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Energy Conservation for a Paint Company Using Lean Manufacturing Technique

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Abstract In this paper, a paint company is taken into consideration and using lean manufacturing techniques, energy conservation is achieved in its different manufacturing processes. There are several ways in which manufacturing organizations can decrease their waste while increasing productivity; one of it is by implementing lean. Several techniques for lean manufacturing such as Total Productive Maintenance (TPM), Overall Effectiveness of the Equipment (OEE), Process Mapping and Value Stream Mapping are discussed throughout this paper, while Overall Effectiveness of the Equipment (OEE) for the dissolvers and the filling lines are also calculated. After going through the process map, value added and non-value added activities were identified. This helped to reduce energy.

Keywords Paint Company, Lean Manufacturing, (OEE)

1. Introduction

In the book, The Machine That Changed the World, James P. Womack, Daniel T. Jones and Daniel Roos [1] describe lean manufacturing as a production phenomenon that recognizes the expenditure of resources for any purpose other than the procreation of value for the end customer to be wasteful, and thus should be eliminated. "Value" is any action or process that a customer is willing to pay for. Lean Implementation helps in reducing waste and production time and cost. This automatically increases the quality of the product. Improving and optimizing of discreet processes is also part of lean manufacturing [2]. The several tools and techniques used for lean manufacturing in this paper are discussed below.

1.1. Process Mapping

Process Mapping helps in understanding, analyzing and documentation of the processes and activities of an organization and aids in recognizing opportunities for improvement. A process map displays the sequential steps involved in converting a specific input into the required output. There are many advantages of process mapping, they are:

- Effective communication between management, staff and users.
- Identifying efficiency issues.
- Work process can be understood better.

1.2. Total Productive Maintenance

Total Productive Maintenance (TPM) is a basic approach used all over the world for the maintenance of equipment. This in return helps in reducing:

- Breakdowns
- Small Stops or Slow Running
- Defects
- Accidents [3]

1.3. Overall Equipment Effectiveness

OEE (Overall Equipment Effectiveness) recognizes the percentage of planned production time that is truly productive. An OEE score of 100% means perfect production. OEE can be useful for the following reasons:

As a benchmark – It can be used to compare the performance of a given production asset to industry standards, to similar in-house assets, or to results for different shifts working on the same asset.

As a baseline – It can be used to track progress over time in eliminating waste from a given production asset.

OEE is the ratio of Fully Productive Time to Planned Production Time. In practice it is calculated as follows:

$$OEE = Availability \times Performance \times Quality \quad (1)$$

Where:

$$Availablity = \frac{Net\ \ Run\ \ Time}{Total\ \ Available\ \ Time - Total\ \ Planned\ \ Downtime}\ [in\ \min] \quad (2)$$

$$Peformance = \frac{\Pr oduced\ \ Number\ \ of\ \ Batches/ShiftHr}{T\arg et\ \ Number\ \ of\ \ Batches/ShiftHr} \quad (3)$$

$$Quality = \frac{\text{Produced Number of Batches}}{\text{Produced Number of Batches} + \text{Number of Rejected Batches}} \quad (4)$$

Another method by which OEE can be calculated is given by equation (5) below.

OR

$$OEE = \frac{\text{Good Pieces} \times \text{Ideal Cycle Time}}{\text{Planned Production Time}} \quad (5)$$

Where:

- Good Pieces (pieces that are manufactured without any defects).
- Ideal Cycle Time (the theoretical fastest possible time to manufacture one piece).
- Planned Production Time (the total time that the production asset is scheduled for production).
- Fully Productive Time (producing only good pieces, as fast as possible, with no down time) [4].

2. Background

Many companies, all around the world, these days are applying "Lean" in their manufacturing processes. This helps them to reduce waste and production costs, while product quality is also benefitted. Throughout the manufacturing processes it should be made sure that the activities are used in such a way that they add value form the customer's point of view. It is also necessary to include all the five steps mentioned below, in order to remain competitive and successful in the market. These five steps form the main tools of lean manufacturing technique.

1. Cellular Manufacturing – Cellular manufacturing assists in organizing the entire process for a product or similar type of product into a group of team members. It has all the machines and equipments needed, and known as a "cell". Facilities within the cells are arranged to ease all operations.

2. Just In Time – Just in time is a pull system where the demand is transmitted backwards from the final assembly all the way to raw material after the customer has made an order. This helps in checking if all the requirements are completed.

3.Value Stream Mapping – The value stream mapping is a mechanism to compile the complete manufacturing process, all the way from raw material to the delivery to the customer. The main purpose of this is to identify and eliminate waste in the process. It aids in separating value added from non-value added activities.

4. Total Preventive Maintenance – Regular equipment maintenance should be carried to discover anything unusual. Breakdowns can be prevented in this manner.

5. Setup Reduction – Continuously try to reduce the setup time on the machine [5].

Japanese were the first to implement lean methodologies, such as Kaizen and Total Productive Maintenance (TPM) into their manufacturing processes. Nowadays, it is seen that not many people are joining manufacturing industries because of the economical changes in the society. Continuous Improvement, which is also part of lean manufacturing, is essential to survive and flourish in the market.

Due to lack of knowledge, in the earlier centuries, lean manufacturing was never applied as a whole. Nonetheless, they have now started to understand its importance and the fact that it is a philosophy, rather than a set of techniques and tools. Lean Manufacturing is an efficient way to reduce waste, using the resources in production [6].

Due to several barriers noticed by managers, 'lean' was never applied to continuous processes in the manufacturing sector. In one of the papers by Fawaz A. Abdulmalek and Jayant Rajgopal [9] lean principles form the discrete manufacturing principles for a still mill. The main tool used to identify opportunities was Value Stream Mapping, while a simulation model was also developed to describe the 'before' and 'after' scenarios. This helped in decreasing production lead time and work in progress. The results for the model show that it is possible to implement lean in every sector of manufacturing, if proper procedures are followed.

In another paper by T. Melton [7], he mentions that although manufacturing industries are aware of the benefits of lean, but fewer industries have fully tried to implement it. Lean is not just changing a few steps or procedures but it should bring an overall change to the whole business. It helps managers manage employees to do their daily work. As already mentioned above, lean thinking was based in the history of Japanese manufacturing techniques which is now being applied world-wide within many types of industries.

3. Process Mapping Production and Planning

The first step towards implementing lean in any manufacturing organization is to go through their process map, as this helps to recognize all the value added and non value added activities. The figure 1 shows the process map in the form of a flow chart for the manufacturing a batch of paint in chronological order. After spending time on their shop floor for a day and going through their process on a step by step basis, several loopholes were recognized, such as:

1. Inaccurate and incorrect manual data entry for the dissolver handbooks by the shop floor operators. This later on created problem for the person who entered this data in the system and in return creating improper entries in the main system.

2. The process parameters were not followed accurately, such as:

a. The speed was not changed on time. As paint making is a chemical process, certain ingredients should be mixed at a certain speed. Not doing so, can affect the quality of the paint.

b. Ingredients were not entered at the exact time. As this is a chemical process, altering the insertion of ingredients will

affect the end product.

c. Time was not managed properly. Every process of the paint making should follow a certain time limit, but usually this was not done; sometimes more time was given to certain process. This increased the total time taken for manufacturing a can of paint.

3. Miscommunication between) Laboratory and the shop floor at times wasted a lot of time. For example, at times the shop floor workers forgot to inform the Quality Control (QC) Laboratory about the tinting process.

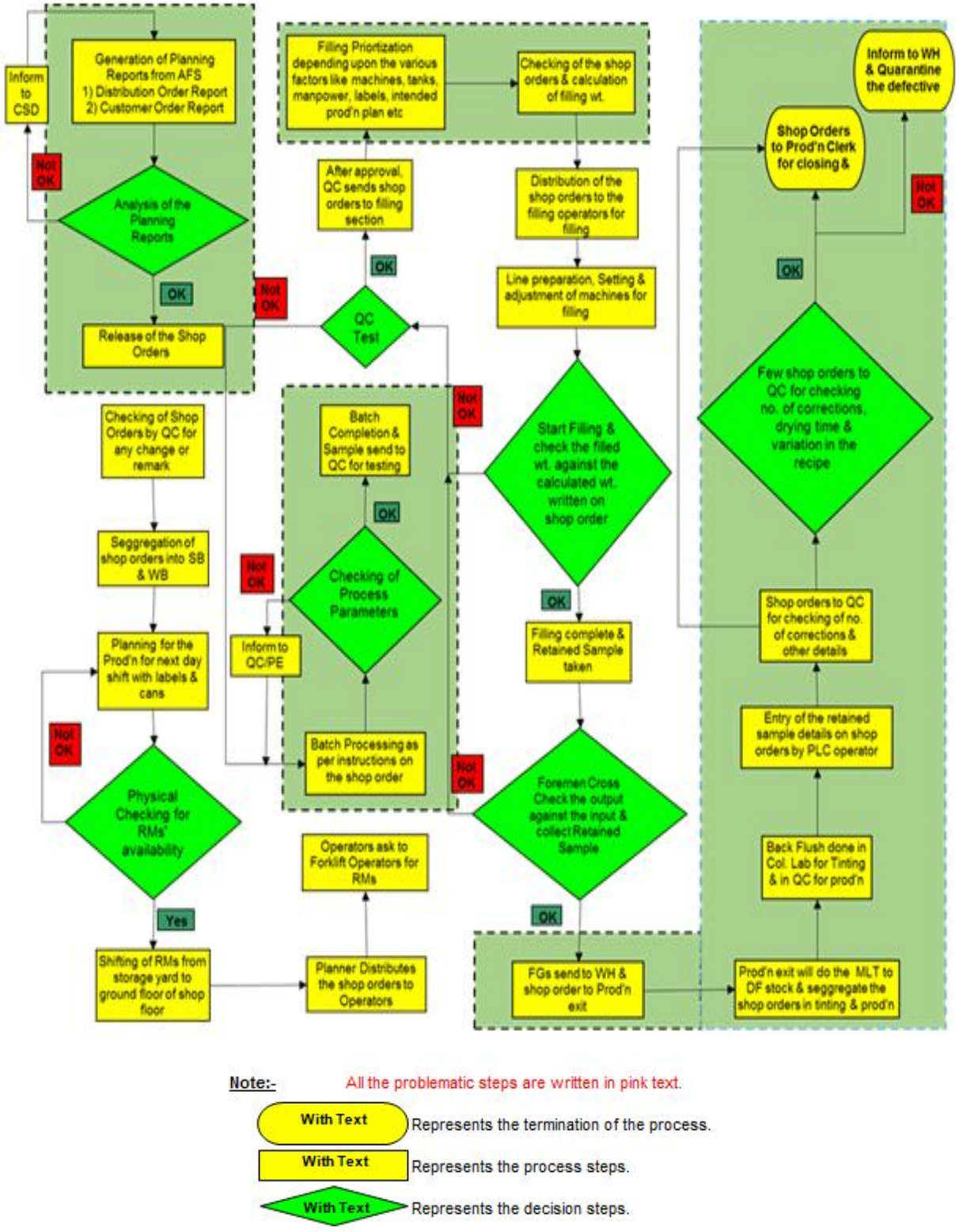


Figure 1. Process Map for Production and Planning

4. Action Plan – How to Overcome these Problems/Bottlenecks

All the problems/bottlenecks faced in the processes mentioned in the previous sectio can be improved using the following methods:

1.Regular checks have to be kept on the employees to ensure continuous improvement.

2.Educating the employees about the importance of lean manufacturing.

3.Training the employees to follow the rules and regulations of he chemical process.

4.The PLC operator has to mention it beforehand on the batch slip, everything that needs to be done with the produced batch of paint.

The time that can be saved by applying all the actions mentioned above is given in the table below.

Table 1. Total time saved from bottlenecks

S#	Problems	Time Saved [in minutes]
1.	Not following the process parameters properly	10
2.	Inaccurate entry of data in the books	15
3.	Communication delay between shop floor and QC laboratory	5
	Total Time Wasted	30

The total minutes that can be saved if these problems and bottlenecks are avoided are 30 minutes. As time is directly proportional to energy, 30 minutes of the worker's energy can be saved, who is working for extra time on the shop floor. This would also lead to a leaner environment, where time and quality, both would be improved.

Total minutes of man energy saved=30 minutes.

5. Results

5.1 Value Stream Mapping

After recognizing the bottlenecks, the process was value stream mapped. The main advantage of value stream mapping is recognizing activities that add value to the product from the customer's perspective. For this reason, all the activities are noted down, with the time spent on each activity, as shown in table 2. Some activities that are interrelated were combined with the dotted lines, as shown in Figure 1.

After all the activities were recorded, the value added and non value added activities were recognized and separated. In the end, this provided with the actual time taken for the activities that added value from the customer's point of view. The table 3 shows the following.

Table 2. Total Time Taken for all the Activities

Str. No.	Activity	Total Time (in Minutes)
	Generation of Planning Reports of two kinds: 1) Distribution Order Report 2) Customer Order Report	180-non
	Analysis of the Planning Reports	
	Release of the Shop Orders	
	Checking of Shop Orders by Quality Control for any change or remark	60-non
	Segregation of shop orders into Solvent Base & Water Base	5-non
	Planning for the Production for next day shift with labels & cans	90-non
	Physical Checking for Raw Materials' availability	90-non
	Shifting of Raw Materials from storage yard to ground floor of shop floor	60
	Planner Distributes the shop orders to Operators	10-non
	Operators ask to Forklift Operators for Raw Materials	30 (For Water Base
		45 (For Solvent Base)
	Batch Processing as per instructions on the shop order	100
	Checking of Process Parameters	
	Batch Completion & Sample send to QC for testing	
	Quality Control Test	3
	After approval, Quality Control sends shop orders to filling section	12-non
	Filling Prioritization depends upon various factors like machines, tanks, manpower, labels, intended production plan, etc.	15-non
	Checking of the shop orders & calculation of filling wt	
	Distribution of the shop orders to the filling operators for filling	5-non
	Line preparation, Setting & adjustment of machines for filling	15
	Start Filling & check the filled wt. against the calculated wt. written on shop order	155
	Filling complete & Retained Sample taken	2
	Foremen Cross Check the output against the input & collect Retained Sample	7
	FGs send to WH & shop order to Production exit	180-non
	Production exit will do the MLT to DF stock & segregate the shop orders in tinting and production	
	Back Flush done in Col. Lab for Tinting & in QC for production	
	Entry of the retained sample details on shop orders by PLC operator	
	Shop orders to QC for checking of no. of corrections & other details	
	Few shop orders to QC for checking no. of corrections, drying time & variation in the recipe	
	Shop Orders to Production Clerk for closing & filing	
	Total Time	1034

Table 3. Value Stream Mapping – Separation of Value Added and Non-Value Added Activities

Value Added	Non Value Added
Shifting of Raw Materials from storage yard to ground floor of shop floor	Generation of Planning Reports of two kinds: 1) Distribution Order Report 2) Customer Order Report
Operators ask to Forklift Operators for Raw Materials	Analysis of the Planning Reports
Batch Processing as per instructions on the shop order	Release of the Shop Orders
Checking of Process Parameters	Checking of Shop Orders by Quality Control for any change or remark
Batch Completion & Sample send to QC for testing	Segregation of shop orders into Solvent Base & Water Base
Quality Control Test	Planning for the Production for next day shift with labels & cans
Line preparation, Setting & adjustment of machines for filling	Physical Checking for Raw Materials' availability
Start Filling & check the filled wt. against the calculated wt. written on shop order	Planner Distributes the shop orders to Operators
Filling complete & Retained Sample taken	After approval, Quality Control sends shop orders to filling section
Foremen Cross Check the output against the input & collect Retained Sample	Filling Prioritization depends upon various factors like machines, tanks, manpower, labels, intended production plan, etc.
	Checking of the shop orders & calculation of filling weight
	Distribution of the shop orders to the filling operators for filling
	FGs send to WH & shop order to Production exit
	Production exit will do the MLT to DF stock & segregate the shop orders in tinting and production
	Back Flush done in Col. Lab for Tinting & in QC for production
	Entry of the retained sample details on shop orders by PLC operator
	Shop orders to QC for checking of no. of corrections & other details
	Few shop orders to QC for checking no. of corrections, drying time & variation in the recipe
	Shop Orders to Production Clerk for closing & filing
Total minutes=387	Total minutes=647

From table 3, it is noticed that although some of the non-value added activities are necessary but they do not add value from the customer's perspective. For example, getting the approval from the higher management may seem necessary for the company's perspective, but the customer is only interested in the end product. It was found out that only 37.42% of the activities are value added, while the rest of the 62.57% are 'necessary' non-value added activities.

The table 4 below shows the summary for the total time taken for the activities in value stream mapping.

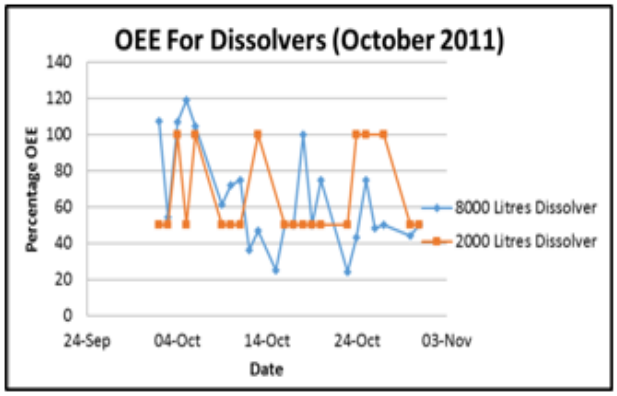
Table 4. Summary of Value Stream Mapping

	Time [in minutes]
All the activities in the Process Map	1034
Value added activities	387
Non-value added activities	647

5.2. Overall Equipment Effectiveness (OEE)

5.2.1. OEE for the Dissolvers

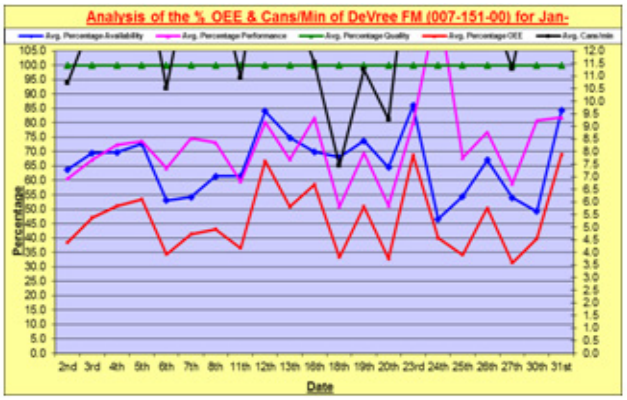
After value stream mapping, OEE is calculated for the dissolvers and the filling lines. The graph below shows the Percentage OEE for one of the 8000 and 2000 liter Dissolvers for the month of October.



Graph 1. OEE for Dissolvers

5.2.2. OEE for The Filling Lines

In the case of filling lines the Average Percentage OEE is calculated. This is because different products are being filled from the same line. The table and graph below show the average percentage OEE for the filling lines for the month of January.



Graph 2. OEE for Filling Lines

5.2.3. Observations from Both the Above Graphs

From the graphs of the Dissolvers and the filling lines it has been found out that:

1. OEE for every machine is different and it does not follow any particular trend line.
2. OEE cannot be predicted, as it keeps on changing everyday according to the needs of the customer and the orders placed for day.

6. Discussions and Conclusions

After going through their process map and value stream mapping the activities, it is understood that lean manufacturing should form an important basis for all the industrial processes. It is a method towards a successful business, as it helps in decreasing waste and increasing productivity, which eventually aids to conserve energy.

The most crucial step towards a lean environment is that the employees of the company are constantly being reminded of the importance of lean implementation to the company and its employees. If lean is properly implemented throughout the system, quality and time, both can be enhanced. This will increase the profits of the company, which would in return result in a raise in salaries. It is found out that around 30 minutes of energy can be saved, if bottlenecks can are avoided.

It also noticed that the non value added activities cannot be removed altogether, as some non value added activities are very necessary for the processes to progress. Although, the time taken to complete these non value added activities could be decreased.

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