Lean Manufacturing and the Toyota Production System

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The use of the term "Lean", in a business or manufacturing environment, describes a philosophy that incorporates a collection of tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers. Becoming "Lean" is a commitment to a process and a tremendous learning experience should you attempt to implement Lean principles and practices into your organization.

The term Lean in the manufacturing environment also refers to the Toyota Production system established by the Toyota Corporation. Within the organization, four prominent gentlemen are credited with developing the system: Sakichi Toyoda, who founded the Toyoda Group in 1902; Kiichiro Toyoda, son of Sakichi Toyoda, who headed the automobile manufacturing operation between 1936 and 1950; Eiji Toyoda, Managing Director between 1950 and 1981 and Chairman between 1981 and 1994; and Taiichi Ohno, the Father of the Kanban System.

Sakichi Toyoda invented a power loom in 1902 and in 1926 an automatic loom capable of detecting a snapped thread that automatically stopped the loom thus preventing production of poor quality. That same year, 1926, he founded the Toyoda Automatic Loom Works that manufactured automatic looms. In 1937, Sakichi sold his automatic loom patents to a company in England to finance an automobile manufacturing operation with his son Kiichiro managing the new venture. At the same time in Yokohama, Japan, the Ford Motor Company was building Model A cars and trucks with mixed models in a plant converted over from the Model T. At this time, Ford was the largest manufacturer of automobiles in Japan with General Motors as the second largest manufacturer, together producing over 90% of the vehicles manufactured in Japan. The new automotive venture for the Toyoda Group was risky.

Kiichiro Toyoda, the son of Sakichi, who possessed a greater interest in engines and automobiles then textiles and loom production, convinced his father to establish an automotive operation in 1936. As managing director of the new operation, Kiichiro traveled to the Ford Motor Company in Detroit for a year of studying the American automotive industry. Kiichiro returned to Japan with a strong knowledge of the Ford production system determined to adapt the system to smaller production quantities. In addition to the smaller production quantities, Kiichiro's system provided for different processes in the assembly sequence of production, the logistics of material simultaneous to production consumption, and a supplier network capable of supplying

component material as required. The system was referred to as Just-in-Time within the Toyoda Group.

Eiji Toyoda, a nephew of Sakichi Toyoda, joined the Toyoda Automatic Loom Works family business after graduating from the University of Tokyo in 1936. In 1950, Eiji was named Managing Director of the Toyoda Automotive Works when the Japanese government forced Kiichiro Toyoda into reorganizing the Toyoda Group. The forced reorganization separated the family businesses and resulted in the resignation of Kiichiro and his entire staff. In the first year as Managing Director, Eiji traveled to the United States to study the American automotive industry and report on American manufacturing methods. After touring the Ford Motor Company operations, Eiji returned to Japan with a desire to redesign the Toyoda Automotive Works plants. An important process learned during the trip was the Ford Motor Company suggestion system. Eiji instituted the concept and it is considered to be one of the major building blocks of the Toyota Production System of continuous improvement (Kaizen).

In 1957, Eiji renamed the Toyoda automotive operation The Toyota Company and again in 1983 to the Toyota Motor Corporation. In 1982, he established the Toyota Motor Sales USA. In 1986, Eiji returned to the United States to renew his study of the American automotive industry. Upon his return to Japan he presented the employees with new challenges. The Toyota Motor Corporation could not just copy the American automotive industry, but needed to produce superior automobiles, and do it with creativity, resourcefulness, wisdom, and hard work.

Taiichi Ohno, considered to be the creator of the Toyota Production System and the Father of the Kanban System, joined the Toyoda Automatic Loom Works after graduating from Nogoya Technical High School in 1932. Early in his career, he expanded upon the JIT concepts developed by Kiichito Toyoda to reduce waste, and started experimenting with and developing methodologies to produce needed components and subassemblies in a timely manner to support final assembly. During the chaos of World War II, the Loom Works was converted into a Motors Works and Taiichi Ohno made the transition to car and truck parts production. The war resulted in the leveling of all Toyoda Group Works production facilities, but under the management of Eiji Toyoda, the plants were gradually rebuilt and Taiichi Ohno played a major role in establishing the JIT principles and methodologies developed in the Loom manufacturing processes.

At the reconstructed Toyoda Group Automotive Operations, Taiichi Ohno managed the machining operations under severe conditions of material shortages as a result of the war. Gradually he developed improved methods of supporting the assembly operations. The systems that were developed(the Toyota Production System), Ohno credited to two concepts. The first concept from Henry Ford's book *Today and Tomorrow* published in 1926 provided the basis of a manufacturing production system. The second

concept was the supermarket operations in the United States observed during a visit in 1956. The supermarket concept provided the basis of a continuous supply of materials as the supermarket provided a continuous supply of merchandise on the store shelves.

Two other gentlemen who helped shape the Toyota Production System were Shigeo Shingo, a quality consultant hired by Toyota, who assisted in the implementation of quality initiatives; and Edward Deming who brought Statistical Process Control to Japan.

The principles and practices of Lean are simplistic and developed over a 90-year period of time. While they have evolved by trial and error over many decades, and many prominent men have contributed to their development, the principles and practices are not easily to implement, which many companies will attest too. Implementation requires a commitment and support by management, and participation of the all personnel within an organization to be successful.

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Thinking of Lean Manufacturing Systems

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The importance of Lean Manufacturing System is better comprehended when its impact of change on economics is thoroughly understood. The manufacturing engineering philosophy is pivoted on designing a manufacturing system that perfectly blends together the fundamentals of minimizing cost and maximizing profit. These fundamentals are Man (Labor), Material and Machines (Equipment) - called the 3Ms of manufacturing. A well balanced 3M results in

- Maximum utilization of Man - skilled and/or unskilled
- Optimal module size - cellular and/or plant
- Smooth traffic flow - of materials, man, automotive
- Minimum total manufacturing cost - of products produced
- Reduce investment
- Reduce labor requirement
- Utilization of more productive equipment
- Disposition of less productive equipment
- Flexibility to be contemporary / keep pace with market / customer changes
- Increase Return On Net Asset

There are three steps involved to accomplish the ultimate manufacturing engineering philosophy:

1. Design simple manufacturing system, commence the system design as simple as possible with low volume through the system;
2. Realize there is always room for improvements, refine the first step above as best as possible; and
3. Continuously improve the lean manufacturing system design concept with appropriate insertion of and balance of automation, conveyors and where necessary, buffer stocks.

Alternative concepts may be generated that could satisfy product and marketing technical requirements based on thorough review or re-examination of intra- and/or inter- technologies, past production process errors and lessons learned, competitive analysis, techno-communication as may be applicable. The final selection of manufacturing system concept(s) to be adopted for further consideration or development should be based upon analysis performed in conformance with established selection criteria. Let us consider two manufacturing systems that when combined give Lean Manufacturing - Flow Manufacturing System and Agile Manufacturing System.

Design Simple Manufacturing System

Flow manufacturing is a time-based process that pulls material through a production system without any interruption. This is a fundamental principle of Lean Manufacturing. This process concept can be achieved by--rapidly flowing **material** from raw to finished good--systematically balancing **man** (operator) and **machine** (equipment) to customer requirement.

The goal of Flow Manufacturing is to provide the ultimate response and produce to customer requirement. The benefits of this goal include:

- decreased Total Product Cycle Time,
- less inventory,
- increased productivity, and
- increased capital equipment utilization.

In Flow Manufacturing, the performance is measured by the Total Product Cycle Time (or Critical Path). Total Product Cycle Time is the longest lead time path from raw materials to finished goods. This is the quickest possible response to a customer order with finished product. Lead Time Analysis is derived from the Critical Path which enables us to highlight opportunities to reduce or eliminate NVA activities and thereby shorten the Total Cycle Product Time. By reducing the variations in the rate of flow in a manufacturing system, the lead time may be shortened. The variations can be reduce with

- random downtimes, higher uptime through quick changeover, lower downtime, etc., and
- improved quality through error proofing, self checking equipment product centered cellular layout.

Agile Manufacturing is a profitable manufacturing system that is closely related to the concept of Flow Manufacturing. It builds on the Flow Manufacturing concept to reduce lead time, optimize asset utilization and build to customer demand by focusing on being able to quickly respond to customer requests. It assumes that the customer requirement (specifications and volumes) is subject to continuous changes. A form of measurement of Agile Manufacturing performance is the program lead time.

Realize There is Always Room for Improvements

The ultimate goal is a system that has a smooth flow of material while maximizing the value added (VA) activities of the operator. Usually there are many situations in System Design Process that require special consideration. A few of these situations include:

- Manufacturing Process - is the equipment used to create, alter, assemble, measure or test the product with the objective of meeting a pre-determined product requirement. The equipment include machines, fixtures, tools, gauges such as lathes, drills, grinders, test stands and so on.
- Manufacturing System - is the combination of man and manufacturing process(es). These two are often linked together with material handling (manual or automated) to move the material or product from one manufacturing process to the next.
- Value Added (VA) - is any activity performed to a product as it moves through the production process that the customer perceived as actually adding value to the product.
- Non Value Added (NVA) - is all other activity associated with the production process that may or may not be necessary to be performed but it is nonetheless performed at present pending the emergence, awareness or availability of better methods.

Total Product Cycle Time (also known as Critical Path) is the longest lead time path from raw material(s) to finished goods. This is the quickest possible response to a customer order with a finished product. NVA activities in manufacturing system is waste. These wastes are correction, over production, movement of material, motion, waiting, inventory, and processing. Improving the flow of material through improved system layout at the customer's required rate (takt time) would reduce waste in material movement, inventory (work in progress) and improve the ability to be a JIT manufacturer. Therefore it is essential to properly apply the methodology of Lean, Flexible, Customer Focused Cellular Layout, Material Flow and Transfer, Takt Time and Operator Utilization in order to achieve the goal of Flow manufacturing and JIT.

Continuously Improve the Lean Manufacturing System Design

To be able to quickly respond to customer requirements and be a JIT manufacturer concurrently, one of the keys is to have the flexibility of equipment and have the ability to align it with product flexibility. Due to the uncertainty in customer requirement, it is important to examine manufacturing cost over a range of volumes.

Traditionally, there is a steep drop in manufacturing cost as the ideal volume requirement is approached and a steep rise as the volume is in excess of requirement. This system is generally characterized by:

- investment committed upfront, usually very high,
- more rigid and complex equipment, often not technologically modern, and
- larger capacity increments, high customer volume requirement for long period.

However, in Lean Manufacturing, the manufacturing cost does not have such a steep drop as volume requirement changes. This is because of the product flexibility and equipment flexibility that can be incorporated into the Lean Manufacturing System. This system is usually characterized by:

- investment committed as needed,
- more equipment flexibility,
- more adaptable to uncertain markets (volume / product), and
- smaller capacity increments, more product flexibility.

Lean Manufacturing System has potential for greater profit (higher RONA). The profitability depends on the utilization of its resources - the 3Ms viz

- Material moving rapidly from VA to VA operations
- Man working constantly by adding value to the product
- Machine running in a more productive manner according to customer requirement

Lean Manufacturing System can be adopted in new manufacturing system, existing manufacturing system requiring capitalization, equipment or product relocation.

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