IDENTIFICATION OF LEAN MANUFACTURING STATUS IN LOCOMOTIVE MANUFACTURING INDUSTRY- A CASE STDUY

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ABSTRACT

The technology during the 21st century offers a great promise to the people all over the world. The latest advances in Engineering Science and technology have given engineers powerful tools fore-assessing and reorganizing the systems. The present study has been undertaken for analyzing different types of wastes in a Diesel Locomotive Plant's Carbon Brush shop with an aim to design strategies for developing and implementing a Lean Manufacturing Program in such machine shops. The study has been carried out in a phased manner. Various phases of the study have been, clarifying the context through a review of literature; understanding and assessing the current status of in the organization and identifying the areas which need to be taken up for further, detailed analysis of wastes and aligning them to Lean Manufacturing principles.

Keywords: Lean Manufacturing, Value Stream Mapping, Waste

1. INTRODUCTION

Lean manufacturing derives its name from the manufacturing systems and processes of the Toyota production system that are so effective at producing at low cost, and short cycle times. These systems are highly flexible and responsive to customer requirements. Lean manufacturing is a multi-dimensional approach that encompasses a wide variety of management practices, including just-in-time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system. The core thrust of lean production is that these practices can work synergistically to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste [Shah & Ward, (2003)]. Lean Manufacturing, also called Lean Production, is a set of tools and methodologies that aims for the continuous elimination of all waste in the production process. The main benefits of this are lower production costs; increased output and shorter production lead times. More specifically, some of the goals include: Defects and wastage - Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, and costs associated with reprocessing defective items and unnecessary product characteristics which are not required by customers. Cycle Times - Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times. Inventory levels - Minimize inventory levels at all stages of production, particularly work-in-progress between production stages. Lower inventories also mean lower working capital requirements. Labor productivity - Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or unnecessary motions).Utilization of equipment and space - Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime. Flexibility - Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time. Output - Insofar as reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can, generally increase output from their existing facilities.

2. LITERATURE REVIEW

Manufacturing systems are classified into two major classes; discrete manufacturing and continuous manufacturing (also referred to as the process industry). Discrete manufacturing refers to making discrete products such as an engine, an automobile, a drive shaft, a coffee maker, or a washing machine. On the other hand, continuous manufacturing includes making products that are measured or metered rather than being counted. Examples include paint, steel, textile, flat glass, resin, oil, and flour [Needy and Bidanda, (2001)]. [Sandras, (1992)] states that the differences that are distinctive to the process industry from the stand point of JIT (which is a lean tool) must be sorted out from those that are familiar in the discrete industry. He further stresses that those characteristics that are difficult to address must be sorted out from those that are not as hard. [Sandras, (1992)]. The process industry can be thought of as producing materials rather than producing items as in the discrete manufacturing industry. These two industries have features in common. However, the big difference is in the continuity of operation. In the process industry it can be so expensive to shut down a process that it creates a big challenge from the logistical standpoint. [White, (1996)]. Ultimately however, within a continuous process manufacturing environment, almost always, discrete parts are produced. The lean manufacturing concept can be applied to those processes where discrete parts are produced [Billesbach, (1994)]. The idea is to take those practices that are used to eliminate waste in discrete manufacturing and apply them to the constraints that are common to the process industry. ‘Some of the unique constraints, while difficult technically, may not be difficult from a JIT perspective (e.g. environmental issues)’ [Sandras, (1992)]. After those constraints are eliminated, one is left with the distinctive and difficult issues for each industry. One should then keep an eye on these by trying to minimize their impact while gradually trying to get rid of them.Cellular manufacturing is a concept that increases the mix of products with the minimum waste possible. A cell consists of equipment and workstations that are arranged in an order that, maintains a smooth flow of materials and components through the process. An ideal, lean cell would have all machines needed to process a part located very close together, single –piece flow of parts between operations, and operators running multiple machine types [Cochran et al, (1998)]. [Aytac, (2003)]. The process goes on as each process pulls the needed parts from the preceding process further up stream. The whole process is coordinated through the use of a Kanban system. Shipments under JIT are in small, frequent lots. A Kanban is used to manage these shipments. Kanban is an information system that is used to control the number of parts to be produced in every process [Monden, (1998)]. The most common types of Kanban are the withdrawal Kanban, which specify the quantity that the succeeding process should pull from the preceding process, and the production kanban, which specifies the quantity to be produced by the preceding process [Monden, (1998)]. JITD requires the exchange of frequent, small lots of items between suppliers and customers, and must have an effective transportation management system because the transportation of inbound and outbound material can have a great effect on production when there is no buffer inventory [Spencer, et. al. (1994)]. The automotive industry has been strongly influenced by the fundamental concept of JIT. Toyota for example led the way in using JIT where principles have been used with its suppliers [Womack et al., (1990)]. In the fifties, the Japanese shipyards implemented JIT in their steel deliveries from steel mills. [White, (1992)] states that JIT practices have been implemented in industries like electronic/electric, transportation equipment, health and medical components, and machinery.

3. DESIGN OF STUDY

Diesel loco modernization works (Patiala) was conceived for manufacturing sophisticated components to meet the maintenance need of diesel traction fleet of Indian railways. Diversity of technology involved under one roof at DMW is unmatched not in Indian railways but also in the 52 industrial set ups around the globe. Manufacture of carbon brushes on one hand and the traction gears on the others; remanufacture of traction generators to machine of engine blocks stretches the imagination of even well experienced engineers. To manage such a plant of diverse activities and to maintain the healthy and rhythmic throb of such complex system calls for paramount professional skills. Unlike other production units, DMW does not have an assured captive market for the products. For most of its products, DMW has to compete with other private and public sectors enterprises that have been supplying these items to zonal railways for decades.

4. METHODOLOGY

Cam shaft section has been chosen for the detailed study of status on lean manufacturing implementation. The steps of camshaft machining are as follows. Cut length of 46.7” of raw material (Alloy Steel) using a band saw.

- Face end center at both ends.
- Turn bearing dies. Also turn pilot, flanges and form grooves in the remaining length.
- Drill oil hole by a gun drill.
- Drill and ream indicating hole, on the flange end by a radial drilling machine bench.
- Milling of the camshaft making exhaust, air, and fuel cam.

- Bench and deburr and relieve stresses by heat treatment.
- Harden the cam and bearing to required hardness by induction hardening process up to a case depth of about 4.5-5.5mm.
- Rough grind bearing diameters on a grinding machine.
- Lathe work
- Flange drilling on the radial drill.
- Finish grind bearing diameters on the cam grinding machine
- Inspection

5. ANALYSIS AND RESULTS

The different types of wastes that have been identified for detailed analysis after the preliminary study are (1) Defects, (2) Inventory, (3) Excessive Material Movement, (4) Delay due to Waiting, (5) Overproduction and (6) Inappropriate processing. After the analysis, the job needing redesign to reduce the waste have been identified and then by using the cause and effect diagram, the root causes of problems relating to wastes have been identified. Appropriate controls for the identified causes have been developed for each waste and its impact on implementation of Lean Manufacturing principles has been listed. For the purpose of modeling for developing a strategy for implementation, the controls identified have been grouped into broad generalized categories. Expert opinion has been utilized to identify factors and parameters affecting development of a generalized approach for implementation. Generalized of various measures for developing an approach to be used by industry in future has been suggested using expert opinion. It has further been suggested that the implementation of the development approach be carried out in three phases.

5.1 ANALYSIS OF WASTE

For the purpose of analysis, the waste has been categorized into six different types:

1. Defects
2. Excessive inventory
3. Waste due to unnecessary material movement.
4. Delay due to waiting.
5. Overproduction.
6. Inappropriate processing.

The detailed analysis of each of above types has been presented in the next section.

5.1.1 Defects:

Data of cam shaft produced along with the number of defective cam shaft, for different part numbers, has been compiled from the company records. Table 5.1 presents the data along with the percentage of defectives produced.

Table 5.1: Total Camshafts Produced in April (2008)

Sr. No.	Part No.	Total Quantity Produced	Quantity Goods	Quantity Rejected
1	10210982	10	7	3
2	10211007	7	5	2
3	10216534	65	61	4
4	10216546	68	62	6
5	10216558	8	8	------
6	10216560	55	52	3
7	10216571	60	60	------
8	10216583	45	45	------
9	10216595	53	49	4
10	10216601	50	50	------
11	Total	421	399	22

Company reported a rejection of 5.2% during April (2008) The high scrap percentage in the CBS reveals large amount of wastage in term of lost material, machine time, labour, energy and other resources.

5.1.2 Inventory Analysis

The analysis of waste caused due to excess inventory levels has been categorized into Raw Material, Work in Process (WIP) and Finished Goods Inventory

Raw material

Table 5.2 shows the status of raw material inventory as on April 2008. Typically the monthly customer requirement is about 399 Camshafts. With an average rate of 106.5 kg per Camshaft, a total of 37275 kg material is required to meet the customer's monthly requirement. Thus the material required by the customer is only 30% of the raw material (166971.5 kg) available in stock, which indicates that only about ¼ th of the raw material inventory is utilized every month and the rest depreciate.

Table: 5.2: Raw material Inventories in Store

Sr. No.	Material type on 31-04- 2008 (alloy steel 120 mm)	Total
1.	Raw Material	166971.5

Work In Progress (WIP)

In the present case, because of different setup and cycle times at various stations, This is also due to the problems with line balancing where in there is large difference in setup/cycle times at various stations. The facility, however, has a WIP inventory of 411 parts which is very high as shown in Table 5.3.

Table: 5.3: Total WIP Inventory

Sr. No.	Machine Station	Total WIP (No. of Pieces)
1	Band saw	130
2	CNC turner	45
3	Radial drill	40
4	Gun drill	125
5	CAM milling	15
6	Benching	12
7	Cylindrical grinding (rough)	18
8	Lathe (1 & 2)	1
9	CAM grinding	2
10	Cylindrical grinding (Finish)	5
11	Inspection	18
	Total	411

The excessive WIP inventory in this case is 89%.

Finished Goods Inventory

Table 5.4 shows that quantity of total finished product is 399 pieces which is as per customer's monthly requirement.

Table: 5.4: Total Finish Product Inventory in Progress Department Finished goods inventory

Sr. No.	Part No.	Quantity no. of parts
1	10210982	7
2	10211007	5
3	10216534	61
4	10216546	62
5	10216558	8
6	10216560	52
7	10216571	60
8	10216583	45
9	10216595	49
10	10216601	50
11	Total	399

5.1.3 Waste Due to Unnecessary Material Movement

The unnecessary transportation of material is a common cause of waste in the factory. In this case, the material does not follow a specific line flow due to which material moves from one station to another in a haphazard manner. In order to reduce this waste, the layout of the light machine Shop (LMS) is proposed to be amended to facilitate single piece flow and also reduce unnecessary material movement in the shop. Some other reasons for excessive material movements are (a) There are delays in movement of pieces in between stations; (b) Some stations are hard to access. Thus, it is observed that in the existing layout material movement is very high and will be reduced by at least 75% by changing to the new layout. In the new layout, the material movement distance has been reduced to 131.5 meters compared to 537.45 meters in the existing layout.

5.1.4 Delay Due to Waiting

The study has been carried out in the LMS of DMW, Patiala. The office and store workplaces have not been studied since productivity is more directly measured in production shop floor and profitability of the whole organization depends primarily on the productivity of operations carried out on the shop floor. The direct observation of the work was started in the LMS. The job was broken down into tasks, and further into observable elemental operations. These elemental operations were subsequently evaluated. A breakdown of tasks needing immediate changes or an in-depth study was thus carried out. Waiting time in the LMS can be classified into two categories: (i) Avoidable Delays (ii) Unavoidable Delays. Avoidable delays are due to excessive breakdowns, willful absenteeism, large setup/cycle times, and operators missing from workstations. Unavoidable delays are allowances given due to fatigue or rest on prescribed by the International Labour Organization. The emphasis in this work has been to reduce the avoidable delays .for this purpose a complete analysis of the existing data on Absenteeism, breakdown, setup times and cycle times was carried out for a period of three months. The data is presented in table 5.5. Once the existing situation was known, efforts were made to reduce these times to eliminate wasteful activities. Table 5.6 shows the data for avoidable delays after implementation of some of the controls in July 2008.The data pertain to period 15, July to 14, August 2008. The data has been analyzed and following improvements in reduction of delays due to unnecessary waiting time are seen.

Table 5.5: Avoidable delays (April to June 2008)

Sr. no.	Machine Number	Machine name	Cycle Time (Ct)	Set up time	Absenteeism%	Breakdown%	Operator missing form work station (number of Min in 8hr)
1	176	Band saw	28	40	4	18	20
2	…..	Centering	45	66	7	22	42
3	1027	Punching press	0.07	22	1	16	21
4	…….	CNC turning	120	15	6	18	16
5	189	Gun drill	36.16	20	5	24	27
6	75	Radial drill	82	22	10	26	21
7	1115	CNC cam milling	45	15	2	21	18
8	271	Cylindrical grinder	95	18	20	19	15
9	471	NH-26 Lathe	135	28	5	17	25
10	451	NH-22 lathe	135	28	4	12	17
11	178	Cylindrical grinder	94.46	18	2	18	22
12	126	CAM grinder	104	15	2	22	24
13	1116	CNC cam grinder	115	15	3	23	30
14		Average			5.46	19.69	23

Table 5.6: Reduction in delays

Sr. No.	**Operation**	**Cycle Time (Sec)**			**Setup Time (Sec)**			**Breakdown(%)**		**Absenteeism(%)**		**Operator missing form work station (Number of min in 8 hr.)**		
		Before	After	%age Reduction	Before	After	%age Reduction	Before	After	Before	After	Before	After	%age Reduction
1	Centering	45	4	7	66	40	39	7	5	22	15	42	20	52.38
2	Radial Drill	82	6	37	22	20	9	10	7	26	21	21	17	19.04
3	NH-lathe	135	100	26	28	22	21.42	4	2	17	13	25	15	40

1. The cycle time will reduce by about 0.50 % at each station.
2. The setup time will reduce by about 0.33% at each station.
3. The break down will reduce by about 12.5% at each station.
4. The absenteeism will reduce by about 31% at each station.
5. The operator missing from work station will reduce by about 31.5% at each station.

5.1.5 Overproduction

Overproduction is not that common in the factory, since all carbon brush is made to customer order. A bigger problem is that some of the carbon brushes are not delivered to the customer in time. The delays are often caused by part shortages that have occurred because of supplier and delivery problem. Carbon brushes are sometimes produced when shortages exist and cannot be delivered until rework and missing parts arrive. This means those carbon brushes that are ready, except from the rework must be stored in yard. In some way this is overproduction, because the carbon brush are produced before they actually can be delivered.

5.1.6 Inappropriate Processing

In DCW, there is high amount of the inappropriate processing. Incorrectly designed processes are a source of waste. The processes in the organization must continuously be reviewed and improved. Activities in processes can either add value to the customer, be necessary for the function of the process or non-value adding. The rework after the rejection is also the excessive processing.

6. CONCLUSIONS

1. Wastes identified after implementation of lean manufacturing principles serve as a starting point for bringing in improvements in any manufacturing facility.

2. For bringing an overall improvement in the work particles and also to implement lean manufacturing principles, elimination of causes of the wastes as indicated above is necessary.

3. For reducing the wastes, the provisions or control to be evolved would be engineering controls related to equipment etc. in 75% to 100% of the cases. Administrative controls and work simplification would be of a very limited use.

4. The waste associated with defects and inappropriate processing can be reduced with a small effort in a short time frame with low cost.

5. Problem related to inventory can be solved by engineering controls. Most of the control can be implemented in a short period of time and with a small effort and low cost.

6. The excessive material movement and delay due to waiting can be reduced by higher cost and small effort in reducing breakdown, absenteeism.

7. The implementation plan of the provisions after the detailed analysis has been divided into three phases starting from less expensive, less effort involving, more productive and simpler provisions. This will facilitate feedback and correction, and will provide immediate and encouraging results for reducing waste for continuing with the implementation process of the subsequent phases.

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