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MANUFACTURING PROCESS IMPROVEMENT USING LEAN TOOLS

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ABSTACT: Lean Manufacturing is a technique originally developed in the automotive industry that concentrates on shortening the time between the customer's order and shipment. Lean manufacturing has been applied very successfully in manufacturing operations, resulting in shorter production lead times, greatly reduced inventories, and significantly enhanced profitability. These techniques also promote improved flexibility, enhanced reliability and substantial cost reductions [1-4]. This work addresses the implementation of lean tools in a job shop production system, with a focus on elimination of process bottle necks and elimination of manufacturing wastes. Value stream mapping (VSM) was the main tool used to identify the opportunities for various lean techniques. The primary motive is to evolve and test several strategies in the elimination of bottle necks and wastes on the shop floor. The effects of lean and the value addition are clearly demonstrated by the VSM. A noticeable reduction in lead time and work-in-process inventory level is also achieved.
Keywords: Lean manufacturing, Value stream mapping (VSM), Lead time

1. INTRODUCTION

Waste elimination is one of the most effective ways to increase the profitability of any business. Processes either add value or waste during the production of a goods or service. Waste and its elimination form the core of the Toyota Production System [5], also known as lean manufacturing. Lean typically targets the seven so-called deadly wastes, which are: (i) overproduction (ii) unnecessary inventory (iii) excess motion (iv) waiting (v) transportation (vi) inappropriate processing (vii) non-right the first time, defects. Applications of lean manufacturing have spanned many sectors including automotive, electronics, white goods, and consumer products manufacturing [6]. To eliminate waste, it is important to understand exactly what waste is and where it occurs. While products differ significantly between factories, the typical wastes found in manufacturing environments are quite similar. For each kind of waste, there is a strategy to reduce or eliminate its effect on a company, thereby improving overall performance and quality. Discrete Event Simulation is one tool for identification of production waste and VSM and other process modeling methods are also used in lean manufacturing system development and analysis [7].

In this work, a job shop production facility which deals with home appliance spares (housing, gear supports), automobile and farm equipment spares (brake piston, bearing cap, balancing mass, pad holder) is considered. In order to compete with their counterparts, this manufacturer must prepare for a new business world where variety and customization of products become the norm. They need to increase their market share and differentiate from their competitors. Moreover, due to the market crisis the differences are required not only to increase market share but also to stay in business. Consumers constantly demand better, faster, cheaper and customized goods. An important philosophy that fits these goals is lean manufacturing. This work intends to show a solution to improve the manufacturing processes with the use of lean manufacturing tools. The major focus is on the component named "brake piston" which is currently one of the major products produced with customer demand of 3000 pieces per month. The system follows "make-to-order" inventory policy. It currently takes a long lead time to get through. Presently the customer order is batched on the shop floor to reduce the number of time consuming changeovers. This creates a need for the reduction of production lead time and other non-value added times.

2. BRIEF LITERATURE REVIEW

The characteristics and impacts brought by lean tools and techniques have been presented in a number of works [8–11]. The successful application of various lean practices had a profound impact in a variety of industries, such as aerospace, computer and electronics manufacturing, forging company, process industry (steel), and automotive manufacturing. Their methodology is similar, using lean tools, and they are adapted to the study variables, but the improvement point and the results achieved are different. Many lean manufacturing tools to be used in conjunction with VSM were proposed by number of researchers [1, 12-16]. Sullivan et al provides how value analysis time profile in conjunction with VSM methodology is beneficial to make a change either at an intra or interfirm level. A case study of an automobile company has been described to illustrate the methodology and to highlight the role of this tool as a simulation device to quantify the impact of improvement activities. One of the major challenges for manufacturing industry is to manufacture variety products with a minimum lead time, reduced inventory and world class quality. There is a need to help the manufacturing companies to improve their competitiveness. In this paper, a case study conducted at job shop production facility is presented and some of the observations may be useful to the practitioners for motivating their efforts in implementing lean in small and medium enterprises.

Figure 1. Selected component "brake piston"

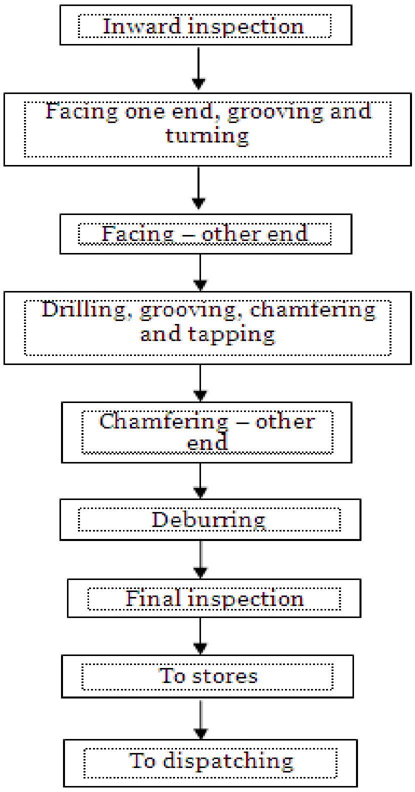

Figure 2. Major operations involved

3. PROBLEM ENVIRONMENT

The name of the product selected in this work is brake piston which is an integral part of farm equipment (Figure 1). Figure 2 shows the major operations involved in the manufacturing of brake piston. Cycle time for various operations is summarized in Table 1.

Table 1. Summary of cycle time for various operations

Sl. No.	Description	Facing one end, grooving and turning	Facing – other end	Drilling, grooving, chamfering and tapping	Chamfering – other end
1.	Cycle time (sec)	510	60	340	60
2.	Number of shifts	3	3	3	3
3.	Change over time (min)	60	20	90	30
4.	Number of operator	1	1	1	1

After several brain storming and a thorough study of the shop floor, it was observed that manufacturing operations sequence consists various forms of non-value-adding activities as follows:

- Back-tracking of parts - increased transportation distance and time
- All the operations involve batch processing in the existing layout

   » Since all the machines in the existing layout involve batch processing, the nature of inventory involved between the machines in the form of Work-in-Process is appreciable and could be possibly reduced to enhance the process effectiveness

The main goal is to develop different strategies to reduce the level of non value activities present in any form by implementing the various lean tools. The work targets are as follows:

» Identification of critical (bottle-neck) operation
» Analysis and incorporation of a feasible lean solution that would serve to eliminate the waste
» Elimination of back-tracking movements - demands a proper change in the physical arrangement of parts (layout)
» Establishment of flow manufacturing

4. IMPLEMENTATION AND RESULTS

4.1 Continuous flow

As a first step to establish continuous flow, VSM is done. The current state map presents the existing position of the company. The critical problem areas and different kinds of non-value added activities are identified in this stage. The next step is development of future state map. In order to develop the future state map, the current state map was analyzed using the steps and guidelines developed by Rother and Shook [17]. The last step is analysis of the results obtained after implementing the proposed changes. This has to be quantified in terms of lead time reduction, cycle time reduction, inventory reduction, etc. All the data for current state map are collected according to the approach recommended by Rother and Shook [17]. The data boxes are prepared to capture the changeover time, available time and cycle time. The information flow is also captured. The production lead time and value-added time are noted on the current state map. It provides the snapshot in time. Inventory storage points in between the stages are shown in triangles. The timeline at the bottom of the current state map has two components. The first component is the production lead time and second component is value-added time or processing time. Value-added time is calculated by adding the processing time for each process in the value stream. The cycle time for each is the average cycle time, which is determined by using actual data from the company. This current state map provides a picture of existing positions and guide about the gap areas. It helps to visualise how things would work when some improvements are incorporated. The gap area in the existing state results in a road map for improvement. Figure 3 shows the current state map.

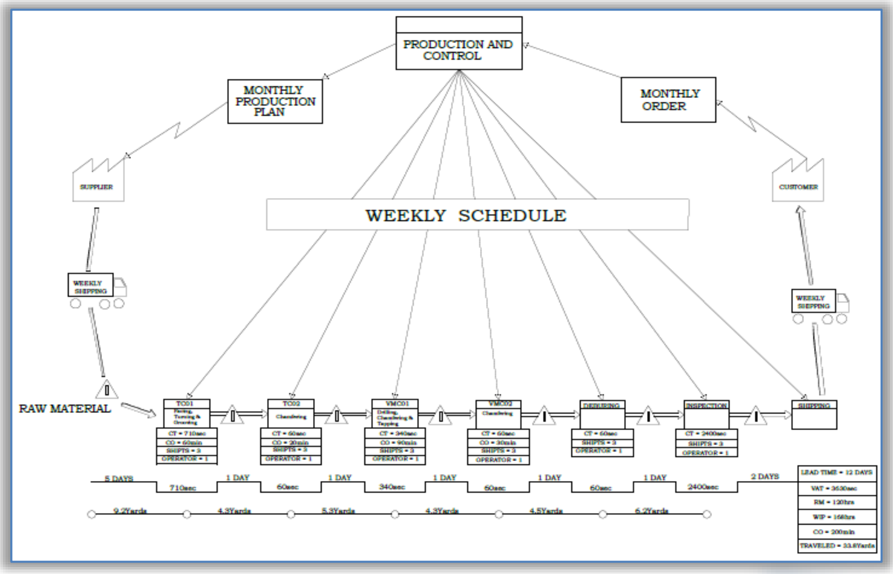

Figure 3. Current state map

4.2.Redesign of existing layout – Visual examination method

From the existing layout, it is observed that the distance traveled by the component before the completion of all manufacturing operations is 90 feet. This can be attributed to the fact that there is back–tracking involved in the existing layout which suggests that there is a scope for improvement. Emphasis is always on increasing the percentage of in–sequence movement. During the redesign, the layout is changed without affecting the precedence constraint in such a way that the machines that involve batch processing are kept in cell 1 and machines involving single piece processing are kept in cell 2. In this process,

Table 2. Characteristics of the redesigned layout

Cell 1: Facing, grooving and turning	
Worker movement	Reduced
Set up time	Reduced
Inventory and lead time	Reduced
Worker utilization	Improved
Free space in cell 1	20 feet
Cell 2: Drilling, grooving, chamfering and tapping	
Free space in cell 2	less than 15 feet

space constraint is another factor that is kept in mind. Work-space is an imaginary area occupied by a machine wherein the distance between successive machines is always greater than four feet [18]. The term work-space includes the space occupied by every machine plus some of free space on either side of a machine. The characteristics of the redesigned layout are given in Table 2.

4.3.Definition of future state

After successful introduction of continuous flow it has been decided to implement different lean tools based on the nature of other manufacturing wastes identified. The summary of improvement activities identified is given in Table 3 and the same actions are considered for future state also.

Table 3. Definition of future state

Types of waste	Current state	Cause	Effect	Future state
Unnecessary/ Excessive human motion	Movement of the workers between the processes	Layout, location and procedural issues.	Leads to fatigue	Layout redesign
Transport	Transfer using material handling equipment	Layout	Integrity of material	Kanban pull system
Inventory	work in process inventory	Lead time	Space requirement	JIT principles
Over processing	Information flow	Manual system	Extra time	Made to order
Spillage/rework	-	Mishandling of machines	unclean environment	Online inspection
Space	-	Improper layout	More material movements	Cellular layout

5. CONCLUSIONS

The job shop production system must seek improvement alternatives as a part of their strategy to stay in business, to remain competitive and to increase their market share in a tougher market. Lean manufacturing tools, as the one studied in this work, proved to be good strategies to achieve improvements that significantly outweigh the cost of the implementation. This work gives a set of alternatives to improve the output of a productive system without incurring in major investment.

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