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Lean Manufacturing Implementation in Small and Medium Industry

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Abstract

Lean manufacturing is an approach that aims to remove and reduce wastes in every aspect of production including the customer relations, supplier systems, product design, and plant management. The purpose of this study is to identify low productivity activities at an electronic company assembly line. An actual case study at an electronic company in Malaysia was conducted for this purpose. WITNESS simulation software was used in this study to identify the waste that existed in the production line. It was identified that Gauging Process of the assembly line had been addressed as the production line with the lowest productivity. The lean manufacturing concept employed has identified and rectified the problems related to low productivity in the assembly line based on Witness simulation results. The method used in the study has been acknowledged as a standard for future line set-up.

Keywords: lean manufacturing; WITNESS; simulation; assembly line; waste reduction.

1. Introduction

Lean manufacturing is a method to reduce wastes in every aspect of production. It can be implemented by companies to remain competitive by having quality products at low cost and fast delivery. The study was to implement lean manufacturing at a Small and Medium Enterprises (SME) company, where existing process implementation needs to be identified and later a new improved process should be figured out to be a basis for future set up. In this particular SME, suitable methods or tools based on lean manufacturing perception were to be applied to overcome problems that occurred at the production line [1]. The SME company produced trimming potentiometers, position sensors, resistor and resistor networks, integrated passive networks, turns counting dials, precision potentiometers, transformers and inductors, hybrid and power hybrid microcircuits. The main purpose of this study was to identify low productivity activities at an electronic company assembly line by using lean manufacturing method and Witness simulation in order to offer solutions for the company to increase productivity and processing.

1.1 Type of waste

Lean manufacturing is commonly known as Lean Production System (LPS) which is based on Toyota Production System (TPS). To prevent any misperception, the word 'Toyota' is changed and named as 'Lean'. The main purpose of system is to eliminate numerous kind of wastes through improvement actions [2]. Lean manufacturing classified seven types of wastes such as; product defects, waiting time, processing waste, overproduction, motion waste, inventory, and transportation [3]. In general, basic understanding about wastes; defect is manufactured products that are out of specification [4], service components that cause in rework, scrap, checkup, flawed materials or replacement production. Waiting time means postponements allied with stock-outs, equipment downtime, machine breakdown, capacity bottlenecks and lot processing delays [5]. Processing waste is processed phases that are not essential to manufacture the product [6]. Overproduction is more products being produced than demand and before it is needed. Motion waste is defined as a human motion that are pointless and work-in-process (WIP) moving extensive distances [7]. Then, inventory is additional raw material, finished goods, or WIP, which contributes towards pending further processing, while transportation, waste means work done to transport unnecessary stock to a warehouse [7][8][9]. Based on a research that had been done in 200 SME companies, their perceptions toward lean are cost saving, continuous improvement, waste reduction, tools and technique to improve production operation, fully integrated management philosophy, a way of life, comprehensive system of organizing and managing the supply chain and lastly is headcount reduction [10].

1.2 Recommended practices

The cluster of lean production methods is grouped into five categories as shown in Table 1 [1]. Based on the study, the recommended practices are sorted according to types of lean methods [10] [12] [13].

Table 1. Cluster of lean production methods

Type	Lean Methods
Machinery and equipment	Low Cost Automation
	Overall Equipment Effectiveness (OEE)
	Preventive Maintenance
	Single Minutes Exchange of Dies (SMED)
	Total Productive Maintenance
Material flow and layout	Cellular Manufacturing
	First in first out (FIFO)
	One-piece-flow
	Simulation software
	Optimization of the supply chain
	Value Stream Mapping (VSM)
	Work station design
Organization and staff	5S
	Autonomous work groups
	Benchmarking
	Ideas management
	Job rotation
	Lean office (Administration)
	Kaizen
	Standardization
Production planning and control	Just in Sequence
	Just in Time
	Kanban
	Line Balancing and Muda reduction
	Milkrun
	PPS Simulation software
	Optimal lot size
	Visual Management
Quality	FMEA
	Poka Yoke
	Quality Circles
	Six-Sigma
	Statistical Process Control (SPC)
	Supplier Development
	Total Quality Management
	Zero Defect

2.0 Methodology

In completing this project, wise and smooth approaches were planned in details. The improvement activity was following Plan-Do-Check-Act (PDCA) method. Some visits were planned to study the current condition and observe areas that need to be improved. Firstly, the data collection was made by having interview sessions with the company supervisor and also their workers. Another approach used to get the data collections was by *'Genchi Genbutsu'* which means go and see the actual situation. Literally, by doing this approach, it helps to have a better understanding of the current condition at the factory. Other than *'Genchi Genbutsu'*, *Gemba* is another approach used to find abnormality through observation which helped to identify main processes in production.

Once the data was captured from the study, it should be simulated by using Witness software. The core of this software was to establish a dynamic process simulation based on the data input. Witness simulated the current performance and triggered the user on the abnormalities in the production system. It also suggested the areas to be improved in order to achieve desired process performance and also supported continuous improvement activities [11]. The Witness simulation software was able to create a variety of discrete and continuous elements. Depending on the type of element, each element could be in any number of 'states' which means either idle, busy, blocked, in-setup, broken down, and waiting labour [11]. At the end of the simulation activity, the result from the data will be analysed and improvements will be made for future set-up.

3.0 Result and discussion

Current data collection as shown in Table 2 and Table 3 was the initial input to the Witness simulation activity. This data input was necessary for commands used in the software. Layout of the focused cell was become the main focus area in this study as shown in Fig.1. This layout was then transferred into Witness environment as in Fig. 2.

Table 2. Data collections at current production

Demand per day	4000
Working Hours per day	10 hours
Break per day	0.75 hours
Available Working Hours per day	9.25 hours
Takt Time	8.3 seconds
Target per Hour	433
Conveyor Speed (m/s)	0.03

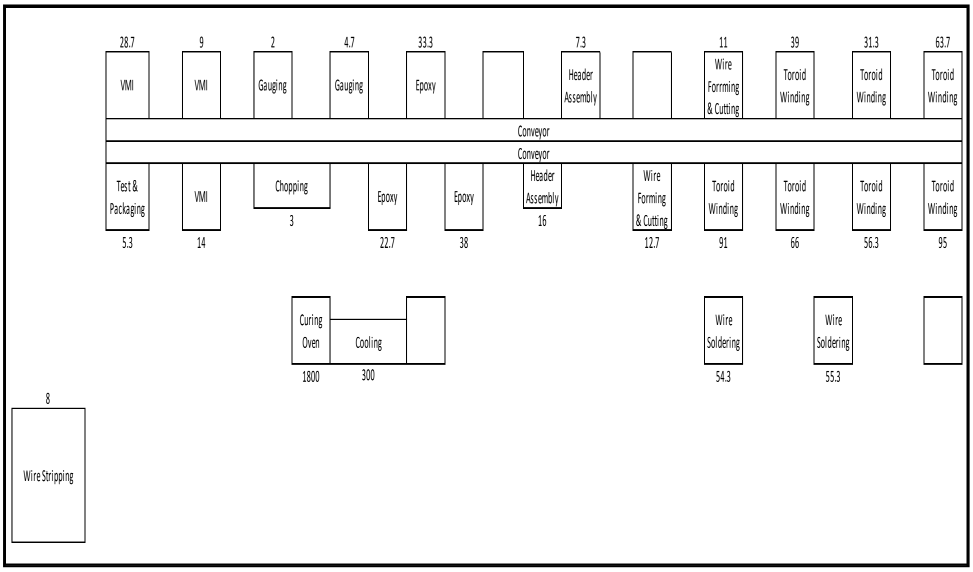

Fig. 1. Current layout in focused cell

Table 3. Cycle time for each worker

Workers	Process	Cycle time 1 (Sec)	Cycle time 2 (Sec)	Cycle time 3 (Sec)	Ave. Cycle Time (Sec)
1	Wire Soldering	59	58	46	54.3
2	Wire Soldering	60	58	48	55.3
3	Toroid Winding	99	99	86	95
4	Toroid Winding	56	55	58	56.3
5	Toroid Winding	67	64	68	66
6	Toroid Winding	92	91	89	91
7	Toroid Winding	62	65	64	63.7
8	Toroid Winding	34	29	31	31.3
9	Toroid Winding	40	38	39	39
10	Wire Forming & Cutting	12	10	11	11
11	Wire Forming & Cutting	13	12	13	12.7
12	Header Assembly	13	15	14	14
13	Header Assembly	7	8	7	7.3
14	Epoxy	40	37	37	38
15	Epoxy	40	30	30	33.3
16	Epoxy	24	22	22	22.7
17	Chopping	3	3	3	3
18	Gauging	4	5	4	4.7
19	Gauging	2	2	2	2
20	VMI	5	15	7	9
21	VMI	13	15	14	14
22	VMI	31	27	28	28.7
23	Test & Packaging	6	5	5	5.3

3.1 Data Analysis of Current Production

The simulation showed that after 4.8 hours of working, the output obtained were 1041 pieces. The performance of it is calculated below:

$$Performance=\frac{(1041\ pieces/288\ minutes)}{7\ piece\ per\ minute}\ x\ 100=51.64\% \qquad (1)$$

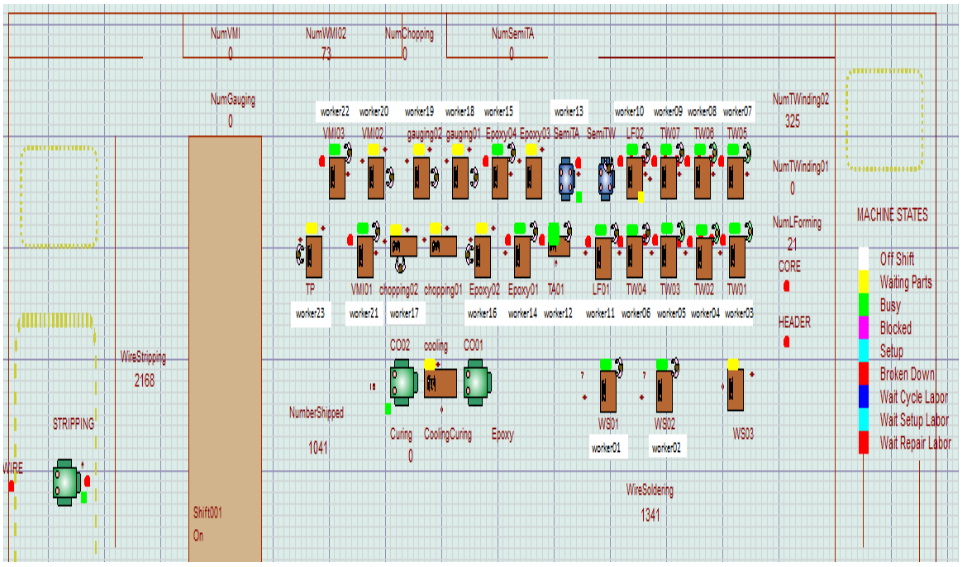

Fig. 2. Layout of current production in Witness

According to the Witness results of performance of each labor shown in Table 4, it showed that Gauging Process has workers with high percent of idleness. By referring to this result, further improvement process needs to be done.

Table 4. Data for buffer in current production

Name	Total In	Total Out	Now In	Avg. Size	Avg. Time
NumTWinding02	946	621	325	161.62	3095.63
NumTWinding01	684	684	0	0.33	8.62
Epoxy	1279	1279	0	0	0
NumLForming	1303	1282	21	10.18	141.62
NumGauging	1116	1116	0	2.25	36.55
WireSoldering	4613	3272	1341	667.43	2621.68
NumWMI02	1116	1043	73	31.26	507.5
NumVMI	1041	1041	0	0.01	0.09
NumChopping	1116	1116	0	0.89	14.45

3.2 Data Analysis of First Improvement

The method used to create an improved process was by referring to the percentage of the idleness of the labors in the current production. Witness simulation reported that two labours from the Gauging Process station has a high percent of idleness compared to others. Based on this report, it was considered that one workstation should be reduced and re-run the process in Witness to analyse the effect of reducing one labour, meaning the workstation was reduced from 23 to 22 as in Fig.3. Worker 19 was chosen to be removed because she has the highest percent of idleness of 93.84%. After the workstation has been removed, the labours performance did not have any different except for Worker 17, which was reduced from 85.53% to 71.05% of idleness since she handled the process that had been removed from Worker 19. Meanwhile, the output gained in this improvement was equal to the current production. The result proved that it was significant to reduce the workstation since the performance remained equal to the performance of the current production. The performance of this improvement was still 51.64%.

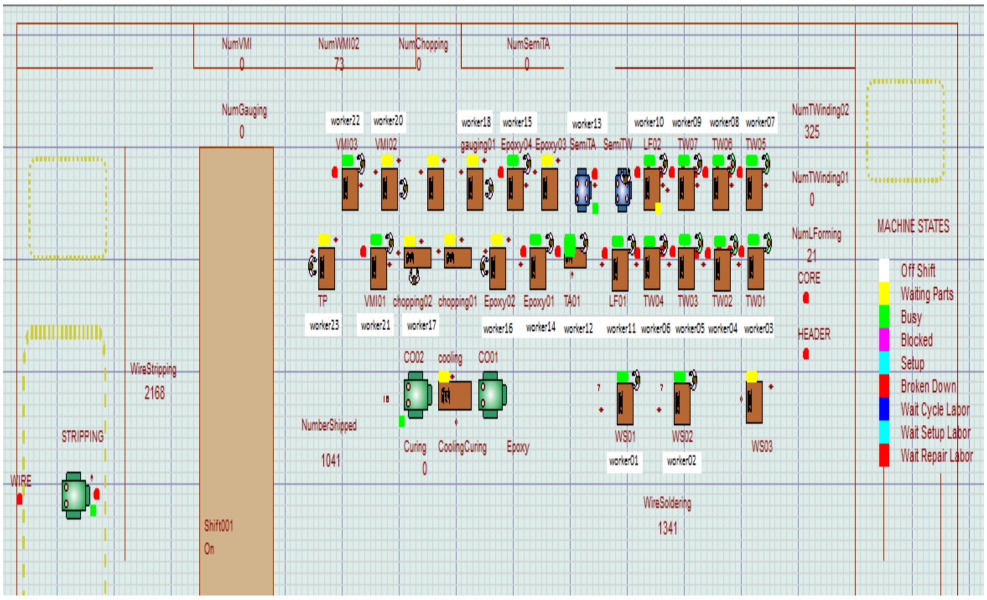

Fig. 3. Layout of first improvement in Witness

Table 5. Data for buffer in first improvement

Name	Total In	Total Out	Now In	Avg Size	Avg Time
NumTWinding02	946	621	325	161.62	3095.63
NumTWinding01	684	684	0	0.33	8.62
Epoxy	1279	1279	0	0	0
NumLForming	1303	1282	21	10.18	141.62
NumGauging	1116	1116	0	2.25	36.55
WireSoldering	4613	3272	1341	667.43	2621.68
NumWMI02	1116	1043	73	31.26	507.5
NumVMI	1041	1041	0	0.01	0.09
NumChopping	1116	1116	0	0.89	14.45

3.3 Data Analysis of Second Improvement

The second improvement was made by using the layout from the first improvement by having only one labour for Gauging Process. A re-allocating method was used in this improvement cycle by re-allocating the free labour from the first improvement (Worker 19) to a process that needed more workers. This improvement was carried out by referring to the buffer statistics of the Witness report. The free labour should be re-allocated to a workstation that has a bottleneck such as high capacity of buffers. The final improvement increased the company's productivity when the labour was re-allocating to VMI process. The analysis for the second improvement as shown in Fig. 4 increased the productivity of the production from 1041 to 1109 pieces of the total output. The productivity for this improvement was calculated below.

$$Performance = \frac{(1109\ pieces/288\ minutes)}{7\ piece\ per\ minute} \times 100 = 55.01\% \qquad (2)$$

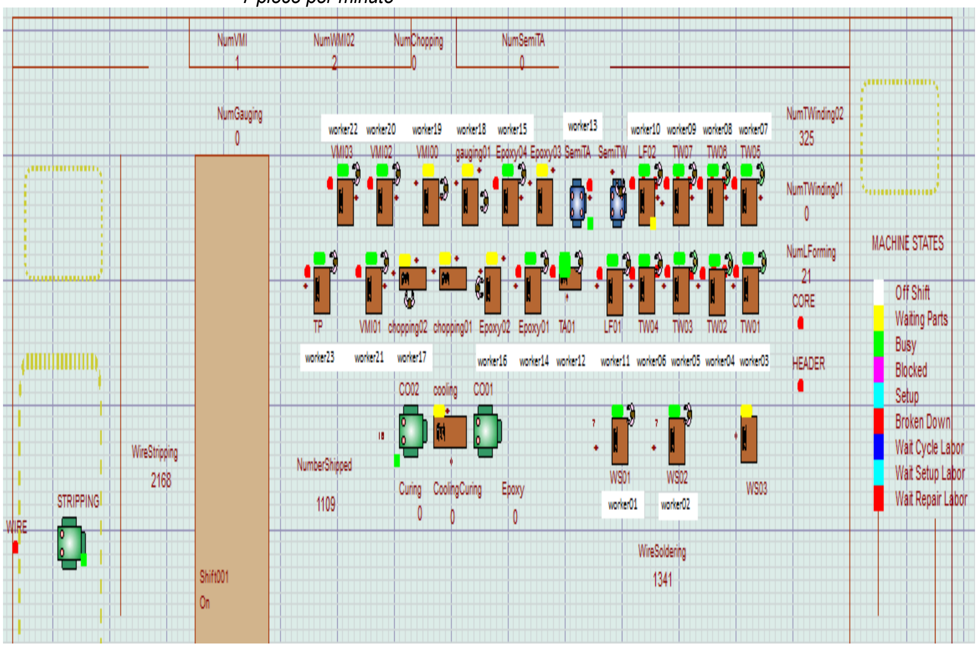

Fig. 4. Layout of second improvement in Witness

After second improvement cycle, the capacity of buffer for the process was decreased and making the *total in* of the process is approximately equal to the *total out*. This improvement helped the production by increasing the output.

Table 6. Data for buffer in second improvement

Name	Total In	Total Out	Now In	Avg. Size	Avg. Time
NumTWinding02	946	621	325	161.6	3095.63
NumTWinding01	684	684	0	0.33	8.62
Epoxy	1279	1279	0	0	0
NumLForming	1303	1282	21	10.2	141.62
NumGauging	1116	1116	0	2.3	36.55
WireSoldering	4613	3272	1341	667.4	2621.68
NumWMI02	1116	1114	2	1.3	20.25
NumVMI	1111	1110	1	0.0	0.21
NumChopping	1116	1116	0	0.9	14.45

3.4 Precedence Diagram

Precedence Diagram is a network showing a sequence of the task, with work element represented by nodes and precedence relationships represented by a line. Table 7 displays the details of each workstation on this production and based on the optimised data, a precedence diagram is constructed as in Fig. 5.

Table 7. Precedence data

	Work Element	Precedence	Time (min)
A	Wire Cutting		0.13
B	Wire Soldering	A	0.91
C	Wire Soldering	A	0.92
D	Toroid Winding	B, C	2.53
E	Toroid Winding	B, C	1.59
F	Toroid Winding	B, C	1.48
G	Toroid Winding	B, C	1.72
H	Toroid Winding	B, C	1.61
I	Toroid Winding	B, C	0.86
J	Toroid Winding	B, C	0.73
K	Wire Forming & Cutting	H, I, J	0.18
L	Wire Forming & Cutting	D, E, F, G	0.21
M	Header Assembly	L, K	0.23
N	Semi Auto Header Assembly	M	0.12
O	Epoxy	N	0.63
P	Epoxy	N	0.38
Q	Epoxy	N	0.56
R	Curing	O, P, Q	35
S	Chopping	R	0.05
T	Gauging	S	0.08
U	Gauging	S	0.03
V	VMI	T, U	0.15
W	VMI	V	0.23
X	VMI	V	0.48
Y	Test & Packaging	W, X	0.09

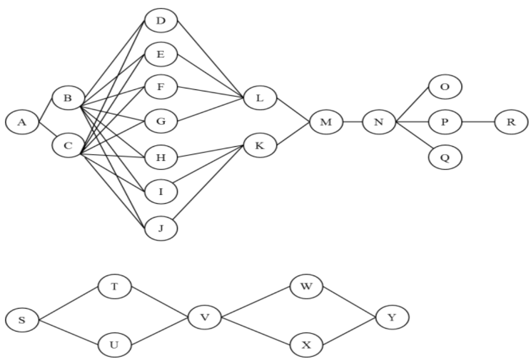

Fig. 5. Precedence diagram

4. Conclusion and recommendation

This study was conducted to identify low productivity issue at the assembly line of an electronic industry in Malaysia. Previously, the company was facing problems in identifying wastes that exists in the production lines. The company has the knowledge on lean manufacturing method, however the company was unable to find suitable lean method to be implemented. The critical issue was to find the best way in order to maximise the productivity. By conducting qualitative and quantitative studies, the practices which contributed to low productivity had been identified and simulated by using WITNESS software. According to the simulation results, processing waste has been identified as the highest score which did not contribute any benefit to the production activity. Benefit gained from the improvement helped the company to reduce cost as well as the productivity was increased since one of the bottlenecks has been identified and rectified. Based on the results, lean theories had been proved to contribute to the betterment of an electronic assembly production. Furthermore, the evaluation from WITNESS simulations highlights an alternative in identifying problems as well as to figure out ways of improvement that could be applied in the production line. Finally, this study suggests for future production set-up for the particular electronic assembly line by integrating virtual simulations, real and standardised work.

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