International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

Production Lead Time Reduction in a Battery Manufacturing Unit using Lean Manufacturing

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Abstract **- Lean Manufacturing is an effective management philosophy for improving businesses in a competitive market by eliminating waste and improving operations. Value Stream Mapping (VSM) is the preferred way to support and implement lean. VSM is a visual illustration of the entire value stream (from customer order entry through purchasing, manufacturing and deliver the finished product to customer). This paper describes the reduction of production lead time in a battery manufacturing unit, and to deliver the products on time to customers. This involved mapping the activities of the firm, and identifying opportunities for improvement. Current State Map is prepared to describe the existing position of firm. The current state is analysed to identify sources of waste which are then eliminated. Future state map is prepared to show the improvement areas. The achievements of valve stream mapping are reduction in production lead time and inventory levels.**

Key words: Lean manufacturing; valve stream mapping; lead time

1. INTRODUCTION

Manufacturing companies have been faced with increasing amounts of pressure from customers and competitors in the past couple of decades. Customers have higher expectations from their purchases, and manufacturers can meet these expectations by increasing a product's quality, reducing delivery time, and minimizing product costs. This has forced the manufacturing industry to implement new production strategies to enhance their competitiveness in the global market place. Lean manufacturing was first implemented by Toyota Corporation in response to the mass-production model.

Lean is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for. Basically, lean is centered around creating more value with less work. Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) and identified as "Lean" only in the 1990s. It is renowned for its focus on reduction of the original Toyota seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. In this paper, an attempt is made to decrease the production lead time in a battery manufacturing unit by using value stream mapping as a tool. The production lead time is more for manufacturing one battery, which results in customer requirement not being met.

2. LITERATURE REVIEW

Taho Yang, Yiyo Kuo (2015) Value stream mapping (VSM) is a useful tool for describing the manufacturing state, especially for distinguishing between those activities that add value and those that do not. It can help in eliminating non-value activities and reducing the work in process (WIP) and thereby increase the service level. This research follows the guidelines for designing future state VSM. These guidelines consist of five factors which can be changed simply, without any investment. These five factors are (1) production unit; (2) pacemaker process; (3) number of batches; (4) production sequence; and (5) supermarket size. The results show that the future state maps can increase service level and reduce WIP by at least 29.41% and 33.92% respectively.

Lluis Cuatrecasas-Arbos (2011) et al, developed a spreadsheet model for manufacturing system by means of the Operations-Time Chart (a graphical tool). The OT-chart permits a visual tracking of the parameters (productivity, lead-time, inventories, downtimes and wait times) throughout each process and displays the effects of changing input parameters. It also provides tracking of different types of waste and supports inventory supermarkets and pull scheduling. They have concluded with the case study of plant redesign from a conventional batch and-queue production system into a lean manufacturing system.

Stephen L.Woehrle (2010) et al, developed a concept for creating dynamic value stream mapping and lean accounting box scores to support lean implementation. They describe value stream mapping, simulation, and lean accounting in order to incorporate and integrate them for the purpose of solving the dilemma between lean implementation benefits and financial and accounting reporting methods. They have concluded that lean has proven to be an effective management philosophy for improving businesses in a competitive market by eliminating waste and improving operations, rapid reduction in inventory levels.

Ibon Serrano Lasa (2009) *et al*, illustrate and analyse the causes for the limited adoption of Lean manufacturing concepts in proposals for the redesign and improvement of productive system. They have discussed about the following: 1.Selection of ideal cases 2.VSM application 3. Process evaluation. They have concluded, after redesigning the system from the existing to Lean, the benefits obtained are well on comparing it with the current scenario. This establishes a continuous improvement throughout.

Modarress (2005) et.al, consider the advanced techniques to achieve the goal in competitiveness across the firms. The techniques include lean manufacturing, target costing and value analysis. The term target costing is based on the customer's willingness to pay for the particular product which is followed by value analysis. Value added analysis eliminates the non value added costs for reducing the price of the product. The author proves the theory with the help of a case study of Boeing 767 and concludes the influence of lean manufacturing and value added analysis in the manufacturing environment.

3. DESCRIPTION OF THE EXISTING PRODUCTION SYSTEM

The project work is carried out in a battery manufacturing unit. The various divisions in this unit are

- Industrial battery division which manufactures Valve Regulated Lead Acid batteries.
- Automotive battery division dedicated for automotive batteries for four wheelers.
- Plastic division dedicated for containers, covers.

The division selected is Industrial battery that is dedicated for industrial batteries. This division manufactures Lead Acid Batteries of different capacities.

After through study of the system, a brain storming session has been made for selection of the battery, for establishing lean. The battery identified is 65 Ah Medium Valve Regulated Lead Acid (MVRLA) Battery because lead time is more. The objective is to use value stream mapping to first map the current state and then to identify sources of waste and to eliminate this waste, to meet customer requirement.

3.1 Current State Map For Existing System

A value stream is all the value added and non value added activities currently required to bring a product through the main flows essential to every product:

1) The production flow from raw material into the arms of the customer,

2) The design flow from concept to launch.

This work looks at the production flow from customer demand back through raw material. Value stream means working on not just individual processes, and improving the whole. It will go all the way from molecules into the arms of the customer; there will be a need to follow the value stream for a product across many firms and even more facilities. This paper work concentrates on the production flow of a dedicated process, including shipment to the plant's customer and delivery of supplied parts and material, where future state vision is designed and start implementing it right away. Value stream mapping is a pencil and a paper tool that helps to understand the flow of material and information as a product makes its way through the value stream. Value stream mapping can be a communication tool, a business planning tool, and a tool to manage the process. Value Stream Mapping initially follows the steps shown below. The first step in the drawing is the current state, which is done by gathering information on the shop floor. This provides the information that is needed to develop future state. Future state ideas will come up while mapping the current state. Likewise, future state will often point out important current-state information that is overlooked. The value stream mapping for current state is shown in figure no.1.

Analysis Of Current State

From the current state map the following details are obtained. The production lead time is 36.8 days. The non value added time is 28.7 days.

Super Market Pull System

The super market pull systems are implemented between processes. As the customer process consumes a product, a signal is delivered to a supplier process to replace it.

Types of Inventory

Cycle stock

Inventory required for normal state

Buffer stock

Inventory required to accommodate variation in volume and mix.

Safety stock

Inventory required to protect things that could go wrong.

Proposed inventory = Cycle stock + Buffer stock + Safety stock

The purpose of value stream mapping is to highlight sources of waste and eliminate them by implementation of a future state value stream that becomes a reality within a short period of time. The goal is to build a chain of production where the individual processes are linked to their customer(s) either by continuous flow or pull, and each process gets as close as possible to producing only what its customer needs when they need it.

In facility with an existing product and process, some of the waste in a value stream will be the result of the product's design, the processing machinery already

bought, and the remote location of some activities. These features of the current state probably cannot be changed immediately. Unless it is a new product introduction, the first iteration of the future state map should take product designs, process technologies, and plant locations as given and seek to remove as quickly as possible all sources of waste not caused by these features. Subsequent iterations can address product, design, technology, and location issues. Once the future state thoughts are worked out, the future state map can be mapped.

4.1 Inventory Calculations For Proposed State

• Lead alloy storage

In current state map the lead alloy storage is 14 Days. By implementing super market pull system an order will be placed with the supplier every week. Based on production capacity of oxide plant lead alloy storage is calculated. In the proposed state the lead alloys storage will be maintained as 7 Days. By maintaining 7 days inventory any sudden changes in demand can be easily meet.

Grid casting

In current state the average inventory for grid plates is 5 days. By implementing super market pull system between grid casting and pasting the inventory will reduced.

Table 4.1. Proposed inventory for lead alloys

PROCESS NAME	PRODUCTION CAPACITY/WEEK (Kg/hr)	AVERAGE INVENTORY(Days)
Oxide plant	91875	7

Proposed inventory = Cycle stock + Buffer stock + Safety stock

Table 4.2 proposed inventory for grid casting

STOCK	QUANTITY(PLATES)	AVERAGE INVENTORY (Days)
Cycle stock	250000	1.5
Buffer stock	300000	0.5
Safety stock	100000	0.5
Total stock	650000	2.5

Plates curing

In current state the average inventory is 4.8 Days. By implementing super market pull system in pasting and assembly the inventory is calculated based on production capacity of assembly.

Table 4.3 Proposed inventory for Plates curing

STOCK	QUANTITY(PLATES)	AVERAGE INVENTORY (Days)
Cycle stock	239023	1.4
Buffer stock	119512	0.5
Safety stock	119512	0.5
Total stock	478047	2.4

Assembly

In current state the average inventory is 2.6 Days. By implementing super market pull system between assembly and formation the inventory is calculated based on production capacity of formation

Table 4.4 Proposed inventory for assembly

STOCK	QUANTITY (DUFF BATTERIES)	AVERAGE INVENTORY (Days)
Cycle stock	5000	1.0
Buffer stock	2500	0.5
Safety stock	1715	0.3
Total stock	9215	1.8

Formation

In current state the average inventory is 1 Days. By implementing super market pull system between formation and finishing the inventory is calculated based on production capacity of finishing.

Table 4.5 Proposed inventory for formation

STOCK	QUANTITY (BATTERIES)	AVERAGE INVENTORY (Days)
Cycle stock	2500	0.5
Buffer stock	1371	0.2
Safety stock	687	0.1
Total stock	4558	0.8

Finishing

In current state the average inventory is 1.32 Days. By implementing First In First Out (FIFO) system between finishing and dispatch. The inventory is calculated based on customer demand.

Table 4.7 Proposed inventory for finishing

STOCK	QUANTITY (BATTERIES)	AVERAGE INVENTORY (Days)
Cycle stock	3000	0.5
Buffer stock	1500	0.2
Safety stock	500	0.1
Total stock	5000	0.8

Future State Map

After a detailed analysis on the current state map the proposed map is devised. The super market pull system is implemented from Grid casting to Formation stage the average inventory is reduced. The First In First Out (FIFO) system is implemented after Finishing the inventory is reduced from 1.32 days to 0.8 days. The goal is to build a chain of production where the individual processes are linked to their customer(s) either by continuous flow or pull, and each process gets as close as possible to producing only what its customer needs when they need it. The future state map is shown in figure no.2.

4.2 Proposed Inventory For Future State

The production lead time for future state was proposed after examining the process and making the process flow continuous without holding more invntories.

Table 4.8 Average inventory for current and proposed state

PROCESS	AVERAGE INVENTORY (Days)	
	CURRENT STATE	FUTURE STATE
Lead alloy storage	14	7
Grid casting	5	2.5
Plates curing	4.8	2.4
Assembly	2.6	1.8
Formation	1	0.8
Finishing	1.32	1
Total	28.72	15.5

5. CONCLUSION

After a detailed analysis on the current state, a future state map was devised. Several techniques like first in First out (FIFO), Kanban system and supermarket pull systems were used to make the flow continuous in the proposed state. The non value added time reduced from 28.7 to 15.5 days in the proposed state. The value added efficiency will increase from 21.8% to 34.1%. The production lead time is reduced from 36.8 to 23.5 days. It has been found that we need to concentrate on Non-value adding activity operations.

The inventory between work stations is minimized by maintaining a continuous flow. As the inventory level reduces, Production lead time is also reduced. As lean implementation is cross functional, the team work is also established.

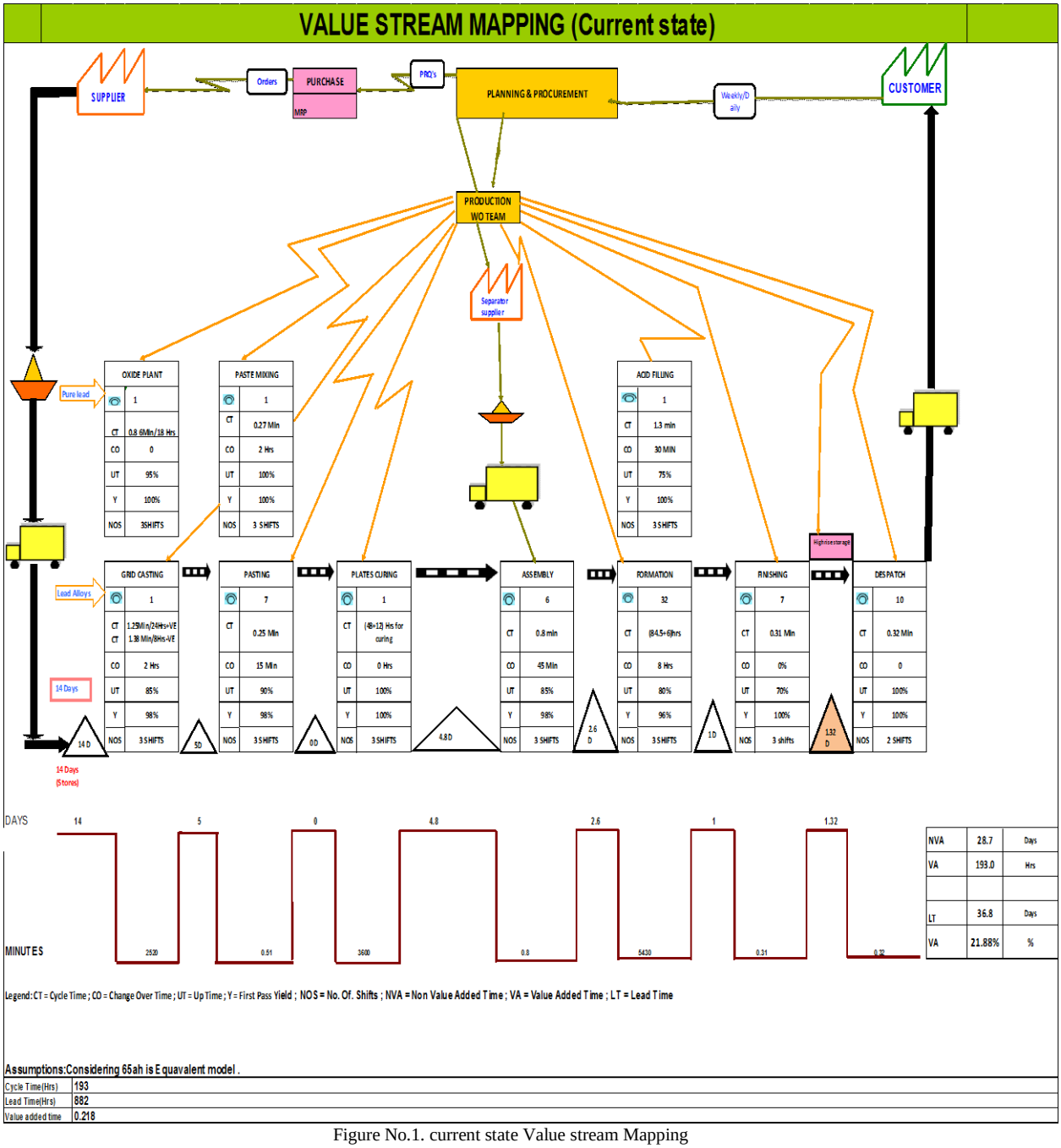

Figure No.1. current state Value stream Mapping

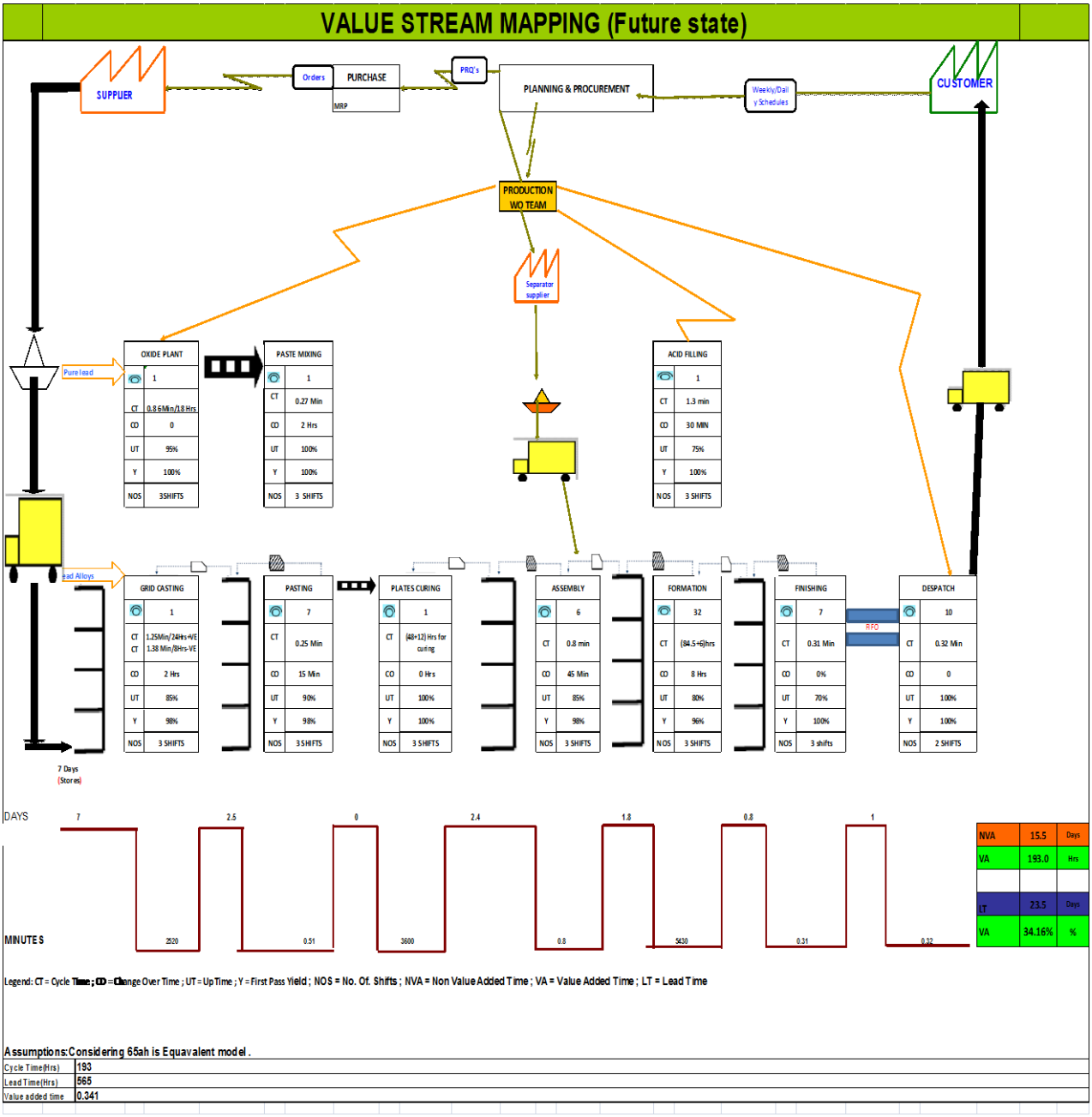

Figure No.2. Future state Value stream Mapping

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