Implementing Lean Manufacturing to the Breaker X Final Assembly Line

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Abstract **—** *Lean manufacturing is a practice based on preserving the value of a product or service, with the minimum work and materials required to complete it. It is derived from the Toyota Production System and concentrates in eliminating waste and non-value added work while maintaining high standards of quality and customer satisfaction. The implementation of lean manufacturing on any service or production line, can help minimize scrap or idle time, increase productivity, increase sales and returns, maximize infrastructure and time, and produce a quality product that can compete in today's market. Our company launched a new product into production, but the assembly line wasn't keeping up with the production needed. The implementation of this practice results in minimal inventory, minimum employee overtime, and higher production while maintaining the standards of quality. The two main outcomes from Lean Manufacturing was 150% increase in production and over $128K in overtime savings.*

Key Terms **—** *Just-in-Time, Kanban, Lean Manufacturing, Value Stream Map*

PROBLEM STATEMENT

Breaker X Thermal Magnetic Trip (FC100) is a 100A circuit breaker that is moving from the developing phase to production. After obtaining all the certifications thru sample units, a personnel consisting of 12 operators and 1 supervisor were assigned to the final assembly line. Two months into production, the assembly line can't produce more than 130 units on an 8 hour shift. To comply with the demand, production doesn't have a choice but to work overtime during afternoons and weekends. This research will focus on implementing lean manufacturing to the final assembly line and maximize production without risking the quality of the product.

Research Description

The initial final assembly setup for the Breaker X Thermal Magnetic Trip is not producing the outcome numbers that management was expecting. The movement from developing phase to a production line was a partial success because it complies with all the certification requirements, but to make production numbers the company was investing in a lot of overtime. After a Kaizen event, the part movement was the problem that can be the biggest area of improvement. This research will focus on implementing a lean manufacturing layout with a Just in Time final assembly line.

Research Objectives

The objectives of this research are:

- Increase production from 130 units to at least 200 units on an 8 hour shift.
- Reduce the necessity of overtime to comply with production numbers.
- Reduce inventory by implementing a Just in Time production line.
- Increase and maintain a high level of quality.

Research Contributions

The success of this project will increase profits to our company. A lean final assembly line will reduce waste and maintains high levels of quality. By avoiding overtime as much as possible we will reduce the overall cost of production and personnel fatigue.

LITERATURE REVIEW

During the implementation of a lean process, it's important to analyze each step in the original process before making changes. In our case the lean effort aimed to increase production without risking the quality of the product. Techniques used included process mapping, Value Stream, Flow, re-layout, Kanban, time studies and Just-In-Time.

Lean Production is an integrated set of activities designated to achieve production using minimal inventories of raw material, work-in-process, and finished goods. Parts arrive at the next workstation "Just-In-Time" and are completed and move through the process [1]. Some of the most used lean principles are Value Stream, Flow and Just-In-Time.

The Value Stream is the set of all the specific actions required to bring a specific product (whether a good, a service, or, increasingly, a combination of the two) through the three critical management tasks of any business: the problem-solving task running from concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product in the hands of the customer [2].

Flow is the movement or arrangement of the specific actions identified during the Value Stream analysis. Once value has been precisely specified, the value stream for a specific product is fully mapped by the lean enterprise, and obviously wasteful steps eliminated, it's time for the next step in lean thinking – value-creating step Flow [3]. With this step Flow, engineering can re-arrange the floor layout for a smoother parts transition.

Just-In-Time means producing what is needed when needed and no more. Anything over the minimum amount necessary is viewed as waste, because effort and material expended for something not needed now cannot be utilized now [4]. This will help with the organization and minimize waste in the assembly line. To regulate JIT, a Kanban control system is necessary. This will enable that the authority to produce or supply additional parts comes from downstream operations.

In addition to this lean will reduce internal costs, processes will be more efficient, less wasteful. The company will have less of the businesses cash tied up in wasteful inventory and work in progress enabling to spend it where you want. Lean will improve the staffs morale as they become more and more involved in the business and improving what the company does, their motivation will improve dramatically.

Some of the operations used in the final assembly line for Breaker X are riveting, small press, calibration, testing, cooling (cooling towers), labeling and final packing. The flow of the operations goes from small assemblies, to internal components assemblies, closing the unit, calibrating the unit, cooling the unit, testing the unit, laser labeling and packing. The calibration and testing machine have a maximum capacity of 6 units (each) a time and the Just-In-Time will help maximize the production out of these stations. If a steady flow of units are not going thru these stations during the whole shift, these can create a bottle neck and the production output will be affected.

METHODOLOGY

The first step will be to create teams of 7, which will include personnel directly related with the assembly line (12) and external personnel (2) that will act as third party objective team members. Involving the personnel from the assembly line is really important so they can take ownership of the process and do not go against the changes.

Teams will break apart the whole process into the simples' operations possible and create the Value Stream Map (VSM). After discussing and analyzing every step, categorize them between:

- Value Added: activity that directly adds value to the product.
- Incident Work (NVA): Any work carried out that not increase product value, but

unavoidable with current technology or methods.

- Waste: Any activity that does not add value to the product. Some wastes that can be easy identified are overproduction, inventory, waiting, motion (unnecessary), transportation, rework and over processing.

The team will eliminate as much waste as possible from the assembly line and create the new flow diagram. This will provide a visual graphic to see which operation are feeding others. This will give an overview on how the new layout will look like.

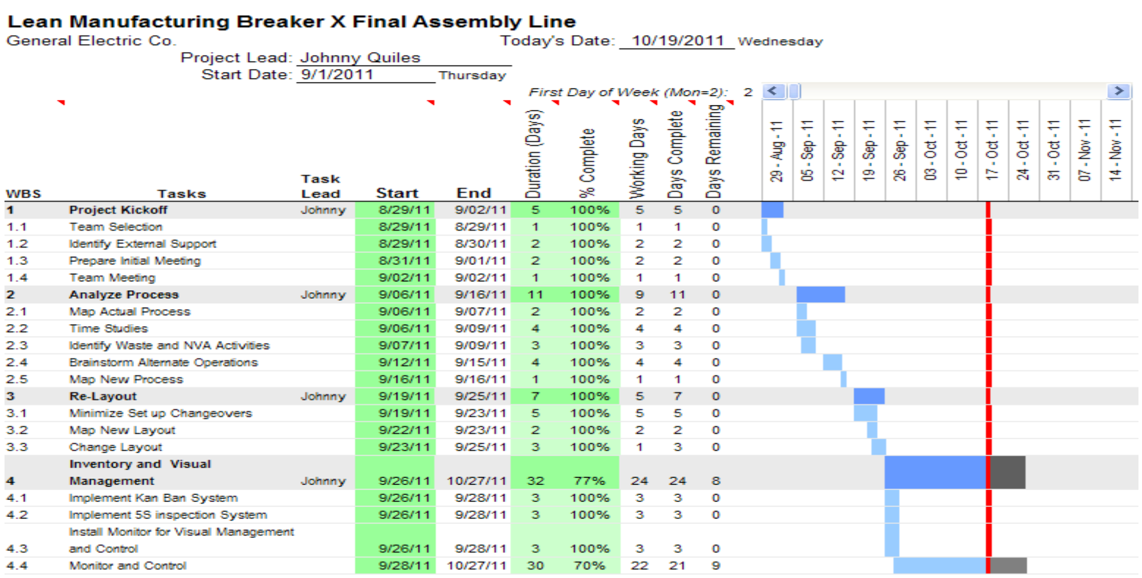
To create a Just-In-Time flow, time studies will be conducted on each operation. This way we can create a process where each part is created just when needed, used and passed to the next operation. This will eliminate the majority of the inventory, create a cleaner work area and eliminate waste. Time studies let the team know if more personnel are necessary or how to move them around to maximize the output of the line.

The different areas for the final assembly line are:

- Sub-Assemblies
- Major Assemblies
- Final Assembly
- Testing
- Labeling & Packing

With the number of single operation stations needed to create a Just in time flow, the team is going to create the floor layout that will maximize the flow. After approval, facilities will incorporate the layout on a weekend shutdown. Also, all the riveting fixtures are going to be machined down to avoiding changing the machine set ups. This will minimize changeover set ups from one sub-assembly to the other. Now the set up changeover will only consist on changing the fixture and the riveting tip. A Kanban system will be implemented to keep the area in compliance with 5S and to avoid mixing scrap and defect parts with the production population.

The final step is to implement Visual Management and Control. The aim of these indicators is to make obvious to everyone the current situation status of the machines, assemblies, resources or anything abnormal, so corrective actions can be taken immediately. Figure below is the Project Gant Chart (Figure 1) for this project.



Lean Manufacturing Breaker X Final Assembly Line

General Electric Co. Today's Date: 10/19/2011 Wednesday

Project Lead: Johnny Quiles

Start Date: 9/1/2011 Thursday

First Day of Week (Mon=2): 2

WBS	Tasks	Task Lead	Start	End	Duration (Days)	% Complete	Working Days	Days Complete	Days Remaining
1	**Project Kickoff**	Johnny	8/29/11	9/02/11	5	100%	5	5	0
1.1	Team Selection		8/29/11	8/29/11	1	100%	1	1	0
1.2	Identify External Support		8/29/11	8/30/11	2	100%	2	2	0
1.3	Prepare Initial Meeting		8/31/11	9/01/11	2	100%	2	2	0
1.4	Team Meeting		9/02/11	9/02/11	1	100%	1	1	0
2	**Analyze Process**	Johnny	9/06/11	9/16/11	11	100%	9	11	0
2.1	Map Actual Process		9/06/11	9/07/11	2	100%	2	2	0
2.2	Time Studies		9/06/11	9/09/11	4	100%	4	4	0
2.3	Identify Waste and NVA Activities		9/07/11	9/09/11	3	100%	3	3	0
2.4	Brainstorm Alternate Operations		9/12/11	9/15/11	4	100%	4	4	0
2.5	Map New Process		9/16/11	9/16/11	1	100%	1	1	0
3	**Re-Layout**	Johnny	9/19/11	9/25/11	7	100%	5	7	0
3.1	Minimize Set up Changeovers		9/19/11	9/23/11	5	100%	5	5	0
3.2	Map New Layout		9/22/11	9/23/11	2	100%	2	2	0
3.3	Change Layout		9/23/11	9/25/11	3	100%	1	3	0
4	**Inventory and Visual Management**	Johnny	9/26/11	10/27/11	32	77%	24	24	8
4.1	Implement Kan Ban System		9/26/11	9/28/11	3	100%	3	3	0
4.2	Implement 5S inspection System		9/26/11	9/28/11	3	100%	3	3	0
4.3	Install Monitor for Visual Management and Control		9/26/11	9/28/11	3	100%	3	3	0
4.4	Monitor and Control		9/28/11	10/27/11	30	70%	22	21	9

Figure 1

Project Gant Chart

RESULTS AND DISCUSSION

The first step was to do the process map and conduct time studies. Here is the flow diagram (Figure 2) for the final assembly line:

During the Value Stream Map, the team separated every single detail in the assembly line and categorized them between Value Added, Incident Work (NVA) and Waste. Anything that was assembly or sub-assemblies (circles in Figure 2) was categorized as Value Added steps. The Cassette Photo Inspection and Mechanism Inspection (I-1 and I-3 in Figure 2) were categorized as Incident Work. The Wastes identified during the VSM were: all the different incoming inspections, machine set ups, excess inventory and the time moving parts/assemblies from one station to the other.

All incoming inspection was removed for the assembly line and delegated to the Quality Department. Every lot of part coming into the assembly line will be already inspected and approved at the plant incoming port.

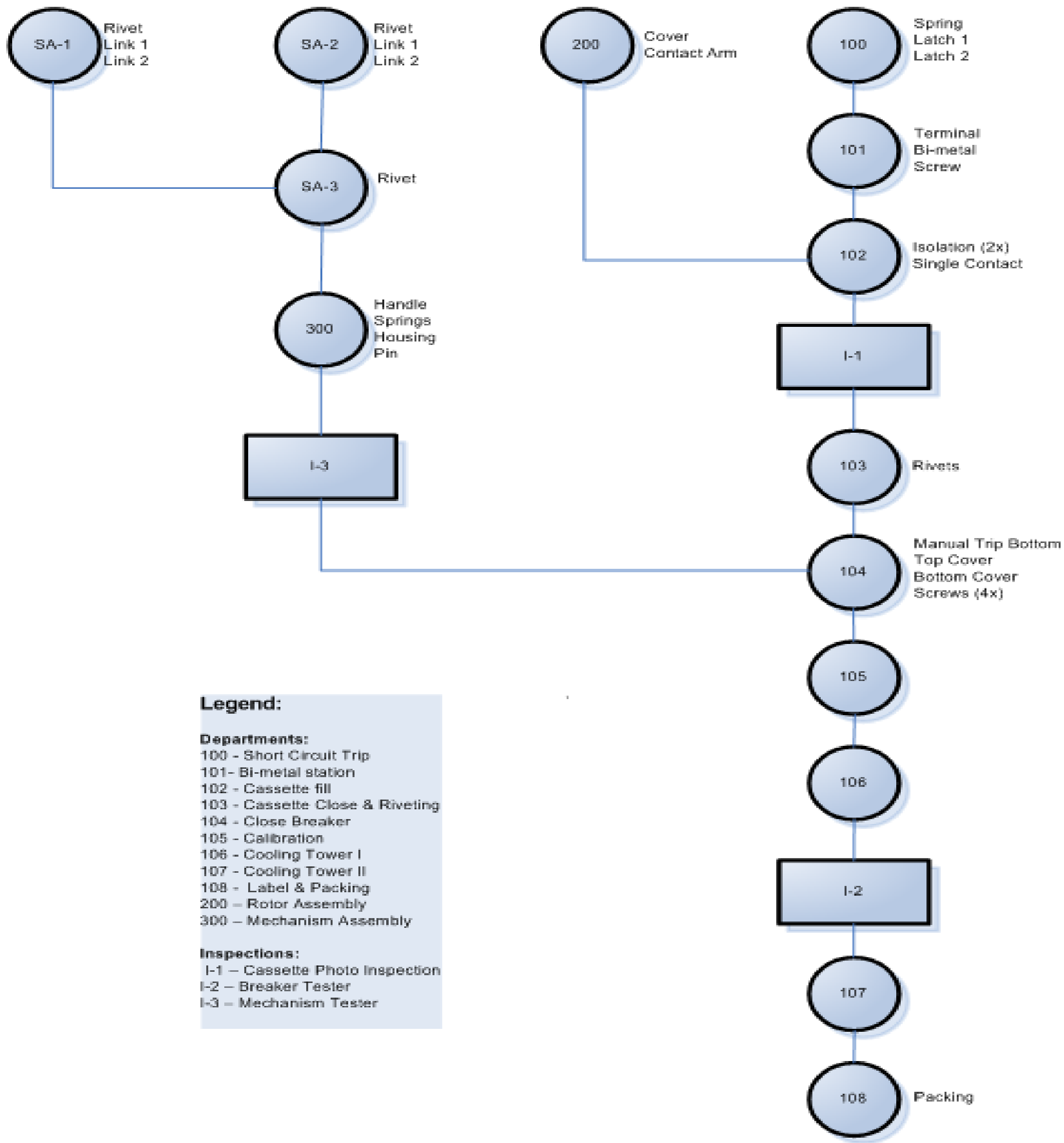


Figure 2
Flow Diagram of the Final Assembly Line

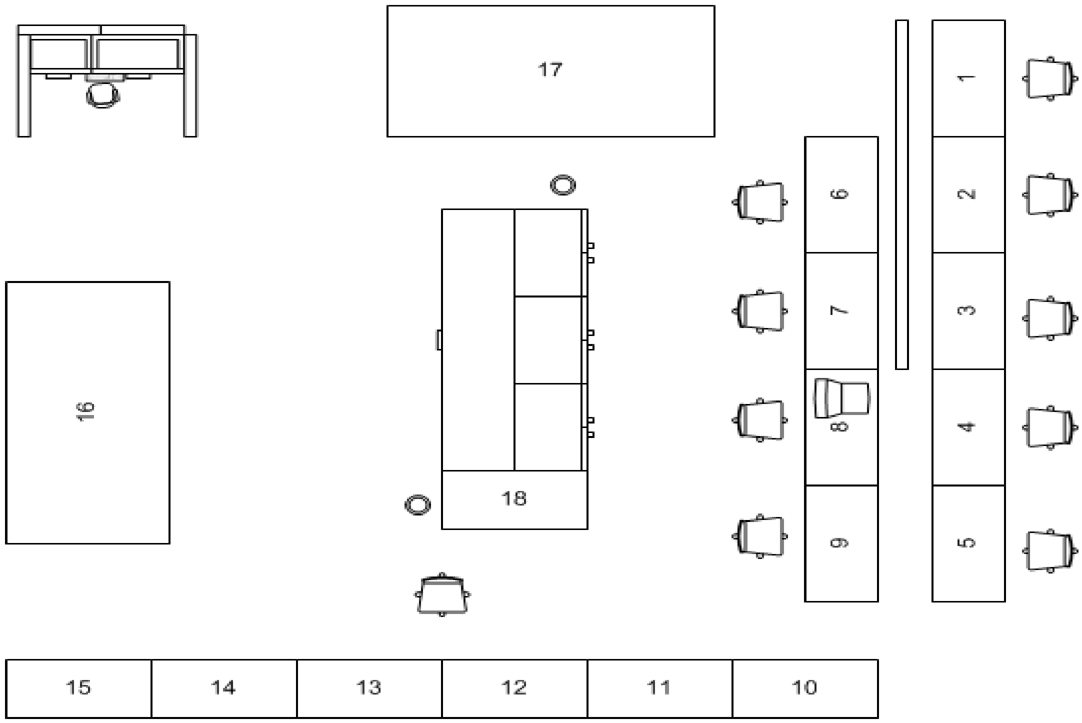


Figure 3
New Floor Layout

Figure Legend:

1. Short circuit Trip
2. Mechanism Sub-Assembly 1 / Bi-Metal Assembly
3. Mechanical Sub-Assembly 2 / Arc Chutes (buffer) / Short Circuit Trip (buffer)
4. Mechanism Sub-Assembly 3 / Rotor Station
5. Mechanism Assembly
6. Arc Chutes Station
7. Cassette Fill Station
8. Photo Inspection / Cassette Closing Station
9. Mechanism Tester / Breaker Closing Station
10. Breaker Calibration (6 Units at a time)
11. Cooling Tower 1
12. Breaker Tester (6 Units at a time)
13. Cooling Tower 2
14. Laser Labeling
15. Packing
16. Storage & Shipping Area
17. Incoming Area
18. QA / Rework Area

A new layout was designed to maximize parts/assemblies movement from one station to the other. A conveyor belt was added in the middle of the stations to move assemblies that we couldn't place together. The excess of inventory was removed and 5S was implemented.

The teams notice that there was a lot of waste coming from setups and process flow. The riveting machines are used for three different operations and there's time wasted during the change up in setups. Every fixture used has a different high and this make the operator to adjust the riveter every time they change from one sub-assembly to the other.

The team decided to take all fixtures to the tool room and performed some machining to level every single one to the same height. The next step was to design a base, were can be attach those fixtures to and if necessary perform all three different sub-assemblies at one step.

For the time study, three different operators per 10 steps each were selected and the average time for every single operation was calculated. The total time to make one single unit is 20.67 minutes (1,240 seconds). Using a daily effectiveness of 7.5 hours per operator (27,000 seconds) and the desire production (200 units/day), the assembly line will need 9.18 operators plus one supervisor. This mean, that if we can get a good line balancing, we can employ one actual employee in other task or assembly line.

Using the numbers above, the team calculated the cycle time at 135 seconds per unit. Only two stations (Arc Chutes and Short Circuit Trip) exceed this cycle time. Using line balancing, the operator at Mechanism Sub-Assembly 2 will support these two stations to maximize the work output. Since these are small sub-assemblies, the assembly line will set buffer storage of Short Circuit Trip (150 units) and Arc Chutes (300 units), so the balance of the line doesn't get affected. The rest of the station are combined to get as close as possible to the 135 second per unit cycle time and process flow. The area of calibration, tester and label can be run by one person because it's just place the unit and run the program machines. The packing for this type of breaker is done in bulks of 96 units so the time spent doing so it's minimum.

The Kanban system will consist of red and blue bins. The red bins will be Scrap and Waste, and it will be discard everyday at the end of the shift. Since this breaker consists of small parts, blue bins will be filled at the end of the day with all the material needed for the next day production. Also at the end of the day, the Mechanism Sub-Assembly operator will provide with the buffer parts for the next day to the Arc Chutes and Short Circuit Trip stations.

A computer monitor was installed over the Tester Station to provide with the production numbers, Pass/Fail yield, stoppages, and major defect problem. These will help to management to see the progress of the line and act on time in case any problem occurs. Figure 3 shows the new floor layout.

CONCLUSION

After implementing some elements of lean manufacturing culture, the output on the final assembly line for the Breaker X Thermal Magnetic Trip has increased by 150 percent. The assembly line output was increased from 130 units to an average of 193 units per day. Several factors including machine stoppages, defective parts and humans factor hasn't help us to get to the 200 units per day goal. Engineers are working into implementing a preventive maintenance for all equipment to minimize machine stoppages. Quality Assurance department is doing their part to avoid defective part make their way to the assembly areas. Supervisor are performing cross training for all operators on their proficiency level, to ensure the absent of one employee will not have a major impact on a production day output.

Using line balancing, we eliminated one full employee equivalent to $20,000 per years in saving. When the line get to the 200 units per day goal, the reduction of overtime will save our company approximately $128,960 per year. The assembly line still uses no more than 2 hours per week to cover the 35 unit weekly gap.

Just in Time was implemented and there is no more that a daily use of inventory. All areas have been marked, red for scrap and blue for good parts/assemblies.

The production of 63 (average) units more per days increases productions sales by $3,276,000 annually. Quality and Engineering still gathering data to estimate savings in Scrap, Rework and Waste.

REFERENCES

[1] F. Robert Jacobs & Richard B. Chase, *Operations and Management, The Core*, 2008, Page 225.

[2] James P. Womack & Daniel T. Jones, *Lean Thinking, Banish waste and create wealth in your corporation*, 2003, Pages 19 – 21.

[3] James P. Womack & Daniel T. Jones, *Lean Thinking, Banish waste and create wealth in your corporation*, 2003, Pages 21 – 24.

[4] F. Robert Jacobs & Richard B. Chase, *Operations and Management, The Core*, 2008, Page 228.