Pearson BTEC Level 5 Higher Nationals in Engineering (RQF)

Unit 49: Lean Manufacturing

Unit Workbook 3

in a series of 4 for this unit

Learning Outcome 3

Process Improvement Tools

1.1 Common Tools and Techniques

In order for a company to run as smoothly and efficiently as possible, it is necessary to know which tools to use. There are many different tools which can be applied company processes which can help to improve the efficiency of these processes. The improvements may be experienced incrementally or, alternatively there may be a breakthrough event which dramatically improves process(es). The processes which contribute, and drive customer satisfaction should be evaluated continually, and any improvements should be implemented accordingly. The overall aim and rationale for any company implementing these tools is to continually improve processes, to put it plainly, to get better all the time.

1.1.1 Seven Wastes

Waste, as discussed previously in this unit is any activity that does not add value from the customer's perspective. The 'Seven Wastes' of Lean Manufacturing are the different types of waste that can occur in a manufacturing company. These seven classes of waste are what any lean manufacturing methods aim to eliminate and, in the UK, these are often known as 'TIMWOOD'. The Seven Wastes are Transport, Inventory, Motion, Waiting, Over-production, Over-processing and Defects, as follows:

1. **Transport**

Transport is essentially the movement of inventory or products from place to another. This could be a small distance from stores to the machine shop or a larger distance such as from a production facility in Indonesia to a distribution centre in the U.K. The transportation provides no added value to the product, it does not change it in any way and a customer would have no interest in paying for this process. With the waste of transport, there are usually other associated costs such as safety procedures, storage space, operational staffing and handling machinery. Additionally, transportation can result in succeeding processes being delayed whilst waiting for the goods or materials to arrive. Transportation also presents another potential risk, when goods or materials are transported there is a danger that they may be damaged or even lost.

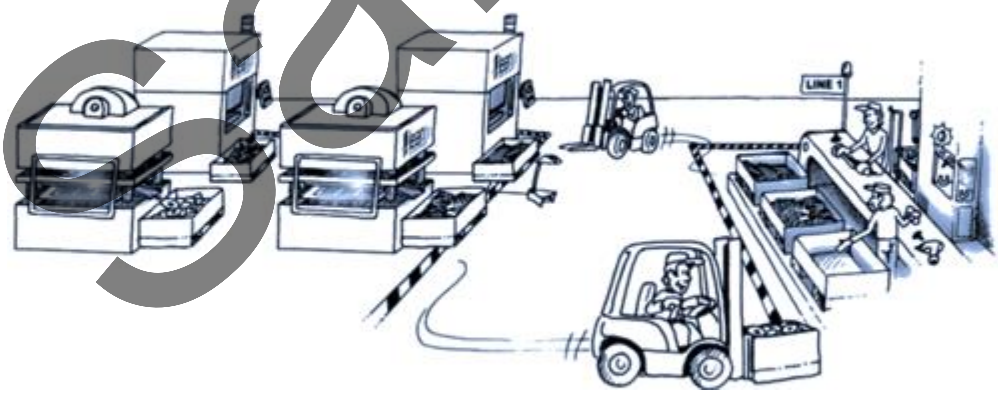

Figure 1.1: *Waste of Transport*

The waste of transport has several different causes and one of the major causes tends to be overproduction, which consequently may result in the waste of inventory, and that in turn may result in a further waste of transportation. Another cause of the waste of transportation is inefficient organisational layouts, companies often layout their shop floor into distinct separate areas depending on the function being performed. For example, a part may be worked on using a milling machine and then be transported to be worked on using a lathe. There may be large gaps separating these two functional areas which requires additional actions to be performed such as the use of a forklift to move the piece being worked on.

Clearly in an example like this, it would be beneficial to change or develop the layout so that the spaces between operations are reduced and, in turn, delays are also reduced. The use of 'value stream mapping' may also be applied, which is discussed later in this workbook.

2. Inventory

Inventory is any parts or goods, whether these are parts or goods that are in progress or the finished article. Up until the point that the goods have been sold to the customer, they have a cost associated with them, a cost that the company must account for and shoulder. On top of the raw costs of the inventory, there are other linked costs which may not be immediately obvious. This inventory requires an area to be stored in, as well as packaging and possibly additional transportation, along with costs associated with the staff to actually carry out the management of the inventory and even insurance. Over-production is usually the main reason that leads to the waste of inventory and these two types of waste are intrinsically linked. Another factor that leads to the waste of inventory can be a poor layout and an in-balanced workflow, both of which can lead to a build-up of inventory either before or after processes.

In order to reduce the waste of inventory a company should adopt the lessons of lean manufacturing, making the value flow at the demand (pull) of the customer. Production must be balanced with assembly/finishing processes so that inventory does not accumulate in between these different processes.

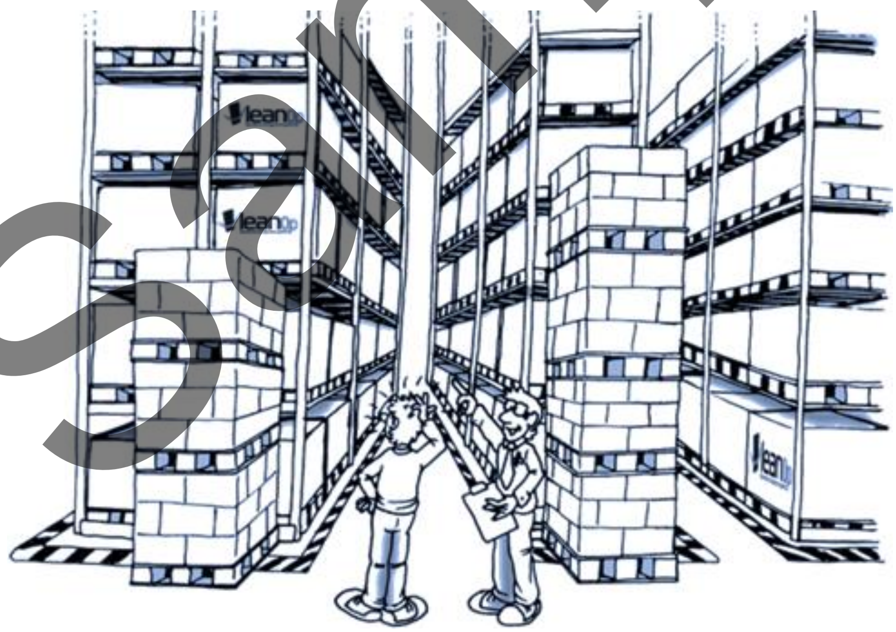

Figure 1.2: *Waste of Inventory*

3. Motion

Motions by either human workers or by machines which are not easy and simple to do are classed as unnecessary. A good example of this could be a worker having to reach up to a high shelf by their side in order to retrieve a part and then use it as part of an assembly. If the part could be supplied to the worker straight ahead of them at the midriff level, then this would significantly reduce the amount of time it takes to retrieve the part and would also reduce the stress on the worker. It is essentially a waste to move when you are not adding any value to the product you are working on.

The waste of motion has several main causes regarding layout, location of parts and tools and a lack of space. As well as these, the waste of motion may also be caused by working processes or part design which requires workers to re-orientate the work in progress regularly.

Motion clearly cannot be removed completely from a process, but the aim should be to minimise it as far as possible. This will always make working processes easier and less stressful to complete. A useful tool to eliminate motion is 5S which is another lean methodology used to organise workplaces. It is a highly effective tool for creating orderly storage areas for tools and parts, it will also help to create standard operating procedures for the best way to perform a particular process.

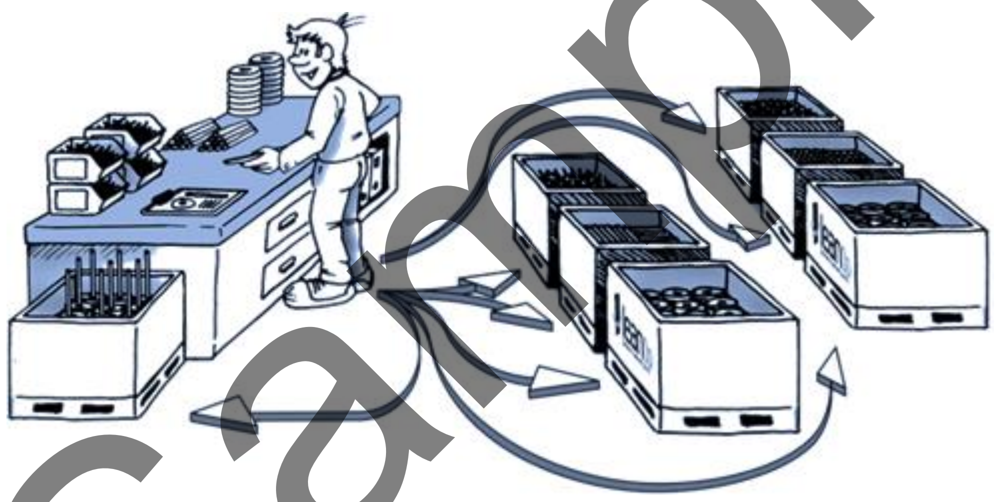

Figure 1.3: *Waste of Motion*

4. Waiting

Often in businesses, time is spent just waiting for an answer from other departments or other offices, waiting for machine maintenance, machines to finish processes or waiting for deliveries of parts or materials from suppliers. Workers may often work more slowly to disguise the fact that they are waiting for parts/materials to be delivered to move onto the next part of the process. This waiting causes a disruption to workflow and, as such, is a major debilitating factor affecting a company striving for lean manufacturing. Time spent waiting could be spent adding value to a product and often the time that has been wasted by waiting is made up for through overtime, which in turn costs the company more money.

Processes that are unbalanced result in the waste of waiting, if one task takes a longer period of time then the workers in the process immediately following will be waiting or performing processes slowly so as to company tries to get the most out of it. Additionally, there may be a poor relationship with a supplier so that the company requests more material/stock than is needed due to a mistrust of the supplier being able to fulfil the order properly.

Furthermore, the company themselves may not actually have confidence in some of their own processes, therefore managers plan to allow for delays and disruptions in production flow by overproducing to allow other processes to have some work to do rather than waiting for preceding processes. Rather than solving the issues causing disruptions, they are hidden by non-value-adding actions. Finally, companies aim to forecast the demand of their products and there are bound to be miscalculations which then lead to over-production.

Once a company has recognised that they are over-producing, they will clearly be more able to remedy the situation. Some of the production planning software systems that companies use may well be contributing to the issue of over-production, so they should be reviewed to ascertain their usefulness. When a company rearranges their workflows to accept a leaner system such as J.I.T. and uses systems such as value stream mapping and Kanban, they will be able to improve their processes so that over-production issues are more easily highlighted and solved.

Figure 1.5: *Waste of Over-Production*

6. **Over-Processing**

Over-Processing is any action that is essentially over and above what is necessary for providing the customer with a product that they require. These actions range from unsuitable processes and overly-tight tolerances to machines which are disproportionately large for the level of work they are being applied to. Over-processing causes unnecessary time and resources to be used and this then leads to stress for workers and wear on machines. Ambiguous standards of work and vague specifications often lead to over-processing, when unnecessary processes are applied to parts which do not require them.

There are several methods that can be used to minimise the waste of over-production, the main improvement method is to instil standard operating procedures for workers to comply with as well as train them appropriately. Additionally, the actual designs of parts can be looked at to evaluate if they have been over-engineered and processes can also be reviewed to find if there are simpler ways of completing tasks.

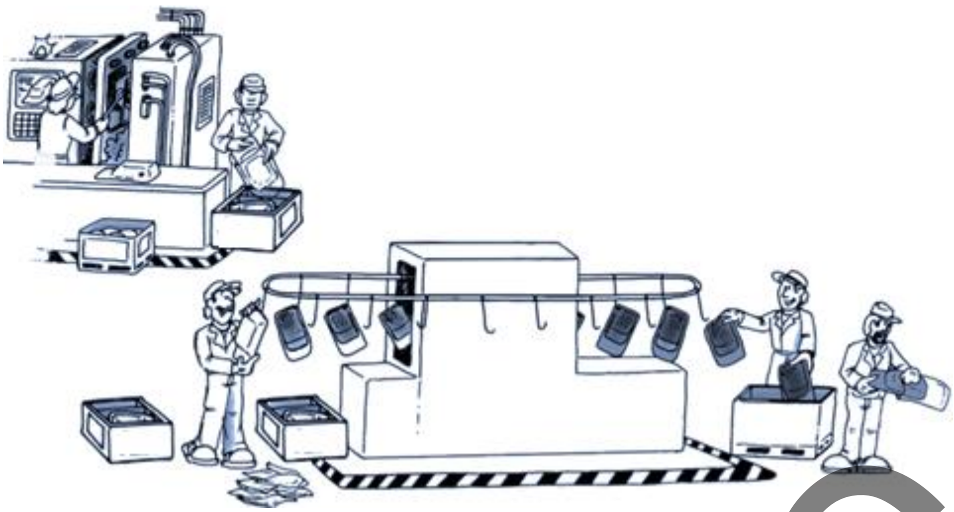

Figure 1.6: *Waste of Over-Processing*

7. **Defects**

Defects are generally a more clearly identifiable form of waste but if a defect is not identified prior to reaching a customer then the effects will likely be very negative and costly to remedy. All of the associated costs of defects are not initially obvious, a part or product with a defect may well have to be re-worked or replaced, however there are a multitude of other costs indirectly linked. These other costs range from administrative work, rescheduling, machine re-setup, transportation and loss of custom.

There are several different problems which may lead to defects occurring, problems such as variation in process application depending on the worker or machine that has worked on the part/product, mis-assembly do to poor design, inadequate training and rewarding quantity output rather than quality.

Autonomation can often reduce the number of defects as machines can identify defects and bring them to attention immediately. Having standard procedures in place for assembly or working on parts will also help to reduce the number of defects occurring. Empowering the relevant process teams to actively problem-solve is also key to preventing defects as the team will use their own talents to identify and work around issues that may arise.

There is arguably an eighth waste in the form of the waste of talent or human potential, this often happens when management is separated from the workers. The management includes strategic planning and controlling of important processes but if this management process is entirely separate and ignorant of the workers who are carrying out the practical processes then it is very difficult to monitor and improve the overall process. Workers who have knowledge and experience of the processes involved are able to provide insight to management so that they may be able to better drive and improve said processes.

1.1.2 Continuous Flow

Continuous flow is a process that is directly contradictory to that of batch production, it is also sometimes referred to as repetitive-flow manufacturing. The idea of continuous flow is that processes must be continually interrogated and improved, this calls for all parts of the production system to be integrated. The aim of continuous flow is to move a single unit in each step of a process, as opposed to considering units as batches. The following diagrams helps to explain how continuous flow aims to consider a manufacturing/assembly process compared to a batch-type process.

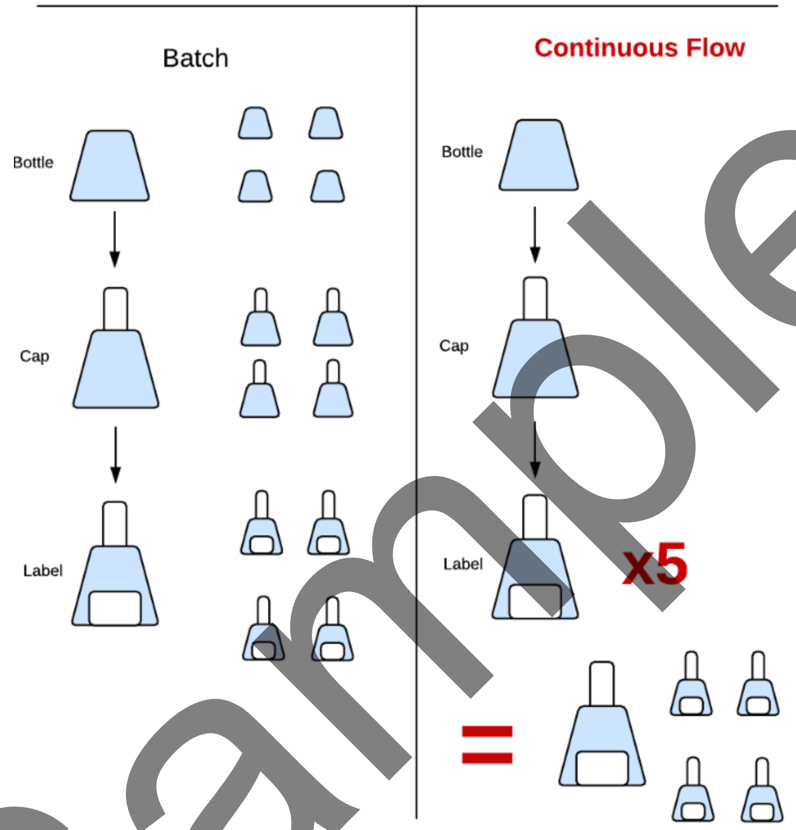

Figure 1.8: *Continuous vs. Batch*

This process is much more efficient so long as the following unit is brought into the process as soon as the preceding unit has finished the first step. This method is commonly used in the car manufacturing industry to spectacular effect and can run 24/7 with minimal human input.

1.1.8 Total Preventive Maintenance (TPM)

The main aim of TPM is to increase productivity by involving the workers and operators of machines in the maintenance of those machines. It is a holistic concept that promotes a pro-active approach and targets several different results such as fewer delays, defects and breakdowns as well as a zero-accident record.

There are eight 'pillars' of TPM, each contribute to the process as a whole and, when combined together, can produce world-class results. The foundation of TPM is usually the 5S methodology, which is a lean tool that essentially creates orderly storage areas and standard working procedures.

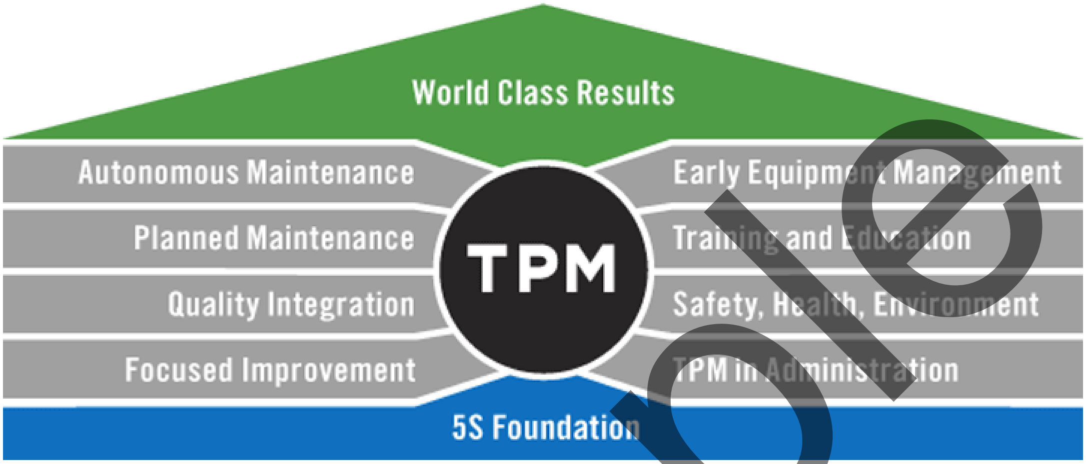

Figure 2.3: *8 Pillars of TPM*

Autonomous Maintenance: Responsibility for routine maintenance is given to machine operators, this gives them a greater sense of ownership, as well as improving operator's knowledge. Potential issues can be foreseen by the operators who are familiar with the everyday operation of the machines and tools and specialist maintenance staff are also free to attend to higher level tasks.

Planned Maintenance: Maintenance tasks are carried out on a schedule which limits the chances of breakdowns caused by wear and tear. The maintenance can also be conducted when a machine is on downtime, so as to reduce disruption to production.

Quality Integration: Machinery and processes have fault detection and prevention built in so that defects are identified as soon as possible, and improvements are targeted using a root cause analysis such as the 5 Whys.

Focused Improvement: Improvements to processes happen incrementally through routine analysis of the process by the group of workers involved in it. The different abilities and talents of each worker are utilised to attain a practical outcome.

Early Equipment Management: New equipment and machines are designed with contribution from the knowledge gained from the previous usage of equipment. As a result, there will likely be fewer start-up and adjustment issues as well as improved performance and easier maintenance.

Training and Education: All relevant staff are given adequate training so as to achieve the goals set out by TPM. Operators gain more knowledge and skills required for routine maintenance, the maintenance staff

1.1.9 Plan-Do-Check-Act (PDCA)

This method of process improvement and problem-solving is especially useful for repetitive processes and it consists of four steps that, themselves should be repeated over and over:

1. **Plan**

Identify a problem/opportunity and define what change is to be actioned to improve the process, this can be done by using a tool such as the 5 Whys or another similar method.

2. **Do**

After identifying the improvement to be made, it is then to be initially implemented on a small scale. Rather than a company-wide change, it is a good idea to test on a scaled-down version in order to see the proof that the change is giving the desired results.

3. **Check**

Compare the results of the new process to those of the previous process, keeping in mind that an improvement in one area may well correspond to a deterioration in another. Therefore, the new process should only be approved it is beneficial to the company as a whole and in the long term.

4. **Act**

If the new process is successful, then it can be scaled up and repeated on a bigger scale. PDCA is not a one-time use method and should be continually employed to keep improving the process until it becomes as efficient as possible.

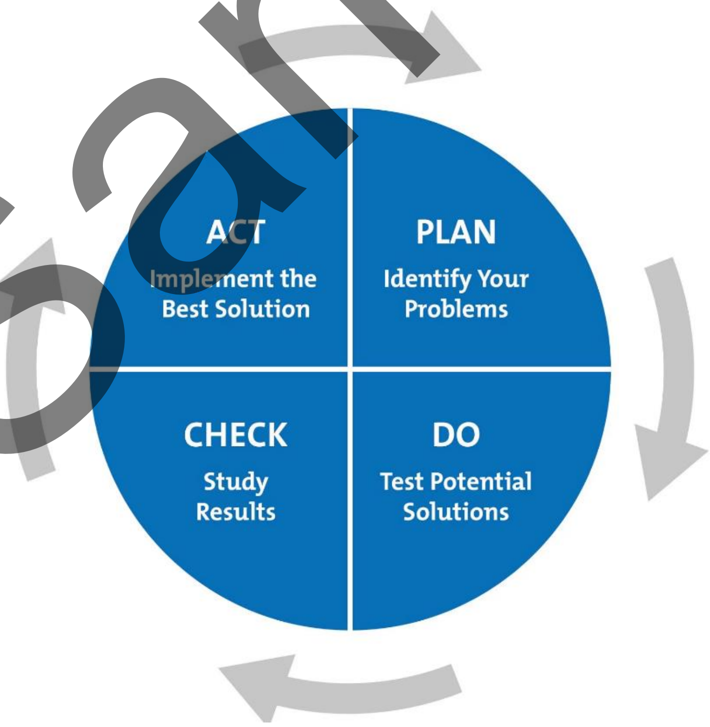

Figure 2.4: *PDCA Cycle*

1.1.10 Single Minute Exchange of Die (SMED)

SMED is a method of lean production that seeks to reduce changeover time between one product/action and the next. Ideally any change to machinery should be made whilst the machine is still running because this will drastically reduce machine downtime whilst improving flexibility and responsiveness. A machine may not necessarily be part a mass production factory, it may simply be a process that produces more than one end result.

The key to SMED is to identify which elements are internal and those that are external. An internal element is any element that must be completed whilst the machine is down, whilst an external element is one that can be performed whilst the machine is still running. Once identified, as many of the internal elements as possible should be converted to external, thus leading to reduced downtime.

In order to convert internal to external elements, there are several techniques that can be implemented to facilitate this, such as: advanced preparation, using jigs, using modular equipment or modifying equipment to be easier to use and clean. When changing a machine over from producing one product to another, this should be made as easy and simple as possible. Methods for streamlining this change over include using quick-release mechanisms instead of bolts, eliminating adjustments, reducing motion and waiting and standardising tooling.

A prime example of a process that implements SMED effectively is a Formula One pitstop crew when they refuel the car, change wheels and nose cone. All possible internal elements have been externalised, originally when Formula One racing began there was one worker who manually removed each wheel separately, currently each wheel has a dedicated worker who removes it and fixes a new wheel, complete with a pre-heated tyre. All bolts fixing the wheels onto the car have been made to be removed very quickly and each person has a dedicated task to perform, within a dedicated area. The improvements have been implemented over time have led to a significant time reduction; A pit stop time in the 1950's was approximately one minute and in the 1990's the time taken was down to 7 seconds. The format has since changed so that refuelling and changing tyres in the same pitstop is no longer permitted, however the SMED method is still being utilised to improve the process.

Figure 2.5: *Formula One & SMED*