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Improvement of Crankshaft Assembly Supply Chain Using Lean Techniques-A Case Study

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ABSTRACT
In today's competitive business world, companies require small lead times, low costs and high customer service levels to survive. Because of this, companies have become more customers focused. Manufacturing industries face continuous pressure to reduce the price to remain in the market. The objective of this paper is to identify areas of wastes and how these can be reduced or eliminated using lean Techniques from the crankshaft assembly supply chain of a leading Two Wheeler Manufactures in south India. It is useful to map the dynamics of the supply chain focusing on how the demand information is passed from the final customer, back to the material suppliers and manufactures inside the company. So in this paper attempt has been made to find work in process, lead time, Inventory carrying costs and reduction of value in terms of Rupees from the current process to the proposed process.

***Keywords*-Lean, Supply Chain, Waste Reduction, Value Stream Mapping**

1. Introduction

Success in modern manufacturing industry directly correlates to how a company handles global competition. Cost effective solutions and practices are essential to stay competitive in the market. Many manufacturing facilities have experienced the drastic changes and are in a process of undergoing physical and cultural transformation to adopt the concept of lean thinking. Lean has been originally created and defined as the process of eliminating waste (Womack et al. 1990) Toyota along with the support a system to reduce or eliminate waste and non-value added activities from the various processes (Ohno, 1988; Shingo and Dillon, 1988). The conceptual framework for categorizing all of the tools and practices of lean production in five basic areas:

- **Value:** Define value from the standpoint of the customer. However, in reality, the final customer is the only one who can specify the value of a specific product or service by paying a price for it.
- **Value stream:** View your product delivery system as a continuous flow of processes that add value to the product.
- **Flow:** The product should constantly be moving through the value stream towards the customer at the pace of demand.
- **Pull:** Product should be pulled through the value stream at the customer's demand rather than being pushed on to the customer.
- **Perfection:** The never-ending pursuit of eliminating waste in the system such that the products can flow seamlessly through the value stream at the rate of demand.

2. Literature Review

Consumers today are frequently requesting a greater range of products which in turn puts a greater demand on the processing plants and supply chains. The supply chain has been defined by Stevens (1989) as "a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via feed forward flow of materials and feedback of information".

A supply chain is dynamic and involves the constant flow of information, product and funds between different stages. A typical supply chain may involve a variety of stages such as:
• Customers
• Retailers
• Wholesalers/Distributors
• Manufacturers
• Component/Raw material suppliers

The appropriate design of the supply chain will depend on both the customer's needs and the roles of the stages involved.
This paper will show how inventory reductions can be made throughout the supply chain in the industry by using Value Stream Mapping to analyse the processes involved in manufacturing and to identify key areas of wastage and possible solutions to overcome these.

Value Stream Mapping (VSM) was chosen as a tool to gather information on the crankshaft assembly supply chain because it has been used successfully by many organisations to plan and identify internal improvements [1]. Furthermore when used appropriately it can help the process industry eliminate waste, maintain better inventory control, improve product quality, and obtain better overall financial and operational control [2].
Jones and Womack (2000) define Value Stream Mapping as 'The simple process of directly observing the flows of information and materials as they now occur summarising them visually and then envisioning a future state with much better performance''.

Value Stream Mapping has been used in previous work by Jones and Womack (1996) & Rother and Shook (1999). These studies focussed on lean manufacturing and how

waste can be reduced/eliminated from the value stream. Further studies carried out by Abdulmalek, Rajgopal (2005); Seth, Gupta (2005) & Hines et al (1998) also adopted the 'lean' approach to manufacturing and identified the opportunities for lean techniques and product improvements in the manufacturing sectors. More recently value stream maps have been used to understand the flow of material and information in office activities.

The ultimate goal of VSM is to identify all types of waste in the value stream and to take steps to try and eliminate these (Rother and Shook, 1999). Waste can be any part of a process that takes time and resources but adds no value to the product and can even includes something as small as taking extra footsteps to bring a product to another part of the factory.
Hines et al (1999) discovered that for the vast majority of the time whilst products are within the defined supply chain no value is being added [3].

Value Stream Mapping aids in the development of a "current state map" which shows a visual representation of how the company is currently operating; it records process information and information flow which can be used to identify key wastes, problems and opportunities [4]. Once the current state map has been analysed the future state map can then be produced to show how the company could operate more effectively.

Taylor (2005) stated ''Value Stream Maps are a very effective method for summarising, presenting and communicating the key features of a process within an organisation''.
The aims of this research were to:
• Understand the 'current state' of the crankshaft supply chain.
• Identify key areas of waste, problems and opportunities across the supply chain.
• Develop a 'future state vision' of each of the supply chains.
• Develop an 'action plan' to achieve the future state.

3. Methodology

This section describes the methodological approaches adopted for this research. This includes the value stream mapping of the crankshaft assembly supply chain and semi structured interviews with key respondents to further enhance the information captured from the shop floor [4]. The Value stream mapping for the case study was carried out based on the methods used by Jones and Womack (1996) and Rother and Shook (1999). These methods were used because value stream mapping tools were first popularised by these authors. Value stream mapping was carried out whilst walking around the factory floor and talking to key individuals in each area [5].

The data collection started in the suppliers department through each of the individual processes identifying the linkages between the states of production and establishing the flow of information and material resources. Data such as process cycle times (CT) and number of workers were also recorded to add to the current state map so an overview of how the company currently operates could be viewed. In order to convert the data obtained into a current state map icons were drawn representing each of the process steps and flow of materials [6].

Logistics, supplier and production control icons were added including the truck icons to show deliveries from suppliers and deliveries to the logistics warehouse [7].Electronic information flow icons were added to show information sent to and from customers and suppliers and a timeline was placed alongside the current state map to show the approximate process times [8].Upon completion of the mapping exercise an interview guide was designed in order to gain more detailed information about each of the companies with regards to their suppliers, customers and processes, for example:

- Customer demand
- Ordering Frequency
- Shipping frequency

The questions were open ended and were designed to allow a greater understanding of the company and the way in which each of the processes played a part in the manufacturing of the product. The questions were asked to those representatives whom the site managers had identified as being the most knowledgeable in those particular areas [9].

These interviews allowed a rapport to develop between the researcher and the interviewee therefore allowing the researcher to probe and divulge on the respondent's answers. This information was vital in understanding what the company does and how they achieve this. The data from value stream mapping and the semi structured interviews was used to construct the current state map of the company. This map shows the processes and information flows of how manufacturing currently operates throughout the factory [10]. It is important to note that only the main product line (identified by the site managers) in the factory was mapped since Value Stream Mapping is a very time consuming process.

4. Application of VSM in a manufacturing industry: a case study

A case study conducted at a two wheeler manufacturing company is presented and some of the observations may be useful to the practicing engineers in implementing VSM in small, medium and large enterprises. Much of the earlier work have attempted complementary lean manufacturing tools in large scale industries and have recorded their experiments. Hence, there is a need to implement such a lean tool in small and medium size industries.

1.1 Selection of Critical Product Family

The first step is the selection of the critical part family. After the thorough study of all part families, one part family was rather preferred over all the product families. The crankshaft assembly is one of the main assemblies in an engine. It consists of several parts namely the flywheel, connecting rod, LH and RH shaft, key, plug, washer, crankpin etc.

1.2 Documentation of Supplier and customer Information

Interaction with the manager revealed information regarding its suppliers and customer's requirement. It was understood, the company has a wide range of customers. The details about the raw materials, its vendors, location and the component costs were also collected.

1.3 Current State Map

Fig. 1 below shows the current state map. The crankshaft assembly consists of ten components that are sourced by different suppliers from various parts of the country. These parts are initially processed at the machine shop. Then the process of crankshaft assembly, engine and vehicle assembly takes place. This current state map includes lead time, work in progress (WIP), transportation time etc. It indicates different processes and the links between them. It illustrates information flows as well as material flows. As per the current state the production control department provides daily and monthly schedule electronically to the assembly stations and its suppliers respectively. The box below the suppliers indicates the lead time, inventory and finished goods (in days) at each supplier stage. A large amount of inventory is carried at each stage increasing the net value of the chain. Inventories of about 300 sets were carried after each assembly stage. The assembled vehicles are transported daily to the customers. The company produces 300 numbers of crankshaft assemblies daily.

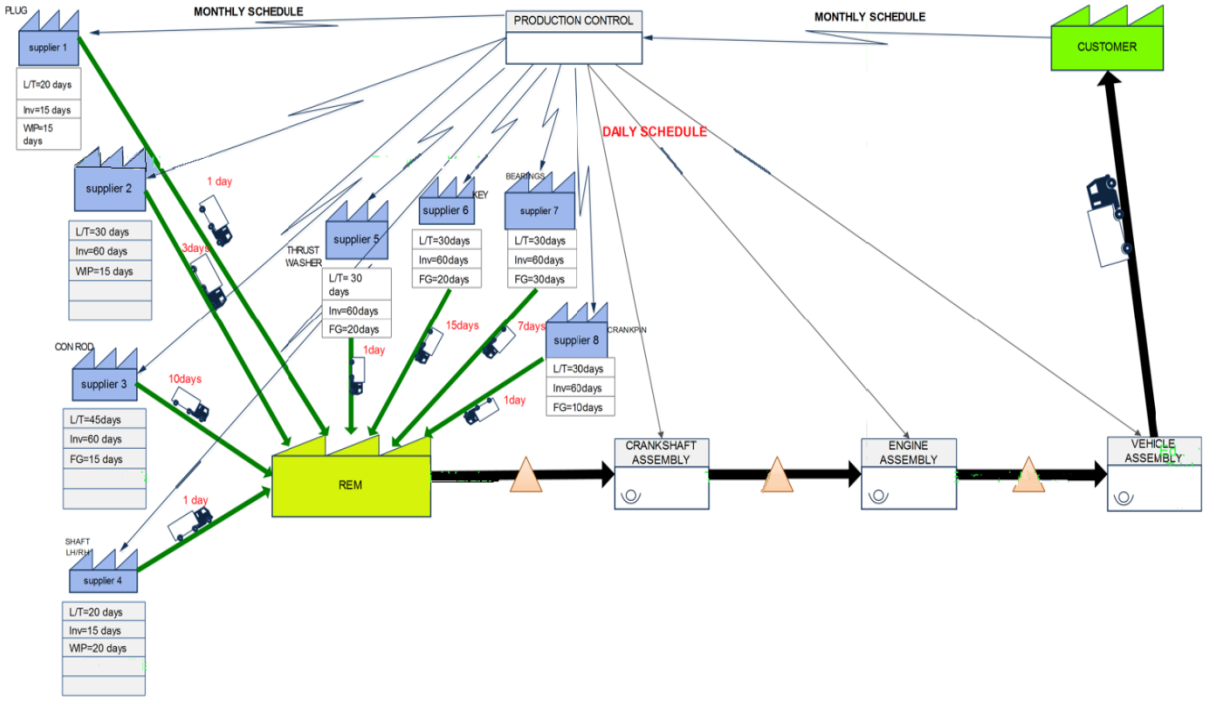

Figure 1 Current State Map

D. Future State Map

Workings on the gap areas identified by the VSM of the current state of crankshaft assembly supply chain, some modifications are proposed as indicated in Fig. 2. By analysing the current state map the lead time and the amount of inventory are the problems identified. Lean production was about creating value for the customers with minimum amount of waste and a high degree of quality.

The positive points of reducing inventory are as follows:

- Reducing tied up capital
- Smoothing production flow
- Lowering space rental costs
- Shortening throughput time

Reducing inventory also reduces other areas of wastes.

The possible solutions for reducing these wastes are listed below:

- Bringing the parts to arrive directly at the assembly station the lead time can be reduced.
- Inclusion of Supermarkets before the assembly of crankshaft and after the vehicle assembly eliminates the inventory.
- Implementing pull system can reduce the unnecessary inventory and the cost incurred in carrying those inventory.

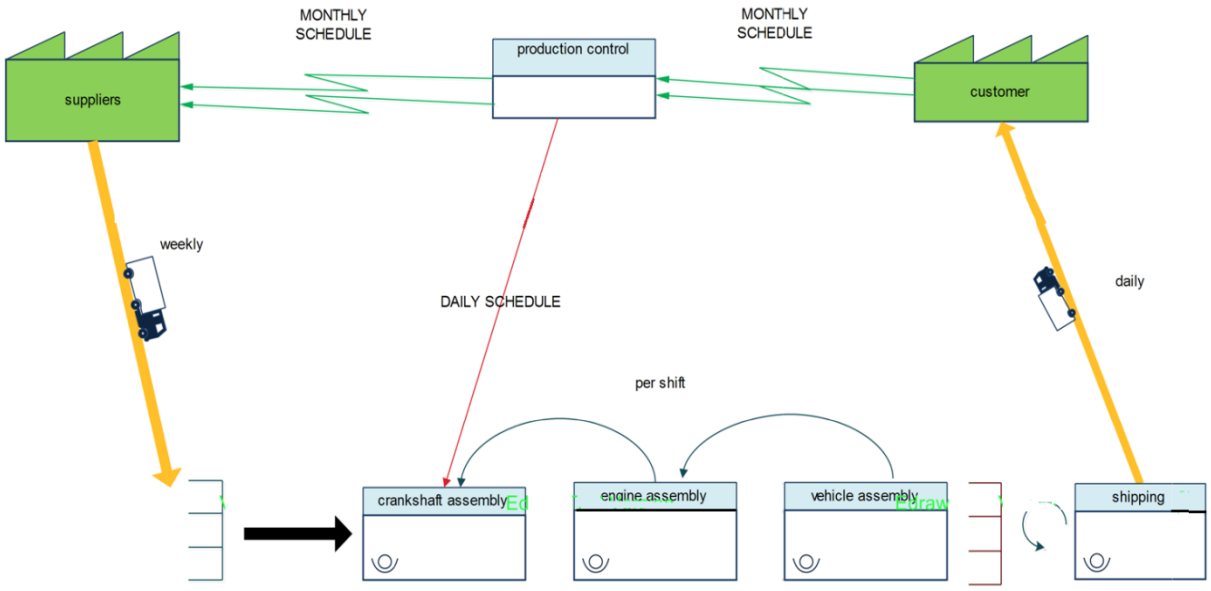

Figure 2 Future State Map

5. Conclusion

This study shows how VSM supports the lean supply chain and identifies potential opportunities for continuous improvement to eliminate waste. Culture change is a long term philosophy is highlighted as the foundational for Toyota and other companies to sustain success. This paper not only shows the value of VSM as a supply chain tool for implementing lean production; but also provides industrial insight for those hesitant companies to effectively implement lean supply chain [9]. We also discuss how a complex supply chain problem can be systematically analyzed and improved effectively by value stream mapping. Future research may consider the use of the proposed VSM system for other non-manufacturing industries.

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