An Introduction to Lean Manufacturing

Overview

In production plants across the globe, lean manufacturing techniques are being utilized to meet increasing demands placed on manufacturers. Buyers now require quicker turnaround, better service, and higher quality – all at a competitive price. Originally developed as a methodology to make production processes highly efficient, lean manufacturing techniques have been adopted by more than 72% of machine shops across the country.[1] For many, these techniques have helped them to dramatically increase their competitive edge, while continuing to remove wasteful practices and contribute to the bottom line.

What is Lean Manufacturing?

While the basic lean model was introduced more than 100 years ago, it has continued to evolve over time – from Henry Ford's continuous assembly lines for the Ford Model T, to the concept of interchangeable parts used by Eli Whitney and Samuel Colt, to the Toyota Production System. These concepts, in addition to a multitude of others, have come together to formulate what we know today as lean manufacturing.

The core idea behind lean manufacturing is maximizing customer value while minimizing waste, thereby achieving manufacturing excellence through the creation of more value with fewer resources. Waste is defined as an activity that does not add value to the product. Through the elimination of waste along the entire process, rather than at isolated points, companies are able to create processes that need less human effort, less space, less capital, and less time to produce high quality, lower cost products compared with traditional business systems.[2]

Guiding Principles of Lean

Given the shift towards a customer centric environment while facing formidable competition, many manufacturers are proactively implementing lean principles to help eliminate waste and increase efficiencies rather than relying on processes and procedures that have been used in the past. In order to help guide companies through a lean transformation, Womack and Jones developed a five-step thought process detailed in their book, "Lean Thinking".

1 Modern Machine Shop, Top Shops Benchmarking Survey - August 2011, http://mms.epubxp.com/title/10450
2 Lean Enterprise Institute, What is Lean?, http://www.lean.org/WhatsLean/, August 2011

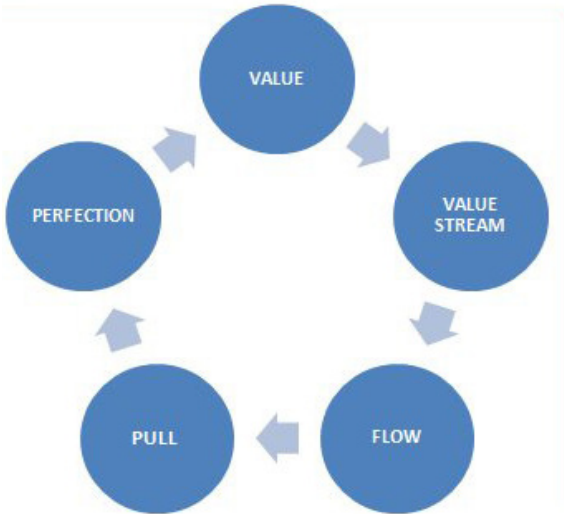
1) **Specify Value:** The first step in implementing lean thinking into manufacturing processes is to identify the value of a specific product from the customer's perspective. Value can only be defined by the ultimate customer, and must be created by the producer.

2) **Identify the Value Stream:** Identifying the entire value stream for each product will almost always reveal three types of actions along the value stream, including steps that create value, steps that create no value but are unavoidable with current technologies and production assets, and non-value adding steps that can be eliminated.

3) **Create Flow:** Once value has been precisely specified and the value stream for a specific product fully mapped, making work elements flow continuously with minimal queues with no rework or stoppages is the next step in a lean transformation.

4) **Establish Pull:** After wasteful steps have been removed, and flow has been established, the ability to deliver only what is wanted by your customer, and only when they want it, is the fourth principle of lean thinking – pull. Allowing customers to pull a product through the process is indicative of the organization's ability to be responsive to a customer's needs.

5) **Seek Perfection:** As organizations bring their processes through the initial four principles, accurately specifying value, identifying the value stream and removing wasteful steps, creating flow, and letting customers pull value from the enterprise – the fifth principle, perfection becomes attainable.



The five steps outlined by Womack and Jones represent a continuous cycle of improvement, and act as the foundation for the successful implementation of lean in a facility.

While there is no such thing as a "perfect" process, companies can constantly strive for perfection through the elimination of waste. In the Toyota Production System (TPS), developed by Taiichi Ohno, Shigeo Shingo, and Eiji Toyoda, one of the major precursors to lean manufacturing, the elimination of waste is one of the main objectives – even going so far as to identify seven different types of wastes, known as the "Seven Deadly Wastes".

Eliminating the Seven Deadly Wastes

The seven deadly wastes of manufacturing are activities that have been identified as non-value adding events or processes that hinder profitability in a company. All finished goods and batched

inspections include the seven deadly wastes – however, being cognizant of this fact can help to eliminate the waste while achieving maximum efficiencies. Below are the seven deadly wastes and lean tools that can be implemented to counteract waste.[3]

Waiting: Time spent waiting on something, or someone to complete a task
Lean Tool: Design processes so that flow is continuous and there are minimal (or no) buffers between steps in production (Continuous Flow).

Motion: Any unnecessary movement of people that does not add value to the product or service
Lean Tool: Ensure that work areas are logically organized, i.e. rather than having a worker walk 20 feet to pick up spare parts every half hour, minimize the distance to 5 feet to significantly reduce excess motion.

Overprocessing: Using more energy or activity than is needed to produce a product
Lean Tool: Look for potential simplifications to the manufacturing process, i.e. instead of completing 100% inspections on parts that never fail, reduce the number of parts inspected to greatly reduce processing time.

Inventories/Queues: Excess product waiting to be processed
Lean Tool: Excess, or just-in-case inventory, can result in lost money/resources caused by storage. Aiming for just-in-time inventory reduces downtime associated with inventory problems.

Transportation: Unnecessary movement to get goods from one process to the next
Lean Tool: The transportation of goods or material can be risky – incurring damages or delays while in transit uses up resources. Effective planning can ensure that excess wastes in terms of moving do not occur.

Overproduction: Making more parts or information than is required
Lean Tool: Pacing material flow through production to match customer demand can help to minimize overproduction, and is more cost efficient in the long run.

Fixing defects/mistakes: Time spent repairing or reworking material or information
Lean Tool: The cost of fixing defects or mistakes is often cheaper the sooner it is found – for example, mistakes found at raw materials inspection may only cost $10 to isolate and fix, whereas fixing a product at the work-in-progress stage may cost hundreds of dollars.

The Lean Transformation: Do More, With Less

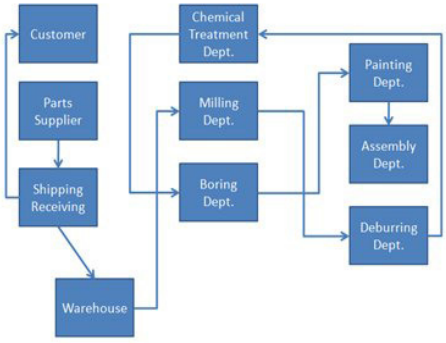
"Lean is not simply a toolbox, but a total perspective." Undertaking a lean transformation can be

3 LeanProduction.com, The Seven Deadly Wastes, http://www.leanproduction.com/pdf/the-seven-deadly-wastes.pdf

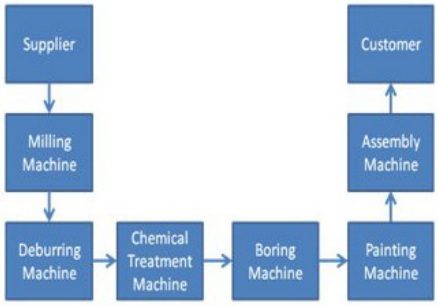
a difficult transition; however, understanding that lean is a cultural concept, affecting every level of an organization, will result in a successful implementation. From the production floor to C-level management, it is critical for teams to understand the concept and buy into the overall goal. Below are a few common lean tools and practices implemented in the process of bringing on a lean transformation.

Cellular Manufacturing: Arranging production work stations and equipment in a sequence that supports a smooth flow of materials and components through the production process with minimal transport or delay. Shifting from traditional "batch and queue" mass production systems to a "single piece flow, pull production" system, cellular manufacturing helps to eliminate overproduction and reduce defects.[4]

Example: Allowing organizations to be flexible in terms of production setup and delivery, cellular manufacturing helps to facilitate faster turnaround, and reduce work-in-process inventory, while optimizing the layout on the production floor.



Typical batch & queue system



Cellular manufacturing layout

5S Workplace Organization: A series of activities for eliminating wastes that contribute to errors, defects and injuries.[5]

1S – Simplify: Clearly distinguishing what is necessary and disposing of the unnecessary.

4 United States Environmental Protection Agency, Lean Thinking and Methods: Cellular Manufacturing, http://www.epa.gov/lean/environment/methods/cellular.htm

5 The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer - Jeffrey Liker

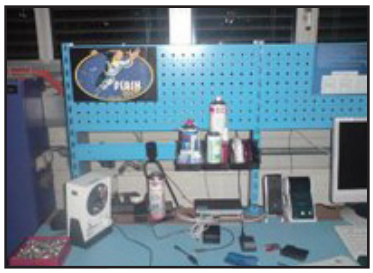
2S – Straighten: Organizing the necessary items so that they can be used and returned easily.

3S – Scrub: Cleaning floors, equipment, and furniture in all areas of the workplace.

4S – Stabilize: Maintaining and improving the standards of the first three S's

5S – Sustain: Achieving the discipline of properly maintaining the correct 5S procedures and continuously improving to making maintaining 5S easier.

Example: The images below show 2S – Everything has a proper location and an organized method of location marking.

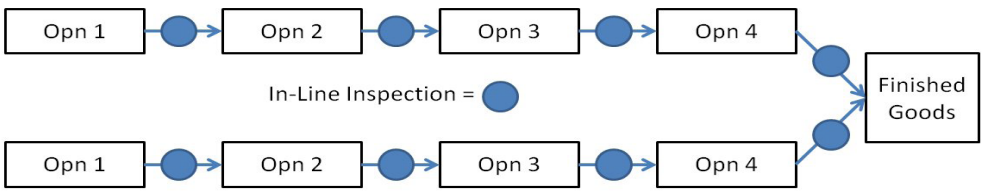


Before

After

In-Line Inspection: Removing the need for separate testing and inspection labs, in-line inspection allows workers to perform inspections directly on the line to ensure the accuracy of in-process work. Verifying measurements on the line, rather than having to bring a part to a separate temperature controlled room, helps to create more efficient workflows and streamlines the inspection process.

Example: In a lean work cell, the goal is to eliminate scrap, while building quality into the process. One way to accomplish this is to implement portable CMMs on the line, increasing production efficiencies and producing higher quality finished goods. Mounted directly on the machine, portable CMMs eliminate the need to bring part to a quality lab – saving the company time and money. By utilizing portable metrology tools such as articulating arms designed to withstand harsh working environments, operators are able to quickly identify defects of parts in-process.



Total Productive Maintenance (TPM): A maintenance process developed to improve productivity by making processes more reliable and less wasteful, the goal of TPM is to maintain a plant or equipment in good condition without interfering with the daily process.

Example: By implementing TPM, companies can minimize the unexpected failure of equipment and reduce plant downtime through regular maintenance. One way to accomplish this is to implement portable CMMs such as laser trackers or articulating arms to align fixtures and calibrate machines. Regular maintenance allows for maximum uptime and accurately produced parts.

Kaizen: Often considered to be the "building block" of all lean production methods, kaizen, or rapid improvement processes, focuses on eliminating waste, improving productivity, and achieving sustained continual improvement in targeted activities and processes of an organization.[6]

Aiming to involve workers from multiple functions and levels in the organization in working together to address a problem or improve a process, the team uses analytical techniques such as value stream mapping and "the 5 whys", to identify opportunities quickly to eliminate waste in a targeted process or production area.

Example: After identifying an area for a rapid improvement event, such as a production area where significant bottlenecks or delays occur, the kaizen team must identify the root cause of the problem. This can be accomplished by utilizing the 5 whys technique, i.e.:

- Why did the machine stop? There was an overload, and the fuse blew.
- Why was there an overload? The bearing was not sufficiently lubricated.
- Why was it not lubricated sufficiently? The lubrication pump was not pumping sufficiently.
- Why was it not pumping sufficiently? The shaft of the pump was worn and rattling.
- Why was the shaft worn out? There was no strainer attached and metal scrap got in.

Once the root cause of the problem has been identified, the team can then work to collect information on the targeted area, such as measurements of overall product quality; amount of work-in-progress; and scrap rate and source of scrap. Analyzing this data allows the team to identify areas for improvement, and test improvement options before implementation.

A key portion of a kaizen event is the follow-up activity to ensure improvements are sustained and not just temporary. Following an event, the team routinely tracks key performance measures to document improvement gains to assess performance and identify modifications that may be necessary to sustain the improvements.

Portable CMMs and Lean Manufacturing

Ideal for a variety of applications including 3D modeling, reverse engineering, alignment, machine installations, and rapid prototyping, portable CMMs such as articulating arms and laser trackers have become critical components in the implementation of lean principles. Providing companies with a way to help streamline inspection processes, create flow and eliminate deadly wastes in a lean manufacturing environment, portable CMMs enable companies to do more with less.

6 United States Environmental Protection Agency, Lean Thinking and Methods: Kaizen, http://www.epa.gov/lean/environment/methods/kaizen.htm

One of the major elements of lean manufacturing is the concept of creating flow. By making work elements flow continuously with minimal queues and no rework or stoppages, a company is one step closer to reaching optimal levels of production. Creating flow through the implementation of portable CMMs on the line simultaneously eliminates two of the deadly wastes, waiting and transportation.

For example, by mounting an articulating arm directly on a machine producing a part, operators are able to create flow between each station and eliminate the waiting periods commonly found in batch and queue manufacturing. Eliminating machine outage time necessary for off-line inspection, operators are able to reduce inspection times without having to transport materials to inspection rooms while mitigating measurement variability between users.

Fixing defects is another example of a deadly waste that can be helped through the implementation of portable CMMs. Many companies utilize portable CMMs such as laser trackers and articulating arms for incoming and in-process inspection. For example, by implementing an articulating arm to inspect parts as they arrive, defects can be eliminated at the raw materials stage, preventing incorrect products from making it further into the production process. Additionally, laser trackers can be used for in-process inspections, ensuring that components are aligned correctly for works-in-process, eliminating rework at final inspection. Discovering any errors early on in the production process saves companies valuable time and money.

Summary

In order to stay afloat in today's competitive manufacturing environment, many companies have implemented lean manufacturing techniques to create more efficient workflows. Through the elimination of waste and the creation of flow through the various processes, companies are able to eliminate costly scrap and rework while contributing to their bottom line.

Implementing portable CMMs into standard workflows has helped many companies to achieve their lean manufacturing goals; in many cases, companies who have implemented portable CMMs directly on the line for in-process inspections have seen a reduction in inspection time of up to 60%. Used to ensure accurate alignment and precision measurements, portable CMMs such as the FaroArm, FARO Gage and FARO Laser Tracker have become critical in helping companies to achieve various lean principles.

To learn more about creating efficient workflows using portable CMMs, visit www.faro.com