Pearson BTEC Level 5 Higher Nationals in Engineering (RQF)

Unit 49: Lean Manufacturing

Unit Workbook 2

in a series of 4 for this unit

Learning Outcome 2

Toyota Production System

1.1 The Toyota Production System

1.1.1 What is the Toyota Production System (TPS)?

The Toyota Production System (TPS) is essentially a form of 'lean production' which has been developed by the Toyota company over many years. It was started as a step up from the mass production methods employed by American companies such as Ford. TPS eventually evolved and led to the term 'lean manufacturing' and gave rise to several other systems that have borrowed ideas and philosophies from this. The TPS method has advanced and grown beyond just the mass manufacture of cars, it has progressed to be used in all types of manufacturing such as aeronautical, nuclear, building construction and a vast number of other sectors. Its common principles have even gone on to influence other business types other than manufacturing, namely in the service industry.

The TPS is based on several fundamental principles and philosophies which were started by the founding Toyoda family and later developed by the company's executive, Taiichi Ohno. Toyota continues to be a market-leader thanks, in no small part, to the TPS which is continually being refined and improved in order to achieve large volume manufacturing along with high flexibility, all the while maintaining low inventory levels as well as minimal defects. The application of the TPS to its operation has allowed Toyota to get its products to market quicker than its competitors with fewer snags. As a consequence, Toyota creates satisfied customers who are more inclined to purchase their products over other competitors.

Figure 1.1: *Toyota RAV4 Sports Concept*

1.1.2 The Two Pillars of the TPS

There are two main conceptual 'pillars' of the TPS which are called Just-in-time and 'Jidoka'. Just-in-time means that the company 'makes only what is needed, only when it is needed and only in the amount that is needed' and 'Jidoka' means Autonomation, i.e. automation with a human touch. These two pillars are said to support the TPS 'house' and without either one of the pillars, the 'house' will collapse and result in inefficiencies.

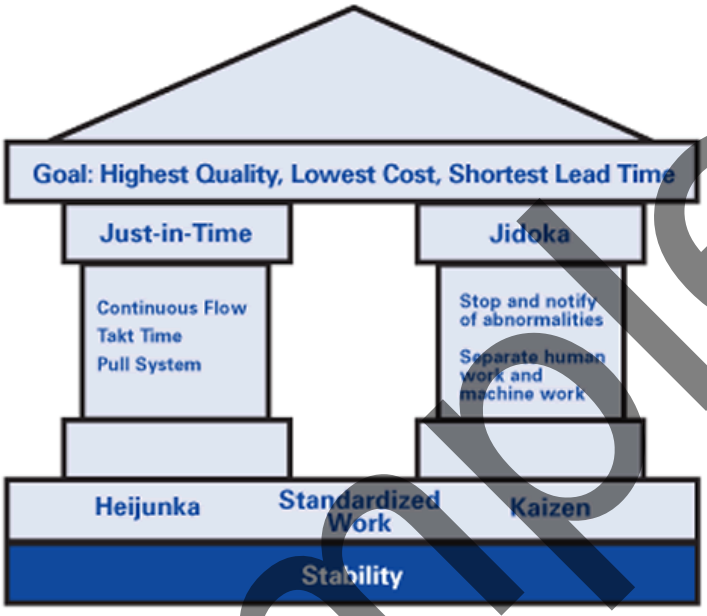

Figure 1.2: *Toyota Production System 'House'*

Just-in-time: 'make only what is needed, only when is it needed and only in the amount that is needed'.

The aim of the Just-in-time process is to efficiently produce goods within the shortest possible time period and in order to do this several methods are followed:

1. When a product is requested, the process must be started as soon as possible, therefore the workers at the beginning of the production line must also be informed as soon as possible.
2. The assembly line should be equipped with the exact number of all the parts required so that whichever type of product that is requested can be produced efficiently and speedily.
3. This assembly line must also replace the parts being used by taking the same number from the process that produces the parts. By doing this, over-stocking is reduced as only what is required is being replaced.
4. The prior process should be made up of low quantities of all parts and produce only the quantities of parts that are requested from the following process.

Figure 1.3: *Just-In-Time Features*

Jidoka: 'autonomation – automation with a human touch'.

In order for the Just-in-time process to work correctly, all the constituent parts being produced must comply with pre-existing standards of quality. This is accomplished using Jidoka:

1. Jidoka means that as soon as normal processing is finished, the machine stops in a safe and timely manner. In addition, it means that should a problem arise concerning quality or equipment, the machine is able to identify this issue independently and then stop its process, which avoids more faulty products being produced. Consequently, only products that pass these quality checks are progressed onto the next processes in the production line. This also avoids building of a number of faulty products.
2. A machine ceases production automatically when it has finished its process or if a defect is detected and then flagged immediately. As a result, the workers operating the machines are able to simply continue to work using another machine, whilst at the same time diagnose the cause of potential faults or defects. Overall, this results in each worker maintaining command of multiple machines, which leads to an increase in productivity, whilst solutions to faults and inefficiencies lead to continued improvements and better capacity for processing.

1.1.3 Goals of the TPS

The main aim of the TPS is to eliminate three fundamental issues: Inconsistency/Un-evenness, Overburden and Waste – known as 'Mura', 'Muri' and 'Muda'. In theory, this improvement process will work as such:

- The minimising of this inconsistency/un-evenness results in less stress/overburden (Mura) because there are less errors occurring.
- A process is started which is easy to repeat and brings about sleek and stable results, therefore eradicating inconsistencies in the production line (Muri).
- This reduction of stress, consequently, reduces waste (Muda) which is generally believed to occur in eight different ways:

1. Waste of overproduction
2. Waste of time waiting for responses, products or parts
3. Waste of transportation
4. Waste of over processing
5. Waste of inventory/stock
6. Waste of movement
7. Waste of making defective products
8. Waste of underutilised workers

Figure 1.4: *Mura, Muri & Muda*

1.1.4 Principles of the TPS

The TPS is intrinsically connected to a system called The Toyota Way, which is essentially just an evolved version of the TPS. The Toyota Way is an extended version of the TPS which sets out the main principles that guide both of the systems. There are fourteen principles which make up the foundation of the TPS, these are split into four categories:

a) **Philosophy as the Foundation**
b) **The Right Process Will Produce the Right Results**
c) **Add Value to the Organisation by Developing Your People and Partners**
d) **Continuously Solving root Problems Drives Organisational Learning.**

Philosophy as the Foundation

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals. Consider the overall company vision and mission statements whilst implementing the lean philosophy, both ideals can be incorporated, and the lean philosophy will help to achieve company goals.

The Right Process Will Produce the Right Results

2. Create a continuous process flow to bring problems to the surface.
3. Use 'pull' systems such as J.I.T. to avoid overproduction. *
4. Level out the workload (work like the tortoise, not the hare).
5. Build a culture of stopping to fix problems, to get quality right the first time.
6. Standardised tasks and processes are the foundation for continuous improvement and employee empowerment.
7. Use visual control so no problems are hidden
8. Use only reliable, thoroughly tested technology that serves your people and process.

Add Value to the Organisation by Developing Your People and Partners

9. Grow leaders who thoroughly understand the work, live the philosophy and teach it to others.
10. Develop exceptional people and teams who follow your company's philosophy.
11. Respect your extended network of partners and suppliers by challenging them and helping them improve.

Continuously Solving Root Problems Drives Organisational Learning

12. Go and see for yourself to thoroughly understand the situation.
13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.
14. Become a learning organisation through relentless reflection and continuous improvement.

*(Pull systems in manufacturing seek to supply only what is required, only when it is required. The opposite of a pull system is known as a 'push' system, whereby material is pushed downstream regardless of whether resources are available).

1.2 Comparison of TPS with Other Systems

1.2.1 Alternative Lean Production System Approaches

Over time, large companies have created their own systems of operation as well as utilised aspects of other successful manufacturing systems. State-of-the-art manufacturing facilities have produced a vast number of high-quality products using one or a combination of manufacturing systems/philosophies. Whichever system they use, the aim is always the same: to achieve world-class operations by reducing waste and lead times. Many of the alternative systems in use today might focus on only one aspect of the original TPS, whilst others are entirely original systems.

Several of the key manufacturing philosophies include:

Kaizen/ Toyota Production System: (A Japanese, just-in-time system, as described previously)

Lean Manufacturing/ The Toyota Way: (An evolution of the original method)

Six Sigma: (A set of techniques & tools for process improvement, introduced by Motorola in the 1980's)

Lean Six Sigma: (A combination model of the best features of Lean Manufacturing and Six Sigma)

Other types of lean production/manufacture include the Nissan Production Way, 5S, Kanban, Cell Production and Simultaneous Engineering.

To give a simple example of how a lean system can improve a process, one could use a paper airplane process as such:

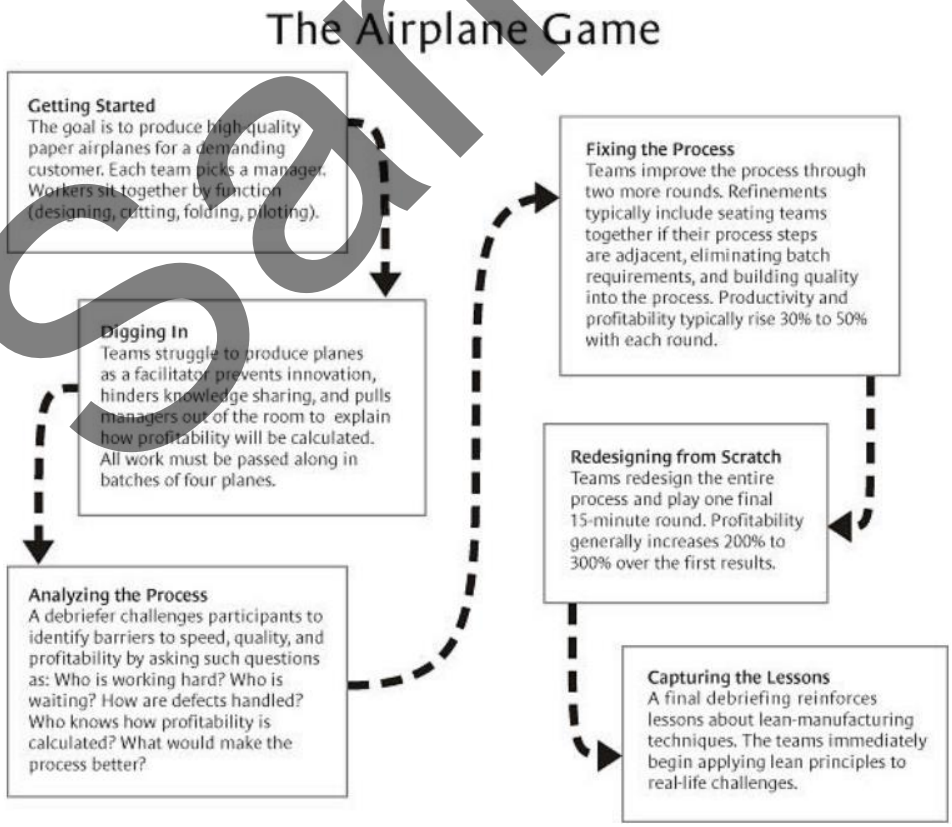

Figure 1.5: *The Airplane Game*

1.2.2 Six Sigma vs TPS

One of the most widely used alternatives to the TPS/ The Toyota Way is Six Sigma. It shares the same goal of eliminating waste and lead time, which creates the most efficient system possible, however these two methods do differ in one key point. The primary way in which these two systems differ is how they identify the main cause of waste (Muda). The Six Sigma system puts forward that the main cause of waste originates from variation within processes. Generally, Six Sigma is different to other Lean systems because it focuses on reducing variability and eliminating defects.

Six Sigma is commonly used by large multinational companies such as Motorola, Boeing, Dell, General Electric and Ford. This method and the TPS/Kaizen method, however are not mutually exclusive as several companies, such as Ford, utilise both methods to some degree.

Six Sigma uses two methods to implement projects, known as DMAIC and DMADV. Each method consists of five sections and they are compared to the methods used by the TPS/Kaizen method in the tables below:

Six Sigma: The Basics	**Kaizen/TPS: The Basics**
Focuses on eliminating defects.	Focuses on eliminating waste.
Data drives change.	People drive change.
Results orientated.	Process Orientated
Decisions are based on facts.	Decisions are based on knowledge and experience.
Requires structural change.	Requires cultural change.
Six Sigma: Key Points	**Kaizen/TPS: Key Points**
'Critical to quality' – term used to describe fundamental customer expectations from a product or service.	Good things come in small packages – everyone in a company is encouraged to make small improvement suggestions on a continual basis.
Quantify everything – analysing statistics and data requires everything to be measurable.	Everyone counts in large amounts – whole company must be engaged. All ideas equally considered, with successful ones recognised and rewarded.
Focus on financials – end results must justify the costs of improvements.	Take out the trash – eliminate all waste; any activity that adds time and/or cost but not value.

Figure 1.6: *Six Sigma vs. Kaizen/TPS Basics & Key Points*

1.3.2 Implementation of Common Practices

One of the challenges faced by companies attempting to adopt Six Sigma and other lean principles is that of quantifying previously un-quantified processes and actions. The must come up with a metric by which to measure and track performance, this creates data which then drives change in the processes.

To give a practical example of quantifying performance and tracking data of specific processes, one could look at a financial services company and use a table like the below:

Process step	Metric	Purpose of metric
Input	Applications input per employee per hour	Individual performance
	Applications input by the staff per hour	Unit performance
Underwriting support	Number of follow-up calls for medical tests and records per week	Performance of unit supplying medical tests and records
	Phone calls answered per day	Unit performance
Underwriting	Number of new cases, follow-ups, or approvals per week	Individual performance
	Frequency of physician statements ordered from doctors	Cost management (there is a cost associated with each physician statement)
	Percentage of cases issued, declined, or rated	Individual performance
Policy issuance	Policies issued per person per hour	Individual performance
	Policies issued by the entire issue staff per hour	Unit performance

Figure 1.9: *Process Step Quantification & Purpose Example*

If a company can standardise procedures this will greatly improve their efficiency (reduce waste), an example of this could be in a café as shown:

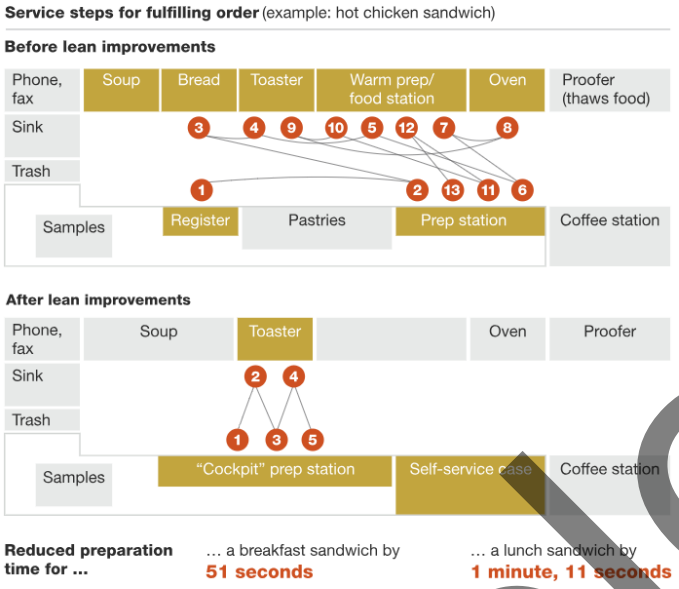

Figure 2.1: *Standardised Procedure Example*

Another key action is to eliminate waste in the form of delays, a practical example for an airplane travel company to identify where the waste occurs and how to eliminate it in turnaround between flights could be as follows:

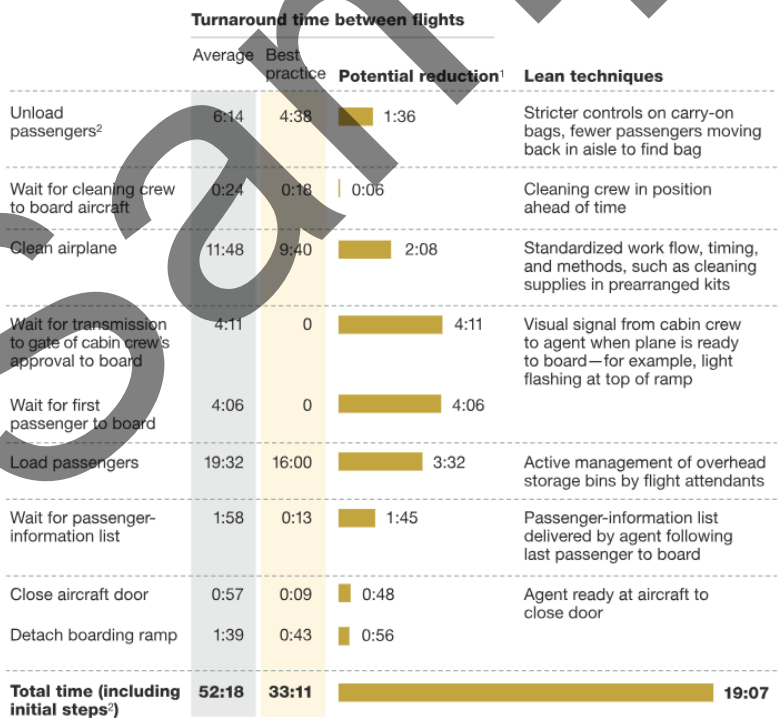

Figure 2.2: *Waste Elimination Example*