Empirical Quality Control Analysis on Manufacture Industry Process: A Case Study in Development Country

Armin Darmawan*[1], Syamsul Bahri[1], Alamsyah[1]
[1]Program Studi Teknik Industri, Jurusan Teknik Mesin Fakultas Teknik Universitas Hasanuddin
Jl. Perintis Kemerdekaan Km. 10 Tamalanrea - Makassar, 90245
*Email: darmawanarmin@gmail.com

Abstract

This article presents an empirical study on quality control in a manufacture industry to determine level of quality control. Case study conducted in a manufacture that produce many concrete products with different specification and size. Paving block product is the main focus on this study. The industry faces problem related the defective product that influence to low performance and high production cost. Therefore, it is crucial to address the main problem and map the level of quality process using Six Sigma approach. Six Sigma is one the most used structure and systematic tool in defining problem, determine the key factors, map the level quality process, and improvement opportunities. The results show that most defect is dominated by Cracks with the percentage of 94,43 % , fracture with 3,91 % and Broken with 1,67 % which will be classified as Critical To Quality (CTQ). Sigma level that obtained from the production process is 4,23 with the level of defective to 3.198 units per million opportunities (DPMO).

Keywords**:** *CTQ, DMAIC, quality control, six sigma*

I. Introduction

The production process that concern about quality will produce a product that is free from damage. This can avoid waste and in efficiencies so that the production cost per unit can be reduced and the price of the product can be more competitive. Improvements to the quality of the production process must be done continuously in order to minimize product defects. One method that can be used to control the quality and overcome the number of defective products is with the Six Sigma method. Six sigma literature is extensive, although there are many reports on its application, it is extremely important the gathering empirical evidence to build a body of six sigma with better explanatory capability [1].

Six Sigma is a statistical concept that measures a process associated with defects in level six sigma with only 3.4 defects in a million chance. Six Sigma was a management philosophy that focuses on removing defects by emphasizing the understanding, measurement and process improvement [2]. Six sigma is a method or technique for controlling and improving the quality of which is a dramatic new breakthroughs in the field of quality management [3]. Six Sigma implementation can be helpful in reducing the nonconforming units or improving the organization quality and personal development [1]. Six Sigma is the one most tool in identifying and mapping level of quality control production process in developed country.

In the development country, manufacture industries do not consider to monitor the level of quality process. They tend to focus on how to produce as much as possible and gain the maximum profit. The implication of this condition can be identified in recent years that their product can not be competed in regional dan global market. For that, it is important to keep an attention to quality process on manufacture industries in development countries.

II. Methodology

In this study several methods of data collection that field research, a method that is done by direct observation to the company to obtain the data through direct observation of the object to be studied and collected primary data by conducting interviews with several employees. In addition to the primary data, the data used in this study are secondary data from company documentation related to the amount of production and the number of defects produced in last three years (2013-2015).

The main focus in this research is production process of paving blocks (K225) with the size of 10,5 x 21 cm and 6 cm thick.

1. Define

- Process Mapping

This case study map out six stages in production process as shown below.

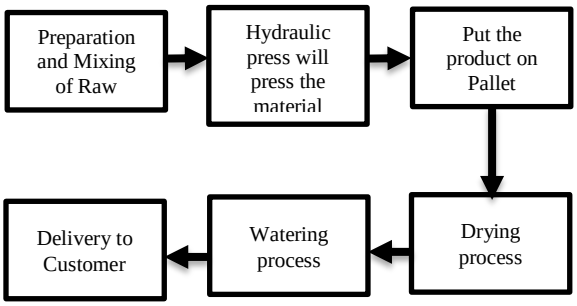

Figure 1. Production process

- Critical to Qualiy (CTQ)

Table 1. CTQ sequence potencial

Defect Type	*Total Defect*	*Percentage (%)*	*Cumulative*
Crack	77.353	94,43	94,43
Fracture	3.200	3,91	98,33
Breaks	1.365	1,67	100
TOTAL	81.918	100	-

The cumulative percentage of sequence CTQ (Critical to Quality) in the production process of paving blocks for more details presented in the following Pareto diagram.

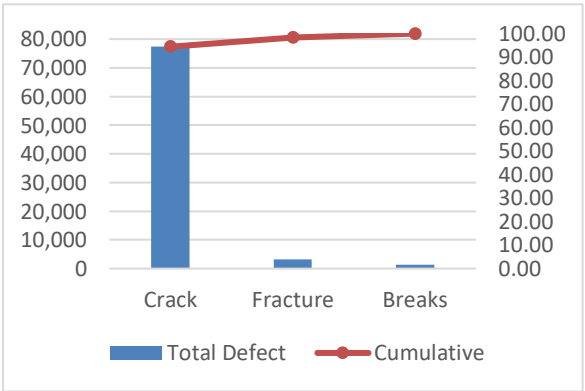

Figure 2. Pareto diagram of paving block total defect in 2013-2015

Based on the Pareto diagram, it is known that the type of defects generated in the production of paving blocks in a row is cracked by 94.43%, fracture 3.91%, and breaks, 1.67%.

2. Measurement

- Capability Process

Measurement of the stability of this process serves to determine how stable the process of production of paving blocks in keeping the quality or how stable production process to meet specifications set by the company management. Calculation results can be seen in the Table 2.

From the calculation in table 2, then the next step can be made p control chart as shown below.

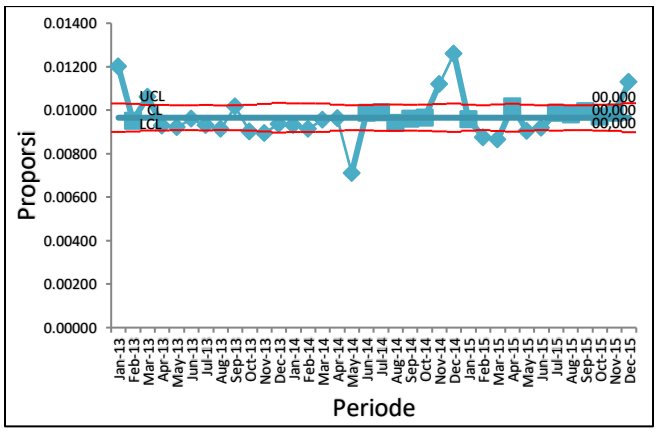

Figure 3. p-chart defect unit in paving block production

Based on Figure 3. indicates that the process is not under control because there are some measurement data that are beyond the limits of control, but it also indicates that there is special cause variation in the production process that need improvement process, special causes partly caused by the presence of wood pallets are damaged. To be able to measure or analyze the capability of a process, the process must be in control [3]. So some measurement data that causes uncontrolled process or extreme data needs to be removed in order to continue the calculation process capability.

Table 2. Summary of results defect proportion

No	Month	Total Production (Unit)	Total Defect (Unit)	Proportion	UCL	LCL	CL
1	Jan-13	200.918	2.411	0,01200	0,01031	0,00900	0,00965
2	Feb-13	212.341	2.018	0,00950	0,01029	0,00902	0,00965
3	Mar-13	249.214	2.645	0,01061	0,01024	0,00907	0,00965
4	Apr-13	249.113	2.314	0,00929	0,01024	0,00907	0,00965
5	Mei-13	264.000	2.431	0,00921	0,01023	0,00908	0,00965
6	Jun-13	264.000	2.532	0,00959	0,01023	0,00908	0,00965
7	Jul-13	249.810	2.322	0,00930	0,01024	0,00907	0,00965
8	Agu-13	271.134	2.475	0,00913	0,01022	0,00909	0,00965
9	Sep-13	261.381	2.654	0,01015	0,01023	0,00908	0,00965
10	Okt-13	246.174	2.221	0,00902	0,01025	0,00906	0,00965
11	Nov-13	214.613	1.921	0,00895	0,01029	0,00902	0,00965
12	Des-13	183.741	1.721	0,00937	0,01034	0,00897	0,00965
13	Jan-14	198.374	1.847	0,00931	0,01031	0,00900	0,00965
14	Feb-14	199.321	1.821	0,00914	0,01031	0,00900	0,00965
15	Mar-14	201.934	1.931	0,00956	0,01031	0,00900	0,00965
16	Apr-14	241.193	2.323	0,00963	0,01025	0,00906	0,00965
17	Mei-14	263.144	1.865	0,00709	0,01023	0,00908	0,00965
18	Jun-14	254.713	2.515	0,00987	0,01024	0,00907	0,00965
19	Jul-14	235.371	2.334	0,00992	0,01026	0,00905	0,00965
20	Agu-14	234.714	2.213	0,00943	0,01026	0,00905	0,00965
21	Sep-14	243.713	2.341	0,00961	0,01025	0,00906	0,00965
22	Okt-14	237.174	2.290	0,00966	0,01026	0,00905	0,00965
23	Nov-14	217.373	2.432	0,01119	0,01028	0,00903	0,00965
24	Des-14	201.841	2.542	0,01259	0,01031	0,00900	0,00965
25	Jan-15	241.815	2.321	0,00960	0,01025	0,00906	0,00965
26	Feb-15	264.114	2.311	0,00875	0,01023	0,00908	0,00965
27	Mar-15	231.491	1.999	0,00864	0,01026	0,00905	0,00965
28	Apr-15	208.141	2.119	0,01018	0,01030	0,00901	0,00965
29	Mei-15	241.814	2.186	0,00904	0,01025	0,00906	0,00965
30	Jun-15	264.812	2.432	0,00918	0,01022	0,00908	0,00965
31	Jul-15	241.741	2.387	0,00987	0,01025	0,00906	0,00965
32	Agu-15	262.311	2.572	0,00981	0,01023	0,00908	0,00965
33	Sep-15	263.414	2.621	0,00995	0,01023	0,00908	0,00965
34	Okt-15	241.231	2.342	0,00971	0,01025	0,00906	0,00965
35	Nov-15	234.819	2.321	0,00988	0,01026	0,00905	0,00965
36	Des-15	193.734	2.188	0,01129	0,01032	0,00899	0,00965
TOTAL		8.484.741	81.918				

Here are the results of calculation of the percentage of disability product (proportion), CL, UCL and LCL after the elimination of data that are beyond the control limit.

Table 3. Summary of results defect proportion (revised version)

No	Month	Total Production (Unit)	Total Defect (Unit)	Proporstion	UCL	LCL	CL
1	Feb-13	212.341	2.018	0,00950	0,01023	0,00896	0,00960
2	Apr-13	249.113	2.314	0,00929	0,01018	0,00901	0,00960
3	Mei-13	264.000	2.431	0,00921	0,01017	0,00903	0,00960
4	Jun-13	264.000	2.532	0,00959	0,01017	0,00903	0,00960
5	Jul-13	249.810	2.322	0,00930	0,01018	0,00901	0,00960

6	Agu-13	271.134	2.475	0,00913	0,01016	0,00903	0,00960
7	Sep-13	261.381	2.654	0,01015	0,01017	0,00902	0,00960
8	Des-13	183.741	1.721	0,00937	0,01028	0,00891	0,00960
9	Jan-14	198.374	1.847	0,00931	0,01025	0,00894	0,00960
10	Feb-14	199.321	1.821	0,00914	0,01025	0,00894	0,00960
11	Mar-14	201.934	1.931	0,00956	0,01025	0,00895	0,00960
12	Apr-14	241.193	2.323	0,00963	0,01019	0,00900	0,00960
13	Jun-14	254.713	2.515	0,00987	0,01018	0,00902	0,00960
14	Jul-14	235.371	2.334	0,00992	0,01020	0,00899	0,00960
15	Agu-14	234.714	2.213	0,00943	0,01020	0,00899	0,00960
16	Sep-14	243.713	2.341	0,00961	0,01019	0,00900	0,00960
17	Okt-14	237.174	2.290	0,00966	0,01020	0,00900	0,00960
18	Jan-15	241.815	2.321	0,00960	0,01019	0,00900	0,00960
19	Apr-15	208.141	2.119	0,01018	0,01024	0,00896	0,00960
20	Jun-15	264.812	2.432	0,00918	0,01016	0,00903	0,00960
21	Jul-15	241.741	2.387	0,00987	0,01019	0,00900	0,00960
22	Agu-15	262.311	2.572	0,00981	0,01017	0,00903	0,00960
23	Sep-15	263.414	2.621	0,00995	0,01017	0,00903	0,00960
24	Okt-15	241.231	2.342	0,00971	0,01019	0,00900	0,00960
25	Nov-15	234.819	2.321	0,00988	0,01020	0,00899	0,00960
TOTAL		5.960.311	57.197				

The results of calculation of the percentage defect product (proportion), CL, UCL and LCL after the elimination of data that are beyond the control limit.

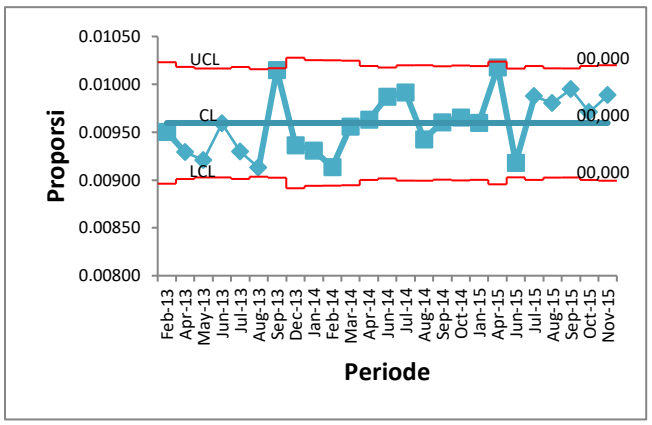

Figure 4. Control chart of Paving Block after revised

Figure 4. above can be seen that the process is already in a stable state because all processes are under control.

- Sig Sigma Level

Measurement of Six Sigma Level and Defect per Million Opportunities (DPMO). Table below shows of the results of calculation of DPMO (defects per million opportunities) and sigma value achievement.

Table 4. Measurement of Sigma Level

No	*Month*	*Total Production (Unit)*	*Total Defect (Unit)*	*DPU*	*DPO*	*DPMO*	*Sigma Value*
1	Feb-13	212.341	2.018	0,009504	0,003168	3.168	4,23
2	Apr-13	249.113	2.314	0,009289	0,003096	3.096	4,24

3	Mei-13	264.000	2.431	0,009208	0,003069	3.069	4,24
4	Jun-13	264.000	2.532	0,009591	0,003197	3.197	4,23
5	Jul-13	249.810	2.322	0,009295	0,003098	3.098	4,24
6	Agu-13	271.134	2.475	0,009128	0,003043	3.043	4,24
7	Sep-13	261.381	2.654	0,010154	0,003385	3.385	4,21
8	Des-13	183.741	1.721	0,009366	0,003122	3.122	4,23
9	Jan-14	198.374	1.847	0,009311	0,003104	3.104	4,24
10	Feb-14	199.321	1.821	0,009136	0,003045	3.045	4,24
11	Mar-14	201.934	1.931	0,009563	0,003188	3.188	4,23
12	Apr-14	241.193	2.323	0,009631	0,003210	3.210	4,23
13	Jun-14	254.713	2.515	0,009874	0,003291	3.291	4,22
14	Jul-14	235.371	2.334	0,009916	0,003305	3.305	4,22
15	Agu-14	234.714	2.213	0,009428	0,003143	3.143	4,23
16	Sep-14	243.713	2.341	0,009606	0,003202	3.202	4,23
17	Okt-14	237.174	2.290	0,009655	0,003218	3.218	4,22
18	Jan-15	241.815	2.321	0,009598	0,003199	3.199	4,23
19	Apr-15	208.141	2.119	0,010181	0,003394	3.394	4,21
20	Jun-15	264.812	2.432	0,009184	0,003061	3.061	4,24
21	Jul-15	241.741	2.387	0,009874	0,003291	3.291	4,22
22	Agu-15	262.311	2.572	0,009805	0,003268	3.268	4,22
23	Sep-15	263.414	2.621	0,009950	0,003317	3.317	4,21
24	Okt-15	241.231	2.342	0,009709	0,003236	3.236	4,22
25	Nov-15	234.819	2.321	0,009884	0,003295	3.295	4,22
	TOTAL	5.960.311	57.197				
	Average			0,009594	0,003198	3.198	4,23

3. Analysis

The third phase in the DMAIC cycle is the process Analysis. Where in this phase will be described in a special cause variation in the production process. This study used a Fishbone Diagram to determine the cause of defective.

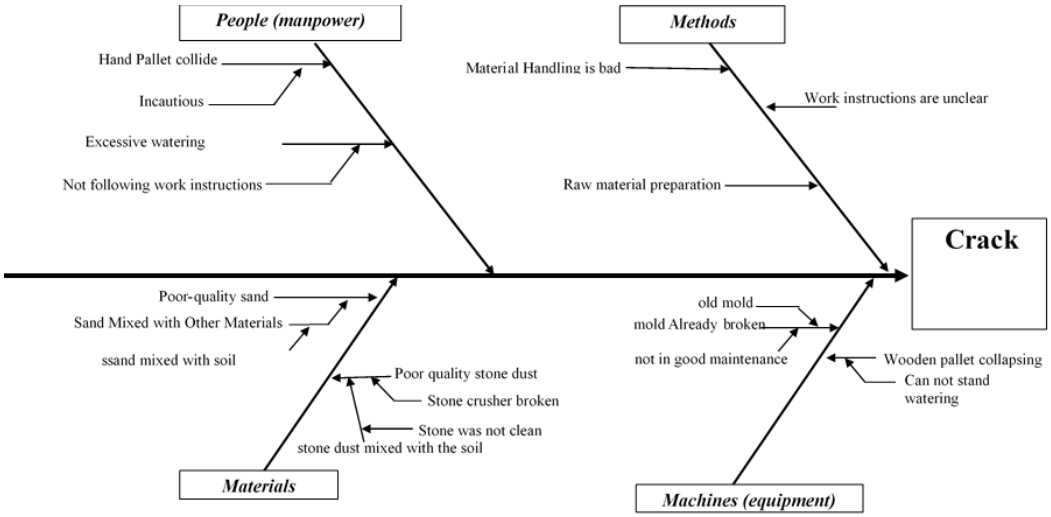

Figure 5. Fishbone diagram for cracks

Diagram analysis describes that the main factor is the cause of the defect are machines and material factors. At machines factor, wood pallets which collapsed due to watering process that continues resulted in many product experience of defect and mold that worn that resulted in the overflow of the material to be printed. At the material factors, the quality of sand and stone dust that bad, affect quality of paving blocks, sand and stone dust mixed with other material will degrade the quality of the material itself.Improvement

An action plan for implementing six sigma quality improvement. After identifying the cause defect for the production process, then formulate a recommendation or proposed improvement actions in general in an effort to reduce the level of product defective.

Table 4. Recommendation

Element	*Causative factor*	*Recommendation*
Machine	1. Mold has worn that results in overflow of the material to be printed, this is caused by the mold which already began to malfunction. 2. The collapse of wood pallets due decomposing	1. Perform regular maintenance of the mold, not only carried out only when the mold damage (preventive maintenance). 2. Provide component parts are often damaged so as not to obstructing the proper course the production process. 3. Replace Wooden Pallet with Pallet that made of steel and other materials which are more resistant to water.
Man	1. Workers doing the watering excessively, due to lack of knowledge and experience working on the handling of the product. 2. Workers are less careful in transporting the product, which causes friction between the products.	1. Conducting human resource development training programs that are conducted regularly, both for new workers, as well as the old workers. 2. Monitoring carried by the Supervisor of workers increased. 3. Develop a standard quantity and duration appropriate watering to avoid excessive watering. 4. Provide punishment to workers that disobey to the rule in order to avoid the same act next time
Material	1. Low level quality sand greatly affects the quality of Paving Blocks, sand mixed with other material will degrade the quality of the material itself. 2. Quality of Stone dust that adversely affects the quality of the product.	1. Check again the raw material that received from suppliers more carefully and check whether it meets the required specifications or not. 2. Changing supplier of raw material providers that committed to maintaining the quality of the material on offer 3. Separate raw material that damaged or defective with raw materials that have good quality.
Method	1. Transportation Process of Finished products less appropriate 2. Raw Materials Preparation bad 3. Work instructions are not clearly understood by the worker make the workers made a mistake and negligence.	1. Make a special lane where the finifhed goods only through that path thus avoid the collision when the pallet is transported. 2. Create a permanent place where a demolition material can be do and maintain the quality of the material. 3. Work instructions given in writing, accompanied by a detailed verbal explanation and carry out regular briefings at beginning and end of each work.

4. Control

In order to achieve the stability in the production process, the recommendations were determined and need to implement. In this phase there are several ways to ensure that every recommendation implemented. One of this way is to adopt and implement the PDCA (Plan Do Check Action) steps.

III. Conclusion

The implementation of Six Sigma shows that considered succesful in identifying and mapping level of quality production process in this industry mainly in development country. This study case can be one sample the best practice in mapping quality in manufacture industry particularly in development counrtry.

Therefore, from this case study, the level of sigma obtained from the calculation using the six sigma on January 2013 - December 2015 period was 4.23 with the possibility of damages amounting to 3,198 unit for million units of production, the level of sigma is already at the level of average of the US industry, better than the average level of sigma of Indonesian industry which stood at 2 - 3 sigma. Potential monthly losses incurred by the company due to a crack amounted 500 US Dollar. This of course be a great loss if not treated, because the more products that fail in the production process must lead to increase production costs.

Factors that cause crack the most dominant influenced by elements Machine and Materials. On Machine element, the worn mold and collapse of wooden pallet to be the cause of defect. In Material element due to the poor quality sand and stone dust.

References

[1] Valles, A., Sanchez, J., Noriega, S., & Nunez, B. G. (2009). Implemenatiton of Six Sigma in a Manufacturing Process: A Cse Study. *International Journal of Industrial Engineering*, 171-181.

[2] Bruce, G. (2002). *Six Sigma for Managers.* Canada: Mc Graw Hill Book.

[3] Gasperz, V. (2007). *Lean Six Sigma.* Jakarta: PT Gramedia Pustaka.

[4] Pande, P.S., Neuman R.P., Cavanagh R.R. *(2002), The Six Sigma Way (Bagaimana GE, Motorola dan Perusahaan Terkenal Lainnya Mengasah Kinerja Mereka)*, ANDI, Yogjakarta.