Improving the Efficiency of Personal Care Liquids Line in a Company to Reach World Class Manufacturing

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Abstract

Most of the companies are seeking to reach to World Class Manufacturing (WCM) by improving their production lines, and increasing the lines' efficiency. WCM can be reached by using Total Productive Maintenance (TPM), Six Sigma, and Lean methods. This review paper shows which is the best method to improve line efficiency and eliminate wastes of any production line to reach WCM. Several studies and researches especially for Fast Moving Consumer Goods (FMCG) companies showed that implementing lean methods and tools has been successful in dealing with low efficiency lines issue.

Key Words: World Class Manufacturing, Lean Manufacturing, Overall Line Effectiveness, Efficiency improvement, Production line efficiency,

Introduction

Recently, a great number of companies are seeking to reach World Class Manufacturing (WCM) level. Despite the huge improvements they do, there is still a bigger and better potential to utilize resources and reach better efficiency. Production plant efficiency depends on how effectively it uses its inputs which are machine, materials, man and methods [1]. It is important to analyze and measure efficiency because it indicates whether things are done correctly or not. This paper will discuss how to reach WCM as well as improving the efficiency.

Literature Review

In order to improve production efficiency and maximize the output to confirm with the requirements, all losses that are associated with these inputs should be identified and eliminated [2]. These losses are defined as equipment losses which includes: Breakdown loss, Set up & Adjustment loss which occurs during a changeover between products, Cutting blade replacement loss that happens during changing any consumable tooling item when it has become worn/ineffective or damaged, Start-up loss, Minor Stoppage losses which are often chronic losses that are regularly repeated and often not recorded and usually have less than one minute duration, idling loss, Speed Reduction loss, Defect & Rework loss and Shutdown loss. Manpower losses such as: Management loss which are waiting time losses generated by management problems, Motion loss, Line Organization loss which results from a shortage of operators on the line, Distribution loss which is the wasted time that is experienced in the incorrect or inefficient delivery of materials or products to and from the factory or the production line, and Measurement and Adjustment loss. Other losses include yield, energy and tools losses. The definition of these losses is illustrated in Table 1.

At the same time the organizations seeking continuous improvements are simultaneously becoming a World Class Manufacturing (WCM). Researches shows that there is no one agreed upon definition of WCM, as the “best” practices differ from an organization to another [3]. Multinational manufacturers’ approach is to implement one improvement

method, afterwards they add other improvement methods that compile with the original method. This approach combination is referred as WCM in which there is a mixture of logistic, quality and productivity oriented improvement methods, such as Lean + Six Sigma + Total Productive Maintenance (TPM), and. For example, Philips Company chose Six Sigma as the original method, Scania Company started with Lean, while other company started with TPM, but these organizations have eventually integrated the other improvement methods [4].

Table 1: Categories of losses

Categories	Types of losses
Equipment losses [2, 28]	**Breakdown**: This type of loss occurred when the equipment breaks down and causing the whole line to stop. And it is usually caused by a failure in the machine components, this loss is measured by the unit of time.
	Minor stoppages: This loss is a small stoppages that are not recorded as breakdowns, it causes the machine to stop and being idle for a short periods of time (less than ten minutes).
	Speed reduction: This loss happens when the line's speed setting is less than the line speed capability, and its measurement is expressed by the rate of output per time unit.
	Set up & Adjustment: This type of loss arises when the line needs to be changed over to suits the production of another type of product and it is measured by the time it takes to change and adjust the line settings until reaching the optimal condition of the desired product.
	Start up: This loss describes the time needed for the line to get its equipment to a steady operation state, whether after a planned shutdown or a breakdown.
	Shutdown: This loss happens when the line is purposely shuts down during the production plan. It can be caused by many reasons such as, periodic maintenance, cleaning or inspections.
Manpower losses [2, 28]	**Management loss**: This loss happens due to waiting time that occurs due to management problems. It causes waiting for materials, instructions, repairing, etc.
	Motion loss: This type of loss resulted from unnecessary movement due to an inefficient layout. It includes excess motions such as walking, stretching, and bending.
	Line organization loss: This loss happens when there are lacking workers, so the existing workers have to work on multi machines to balance the work.
Energy, Yield, and Tools losses [2, 28]	**Energy losses**: This loss occurs due to an ineffective usage of input energy, such as the energy loss during the waiting or idling time.
	Yield losses: This type of loss describes the losses of the input materials and the quality of the products. That means increase the usage of some raw materials to get a better quality of the finished product, so losses of materials occurred.
	Scrap material: This type of loss describes the items that damaged during the production process, that means it can't be reused. Also, it can be left over from manufacturing activities, so it may be sold or reused.
	Loss of material quality: This loss happens when the suppliers provide poor materials' quality, and that causes problems in the production.
	Die, Tool and Jig Losses: This loss happens when there are maintenance and refurbishment of the production line, thus it uses spare parts for the items on the line.

The reasons of integrating three improvement methods are as follows: Six Sigma is considered as the base of implementing TPM and ease the shop floor workers to understand the essential factor for TPM success. Moreover, Six Sigma has been recognized as an improvement tool same as Lean Manufacturing, and that leads to conflicts of interest and ineffective consumption of resources when implementing them separately or sequentially. Therefore, they have been integrated as "Lean Six-Sigma", to gain the strengths of each simultaneously. Lastly,

the transformation between processes has improved and the effectiveness of these processes have been enhanced by linking both TPM and Lean [3, 5].

The following sections of this paper contains a detailed explanation of WCM, TPM, Lean, and finally, Six-Sigma.

World Class Manufacturing

Companies around the Globe are aiming to become a "world class manufacturing" (WCM) organization. However, Mey [6] stated that researches have shown only few organizations that have achieved the WCM successfully, but the majority are failing to start the right practices. The reason behind this is the fact that there is no one specific best practice framework or principle for implementing WCM [3, 6].

Mey [6] defined "World Class Manufacturing" as a strategy that aims to achieve continuous improvement of the overall practices of the organization, has zero breakdowns, and in addition increases the productivity. Moreover, it focuses on the elimination of losses from their root causes. Although companies use a combination of different tools to achieve WCM, a study done by Okhovat et al. [3,7], showed that 40% of leading companies agreed that the combination of TPM, Lean, and Six Sigma is the best combination to address the company's requirements to achieve WCM. A case study done in ArcelorMittal (the world's leading steel company), showed that utilization was increased by 8.35% as a result of implanting WCM strategy. Mey [6] believes that although becoming a World Class company is not a simple process, integrating the productivity improvement initiatives (TPM & Lean Manufacturing) to ArcelorMittal strategy supported in pushing them to become a World Class company.

Some of the frameworks that are used in WCM are explained below:

- ***Overall Equipment Effectiveness***

Overall Equipment Effectiveness (OEE) is an improvement measure. It helps in giving an indication of the overall efficiency. Companies with high OEE (85% and above) are categorized as a WCM company in their production operation [6].

- ***Roll-Out***

To target each loss and focus on what area to be improve, Roll-Out technique along with loss analysis will help to identify the pillars that need improvement, and other pillar will be discarded for the time being [6].

Lean Manufacturing

Nowadays, many organizations are adopting lean manufacturing to gain the power to compete in the global competitive market. Deshmukh et al. [7] stated that as consumers' needs and demands are increasing, principles of lean manufacturing are essential to help production and services industries grow and survive.

Cheng Wong and Yew Wong [8], the first main goal of lean manufacturing is to use less of everything to deliver a product or service. The second main goal is waste elimination to improve productivity, efficiency, quality, and reduce both lead time and cost. There are seven major wastes that are considered in the lean manufacturing which are: overproduction, waiting inventory, waiting time, unnecessary transportation, unnecessary processes, unnecessary motion, and defects products. While the key philosophies of lean are seeking perfection, wastes elimination, and a continual improvement. Simons and Zokaei [9], lean encourages enhance employees' ability to solve problems and participation in suggesting improvements.

A previous study has done by [8] reported that lean manufacturing is applicable in 14 key areas: work processes, equipment, quality, product design, employees, inventory, scheduling, tools and techniques, material handling, layout, ergonomics and safety, management and culture, suppliers, and customers. The most vital and commonly applicable areas in lean manufacturing are equipment, scheduling, quality, employees, and suppliers.

Deshmukh et al. [7] suggested that there are many tools and techniques for implementing lean principles, ordering these tools by popularity: Kaizen, SMED and VSM. The tools and techniques will be explained in the following.

- ***Kaizen***

Kaizen is a Japanese word that refers to the act of continuous improvement. It is defined by Besterfield [10] as a process that encourages small incremental improvements to get more effective and efficient processes. It is mainly emphasizes processes simplification by breaking them down into sub-processes, for easier improvement implementation and less or no expenses.

A study [5] has showed that Kaizen is considered one of the lean manufacturing tools. Moreover, Deshmukh et al. [7] stated that, Kaizen is the most preferred tool in the manufacturing sector, as it can be used in all manufacturing processes, adapt all suggestions, and be flexible in both small and big improvements.

- ***Just in Time (JIT)***

Besterfield [10], the main philosophy of JIT is pulling the system to reduce inventory. The pull system means that the materials or services are to be pulled through the system by a request from an internal or external customer. In other words, the right materials are placed only when and where it is needed and with the needed amount. JIT involves Kanban which is described by Aljunaidi and Ankrah [28] as to as to produce to order, no more and no less.

- ***Workplace organization (5S process)***

This process aims to establish a smooth and effective process flow by keeping the workplace organized and clean [10]. The 5 steps of 5S's are: **Sort**: categorize all items into necessary items to keep, items belong to others to return, and disposal items to remove. **Straighten**: organize the kept items in a way that reduces wasted motions. **Shine**: housekeeping practices, to provide a workplace that is easier to identify any problem and to avoid accidents. **Standardize**: documentation step is important to guarantee that all processes are performed in the same manner. **Sustain**: maintain the results from the previous S's by conducting regular checks and audits. Some organizations add a sixth S to the process, which indicates Safety [10].

A study [12] demonstrated that 5S tool is compatible with many other methods. It is considered as a foundation and facilitator in implementation of Kaizen, TPM, TQM, QCS, Toyota Production System (TPS), JIT, six sigma, and ISO standards.

- ***Single- Minute Exchange of Die (SMED)***

A study of Resnick et al. [13], SMED is one of the lean manufacturing tools that is concerned with the changeover time, which is the time needed to convert and setup the process of one product to another product. This tool provides an efficient conversion, emphasis on reducing the changeover time, and improve the processes flow.

- ***Value Stream Mapping (VSM)***

VSM is a graphical representation of all the carried activities for delivering a product or service to consumers as described by Besterfield [10]. Those activities should describe the flow of raw

material from suppliers until it reaches the consumer as finished goods or services. Preferably there should be one VSM for each process in the organization and includes only the value-added activities. The first step in the VSM technique is to construct a map for the current state, then construct the map for the ideal state, and finally, the improvement actions are the differences between the two maps.

Total Productive Management

Total Productive Management (TPM) joins everyone in the organization to reduce the six big losses that lead to decreasing the Overall Equipment Effectiveness (OEE) [3]. The six types of losses can be identified by using TPM and they are breakdowns, changeovers, minor stoppages, reduced speed, defects, and setup scrap. By determining these losses, OEE can be calculated by multiplying time availability, performance efficiency and good quality rate (Availability * Performance * Quality) [14]. The availability can be identified by the breakdowns and changeovers. The performance will be known by calculating the minor stoppages and reduced speed. Finally, the quality can be identified by defects and setup scrap [3].

Therefore, the TPM target is to improve the OEE and labor productivity which will help achieve its ultimate goals which are zero equipment failure (Breakdown), zero defects, zero rework, and zero accidents [14]. According to Japan Institute of Plant Maintenance [15], the TPM is based on eight main pillars which are Autonomous Maintenance, Focused Improvement, Planned Maintenance, Skill-up Education and Training, Quality Maintenance, Safety and Environment, Maintenance Prevention, and Support Systems [14]. Implementing and controlling the pillars will contribute to achieving the TPM target.

TPM tools are presented by using PDCA cycle (Plan - Do - Check - Action), DMAIC (Define, Measure, Analyze, Improve, and Control) process of performances improvement. Furthermore, Pareto Analysis, 5-Whys Analysis, Statistical Process Control, Problem Solving Techniques such as, Brainstorming, Cause-Effect Diagrams, and 4M (Method, Material, Manpower, Machine), Poka-Yoke Systems, Autonomous Maintenance, Continuous Improvement, 5S, Setup Time Reduction, Waste Minimization, and Bottleneck Analysis [16, 15].

Six Sigma

Six Sigma is used for achieving, sustaining and maximizing business success and reducing defects in the organization. It is defined as an organized and systematic method for strategic process improvement, and new product and service development that relies on statistical methods and the scientific method to reduce defect rates that is identified by the customers [17, 18]. When there are products which should meet high quality standards, or which should be within certain limits, Six Sigma is the most suitable method to apply [4].

As stated by Kwaka [20], six sigma method includes measured and reported financial results, uses data analysis and project management techniques. Six sigma uses DMAIC methodology, as Ertürka and Tuerdi [21] stated DMAIC is based on the quality engineering field, total quality management and Taguchi's concept.

After defining all possible methods for reaching WCM, it has been identified that lean manufacturing is the most suitable method, since many companies had low productivity problem. Following are some companies' shows the successful implementation of lean manufacturing that resulted in improving the efficiency and eliminating the wastes.

1- During the production processes in a Fast Moving Consumer Goods (FMCG) company, there were several activities which caused waste, so the cycle time for the production was longer. The company adapted lean manufacturing methods by applying value stream mapping (VSM) to find non-value-added activities to be reduced and removed. Using VSM tool contributed to reducing the lead time value from 678.11 minutes to 426.69 minutes that mean 37% reduction [19].

2- Some researchers have studied the performance of several industries that adopted lean manufacturing principles. Some of these industries involved in the study are bottle molding manufacturer, pharmaceutical masks manufacturer, electrical component manufacturer, and customized gear component manufacturer. The results after a period between four to seven years of lean principles implementation are, increase in companies' growth by almost 12-14% and increase in the production productivity by almost 10-20% [7].

3- A study [20] for lean manufacturing implementation concluded that Kaizen is an effective tool to eliminate losses and wastes in production. This study was done in ABC Company to reduce the time losses of production, where loss time was 15.48 hours out of the total observed 60.97 hours. To propose a solution, PDCA cycle was used, and the solution reduced production lead time by almost 14.93%.

4- A manufacturing organization in India [21], it did not give attention to the machines and that led to many breakdowns which reduced the OEE. After implementing several studies and arrangements, the organization decided to apply Kaizen. This application affected different aspects such as decreasing the running time losses and rejection. Also, the output and efficiency were increased. All of these changes affected the OEE and it increased from 59% to 70%.

Conclusion

After defining all the possible methods to reach WCM, many researches and case studies ensure that the best way to increase the efficiency in the production lines is lean tools, and that will help to go a step further in reaching WCM level.

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