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Productivity improvement through application of theory of constrains and lean principles

M. Sikkandarbasha, A.N. Balaji

U.G. Student, Department of Mechanical Engineering, K.L.N. College of Engineering, Madurai, Tamil Nadu, India

Professor, Department of Mechanical Engineering, K.L.N. College of Engineering, Madurai, Tamil Nadu, India

ABSTRACT— Now a days, the world economy brings great competition between companies that creates an intense pressure. Because of this increasing competition, companies want to improve their process for becoming more efficient to lower costs while improving their quality level and providing a better service. The purpose of this project is to discover areas of improvement in a production flow and to give suggestions on these through finding and eliminating waste in the production environment. Theory of constrains is used to identify the critical points in the production flow. The production flow of a product is mapped by using value stream mapping and analyzed to eliminate the activities which affects the production flow of the product. Change over time reduction method is suggested as a way to eliminate the non value added activities.

KEYWORDS— theory of constrains, lean, productivity, improvement

I. INTRODUCTION

Today's globalization in the world has a huge effect on the competitive environment of industry. So that companies want to be better in almost every area in order to survive. All companies have universal goals like low cost, high profit and quality which affect competitiveness. In the history of industry, the philosophy of manufacturing has changed. The first one, which based on task, was craft production but it was eliminated when the idea of mass production was discovered Nowadays, after the importance of the customer satisfaction is understood by companies, the idea of manufacturing is getting into a new perspective which is called lean production. The term "lean manufacturing" was invented by the International Motor Vehicle Program (at MIT) during the late 1980's but the idea was first told by Taiichi Ohno of Toyota Motors in early 1950's. Applying a successful lean concept will provide some benefits such as reduction in lead times, costs, delivery times and increase in market share, increased profit, increased productivity, high effectiveness and service diversity. Lean has been a huge success, but it has serious limitations such as long time taken, high cost involved, slower execution and less number of improvements in the bottom line. It doesn't guide from which weak area to start in for reaching goal of perfection thereby, creating priority quarrels among different department. On contrast, The Theory of Constraints (TOC) provides a well defined methodology for identifying the priority area and focusing improvements locations having the maximum impact on the entire organization in totality. The combination of the TOC and Lean (TOC –Lean) has become more powerful tool for improving profits and performance.

II. PROBLEM DESCRIPTION

Customer satisfaction is the main goal of companies to survive in this competitive manufacturing environment. In many companies, the management wants to implement a standardized work procedure to reduce their production wastes and to be JIT. However, they fail to implement it. Usage of lean tools will help to reduce waste in production. Main aim of this paper is to find waste in the production flow of a product and to give suitable suggestions to reduce those wastes.

III. LITERATURE SURVEY

According to Mike Rother, real difficulty in increasing productivity is in identifying the wastes in the flow of a product. In Toyoto Production System, the mapping of information and material flow of a product is a very helpful tool to improve productivity. Mike Rother suggests the mapping method, called as "value stream mapping" for companies which are trying to improve their productivity. It is a very effective tool for identifying keen areas for improvement.

Shigeo shingo, author of SMED (Single Minute Exchange of Die) system, told that the major difficulty in many companies was low volume production. This low volume production constitutes a main problem, the setup operations required- calibration, switching of tools and dies. Frequent setup are required to produce many parts in low volume.

In the view of Jay Jina (1997) [5], application of lean principles will be much helpful for the companies which need continuous improvement and reduction of wastes in the industry.

IV. METHODOLOGY

Application of lean concepts to find out waste is the useful one. But which tool we are going to use is the main factor. Value stream mapping is a universal tool proposed by Mike Rother for the companies which want to improve their productivity. In value stream mapping, the material and information flow is noted in the production flow of a product. Thorough analysis of value stream map will help to find out the wastes present in that production flow. This project aims to eliminate waste for a given product family in the production environment. So that a value stream analysis was conducted, and two value stream maps were created; one showing the current state and another showing the desired future state.Times have been measured by using stop watches in the production processes to complement the value stream maps. After the creation of current state map, the production flow is analyzed. Factors which are affecting the flow is found and suitable solutions are generated. From the brainstorming sessions change over time reduction implementation is suggested as a solution to save production time. Data required for change over time reduction implementation is generated using video time study.

A. Value Stream Mapping

In Value Stream Mapping, the current state of the production is mapped. A value stream map is a lean tool used to visualize the material and information flow in the production environment. This will lead to the discovery of waste in the production flow. This mapping method starts with the demand from the customer, i.e. from the end of the flow. This is used to understand the customer. The mapping is then continued backwards through the value stream. As the process is mapped an understanding of the production flow is developed. The process should be viewed with a possible and suitable future state in mind. When the current state is mapped a goal should be formulated and a future state map should be created. The gaps will be present between the two maps and these gaps are needs for improvements. The improvements needed should be formulated in an action plan which will take the company from the current state to the future state [4]. When conducting a value stream analysis, great importance should be given to go out to where the process is physically placed to personally verify that the company documents are in accordance with the actual process [4].

1) Current state map

The current state map of the product Lower Plate (Big) is shown in figure 1. From the current state map, we can understand that there are many areas that needs improvement. In this current map, following wastes are present :

- Inventory
- Push production
- Long Change over time
- Unwanted transportation of materials
- Non continuous flow of materials
- Over production

B. Value stream analysis

In this session, the value stream which is mapped is analysed. From brain storming sessions, more number of ideas are generated. Single Minute Exchange of Die is proposed as the most suitable solution, but where to apply this method? In this situation, Theory of Constrains is used to find out the bottleneck machine [1]. Applying Theory Of Constrains to the current state map, 300 ton power press is found as the bottle neck machine. This 300 ton power press is taken as a model machine for the entire shop floor for future implementation.

B. Change over time reduction (SMED)

The word SMED stands for Single Minute Exchange of Die. If we change the tools of a machine at faster rate, we can save more production time. It will result in greater quality and on time delivery. According to SMED methodology, machine set-up change over is of two types:

- Internal Set-up
- External Set-up

Internal set-up is the change over activities which can only be done when the machines stop or shut down. External set-up activities can be done while machines are running. The aim is to do most of the change over activities while machine is in operation so that the idle time of the machines will be reduced. From the figure 2, it is understood that eliminating internal activities as much as possible will reduce the setup change over time i.e., the time when the machine is not running.

Fig 2. Set up time

SMED is a four stage methodology. First step is to identify the internal and external change over activities. There is no change in worker time but the focus is given to internal activities because each stopping of machine will reduce the production time. Some change over activities can be done while the machine is running. These activities can be found by video tapping, stop watch time study and interviews. The second stage is converting internal steps to external steps. To achieve this, all internal setup steps should be analyzed deeply to separate them as external steps if possible. After defining the internal as external setup steps, all the aspects of setup are improved in step three. In the last stage, unwanted activities are removed and this step leads to standardization of change over process. All the tasks involved in the change over, its improvement ideas and the corresponding time is shown in table 1.

1) Separating internal and external activities

This step is done by using stop watch time study and video study. Total number of activities are noted and they are examined to classify as internal and external setups. The classification of setups for 300 ton power press is shown below :

Total number of activities = 150
Before classification,
No of internal activities = 150
No of external activities = 0
After classification,
No of internal steps = 72
No of external steps = 78

2) Converting internal into external setups

After classification, some of the internal activities can be improved as external activities in order to reduce setup time.

No of internal activities defined = 72
No of activities improved = 24
Remaining internal activities = 48

3) Improvement in internal and external activities

This step requires thorough analysis and knowledge to improve the setup activities. Some activities can be combined as a single activity so that the setup time can also be reduced.

No of internal activities = 48
No of improved activities = 16
Now, no of activities in internal setup = 32

4) Standardization of setup

In this step, the setup activities are classified and standardized. This standardized procedure can be used as a manual for future implementation for other machineries.

Before improvement,
No of internal activities = 150
No of external activities = 0
After improvement,
No of internal activities = 32
No of external activities = 43
So, no of setup activities = 32

5) Time improvement after implementation

Total time taken for setup change over = 172 min 42 sec
Time taken for change over after improvement = 26 min 17 sec
Total saved time = 146 min 25 sec

6) Productivity improvement after implementation

Cycle time of one product = 3.53 seconds
Total saved time = 146 min 25 sec = (146×60) + 25 = 8785 seconds
Production for saved time = 8785 ÷ 3.5 = 2510 products

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VI.CONCLUSION

Lean is a huge successful tool all over the world. TOC is a technique that gives some fundamental similarities as well as differences with Lean. Lean has some limitations on its own but, if combined with TOC, all the limitations can be easily removed to reach the goal of perfection. The TOC–Lean combination can solve any kind of problem which arises throughout the organization. Thus, TOC and Lean (TOC –Lean) combination becomes more powerful tool for improving profits and performance.

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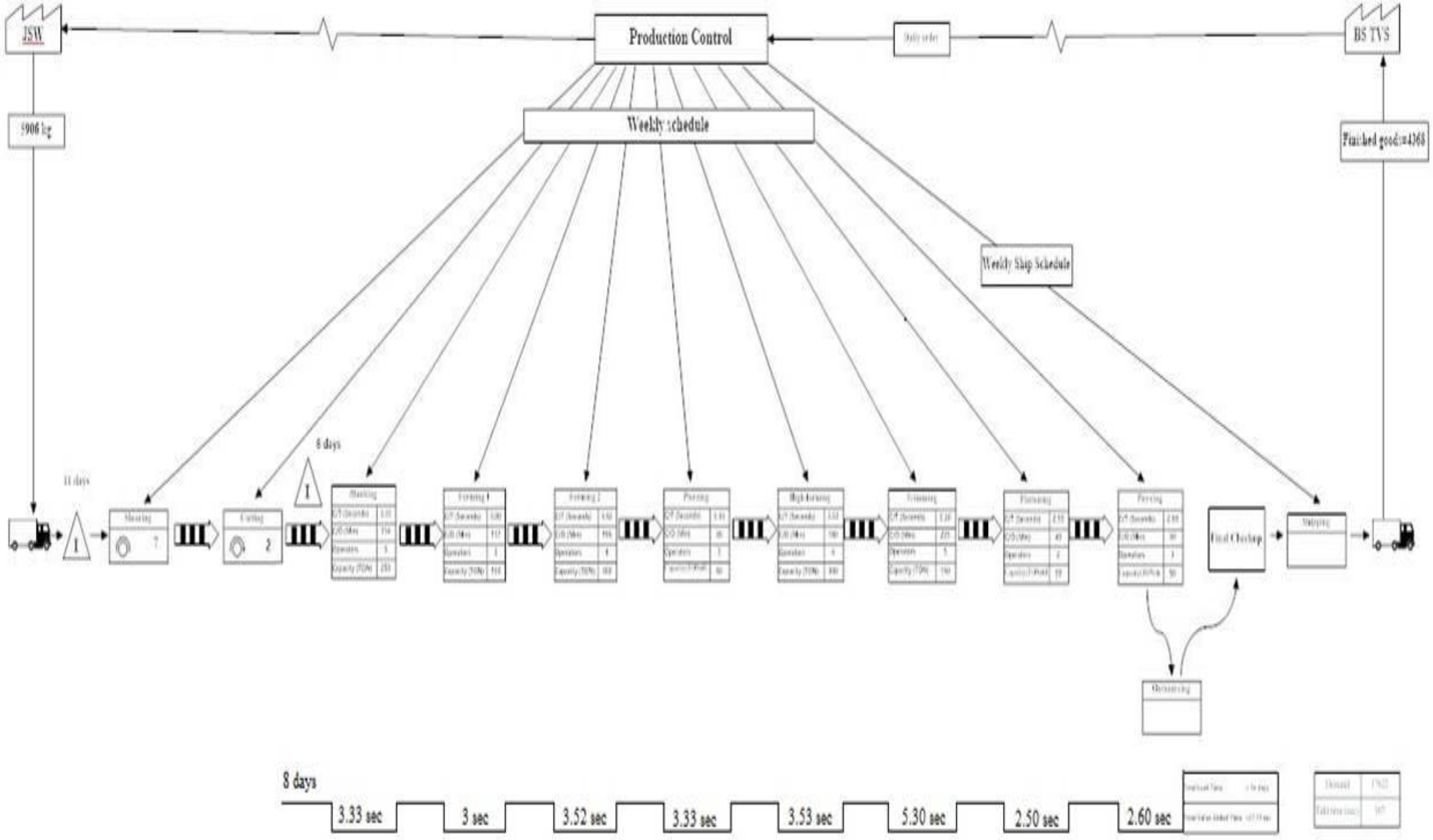

Fig 1. Current state map for lower plate (big)

Table 1. Task, improvement ideas and its time

AREA/DEPARTMENT PRODUCTION						NO .OF OPERATORS 3	TOOLS REQUIRED ALIGN KEY, BOLTS, SPANNER, SLIP GAUGES, HAMMER	DATE	
NO	TASK/OPERATION	TASK TIME (MIN :SEC)		CATEGORY (BEFORE)		IMPROVEMENT IDEAS		CATEGORY (AFTER)	
		CUMULATIVE	ELEMENT	INTERNAL	EXTERNAL			INTERNAL	EXTERNAL
1	Cleaning tool	1:37	1:37	1:37					
2	Removing stripper	0:05	0:05	0:05					
3	Removing rubber bushes	0:05	0:05	0:05					
4	Searching bolts	0:09	0:09	0:09		Introducing point of use storage			0:09
5	Checking tool assembly	0:48	0:48	0:48		Standardised work procedure can be done			0:48
6	Rechecking the assembly	0:42	0:42	0:42		Non value added activity			0:42
7	Removing machine slotter bolts	1:19	0:16	0:16		Positioning of bolt / Design can be changed			0:16
8	Removing machine slotter	0:09	0:09	0:09					
9	Assembling tool, die	0:41	0:41	0:41		It can be avoided			0:41
10	Operator walking	0:12	0:12	0:12		unwanted operator motion should be avoided			0:12
11	Removing upper plate bolts	0:28	0:07	0:07		positioning of bolts can be changed			0:07
12	Removing lower plate bolts	1:02	0:31	0:31		positioning of bolts can be changed			0:31
13	Loosening ram bolt	0:12	0:06	0:06					
14	Operator bend down & taking hammer	0:09	0:09	0:09		introducing point of use storage			0:09
15	Loosening lock nut	0:21	0:21	0:21					
16	Removing tool slotter	0:12	0:12	0:12					
17	Removing lower plate bolts	0:40	0:20	0:20					
18	Loosening & removing clamp	0:06	0:06	0:06		Clamp design can be changed			0:06
19	Removing clamp2	0:21	0:21	0:21		Clamp design can be changed			0:21
20	Cleaning	0:06	0:06	0:06		Unneccessary cleaning should be avoided			0:06
21	Removing cushion pin	0:11	0:11	0:11					
22	Bringing scissor lifter	1:43	1:43	1:43					
23	Lifting scissor lifter	0:18	0:18	0:18		Scissor lifter can be lifted already while bringing			0:18
24	Placing old tool on lifter	0:14	0:14	0:14					
25	Separating upper, lower plate	0:15	0:15	0:15					
26	Removing cushion plate, pin	0:15	0:15	0:15					
27	Placing stripper on lifter	0:05	0:05	0:05					
28	Taking tool to tool room	1:10	1:10	1:10					
29	Placing tool parts on rack	0:21	0:21	0:21					
30	Bringing scissor lifter for taking pillar	1:07	1:07	1:07					
31	Adjusting lifter to hold pillar	0:33	0:33	0:33		Adjustment can be avoided			0:33
32	Placing pillar on lifter	0:05	0:05	0:05					
33	Placing pillar on rack	0:40	0:40	0:40					
	CHANGING BED RING								
34	Removing bed ring from machine	0:43	0:43	0:43		Standardisation of bed ring size			0:43
35	Placing bed ring on rack	0:08	0:08	0:08		Standardisation of bed ring size			0:08

Table 1. Task, improvement ideas and its time

AREA/DEPARTMENT PRODUCTION						NO .OF OPERATORS 3	TOOLS REQUIRED: ALIGN KEY, BOLTS, SPANNER, SLIP GAUGES, HAMMER	DATE
NO	TASK/OPERATION	TASK TIME (MIN :SEC)		CATEGORY (BEFORE)		IMPROVEMENT IDEAS	CATEGORY (AFTER)	
		CUMULATIVE	ELEMENT	INTERNAL	EXTERNAL		INTERNAL	EXTERNAL
36	Taking pins for new ring	0:35	0:35	0:35		Standardisation of bed ring size		0:35
.37	Placing pins on bed	0:19	0:05	0:05		Standardisation of bed ring size		0:05
38	Placing outer ring	0:21	0:21	0:21		Standardisation of bed ring size		0:21
39	Placing inner ring	0:15	0:15	0:15		Standardisation of bed ring size		0:15
40	Removing bottom plate bolts	0:38	0:19	0:19		Standardisation of bed ring size		0:19
41	Removing bottom plate	0:12	0:12	0:12		Standardisation of bed ring size		0:12
….	……..	……	…..	…..		…..		…..
…..	……..	…..	…..	…..		…..		…..
134	Trial run 3	0:21	0:21	0:21		Standard procedure		0:21
135	Taking product to inspection	1:07	1:07	1:07		It can be avoided		
136	Quality check up	3:17	3:17	3:17				
137	Tightening ram bolt	0:36	0:36	0:36		It should be avoided		0:36
138	Trial run 4	0:12	0:12	0:12		Standard work procedure		0:12
139	Taking product to inspection area	0:49	0:49	0:49		It can be avoided		0:49
140	Quality check up	0:48	0:48	0:48		standardized procedure will redude frequent quality check ups		0:48
141	Discussing with factory manager	4:31	4:31	4:31		Standard procedure		4:31
142	Taking product from F.M., room to inspection	0:46	0:46	0:46		Standard procedure		0:46
143	Quality check up	1:26	1:26	1:26		It can be avoided		1:26
144	Discussing with tool room manager	0:25	0:25	0:25		It can be avoided		0:25
145	Machine waiting	33 minutes	33 minutes	33 minutes		Raw material should be ready		33 minutes
146	Trial run 5	0:47	0:47	0:47		Standard procedure		0:47
147	Bringing trolly	4 minutes	4 minutes	4 minutes		It should be done as external		4 minutes
148	Starting production	9 minutes	9 minutes	9 minutes		It can be avoided		9 minutes
149	Production of parts	6 minutes	6 minutes	6 minutes		trial run kind of production can be avoided		6 minutes
150	Idle(for Quality check up & restarting)	28 minutes	28 minutes	28 minutes		idle time can be avoided		28 minutes
	Total time taken for change over			172 : 42		Total saved time		146 : 25