The Impact of Lean Production on the Cycle Time: A Case Study of a Welding Assembly Line in Kerala

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Abstract— The growing global competition is forcing the organisations to reduce the cost for increasing the profit. Lean manufacturing is a powerful tool for attaining this. The history of lean manufacturing starts from the craft production of 1900's. It is evolved through the contributions of F.W. Taylor, Henry Ford, Eiji Toyoda & Taiichi Ohno. The main concept of the lean manufacturing is the reduction in cost by eliminating waste. However, not all lean implementations have produced such results. In this study, a critical examination of lean manufacturing implementation experience at the welding department of a medium size industry located in Kerala, India. . Cycle time reduction is an important way by eliminating or reducing non-value-added activities. To reduce the overall cycle time of manufacturing, the cycle time of each sub-assembly needs to be reduced. Reducing cycle time will have a significant impact on a company's bottom line when implemented. The outcome of this study leads to substantial reduction in cycle time, reduced defects, better utilization of human resource and machines, and reduced cost of maintenance. It has been proved and validated by an empirical relation. The cause and effect diagram is used for analysing the cycle time reduction. The Quality control chart is also used. The improved return on investment (ROI) and reduction in cycle time shows the feasibility. The data for this study were obtained through interviews, Questionnaire survey and archival sources.

Keywords: Lean Manufacturing, cycle time, welding industry.

I. INTRODUCTION

The history of lean manufacturing starts from the craft production of 1900's. From the era of craft production, F.W. Taylor contributed to standardisation of work, reduction in cycle time, time & motion study which result in mass production. During 1913, Henry Ford developed the concept for interchangability and eases of assembly parts which results in the reduction of action by workers. This leads to the development of assembly line concept. In 1950's EIJI TOYODA & TAIICHI OHNO from Toyota developed JIT manufacturing (pull system) and techniques for waste (Muda) Reduction which developed into Lean Manufacturing.

The word meaning of lean is strong & efficient or thin & fit. This is possible by eliminating the wastes. Old version of economics pointed that cost + profit = price. But now due to the global competition in the market, price cannot be increased as we wish. So the economic definition changes to price – cost = profit. So, we have to reduce cost without decimating our team members or reducing our maintenance budget or weakening the company in long term.

Many manufacturers are now critically evaluating their Processes to determine their effectiveness in bringing maximum value to customers, Factory management techniques of yesterday are being replaced by more efficient methods that greatly minimize delays, reduce costs, and improve quality. Cycle time is the time required to complete a given process. Cycle time reduction is identifying and implementing more efficient way to do things by eliminating or reducing non-value-added activities. To reduce the overall cycle time of manufacturing, the cycle time of each sub-assembly needs to be reduced. Reducing cycle time will have a significant impact on a company's bottom line when implemented.

A. *What is Waste?*

Waste is anything that happens to a product that does not add value from the customer's perspective. Waste takes many forms and can be found at any time and in any place. It may be found hidden in policies, procedures, process and product designs, and in operations. Waste consumes resources but does not add any value to the product. Products being stored, inspected or delayed, products waiting in queues, and defective products do not add value.

Wastes to be eliminated in Lean Manufacturing studied from literature. Some of them pointed seven main wastes and some other proposed two more. They are : Over Production, Unnecessary Inventory, Unnecessary Delay, Unnecessary Transportation, Unnecessary Processing, Unnecessary Motion, Defective Parts, Underutilisation of People, Underutilisation of Facilities

B. *Benefits of Lean manufacturing*

1) Advantages of Lean manufacturing are:

1 Increased overall productivity
2 Reduced amount of floor space required
3 Reduced manufacturing lead time
4 Improved flexibility to react to changes
5 Improved quality

2) The disadvantages are:

1 Difficulty involved with changing processes to implement lean principals
2 Long term commitment required
3 Very risky process - expect supply chain issues while changing over to lean

C. *Value stream mapping*

Lean manufacturing uses tools like one-piece flow, visual control, kaizen, cellular manufacturing, inventory management, Poka yoke, standardized work, workplace organization and scrap reduction to reduce manufacturing waste. The value stream mapping (VSM) is an excellent tool for any enterprise that wants to become lean

The value stream mapping is a tool created by the lean

Production movement for redesigning the productive systems. Even though diverse applications have been developed in recent years, VSM's origins are mainly focused on the analysis and improvement of manufacturing environments with disconnected flow lines. This framework is defined and described by Hayes and Wheelwright in their well-known product-process matrix. As regards the application process, VSM is based on five phases put into practice by a special team created for such a purpose the phases are:

1 Selection of a product family;
2 Current state mapping;
3 Future state mapping;
4 Defining a working plan; and
5 Achieving the working plan

A value stream consists of everything including the non-value added activities and provides a pictorial view of what elements of the process the customer is willing to pay for. Current state and future state maps have been highlighted to illustrate the benefits of a lean system pictorially and a method of constructing an action plan has been discussed. In current state mapping, the existing/ current position of shop floor of any manufacturing facility is described. In future state mapping, the proposed/future position of shop floor of any manufacturing facility in order to bring some improvement is shown.

II. METHODOLOGY

.The data is collected using an interview and questionnaire survey. Cause effect diagram and brain storming sessions were conducted to identify the problem. Lean techniques were introduced to rectify the problems. Control chart was used to verify the result. Return for investment was also calculated to check the feasibility.

A. Problem identification

The currently using manual assembly consumes more cycle time, more man power, and gives more operator fatigue. Also it results with improper welding, poor aesthetic appearance and less productivity. This is resulting in poor customer satisfaction

The data collected for manual welding operation performed by different operators is given below. The summary of report shows the welding time for each product.

Sl. No.	Product	Time taken in (sec)		
		Worker 1	Worker 2	Worker 3
1	P1	245	249	249
2	P2	252	251	251
3	P3	252	252	250
4	P4	252	249	249
5	P5	248	250	250
6	P6	247	248	249
7	P7	250	253	251
8	P8	251	248	249
9	P9	250	251	253
10	P10	253	249	249
Average Time		250	250	250

Table 1: Time taken for Assembly (Initial)

B. Development of Lean Techniques

The tool cause and effect diagram was used for analyzing the cycle time reduction. This diagram is a graphical tabular chart to list and analyze the potential causes of the given problem. To find the various causes and their remedies brainstorming session was conducted. It was effective and creative thinking technique. It helps to get a large number of ideas from a group in a short time. The following steps in a brainstorming session.

1 Announced the purpose of the meeting to everyone.
2 Encouraged valuable ideas
3 Wrote all the ideas suggested

Once all the ideas have been mentioned and recorded, time was taken to answer questions and clarify the suggestions.

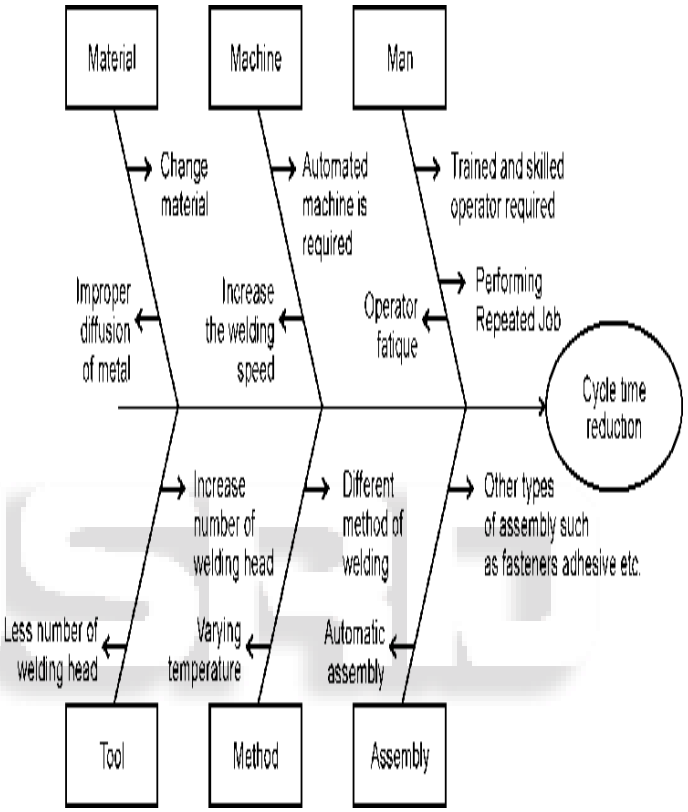

Fig. 1: Cause- effect diagram

Based on the cause and effect diagram and the output of brainstorming value stream maps were developed. The techniques of 5S, cellar manufacturing and single minute exchange of dies were introduced to the system. By using above techniques, the waste time like waiting time and processing time were reduced which lead to reduction in cycle time.

Sl. No.	Product	Time taken in (sec)		
		Worker 1	Worker 2	Worker 3
1	P1	48	47	46
2	P2	48	49	47
3	P3	48	48	47
4	P4	49	49	48
5	P5	48	47	48
6	P6	47	48	49
7	P7	48	47	50
8	P8	49	47	48
9	P9	46	50	47
10	P10	49	48	50
Average Time		48	48	48

Table 2: Time taken for welding (Improved)

C. Control chart

Lot number	Number inspected	Number of defects	Number of defects per unit
1	5	3	0.6
2	5	2	0.4
3	5	1	0.2
4	5	0	0
5	5	2	0.4
6	5	1	0.2
7	5	1	0.2
8	5	0	0
9	5	2	0.4
10	5	3	0.6
$\Sigma_n = 50$		$\Sigma_c = 15$	

Table 3: Time taken for welding (Initial)

The following data shows the number defects per lot in is successive lots of 5 welded assembly each.
Here U-chart is selected for analysis.
Average number of defects per unit =

$$\bar{u} = \frac{\Sigma c}{\Sigma n}$$

$$\bar{u} = \frac{15}{50} = 0.3$$

So, Control limits or center line, CLu = $\bar{u} = 0.3$
Upper control limit, UCLu =

$$\bar{u} + 3\sqrt{\frac{\bar{u}}{n}} = 0.3 + 3\sqrt{\frac{0.3}{5}}$$

$$= 1.034$$

Lower control limit, LCLu=

$$\bar{u} - 3\sqrt{\frac{\bar{u}}{n}} = 0.3 - 3\sqrt{\frac{0.3}{5}}$$

$$= -0.434$$

(Taken as 0)

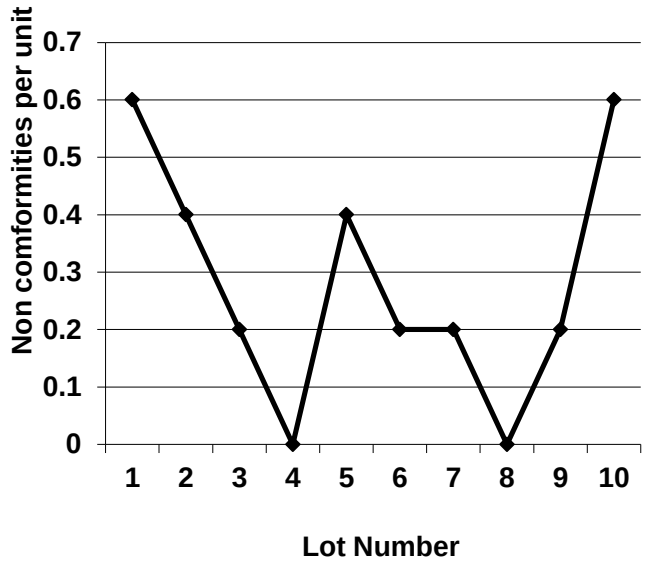

Fig. 2: Control chart for different lots

The control chart shows that all the lots are under control.

D. Calculation of Return for investment

Total cost for implementing the techniques = Rs.2, 80,000.
Time saving by the new process = 202 sec.
Total number of product manufactured per year = 75,000 (approx.)
So, expected saving per year

$$= \frac{202 \times 75{,}000}{3600}$$

Total time saved per year = 4,208 hrs.
Labor cost per hour = Rs.200
RoI per year

$$= \left(\frac{4208 \times 200}{2{,}80{,}000}\right) \times 100$$

= 300 %

The above calculated improved productivity and RoI shows the new method is valid and feasible one.

III. CONCLUSION

By implementing lean manufacturing principles the unnecessary time for performing the welding operations were drastically reduced, which lead to cycle time reduction of the above welding process. This reduction in cycle time has significant impact on company's productivity. The quality control chart also shows that the process is under control. The value stream map developed gave a good idea of the processes and the changes to be done.

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