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LEAN MANUFACTURING AS LINE-BALANCING CONCEPT

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ABSTRACT
Textile and apparel industries are time consuming and labor oriented. Therefore to control cost and waste reduction is main concerns for maintaining the economy of these industries. A number of techniques are followed to control the overall cost like removing non-productive works. Lean manufacturing is also a kind of approach for the same. It is a systematic approach to identify and remove wastes (non-value added activities) which were originated and developed in Japan. As lean manufacturing eliminates numbers of the problems associated with poor production and line balancing so particularly suitable for companies those do not have strong material requirements planning (MRP), production scheduling and production allocation systems in place. This management tool helps in visualizing the different wastes generated in the organization (during the production) and future possibilities of eliminating or reducing them. Present review is an attempt to highlight application areas of lean manufacturing in textile and garment industries as a line balancing concept.

INTRODUCTION
Lean means manufacturing without waste. Lean manufacturing systems are aimed towards attaining the shorts cycle time by eliminating waste [1]. Lean manufacturing is a business philosophy that continuously shortens the time between customer order and shipment by eliminating everything that increases the cost and time [2].
Lean manufacturing is the concept to more value for less work. The objective of lean manufacturing is to minimize the consumption of resources that add no value to a product. Lean Manufacturing systems have their respective strengths and weaknesses. When these are applied in a correct manner, the strengths and weaknesses of the Lean Manufacturing systems are applauding[3] .

It is the pull based manufacturing system and this is the fundamental principle of lean manufacturing. Lean manufacturing is also known as the Toyota Production System (TPS) and emphasizes on understanding the customer requirements, which was established in 1970's by Toyota Motors[4]. This results in reducing the time line by removing the non-value added waste. Lean always focuses on identifying and eliminating waste resulting in full utilization of all the activities. In the lean Philosophy "value" is determined according to the customer's requirement[5]. It means what the customer desire therefore lean always optimizes the process according to the customer requirements [2]. Value stream mapping towards the value added and non value (NV) added activity is essential for manufacture a product for raw material to final product. This is the way to minimize the non value added activity towards the value chain instead replacing the value added activity [3].
VSM i.e. Value Stream Mapping, is a method to describe the flow of material and information through the production system. It helps to find out where value is added and lost by portraying the processes graphically. The ratio of value added to total lead time is determined; the current lead time, inventory levels and cycle times[3]. The visual representation provides a view where the costs can be reduced and improvements can be made. Then the future state can be designed where wastage steps are left out and continuous flow and pull production are introduced[6].

PRINCIPLES OF LEAN MANUFACTURING
Lean manufacturing focuses on eliminating the waste during the product manufacturing at very low cost to the manufacturer and customer. The major principles of Lean are as follows;

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Principle of lean manufacturing	Definition
Elimination of Waste	Eliminate those activities that do not add values in an organization. It includes over production, waiting time, processing, inventory, and motion[7].
Increased Speed and Response	For the better process designs allow efficient responses to customers' needs and the competitive environment[8].
Improved Quality	Poor quality creates waste, so improving the quality is essential to the lean environment[9].
Reduced Cost	Simplifying the processes and improving efficiency translates to reduced costs[7].

KIND OF WASTES

The different kinds of wastes in a process line can be categorized in different categories[3]. These wastes are reducing the production efficiency, quality of work as well as increasing the production lead time.

Type of waste	Definition
Overproduction	manufacturing the products more than the required at given point of time[14] i.e. manufacturing the products without actual order creating the excess of inventories which needs extra staff members, storage area as well as transportation[9,10].
Waiting	Waiting for the raw material, machines and information etc. is known as waiting and this is the reason of the wastage of productive time[12] . The waiting can occur in various ways for example; due to the unmatched worker/machine performance breakdowns, lack of the work knowledge, stock outs etc.
Unnecessary Transport	This is due to the carrying the work in process (WIP) in insufficient transport or long distance and moving material from one place to another place is known as the unnecessary transport[8].
Over processing	Working on a product more than the requirements are turned as over processing. The over processing may occur improper tools. This is the waste of time and machines which does not add any value to the final product [3].
Excess Raw Material	This includes excess raw material, finished goods causing longer lead times , damaged goods, transportation and storage costs and delay[9]. Also requiring the extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime and long setup times[11].
Unnecessary Movement	any wasted motion that the workers have performed during their work is turned as unnecessary movement e.g.; movement during searching for tools, shifting WIP etc[11].
Correction of Defects	A defect in the processed parts is turned as waste. Repairing these defective products or replacing these products due to poor quality i.e. the waste of the time and the efforts[12].

THE TOOLS, TECHNIQUES AND THE STRUCTURE OF THE LEAN MANUFACTURING

There are various key lean tools and techniques are used in proper ways will give the best results. Once the source of waste is identified then it is easier to use these lean tools and techniques to reduce or eliminate the waste. Some of the lean tools are discussed below and the structure shown in the figure;

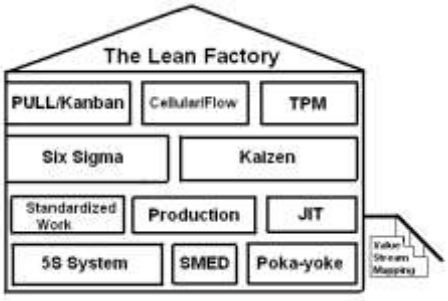

Figure: Key Lean Tools[13]

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KAIZEN

kaizen is also known as the rapid improvement process. These processes are considered to be the building block of all production methods. Kaizen focuses on eliminating waste in the targeted processes of the organization and improving the productivity[11]. The strategy of kaizen or rapid improvement processes aims to involve workers from multiple functions and levels in the organization in working together to improve a particular process. The team use as analytical techniques, such as Value Stream Mapping, to identify the opportunities to eliminate waste in a targeted process. Kaizen or rapid improvement process can be used as implementation of tools for most of other lean methods[13].

5 Ss

5Ss is a system used to reduce the waste and optimize productivity through maintaining workplace and using visual cues to achieve more consistent results. The 5S pillars are; Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu), and Sustain (Shitsuke), provides a method for organizing, cleaning, developing and sustaining the productive work environment [13]. This lean method encourages workers to improve their working conditions and facilitates their efforts to reduce waste, in-process inventory and unplanned downtime time. 5S makes the foundation for other lean methods, such as total productive maintenance, cellular manufacturing, just-in-time and Six Sigma[12].

TOTAL PRODUCTIVE MAINTENANCE (TPM)

Total Productive Maintenance (TPM) seeks to involve all the levels and functions of organization in maximizing the overall effectiveness of production equipment[7]. The traditional preventive maintenance programs are centered in maintenance department; TPM seeks to involve workers of all departments, from the plant-floor to senior executives for ensuring the effective operation of equipment[4]. TPM also focuses on preventing breakdown designing and installing equipment that need little or no maintenance, "mistake-proofing" equipments, and quickly repairing equipment after breakdown occur. The goal of the TPM's is the total elimination of all losses, including breakdown, equipments setup, minor stoppages, reduced speed, defects and rework, and process upset and startup conditions[11].

CELLULAR MANUFACTURING/ONE PIECE FLOW SYSTEMS

In this manufacturing system work is arranged in a sequence that supports a smooth flow of materials and components through the manufacturing process with minimal transport. The aim of the cellular manufacturing is to move products through the manufacturing process one-piece at a time, at the rate determined by the customer's needs[12]. Cellular manufacturing also provide companies with flexibility to the product type and features on the production line in response to a particular customer demands. To make the cellular design work, an organization must replace large and high volume machines with the small, flexible and "right-sized" machine to fit for the process[14].

JUST-IN-TIME (JIT) PRODUCTION SYSTEMS/KANBAN

JIT and cellular manufacturing are closely related production systems, as a cellular production layout is typically required as prior conditions for achieving just-in-time production[12]. JIT techniques work to level production, spreading production evenly over time to foster a smooth flow between the processes[14]. JIT frequently uses the physical inventory control kanban to single the need to move or produce new raw materials from the previous process. There is some of the benefits of JIT are:

- JIT reduces the inventory costs by eliminating the unnecessary work-in-process.
- Since unit is produced only when they are needed, quality problem can be detected easily and early. Since inventory is reduced, the waste of the storage space will also be reduced. And preventing excess production can uncover hidden problems.

STANDARDIZATION OF WORK

Standardization of work is a very important principle of waste elimination from the standardization of worker actions. It basically ensures that each and every job is carried out in effective manner. No matter, which is doing the job the same level of the quality should be achieved[12]. The Toyota workers follow the same processing steps all the time. This includes how much time is needed to finish a job, which order of steps to follow for each job. By doing this ensures that line balancing is achieved, inventory is minimized and non-value added activities are also reduced. A tool is used as a standardize work is called "takt" time.
Takt time is calculated using the following formula:

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Takt Time (TT) =Available work time per day / Customer demand per day

SIX SIGMA

This is a system used to analyze the systemically reduction in a process. It was developed by the Motorola in 1990s. Sigma is a Greek alphabet letter that is used to describe the variability. Six Sigma methods are implemented in lean manufacturing systems or using other lean methods. It has involved some other companies to include methods for implementing and maintaining the process performance improvements[,1415].

VALUE STREAM MAPPING

Value Stream Mapping (VSM) is a method of visualization of tools of the Toyota version of Lean Manufacturing (Toyota Production System)[10]. VSM helps to understand the process using the tools and techniques of Lean Manufacturing. The main objective of VSM is to identify, demonstrate and reduce waste in the process. VS in both value added and non-value added presently require bringing a product through the main flows essential for each and every product. VSM can help from the starting point to the management, engineers, production associates, schedulers, suppliers and the customers recognizing waste and identifying their causes. It is useful and very simple. Value Steam Mapping makes the outlines of the current and the future state of the production systems by allowing users to understand their wasteful acts and need to be eliminated. Then the users apply lean manufacturing principals for future state[15].

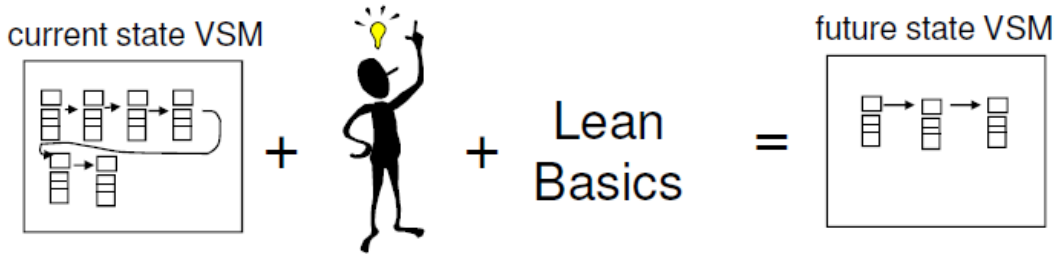

Figure: VSM concept

Value Stream Mapping (VSM) provides a "blueprint" to an origination for strategic planning to bring the principles of lean thinking for their transformation into lean enterprise.

CONCLUSION

Thus it can be concluded that lean manufacturing is an efficient management tool for eliminating the waste, efficient working conditions, skilled labor, time management following quality standards. Some companies are following different management tools of line balancing like Six Sigma, VSM resulting in better production with improved quality. Thus lean manufacturing can be a better line balancing method if followed efficiently and with all standardized parameters of it.

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