Productivity Improvement of Circuit Breaker Manual Assembly Line

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Abstract— The current paper addresses the productivity improvement of manual assembly line by making use of operational analysis in the framework of lean production A methodology is proposed that helps to improve productivity of circuit breaker assembly process. The methodology consists of selecting a product or product family to be studied followed by the current process study. Operational analysis enables the reduction of nonproductive tasks and results in set of standardized work elements along with the set of standard procedures for performing the operations. Any small change which lead to improve productivity in the organization will directly affects its growth. Productivity improvement is to do the right things better and make it a part of continuous process. Therefore, it is important to adopt efficient productivity improvement technique to ensure individuals and organization's growth in productivity. This paper seeks to analyze the internal product flow in assembly line of Circuit breaker manufacturing company located in Nashik. An objective of this paper is to identify nonvalue added activities and reduce the same and propose a future state map to reduce the production lead time. This study focuses on the implementation of lean tools and techniques in the circuit breaker manufacturing industry. The paper presents improvement, cost reduction, standardization assembly cycle time optimization of circuit breaker assembly using lean tools & techniques. These techniques are Just in time, cellular manufacturing, visual management, Poka-yoke, Standardization, Kaizen techniques, Time study, Work study, Line balancing etc.

Keywords: Circuit Breaker, Manual Assembly Line

I. INTRODUCTION

Productivity is nothing but reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people. Productivity denotes relationship between output and one or all associated inputs.

The productivity of a certain set of resources (input) is therefore the amount of goods or services (output) which is produced by them. Land and building materials, machines, manpower (labor), technology etc. are the resources at the disposal of a manufacturing company. Therefore higher (improved) productivity means that more is produced with the same expenditure of resource i.e. at the same cost in terms of land, materials, machine, time or labor, alternatively, it means same amount is produced at less cost in terms of land, materials, machine time or labor that is utilized. Assembly lines are one of the most widely used production systems.

Improving productivity means increasing or raising productivity with the help of using same amount of materials, machine time, land, labor or technology. The following examples of each type of productivity may make improved or higher productivity meaning clearer. Productivity of a manufacturing system can be defined as the amount of work that can be accomplished per unit time using the available resources. A set of other measures such as assembly line capacity, production lead time, no of value added (VA) and non-value added (NVA) activities, work in process, material handling, operator motion distance, line configuration and others, along with the throughput and utilization rate, Completely characterized the performance of the production system.

Manual assembly lines are most common and conventional and still provide and attractive and enough means production for products that require fewer production steps and simple assembly processes. Global competition is forcing firms to lower production costs and at the same time improve quality with lower production lead times. With the introduction of Lean Manufacturing, this systematically and continuously identifies and eliminate waste at all level of production system, many improvement opportunities which substantially increase the assembly line productivity can be successfully implemented.

Lean manufacturing is systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection. The focus of the approach is on cost reduction by eliminating non-value-added activities. Lean manufacturing is originated from the Toyota Production System. The various tools and techniques of lean manufacturing are just-in-time (JIT), cellular manufacturing, total productive maintenance, single-minute exchange of dies, production smoothing etc. which have been widely used in industry. It achieves the benefits like reducing the inventory & lead time, reducing the waste, improving productivity & quality, increasing overall customer satisfaction & improving employee involvement and morale.

II. METHODOLOGY:

The methodology included firstly the circuit breaker assembly study for which the changes are to be done and is to be standardized. Then the waste identification is done, by observing the assembly process and the workers problems etc. then there was a task of finding out the solution. Workers were also allowed to suggest the improvements as it was a lean approach to eliminate the waste of unused employee creativity. Then the suggested changes and other useful changes were done on production assembly line. These changes are to be implemented by a lean procedure. Thus, the changes were done and implemented by reflecting in the assembly process. Productivity improvement techniques can be applied effectively in enterprises of any size, from one-person companies to corporations with thousands of staff.

Japan developed number of productivity improvement techniques after World War II .The

TPS comprises the following productivity improvements components. Toyota, a giant Japanese automobile company was pioneer in development and application of various productivity improvement techniques under Toyota Production System (TPS).

A. Jidoka –

Jidoka is a Toyota concept aimed at describing the man-machine interface such that people remain free to exercise judgment while machines serve their purpose. The jidoka system shows faith in the worker as a thinker and allows all workers the right to stop the line on which they are working. Jidoka is often referred to as „automation with a human mind". The jidoka way of working consists of following three principles- Do not make defects, do not pass on defects, do not accept defects Establishing a continuous flow of work is vital for the successful implementation of Lean in any organization. Doing so will allow you to deliver value to your customers exactly when they need it without keeping too much inventory.

B. Heijunka-

Heijunka is a Lean method for reducing the unevenness in a production process and minimizing the hance of overburden. The term Heijunka comes from Japanese and literally means leveling. It can help you react to demand changes and utilize your capacity in the best possible way. Heijunka focuses on achieving consistent levels of production. It incorporates the principles of line balancing by attempting to equate workloads, leveling demand out by creating an inventory buffer and replenishing that buffer. It believes in providing even workload for all employees. Heijunka has the capability of reducing lead times by minimizing time losses due to frequent process changeovers.

C. Work Study-

Work study is an important management tool to achieve higher productivity. It is related to human work, method of doing work and standard of performance. The survival of any organization is dependent on use of latest technology and efficient methods of production. To improve efficiency of production it needs effective utilization of plant, equipment and labor. This can be achieved by using work study which studies method and evaluate the performance. It divides work into smaller elements, studies it, and rearranges it to get same or greater efficiency at reduced cost.

D. Line Balancing-

Line balancing is one of the methods. Which is helping to leveling the workload across the work station, remove bottleneck station, remove excess capacity in the manufacturing line and optimal resources are being used to meet the customer requirements on time. Line to be balanced in effective manner on the line balancing parameters like grouping of the workstation, leveling of workload, remove bottleneck station, remove excess capacity, remove excess work in progress, effetely use no of manpower utilization, man movement, material movements, Space utilization, manufacturing lead time.

E. Kaizen techniques-

Kaizen (Continuous improvement) is a management supported employee driven process where, employees make a great number of continuous improvements effort.

Kaizens Detail-

Sr No	Station	Kaizen Reported
1	Pole assembly Station	1) Implementation of fixture for torque application at pole assembly station. 2) Improvement in VI holding method. 3) Special trolley implemented for storage of Pole as well as VI.
2	Frame mounting station.	1) Implementation of Earthing fixture at Frame mounting station. 2) Lifting hook storage trolley implemented.
3	Pole mounting station	1) Implementation of template for pole assembly alignment purpose. 2) Connection arm storage trolley implemented.
4	Drive mounting station	1) Tripping spring assembly fixture implemented. 2) Gun storage arrangement at drive mounting station.
5	Fabrication station.	1) Gun storage arrangement at fabrication station. 2) Special torque wrenches provided for torque application to tulip.
6	Endurance station	Implementation of Motorized endurance fixture instead of Pneumatic Endurance Fixture.
7	Wiring Station	1) Breaker locking and clamping arrangement at Wiring station. 2) Implementation of Rotary switch wiring assembly instead of switch mounted wiring.
8	Testing station.	1) Implementation of movable table at testing station to move breaker into 360 direction. 2) Implementation of breaker tripping tool. 3) Wire storage arrangement improved at breaker testing station.
9	Racking mounting station.	1)Pneumatic lifter and circuit breaker clamping arrangement for racking mechanism fixture 2) Bari cation implemented at Racking station.
10	Finishing station.	Implementation of special tool for removing lifting hook from the circuit breaker.

F. Five Ss of Housekeeping:

A structured approach to achieve clean and orderly workplace by fixing place for everything. Five Ss is an abbreviation for

the Japanese words: Sort, Set in Order, Shine, Standardize & Sustain.
Sort- Getting rid of unnecessary items.
Set in Order-Arranging items systematically for easy retrievability.
Shine – Keeping workplace clean and shine.
Standardize- Scheduling regular cleaning and clearing out operations.
Sustain- Making all the above task meet agreed standards at agreed intervals.

G. Waste elimination:

Waste elimination implies an „on going" and systematic reduction or elimination of waste. There are eight kinds of major waste. Waiting, Overproduction, Rework, Motion, Processing, Inventory, Intellect, Transportation. It helps to eliminate redundant processes or parts of processes, delete non-value-added activities, simplify motions, minimize fatigue, reduce wait time, etc.
Poka-Yoke
Poka-Yoke Details-:

Sr no.	Station	Poka-yoke Reported.
1	Pole Assembly station	1) Implementation of fixture for torque application at pole assembly station. 2) Improvement in VI Holding method.
2	Frame mounting station	1) Implementation of Earthing fixture at Frame mounting station.
3	Pole Mounting station	1) Implementation of template for pole assembly alignment purpose.
4	Drive Mounting station	1) Tripping spring assembly fixture implemented.
5	Fabrication Station.	1) Special torque wrench provided for torque application to tulip.
6	Wiring station.	1) Implementation of Rotary switch wiring assembly instead of switch mounted wiring.
7	Testing station	1) Implementation of breaker tripping tool.
8	Racking Mounting Station	1) Pneumatic lifter and circuit breaker clamping arrangement for racking mechanism fixture

It is powerful and comprehensive method of „error proofing". A work processes to eliminate inadvertent errors to ensure quality products and services. It helps in defect prevention and defect detection

H. Total Productive maintenance (TPM):

TPM is keeping machines in good working condition through systematic maintenance of equipment so that they fail less frequently, and production process continues without interruption

I. Just-In-Time:

JIT is a management philosophy aimed at eliminating waste from every aspect of manufacturing and its related activities. The term JIT refers to producing only what is needed when it is needed and in needed quantity. The aim of JIT in a factory is to reduce lead times, minimize inventory, reduce the defect rate to zero and accomplish all the above at minimum cost.

J. Kanban:

Kanban is a manual production scheduling technique controlled by a process or machine operator. Kanban means card in Japanese, is attached to given number of parts or products in the production line instructing the delivery of given quantity. The Kanban card after all parts/products have been used up is returned by the operator to its origin. Production is controlled through demand originating from external customer.

K. Visual management:

Visual management is the method of providing, in a clearly visible manner, to both workers and management, information on the current status including target of the various operations performed as well as various work pieces found at the workplace.

L. The PDCA Cycle:

The PDCA (Plan-Do-Check-Act) cycle is an endless improvement cycle which demands that each team Plans (establish a target for improvement through action plan), Does (implement the plan), Checks (monitor and evaluate effects), Acts (Standardizes new procedures or set goals for further improvement). Since every process is initially unstable, it must be stabilize using SDCA (Standardize-do-check act) cycle. Thus, a SDCA cycle must precede every PDCA cycle to consolidate gains into current process before raising the standard threshold.

Time Study data before research work.

VD4 12kV Low rating line.	Frame Assembly	Pole Mounting	EL Drive Mounting	Fabrication Mounting	Endurance testing	Wiring with Coil Assembly.	Electrical testing.	Racking Mounting	Racking operations	HV & Contact resistance ,2KV	Finishing	Total	Bottleneck	
Time study	13	18	18	15	15	16.5	30	15	14	16.5	17	184		Time
Manpower	1	1	1	1	0.5	2	2	1	1	0.5	1	12		510
No of Workstation	1	1	1	1	1	1	2	1	1	1	1	11		CB / Day
Time per St.	18	18	18	18	18	18	18	18	18	18	18	18	18	28.33333
Bottleneck	18	18	18	17.5	17.5	17.5	18	18	18	17.5	18			
													0.85	24.08333

III. RESULTS

VD4 12kV Low rating line.	Frame Assly	Pole Mounting	EL Drive + Shaft Assly	EL Drive Mounting	Fabrication Mounting	Endurance testing	Wiring with Coil Assly.	Electrical testing.	Racking Mounting	Racking operations	HV & Contact resistance ,2KV	Finishing	Bottleneck	
Time study	13	18	8	17.5	15	15	16	30	12	12	13.5	15		Time
Manpower	1	1	1	1	1	0.5	2	2	1	1	0.5	1		510
No of W/S	1	1	1	1	1	1	1	2	1	1	1	1		CB / Day
Time per Stn.	12	13	8	12.8	11	12.8	13	13	12	12	12.8	13	12.8	39.844
Bottleneck	13	13	12.8	12.8	12.8	12.8	13	13	12.8	12.8	12.8	13		
													0.85	34
Available Time	510	510	510	510	510	510	510	510	510	510	510	510		
Available capacity	43	40	64	40	46	40	41	40	43	43	40	40		
85%	36	34	54	34	39	34	35	34	36	36	34	34		

A. Standardization.

The standardization or the Kaizens are implemented for the circuit breaker assembly line. Productivity improved from 24 nos. circuit breakers to 34 nos. circuit breaker per day per shift. Due to poke yoke technique rejection on the material required for breaker assembly controlled and quality improved. Due to sub-assemblies outsourcing assembly time reduced.

B. Cost Reduction

1) Cost saving up to 88k per annuum by implementing subassemblies of rotary switch wiring components at supplier end.
2) Cost saving up to 27k per annum by implementing subassembly of Earthing assembly at supplier end.

C. Waste Reduction

By reducing nonvalue added activities waste reduction achieved and lead time for assembly also reduced.

D. Cycle Time optimization

By implementing Kaizens techniques cycle time optimized at circuit breaker assembly line.

IV. CONCLUSION:

This study focuses on the implementation of lean methods and techniques in the circuit breaker manufacturing industry. The project presents improvement, cost reduction, standardization and assembly cycle time optimization of a circuit breaker using lean techniques. Amongst various tools of lean manufacturing techniques like waste elimination, standardize work approach, visual management etc. are used

The objective of this project was to use lean manufacturing tools to help the industry to eliminate waste, improve product quality and increase the productivity of VD4 low rating line circuit breakers. KAIZENS and POKA_YOKE implemented to reduce the waste and increase productivity with quality. Waste of unused employee creativity is eliminated as workers were involved to suggest the changes or modifications. Also, by studying the current assembly process and sequence, the assembly procedure document is prepared to increase the easiness of the workers for doing assembly and to reduce the wastes like incorrect processing and defects. The waste of waiting and unnecessary movement is overcome by providing required data like list of hardware to the workers. This reduced the time of completing the assemblies and the cycle time is thus optimized.

The circuit breaker assembly method changed as per new desired process to increase productivity. Also the assembly process decided to help the workers to perform the assembly easily and to reduce the defects which led to optimize the cycle time of the assembly approximately 12 min on each station.

From the research work it can be concluded that lean manufacturing techniques can be used in any type of the industry and any type of the product to reduce the waste related to the manufacturing of that product.Waste like incorrect processing can be reduced by visual management techniques which also achieve the cycle time optimization.

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