Feasibility of A Powder Coating Process inside Indian Paint's Company through VSM Approach

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Abstract*: *Paint manufacturing industries in common are facing yield loss and poor quality of the products that has led to low productivity, longer production lead time, rework and rejection. The focus is on the efficiency of the plant, and these factors will reduce the overall efficiency of the plant. The purpose of the study is to implement a lean tool that is Value Stream Mapping. The objective is to identify the waste and eliminate them in the plant. For collecting the information required to complete the project, the researcher will take a tour to the shop floor which will enable the researcher to be familiar with the activities that are taking place, and this will help in getting a vague idea about the process and the production flow. The result obtained was observed, and suitable suggestions were proposed to overcome the problems that the industry is facing.

Index Terms*: *Lean Manufacturing, Paint manufacturing industry, Value Stream Mapping, Powder Coating Process

I. INTRODUCTION

In the present scenario, the world has become competitive, and all the organizations are working hard on getting more work done in less time and with greater ease. In any manufacturing, it becomes necessary to eliminate any form of waste that trouble the production process and leads to low efficiency of the production plant. The primary focus is to maximize the flow that would ultimately result in reaching customer demand and the customer satisfaction by providing the right product at the right time in the correct quantity and even quality at a right reasonable price. All these achieved by following a way in facing the competitiveness and finding solutions to the problems encountered. The problem tackled by Lean manufacturing system was developed by Toyota and termed as Toyota Production System (TPS). Lean manufacturing is primarily used to reduce all forms of waste in the process, thus leading to a problem-free atmosphere [1].

The lean system helps the organization by eliminating wastes that are in the way of excess production, unnecessary movement of materials, waiting and delays, over processing, workers movement, rework and rejections. In the manufacturing industries, the lean system has become essential to reach the organization's aggressive goals. Lean approach is suitable for a continuously evolving the system and enables a steady production system and attain excellent efficiency in the production system [2]. In a paint manufacturing industry, it becomes necessary to follow the lean practices as the production system focusses on augmenting the production process efficiency. The paint manufacturing sector is growing in competitiveness and the products thus manufactured must meet the customer requirements and specifications. It becomes necessary to stand ahead of the other competitors, and this is done by reducing all types of wastes in the production process, and there is a need to implement lean principles. There are examples of paint manufacturing companies wherein slight color dullness has resulted in rejecting the entire batch/lot products. The customer preference is the issue that relates to wasteful activities unless quality is not maintained and unproductive production process are studied from the past literature [3]. In the next section, taking hints from the previous works leads to support our investigation.

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II. LITEARURE REVIEW

A. Definition of Lean Manufacturing

Lean manufacturing is defined as a comprehensive set of techniques that allow reducing and eliminating the wastes. There is seven waste that commonly overlooked, and they need to be addressed immediately [4] (Hines et al., 1998). The seven wastes are (1) faster-than-necessary pace (2) waiting (3) conveyance (4) processing (5) excess stock (6) unnecessary motion and (7) correction of mistakes [5]. Making the company thinner, more flexible and more responsive by reducing the waste is the need of the hour. According to Bhatia and Drew [7], the lean system consists of five principles to be followed that deliver value to the customer that minimizing the loss. One of the tools in the lean analysis is the status of operation and streaming the flow paths. Lean tools and techniques are selected and applied to minimize the losses, wastages, overstocking, and hence the producing the product at a competitive price. This technique is known as value stream mapping, and scope for every process in the value stream may arrive at an optimized solution.

B. The Lean Principle

The five lean principles are applicable and adaptable at all manufacturing companies [8] [9] [10] [11] [12] [13]. 1st Principle: According to the customer perspective accurately specify the value for both products and services.2nd Principle: Remove the non-value-added activities by identifying the value stream for the products and services.3rd Principle: Make sure that the product and service flow without any interruption across the value stream.4th Principle: Follow the pull system of production.5th Principle: Continuously improve the system by removing wastes.

Caution to be exercised to integrate few of these principles and to study the system and adopt all the lean principles. The purpose of this study is to identify the non-value-added process and waste thus eliminating them in the powder coating material preparation inside a paint manufacturing plant.

C. Value Stream Mapping

Value Stream Mapping (VSM) is a procedure that was initially created by Toyota and after that promoted by the book, 'Learning to See' [14] gained much momentum in the western world. The Value Stream Mapping is utilized to discover and squander in the quality stream of an item. When waste is distinguished, then it is simpler to decide to dispose of it. The motivation behind VSM procedure is to bring changes at the framework level. The VSMs are drawn for the entire strategic business process or in few cases; it is used to analyze a portion of the unit as a contingency approach. The Value stream maps show the process procedure in a typical stream form.

On the other hand, notwithstanding the data typically found on a methodology stream chart, quality stream maps demonstrate the data stream essential to arrange and meet the client's frequent requests. Different methodology on data incorporates the process durations, inventories, changeover times, staffing and modes of transportation and other representations. The critical profit to value stream mapping is that it concentrates on the entire value stream to discover framework squanders and attempt to wipe out the entanglement [6]. For the most part, the value stream maps are of three sorts. The reality show is the Present State Value Stream Map (PSVSM) that mimic of the current circumstance. The goal or objective of the process activity is known as Future State Value Stream Map (FSVSM) that aims at acquired by evacuating squanders (that could be dispensed with in the brief time like three to six months). Next step is to develop Ideal State Value Stream Mapping (ISVSM) from the PSVSM, by acquiring the expelled squanders from the stream.

The VSM intended as an instrument for highlighting exercises. In lean Philosophy, it is termed as Kaizen exercises, for waste diminishment. When the squanders are highlighted, the motivation behind a VSM is to impart the opportunities, so they are prioritized and followed up action is taken. Subsequently, the prioritization and activity must take after the VSM else it is merely a waste like different squanders.

The VSM interknitted with OEE; this gives a clear indication of the process parameters that directly affect the planned cycle time, in some case meeting the Takt time as per customer demand. The reality of OEE is that it hints us the causes for actual cycle time above or below the ideal cycle time. OEE metric suits when throughput time (units/time) for every machine is accessible and thus tweaking of the process parameter like the delay, waste, retraction, breakdown/preventive maintenance, availability, and performance.

D. Overall Equipment Effectiveness (OEE)

The OEE gives straightforward and united recipes to measure the viability of the equipment or generation framework. Besides [15] bring up that it can likewise be utilized as a marker of methodology change exercises since OEE is straightforwardly interlaced to the misfortunes and additionally OEE uses 40 Operations Management principles that may be used to analyze execution over the processing plant highlighting poor line execution alternately to measure upgrades made. Besides enhancing might be sought after by (a) backtracking to figure out what misfortune decreases viability (b) identifying bottlenecks as the slowest machine, as well as the machine both slower and less compelling [16]. All these objectives need a focused methodology around the Deming Cycle or PDCA Cycle (also known as PDSA Cycle). It is a change cycle to build the plant OEE rating until the target objectives, and world-class producing status is accomplished. This thread in identifying the problem faced in the paint industry and is stated as.

E. Problem Statement

Conventionally paint manufacturing industry products are manufactured in the batch processing system. There are non-value-added activities observed that needs to be eliminated thereby increasing the throughput by enhancing its capacity and efficiency. Next is to set up feasible research objectives that are achievable.

F. Research Objective

To standardize the various operations that are taking place. To mimic the present, and to check for value-added and non-value-added activities and thus eliminating the wasteful activities by framing a future state map and furtherance continuous improvement. Validating the current state and future state maps for its effectiveness.

To achieve these objectives research questions about process evaluation were addressed such as: What are the different types of wastes that are found in the plant? What are the lean tools used to overcome the existing problems in the plant? What are the factors that are influencing the less effective in the plant? Followed by the execution plan as a method to be performed in data collection.

III. METHODOLOGY

Action research approach was used to plan, act, observe and reflect the process which is similar to the PDCA cycle of Deming. The data was collected from the field study inside a favorite Indian paint manufacturing company that manufactures paints and coating materials. The products are (a) Building Coatings (house paints) that is applied on the outer surface and inside waterborne latex, outside and inner part dissolvable borne paints, compositional enamels and wood, and furniture. (b) Mechanical coatings that used in auto, truck, airplane, railroad and metal beautifying, hardware and supplies, paper and paperboard coatings, electrical protecting varnishes and attractive wire coatings. (c) Special-purpose coatings that are used for mechanical support, marine coatings, movement paints, metallic paints, and vehicles resurfacing coatings, aerosol paints, top coatings, and multi-color paints.

All the observations are made from direct live observations on the shop floor and the situations on the shop floor. Data collected in a recorded sheet starting from time recording, movement register, and process analysis via observation, discussion, and past recorded plans.

A. Steps of Value Stream Mapping for Paint Manufacturing Industry

The VSM structure and analysis is followed according to the Steps by Step procedure is given by [17] as it follows.

Step 1: Initially the type of product family is chosen to construct the map. Since they produce only one type of product that is powder

coatings, it is considered to build the current state value stream map.

Step 2: After the product is chosen, the process steps are understood by walking through the entire plant and understanding the material and information flow. Once it is done, mapping of the process is done at the door to door level. Networking the activities on a rough paper is developed to know.

Step 3: The start and stop point of the process is defined to construct the map. Once it is done, in the next step the customer demand per day is added.

Step 4: In German Language 'Takt' refers to a pulse of the system, the maximum quantity of time a product requires to fulfill the customer needs [18]. Takt time is calculated from the client demand and considering the time, the plant is operational. To calculate the plant operation time various constraints such as working shifts per day, hours per day, available time per shift and break time per shift is considered. The calculations for the takt time is done (Eq. 1) and tabulated shown in Figure 2, Figure 3 and Figure 4. The net available time includes the time waste in the non-valued process. The customer demand varies with the dynamic situation and entire supply chain in the industrial requirements.

$$\textbf{\textit{Takt time}} = \frac{\textit{Net availabe time per day}}{\textit{Customer demand per day}} \quad (1)$$

Step 5: As the takt time is calculated, next the current state map is constructed. Customer details are shown on the top right-hand side of the map, and the construction of the Current State Map is initiated by considering the end of the process that is at the customer end and goes upstream. When the customer details are found, the construction of the map is developed in the backward pass.

Step 6: Once the customer details are obtained and entered, the next step is to focus on the material flow. The different processes are entered in the process and data boxes (Figure 2, Figure 3 and Figure 4). The various method includes pre-mixing, mixing, extrusion, grinding and packing. The data related to these operations are entered in the data box that is below the process box consists of some operators, cycle time, change over time and number of shifts.

Step 7: Once the process and data boxes are filled, add the inventory and waiting times. It is represented by a triangle with 'I' in the middle. For inventory, the numbers of pieces in between the process are counted, and they are entered below the triangle. These pieces are converted into days' supply by dividing the number of pieces by average daily demand which was used to calculate takt time.

Step 8: After the material flow between the processes is shown, next is to add the information flow. A single line arrow represents it, and if it is electronically communicated, then a lightning bolt looking arrow line is drawn. This information flow is directed from customer to the production office and from there to the supplier of raw materials. Based on the customer orders, the order will be placed to the supplier and forecast is done for future orders.

Step 9: Following the information flow, the timeline is added at the bottom of the value stream map. The stepped-saw tooth line is used to separate the value-added cycle time from the non-value-added time. Cycle times are taken from the data box. Finally, the values of value-added cycle time and the inventory times are summed up and displayed on the timeline. The total inventory time is called the production lead time. Process cycle efficiency was calculated by dividing value added time by production lead time.

Step 10: All relevant information is taken to construct the current state value stream map. Once it is done, the improvement areas are highlighted using kaizen burst.

Step 11: Finally, suggestions for improvements are discussed with the team, and future state value stream map is constructed to highlight the improvements by considering the data for the current state value stream map.

IV. RESULTS & DISCUSSION

Table 1: Current State Value- added Process parameters and after implementing Super Market

Parameters	Powder Coating Materials Preparation Process				
	Pre-Mixing	Mixing	Extrusion	Grinding	Packing
Cycle Time (min)	3	5	80	90	30
Qty per Cycle (Item)	400	400	400	400	1
Capacity (item/Day)	119625.6	59333.33	4350.00	3888.9	1794.0
Pre OEE Capacity (Item/Day)	120000.0	60000.0	4500.00	4000.0	1800
OEE Percent (%)	99.50	75	77	76	99.7
Change Over (CO/day)	1	1	1	1	1
Time per Change Over (min/CO)	1.3	10	30	25	3
Total (Sec)	150	360	4800	5400	30
Lead Time: 12.02 Days					
Total Value Added: 179.50 Sec					
Percentage of Value added: 1.55 %					
Takt Time: 15.20 Sec/ item					
Total cycle time: 10770.00 Sec					
After Implementing Super Market Concept and adopting Kaizen bust					
Lead Time: 7.56 Days					
Total Value Added: 179.50 Sec					
Percentage of Value added: 2.54 %					
Takt Time: 15.20 Sec/ item					
Total cycle: 10770.0 Sec					

The preparation process of manufacturing powder coating materials involves five essential functions. The raw material for the supplier from the central stores moves to the shop floor, wherein pre-mixing is done and mixing thoroughly to get homogeneity is then extruded through extrusion machine. The fine grits obtained by grinding the finally the packed to be supplied to a customer or the store department, all the flow of the process is sequential (Figure 1).

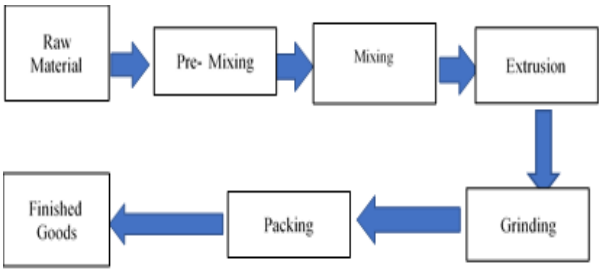

Fig.1: Powder Coating Process Stream

The data pertaining cycle time in the machine, the quantity per cycle, the capacity of the machine, pre-OEE capacity, OEE expressed regarding percent, along with changeover. The changeover times were recorded and observed with time study method and the results evident (Table 1) for developing the VSM essential data inputs are essential. The constructed current state value stream map, with improvement highlights, future state Value Stream Map based on the current state of values streamed map (Fig. 2, Fig. 3 and Fig. 4).

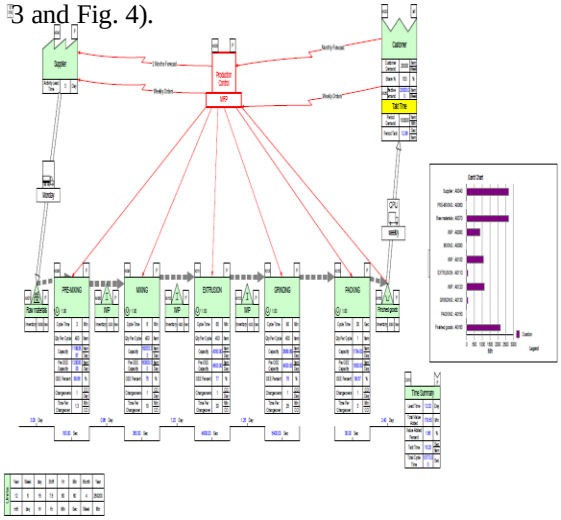

Fig. 2: Current State Value Stream Map

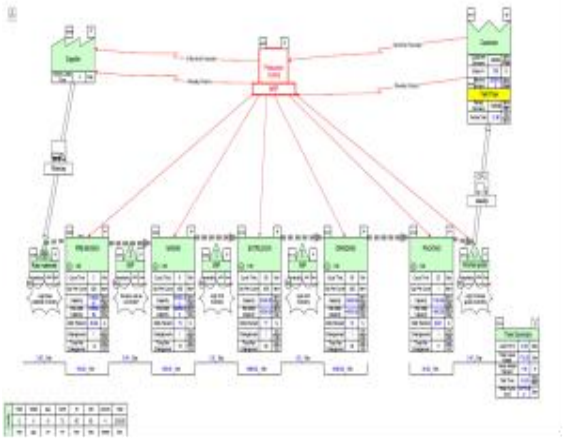

Fig. 3: Current State Value Stream Map with Kaizen Burst

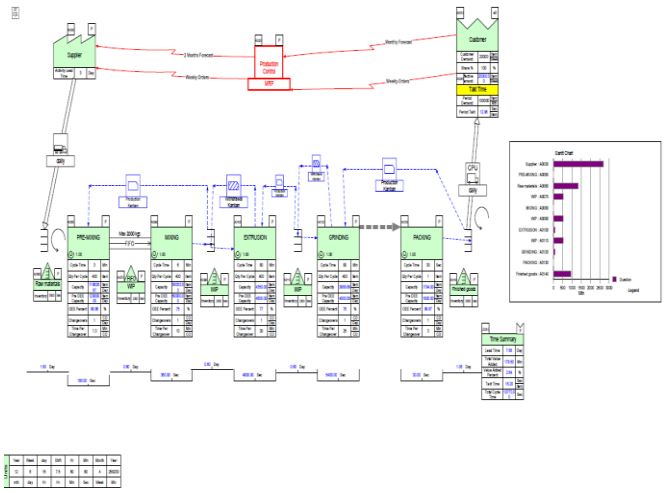

Fig. 4: Future State Value Stream Map

The current state value stream map is to design with the real data as the customer demand per week was 20000 kgs, based on this Takt time calculated is 12.96 seconds per kg, which aggregates the customer demand is one kilogram of product every 12.96 seconds (Figure 2). The customer request weekly orders to the production department by electronic media (email) and their monthly predicated requirements. The production department sends the information to their respective supplier including weekly supplies and two months estimate as per of the customer orders. The different process involved to arrive at the final product is entered in the map, and the cycle time, changeover time, OEE values and number of operators are entered. The work-In-Process (WIP) inventories between the processes are entered in the map. Finally, production lead time (PLT) and processing time (PT) is calculated.

The PLT is compiled by dividing the inventory between the processes by the customer demand per day. Total production lead time is calculated by adding all the lead times of processes and the processing time is calculated by adding the cycle time of all the process. The calculated PLT was 12.02 days and the processing time is 179.5 minutes. Kaizen burst is a cloud-like an icon that is used to highlight where improvements are needed. From the obtained current state map, areas to be improved are highlighted (see Figure 3). After the current state map gives a complete picture of the current scenario, it was observed that there is inventory accumulation between the processes. While this research study was carried, it was found that the lack of standard inventory control system affected the management of stocks inside the paint manufacturing plant. The procured raw materials were piled up due to anticipated storage, and erratic consumption at different process centers thus leading to the high inventory of items. It was observed that the rotator dies used in the extrusion and grinding process had a high changeover time. If appropriate action is taken with mutual consent, this wasteful activity can be reduced. All these issues were highlighted using kaizen burst on the future state value stream map drawing the illustration and discussing with the unit manager the future state stream map was constructed.

The future state was mapped to suggest improvements in reducing inventory and change over time. Suggestions were given to reduce the raw material inventory to the plant to incorporate Supermarket which is represented by reverse E shape icon (Ǝ). The supermarket stores contain limited inventory, and as soon as the raw material is withdrawn from the next process, the production control is alarmed, and they place the order to the supplier to refill the supermarket. In that way, the inventory can be less and kept stable, and it will be available whenever needed. Between the pre-mixing stage and the mixing stage, a FIFO lane can be introduced to control the high inventory. The concept like First In First Out (FIFO) might yield less storage space and thus the observed cycle time of both the process is less, these two operations can be combined. This inventory may be controlled. FIFO lane works in a way that, the upstream process produces limited products. When the FIFO lane is full, the production is stopped from the upstream process until the downstream process uses items in the inventory. In this way, the FIFO lane prevents the pre-mixing process from overproducing.

A supermarket is placed after the mixing process, and whenever a product is needed, the Extrusion process goes to the supermarket and withdraws what is needed. Once a product is withdrawn from the supermarket, a production Kanban is sent to a pre-mixing zone to produce the amount of product removed to refill the supermarket [19]. In this way, the inventory is kept low and without any fluctuations. The supermarket is placed in every process so that limited products are produced and controlling the inventory between them. By implementing this Production lead time is expected to reduce to 7.55 days from 12.02 days. The future state map with FIFO lane and supermarket is shown in Figure 4.

A. Validating the current state and future state map

The data obtained was inputted to the software, and the map was created using the VSM icons available in the software. The current state map was created first, and once all the icons are placed and connected, data is entered for all the process, and the map is checked for errors. Once the error check is done, the data associated with the map is calculated automatically by the software, and it is displayed. Once the current state map is validated, the future state map was framed by following the same steps and finally the production lead time was calculated, and the future state map was validated. The current state and future state map were validated using the eVSM software. The software is a company purchased licensed version and could not be displayed in this paper that violates the non-disclosure agreement. However, the company permitted to researchers to use process parameters. The plant operation manager who is a subject expert accepted the validation and appreciated this research work. The current state and future state map created using eVSM software are shown in Figure 2, Figure 3 and Figure 4. Thus, all maps were validated using the eVSM software. The data obtained was inputted to the software, and the map was created using the VSM icons available in the software. The current state map was created first, and once all the icons are placed and connected, data is entered for all the process, and the map is checked for errors. Once the error check is done, the data associated with the map is calculated automatically by the software, and it is displayed. Once the current state map is validated, the future state map was framed by following the same steps and finally the production lead time was calculated, and the future state map was validated. The current state and future state map were validated using the eVSM software. The software is a company purchased a licensed version and could not be displayed in this paper that violates the non-disclosure agreement. However, the company permitted researchers to use process parameters. The plant operation manager who is a subject expert accepted the validation and appreciated this research work. The current state and future state map created using eVSM software are shown in Figure 2, Figure 3 and Figure 4. Thus, all maps were validated using the eVSM software.

V. CONCLUSION

The illustration of the process for powder coating material is developed through the VSM approach and the validating the model developed was validated in the e- Value Stream Mapping software. This process study is a natural while the real changes to be implemented needs a strategy along with the team members from diversified domain experts. To observe the real benefits only after implementing the process change. This study lacks sensitizing the process with detailed data collection at every level. Due to the paucity of time this study is based on the observations from the current state map, suggestions are made regarding the inventory reduction and reducing production lead time with the help of a future state map. Ultimately this yields lean practice of process improvement and performance enhancement. The Effective utilization of space and efficiency of the line is easily monitored to achieve the ideal situation.

REFERENCES

1. D. Magee. “How Toyota Became # 1 Leadership Lessons from the World’s Greatest Car Company,” New York, USA: Penguin Group. p. 67, 2007.
2. N. Sharma and V. N. Bartaria, “Implementation of lean technology using cellular manufacturing in the textile industry,” *International Journal of Advance Engineering and Research Development*, vol. 2, no.5, 40–49, 2015.
3. M. M. Islam, A. M., Khan and M. Z. M. Uddin, “Elimination of non-productive activities is a must in cost and time savings in the sewing section of the apparel industry,” *International Journal of Engineering*, vol. 1, no. 4, pp. 2305–8269, 2013.
4. P. Hines, N. Rich, J. Bicheno, D. Brunt, D. Taylor, C. Butterworth and J. Sullivan, “Value stream management,” *The International Journal of Logistics Management*, vol. 9, no. 1, pp.25–42, 1998.
5. D. Jones, “Applying Toyota principles to distribution, Supply Chain Development Programme,” Workshop #8 Workbook, Britvic Soft Drinks Ltd, Lutterworth, 6–7 July 1995.
6. L. Wilson. “*How to Implement Lean Manufacturing*.” New York: McGraw-Hill Professional Publishing. p. 29–214. 2009.
7. N. Bhatia and J Drew, “Applying Lean production to the public sector,” *McKinsey Quarterly*, vol. 3, pp. 97–98. https://www.mckinsey.com/industries/public-sector/our-insights/applying-lean-production-to-the-public-sector, 2006.
8. T. T. Burton and S. M. Boeder, *The lean extended enterprise: Moving beyond the four walls to value stream excellence*. J. Ross Publishing. Florida, USA, 2003.
9. Froon, “*Implementing lean management globally- Lean around the world*,” ANR: 219987, Published Thesis submitted to Tilburg University, Netherland, awarding Bachelor Organization and Strategy, Accessed from http://www.arno.uvt.nl/show.cgi?fid=120976 , 2010.
10. Nave, “How to compare Six Sigma, Lean and the Theory of constraints,” *Quality Progress*, vol.35, no.3, 73–78, 2002.
11. Tracy and J. Knight, “Lean operations management: Identifying and bridging the gap between theory and practice,” *Journal of American Academy of Business*, Cambridge, vol. 12, no. 2, 8–14, 2008.

12. N. Wood, "Lean thinking: what it is and what it isn't," *Management Services*, vol. 48, no. 2, pp.8–8, 2004.
13. J. P. Womack and D.T. Jones, "Lean thinking: Banish waste and create wealth in your organization, " New York, USA: Simon and Shuster, 397–383, 1996. RevisEd and UpdatEd (1st Ed. publishEd 1996), Free Press, Rockland, Me, USA, 2nd edition, 2003.
14. M. Rother and J. Shook. *Learning to See: value stream mapping to create value and eliminate Muda*. MA USA: Lean Enterprise Institute, 1999.
15. Dal, P, Tugwell, and R, Greatbanks, "Overall equipment effectiveness as a measure of operational improvement A practical analysis," *International Journal of Operations and Production Management*, vol. 20, no. 12, p.1488–1502. 2000.
16. Bisen and s. srivastava. *production and operation management*. lucknow, india: global media, p. 175, 2009.
17. Tapping, T. Luyster, and T. Shuker, *Value Stream Management*, New York, USA: Productivity Press, 2002.
18. Abdelhadi, "Investigating emergency room service quality using lean manufacturing," *International Journal of Health Care Quality Assurance*, vol. 28, no. 5, p. 510–519, 2015.
19. J. Lu, *Kanban - Just-In-Time at Toyota, Management Begins at the workplace*, Edited by Japan Management Association, Tokyo: Productivity Press, 1986.