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Implementation of Six Sigma DMAIC for Improvement of Production Process: A Case Study

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Abstract-CV. Souro Blok is a Manufacturing Company (Construction Material) which is engaged in manufacturing Concrete brick. To maintain market confidence in CV Souro Block products, it is necessary to have quality and consistent products.This paper presents how to implement the DMAIC cycle as an element of continuous improvement in practice. In order to achieve it, the problem of quality and how to control it. Based on company data, an analysis with the application of DMAIC is done. The propositions of improvements, which can be implemented in the company in order to increase the effectiveness of production process, are also presented. Following the Six Sigma DMAIC steps, the company exceeded the established target, significantly improving actualization to reach 9,96 %.

INTRODUCTION

The six sigma method is a method or activity to be able to achieve good operating performance, which is only 3.4 defects for every one million opportunities or 99.99966 percent of products are produced without defects. The use of the design of experiment principle can help companies to solve problems in CV Soru Blok. An optimal combination of factors is needed in order to obtain optimal production performance, in other words minimizing the number of defects that occur. This research will combine the Six sigma method and the response surface method. The aim of this study is to find the sigma value before and after the study. Look for the optimum combination and composition to improve quality by using the Design Of Experiment (DOE) response surface method and determine the SOP for the standard operational at CV. Soru Blok.

CASE STUDY

Define

This study used an instrument consisting of data provided by the company, observations, and experimental data. This data will be used to determine improvements that must be made in the production of concrete blocks to reduce product defects. Secondary data in this study is data provided by the company, either in the form of tables or bookkeeping reports or production data so far. Primary data is data obtained from observations, as well as conducting experiments that become objects to improve the quality of CV Souru Blok.

Measure

After the problem was defined the next step was to collect historical data to get the information about processes which were to be improved, check if there was enough data, documentation of the current situation and also perform the comparative tests. However, the main assumption was to collect and measure data which would be needed at the control stage in order to show the differences and asses the progress. The obtained data are shown on TABLE 1and TABLE 2.

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TABLE 1. Production data of CV Souru Blok

No	Day/Date	Production Amount	Product (%)		Defective Product (%)	
1	11/11/2019	2880	2709	93,12	171	6,88
2	12/11/2019	2880	2679	91,22	201	8,78
3	13/11/2019	2880	2662	90,73	218	9,27
4	14/11/2019	2880	2682	89,24	198	10,76
5	15/11/2019	2880	2667	89,59	213	10,41
6	16/11/2019	2880	2663	89,27	217	10,73
7	18/11/2019	2880	2670	89,51	210	10,49
8	19/11/2019	2880	2663	89,58	217	10,42
9	20/11/2019	2880	2671	89,34	209	10,66
10	21/11/2019	2880	2678	89,27	202	10,73
11	22/11/2019	2880	2680	89,51	200	10,49
12	23/11/2019	2880	2673	89,58	207	10,42
13	25/11/2019	2880	2671	89,55	209	10,45
14	26/11/2019	2880	2678	89,27	202	10,73
15	27/11/2019	2880	2680	89,51	200	10,49
16	28/11/2019	2880	2679	89,53	201	10,47
17	29/11/2019	2880	2671	89,55	209	10,45
18	30/11/2019	2880	2678	89,65	202	10,35
19	1/12/2019	2880	2680	89,79	200	10,21
20	2/12/2019	2880	2679	89,9	201	10,10
21	3/12/2019	2880	2662	89,13	218	10,87
22	4/12/2019	2880	2666	93,12	214	6,88
23	5/12/2019	2880	2669	91,22	211	8,78
24	6/12/2019	2880	2667	90,73	213	9,27
	Rata-Rata	2880	2674.04	90.04	205.71	9.96

TABLE 2. The sigma value before optimization

No	Production Amount	Defective Product	DPU	DPMO	Sigma Value
1	2880	205,95	0,071	71.000	2,97

Analyze

In the Analyze stage, it will be integrated with the RSM Order 1 method which aims to find the root cause and impact of the problem. obtained the model equation and analysis of variance as follows:

$$Y = -6{,}71 + 8{,}997X1 - 0{,}36X2 + 169{,}89X3 + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots$$

Coding :

Y : Response (Total Product)
X1 : Composition of Sea Sand
X2 : Composition of River Sand
X3 : Comparison of Sand and Cement
ε : Eror

The p-value on the lack of fit test is 0.948 or greater than the value of α (0.05), so the decision in the form of H0 is accepted, which means that the model made is in accordance with the data. The p-value for curvature is 0.872 or more than α (0.05), indicating that curvature has no significant effect. From the analysis of the lack of fit regression test and the curvature test above, it is concluded that the first order model is said to be inappropriate, because one of the parameters does not meet it. Because the model in the first order is said to be unsuitable, the analysis is then continued to estimate the higher order model, namely Order II.

Improve

In the second order design, model funding was carried out using a quadratic model. Because the first order cannot provide information about the factors that most influence the response, in the second order the design used is the Central Composite Design (CCD) with a factorial of 23 + 6 (center point) + 6 (axial point).

The model equation for order II is:

Y=-45,81+50,45X1+22,44X2+231,46X3-57,39X12-3,26X22+29X32+3,83X1X2+5,70X1X3 121,13X2X3+e........

Testing the results of the analysis of second order variance above, it can be seen that the simultaneous regression p value is 0.02 or less than the α value (0.05). This means that these factors influence the response. If seen from the p-value of each factor, then the factor is at least α (0.05). To test the interaction between responses, it can be seen that the p-value at X2 * X3 is 0.04 or less than the α value (0.05), this means that the factors X2 and X3 have the greatest influence on the response. After all statistical tests are carried out in the second order, the conclusion is that the second order model is sufficient and suitable to represent the model. Before searching for the optimum point, the model will be refined according to the results of the second order test, namely for the factors that significantly influence the response to be used, only X2 (composition of river sand) and X3 (composition of cement: sand) are used.

$$Y^{u}=4,55+1,27X2+1,23X3+1,55X2^{2}-0,68X3^{2}+1,32X2X3+\varepsilon$$..

From the new equation, the new response value (Y ') will be obtained.

From the 3D curve plot, it is obtained that it is not a perfect parabola, but a saddle point curve, so it is difficult to determine the optimum point of the curve. Determination of the optimum point can be done by analyzing the level of influence of the composition of PS and the composition of Cement: Sand on the total response surface of the Product based on the response surface contour that the total product increases with increasing composition of River Sand and decreasing composition of Cement: Sand.

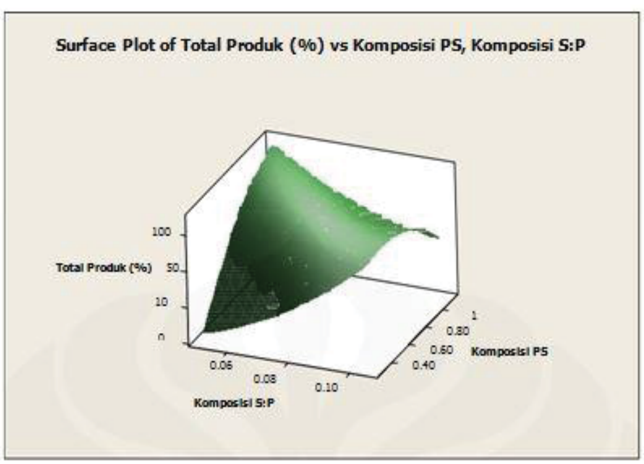

FIGURE 1. 3D Contour Plot for Total Product.

A high quality product, which is close to 100%, is obtained in a high river sand composition range of 0.8-1 and a range of composition of sand: cement 0.08 to 0.10. composition of Cement: Sand = 0.10, where the total product obtained reaches 99.9%, which means that the stationary point is within the predicted maximum range of the total product range.

Control

In addition to the improvement actions in the production process, a Standard Operational Procedure (SOP) will be made to ensure that these improvements will produce a consistent product, in accordance with the wishes of the production. Making SOP can be seen in Table 3.

TABLE 3. Control Results SOP

No	Document type	Approval date	Revision	Title	Work instruction	Information
1	Work instruction	April 2020	-	Composition of River Sand	1	This Work Instruction is based on 100% raw material using river sand.
2	Work instruction	April 2020	-	Composition of Cement: Sand	0,10	This work instruction on the cement: sand ratio uses 1:10

Comparison Before and After Repair

After the Action (standardization) was carried out again, the data comparison was carried out against the brick-based products, so that it was known the effectiveness of the RSM method Experimentation activity.

TABLE 4. Data Before And After Optimization.

No	Day/Date	Production Amount	Before				After			
			Product (%)		Defective Product		Product (%)		Defective Product (%)	
1	11/11/2019	2880	2709	93,12	171	6,88	2856	99,991	24	0,009
2	12/11/2019	2880	2679	91,22	201	8,78	2864	99,994	16	0,005
3	13/11/2019	2880	2662	90,73	218	9,27	2866	99,995	14	0,0048
4	14/11/2019	2880	2682	89,24	198	10,76	2865	99,994	15	0,005
5	15/11/2019	2880	2627	89,59	253	10,41	2871	99,996	9	0,003
6	16/11/2019	2880	2613	89,27	267	10,73	2876	99,998	4	0,001
7	18/11/2019	2880	2570	89,51	210	10,49	2875	99,998	5	0,001
8	19/11/2019	2880	2563	89,58	217	10,42	2877	99,998	3	0,001
9	20/11/2019	2880	2571	89,34	209	10,66	2872	99,997	8	0,002
10	21/11/2019	2880	2578	89,27	202	10,73	2874	99,997	6	0,002
11	22/11/2019	2880	2580	89,51	200	10,49	2876	99,998	4	0,001
12	23/11/2019	2880	2573	89,58	207	10,42	2875	99,998	5	0,001
13	25/11/2019	2880	2571	89,55	209	10,45	2877	99,998	3	0,001
14	26/11/2019	2880	2578	89,27	202	10,73	2874	99,997	6	0,002
15	27/11/2019	2880	2580	89,51	200	10,49	2874	99,997	6	0,002
16	28/11/2019	2880	2579	89,53	201	10,47	2872	99,997	8	0,002
17	29/11/2019	2880	2571	89,55	209	10,45	2874	99,997	6	0,002
18	30/11/2019	2880	2578	89,65	202	10,35	2876	99,998	4	0,001
19	1/12/2019	2880	2580	89,79	200	10,21	2875	99,998	5	0,001
20	2/12/2019	2880	2579	89,9	201	10,10	2872	99,997	8	0,002
21	3/12/2019	2880	2582	89,13	298	10,87	2874	99,997	6	0,002
22	4/12/2019	2880	2586	93,12	294	6,88	2874	99,997	6	0,002
23	5/12/2019	2880	2589	91,22	291	8,78	2876	99,998	4	0,001
24	6/12/2019	2880	2567	90,73	213	9,27	2875	99,998	5	0,001
	Rata-rata	2880	2597.79	90.04	205.95	9.96	2872.5	0.997	7.5	0.003

TABLE 5. The Sigma Value Before And After Optimization

No	Production Amount	Defective Product		DPU		DPMO		Sigma Value	
		Before	After	Before	After	Before	After	Before	After
1	2880	205,95	7,5	0,071	0,003	71.000	3.000	2,97	4,25

From the two tables before and after the repair process, there are significant differences. Prior to repair, the average brick product defect was 9.960% and after repair was only 0.003% there was a difference of 9.957% with a sigma value of 2.97 before repair and 4.25 after repair, meaning that the process of producing a product in accordance with specifications. So it can be concluded that the control taken has been effective for this problem.

CONCLUSIONS

The conclusion is the answer to the objectives, among others:

- In this study, the DMAIC method integrated with the RSM method and SOP control was able to reduce the number of product defects from 9.96% to 0.003% and increase the sigma value from 2.97 to 4.25.
- Of the three factors, namely the composition of sea sand (PL), composition of river sand (PS), and composition of cement: sand that affect the amount of product, namely the composition of PS and composition of S: P alone which have the greatest influence or significant effect on the production of these brick blocks.
- The optimum point predicted from the composition of PS and composition of S: P which produced the maximum product, namely, for the composition of PS = 1 (100%) and composition of S: P = 0.10 (1:10).
- From the experimental results, it produces SOP with 100% work instruction of raw sand using river sand and a material ratio of 1:10 (Cement: Sand).

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