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LEAN MANUFACTURING SYSTEM AND ITS IMPACTS ON WORK ENVIRONMENT AND HUMAN HEALTH IN GARMENTS MANUFACTURING

By

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Abstract

Introduction: In today's modern industrial world all manufacturing entities strive for sustaining the ever changing turmoil of varying resources and demands, a need for correcting and efficient managing of resources and time emerges. Hence, lean manufacturing techniques that have surfaced as the motor tool in controlling and nourish improving the quality of the business. **Aim of work:** To clarify the impact of implementing lean manufacturing system on the work environment and employees' health in the garment manufacturing in order to eliminate the environmental problems, such as air pollutants and hazard wastes. On the other side, lean manufacturing technique aims to eliminate wastes to create a more efficient workplace. **Materials and methods:** It begins by stating the principles and techniques of lean manufacturing system, and the tools used to achieve them. To be more accurate, everything must be related to its environmental effect. This research was applied at the assembly line of Textile Company for apparel Industries focusing on sewing section of Men's T-shirt model. **Results:** This research shows a good impact of implementing lean manufacturing system on work environment by reducing and eliminating production and environmental wastes. **Conclusion:** The research findings show the implementation of lean system can affect directly business and indirectly the work environment and human health. According to this study, quality has been improved; productivity, efficiency, cost has been reduced and profit have been increased. Also, total dust and particulates have been eliminated.

Keywords: Lean Manufacturing, Operators' Health, Environmental Measurements, Hazards and, Pollutants.

Introduction

"Lean manufacturing" is a leading manufacturing paradigm being applied in many sectors of the USA economy, where improving product quality, reducing production costs, and being "first to market" and quick to respond to customer needs are critical to competitiveness and success. Lean principles and methods focus on creating a continual improvement culture that engages employees in reducing the intensity of usage of time, materials, and capital necessary for meeting a customer's needs. While lean production's fundamental focus is on the systematic elimination of non-value added activity and waste from the production process, the implementation of lean principles and methods also results in improved environmental performance. The US Environmental Protection Agency (EPA) sponsored a study on lean manufacturing in 2000 that included a series of case studies with the Boeing Company to explore the relationship between lean production and environmental performance (EPA, 2003).

"Health is a state of complete physical, mental and social wellbeing and not merely the absence of diseases or infirmity". Occupational health hazard is concerned with health hazard in relation to work environment (Mehta, 2012).

Lean Manufacturing system has been implemented in various manufacturing sectors since the early 1990's. Such as Toyota, Pratt and Whitney, Sikorsky, Delphi, Ford, and many other companies have achieved large savings by implementing Lean System (Schmidt, 2000).The implementation of Lean Manufacturing is greatly recommended, in order to identify and eliminate wastes (RviKumar, 2011). Lean Manufacturing is mostly associated with elimination of eight wastes such as (Defects, Waiting, Over-Production, Motion, Over-Processing, Inventory, Transportation, and Correction) (Shah et al., 2007). Lean Manufacturing is s set of tools and methodologies that aims for the continuous elimination of all waste in the production process (Abd El-Aty, 2013).

Paul conducted a study on the physical and mental health status of

garment workers and how problem affect labor productivity, competitiveness of the garment industry in the world market and the working life of the workers, particularly of female workers. It showed that various illnesses and diseases were widespread among the garment workers. A large number of workers were found to continue their work even they were suffering from various diseases and illness. Though the garment workers were very young they suffered from anemia, dysentery, etc… (Paul, 2003).

To implement Lean Manufacturing in any organization, the first step is to identify the Value Stream Map in order to identify the various forms of Non-Added Values in the factory. VSM is a tool used to analyze the flow of materials and information currently required to bring a product or service to a consumer (Garg et al., 2008). Some points have to be raised, such as, selected processes, eight types of wastes, 6s's, and Kanban.

Eight Types of Wastes: 1-Over-production – is unnecessarily producing more than demanded or producing it too early before it is needed.2- Defects – In addition to physical defects which directly add to the costs of goods sold, this may include errors in paperwork, provision of incorrect information about the product, late delivery, production to incorrect specifications, use of too much raw materials or generation of unnecessary scrap. 3-Inventory – Having unnecessarily high levels of raw materials, works-in-progress and finished products. 4-Transportation - Any movement of materials that does not add any value to the product, such as moving materials between workstations. The idea is that transportation of materials between production stages should aim for the ideal that the output of one process is immediately used as the input for the next process. 5-Waiting – Idle time for workers or machines due to bottlenecks or inefficient production flow on the factory floor. Waiting also includes small delays between processing of units. Waiting results in a significant cost insofar as it increases labor costs and depreciation costs per unit of output. 6-Motion – Includes any unnecessary physical motions or walking by workers which diverts them from actual processing work. 7-Correction – Reprocessing is when something has to be re-done because

it wasn't done correctly the first time. This not only results in inefficient use of labor and equipment but the act of re-processing often causes disruptions to the smooth flow of production and therefore generates bottlenecks and stoppages. 8-Over-processing – Unintentionally doing more processing work than the customer requires in terms of product quality or features (Capital, 2004).

The 6 Ss (6S's): is a system to reduce waste and optimize productivity through maintaining an ordinary workplace to achieve more consistent operational results. It derives from the belief that, in the daily work of a company, routines that maintain organization and orderliness are essential to a smooth and efficient flow of activities the s's of 6S are(Sort, Set in Order, Shine, Standardize, Sustain, and Safety) (Ali, 2013).

A Kanban is a tool to achieve just-in-time. It consists of a card containing all the information that is required to be done on a product at each stage along its path to completion and which parts are needed at subsequent processes. A Kanban system consists of a set of these cards, with one being allocated for each part being manufactured and the travel between preceding and subsequent processes. The Kanban system was developed by Toyota to achieve objectives such as reducing costs by eliminating wastes; creating work places that can respond to changes quickly; facilitating the methods of achieving and assuring quality control; designing a work environment that takes into account human dignity, mutual trust, and support; and allowing workers to reach their maximum potential. A Kanban system allows a company to achieve just-in-time production and ordering systems, which allow them to minimize their inventories while still satisfying customer demands (Monden, 1993).

The environmental impact of the manufacturing wastes was studied by Cash and his colleagues in 2005, and results are illustrated in Table 1.

Table (1) Environmental Impact of Manufacture Wastes (Cash et al, 2005)

Waste Type	Example	Environmental Impact
Motion	- Human wasted motion; such as carrying WIP. - Machine wasted motion; such as motion in manufacturing operations and machines are far apart.	- More energy use for transport. - Emissions from transport. - More space required for WIP movement, increasing, lighting, heating, and cooling demand and energy consumption. - More packaging required to protect components during movement.
Waiting	-Waiting for materials to be delivered. -Line stoppage (M/Cs downtime)/ Bottlenecks. - Workers standing around waiting for work.	- Potential material spoilage or component damage causing waste. - Wasted energy from heating, cooling, and lighting during production downtime.
Over Production	-Just in case inventory. -Processing more to avoid changeover. -Manufacturing items for which there are no orders.	- More raw materials, manpower consumed in making the unneeded products. - Extra products may spoil or become disposal.
Over Processing	-Doing more than the customer requires. - Extra processes or operations that won't be paid by the customer.	- More parts and raw materials consumed per unit of production - Unnecessary processing increases wastes, energy use, and emissions.
Inventory	- Excess raw material, WIP, or finished goods.	- More packaging to store work-in-process. - Waste from deterioration or damage to stored WIP. -More materials needed to replace damaged WIP. - More energy used to heat, cool, and light inventory space.
Transportation	-Long route between raw materials & finished goods processes. - Long/ unorganized production lines.	-More engaged space.
Defects/ Correction	-Scrap, rework, replacement production, inspection. -B grades. -C grades.	- Raw materials consumed in making defective products. - Defective components require recycling or disposal. - More space required for rework and repair, increasing energy use for heating, cooling, and lighting.

Aim of Work

To clarify the impact of implementing lean manufacturing system on the work environment and employees' health in the garment manufacturing in order to eliminate the environmental problems, such as air pollutants and hazard wastes. On the other side, lean manufacturing technique aims to eliminate wastes to create a more efficient workplace

Materials and methods

- **Study design:** This study is divided into operational and environmental studies.
- **Place and duration of the study:** This research was applied at the assembly line of Textile Company for apparel Industries focusing on sewing section of Men's T-shirt model. This study was implemented in a factory which contains 2 separated areas (Factory 1 and Factory 2) from October 2014 to March 2015.
- **Study method:** The study started by monitoring the environmental measurements all over the factory to determine the most polluted areas before implementing lean manufacturing system, and then the changes that happened will be tracked and their effects on the environment to see the environmental positive changes.

On the other side, the study focused on a prototype production line as a pilot in Factory 1 which is placed in an international textile company that produces local products and those for international exportation.

The work went further to study the product operations, re-layout the chosen production line and then the factory, also to study the capacity checks for the operators and to find out the bottle necks, and then rebalance the line by releasing the extra operators to get better performance in both directions, operational and environmental. After confirming the optimum line, the whole factory will be standardized as per the prototype line.

Traditional Production System Observations

The raw materials were stored in unorganized stores, in different locations which increase the time taken in searching for supplies and the number

of raw materials in the production line is very high. Steps of implementing lean manufacturing principles to optimize the current system.

Identify the Value Stream Map (VSM) for the product

This step is divided into two stages, the first stage is to construct and draw VSM for the current state and the second stage is to use this VSM to identify the different types of wastes in the manufacturing system. In order to construct the VSM of the product, the following data must be obtained; attributes of the assembly process, information about material flow, cycle times and number of workers per process for each process.

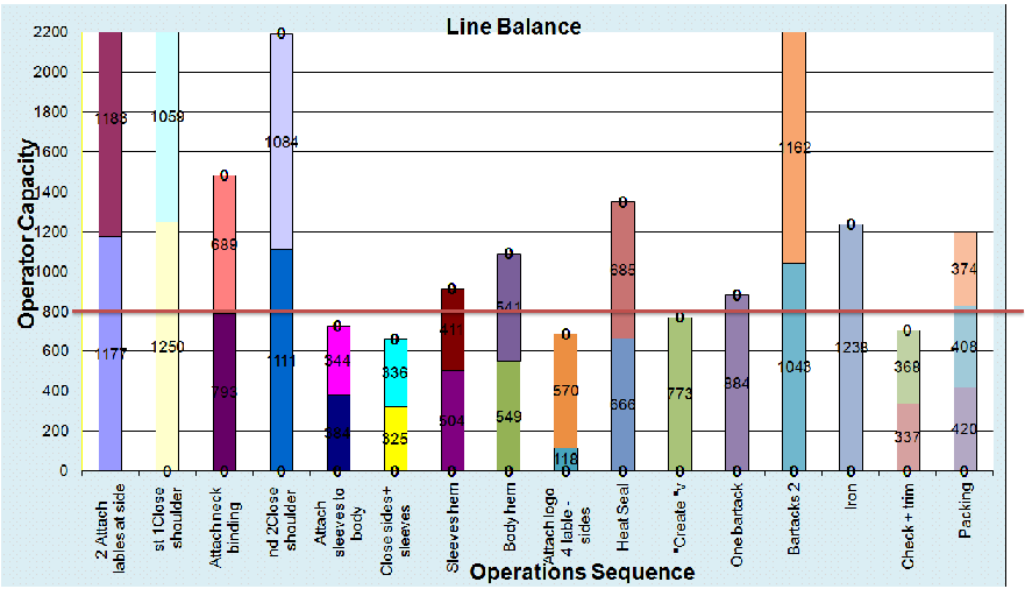

Fig (1) Traditional time line graph

Fig (1) showed the time line graph before implementing lean manufacturing.

From time line graph that depicted in Fig. 1, some observations have been found such as the numbers of Work In Progress (WIP) between each process are not the same, revealing higher number (over production and over processing) which consumes extra efforts, energy and resources.

The total lead time is higher than the real lead time, and the value added time is much smaller than the real value added time, indicating that the status of current production system was unbalanced production system, as well as, overproduction.

Large inventory has been found in the assembly line of the current production system.

Six S's were selected as the second lean manufacturing tool to implement in current system while visual display and control were selected as the third tool to implement. Six S's primary goal was to reduce cost through better workplace organization and improved inventory management, while visual factory aided the understanding of production engineers and line supervisors by inducing clarity on the activities in the workplace.

Produce what customer needs and let the customer pulls value from producer

Some preparation processes have small cycle time if compared to other processes and the quantities which produced from these processes were very high if compared to the required quantities. This was done by implementing pull production or kanban production system for the preparation processes. kanban production system are implemented as follows: (a) Establish a Kanban system by developing and design trolleys for accessories and cut work. (b) Design the signaling mechanism (c) Train the operators (d) Start the kanban (e) Improve the kanban. The required number of kanban that provides form cutting hall were calculated based on the current needs of the organization, not on future plans.

Production leveling

It is a method for planning and leveling customer demand by volume and variety, while keeping the level of production as constant as possible over a specific time period (Hirano, 2009). This step includes constructing a work

balancing diagram of the future state and then using this diagram to examine the effects of these stages by eliminating waste and reducing cycle times of each manufacturing process.

There are two stages which must be followed to accomplish and implement production leveling in its current production system: (a) view the time line diagram and work balancing graph to show the cycle time of each process, (b) balance the assembly process by distributing operator work elements.

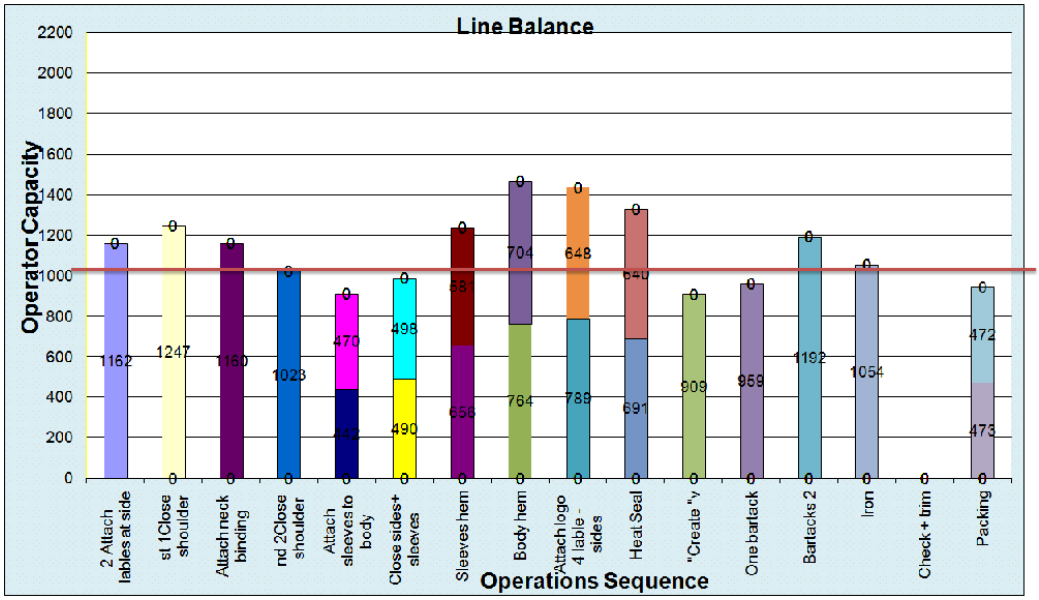

Fig (2) Time line graph after Lean Manufacturing Implementation

Fig (2) showed the time line graph after implementing lean manufacturing.

From time line graph that depicted in Fig. 2, the numbers of work in progress (WIP) between each process became less, over production has been reduced and over processing has been released .

The total lead time has been reduced and non value added activities have been eliminated.

Inventory levels have been eliminated between the processes after implementing lean manufacturing principles.

Standard operations

Standard operations are the final and important step in implementing lean manufacturing and eliminating the wastes. It refers to organizing the job and performing it in the most effective way after leveling by writing each of the process sequences for the assembly, since it does not depend on the presence or absence of operators. The operation also includes minimizing cycle times, overproduction, Work In Progress (WIP), waiting, motion and over processing.

Work instructions of each process for the product were done and accomplished. The team followed the sequences of work instructions of Toyota Production System (TPS), where, it includes in its work instructions three elements: (a) Cycle time: The time necessary to produce one piece or unit (b) Standard operations routine: The order of operations in which workers process a product (c) Standard inventory: The minimum amount of work-in-process inventory necessary to process a product (Muslimen et al., 2011).

Consent

Authors declare that that a verbal consent was taken from the studied production line.

Ethical approval

Authors declare that a verbal approval was taken from the company authorities to implement this study.

Data management

All data values obtained before and after implementing lean manufacturing system were compared using Microsoft Office Excel 2007.

Results

Table (2) Operational Key Performance Indicators (KPIs) before and after Lean Manufacturing Implementation

			Before LM	After LM Implementation	Results
1	Operational KPIs	Total Lead Time	90 Days	54 Days	Reduced
2		Average Lead Time issue RM to FG	27 Days	5 Days	Reduced
3		Non Productive Time %	30%	4%	Reduced
4		Total Product Cycle Time	30.13 Min	16.27 Min	Reduced
5		No. of Operators/ Line	30 Operators	22 Operators	Reduced
6		Production Rate/ Day	800 Pcs	1000 Pcs	Increased
7		Level of Defects %	3%	1%	Reduced
8		Percentage of Rejection %	1.8%	0%	Reduced
9		Line Work In Process (WIP)	5 Days	1 Day	Reduced
10		No. of machines (M/Cs)/ Line	30 M/Cs	20 M/Cs	Reduced
11	Environmental Measurements	Heat Stress			Reduced
12		Sound Pressure			Reduced
13		Light Intensity			Depends on the place and the operation
14		Total Dust Concentration			Reduced
15		Gas Concentration			Constant

Table (2) showed the impact of implementing lean manufacturing system on the production results and the environmental measurements. The Environmental Measurements Monitored by the National Institute of Occupational Health and Safety (NIOSH) for 2015 and 2016

From the key performance indicators (KPIs): Good operational impacts can be found after implementing lean manufacturing system in a garments' factory: (1) Total Lead Time has been reduced by 40%. (2) Average Lead Time Raw Material issue to Finished Goods has been reduced by 81%. (3) Non Productive Time Percentage % has been decreased by 87%. (4) Total Product Cycle Time has been reduced by 46%. (5) No. of Operators per Line has been reduced by 27%. (6) Line Production Rate has been increased by 25%, hence the factory productivity has been increased. (7) Percentage of Rejection has been completely eliminated. (8) Level of Defects has been reduced by 66%. (9) WIP Percentage has been reduced by 80%. (10) No. of Machines per Line has been reduced by 33%, and Rejection percentage has been eliminated.

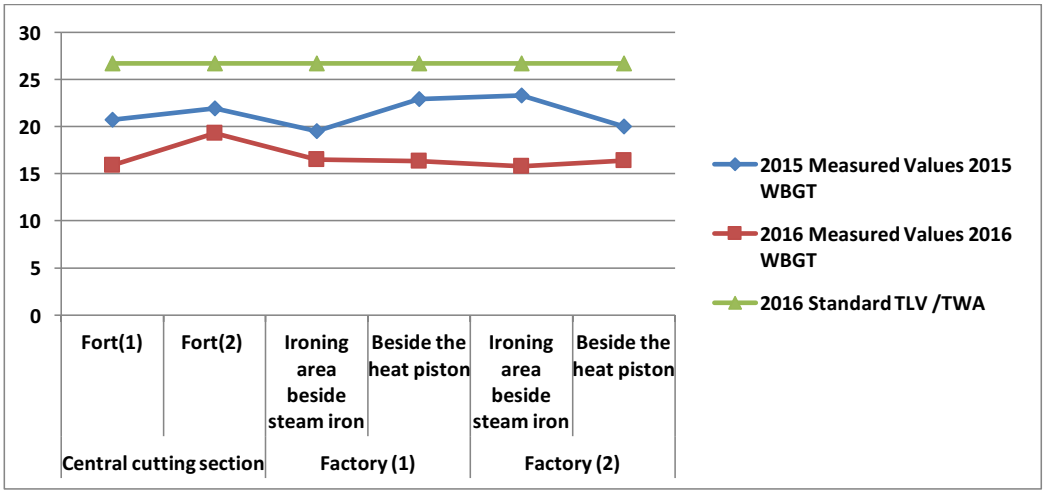

Fig (3) Heat Stress Results

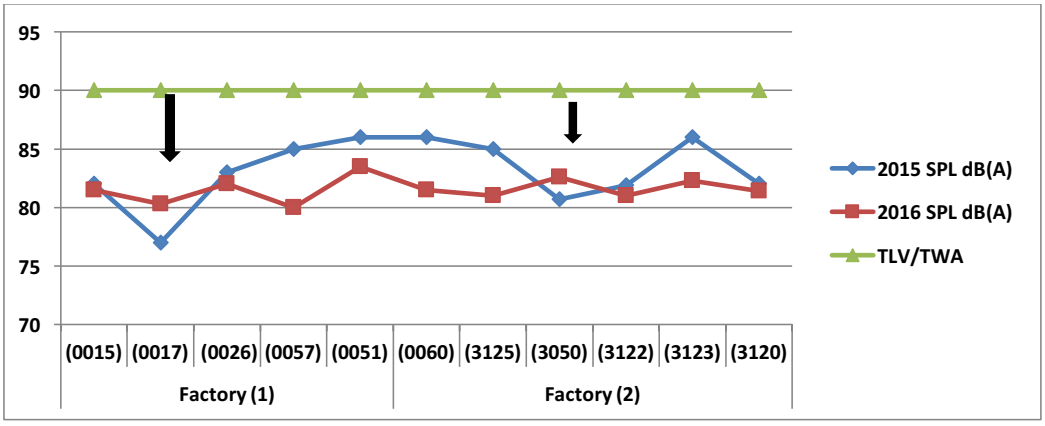

Fig (4) Sound Pressure

Fig (3) and (4) showed the Environmental Measurements of heat stress and sound pressure before & after Lean Manufacturing Implementation

The measurements done in 2015 and 2016 on the Heat stress and Sound pressure are shown to be within the permissible limits and compliance with the law, but lean manufacture (LM) implementation enables the company to get better results of the environmental measurements.

Discussion

Our results showed great impacts of applying Lean Manufacturing system in the industries on the business from one side, total lead time reduced from 90 days to 54 days, total product cycle time reduced from 30.13 min to 16.27 min, production line space reduce by 33%. This is similar to the implementation of lean in 1995 by Lantech on a USA equipment manufacturing company. He reported the following improvements compared to their batch-based system in 1991: manufacturing space per machine was reduced by 45%; defects were reduced by 90%; production cycle time was reduced from 16 weeks to 14 hours - 5 days; and product delivery lead time was reduced from 4-20 weeks to 1-4 weeks (James et al., 1996).

From the environmental and operators' health side, there was a study done in India, 2012 by Rena Mehta about Major Health Risk Factors prevailing in Garment Manufacturing Units of Jaipur, the following results had been found in stitching section: 55% of workers complained from musculoskeletal problems. This was followed by neural problems such as headache (40%), respiratory (30%), skin problem (13%), numbness of hands and fingers (8%), hearing (5%) and visual discomfort (2%).The back problems (27.2%) followed by stiffness at neck and shoulder (22.7%), leg (27%), elbow (7%), arm (6%) and wrist and leg (12%). The operators of the sewing machines reported discomfort in the left shoulder, the neck, the back and the lower extremities (Mehta, 2012).

Our results verify that if lean manufacturing system is implemented significantly in the industries, a lot of improvements will be achieved, and the company will get better environmental performance due to reducing some contamination sources and there impacts on the operators' health as:

1. Noise generated by the sewing machines makes the environment noisy for the workers. Continuous exposure to high level of noise over a period of time results in noise induced hearing loss among the workers.
2. The improper selection of lighting fixtures and their placements further contributes to neural problems.
3. Due to continuous use of steam iron, exposure to dust and loose fibers, the workers may face respiratory problems such as asthma and breathing difficulty.
4. The machines were not properly maintained resulting in hand arm vibration. This manifests as fatigue, pain, numbness and tingling of fingers and arms and headache.
5. In the finishing section, the workers have to work really fast; musculoskeletal problems were common because of repetitive nature of movement and lack of attachments and constrained posture.
6. In the washing section, the workers are exposed to chemicals, particularly bleaches and detergents and are not aware of their health hazards leading to skin allergies.
7. In the quality section, there is a lot of eyes strain leading to headache and visual discomfort among workers.
8. The monotonous work lead to increased worker fatigue due to continuous handling of loads, prolonged standing, repetitive movement of both hands and wrists and awkward postures.
9. The main stress factors were identified as repetitive movements and noisy environment.

Amelioration is achieved by organizing, eliminating, sorting, and removing the unnecessary items and reducing the non value added activities all over the factory including all the sections and factories.

So, the first step is to pay attention to occupational health and safety in this sector and improving working conditions will undoubtedly have considerable impact on the national economy and the quality of people's life and that is what Lean Manufacturing system achieves as per its results.

Conclusion

Lean manufacturing substantially improves the environmental performance of organizations. Reducing common types of manufacturing waste - defects, waiting, overproduction, movement, inventory, over processing, and correction- yields a variety of environmental benefits, including less use of energy, water, and raw materials; reduced generation of solid and hazardous wastes; and lower emissions of hazardous air pollutants. Lean methods, however, often fail to consider two types of environmental waste: the environmental risk of production processes and products and the life-cycle impacts of products or services

By implementing Lean Manufacturing, the following benefits will be gained; more space which helps in building up new production lines in the same place in order not to build-up a new environmental consumption to increase the productivity, saving energy consumed by the extra M/Cs, reducing the heat and noise emissions from the M/Cs which affect operator's health and cause diseases, reducing particulates and dust emissions from the extra M/Cs, eliminating re-consuming new resources and materials to produce produced quantities, and eliminating operators' fatigue due to the defects and reworks.

After implementing the suggested methodology and redesigning the manufacturing system, a lot of benefits have been achieved. Based on the results that have been obtained from the case study, the following conclusion has been established and summarized: Different types of manufacturing and time wastes were decreased, Value Added (V/A) time was increased, Non- Value Added (NV/A) time was decreased. Production costs were decreased, Total Lead Time, Average Lead Time Raw Material issue to Finished Goods have been reduced, Non Productive Time Percentage % has been decreased, Total Product Cycle Time, No. of Operators per Line have been reduced, Line Production Rate has been increased, hence the factory productivity has been increased, Percentage of Rejection has been completely eliminated, Level of Defects, Line Work in Progress (WIP), and No. of Machines per Line have been reduced. On the environmental side, heat stress, sound pressure, personal dust and gas concentration are decreased and there for the other manufacturing hazards have been reduced and eliminated.

Lean concept is not only a set of mutually supporting techniques, but also a global change in organizations culture; this is the most important factor for any quality or productivity improvement.

Conflict of Interest

Authors have declared that no conflict of interest exists.

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