Global Journal of Researches in Engineering: A
Mechanical and Mechanics Engineering
Volume 17 Issue 1 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4596 Print ISSN:0975-5861

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GJRE-A Classification: FOR Code: 091399

Reduction of Production Lead Time using Value Stream Mapping (VSM) Technique

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I. Introduction

The first time that lean concepts were shown to the world was in the book "the machine that changed the world" which is a benchmark among craft production, mass production and lean production (Womack, Jones and Roos, 1990). The lean manufacturing system was built up between 1945 and 1970. After the Second World War, the Japanese economy had collapsed due to the shortage of raw materials, financial and human resources as well as an oil crisis. This research addresses the application of lean manufacturing concepts to the continuous production sector with a focus on the battery industry. The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment, and to evaluate their benefits on a specific application instance. Value Stream Mapping includes all the steps, both value added and non value added, required to take a product or service from raw material to the waiting arms of the customer. This enables to see at a glance where the delays are in process, any restraints and excessive inventory. Current state map is the first step in working towards ideal state for organization. VSM is primarily concerned with mapping the movement of information and materials through the value stream.

Our research objective is

- ➢ To reduce manufacturing lead time and wastes of a particular battery manufacturing company.
- ➢ To increase capacity of that battery manufacturing company. Many unnecessary times have been wasted in various industries. The focus of this research is to eliminate those unnecessary process times and reduce wastes of a particular battery manufacturing company. The main goal is to reduce these unwanted times of the production by using various lean tools. A different layout has been suggested considering various ergonomic and other factors to increase capacity of the overall industry.

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II. Literature Review

The term value stream was first introduced in the book The Machine that Changed the World by Womack, Jones and Roos (1990), and further discussed in Lean Thinking (1996) by Womack and Jones. In a later book by Martin and Osterling, the authors defined: "a value stream is the sequence of activities an organization undertakes to deliver on a customer request." (Martin and Osterling, 2013). More broadly, value stream is the sequence of activities required to design, produce, and deliver a good or service to a customer, and it includes the dual flows of information and material." (Martin and Osterling, 2013). Value stream mapping in the manufacturing environment has been discussed since the technique was used at the Toyota Motor Corporation, and was known as "material and information flows." Toyota focuses on understanding the flow of material and information across the organization as a way to improve manufacturing performance. Ulf K. Teichgräber, Maximilian de Bucourt (2010) utilized VSM to eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services by applying value stream mapping (VSM). The Lean manufacturing technique was used to analyze the process of material and information flow currently required to direct endovascular stents from external suppliers to patients. Based on a decision point analysis for the procurement of stents in the hospital, a present state VSM was drawn. After assessment of the current status VSM and progressive elimination of unnecessary NVA waste, a future state VSM was drawn (Ulf K. Teichgräber, et al 2012). Krisztina Demeter, Zsolt Matyusz (2011) discussed how companies can improve their inventory turnover performance through the use of lean practices. However, there may be significant differences in inventory turnover even among lean manufacturers depending on their contingencies (Cox, A., 2002). Zoe J. Radnor, Matthias Holweg, Justin

Global Journal of Researches in Engineering (A) Volume XVII Issue I Version I Year 2017

Waring (2012), adopted process improvement methodologies from the manufacturing sector, such as Lean Production. In this paper they report on four multi-level case studies of the implementation of Lean in the English NHS. Their results showed that the work generally involves the application of specific Lean 'tools', such as 'kaizen blitz' and 'rapid improvement events', which tend to produce small-scale and localized productivity gains. Although this suggests that Lean might not currently deliver the efficiency improvements desired in policy, the evolution of Lean in the manufacturing sector also reveals this initial focus on the 'tool level'. Bergmiller and McWright (2009) identified manufacturing firms who had implemented lean manufacturing and received one of lean's most distinguished awards, the Shingo Prize (The Shingo Prize for Operational Excellence, 2009). He found that these firms were significantly greener than a general population of other manufacturers in twenty five of twenty-six measures of green manufacturing. Bergmiller and McWright utilized an online survey tool in order to harvest information from Shingo award-winning manufacturers. The survey was divided into three sections, as follows: Status of their plant(s) environmental management system (EMS), Fourteen questions regarding the application of environmental waste techniques at the plant(s) and Ten questions about advantages/ disadvantages of the EMS at the plant(s).Sawhney, Teparakul, Aruna, and Li (2007) show the connection between lean manufacturing and the environmental movement stating that "it is natural that the lean concept, its inherent value-stream view and its focus on the systematic elimination of waste, fits with the overall strategy of protecting the environment", which they call Environmental Lean (En-Lean). The focus group reported that several green manufacturing metrics were more positive in lean manufacturing than batch-style manufacturing: Air pollution was lower in a cellular manufacturing scenario since exhaust and power consumption was less, employee's safety and health were better with an optimized plant layout, exposure to dangerous material was reduced by eliminating unneeded material transfers.Teresko (2004) made the connection between green manufacturing and the lean movement in his research into Bill McDonough's book "Cradle to Cradle". Teresko recites McDonough's statements that the goal of lean, when applied to a manufacturing facilities layout, is to "shrink-wrap a structure around an optimized process; including the entire external commercial environment in the optimized process, integrating all the manufacturing flows from global to national to submicroscopic levels". In the last several years, much research concerning applying techniques such as linear and non-linear programming, and discrete event simulation (DES) as lean tools has been conducted. Multiple authors cite the significant (positive) impact the application of these tools can have in conjunction with the more traditional tools as developed by Toyota (Marvel & Standridge, 2009; Maynard, 2007). Curry (2007) described how DES is used to "allow one to visually see and measure how processes perform over time, including materials, information and financial flows, and how probabilistic variables impact them". Additionally, Curry stated how DES is an extremely valuable compliment to value stream mapping (VSM) because VSM is inherently non-analytical and static in nature.

III. Methodology

To implement a VSM various steps can be followed. Our goal was to find out different types of wastes from the job floor and reduce the cycle time. To achieve our goal we implement the steps shown in following figure:

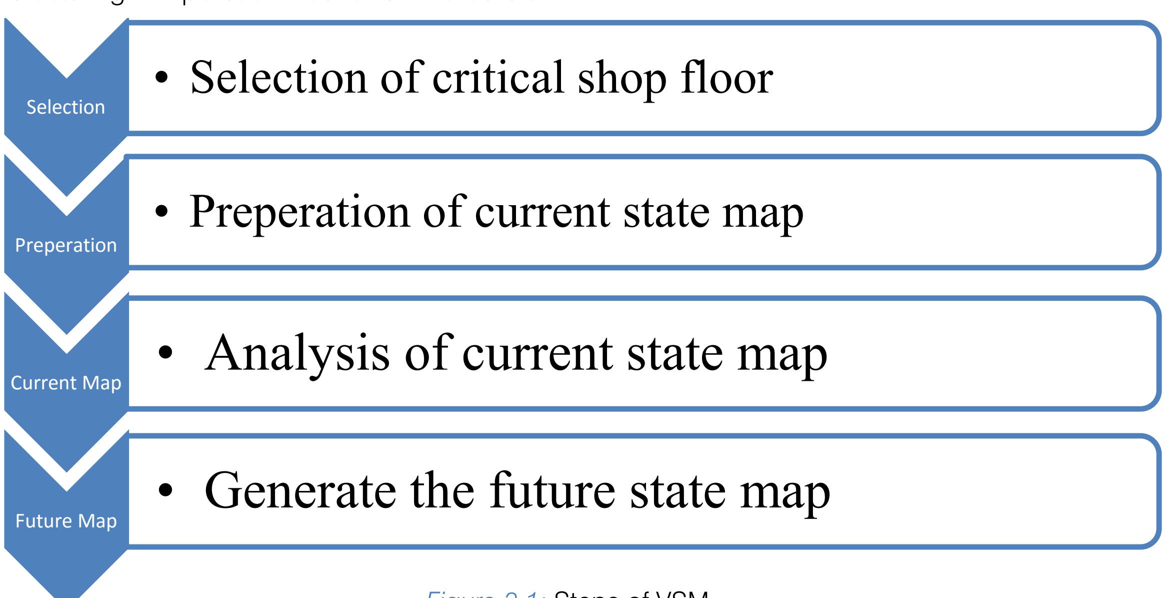

Figure 3.1: Steps of VSM

IV. Data Collection

In Rahimafrooz Battery LTD (RBL) current condition of the production system is very efficient than any other battery companies in our country. The main raw materials for their production are Lead and Poly propylene. The 80% leads are coming from the used batteries which were sold out at the market. There are mainly five job floors, where different types of manufacturing process are being held to produce batteries. Some important information collected to generate current state map of RBL are given below:

a) Job Floor 1- Lead Preparation Plant

Rotary Furnace:
Daily hard lead production rate: 10 metric ton /day
Cycle time: 2 hours

Alloy pot:
Process time: 16-30 hours
Total worker Number: 40 / shift

b) Job Floor 2- Plate Preparation Plant

Grid Casting:
Machine no: 9
Capacity: 10000 pcs/ shift
Aging time: 72 hours

Oxide mixing:
Machine no: 2
Capacity: 14.5 metric ton/day
Aging time: 48 hours

Pasting:
Machine no: 2
Capacity: 75000 pcs /shift (machine-2) and 55000 pcs /shift (machine-1)

Curing chamber:
Machine no: 8
Capacity: 48000 pcs /machine

Formation:
Machine no: 11
Capacity: 12000 pcs / day
Circuit no: 12
Drying:

For positive dry oven:
Machine no: 2
Capacity: 48000 pcs / machine
Processing time: 8-12 hours

For inert gas oven:
Machine no: 1
Capacity: 55000 pcs / day ; Processing time: 85 minutes

Part process under IGO:
Machine no: 4
Capacity: 15000 pcs / day
Processing time: 11 minutes
Total worker number for this section: 55 / shift

c) Job Floor 3- Plastic Molding Section
Machine no: 8 / shift
Amount of polypropylene: 1 ton / shift
Number of workers: 12 / shift

d) Job floor 4- Small Parts Casting Section
Machine no: 4
Number of workers: 6 / shift
Capacity: 1500 pair / shift (lead pot)
Amount of lead: 189 kilograms

e) Job floor 5- Assembly Section
Number of workstation: 1(for N50)
Number of workers: 33-36 / shift
Processing time: 4-5 minutes
TAKT time = Available time to production / required units of production

V. Future State Map Generation

As seen in the figure the current state VSM is displayed. From the figure it can be observed that hard lead produced in the Lead recycle plant is internally supplied to the Plate preparation plant, Small parts casting section and Plastic molding section. Daily production of different batteries from these three sections is supplied to the Assembly line section. We have calculated total value added time from collecting cycle times of each plant. The total value added time for N50 standard dry cell automotive battery is 303.424 seconds. The calculation of daily production of N50 battery is given below:

The daily production hour = 2 shifts = 16*60*60= 57600 seconds
Cycle time for producing one N50 battery = 303.424 seconds
The daily production rate = 190 pcs / day; Shift time = 8 hours
Monthly production rate = 190 * 30 = 5700 batteries

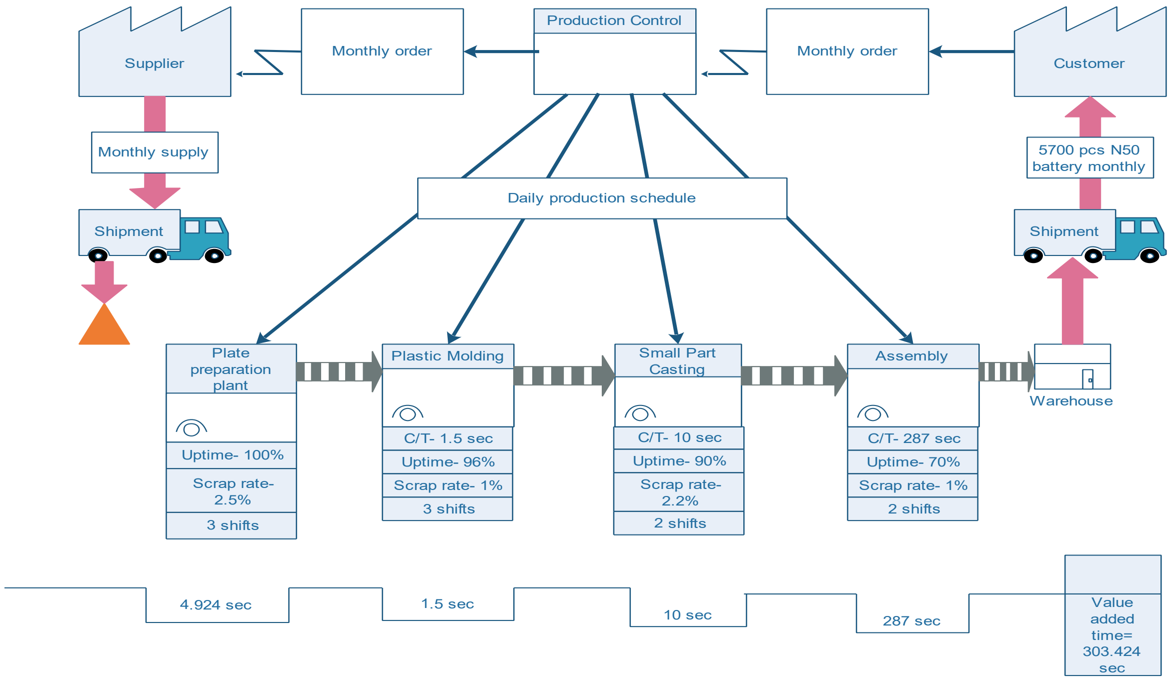

Figure 5.1: Current state map of RBL production system for N50 battery

Future state map gives us the view how a manufacturing plant can operate in improved design comparing to the current situation. Improved stage of information flow, material flow and time flow are displayed in the future state map. Various lean tools to reduce waste throughout the manufacturing plant have been displayed. Raw materials are supplied from local suppliers or imported from abroad. Lead recycles plant supplies lead to the plate preparation, plastic molding and small parts chamber in the assembly section. Plate preparation plant and plastic molding sends plates and plates and boxes to the assembly section.

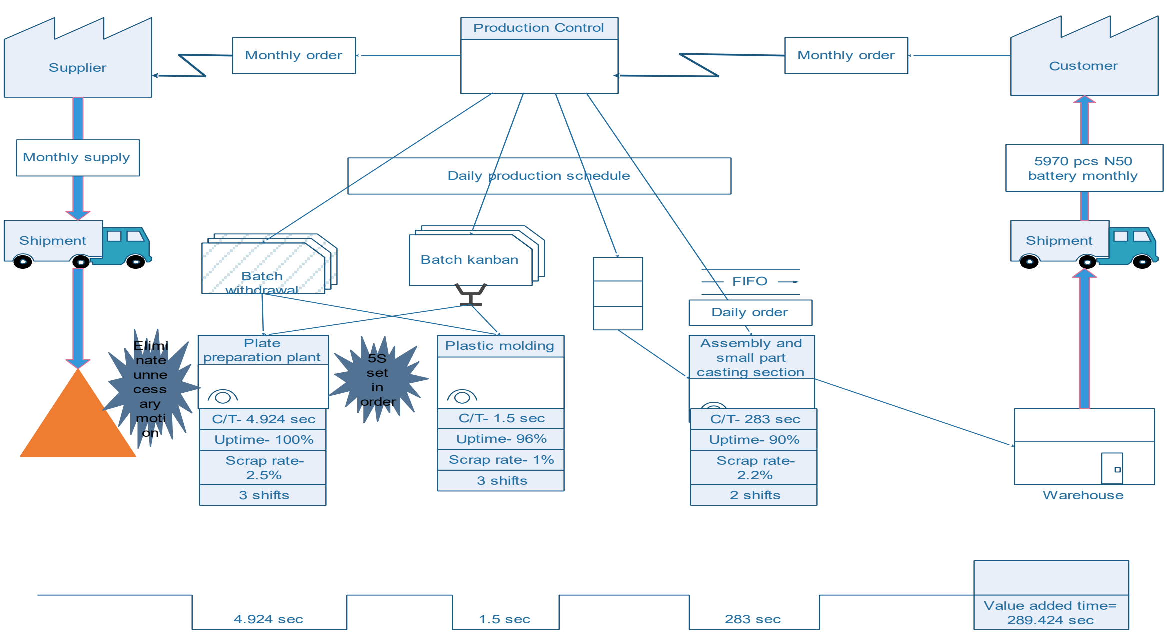

Figure 5.2: Future State Map of RBL to Manufacture N50 Battery

In Future State Map we suggested- Kanban, Kaizen, 5S From the future state map, we can calculate the daily production rate of N50 standard automotive dry cell batteries. Cycle time of each process can be recorded. The calculation is given below:

Total process time = 4.924 + 1.5 + 283 = 289.424 seconds Total production time = 16 * 60 * 60 = 57600 seconds (two shifts)

Per shift = 8 hours

Daily production of N50 automotive batteries = 199 pcs / day

Monthly production of N50 automotive batteries = 199 * 30 = 5970 batteries

We have applied lean manufacturing concept "kaizen" on plate preparation plant and "5S" on plastic molding section. The use of "5S" can ensure improved service and safety and efficiency. 5s is a part of kaizen. Sorting and set in order can ensure better discipline in the use of the equipment. Kanban system can also be used for better information flow. Kanban is Japanese for "visual signal" or "card. Batch production kanban and withdrawal kanban are two types of kanban system. The main function of a withdrawal Kanban is to pass the authorization for the movement of parts from one stage to another. The primary function of the production Kan-ban is to release an order to the preceding stage to another. The primary Function of the Production Kan-ban is to release an order to the precending stage to build the lot size indicated on the card. The production Kan-ban card should have the following Information materials required as inputs at the preceding stage parts required as inputs at the preceding stage information stated on withdrawals Kan-ban. Various lean tools to reduce waste throughout the manufacturing plant have been displayed in future state map. Withdrawal kanban and batch production kanban cards are displayed in the map. Production control section controls better information flow and control information using these kanban cards. Production control then suggests assembly section to apply "FIFO' or first in, first out methods. Kaizen burst icon signals elimination of unnecessary motion in plate preparation plant and application of "5S" in plastic molding section. We reduce 4 minutes in assembly and small part casting section from 287 to 283 seconds by using FIFO method and safety stock. We have reduced almost 10 second in small part casting and plastic molding section by using 5s and withdrawal Kanban and batch Kanban. We also use withdrawal and batch Kanban in plate preparation plant.

VI. Result Analysis

Waste findings are Motion, Ergonomic factors, Transportation & Waiting By applying the improvements, lead time will be reduced. The improvements are shown in the Improvement Chart below-

Table 1: Improvement Chart of N50 Battery

Parameters	N50 Battery
Current Process time	303.424 seconds
Improved Process time	289.424 seconds (4.61%)
Current Daily production	190 pcs / day
Improved Daily production	199 pcs / day
Current Monthly production	5700 pcs
Improved Monthly production	5970 pcs (4.52%)

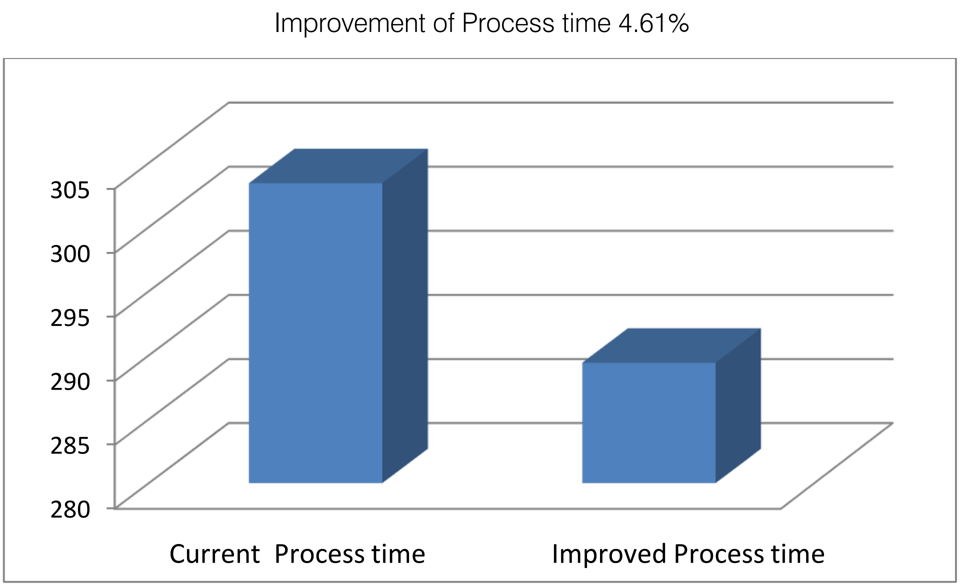

Figure 6.1: Improvement of Process Time for N50 Battery

This graph contains two bars representing the current Process time and future Process time comparison. The current Process time is 303.424 seconds and the improved Process time reduced to 289.424 seconds. The future state map will improve the Process time by 4.61%.

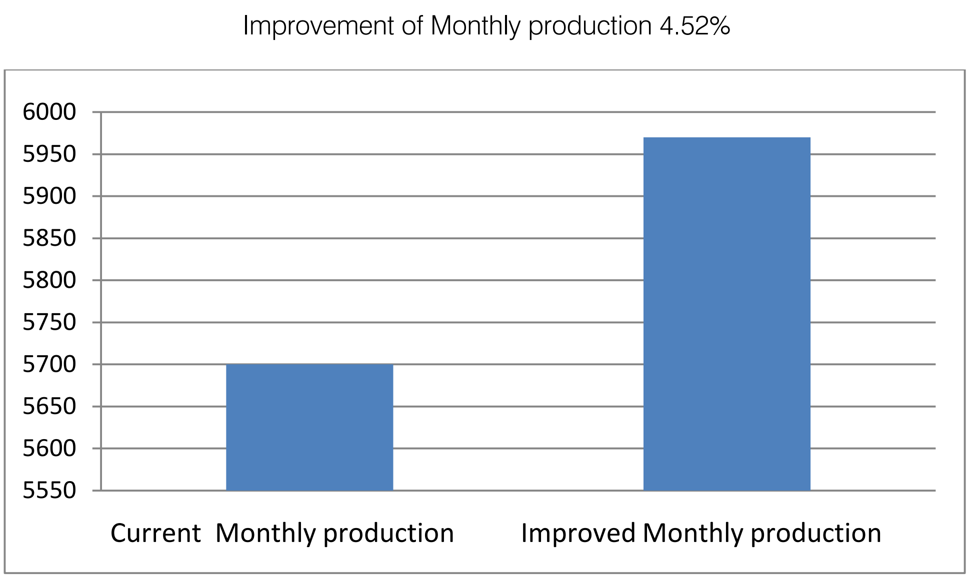

Figure 6.2: Improvement of Monthly production for N50 Battery

This graph contains two bars representing the current Monthly production and future Monthly production comparison. The current Monthly production is 5700 pcs and the improved Monthly production increased to 5970 pcs. The future state map will improve the Monthly production by 4.52%.

VII. Conclusions

The main focus of this research is to reduce the overall lead time and wastes of Rahimafrooz batteries limited (RBL). This paper has suggested a different layout of the assembly section of that particular industry. Value stream map is used in the current situation. Applying lean tools such as kaizen, kanban and 5S turn out to be helpful for better material and information flow throughout the production system. Small parts casting and assembly process joining in two workstations parallel can reduce overall value added time. Thus, daily producing more products and fulfilling customer order in satisfactory manner. Rahimafrooz can reduce their unnecessary non value added activities and ultimately reduce the overall lead time of the process by overall improved layout.Value stream mapping has been indicated as one of the best tool for lean production implementation in a facility. A battery manufacturing plant (RBL) is a complex process. Different types of batteries such as N70, N150, NS40, PCM 15, N100, and N120 all are assembled in the same workstation. For this thesis work, N50 dry cell automotive battery has been selected. Lead recycle plant, plate preparation plant, plastic molding section are all complex manufacturing plants. Value stream map has proven to be effective to analyze RBL's current production state and thus recommendations are suggested.

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