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IMPLEMENTATION OF LEAN MANUFACTURING IN THE PRODUCTION OF PHASE SELECTOR SWITCH (PS63)

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ABSTRACT

At present, companies have been facing severe competition. This situation has brought about several changes in the nature of customer demand. According to one of these changes, customers have begun to demand varied models of the same product or different products in varied volumes.

KEYWORDS: Phase Selector Switch (PS63)

In order to meet this kind of customer demand, modern companies are required to produce varied models of several products in different volumes. The same condition is prevailing in an electronic switch manufacturing industry where they are manufacturing rotary switches of 21 different specifications according to the customer demands. In order to sustain in this competitive environment, it is necessary for them to implement appropriate lean manufacturing tools. In order to face competition, companies are required to manufacture their products at maximum utilization of time and materials. Lean manufacturing tools are very well known for their ability in reducing wastes and non-value added activities. Companies manufacturing electronic switches have been failing to supply right products at right time. Therefore, by adopting proper lean tools they can achieve their required targets at the proper time.

LITERATURE SURVEY

Fawaz A. Abdulmalek and Jayant Rajgopal [1] described a case where lean principles were adapted for the process sector for application at a large integrated steel mill. Rahani AR and Muhammad al-Ashraf [2] described a case where lean production principles were adapted for the process sector of an automotive part manufacturing plant. They explained that Value Stream Mapping (VSM) involves in all of the process steps, both value added and non-value added are analyzed and using VSM as a visual tool to help see the hidden waste and sources of waste. Satish Tyagi, Alok Choudhary, Xianming Cai, Kai Yang [3] focused to exploit lean thinking concepts in order to manage, improve and develop the product faster while improving or at least maintaining the level of performance and quality.

PHASE SELECTOR SWITCH (PS63)

Phase selector switch (PS63) is an electronic device for making or breaking or changing the connections in a circuit. PS denotes Phase Selector and 63 denote the amps. The average demand of phase selector switch per month is 17,000.The following are the components used in the assembly of a phase selector switch (PS63):

TAKT TIME CALCULATION

Assuming a product is made one unit at a time at a constant rate during the net available work time, the takt time is the amount of time that must elapse between two consecutive unit completions in order to meet the demand.

Takt time can be first determined with the formula:

$$T = \frac{T_a}{D}$$

Where
T = Takt time, e.g. [work time between two consecutiveunits
T_a = Net time available to work, e.g. [work time per period]
D = Demand (customer demand), e.g. [units required per period]

Net available time is the amount of time available for work to be done. This excludes break times and any expected stoppage time (for example scheduled maintenance, team briefings, etc.).

Duration of a shift = 4 hours 30 minutes.

Tea time = 10 minutes.

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Settling and clearing time during the start and end of the shift = 20 minutes

Total available production time per shift = 270-10-20 = 240 minutes

Number of working days per month = 26 days

Average demand for phase selector switch (PS63) per month = 17000 switches/month

Average demand for phase selector switch (PS63) per day =17000/26 per day

=653switches/day

Takt time = 240 minutes/924= (240 X 60) seconds/653 components

= 22 seconds/component.

Thus, the takt time was calculated as 22 seconds. This would mean that, in the company, in order to meet the customer demand, for every 22 seconds, one unit of the switch is required to be produced. Hence, the working of the stations should be tuned to produce one unit of the switch for every 22 seconds. Further, all stations are required to operate at a constant rate which would be synchronized with the takt time. In order to achieve this synchronization, work balance has to be ensured. Work balance refers to a situation where all the operators along the production line require the same length of time to perform their tasks. Operating a line in tune to the takt time is a prerequisite to achieve work balance. During the research being reported here, the work balancing study was carried out to see how well the actual work elements will fit into the desired cycle time of assembling the switch.

TIME STUDY

The standard time for various assembly of the phase selector switch is calculated and the non-value added time is also observed in this time study.

Table 1: Time Study

S. No	Process description	Observed time (seconds)										Total observed time (seconds)	Average observed time (seconds)	Rating	Basic time (seconds)
		1	2	3	4	5	6	7	8	9	10				
1	Top assembly	13.1	14.3	13.2	13.6	15.9	13.8	12.8	13.8	14.7	13.5	138.7	13.8	1.03	14.3
2	Top assembly	14.5	14.7	15.5	14.9	14.3	14.1	15.7	14.5	13.9	16.4	148.5	14.8	0.96	14.3
3	Top assembly	13.2	14.3	15.1	12.4	15.9	12.6	13.4	14.1	13.7	12.7	137.4	13.7	1.04	14.3
3	Front plate assembly and knob fixing	4.8	5.2	5.1	4.9	5.3	5.1	4.7	4.9	5.3	4.8	50.1	5	0.97	4.9
4	Front plate assembly and knob fixing	4.6	4.9	4.5	4.8	4.9	4.7	4.8	4.6	4.8	4.6	47.2	4.7	1.03	4.9
5	Inspection	5.4	5.4	5.7	4.8	4.7	5.8	5.6	5.3	6.2	6.3	55.2	5.5	1.02	5.6
6	Inspection	5.4	5.9	5.6	4.9	4.7	6.1	5.5	5.8	6.5	6.7	57.1	5.7	0.98	5.6
7	Base assembly	15.3	16.3	14.5	14.3	16.4	14.3	17.3	15.3	14.1	15.3	153.1	15.3	1.04	15.9
8	Base assembly	16.4	15.9	15.5	17.5	16.4	16.2	17.3	14.9	18.5	16.6	165.2	16.5	0.96	15.9
9	Base	16.4	15.2	17.2	16.3	17.5	16.9	16.6	18.6	17.4	16.9	169	16.9	0.94	15.9

	assembly													
9	Contact assembly	1.8	1.9	1.6	1.6	1.7	1.9	1.6	1.8	1.5	1.7	17.1	1.7	1.06	1.8
10	Contact assembly	1.8	1.6	2.2	2.4	2.1	1.4	1.7	2.1	1.6	2.2	19.1	1.9	0.94	1.8
11	Sticker pasting and packing	7.3	6.9	7.2	7.1	7.5	6.8	7.1	7.2	7.4	6.7	71.2	7.1	0.95	6.8
12	Sticker pasting and packing	6.6	6.2	6.3	6.4	6.7	6.5	6.2	6.5	6.3	6.4	64.1	6.4	1.06	6.8
13	Main assembly	30.6	29.1	28.4	27.2	29.2	31.8	30.6	29.8	28.4	30.1	295.2	29.5	0.99	29.3
14	Main assembly	27.3	26.4	26.1	27.9	27.2	29.1	28.4	28.2	26.8	28.9	276.3	27.6	1.06	29.3
15	Main assembly	28.2	29.9	30.2	28.8	31.3	29.3	27.7	30.8	27.7	31.3	295.2	29.5	0.99	29.3
16	Main assembly	30.2	28.3	29.4	27.2	29.7	30.8	37.9	31.6	30.3	29.3	304.9	30.5	0.96	29.3
17	Main assembly	27.3	29.3	28.4	30.3	29.6	30.1	29.2	28.1	27.8	27.1	287.6	28.7	1.02	29.3
18	Main assembly	31.1	29.4	28.8	32.1	28.3	29.3	31.2	31.6	28.2	32.1	302.2	30.2	0.97	29.3
19	Cap fixing	7.8	9.1	8.7	8.9	7.6	8.6	7.3	7.9	7.5	8.9	82.3	8.2	1.04	8.5
20	Cap fixing	8.5	8.2	9.4	7.9	7.8	8.7	9.1	7.8	9.3	9.4	86.1	8.6	0.98	8.5

Table 2: Basic time calculation

S. No	Process description	Basic time (seconds)	Personal allowance (seconds)	Fatigue allowance (seconds)	Standard time (seconds)
1	Top assembly	14.3	0.71	0.28	15.3
2	Base assembly	15.9	0.83	0.32	17.1
3	Main assembly	29.3	1.5	0.6	31.4
4	Cap fixing	8.5	0.43	0.17	9.1
5	Front plate assembly and knob fixing	4.9	0.25	0.1	5.3
6	Contact assembly	1.8	0.1	0.04	1.9
7	Inspection	5.6	0.3	0.11	6.0
8	Sticker pasting and packing	6.8	0.34	0.14	7.3

Standard Time Calculation

Personal allowance = 5% of basic time

Fatigue allowance = 2% of basic time

Standard time = Basic time + Personal allowance + Fatigue allowance

Non Value Added Time in Current Layout

Non value added time is observed per batch of 30 numbers is shown below in the table3.

Table 3: Non-value added time

S. No	From	To	Time (Seconds)					Average time (Seconds)
			1	2	3	4	5	
1	Base assembly	Main assembly	3.5	3.2	3.6	3.4	3.3	3.4
2	Top assembly	Main assembly	3.5	3.7	3.3	3.4	3.6	3.5
3	Contact assembly	Main assembly	2.1	2.3	2.3	2	2.3	2.2
4	Main assembly	Inspection	2.4	2.2	2.1	2.3	2.5	2.3
5	Inspection	Cap fixing	2.2	2.1	1.9	2.2	2.1	2.1
6	Cap fixing	Front plate and Knob assembly	2.1	2.5	2.3	2.4	2.7	2.4
7	Front plate and knob assembly	Sticker pasting and packing	2.4	2.7	2.3	2.5	2.6	2.5

Total non-value added time per batch = 3.4+3.5+2.2+2.3+2.1+2.4+2.5=18.4 seconds

Non-value added time per switch = 18.4/30= 0.61 seconds.

Cycle time = (17.1/3) + (31.4/6) + (9.1/2) + (6.0/2) + (5.3/1) + (7.3/1) + non-value added time= 5.7 + 5.2 + 4.5 + 3.0 + 5.3 + 7.3 + 0.61= 31.61 seconds per switch.

In the above calculation, since base assembly, top assembly and contact assembly processes were done in a parallel manner the largest time was taken into account i.e base assembly time. For each assembly process, the time required for each assembly is divided by number of workers doing that assembly process in parallel manner. Non-value added time is then added to get the cycle time per switch. The takt time calculated was 22 seconds per switch which is not matched with the cycle time, which implies that the company is not able to meet out the customer demand at prompt time. They are actually doing overtime work in order to meet out the demand due to which extra labour cost is incurred.

VALUE STREAM MAPPING

Current State Map

The Current State Map (CSM) charts the present flow of information and material as a product goes through the manufacturing process. This is vital both to understand the need for change and to understand where opportunities lie.

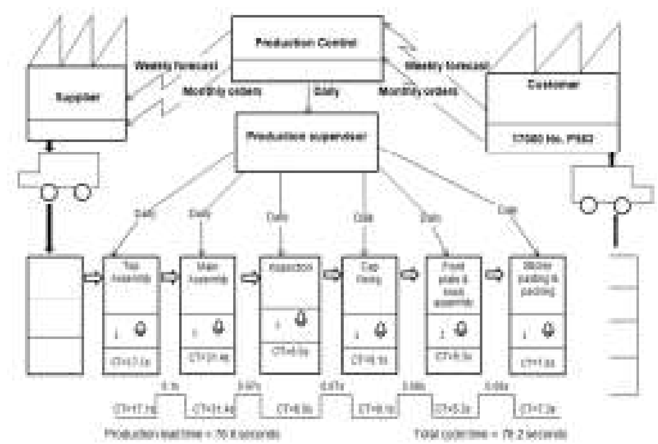

Figure 1: Current state map

After a critical examination of the current state map the following datas were inferred:

There is improper sequence of material flow during the assembly of phase selector switch, the assembly processes that were done in parallel manner were not well balanced, non value added time per switch was observed as 0.4 seconds, production lead time is observed as 76.6 seconds and total cycle time is observed as 76.2 seconds.

Future State Map

The Future State Map (FSM) is a chart that suggests how to create a lean flow. It proposes closing the gap between the CSM and the envisaged. It uses lean manufacturing techniques to reduce or eliminate wastes and minimize non-value added activities. The Future State Map is used to help make decisions that create future process improvements.

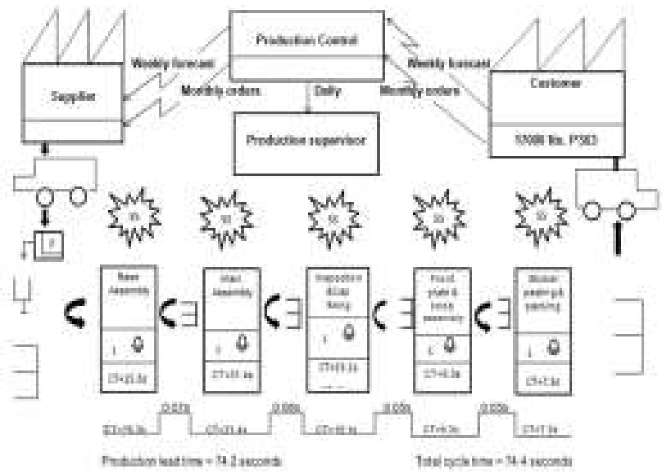

Figure 2: Future state map

The following are the proposals that were depicted in the future state map:

Production lead time is reduced to 74.2 seconds and total cycle time is reduced to 74.4 seconds, Production kanban is to be implemented in order to have good visibility of process flow, 5S system is to be implemented, Inspection and cap fixing processes are to be combined in order to reduce non-value added time and product accumulation.

ASSEMBLY BALANCING

Top, Base and Main Assembly Balancing

In top assembly section three labours are allocated, in base assembly section three labours are allocated and in main assembly section six labours are allocated to do the assembly process. The following time calculations are based upon the number of assemblies that are assembled for time duration of four hours:

Cycle time = 31.61 seconds per switch.

Number of switches that can be assembled for a duration of four hours= 4 hours/31.61

= 4X60X60/31.61

= 455 switches.

Top assembly = 455 numbers

Cycle time for top assembly = 15.3 seconds per switch

Total time required for top assembly = 455 X 15.3

= 6961.5 seconds.

Since three labours are working on top assembly in parallel manner = 6961.5/3= 2320.5 seconds.

Base assembly = 455 numbers

Cycle time for base assembly = 17.1 seconds per switch

Total time required for base assembly = 455 X 17.1 = 7780.5 seconds.

Since three labours are working on top assembly in parallel manner = 7780.5/3= 2593.5 seconds.

For a switch four contact assemblies are required.

Contact assembly = 455X4 = 1820 numbers

Cycle time for contact assembly = 1.9X4= 7.6 seconds per switch

Total time required for contact assembly = 455 X 7.6= 3458 seconds.

Since two labours are working on contact assembly in parallel manner = 3458/2= 1729 seconds.

Main assembly = 455 numbers

Cycle time for main assembly = 31.4 seconds per switch

Total time required for main assembly = 455 X 31.4= 14287 seconds.

Since six labours are working on main assembly in parallel manner = 14287/6= 2381.1 seconds

Lag of time between base assembly and main assembly = 2593.5 - 2381.1= 212.4 seconds

Due to this lag of time accumulation of switches occurs at main assembly which needs to be avoided.

Number of base assemblies that can be assembled in 212.4 seconds =212.4/17.1= 12 switches. These 12 switches has to be assembled by assigning one contact assembly labour for 212.4 seconds. By doing this, accumulation at main assembly can be avoided.

CURRENT ASSEMBLY CALCULATION

The following are the problems faced in the current assembly layout:

Improper sequence of material flow from one assembly to another, unnecessary labour motion, more time required for transport of materials, difficulty in transferring material

In the current scenario, 464 switches can be produced for duration of four hours without considering material transfer time.

Material Transfer time among all the assemblies for four hours = 294.4 seconds

Available time in four hours = (4 X 3600) – 294.4 seconds = 14105.6 seconds

= 3 hours 55 minutes

Total capacity of the assembly for four hours = 464 switches

For 3 hours 35 minutes = (464 X 235 minutes)/240minutes = 455 switches

MODIFIED ASSEMBLY CALCULATION

Non-value added time is calculated for a batch of 30 switches.

Table 4: Non-value added time

S. No	From	To	Time (Seconds)					Average time (Seconds)
			1	2	3	4	5	
1	Base assembly	Main assembly	2.2	2.1	2.4	2.3	2.5	2.3
2	Top assembly	Main assembly	2.4	2.1	2.5	2.3	2.7	2.4
3	Contact assembly	Main assembly	1.7	1.9	1.8	1.6	2.0	1.8
4	Main assembly	Inspection & cap fixing	1.8	1.6	1.9	2.0	2.2	1.9
5	Inspection & cap fixing	Front plate and Knob assembly	1.3	1.8	1.7	1.4	1.3	1.5
6	Front plate and knob assembly	Sticker pasting and packing	1.3	1.8	2.1	1.7	1.6	1.7

Total non-value added time per batch = 2.3+2.4+1.8+1.9+1.5+1.7= 11.6seconds

Non-value added time per switch = 11.6/30 = 0.38 seconds.

Cycle time = (15.3/3) + (31.4/6) + (9.1+6/4) + (5.3/2) + (7.3/1) + non-value added time = 5.1 + 5.2 + 3.7 +2.6 + 7.3 + 0.38= 24.28 seconds per switch.

Material Transfer time among all the assemblies for four hours = 232 seconds

Available time in four hours = (4 X 3600) – 232 seconds= 14168 seconds

= 3 hours 56 minutes

Total capacity of the assembly for four hours = 14400/23.9 switches= 602 switches

For 3 hours 56 minutes = (602 X 236minutes)/240minutes= 592 switches.

Hence, by this proposed assembly layout an additional of 137 (30% increase) switches can be produced in four hours.

CONCLUSION

Summary of the Work

Initially Phase selector switch (PS63) was selected as the candidate component as it has less fluctuation in demand. The problems identified were (i) lack of synchronization between the takt time and the cycle time, (ii) lack of visibility in the assembly process. Value Stream Mapping (VSM) technique was used in order to identify the wastes associated with assembly process. Time study was undertaken for the entire assembly process and critical path was identified. With the help of time study a current state map was developed. A future state map and proposals for implementation were developed. The proposals include kanban system, counter implementation, 5S System, assembly balancing, assembly layout improvement. These suggestions were given to the company and a questionnaire denoting the level of implementation of proposals was obtained from the company.

Contribution

In phase 1 of this project a tentative future state map was developed which is refined during the phase 2 of this project. By implementing various lean tools accordingly the clarity of process flow is made better than before. Cycle time and non-value added time is reduced in such a way that the company will be able to meet out the customer demand at a prompt time.

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