Review on The Concept of Lean Manufacturing And Line Balancing

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Abstract- *Since the Lean thinking and Line Balancing techniques have been developed there has been a tendency to view them in a progression and in isolation. The use of Line Balancing and Lean Manufacturing has to be applied considering market knowledge and both are best suited to satisfying fluctuating demand. Lean Manufacturing requires a level schedule. This view is supported by consideration of an industrial example in this paper.*

Keywords- Line Balancing, Lean Manufacturing

I. INTRODUCTION

During the past years manufacturing carried out a series of technical and organizational development, which strongly increased its efficiency. In so far as Lean Manufacturing and Line Balancing are the more contemporary organizational structure in terms of manufacturing management, as well as the implementation of such structure is improving enterprise's competitiveness, this paper focuses on its nature to manufacturing industry. Therefore, this work is aimed at analyzing the applicability of the Lean Manufacturing and Line Balancing concepts to the supply of services, attention is paid specifically to the manufacturing and assembly firms.

Line Balancing is leveling the workload across all processes in a cell or value stream to remove bottlenecks and excess capacity. Lean Manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination.

II. LEAN MANUFACTURING

Lean Manufacturing is a unified, comprehensive set of philosophies, rules, guidelines, tools, and techniques for improving and optimizing discrete processes.

Lean principles and benefits were applied to all processes (health care, service, high tech, sales & marketing, fast food, etc.). For this reason, some call it "Lean Thinking", rather than the more restrictive title of "Lean Manufacturing".

2.1 History of Lean Manufacturing

Lean Manufacturing started as the Toyota Production System (TPS), developed by the Toyota Motor Car Company. Toyota started by the manufacturing of looms for manufacturing cloth, then branched into bicycles before WWII.[1]

In time, Toyota started to manufacture engines, small delivery vehicles, trucks, and cars. Poor management decisions almost put the company into bankruptcy. Losing face, the Senior Management resigned, and changed their ways. They changed the name of the company, granted workers life-long employment, and went on an aggressive improvement program to try and work their way back from near oblivion. The motivations for TPS were now established. Soon the tools and techniques started to emerge that eased the frustrations with the old, inefficient ways, and allowed Toyota to achieve its TPS goals.

In "**The Machine that Changed the World**" Dr. Womack coined the phrase "Lean Manufacturing" so as to encourage its adoption of TPS methods everywhere. Today Lean Thinking is being used world-wide in a growing number of organizations. It is applied at the point of contact with customers, as well as back room work. It applies to Engineering & Design offices, as well as traffic flow in urban centers.

2.2 Lean Goals and Strategy

The goals of Lean Manufacturing systems differ between various authors. While some maintain an internal focus, e.g. to increase profit for the organization, others claim that improvements should be done for the sake of the customer.
Some commonly mentioned goals are:

1) Improve quality: To stay competitive in today's marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.

2) Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.
3) Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.
4) 4) Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company's inventory costs because of storage needs.

2.2.1 Types of Waste

The elimination of waste is the goal of Lean, and Toyota defined three broad types of waste: *muda*, *muri* and *mura*.[a]

Muri is all the unreasonable work that management imposes on workers and machines because of poor organization, such as carrying heavy weights, moving things around, dangerous tasks, even working significantly faster than usual.*Mura* focuses on how the work design is implemented and the elimination of fluctuation at the scheduling or operations level, such as quality and volume. *Muda* is discovered after the process is in place and is dealt with reactively.

The original seven wastes are:

- Overproduction (production ahead of demand)
- Unnecessary stock (Inventory) (all components, work in process and finished product not being processed)
- Inefficient Transportation (moving products that are not actually required to perform the processing)
- Unnecessary Motion (people or equipment moving or walking more than is required to perform the processing)
- Waiting time(waiting for the next production step)
- Rejects and defects (the effort involved in inspecting for and fixing defects)
- Inappropriate/Over Processing (resulting from poor tool or product design creating activity)

Later an eighth waste was defined by Womack the "waste of unused human talent" to the original seven wastes.

Fig. 2.1 seven wastes
Source: www.google.com/images

2.3 Steps to Achieve Lean Systems

The following steps should be implemented to create the ideal Lean Manufacturing system:

1) Design a simple manufacturing system
2) Recognize that there is always room for improvement
3) Continuously improve the Lean Manufacturing system design

2.3.1 Design a simple manufacturing system

- A fundamental principle of Lean Manufacturing is demand-based flow manufacturing. In this type of production setting, inventory is only pulled through each production center when it is needed to meet a customer's order. The benefits of this goal include**:**
- Decreased cycle time
- Less inventory
- Increased productivity
- Increased capital equipment utilization

2.3.2 There is always room for improvement

The core of Lean is founded on the concept of continuous product and process improvement and the elimination of non-value added activities. "The Value adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated" (Rizzardo, 2003). Improving the flow of material through new ideal system layouts at the customer's required rate would reduce waste in material movement and inventory.

2.3.3 Continuously improve

A continuous improvement mindset is essential to reach a company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance (Suzuki, 1987).

Stephen Shortell (Professor of Health Services Management and Organizational Behavior – Berkeley University, California) states:- "For improvement to flourish it must be carefully cultivated in a rich soil bed (a receptive organization), given constant attention (sustained leadership), assured the right amounts of light (training and support) and water (measurement and data) and protected from damaging."

2.4 Tools & Techniques of Lean Manufacturing:

There are several tools and techniques available for successful implementation of Lean Manufacturing strategy. Although these techniques are applied with respect to the problem statement and can replace each other as situation changes.

- SMED
- Value stream mapping
- OEE
- SOP
- 1-Piece Flow
- KanBan
- Poka Yoke (Mistake Proofing)
- 5S

Due to internal resemblance and interchangeability these tools are very much effective also has wide range of applications in the field of manufacturing.

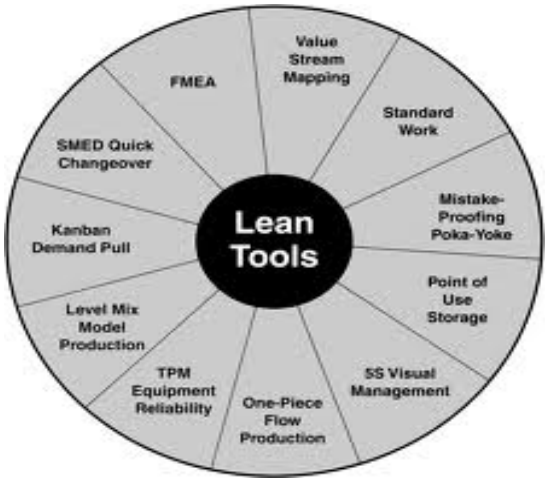

Fig.2.2 Lean Tools
Source: www.google.com/images

2.4.1 Single minute exchange of dies

Single-minute exchange of die is one of the many Lean production methods for reducing waste in a manufacturing process.

It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is key to reducing production lot sizes and thereby improving flow. When there is change in operation with respect to the same machine then the time required to change the die and tool assembly is more than the actual operation time hence these SMED are very helpful to save this time. They will not required just one minute as the name suggest but minimum time as required by the assembly unit to change the die manually. This SMED requires some automation and with that increased maintenance cost.

2.4.2 Value stream mapping:

It is a Lean Manufacturing technique used to analyze and design the flow of materials and information required to bring a product or service to a consumer. At Toyota where the technique originated, it is known as "material and information flow mapping".[1] It can be applied to nearly any value chain. Value Stream Mapping aims to help you understand why your customers buy from you and to identify which of your suppliers are most valuable to your business.

Businesses that have used Value Stream Mapping have reported that the benefits include:

1) **1)**Increased business focus and productivity;
2) Improved margins and profitability;
3) The identification of new revenues and clients;
4) Improved customer loyalty;
5) Improved profitability by identifying and concentrating on the most;
6) Profitable clients;
7) Improved ability to raise capital for the business;
8) Greater awareness of the need for an exit strategy for business relationships.

2.4.3 Overall equipment effectiveness:

Overall equipment effectiveness quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run. It means the machines are used as per their designed capacities and maximum capacity is used. The effectiveness decides the production rate and plant capacity; to achieve maximum

production rate all machines are to be used at 100% effectiveness i.e. OEE is 100%.

2.4.4 Poka Yoke:

This is error proofing technique used to determine late deliveries at the customer side and hence result is unhappy customer. Such errors are detected and eliminated for on time delivery and good quality.

2.4.5 Standard operating procedure:

All operating procedures in the manufacturing are must be as per the standards and perfectly designed. The SOP's will require minimum time span i.e. production rate is maximum, with minimum utilization of inventory. To achieve Lean all non standard processes are replaced by SOP. SOP's may be costly and complicated but will give maximum life span and complete utilization.

Standard operating procedure provides:

- Capable and repeatable processes
- Process control at source
- Improves accuracy of planning
- Better adherence to plans
- A platform from which continuous improvement can be made
- Reduced costs
- Improved quality.

III. LINE BALANCING

Line and work cell balancing is an effective tool to improveassembly line and work cells while reducingmanpower requirements and costs. Assembly Line Balancing is the problem of assigning operations to workstations along an assembly line, in such a way that the assignment be optimal in some sense. Line Balancing is an improved technique of leveling the workload across each process in shop floor to avoid extra workload on a specific machine or worker.

3.1 Objectives of Line Balancing :

1) Everyone should do the same amount of work;
2) Doing the same amount of work to customer requirement;
3) Variation is smoothed;
4) No one overburdened;
5) No one waiting;
6) Everyone is working together in balanced fashion.

3.2 Takt Time

Takt time precisely synchronizes the rate of production to the rate of sales to customers. Takt time is the fundamental concept to do with the regular, uniform rate of progression of products through all stages from raw material to customer. As such it is important in planning, in Line Balancing, and in facility design. It should also be a consideration along a complete supply chain. Takt time is the drumbeat cycle of the rate of flow of products. Understanding takt time is fundamental to analysis and mapping of Lean Operations. Takt time is most simply the average rate at which customers buy products and hence the rate at which products should be manufactured. It is expressed in time units: one every so many minutes or so many minutes between completions. Takt time should drive the whole thinking of the plant and the supply chain. In a plant it is the drumbeat.

Fig 3.1 TAKT time
Source: www.google.com/images

Takt Time = Available Work Time / customer demand

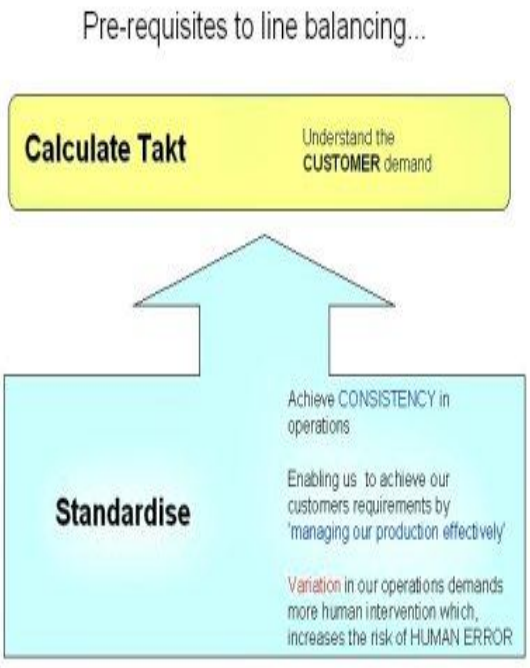

Fig 3.2 Pre-Requisites to Line Balancing
Source: www.google.com/images

IV. INDUSTRIAL EXAMPLES

Here we have discussed two problems where Lean and Line Balancing tools are applied. The attempt is to provide an effective solution as to give minimum time and maximum production.

4.1 UNIT ABC

1) There are five processes in the work cell dedicated to only UNIT ABC.
2) Each process has same demand and **Available Work Time** = **Takt Time**.
3) The LOADING data is found using historical production data of ACCEPTABLE parts only including downtime but only when the processes were scheduled with operator(s).

4.1.1 Problem Statement

The customer only wants acceptable parts and that is what the customer demand is based on within the takt time formula. When figuring the production rates (loading) the scrap or non-conforming pieces must be netted out.

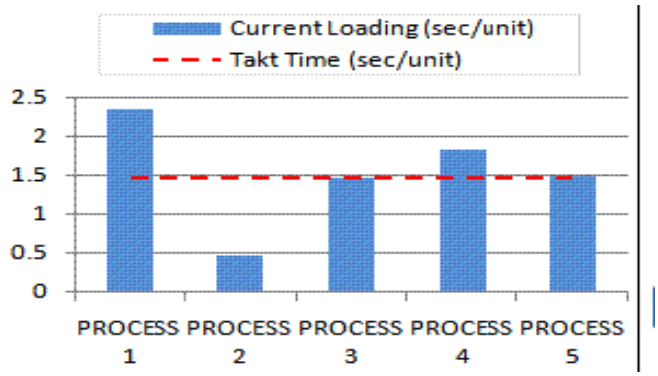

Fig 4.1 1 problem statement- **unit ABC**
source: T.MELTON, 2005

1) Process 1: Taking much longer than takt time. Overtime is probably used to make up production.
2) Process 2: Exceeding takt time, probably a lot of waiting and the excess capacity can be filled by absorbing some of the work from Process 1 and/or Process 4.
3) Process 3 & 5: Very close to meeting takt time, not a focus area but possibly some best practices and application of LEAN tools can improve these loading rates. Improvement in these areas could be used to share workload from constraint processes.
4) Process 4: Taking longer than takt time. Again, overtime is probably used or there are late deliveries, high costs or unhappy customers..

4.1.2 Solution using Lean and line principle

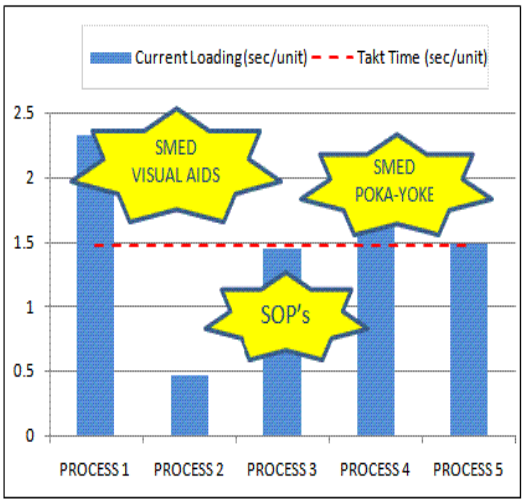

Fig 4.2 solution- unit ABC
source: T.MELTON, 2005

1) Process 1: SMED and visual aids are used to maintain flow of parts in line
2) Process 2: Some work from process 3 and or process 4 is absorbed to reach TAKT time level

3) Process 3 & 5: No focus is required but SOP can be implemented for better efficiency.
4) Process 4: To avoid late deliveries errors are detected and cleared.

4.2 UNIT XYZ

4.2.1 Problem statement

Let us consider that a XYZ unit with a packing operation. There are four sub processes for which there are four operators and each worker do different operation.

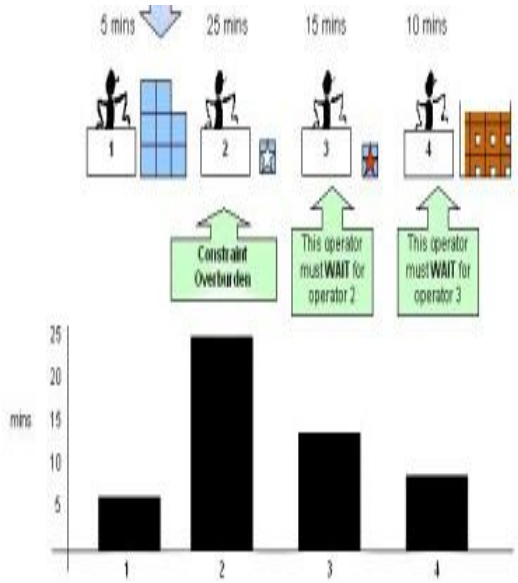

Fig 4.3 Problem statement- unit XYZ
source: T.MELTON, 2005

1) First worker will only cover the product in a box and pass it to next worker. It requires 5 min per item.
2) Second worker will wrap a paper, paste it and then pass it to next process. It requires 25 min which is maximum operation time.
3) Third will stamp it with its specification and pass it to next worker. it requires 15 min.
4) Last worker will pack it in separate box and pass it to delivery section. It requires 10 min.

In this example second worker is overburdened and as a result other two have to wait for second worker to finish his work.

4.2.2 Solution

Solution is provided by assigning some of the work of second operator to first operator that is to avoid overburden, to minimize seven wastes and to promote one piece flow.

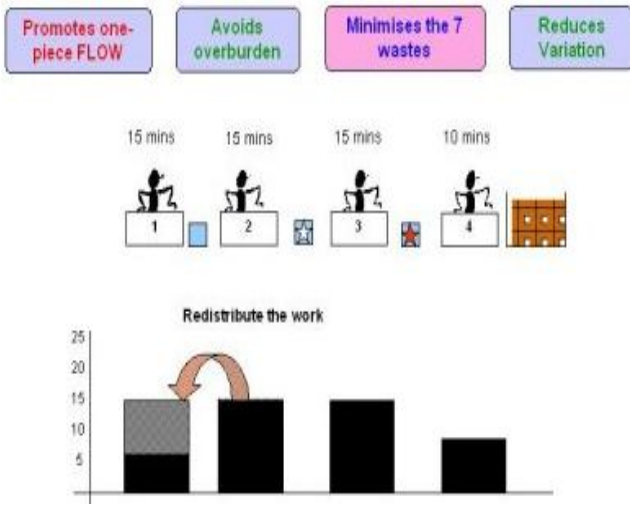

Fig 4.4 solution-unit XYZ
source: T.MELTON, 2005

V. CONCLUSION

From above examples it is to be concluded that the Line Balancing and Lean Manufacturing techniques are important and effective to be applied in manufacturing industry. The problems of overburden, waiting and late delivery are easily solved by making processes in line and applications of Lean tools such as SMED, VALUE STREAM MAPPING also POKA YOKE.

Every manufacturing industry wishes to be maximum effective and highest production rates; which are only possible as Line Balancing and Lean Manufacturing tools are applied.

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