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Implementation of Lean Manufacturing for Waste Reduction in Manufacturing Company

Jitendra Kumar[1], Lalit Pareek[2]
[1]*Professor, BIST, Bhopal*
[2]*M.Tech Scholar, BIST, Bhopal*

Abstract
The present study has been undertaken for analyzing different types of wastes in a selected Machine Shop with an aim to design strategies for developing and implementing a Lean Manufacturing Programme in such machine shops. The study has been carried out in a phased manner. 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 are identified and 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.

Keywords *- Lean Manufacturing, TQM, Waste Reduction, TPM, JIT*

INTRODUCTION

Due to the increasing cut throat competition in the market, the manufacturing companies are striving to reduce their product cost at no compromise of quality. Labor wage is increasing in developed countries; the manufacturing companies have been migrating from the high wage developed world to low wage developing countries. Even though the labor cost is cheaper than in developed countries; due to the specific market nature of the manufacturing industries for example: the short production life cycle, high volatility, low predictability, high level of impulse purchase, the quick market response; Manufacturing industries are facing the many of the greatest challenges these days (Lucy Daly and Towers, 2004). Manufacturing industries in developing countries are more focused on sourcing of raw material and minimizing delivery cost than labor productivity because of the availability of cheap labor. Due to this, labor productivity is lower in developing countries like India than in the developed ones. For example, labour is very cheap in India but the productivity is poor among other developing countries (Shahidul and Syed Shazali, 2011). Similarly, the cost of raw material is a major part of the Manufacturing so there seems to be great need for improvement in this sector. Even in developing countries the CAD and CAM system for machining or cutting has been implemented to save time and for increasing the flawless production. Now the worry is about labor productivity and making production flexible; because the industry is pacing slowly into global environment. Industry is willing to make their production lean and hence the repair work almost zero.

Even today, industries are getting the same or more volumes (orders), but the number of styles they have to handle has increased drastically. Earlier industries were getting bulk order so there is no need to worry; if the production line was set for the first time it would run for a month or at least a week or two. But nowadays due to small order quantities and complex designs, the Manufacturing industry has to produce multiple styles even within a day; this needs higher flexibility in volume and style change over time (Shahram and Cristian, 2011). In some cases it has been observed that, in developing countries the Manufacturing industries are run as family business lacking skilled personnel as well as capital to implement new technologies for improving productivity and flexibility. Because of this, industries have been running in a traditional way for years and are rigid to change. They are happy as long as they are sustaining their business. They don't have much confidence and will towards innovation over old processes. Now the time has come to struggle with global market demand and niche market in manufacturing industries if they want to run it further (Gao, Norton, Zhang and Kin-man, 2009). This volatility of styles can be addressed only by flexibility in manufacturing. The best way to cope with all these challenges is the implementation of lean manufacturing tools. This will serve our purpose of flexibility and save a lot of money by reducing production lead time, reducing the inventory, increasing productivity, training operators for multiple works, and by reducing rework.

IMPLEMENTATION OF LEAN MANUFACTURING

a) Senior Management Involvement -As for any significant process improvement project, the total commitment and support of the most senior management is essential for implementation of lean manufacturing. Problems will almost

certainly arise during the implementation of lean production systems and those problems will likely only be solved if the senior management is fully committed to the successful implementation of lean.
b) Start with a Partial Implementation of Lean - Some companies may initially implement only some of lean manufacturing and gradually shift towards a more complete implementation. In a 2004, a survey of manufacturing companies in the U.S. by Industry Week Magazine, among companies which had commenced lean manufacturing programs, 39.1%reported implementing some aspects of lean, 55.0% reported implementing most aspects of lean and only 5.9% reported complete implementation of lean.
Some simple first steps may include:
• Measuring and monitoring machine capacity and output.
• Creating more clearly defined production procedures.
• Implementing the 5S system for shop floor housekeeping.
• Streamlining the production layout.
c) Start small - It is recommended that companies try to implement lean as a test case at a small part of their operations before applying it through their entire operations, especially for the shift from a push-based to a pull based system since this can potentially be disruptive. For example, the test case may be a single production line or a small series of processes. This will help to minimize the risk of disruption, help educate the staff on the principles of lean while also serving to convince others of the benefits of lean.
d) Use an Expert - It is recommended that for most private companies, it would be the best to use the services of a lean manufacturing expert to help them implement lean manufacturing systems. In particular, the shift from a push-based to a pull-based production system can potentially be quite disruptive so it is best to be guided by someone who has significant experience in this.
e) Develop a Plan - The Company should develop a detailed and clear implementation plan before proceeding with the conversion to lean manufacturing. A list of issues to cover in the implementation plan can be downloaded from the article Building the Lean Machine from the September 2000 issue of Advanced Manufacturing Magazine.

RESEARCH OBJECTIVE

Lean manufacturing is an operational strategy oriented towards achieving the shortest possible cycle time by eliminating wastes. These benefits can be achieved only if the concept is religiously followed in the organization. In simple terms lean manufacturing is without waste. Thus the objective of this research is to find out how we can use lean manufacturing to achieve the following:

- To meet customer demand on time by eliminating non value added work from the process
- To facilitate the new facility suggestions to minimize the work in process inventory
- To create flexibility of style changeover
- To reduce percentage of rework

RESEARCH APPROACH

To address the current issues of the industry, the researcher tries to find out the standard operation time for each operation by using time study techniques and will try to standardize all the operations. Once the standard operation time is obtained work will be done to find out the best suitable production layout and WIP movement methods, which will help to get flexibility in style changeover, should reduce the production lead time, create operator multi-skilling etc. After doing these entire things as paper work, the researcher will implement the research outcomes in the company and the improvement will be measured against the existing process. Basically, this is quantitative research where the researcher is a part of the organization during the study.

LEAN PRINCIPLES

The major five principles of Lean are as follows (Burton T. and Boeder, 2003):
Principle 1: Accurately specify value from customer perspective for both products and services.
Principle 2: Identify the value stream for products and services and remove non-value-adding waste along the value stream.
Principle 3: Make the product and services flow without interruption across the value stream.
Principle 4: Authorize production of products and services based on the pull by the customer.
Principle 5: Strive for perfection by constantly removing layers of waste.

TOYOTA PRODUCTION SYSTEM

It is a manufacturing system developed by Toyota in Japan after World War II, which aims to increase production efficiency by the elimination of waste. The Toyota production system was invented and made to work, by Taiichi Ohno. While analyzing the problems inside the manufacturing environment; Ohno came to conclude that different kinds of wastes (non value added works) are the main cause of inefficiency and low productivity. Ohno identified waste in a number of forms, including overproduction, waiting time, transportation problems, inefficient processing, inventory, and defective products.

Figure 1 shows the Toyota Production System in detail. From this figure it can be seen that TPS is not only a set of different tools but it is the philosophy and integration of different tools and systems to achieve a common goal of waste reduction and efficiency improvement. Each element of this house is critical, but more important is the way the elements reinforce each other. Just in Time (JIT) means removing the inventory used to buffer operations against problems that may arise in production. The ideal of one-piece flow is to make one unit at a time at the rate of customer demand or Takt time. Using smaller buffers (removing the "safety net") means t hat problems like quality defects become immediately visible. This reinforces Jidoka, which halts the production process. This means workers must resolve the problems immediately and urgently to resume production.

KIND OF WASTES

According to David Magee, (Magee, 2007) different kinds of wastes in a process can be categorized in following categories. These wastes reduce production efficiency, quality of work as well as increase production lead time.

1. **Overproduction** – Producing items more than required at given point of time i.e. producing items without actual orders creating the excess of inventories which needs excess staffs, storage area as well as transportation etc.
2. **Waiting** – Workers waiting for raw material, the machine or information etc. is known as waiting and is the waste of productive time. The waiting can occur in various ways for example; due to unmatched worker/machine performance, machine breakdowns, lack of work knowledge, stock outs etc.
3. **Unnecessary Transport** – Carrying of work in process (WIP) a long distance, insufficient transport, moving material from one place to another place is known as the unnecessary transport.
4. **Over processing** – Working on a product more than the actual requirements are termed as over processing. The over processing may be due to improper tools or improper procedures etc. The over processing is the waste of time and machines which does not add any value to the final product.
5. **Excess Raw Material -** This includes excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, the extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
6. **Unnecessary Movement –** Any wasted motion that the workers have to perform during their work is termed as unnecessary movement. For example movement during searching for tools, shifting WIP etc.
7. **Defects** – Defects in the processed parts is termed as waste. Repairing defective parts or producing defective parts or replacing the parts due to poor quality etc. is the waste of time and effort.

Unused Employee Creativity – Loosing of getting better ideas, improvement, skills and learning opportunities by avoiding the presence of employee is termed as unused employee creativity (Liker, 2003).

DESCRIPTION OF LIGHT MACHINE SHOP

Light machine shop is one of the most important shops of diesel locomotives modernization work, which is concerned, with the manufacturing of over 200 components for the diesel engine. The shop has got the most modern technology producing the components to highest accuracy. The light machine shop has been divided into a few major sections as given below.

1. CNC (turning): In this section CNC turning machines have been installed.
2. Camshaft section: The section undertakes manufacturing of camshaft.
3. Connecting rod section: This section undertakes manufacturing of connecting rod.
4. Gear section: About 15 different types of gears are being produced in this section.
5. Center less grinding section: It is used for grinding of thread of gear.
6. CNC machining: In this section CNC machines, which are used, for various machining processes have been installed.
7. Benching section: In this section light jobs like grinding / deburring of jobs by baby grinder are undertaken.
8. Inspection and gauge room: In this section various gauging and inspection equipments are there for measurement and inspection of various components being manufactured in the LMS.
9. Zero bay section: Here the initial processes of manufacturing of various important components such as the axle boxes, connecting rods etc. are undertaken since this is the starting point of various components hence its name.

TYPES OF MACHINES

The important types of machines used in the case study and especially study undertaken are as follows;

Table: 1 Types of Important Machines

1	Centre less grinder	2	Internal grinder
3	Drill machine	4	Radial Drill
5	Surface grinder	6	Centre lathe
7	Milling machine	8	CNC

9	Bench Lathe	10	Spray equipment
11	Jump Drill Machine	12	Punching machine

DATA COLLECTION

Data has been collected by the following methods:

- Observation of the performance of machine and activities.
- Previous records: - Data from records include absenteeism, breakdown, inventories etc.
- Personal interaction: - It includes interviews of personnel directly related to the process.

Identification of Non-Value Added Activities and Their Quantum.

This involves collection and identification of various types of wastes as categorized in lean manufacturing. These are shown in following table 2.

S .no.	Type of waste	Data collection	Waste identification method
1.	Defects	Number of good parts made. Total number of products made. Scrap during processing. Rework during processing.	Difference of output and input. Difference of products made and products supplied.
2.	Inventory	Total raw material in store. WIP-work in process. Finished goods stock.	Data from records
3.	Transportation waste	Distance between machines.	Direct measurement on shop floor.
4.	Waiting	Cycle time, Setup time, Absenteeism Break down. Other Avoidable and Unavoidable delays.	From time study records. Number of absents per month. Number of break down per month.
5.	Overproduction	Total number of parts produced. Total requirement of parts.	Difference in total number of parts made and requirement.
6..	Inappropriate processing	Using wrong set of tools, procedures or systems	From records. Difference between the weight of raw material and weight of finished product.

ANALYSIS OF WASTE

For the purpose of analysis, the waste has been categorized into six different types such as Defects, Excessive inventory, Waste due to unnecessary material movement, Delay due to waiting, Overproduction, Inappropriate processing.

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

4.3.1 Defects

Data of camshaft produced along with the number of defective camshafts, for different part numbers, has been compiled from the company records. Table 3 presents the data along with the percentage of defectives produced.

Table 3: Percentage of defective Parts produced

S.no	Part no.	Total quantity produced	Quantity good	Quantity Rejected
1	10210982	6	4	2
2	10211007	4	2	2
3	10216534	57	56	1
4	10216546	56	55	1
5	10216558	5	5	--------
6	10216560	50	47	3
7	10216571	51	51	--------
8	10216583	36	36	--------
9	10216595	53	49	4
10	10216601	45	45	--------
11	Total	363	350	13

Company reported a rejection of 3.6% during January 2017.
The high scrap percentage in the LMS reveals large amount of wastage in term of lost material, machine time, labor, energy and other resources.

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. Table 4, shows the status of raw material inventory as on 31st January 2017. Typically the monthly customer requirement is about 350 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 26% of the raw material (144971.5 kg) available in stock, which indicates that only about ¼th of the raw material inventory is utilized every month and the rest depreciate.

Table 4: Status of raw material inventory

S. No.	Material Type on 31-01-2017 (Alloy Steel 120 mm)	Quantity in KGS
1	Raw Material	144971.5

b) Work In Progress (WIP)

In the present case, because of different setup and cycle times at various stations, WIP inventory of 50 pieces can be considered to be ideal. 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 398 parts (Refer table 5) which is very high.

Table 5: WIP inventory

S.No.	Machine station	Total WIP (no. of pieces)
1	Cam milling	9
2	Gun Drill	118
3	Band saw	111
4	CNC turner	38
5	Benching	6
6	Cylindrical grinding	15
7	Radial drill	32
8	Lathe (1 &2)	1
9	CAM grinding	1
10	Cylindrical grinding (Finish)	3
11	Inspection	14
	Total	398

The excessive WIP inventory in this case is 87%.
C) Finished Goods Inventory: Table 6 shows that quantity of total finished product is 350 pieces which is as per customer's monthly requirement.

Table 6: Total Finish Product Inventory in Progress Department

s.no	Part No.	Quantity (no. of parts)	Total weight
1	10210982	4	14120.3
2	10211007	2	
3	10216534	56	
4	10216546	55	
5	10216558	5	
6	10216560	47	
7	10216571	51	
8	10216583	36	
9	10216595	49	
10	10216601	45	
11	Total	350	

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:-

1. There are delays in movement of pieces in between stations.
2. Some stations are hard to access.

S.no	From	To	Existing distance in meters	Proposed distance in meters	Total reduction in meters
1	Progress	Band Saw	150	75	75
2	Band Saw	Basic Centering	3.05	3.05	Nill
3	Centering	CNC Turner	24.4	3.05	21.35
4	CNC Turner	Number Punching	36.6	3.05	33.55
5	Number Punching	Gun Drill	3.05	3.05	Nill
6	Gun Drill	Radial Drill	3.05	3.05	Nill
7	Radial Drill	CNC Cam Milling	74.08	3.5	70.58
8	CNC Cam Milling	Benching	3.05	3.05	Nill
9	Benching	H.T.S	105.8	3.05	102.75
10	H.T.S	Cylindrical Grinding (Rough)	25.3	9.15	16.15
11	Cylindrical Grinding	Lathe	3.05	3.05	Nill

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.

SUGGESTED IMPLEMENTATION PLAN

It was then decided to formulate a phase wise implementation approach by picking up the provisions which had higher weighted scores in the above seven major areas. For deciding the number of provisions taken up for implementation in a phase, out of the total provisions under a major area, the proximity or differences of scores around the cutoff were considered i.e. there should be a considerable difference between the score of the last provision in a Phase 1 and the first provision of Phase 2 and so on. Based on all these considerations, the implementation of the provisions has been divided into three phases as an order of priority for implementation in any diesel locomotive industry. The three phases of the suggested approach are presented for the company.

The provision or controls suggested to be implemented in Phase 1

Phase 1 will in general be less costly, easy to implement and would have positive or complementary effect on many other areas in the organization.

Phase 2 includes measures which are slightly more difficult to implement, involves reasonably higher cost, which may require some kind of budgetary provisions and approvals.

Phase 3 includes provisions, which are more related with hardcore technical changes, machinery, equipment and tooling. Implementation of these provisions will involve substantial capital investment and may require a number of iterations and trials for implementation.

CONCLUSIONS

The following salient conclusions were drawn from the study;

- Average monthly rejection of part before the conduct of study was 3.6%.
- The raw material usage is only 26% of the available inventory each month.
- The company has a high WIP inventory which is 87% of what is actually required.
- The finished goods stock inventory is as per requirement.
- 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.
- The cycle time will reduce by about 23% at each station.
- The setup time will reduce by about 24% at each station.
- The break down will reduce by about 3% at each station.
- The absenteeism will reduce by about 5% at each station.
- The operator missing from work station will reduce by about 24% at each station.
- Over production is not very common in this industry as the parts are made against actual order.
- If the raw material diameter is reduced from 120 mm to 115 mm the saving in the raw material requirement is 59%.

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