilize the best practices of operators, maintenance departments and depot service;
- Training for autonomous maintenance.

(Heizer, Render 2011: 690-691)

TPM as innovative Japanese concept, which was developed out of the preventive maintenance concept is also graphically presented in a house concept. The base (foundation) for the TPM is 5S method as problems can not be clearly seen if the workplace is dirty and disorganized.

Today it is already implemented 6S method (described below), which "*activities give management important reference points for judging the company's management capabilities and its power to realize the system"*. (Takeda 2011: 35)

- SEIRI (sort) – it is necessary to decide what is needed at the workplace. All unnecessary clutter, broken, unusable or occasionally used items. has to be removed
- SEITON (systemize) – The layout for tools, gauges and equipment has to be designed. Everything needed has to be easily reached.
- SEISÔ (shine, clean) – all causes of dirt have to be identified and eliminated. Clear responsibilities for cleaning have to be set.
- SEIKETSU (standardize) – develop procedures, schedules and practices. Regular audits using checklist have to be done. It means maintaining an organized, orderly and clean state.
- SHITSUKE (sustain, discipline) – develop and keep the good habits. Make it as the way of healthy and safe work. It is the manager responsibility to keep the discipline and 5S work.
- SHÛKAN (habit) – 5S has to become the habit of all workers in the company.

On the 5S foundation there are 7 pillars:

1. Autonomous maintenance - Developing operators that will be able to take care of the small maintenance tasks in order that skilled maintenance people could spend more time on more value added activities and technical repairs.
2. Kaizen – continuous small improvements and reduction of waste.
3. Planned maintenance – To have proactive maintenance and by that achieve the goals of TPM.
4. Quality maintenance – activities to set equipment conditions that prevent quality defects.

5. Training – in order to have multiskilled employees.
6. Office TPM – to improve productivity and efficiency in the administrative functions.
7. Safety, health and environment – the goal is to create safe and healthy work environment and that surrounded environment is not effected by companies processes.

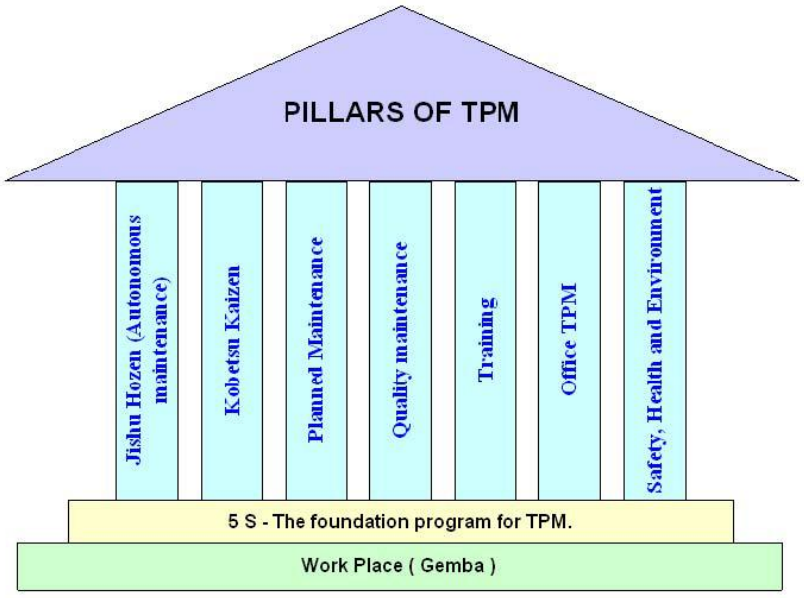


Figure 4-4: TPM (www.plantmaintenance.com)

4.1.6 Visual management

Visual management uses tools- visual aids that help management to communicate strategies, initiatives, targets and goals on the shop floor. Different charts, displays, signs are used as visual management tools.

"Visual management helps to identify the gaps between the standards of the present management and ideal one, and to close it through the energetic kaizen measures." The visual management is not an end in itself, but it is in the first place a tool. (Takeda 2011: 62)

Nowdays more and more electronic tools are used on the shop floor. Andon board is today the most used visual production control device, which can continuously show

the changing status of a production line. It is important that Andon board is placed on the shop floor so, that it is good seen from the all angels of the production line.

Companies are introducing more and more different optical and acoustic signals as advisory and warning signals in case of defects, changing of the tools, set-ups…The workers' task is to set off the signal and team leaders stop the lines, except in case of safety and quality questions. (Takeda 2011: 62)

4.1.7 KAIZEN

Japanese principle of continuous everyday improvements is called KAIZEN and consists from two words KAI- change and ZEN – good. It is important that we think everyday what small improvement we can make in professional and private life, because everyday small improvements lead to big changes.

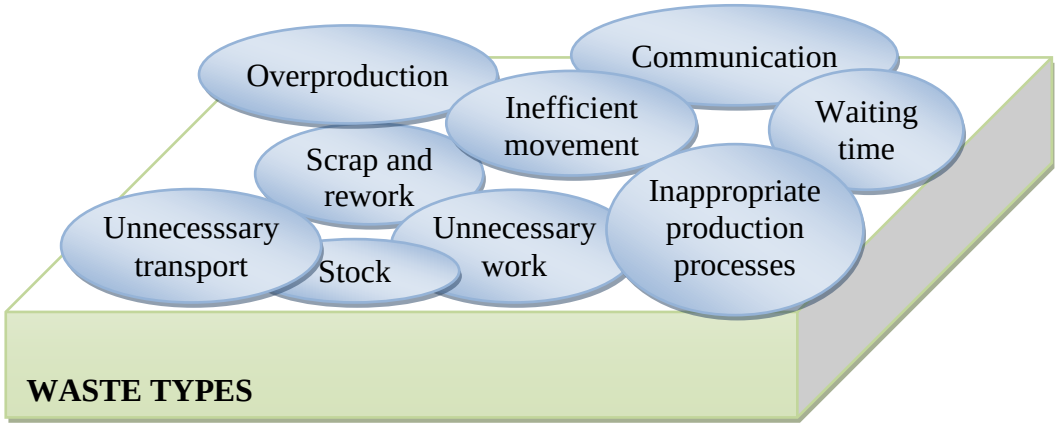


Figure 4-5: 9 types of waste

KAIZEN is among others and important element of lean manufacturing and it is nowdays present in most of the automotive companies. Lean manufacturing does not focus only on eliminating waste of non value added activities (muda), but also of eliminating waste of unevenness or inconsistency (mura) and waste of overburden (muri).

For KAIZEN it is very important to detect and eliminate waste, all the activities that do not add value. At first there were seven types of waste that can be detected in the company, but now can find eight or even nine types of waste:

1. Overproduction;
2. Stock;
3. Waiting time;
4. Scrap and rework;
5. Inefficient movement;
6. Unnecessary transport;
7. Unnecessary work.
8. Communication;
9. Inappropriate production processes.

(Sihn: MBA handouts)

4.1.8 JIT

JIT approach is one of the core elements of the TPS. JIT means that the right parts are delivered in the right quantity and on the right place in the production.

The benefits of JIT are reduced stocks and variability, increased flexibility, improved throughput times, reduced space, reduced lot sizes, reduced set up costs, lower cost of good quality and eliminate waste. All this can be achieved by 5 JIT core elements: JIT partnerships, JIT layout, JIT inventory, JIT scheduling and JIT quality. (Heizer & Render 2011: 656-667)

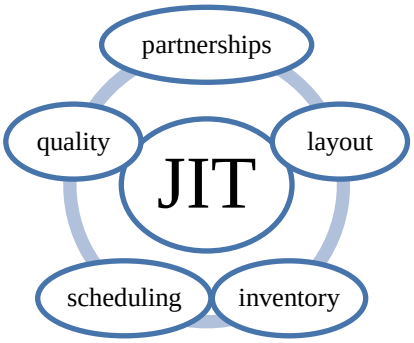


Figure 4-6: JIT 5 core elements

For JIT implementation, company needs good and reliable suppliers (internal and external). If suppliers are not reliable and parts are not delivered in quantity and time as agreed, company can suffer big losses and problems in the production as the line stoppage and non deliveries to the customers are endangered.

The upgrade of JIT nowdays is JIS approach. Where it is not only necessary that the right parts are delivered in the right quantity and on the right place, but they have to be delivered also in the right sequence. Good examples of JIS deliveries are car seats, which have to be delivered in the right sequence at the right station of the production line at the right time.

4.1.9 Flow

In the company there are several important flows: people, information, materials, activities and money. Materials and information flow can be in details analyzed and optimized in the Value stream mapping approach.

In the production we are usually focused on material flow, which is the flow from the delivery of the raw material to the dispatch of the finished part with the best quality, lowest costs and shortest delivery time.

Flow also tends to force the implementation of a lot of the other lean tools. Creating materials and information flow lowers the "water levels" of inventory and exposes inefficiencies that require immediate solutions. (Liker 2004: 88). It is very vividly shown the water and inventory levels in the Figure 4-7 *"High levels of inventory hide problems (a), but as we reduce inventory, problems are exposed (b), and finally after reducing inventory and removing problems we have lower inventory, costs and smooth sailing (c)."* (Heizer & Render 2011: 660).

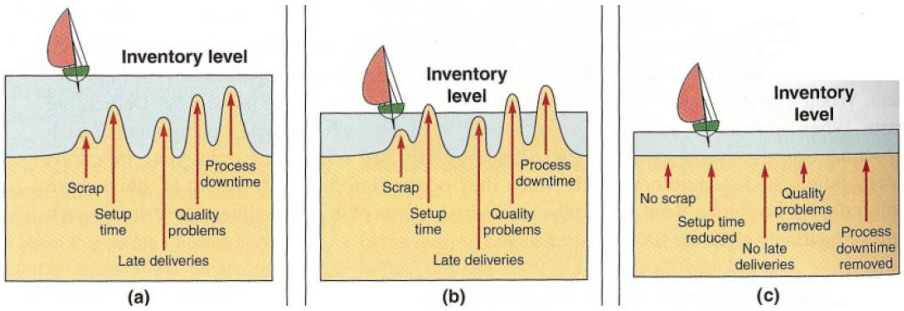


Figure 4-7: Reducing inventory "water levels" (Heizer & Render 2011: 660)

Flow production is the basis for *"securing quality, kaizen activities and job safety through standardization of patterns of activities"*, which can be carried out with rhythmic, repetitive labour. Creating an even flow is the initial concern. (Takeda 2011: 69).

One piece flow is a method where parts are moved from one operation to the next operation piece by piece, so minimum or no stock (WIP) is needed between the working stations. It is very easy to understand method, but more complicated to implement in the company.

4.1.10 Tact time

"Takt is a German word for rhythm or meter." Tact is the rate of customer demand, the rate at which the customer is buying product. In a true one piece flow process, every step of the process should be producing a part at calculated customer demand. If they are going faster, they will overproduce, what is not good as they are creating waste. If they are going slower, they are creating bottlenecks and lowering the productivity. Tact is used to set the pace of production and alert workers whenever they are getting ahead or behind. (Liker 2004: 94-95)

In order to synchronize all processing steps all materials must be brought into flow. For achieving this all machinery has to be set up in the sequence of the work procedures. In order to let each piece or set flow at the pace without standstill also information must flow in tact time.

"Strong fluctuations in the market require constant changes in tact times. The processes in the company must be flexible enough" to cope with changing customer demand and market situation. (Takeda 2011: 107).

4.1.11 Leadership

Leadership is a very important and vast topic, not only in the business world, but also in our everyday life. It exists a lot of literature and definitions of the leadership. What is important is that we distinguish between leaders and managers, because not every manager is a leader.

"Management tends to control, while leadership tends to demand/ expect." (Lidauer MBA handouts)

There were developed many types of leadership: autocratic, bureaucratic, democratic, laissez-faire, charismatic, people oriented, servant, task oriented, transactional, transformational, directive, consultative, participative, negotiative, delegative… It is important that the leader has a leadership style that is adapted to the characteristics of each person and the needs and cutural policy of each company in line with its long term strategy.

"The authentic leaders genuinely desire to serve others through their leadership. They are more interested in empoweing the people they lead to make difference than they are in power, money or prestige for themselves. They are guided by qualities of the heart, by passion and compassion, as they are by qualities of the mind". (George 2003: 12)

In my opinion good and effective leadership is very important and crucial for the long term success of the company. It should not be only important as an element in the production systems, but it should be incorporated in the very heart of the organization. It is true that the biggest asset of the company are its people with their work and knowledge, that is why it is even more important there they have right leaders in order to achieve win win situations for everybody and long term success for the company.

5 Component manufacturer production system

What is the goal of the production system for a component manufacturer?

As I have described in the beginning of the master thesis in introduction the main focus of the company is satisfaction of the customer by offering products with excellent quality, excellent delivery that are also cost efficient.

The company can achieve customer satisfaction by becoming lean, flexible and agile organization. Whole organization not only production process has to adapt to the lean, flexible and agile principles, but it is true that the most efficient results can be seen in the production process.

What does lean, flexible and agile mean?

Lean organization is the organization which is maximizing added value to the customer through reducing waste in the organization. (www.lean.org)

Flexible organization is the organization which is able to cope with the changes in the environment (financial crisis, material prices…).

Agile organization is organization that enables fast and cost optimized flexibility. (Lidauer, MBA handouts).

The comparison between lean and agile is article Lean is not enough described following: *"An objective of lean is indeed to drive out waste in its broad sense – encompassing wasted time, activity, inventory and space – and create processes that flow and are initiated by customer demand. By doing this, costs can be reduces and services significantly improved. Companies that have embraced lean have typically cut inventories and cycle time by 50% in each wave of their lean programme. Lean does not demand expensive investment in IT, nor complex programmes. However, it requires challenging and breaking existing paradigms, and the harnessing of the energy and knowledge of company employees, suppliers and customers.*

Another term used for responsive manufacturing systems is "agile". The agility depends on the lean fundamentals of short cycle time, reduced setup, multi-skilling

and flow being in place. The agility is focused on responsiveness and not cost reduction. " (A. Ross, D. Francis: 19).

What is the right production system for a component manufacturer?

There is no simple and unique recipe for companies how to establish and what is the right production system. Each company is its own world with its own characteristics and specialities, so the production system that is perfect for one company can be unsuitable for the other one. Anyway some similarities and tips can be used for all automotive component manufacturers.

Prerequisite for the production system

In the chapters 1 and 3 it is presented what are the reasons why a company should have a production system. When it is clear for the company what are the benefits of the production system, then it is necessary to look what is the prerequisite for the production system. It is company vision and strategy that is the backbone of each production system. If a company does not have a clear vision and strategy or if they are not clearly communicated to the employees the success of the production system is doomed to failure.

Vision describes long term company view, where and what company wants to be in the future. It is created for 5 to 10 years ahead. Company's vision is defined in a short and clear statement. *"A great vision is inspiring. It gets you and everyone in the organization excited to come to work; it's the cathedral everyone is coming to work every day to construct. A vision must be also strategically sound. You have to have a reasonable shot at getting there."(Weinzweig, 2011)*

The vision can be created for the whole company or also for a specific process. VW Group vision is *"to position VW Group as a global economic and environmental leader among automobile manufacturers by 2018"* (www. volkswagenag.com). The production vision of VW Group is that *"VW Group will be in 2018 a value adding oriented, synchronous company based on the best production system."* (VW MBA lecture 2010)

If the company does not have a vision, it is necessary to create one, before implementing the production system.

Strategy defines more clearly and precisely how the company will achieve the vision. We have in the company usually one vision and more strategies. That means that companies are creating more strategies in order to achieve its vision. Each process can have one or multiple functional strategies and it is important that at strategy implementation we are always checking if the goals, objectives and targets are in line with the vision.

How is the production system stable with strategy and unstable and collapsible without strategy can be very good seen at the VW case in the Figure 5-1.

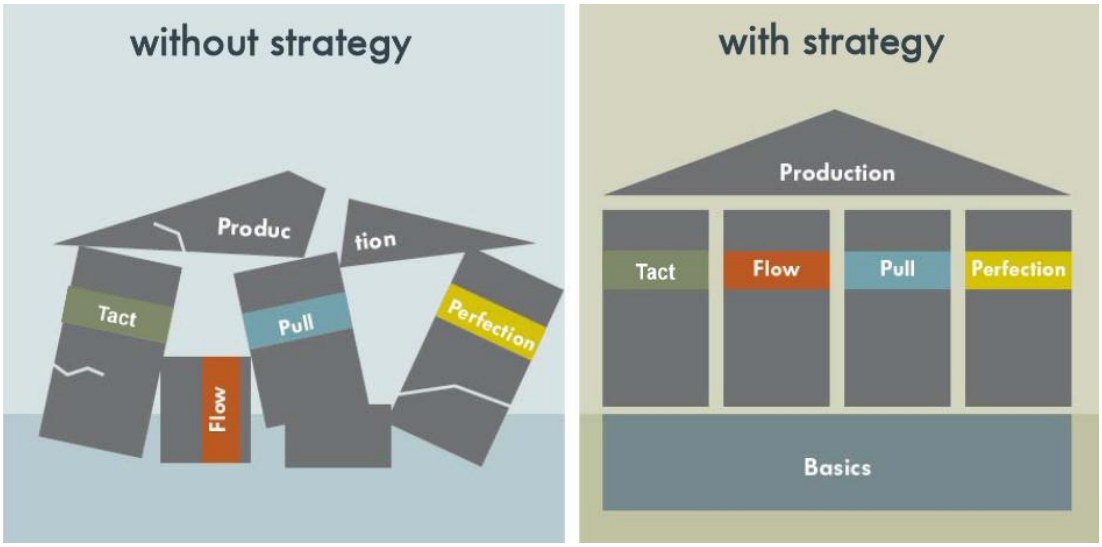


Figure 5-1: VW production system without and with strategy (VW MBA lecture 2010)

Design of the production system

It is not such a simple and irrelevant decision how the production system design should look like and how should all the elements be inserted in it, in order to be clear for all employees.

Designs of the analyzed 15 OEM production systems were not the same. Four of them have the design of the house, three have a shape of the car or truck, pyramid

design was used at two OEMs while other six have its own specific shape (tree, bull and other shapes).

I would propose to use a house design for the production system, because the house shape is easy to understand for all employees. When implementing the production system it is important to include and engage all employees in the company, if we want that the implementation of the production system will be successful.

Toyota decision why they choose house design was following *"Because house is a structural system. The house is strong only if the roof, the pillars, and the foundations are strong. A weak link weakens the whole system."* (Liker 2004: 32).

At the house design it is easy to distinguish between the order and importance of the elements in the production system.

The basis or foundations always form elements which have to be implemented first if we would like that the next steps, elements of pillars and roof, will be successful and that the house will stand still. Because of that employees can easier understand which of the elements are necessary for stable production system. If we take the car or bull design it is not possible to tell only from the design, which are the basic elements, because in such designs all elements are equal.

The pillar elements come after we have successfully made the foundations. The pillar elements are equally important among themselves and also for the stable structure of the production system. There is no hierarchy between them. They form important core structure of the production system.

The roof can be composed of one or more elements, vision, focus of the production system, business policy or everything else that would at best complete the whole design in a systematic and logic way for a specific company.

Synchronized Production System

Term Synchronized Production System was developed by Mr. Hitoshi Takeda. *"It is a system which is aimed at reforming the structure of a company in such a way that the company becomes immune to the recession and can withstand intensive international competition. For this it is necessary to offer high quality at a low cost*

and to be able to react to the increasing diversification. Waste is thus eliminated and the entire chain of processes from order intake to production to delivery is synchronized." (Takeda 2011: 26).

It is important that the entire production system in our company in synchronized, because only by that, we will achieve the goals of the production system and the ultimate goal of the company – long term satisfaction of the customer.

SPS enables companies to reach following objectives:

- Market and customer oriented production (flexible, quick, high productivity);
- Product innovations;
- High quality of the products;
- Competitive prices;
- Shorter delivery times;
- Minimizing the development costs;
- Process optimization.

SPS main emphasis is manufacturing, transport, forwarding and managing. Its aim is to improve each needed component appropriately at the appropriate time by using as few personnel and machinery as possible in the shortest operating time possible. (Takeda 2011: 25)

As shown in the Figure 5-2 SPS always begins with the final goal (securing profit). To achieve this goal it is necessary to introduce next goal (achieving a reduction in production costs) and so on, until we come to the 12 different steps which focus on material, humans and systems: 6Ss, Levelling and smoothing production, One-piece (set) flow, Flow production, Reducing batch sizes, Addresses and storage space, Production in tact time, Quantity management, Standardized work, Quality, Machinery and Kanbans.

SPS stresses also big importance of the employees and mutual human behaviours and relationships as they play the most important role in the SPS. Companies must follow continuous improvement also by constant developing and training employees.

"In introducing the SPS, the relationship of the individual steps to one another must constantly be taken into account. If you try to realize one step by itself, you will soon hit a wall that is made up of the reciprocal influences of the other steps." (Takeda 2011: 229).

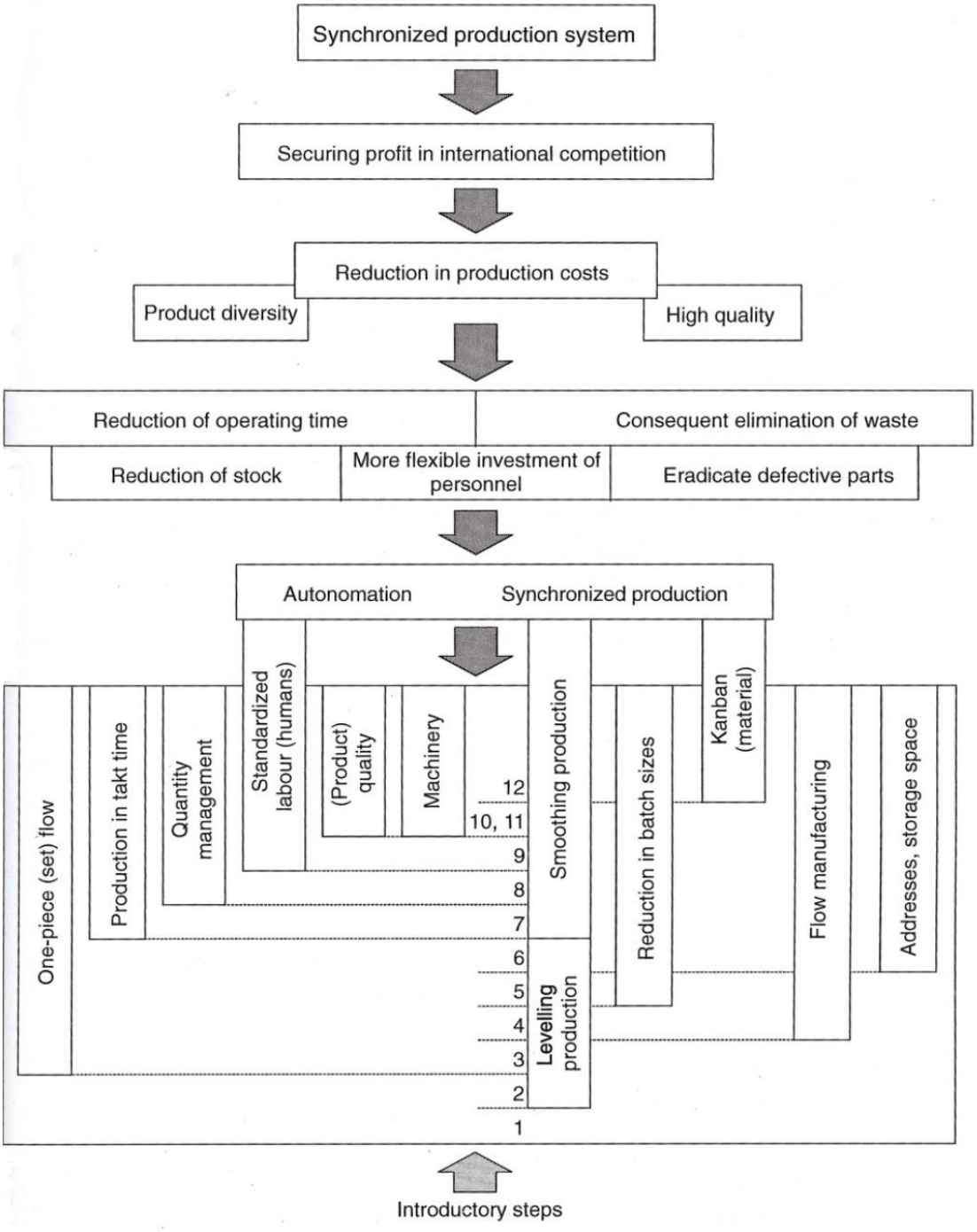


Figure 5-2: Synchronized Production System outline (Takeda 2011: 27)

How many elements to include in the system?

Now that we know that we will use the house design for a production system, we have to decide how many elements and which elements to include in the production system.

From the comparison of the OEMs production systems in the chapter 4 it is clear that there is no rule how many elements should have a production system. The number of elements included was between 6 and 21, which is quite a big difference. On average all 15 OEMs production systems had 14 elements.

It is not important the quantity of the elements, but more their quality. In my opinion having 21 elements in the production system is too much. It is difficult to implement such a production system and also hard for the employees to focus on all elements. The pitfall of having too many elements in the production system is that because of the complexity the interaction between the elements is not good and at the end the production system is not bringing the expected results.

Only the core and relevant elements should be included in the production system. From the comparison in the chapter number 4 I found out that some production systems include elements as vision, corporate values, methods, different kinds of communication, salary systems etc. which are all very important elements for the company, but should be established in the company business policy, culture, strategy or in specific processes but not in the production system.

5.1 Basic elements

Basic elements of the production system are the foundations of our house. It is needed that these elements are established at first in the production system. They have to be implemented 100% before we can start building pillars on those foundations, otherwise our production system will not be stable. I would suggest following five basic elements four the foundation of our production system: 5S, standardization, KAIZEN & CIP, Visual management and Quality.

I have chosen these 5 elements, because they bring order and emphasize the importance of the system in the company. Rules, standards, information and the

importance of the right, quality, efficient and good work have to be clear to each single employee in the company, before implementing further steps and changes. They have to be repeated day by day so long that they become a habit and employees take them for granted. Only by this we can be sure that company's rules, internal regulations are strictly followed and monitored and by this strong foundations for further improvements are built.

All 5 basics elements are according to my analysis also present in most of the analyzed production systems. And we can find exactly all of them in the most, global sales, successful OEMs: Toyota and VW.

5.1.1 5S

The first thing we have to establish in the company is the order and cleanness at the workplace. Quality products are manufactured only in a clean environment and we can not perform and get good results from Kaizen, CIP or any other activities if cleanness and order are not sufficient.

The principles of the 5S or according to Takeda 6S method are already described in the chapter 4. Now let's look at each 5S step and some examples what does 5S method really means in practice.

SEIRI (sort) – In the below Figure 5-3 it is shown, that everything what is not regularly needed at the work place is removed.

Figure 5-3: Sorting (Trumpf Produktionssystem)

SEITON (systemize) – How the layout is designed it is presented in the below Figure 5-4.

Figure 5-4: Systemize (Trumpf Produktionssystem)

SEISÔ (shine, clean) – Figure 5-5 shows dirt removal and cleaning at the workplace.

Figure 5-5: Cleaning (Trumpf Produktionssystem)

SEIKETSU (standardize) – How to maintain an organized, orderly and clean state is presented in the Figure 5-6.

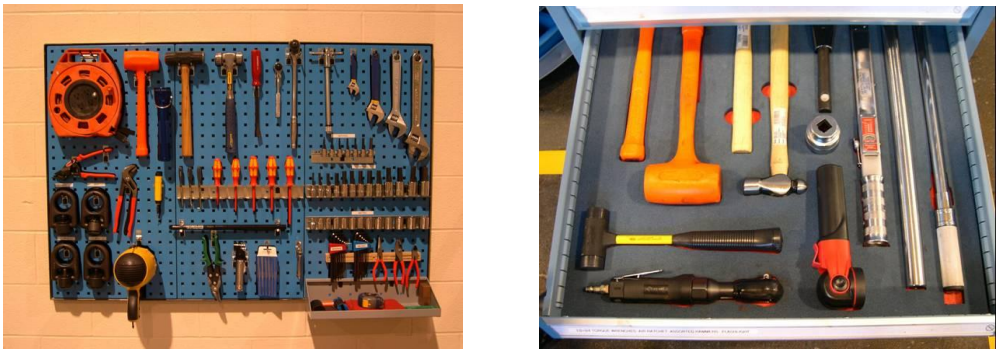
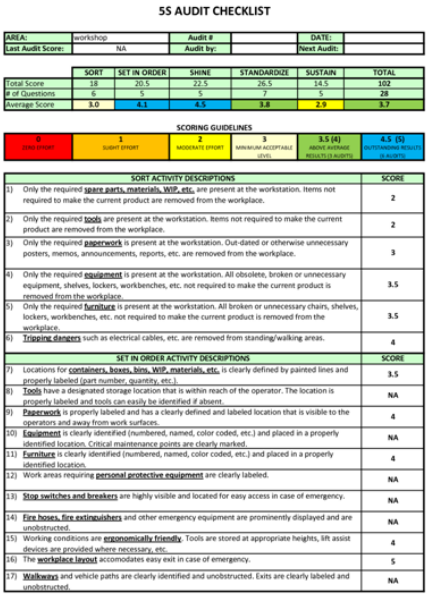


Figure 5-6: Examples of standardization (www.tpslean.com/images/)

SHITSUKE (sustain, discipline) – Examples of regular checks and keeping the good habits are shown in Figure 5-7.



5S AUDIT CHECKLIST

AREA:	workshop	Audit #		DATE:	
Last Audit Score:	NA	Audit by:		Next Audit:	

	SORT	SET IN ORDER	SHINE	STANDARDIZE	SUSTAIN	TOTAL
Total Score	18	20.5	22.5	26.5	14.5	102
# of Questions	6	5	5	7	5	28
Average Score	3.0	4.1	4.5	3.8	2.9	3.7

SCORING GUIDELINES

0 ZERO EFFORT	1 SLIGHT EFFORT	2 MODERATE EFFORT	3 MINIMUM ACCEPTABLE LEVEL	3.5 (4) ABOVE AVERAGE RESULTS (4 AUDITS)	4.5 (5) OUTSTANDING RESULTS (5 AUDITS)

SORT ACTIVITY DESCRIPTIONS	SCORE
1) Only the required **spare parts, materials, WIP, etc.** are present at the workstation. Items not required to make the current product are removed from the workplace.	2
2) Only the required **tools** are present at the workstation. Items not required to make the current product are removed from the workplace.	2
3) Only the required **paperwork** is present at the workstation. Out-dated or otherwise unnecessary posters, memos, announcements, reports, etc. are removed from the workplace.	3
4) Only the required **equipment** is present at the workstation. All obsolete, broken or unnecessary equipment, shelves, lockers, workbenches, etc. not required to make the current product is removed from the workplace.	3.5
5) Only the required **furniture** is present at the workstation. All broken or unnecessary chairs, shelves, lockers, workbenches, etc. not required to make the current product is removed from the workplace.	3.5
6) **Tripping dangers** such as electrical cables, etc. are removed from standing/walking areas.	4
SET IN ORDER ACTIVITY DESCRIPTIONS	**SCORE**
7) Locations for **containers, boxes, bins, WIP, materials, etc.** is clearly defined by painted lines and properly labeled (part number, quantity, etc.).	3.5
8) **Tools** have a designated storage location that is within reach of the operator. The location is properly labeled and tools can easily be identified if absent.	NA
9) **Paperwork** is properly labeled and has a clearly defined and labeled location that is visible to the operators and away from work surfaces.	4
10) **Equipment** is clearly identified (numbered, named, color coded, etc.) and placed in a properly identified location. Critical maintenance points are clearly marked.	NA
11) **Furniture** is clearly identified (numbered, named, color coded, etc.) and placed in a properly identified location.	4
12) Work areas requiring **personal protective equipment** are clearly labeled.	NA
13) **Stop switches and breakers** are highly visible and located for easy access in case of emergency.	NA
14) **Fire hoses, fire extinguishers** and other emergency equipment are prominently displayed and are unobstructed.	NA
15) Working conditions are **ergonomically friendly.** Tools are stored at appropriate heights, lift assist devices are provided where necessary, etc.	4
16) The **workplace layout** accomodates easy exit in case of emergency.	5
17) **Walkways** and vehicle paths are clearly identified and unobstructed. Exits are clearly labeled and unobstructed.	NA

Figure 5-7: 5S audit sheet (http://img.docstoccdn.com)

In the Figure 5-8 it is perfectly presented the situation before and after the implementation of the 5S method in a company.

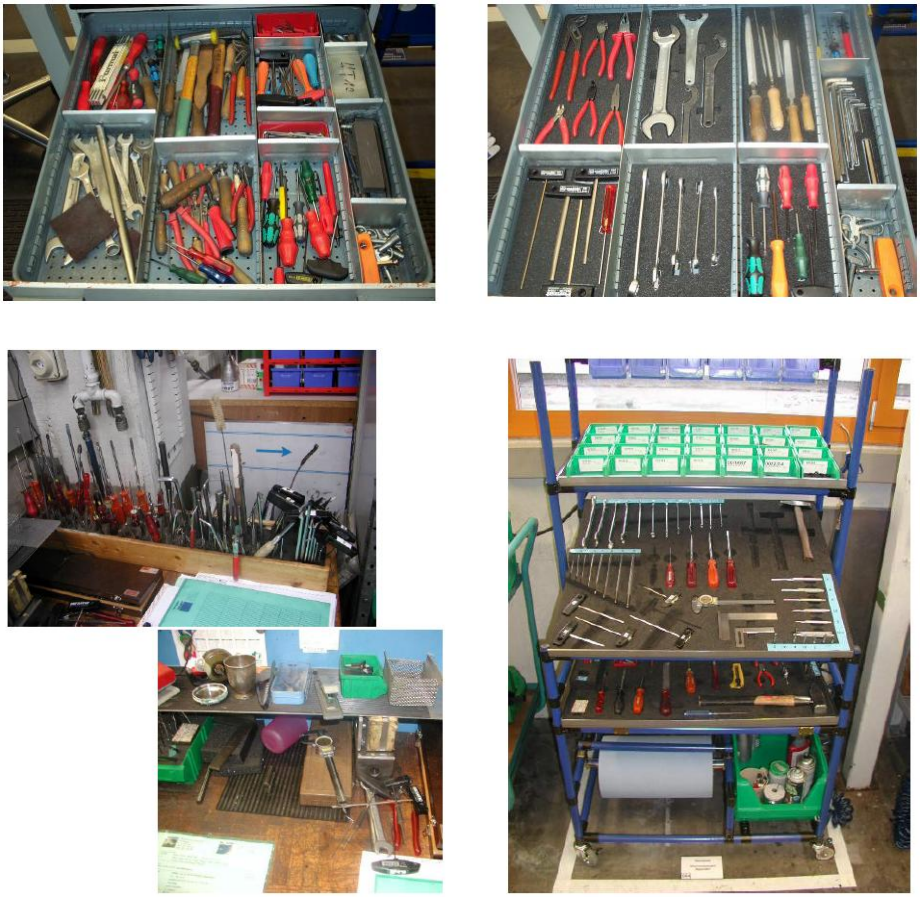


Figure 5-8: Before and after 5S implementation (Trumpf Produktionssystem)

Takeda has added additional, sixth step, of the 5S or better in this case to say 6S method. The sixth step is SHÛKAN (habit). All 5 steps have to be *"internalized through constant, practical repetition (discipline). The 6Ss become self- evident."* (Takeda 2011: 44).

Through the literature study I have also came across the suggestion that the sixth S should be for Safety, which is more and more important at the workplace. Maybe in the future we will have 6S or 7S method instead of 5S method.

5.1.2 Standardization

Standardization is the foundation for many important elements of the production system: quality, flow, pull and KAIZEN, that is why it is an important basic element.

Because of its importance it is crucial that the employees respect and follow the standards. The quality products can not be manufactured at the workplace where each operator or employee does his/her work in a different and its own way. Standards should be clearly set. They should not be fixed for ever, but continuous improved through the work practices and innovation. Mr. Ford knew the importance of standardization and its improvement as he said already in 1926: *"Today's standardization ... is the necessary foundation on which tomorrow's improvement will be based. If you think of "standardization" as the best you know today, but which is to be improved tomorrow – you get somewhere. But if you think of standards as confining, then progress stops."* (Liker 2004: 141).

It is important that the worksheets in the company are created correctly. It is particularly important that the production person is able to write a standard worksheet that workers will understand and use. Mr. Ohno very well described the importance of right worksheets: *"High production efficiency has been maintained by preventing the recurrence of defective products, operational mistakes, and accidents, and by incorporating workers' ideas. All of this is possible because of the inconspicuous standard work sheet."* (Liker 2004: 140)

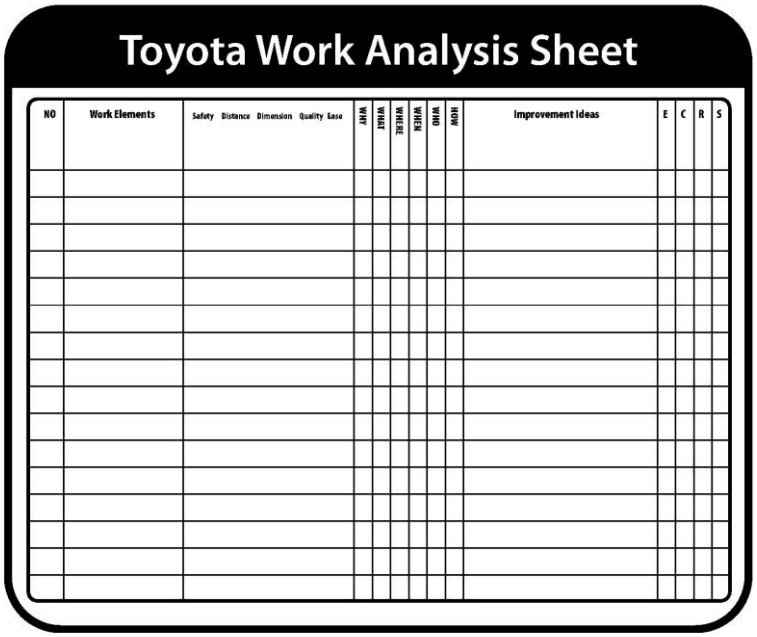


Figure 5-9: Toyota Work Analysis Sheet (www.theleanedge.org)

In the Figure 5-9 it is presented one example of Toyota standardized worksheet.

Once the correct worksheets are developed it is important that they are correctly filled in by workers or operators. Operators are responsible that the right data are put in the worksheet while foremen or team leaders are responsible that the worksheets are properly filled in and that the standards are respected at the workplace.

With the globalization and international trade standardization became more and more important also between customers and suppliers. There are many organizations and standards that are being implemented and required in the business. In the automotive industry ISO TS 16949 (Figure 5-10) and ISO 14001 (Figure 5-11) are today the prerequisite for the business collaboration. They have been developed and implemented mainly to ensure the standardization of the quality. In order to ensure it regular internal and external audits are being performed where it is checked if the company standards are respected and followed at the work place. Once a company receives the certification it is not for a lifetime, but it needs continuously prove that respects all standards.

Figure 5-10: ISO TS 16949 standard (KLS Ljubno)

Figure 5-11: ISO 14001 standard (KLS Ljubno)

There are also customer specific standards. Bigger customers have developed additional to the international standards their own quality and logistics standards and forms in order that all suppliers know and respect their quality and logistics requirements and to receive from all of the suppliers the required data in the correct form. They are also regular reviewed and updated and in most of the cases their final versions can be found in quality specifications and standards on their websites. One example of standardized Feasibility study form from company ZF Friedrichshafen is presented in the Figure 5-12.

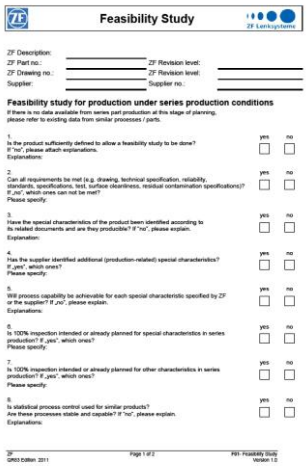


Figure 5-12: ZF Feasibility study form (http://www.zf.com)

5.1.3 Kaizen & CIP

Having implemented 5S and standardization in the company, it is possible now to proceed with the next important element of the production system: Kaizen and CIP. Their characteristics were already explained in the chapter 4. Their main focus is eliminating non value added activities in the company. As it is shown it the Figure 5-13, there is less than 30% of all activities in production value added activities, while in the administration the percentage of the value added activities is even lower, less then 15%.

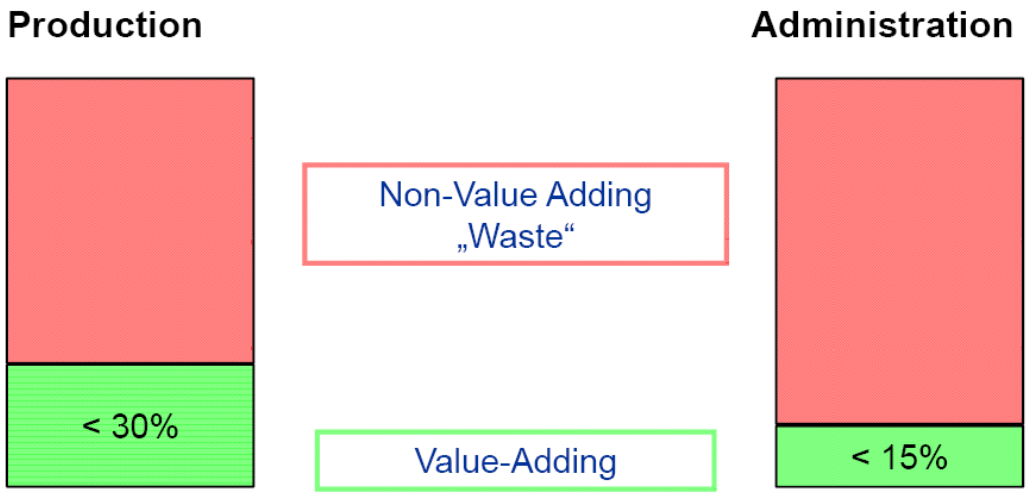


Figure 5-13: Value adding in production and administration (Lidauer, MBA handouts)

It is important to see or learn to see the waste. Different types of waste and their elimination have to be identified in the company by all employees, only by that the KAIZEN and CIP process in the company as whole can be successful.

There are 9 types of waste that could be detected and eliminated in the company:

1. **Overproduction** occurs when the parts are manufactured before they are needed or in bigger quantity as required. Overproduction as a waste causes also other waste that is why it is necessary to eliminate it as soon as possible. The causes for overproduction are usually large production batches, unreliable and unstable processes and fluctuating schedules.

2. **Stock** is a type of waste that is also the result of the overproduction. In the company we have different types of stock: raw material, WIP and finished parts.

   Overproduction is not the only reason why the stock appears. There are different reasons why stock appears (Logistics, MBA handouts):

- Companies create buffers against uncertainties (time and price) in supply and demand;
- Price reductions and lower transportation costs because of high purchased volumes;
- To build up seasonal demand for promotional sales;
- In some cases also to improve quality (temperature, aging process).

  For what ever reason a company is having stocks it means that the money is bound in it. For lean manufacturing it is necessary to minimize all stock levels.

3. **Waiting time** is another type of waste which is found in the company. It is present too often at the work place. Workers/ Operators are waiting: for the machine to finish the operation; they are waiting that previous operations are completed; breakdowns causes waiting; production is waiting for the material from suppliers; processes are waiting for quality checks and measurements etc. That is why it is important to measure waiting time and reduce it constantly. Every second is important.

4. **Scrap and rework** do not present only costs and potential problems at the customers, but also waste in the production. It is extremely important that bad quality is eliminated at the work place or operation where it occurs. If we eliminate bad product only at the final operation and the quality mistake was made already at first operation we have created a lot of unnecessary costs and waste. We have to have stable processes in the production and quality trained people to produce only good quality or to immediately detect bad quality where it occurs, eliminate it and solve the root cause for non quality occurrence.

5. **Inefficient movement** and its waste is in most of the cases connected to the bad design of the workplace, not standardized operating procedures, insufficient training. Waste of inefficient movement is not connected only to the design of the workplace, but often we find inefficient movement also because of the searching of the missing items, information, documentation and instructions. This kind of waste can be eliminated through good design and ergonomics of the workplace on one hand and through efficient material and information flow on the other hand. Value stream managements can be used for improvement of the latter.

6. **Unnecessary transport** with moving goods from one workplace in the company to another does not bring any added value to the customer. It is usually caused because of the complex material flow and bad value stream management. The cause of unnecessary transport can be also the same as for inefficient movement: bad design of the workplace and processes. The consequences of the unnecessary transport are increased WIP and risk for possible damages of the products and by that related quality problems.

7. **Unnecessary work** in related to all unnecessary motion that employees are performing at work: reaching, bending, lifting etc. It is strongly connected to the ergonomics and by that to the safety and health of the employees. Unnecessary work is also caused because of the bad design of the work place and processes. The consequence related to the unnecessary work is apart from the possible safety and health problems of the employees, also increased production time.

8. **Communication** is the waste that was added additional to the traditional 7 types of waste. In the past communication was not causing so many problems as it was very limited and poorly developed, compared to today's different types and increased speed of communication. Communication brought business many advantages on one hand (mobile phones, e-mails, video conferences…) but it created also a lot of waste. This type of waste is on larger scale present in the company administration and it consumes

employee time with non vale added activities. The biggest waste can communication bring in following examples:

- Emails: employees are often receiving e-mails that have nothing to do with their work, but they have to read it and that consumes their time.
- Telephone calls: are often unnecessary when people are double checking the data or information or they are unprepared.
- Meetings: are the biggest consumers of employees' time when they are poorly organized and managed, where there is no clear goal of the meeting and agenda and when people come to the meeting unprepared. Not productive discussions are useless.

9. **Inappropriate production processes** as a waste was also additional added to the traditional 7 types of waste. We already found out that the bad design of the work place causes many wastes: inefficient movement, unnecessary transport and unnecessary work, but inappropriate production processes are different waste type. Using not the right processes or tools at the production process is a waste, because it leads many times to inefficient using of resources, possible quality problems and in many cases it does not deliver the expected results. The right processes and tools do not mean the most expensive processes and tools, but the best ones for the particular production process.

KAIZEN is CIP process in the company. It can not be ever finished. Once we successfully eliminated one waste at the work place, we have to turn the PDAC cycle again and start at the beginning. In some companies there are KAIZEN teams which project is to eliminate waste at different processes in the company. In my opinion it is more efficient if we attract all employees at KAIZEN activities and put KAIZEN deep into the minds of employees to become their working habit.

CIP is an important tool not only for KAIZEN, but for all activities in the company. Company should use CIP cycle model for all processes in order to progress and for its successful long term existence.

5.1.4 Visual management

Visual management is one of the lean tools that can be efficiently used only after successful implementation of 5S, standardization and KAIZEN.

Visual management "*provides a mechanism for continuous improvement through system alignment, goal clarity, engagement of people in the process, and improved communication and information sharing throughout the organization"* (http://eyesonperformance.com).

There are many options of visual management tools and where the company would like to use it. The quality of visual management tools is more important than its quantity. For production process the company should think really well, what data should be visualized in order that would improve on one hand communication and information on the shop floor and to set the motivation for the employees on the other hand. Company needs to think about this already at 5S, standardization and KAIZEN steps. It is important that is clearly identified at each of these steps what visual management tools and where are needed for its successful implementation and reached goals.

Today more and more companies are using Andon boards for the information on the shop floor. Examples of use of Andon boards on the shop floor are presented in the below Figure 5-14, Figure 5-15 and Figure 5-16.

Figure 5-14: Andon board example

Figure 5-15: Automotive Andon board

(both http://www.gs-gmbh.de)

Figure 5-16: Andon board on the shop floor

(http://www.aip-usa.com)

In the Figure 5-16 on top of the display it is seen that company is using also acoustic signals in case of the emergencies or stops. Such signal are very important as workers do not look at Andon boards all the time and if a stop occurs it is very important that operator knows about it and starts immediately eliminating the cause of the stop. If the stop information – red light – is only on the Andon board we can loose some time before operator sees it and starts solving the problem.

It is not necessary that we use Andon boards everywhere on the shop floor. What is important is that we really present employees relevant and important data and information. There should be mainly presented data related to the performances (past, current and target performance) and quality focus and issues. For these reasons we could use as presented in the Figure 5-17 and Figure 5-18 standing or wall visual boards. It is important that we regularly update the information on visual boards.

Figure 5-17: Standing visual board (www.leanproducts.eu)

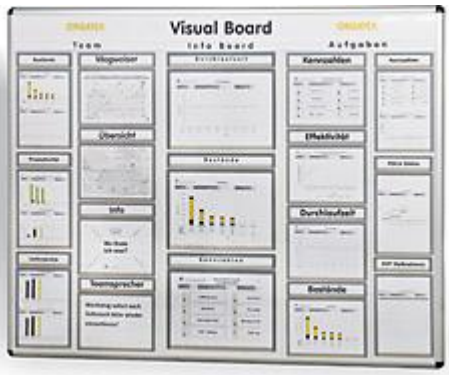


Figure 5-18: Wall visual board (www.leanproducts.eu)

As already explained before at the 5S method description, there are a lot of different visual tools used in order to keep the targeted 5S order. We use in the company also a lot of signs and boards in order to stress possible health and safety dangers. It is also necessary to clearly identify spots and places that people use in case of emergencies (exits, fire distinguishers, first aid kits …).

Position of the visual tools has to be standardized and clearly identified also in the company layout.

5.1.5 Quality

We believe in our company that quality is an argument in sales. Quality of products, delivery and service is important for the satisfaction of the customer and consequently for the long term success of the company.

Quality has to be the goal for all employees and not only quality assurance and control department and management. Each operator on the shop floor is responsible for the quality of his/ her operation; each worker in the company has to be responsible for the quality of his/ her work.

Figure 5-19: Customer satisfaction (Sihn, MBA handouts)

It is very well shown in the Figure 5-19 how quality in the whole company is important for the satisfaction of the customer which is the ultimate business goal. The whole company is contributing to the customer satisfaction: quality of sourcing, quality of production processes and products, quality of logistics, warehousing, packaging and distribution, quality of corrective actions, quality of employee training, quality of target setting, quality of customer data, quality of development and construction, quality of communication and motivation and quality of work planning and control. Each process in the company has to bring quality products and services to its internal or external customers in order that company as a whole would be able to deliver quality to the customer. Quality is not easy, it is needed a lot of effort and hard work to achieve good results. It takes many years that company builds its reputation for the good quality, but it can take only one wrong step that all the past effort and hard work is ruined.

Quality and TQM as an element of the production system was already presented in chapter 4. It is important that company develops its unique quality system, which

would bring the best results. It is not guaranteed that if a company has TQM system that its quality is the best. The analyzed OEMs production systems have quality as an element defined very differently: total quality control, built in quality, quality in process, quality in stations, quality management, TQM, stable quality, standardized quality processes, quality management and quality and robust processes. And this is correct, as there is no unique recipe for quality. Each company should know which part of quality is the most important for their long term business and what is the best way to implement it in the company.

If we look even more in details, we can see that quality is present everywhere in the company and in every element of the production system. The goal of each element is to improve the quality of processes, the quality of work or the quality of the products and consequently by that the quality of the whole company.

It is also very important that we set the standards and develop the processes so that expected quality is achieved immediately, at the first time. By this we avoid waste caused by defects and reworking in the processes, we lower the costs and possible claims and problems by our customers.

The company should continuously strive for improving quality results, both internally and externally. The best way is to develop strategic quality plan for next five to ten years with clear tasks and improvements that need to be done in order to reach each year better results and to improve the quality. According to the objectives and targets of the strategic plan detailed quality plans for different processes have to be developed and constantly, at least on a monthly basis, monitored and analyzed.

5.2 Pillar elements

For pillar elements I suggest 4 elements: tact, pull, flow and levelling the production. All these 4 elements are essential if a manufacturer would like to follow quick changes and fluctuations on the market without big risks. In order words if a manufacturer would like to increase its flexibility, leanness and agility.

Tact, pull and flow elements are according to the analysis present in almost 50% of all analyzed OEMs production systems and there are 33% of the OEMs production systems that have all these 3 elements in their system. Element levelling the

production is present in only 27% of the OEMs production system, but in my opinion it is an important element for the component manufacturer production system, because of the so called “bullwhip effect” (explained in 5.2.4.), which does not affect OEMs, but for component manufacturer it is important and needs to be avoided.

5.2.1 Tact

Producing in tact and reducing the tact times is essential for the component manufacturer. The prefect situation would be that all manufacturing lines would produce at the same optimized tact time. Unfortunately this is seldom possible at complex component manufacturer who is using different processes and different production lines in order to manufacture different products.

The importance of the tact time in the company is very good shown in the below Figure 5-20. If we row the boat everybody at the same pace (tack) the boat goes straight in the desired direction. But if every individual is rowing at his/ her own pace, the boat will not move systematically.

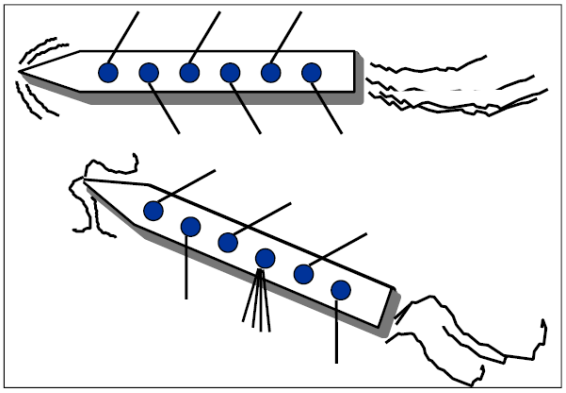


Figure 5-20: Individual vs. System Power (Minichmayr, MBA Handouts)

For real lean manufacturing it is important that products are manufactured according to the customers demands and that the WIP between different processes is reduced or preferably eliminated.

It is important that the set tact times are achieved and that they are not changed. If a problem occurs (lack of mechanical capacity and lack of personnel) the tack time can be reset and this is called exceptional tact time and it can last only until the problem is solved. (Takeda 2011: 108).

The required tact time and actual state should be always presented at the workplace on the board that is visible for everyone. Tact time must always be presented in seconds. There has to be also written the name of the operator and possible reductions of the tack times by improvements. (Takeda 2011: 110). Special focus and trainings have to be performed for the employees who are not achieving the expected tact times. In case it is found out that the operator is achieving actually better tact time than required, then of course the tact time was not set properly and has to be immediately reviewed and reset.

In the complex production it is on the contrary to the assembly line manufacturers extremely difficult to synchronize the tact time for all production lines and all processes for all products no matter of their complexity. It is not impossible, but it requires on one hand huge investments in the production equipment and on the other hand the possibility of reduction in productivity and OEE.

That is why for component manufacturers it is extremely important to identify the bottleneck tact times in the production and eliminate them and by that improving the tact times. For this, company has to analyze both the tact times of the products and tact time of the single process. It is not necessary that for example sizing process, which could be in company in general the bottleneck, is a bottleneck also for a specific product which bottleneck is for example turning operation. That is why it important to perform a good detailed analysis.

After analysis it is company decision if the bottleneck will be eliminated or not. If the elimination is not connected to the huge investments, companies usually decide to invest and improve the tact times. If the required investments are big, then company needs to decide weather to invest in the bottleneck elimination or it is less costly to increase the WIP in this case. At the end of the day it is all connected to the costs and ROI.

By elimination of the existing bottleneck the task is not finished, because then we have immediately new bottleneck. Company needs to improve processes and production lines constantly in order to be competitive and to reduce costs. Eliminating bottlenecks and improving tact times is one of the CIP process in the company.

5.2.2 Pull

Pull principle objectives in the company are that only required and ordered products and information are produced and received from the previous process, minimization of the stock and WIP between processes and reduction of through put time. As for the tact time also in the pull principle it is the customer demand is dictating the production.

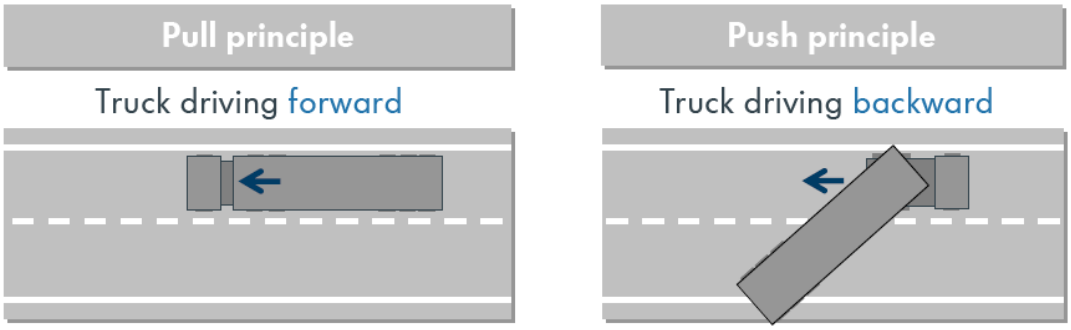


Figure 5-21: Pull vs. Push principle (VW MBA Lecture 2010)

As it is shown in the Figure 5-21 pull principle is the opposite of the traditional push principle in the production. Pull principle presents smooth production as driving the truck forward on the road, while push principle presents a lot of difficulties and waste in the production, especially overproduction, and it is also slowing the production, the same as we would like to drive the truck backward on the road. Push principle occurs when previous processes are manufacturing parts regardless of the needs and order of the next processes. The result of push principles are large all stocks (finished parts and WIP) – overproduction.

The needed increased flexibility and agility on the market requires pull principle, as it is necessary to react quickly at the changes in customers' demands with as little as possible side effects (WIP and inventories). If we are having push principle in the company then any change in the customer demand create a lot of difficulties and bring because of the increased stocks a lot of costs to the company. In a company that is having push principle it is also very difficult to set the KAIZEN thinking and mentality, because the waste of overproduction and stock are constantly produced.

If a company would like to implement pull system it is necessary that the thinking of the employees has to be changed completely in comparison to the push principle. It is

necessary to start planning the production upstream and not downstream anymore. The production is dictated from customer (internal and external) demand and it is pulling the demand downstream the production process. Every step and production that excesses customer demand is a waste and creates unnecessary stock and costs. Some companies are using pull and push principles in the production, but as this might caused confusion which is not recommended, especially if we would like to implement also other lean principles.

The restrictive nature of push system prevents companies from experimenting, improvising and learning as quickly as they might. Push system not only inhibit product innovation but it also makes much harder to implement rapidly incremental process innovations. On the other hand it is pull system that is brining to the company many benefits as: enhanced innovation, increased opportunity for collaboration, closer relationship with the customers and suppliers, more rapid feedback, richer reflection on the result of distributed experimentation and greater scalability. (Brown & Hagel III: 84 and 89)

Pull principle means ideal state of the production and JIT manufacturing. JIT, already explained in the chapter 4, is an important element for the pull principle in the company. It is not important just the JIT manufacturing, but also other JIT components. If we would like to implement in the production pull system it is necessary the processes receive the right product in the right quantity at the right time from the previous process. If this is not working we might have stops in the production, because of the waiting time for the right products or quantities to be delivered. That means that for the right implementation and results of the pull principle we need good internal and external suppliers.

Another important element that is presented many times together with JIT and pull principle is Kanban. Kanban cards are an important element of the synchronized production system and are carrying the information what should be produced, when and in what quantity. There exist two types of Kanban cards: pulling kanbans and production kanbans. Pulling Kanbans contain the information for pulling and transporting for the upstream process, while production kanbans give the production

orders. Both two types are closely linked to each other and circulate within and between factories. (Takeda 2011: 183).

5.2.3 Flow

Material, information and people flow are very important in the organization. Creating the right material and information flow is one of the important pillars of the production system. The flow pillar the same as tact and pull pillars enables the organization that the right parts are manufactured at the right time and in the right quantity and by that to successfully meet customer demand, which in business ultimate goal.

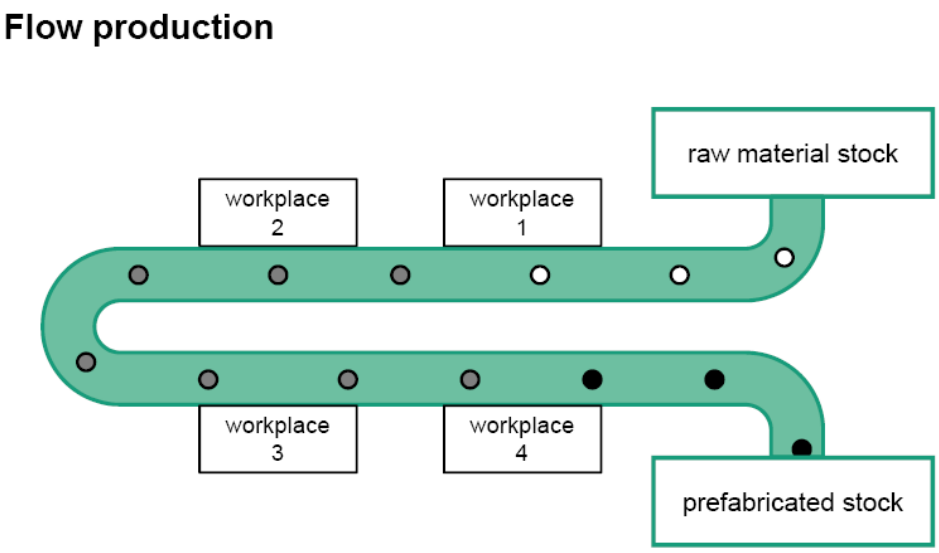


Figure 5-22: Example of a flow production (Sihn, MBA handouts)

It is optimization of flow which makes possible the customer focused production. Optimization of flow brings lean and simple processes, use of flexible production technology, investments in the machines rather than in stock, smaller batch sizes and optimization of factory flow, quality control after every operation, flexible organization and good construction principles. (Palm, MBA handouts)

As already explained in the chapter 4 one piece flow is a method where parts are moved from one operation to the next operation piece by piece, so minimum or no stock (WIP) is needed between the working stations. It is very easy to understand

method, but more complicated to implement in the company. One piece flow is also the starting point for the synchronized production system.

For effective flow production it is important that the company has also lean production layout. It is easier to create lean production flow layout in new plant or hall, but to change the existing non flow layouts in the company it is connected to quite of an investment of money and time.

There exist 12 principles for effective creation of the lean layout (Lidauer, MBA handouts):

1. The starting point of a downstream process is to be located in close proximity to the finish point of the upstream process.
2. Keep conveyors as short as possible.
3. Use one-piece-flow between the operations (if buffers are necessary keep them as small as possible and visualize min/max.
4. Accessibility and transportation mode need to be determined. GOAL: minimize product of transportation volume and distance!
5. Balance all cycles over all main- and sublines.
6. Good visibility of Andon-Boards from all angles – pull lines placed ergonomically.
7. Co-locate machinery and equipment as close as possible. GOAL: minimize space requirements.
8. Avoid “stop-and-go“- stations on manual operations.
9. Automation only where it makes sense! (Safety, Quality, Cost, etc.)
10. Co-locate machinery and automation, co-locate manual workplaces!
11. Optimize processes with “digital factory“ tools.
12. Involve all stakeholders in an early stage of planning.

Important elements that help that production flow flows smoothly and that production can manufacture smaller batch sizes are also quick set up and quick changeovers. In the today changing market and demand situation and flexible production it is more and more important the ability of the production to be able to change from one product type to another as soon as possible. If in the past the changeover time was measured in hours we are talking today about seconds. Some

OEMs are already having the target changeover time of 0 seconds! The quick changeovers and set up times are also connected to the exiting machinery equipment of the production. With the investments it is nowdays possible to create were quick and in most cases even automated changeovers.

It is important that the set ups are performed under control and that are carefully monitored and videotaped. It is proved that reduction of set up times can be reduced up to 50 % through the slight changes. The benchmarked set ups have to be standardized and continuously improved. (Takeda 2011: 84).

"Because lean manufacturing required small batch sizes and high product variation a new method had to be developed to reduce the setup times during the rapid changeover of dies and equipment. In 1985, Dr. Shigeo Shingo introduced his methodology called single minute exchange of dies (SMED)." (Cakmakci 2008: 169)

The SMED method enables to perform equipment setup and changeover operations under 10 minutes. It also improves setup process and provides a setup time reduction up to 90% with moderate investments. Dr. Shingo divided the set up into two parts: internal setup, which can be performed only when the machines are not operating, and external setup, which can be done when the machines are working. External setup work (preparing the tools) can be done before or after the machine is stopped for the set up. The SMED method has 3 steps (Cakmakci 2008: 170):

1. *Separating the internal and external set ups* – at this step we have to ask ourselves do we need to shut down the machine in order to perform a particular activity. By this step the set up can be reduced from 30 % to 50%.
2. *Converting internal setup to external setup* – this step is performed in order to reduce the total time of the changeover. This step can be performed if we prepare of operating conditions in advance and if we use standardized intermediary jigs.
3. *Streamlining all aspects of the setup operation* – at this step we use specific principles (parallel operations, using functional clamps, eliminating adjustment and mechanization techniques …) in order to shorten the set up time.

The same as other methods and principles also set ups and SMED methods have to be a part of a CIP process in the company.

5.2.4 Levelling the production

Production can be organized in the easiest and in the most cost efficient way if the company is manufacturing the same quantity of products constantly. But in today, every day changing and fluctuating demand, this seems impossible.

The fluctuating and quickly changing demand in production is creating and increasing waste in the company. As the customers want on time delivery of what they have ordered, companies have to be prepared always for the peak demands.

If we look closely to the final customer demand and compare it to the demand that the manufacturer is receiving we can see that there are huge demand differences. This is called the" bullwhip effect" which is illustrative presented in the Figure 5-23. Bullwhip effect occurs where the small change in customer demand causes greater variation in demand along the supply chain. If we take the Figure 5-23 for example a slight increase of the customer demand causes great fluctuation and flexibility in quantity for the manufacturer also up to 50%.

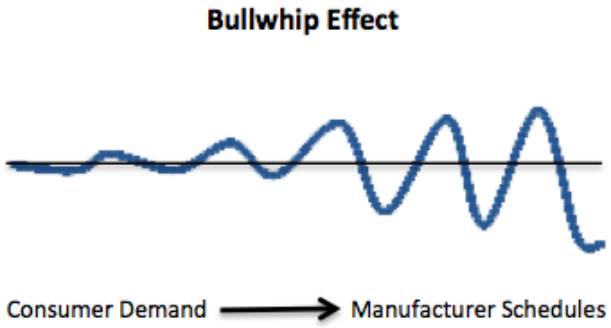


Figure 5-23: The bullwhip effect

This uncertainty is compensated with the creation of the safety stock along the supply chain and is leading to high uncertainty in the production, inefficient production and excessive inventories – waste. The bullwhip effect is mainly cause by bad and delayed information exchange, not efficient forecasting and inventory management.

Production levelling or production smoothing or heijunka (original Japanese term) can help component and also other manufacturers to reduce the risk of bullwhip effect and to develop the production efficiently.

Production levelling is also used in lean companies like Toyota or Nissan. Their belief is that stable workforce leads to better quality of products, fewer dramatic setups and shutdowns and lower absenteeism. (Heizer & Render 2011: 549).

Toyota has found that leaner operation and better customer service and meeting their demand with better quality can be done through levelling the production schedules. By that Toyota was able to reduce the lead times, cut WIP and quote much shorter lead times to the customers and by that increasing their satisfaction. (Liker 2004: 114).

Production levelling is of course closely connected to the levelled schedules. Levelled schedules technique is promoting frequent small bathes rather than a few large batches. It is operation manager's task to make and move small lots so that level schedule is economical. (Heizer & Render 2011: 663).

Heijunka means levelling the production by volume and product mix. It does not really manufacture the products according to the actual flow of the customer orders, as they fluctuate a lot, but it takes the total volume of the orders in the period and levels them out so that the same amount and mix is manufactured every day. (Liker 2004: 116).

If unlevelled production is brining to the companies risk of unsold goods, unbalanced use of the resources, unpredictability of the customers orders and placing an uneven demand on upstream processes levelled production is bringing several advantages: flexibility to make what the customer wants and when they want it, reduced risk of unsold goods, balanced use of labour and machines and smooth demand on upstream processes and the plant's suppliers. By that also suppliers of the company will receive levelled and stable schedules which will allow them to reduce the inventories and risk of not sold goods and by that the supplier will be able to pass some of the savings on to the customer and everybody will get the benefits of levelling. (Liker 2004: 118-119).

5.3 Roof element

For the roof element I suggest to use only one element: perfection, which means fine tuning of all 9 basic and pillar elements on one hand and perfection also in defining company vision, strategies, business policy, code of conduct, mutual relations between the employees and with the business partners and environmental policy. Perfection element is in all those aspects important for the long term sustainable and successful business of the company.

5.3.1 Perfection

As a roof structure of the production system comes, as a cherry on the top of the cake, perfection and along it also precision and passion for details. The word perfection derives form the word "perficio" which means to finish or bring to an end; and as flawless completeness we understand perfection also today.

After the completed 5 basic elements and 4 pillar elements it is necessary to stress the importance of perfection of each element, precision of work and details in every work task of the organization. The state of perfection is when the perfect value is reached without any additional creation of waste. Working on details is extremely important and can bring to the company very important competitive advantages. It is necessary to know your work, processes and company in details. Details are leading to the improved quality and efficiency and they are the true heart and motivation for everyday work.

The best way to illustrate what is meant by perfection, precision and passion for details is with the example of Swiss watches as they are and they have the reputation of high quality perfection product. The same is also in the automotive industry. We have on one hand Fiat cars for which it can not be said that they are example of high quality perfection in the automotive industry and we have Lexus cars on the other hand, which original slogan *"The Relentless Pursuit of Perfection"* perfectly explains it all.

The objectives of perfection are stabilization and optimization of all processes in the company, fine tuning and safeguarding of the quality of processes and product

efficiency, early detection of the defects and problems, their permanent elimination and prevention, passion for details and precision.

There are many elements and tools that we can use for achieving the perfection: quality in all aspects, poka yoke systems, TPM, visualisation, automation… all with the same goal to increase efficiency by zero fault quality. It is necessary that by introducing simple processes we detect defects or deviations and eliminate them sustainably.

5.4 Component manufacturer production system house

Let's look now at the Figure 5-24 of the final structure of the proposed production system for the component manufacturer. As already explained it is divided into three parts:

1. **Basics** with 5 elements:
    - 5S;
    - Standardization;
    - Kaizen and CIP;
    - Visual management and
    - Quality.

2. 4 **pillar** elements:
    - Tact;
    - Pull;
    - Flow and
    - Levelled production.

3. **Roof** with perfection element.

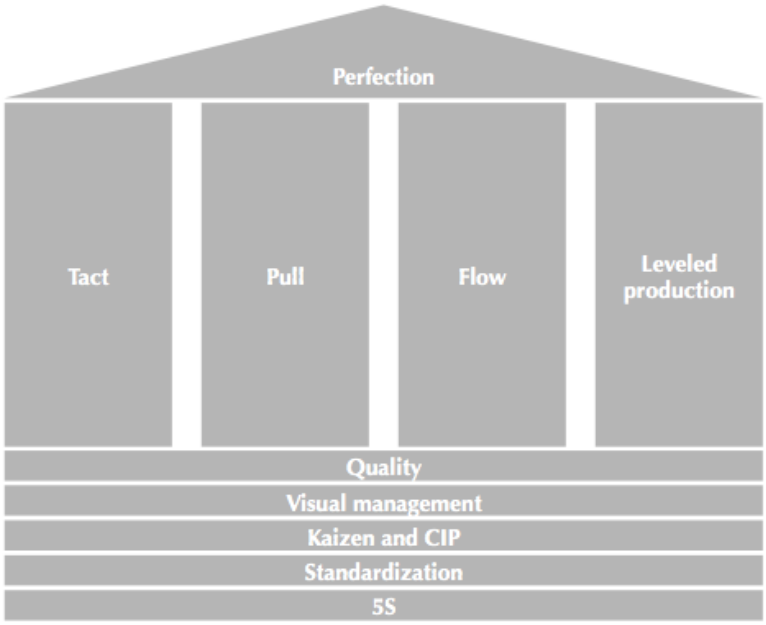


Figure 5-24: Component manufacture production system house

5.5 Implementation of the production system

Once we have created the individualized production system for our company the task is not finished yet. We can have a perfect production system, but if it stays only on the paper, there will be no value added or even more, we have created a lot of waste and spent a lot of energy and time on something that brings no added value to the company.

Behind a good production system has to be also good implementation if we would like to see positive results and desired progress of the company. We can not expect that we can implement the new production system in a week or in a month. We have to be patient and implement it carefully and thoroughly. But it should also not take years to implement it. I have already stressed out that it is extremely important that we are implementing one element after another. Next element can be implemented only when the previous element has been successfully and fully implemented in the company. We can not start with Kaizen activities if 5S and standardization were not implemented right and efficient. It is necessary that we created realistic action and time plan for the implementation of the production system.

I would suggest dividing the implementation in two steps: short term and long term. The short term implementation should focus on the 5 basics elements and should last up to six months. It is recommended to implement perfectly certain element at one production line, which should be used then as a benchmark and motivation for implementation at other production lines. The pillar elements need more time for implementation as they are more complex and connected also in many cases to additional investments. This is a long term project.

Also the implementation of the production system has to be lean. For each element we have to set clear goals which have to be communicated to everyone. It has to be clearly expressed what results we want to achieve, when and what benefits this will bring to the employees and workers. We have to engage all employees into the production system as only with their cooperation the production system will work successfully. There are many examples that prove that the new initiative or project that is "forced" from the top management to the shop floor has very poor rate of success. The same is when company hires external experts to run a project. In many cases external people do not know the company and its culture very well and the projects at the end of the day do not bring the desired results. It is true that in case the company itself does not have the required knowledge it is necessary to hire external experts to work with the employees.

According to professor Lidauer more than 50% of all change initiatives in a company fail or significantly miss the original objectives. Eight steps for successful change management are (Lidauer, MBA handouts):

1. Strongly communicate the urgency of the required change (benchmarks, trends, opportunities, challenged …) and regularly repeat them.
2. Establish a strong team of influential leaders and employees supporting the change initiative.
3. Develop a vision and strategy with the team towards the intended change.
4. Utilize every given opportunity to communicate the vision and convince people by demonstrating personal engagement and leadership.
5. Neutralize the people with negative attitude.
6. Achieve fast results: nothing is more convincing than success and progress.

7. All processes and systems which hinder the progress of change need to be amended. Employees who provide significant contributions should make their way.
8. Institutionalise the newly, changed situation and processes.

It is extremely important that the whole management fully supports the change and the new production system and its implementation. The management should be the most interested in the success and the positive results of the production system as it would bring numerous benefits to the company. If management is not supportive than it is likely that the employees will not take the project seriously and instead of becoming a habit, the production system will not exist in the company for long time. The management should be the ambassador of the production system. It would be extremely beneficial for the successful implementation of the production system if the management would also participate at the informative and team meetings. All employees have to be informed and aware of the importance, positive results and the progress of the production system.

6 Conclusion

In the world, where the only constant is change it is necessary also for the companies that they change constantly. For companies it is important that they become lean, flexible and agile organizations in order to cope with the external, market and customers, and also internal problems. Companies need to continuously improve their business and process in order to survive and become or stay competitive in the long term. It is necessary that the company is always one step in front of the problems and one step in front of the competition.

The production system helps companies to improve and to satisfy the needs of the external and internal customers, by improving three the most important elements: quality, costs and delivery.

The prerequisite for successful production system are company culture, vision and strategies. Company needs in management excellent leaders that clearly set, communicate and believe in the company vision and strategies. It is needed that clear targets and objectives are set for the company as whole as also for each single process, workplace and worker. Also each element of the production system has to have clear objectives if we want that it will be successful.

Through the literature study and analysis of the existent OEMs production systems I have found out that there exist no simple recipe for the production system in the automotive industry. The production systems among 15 OEMs are completely different. They contain different core elements, have different focus and design. And in my opinion this is right, as each OEM is different, even though they are all competing at the same global market place. Each has unique culture, vision and strategies. The same is also for component manufacturers. So it is necessary that the component manufacturer develops its own individualized production system.

The main difference between OEMs and components manufacturers production system is laying in the production process. OEMs are having mainly the assembly production lines which have completely different problems, challenges and opportunities as the manufacturing of the specific component part. That is why it is should be in one sense very dangerous and reckless if a component manufacturer

would simply reapply the one successful OEM production system to his company in belief that the victory is guaranteed. Each company must know own problems and focuses and adapt production system so that it would help to achieve the best expected results in terms of quality, costs and delivery.

When we are developing the production system for component manufacturer it is very important that all steps, decisions and processes are synchronized in order to increase the productivity and to improve each necessary component at the appropriate time.

For the design of the production system is in my opinion the most understandable house design. It is easy to understand for everyone that when we are building the house (production system) we have to build at first the foundations – basics. After foundations are firm we can start building pillars, step by step. And only after the pillars are built and firm, we can put the roof on top. It is necessary to implement each of the three steps with its elements perfectly if we would like to see successful production system.

The implementation step is crucial for success of the production system. The implementation team with the exact time plan and objectives has to be nominated and supported by management in order to increase the employee's awareness and raise the importance of the production system implementation project. It is also necessary to involve all employees and communicate clearly the benefits of each production system element and production system as a whole. Employees have to identify themselves with the project and they need to see clear benefits.

As Toyota Mr. McCurry said: *»The most important factors for success are patience, a focus on long-term rather than in short term results, reinvestment in people, product and plant, and an unforgiving commitment to quality.«* (Liker 2004: 71).

Once the production system is implemented the project is not finished. It has to be practiced everyday to become a habit and continuously improved to follow changing and increasing customer demands.

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