APPLICATION OF LEAN MANAGEMENT IN HIGH-TECH MANUFACTURING SYSTEMS

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Abstract
The paper analyzes the technological applications of Lean Management in options Robotics Cells and Flexible Manufacturing Systems. Specified by the design principles of these manufacturing systems. Emphasized is that high technology support selected elements of lean, working without waste, without loss of time and errors in quality. Lean and high technologies create specific types of manufacturing systems. Lean Manufacturing System can be adopted in new manufacturing system and existing manufacturing system requiring capitalization, product or equipment relocation.

Key words: Lean Management, Robotics Cells, Flexible Manufacturing Systems

INTRODUCTION
During establishing of Lean manufacturing was focused mainly on manually operated machines and manual workstations. Classic Lean approach prefers simple technique and active workers. Development of technologies eliminates differences between lean and automation. New technologies have incorporated elements of lean, working without waste, without loss of time and errors in quality. Lean and high technologies create specific types of manufacturing systems.

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 (Labour), Material and Machines (Equipment) - called the 3Ms of manufacturing. A well balanced 3M results in

- Maximum utilization of skilled Man,  
- Optimal module size - cellular and/or plant  
- Smooth traffic flow - of materials, man, automotive, Minimum total manufacturing cost  
- Reduce investment Reduce labour 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.

The paper analyzes the technological applications of Lean Management in options Cells Robotics Cells and Flexible Manufacturing Systems

CELL MANUFACTURING
The cell layout of workplaces is response to the implementation of the principles of group technology especially in machining parts. Benefits in productivity stimulate cellular growth work to other technologies and work processes. The introduction of lean principles accelerated cell production. Cellular manufacturing is one of the basic principles of lean management.

In the literature are different variations of interpretation of Cellular Manufacturing principles and models. The following selection of definitions explains the principles and activities of CM.

Cellular Manufacturing - "Application of group technology in which dissimilar machines or processes are aggregated into cells, each of which is dedicated to the production of a part family or limited group of families" [3].

Cellular Flow Manufacturing is the linking of manual and machine operations into the most efficient combination of resources to maximize value-added content while minimizing waste. The most efficient combination applies the concept of process balancing. Only in a balanced process will the product continually flow. As a result, parts movement is minimized, wait time between operations is reduced, inventory is reduced, and productivity increases [1].
Strategos Consulting Company [8] explains further features as follows: Cellular 

Manufacturing and work cells are at the heart of Lean Manufacturing. Cells simplify material flow, management and even accounting systems. Cellular Manufacturing seems simple. But beneath this deceptive simplicity are sophisticated Socio-Technical Systems. Proper functioning depends on subtle interactions of people and equipment. Each element must fit with the others in a smoothly functioning, self-regulating and self-improving operation.

Lean cells design principles
1. Continuous material flow: Preferred arrangement is a U formation. Each Sub-process is linked to the next production process. The worker inside the cell requires minimal movement when moving from one job to another.
2. Lean machine tools, Simplification: Workplaces or machines take up little space. This will prevent unnecessary storage components. Dimensionally lean workplaces and machines eliminate unnecessary movement of workers.
3. Workplaces Organization: Slow down or stop the continuous process can be missing or misplaced tool. Tools should be in a magazine, quickly identifiable and accessible. Direct availability of accurate information increases the efficiency of the production cell. Technology and procedures, work instructions, instructions for repair and further information about the production itself, enables workers to make decisions and perform quality work without downtime. Also, information boards must be simple, clear, and easily reusable.
4. Parts manipulation: Workplaces requires replenishment of parts in storage for work cells. Containers must be disposed of outside the workspace manufacturing cells so that workers could work products without interruption.
5. Reconfigurability: Lean manufacturing cell to be easily reconfigurable. One way of reconfiguring the hot swap accessories. Different fixtures can be stored in the workplace and exchanged under immediate production situation. Ability to quickly move each component manufacturing cell becomes extremely important.
6. Quality: The result is a reduction in the continuous production of quality problems. For each part worker can do a visual inspection. If you require control through measuring equipment, part is transferred to the device or the test facility.
7. Maintenance: The modular structure of the cell simplifies operation and maintenance.
8. Accessibility: Parts, containers, tools, racks, clamps and accessories are perfectly adjustable and can be laid quickly readjusted.
9. Ergonomics: Lean manufacturing cell must be designed with the ergonomic parameters that workers carry out manufacturing operations and service work in the correct position, with proper lighting and with respect for other ergonomic factors across manufacturing cell.

ROBOTICS AND LEAN MANUFACTURING

Traditionally, robots have not played a prominent role in the implementation of lean strategies. However, due to robots’ repeatability, speed, accuracy and flexibility, the role of robots in lean implementations is constantly increasing. Automation equipment, which includes robots, is rapidly becoming a core component to lean manufacturing and the reduction of manufacturing costs [7].

Robots are not innately lean since they could be used to automate a faster creation of waste, but they are often integrated within the manufacturing process to support and enhance lean manufacturing system success criteria such as:
- Repeatability - Robots’ drive product quality or consistency and reduces waste.
- Speed - Robots’ can help increase production and reduce wait time.
- Accuracy - Robots’ help to reduce scrap.
- Flexibility - Robots’ reduce training and changeover time – with a target of Single-Minute Exchange of Die, and One-Touch Exchange of Die goals.

Designing the manufacturing system to be lean is one of the largest challenges faced by engineers today. A few of the factors that must be taken into account while designing lean manufacturing systems with robots are:
- Number of product variants, allowable scrap rate, Cycle time requirements by station or operation
- Equipment reliability and downtime statistics
- Flexibility required in the process, human machine interface requirements
- Life cycle of manufactured product to ensure acceptable ROI
- Line automation requirements (% Automation Vs Manual), Line production rate requirement
- Conveyor and other transportation requirements, product handling requirements
- Maintenance requirements, repair time of equipment
- Space availability for robotic operations, safety standards and ergonomics guidelines.
A typical example of the robotic cell is shown on Fig.1. The robotic cell machines components for directional drilling transmission systems. The robot loads and unloads both a machining centre and a CNC lathe.

Fig. 1: Typical U cell with robot. Source: [9]

LEAN FLEXIBLE MANUFACTURING SYSTEMS

The idea of an FMS was proposed in England (1960s) under the name “System 24”, a flexible machining system that could operate without human operators 24 hours a day under computer control.

Early FMSs were large and very complex, consisting of dozens of Computer Numerical Controlled machines (CNC) and sophisticate material handling systems. They were very automated, very expensive and controlled by incredibly complex software. There were only a limited number of industries that could afford investing in a traditional FMS. Currently, the trend in FMS is toward small versions of the traditional FMS, called flexible manufacturing cells (FMC) [2].

Definition of Flexible Manufacturing System is - A highly automated Group Technology machine cell, consisting of a group of processing stations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by an integrated computer system [5].

Flexible Manufacturing System (FMS) is one of the practical implementations of Lean philosophy. By dynamically respond to system statues, FMS is able to significantly reduce the percentage of idle capacity, improve the productivity, and quickly adjust ongoing production based on continuous changing market condition. To achieve the flexibilities included in FMS, machine, process, routing, operation, production, volume, layout, and production flexibilities [4].

The combination of both processes provides more flexibility with lean advance system. Lean implementation is process focused on getting the right things to the right place at the right time in the right quantity to achieve perfect work flow, while minimizing waste and being flexible and able to change with Flexible Manufacturing System. In flexible manufacturing, customers have so much option when selecting goods. In lean manufacturing, companies offer one or two versions of a product with reducing wastage. In starting of this implementation, it required much cost for this and co-ordination for this but sometimes these factors does not full fill. Both manufacturing methods can lead to customer satisfaction. It also worked on reducing the cost for customer better feedback and improve industrial production rate.
Design of LEAN 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 [10].

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, fewer inventories, increased productivity, and increased capital equipment utilization.

In Flow Manufacturing, is the performance 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 that 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 reducing with random downtimes, higher uptime through quick changeover, lower downtime, etc., and improved quality through error proofing, self-checking equipment product centred cellular layout.

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 includes machines, fixtures, tools, and gauges such as lathes, drills, grinders, test stands and so on.
- Manufacturing System - is the combination of man and manufacturing process. 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.

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\text{Difference} & \text{Lean manufacturing system (LMS)} & \text{Flexible manufacturing system (FMS)} \\
\hline
1 & This is a wastage and quality control system. & This is a tool for provide industry & customer flexibility. \\
2 & It focuses only on industrial benefits & It aims for both, industry & customer \\
3 & It is a system aims to use everything for process in given inventory or controlled inv. & It has the same aim with customer satisfaction & industrial with more flexible way. \\
4 & It has a less flexibility in process. & It has more operational & customer needs flexibility. \\
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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, more equipment flexibility, more adaptable to uncertain markets (volume / product), and smaller capacity increments and more product flexibility.

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

References

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