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The Analysis of Waste in Paving Production Process by Using Lean Six Sigma Method

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Abstract— CV. X works in manufacturing such as produce paving, concrete brick, road curb, concrete buis, culvert, udith, and panel that located in Cilegon, Banten. The commonly problem faced by CV.X is found some waste in process of paving production such as waiting and transportation. Production pprocess of paving are stirring, printing, drying, and watering process. The aim of this study is to know the score of Process Cycle Efficient (PCE), the level of sigma paving hexagon. In this research, the researchers used Lean Six Sigma and FMEA method. According to analysis of data, known that the initial Process Cycle Efficiency (PCE) is obtained at 8,94%, the sigma level of paving hexagon is 4.02, and waste found waiting, transportation, invention, and defect. The improvement conducted for better condition of Lean, it is increasing the score of Process Cycle Efficiency (PCE) by changing value stream and decreasing or deleting the waste activities. The result of improvement got the Process Cycle Efficiency (PCE) score is increasing becomes 96.94%. from analysis of FMEA, type of waste *defect* with type broken paving become repairing priority firstly because have high value of RPN that was 270 and repairing priority continuously to reduce waste of transportation, *defect* by type of cracked paving, and *waiting*.

Keywords: Lean Six Sigma, Process Cycle Efficiency (PCE), waste

I. INTRODUCTION

Many manufactures both of manufacture and service compete draw consumer's attention. Quality was an indicator that a product was received or rejected by consumer. The effort to increase quality needed to be done to gain consumer of confidence in a product. In addition, in the production activities to produce quality products, need to be accompanied by a reduction in activities that did not provide added value so that it could cause waste. The technique or concept that can be used in an effort to reduce waste and improve quality was *lean six sigma. Lean six sigma* become a methodology in an effort to reduce waste and improve the quality of the production process [1]. Lean six sigma was combination waste reduce technic and repaired process that was *lean manufacturing* and *six sigma.* [2].

Several studies related to quality control and waste minimization have been carried out by several previous researchers. Reference [3] in their research in PT. XYZ conducted a quality control using the lean six sigma approach. The company was experiencing problems, namely the waste in the ongoing production process. To repair continuously was applied 5S for the company and was conducted an evaluated periodically. Reference [4] in their research in PT. X it was known that the machine used for production was not yet known the standard operating time and the level of performance. In addition, waste still occurs frequently on these machines. By using the lean six sigma method, was gotten the result of operational activity was increased. Reference [5] proposed an improvement model with lean six sigma to improve company products and/or services, improve processes, reduce costs, increase city profits and customer satisfaction. The model was proposed in the context of a Portuguese telecommunications company where the project management processes system was based on the Project Management Institute (PMI) standard. Reference [6], have applied lean six sigma method to analyze quality of product which focuses on controlling dominant defects. To identify the cause of defect, *Failure Mode and Effect Analysis* (FMEA) techniques can be used, then can be given a propose improvements based on priority. Reference [7] conducts research in sugar company to improve the quality fefined sugar with the concept of lean manufacturing. The results showed that the application of lean can reduce the number of nonconformities products which means linear with an increase in the value of PCE, while total manufacturing lead time and process lead time decrease. Therefore, this research conducted an analysis of efforts to reduce waste and improve quality through determining the value of PCE in the hexagon paving production process, knowing the sigma level of hexagon paving, and knowing the type of waste that occurs in hexagon paving production process, knowing the sigma hexagon paving level, and knowing the type of waste that occurs in the hexagon paving production process. In addition, the identification of the causes of waste and product defects was carried out with the FMEA concept, so that suggestions can be given based on priorities by looking at the Risk Priority Number (RPN) ranking of each incident.

II. METHOD

In this research, data analyzing was conducted by some steps, as follow:

- Step of *Define*, in this step researcher identified process of production hexagon paving, drew *current Big Picture Mapping* (BPM), identified *waste* based on *Seven Plus One Type of Waste*, and identified *Critical to Quality* (CTQ).

- Step of *Measure*, in this step was conducted assessment of *Process Cycle Efficiency* (PCE) by using formula as follow [8]

$$PCE = \frac{\text{Value Added Time}}{\text{Total Lead Time}} \quad (1)$$

Then, was conducted the calculation DPMO in order to sigma level can be known. The calculation of DPMO was conducted by formula as follow [9]

$$DPMO = DPO \times 1.000.000 \quad (2)$$

To find sigma level can be used conversion table of DPMO or use *software Microsoft Excel* by formula: [9]

=NORMSINV((1000000-DPMO)/1000000)+1,5 (3)

- Step of *Analyze*, in this step researcher will analyse of waste.
- Step of *Improve*, researcher will give a proposing to repair on process of production by repairing *value stream* then draw a *future Big Picture Mapping* (BPM) and identifiy causes of waste by using FMEA.

III. Results and Discussion

A. *Define Step*

In the process production hexagonal paving, there are processes that must be passed, namely stiring, forming, drying, and watering. The result of waste identification was shown on the table 3. Based on the production data that has been obtained it can be described the current process flow conditions or *current Big Picture Mapping* (BPM) and shown on the figure 1. Next, CTQ identification is carried out which aims to find out the cause of defects in the product. In defects, the CTQ is broken and cracked. In detail, product defect data is shown in table 1. Based on the identification of waste that has been done, found four types of, namely waiting, transportation, inventory, and defects.

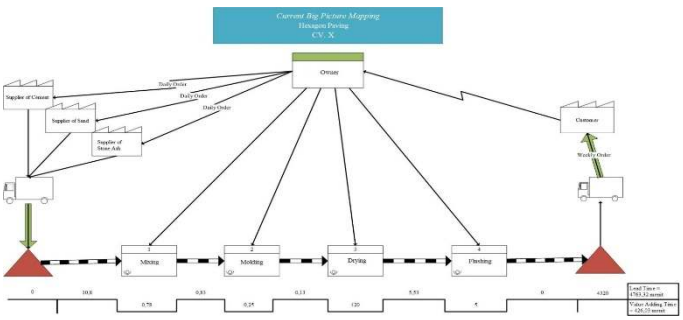

Fig. 1. *Current Big Picture Mapping* process production hexagonal paving

TABLE 1. RECAPITULATION OF HEXAGONAL *DEFECT PAVING*

No	Month	Amount of production		amount *Defect* (Pc)	
		(m^2)	(Pcs)	Broken	Cracked
1	January	95	2470	20	4
2	February	70	1820	9	6
3	March	80	2080	9	5
4	April	120	3120	23	17
5	May	65	1690	21	11
6	June	45	1170	9	12
	Total	475	12350	91	55

B. *Measure Step*

The four step prduction processes of paving, can be used as the basis for designing a big picture mapping with the support of other data. At this stage, a PCE calculation is performed.

$$PCE = \frac{426,03}{4763,32} = 0,0894 \; x\,100\,\% = 8,94\,\%$$

From the result of PCE calculation based on score *value added time* and *total lead time* was obtained value PCE beginning was 8,94%. By using calculation on Ms. Excel then was obtained sigma level of product hexagon paving was 4,02. The calculation formula DPMO as follow:

$$DPMO = \frac{146}{(12350 \times 2)} \times 1.000.000 = 5910,931$$

C. *Analyze Step*

In this step, Waste analysis has been carried out in the hexagon paving production process. From the depiction of BPM and identification of waste, it was found that four wastes occurred in the hexagon paving production process, namely:

1) *Delay* (*waiting*), in the hexagonal paving production process, operators are found waiting for the machine to be ready for use, because the machine must be set up first.
2) *Transportation, Movement of paving to the place of drying and storage that is too much and the distance of the paving conveyance that is too far away, namely the place of final storage.*
3) *Inventories, Inventories that occurs in the hexagonal paving production process at CV. X is the amount of overproduction that is intended as a supply to deal with demand outside the order.*
4) *Defect,* In addition to the three wastes above, in the hexagon paving production process found a type of waste defect.

D. *Improve Step*

In the improve step, identify the causes of waste that have been found. To carry out this identification, the method used is FMEA in which this method will be weighed against the causes of waste. From the RPN value, it will then be determined the proposed improvements made based on priority by looking at the RPN ranking. The results of FMEA analysis shown in apendix 1.

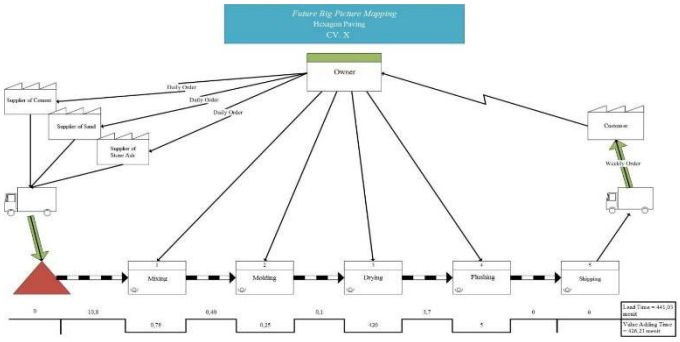

Fig 2. *Future Big Picture Mapping* process production hexagonal paving

TABLE III. PRODUCTION PROCESS ACTIVITIES

No	Activities	Types of waste	Time Before Analysis (minute)	Time After Analysis (minute)
1.	Set up machine	*Delays* (*waiting time*)	10	10
2.	Transfer of raw materials to the mixer	*Transportation*	0,8	0,8
3.	Stirring of raw materials	-	0,78	0,78
4.	Waiting for the printing process (the printing press is waiting for the raw materials to be used)	*Delay* (*waiting time*)	0,61	-
5.	The operator cleans the printing press from debris from spilled material or other objects	-	-	0,18
6.	Take the tray to be stored in the printer	*Transportation*	0,05	0,05
7.	Move raw materials into the printing press	*Transportation*	0,17	0,17
8.	Printing process	-	0,25	0,25
9.	Move paving from printer to place A	*Transportation*	0,05	-
10.	Move paving from printer to place B	-	-	0,1
11.	Move paving from place A to place B	*Transportation*	0,08	-
12.	Drying Proses	-	420	420
13.	Take conveyance from place C to place B.	*Transportation*	2	-
14.	Take conveyance in place B	*Transportation*	-	0,17
15.	Move paving from place B to conveyance (1 ware)	*Transportation*	0,05	0,05
16.	Move paving from place B to place C	*Transportation*	3,4	3,4
17.	Operator conducted moving from conveyance to pallet	*Transportation*	0,08	0,08
18.	Watering (once)	-	5	5
19	Paving was saved	*Inventories*	4320	-
	Lead Time		4763,32	441,03

In addition to making FMEA, in the improve phase there is also an analysis of *future big picture mapping*. After the PCE value is obtained from the current big picture mapping and the type of waste is known, the next step is to make improvements to the value stream by reducing some processes that are considered non value added and necessary but non value added. This is intended to increase the value of PCE in the production process in the future. figure 2 shows the future big picture mapping for hexagon paving products.

From the figure 2 can be known the total *lead time* was 441,03 minutes or 7,35 hours. With this it can be calculated the value of PCE after improvement based on future big picture mapping. Here are the calculations:

$$PCE = \frac{426,21}{441,03} = 0,9664 \ x100\ \% = 96,64\ \%$$

A comparison of the activities of the hexagon paving production process before and after the improvement is shown in table 3.

IV. Conclusion

As conclusion or the important point from this research can be gotten based on result analysis as follow:

- On the current *BPM* was obtained *total lead time* was 4763,32 minutes and *value added time* was 426,03 minutes. From the calculation result was obtained the score of *PCE* the first phase of production process hexagonal paving was 8,94%, and sigma level the paving product was 4,02.
- *Waste* which was found on hexagonal paving production, they are *waiting*, *transportation*, *inventories*, and *defect*. Based on the analysis FMEA was obtained critical *waste* that is *waste defect* on failure mode broken paving.

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