Chapter

Analysis of Quality Control of the Production Process of Rotary Kiln III Using the Lean Six Sigma Method at PT. XYZ Southeast Sulawesi

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Abstract

Quality control is a verification system from a process level to measure the characteristics of product quality, compare specs and ensure quality in accordance with the predetermined standards. PT. XYZ Southeast Sulawesi is one of the FeNi (FerroNickel) processing factory companies that really pay attention to the quality of the products produced, in the work division at PT. XYZ Southeast Sulawesi still has defective products, one of which is the Rotary Kiln III section. Therefore, research is carried out in that section to detect out what factors cause product failures and seek improvement suggestions to minimize the types of failures that occur. The method used is Lean Six Sigma. The stages in this analysis use the define, measure, analyze, improve, and control (DMAIC) stage. The average value of the Sigma level in the Rotary Kiln III section is 4028 with a DPMO value of 5745. In the Rotary Kiln III section, the root cause analysis of the problem with a Fishbone diagram is then executed to improve using the FMEA method.

Keywords: quality control, Lean Six Sigma, DMAIC, fishbone, FMEA, clinker, RPN

1. Introduction

Quality is a dynamic condition related to products, services, people, processes and the environment that satisfy or exceed consumer expectations [1]. Good quality according to the manufacturer is if the product produced by the company is in accordance with the specifications determined by the company, continuous quality improvement is absolutely necessary in industrial competition [2]. Product quality is an overall evaluation process to customers for improving the performance of a product [3]. Quality control is a system of verification and maintenance or maintenance of a desired level or process by means of careful planning, use appropriate equipment, continuous inspection, and corrective action where necessary [4, 5]. Quality control is an activity (company management) to maintain and direct the quality of the company's products or services as planned by Ahyari [6]. Minimizing defects is an effort that must be performed continuously in terms of improving the quality of a product. Therefore, it is very important for companies to implement a method of quality control and improvement that can help reduce defects in developing products [7].

PT. XYZ Southeast Sulawesi is one of the companies processing FeNi (FerroNikel). The processes that exist in PT. XYZ Southeast Sulawesi starts with ore preparation, smelting, to refining. One of the ferronickel processing processes at PT. XYZ Southeast Sulawesi is the calculation process of laterite nickel ore in Rotary Kiln. The calcination process is a part of ore preparation, which aims to prepare the laterite nickel ore before smelting, namely by suppressing the water content of the crystals in the ore while reducing some of the ore to metal. The calcination process in the Rotary Kiln often feels so much that the Clinker is formed.

In the Rotary Kiln production process, at that place are operating parameters that must be considered in order for the process to run smoothly, the first parameter is the fullness of the Rotary Kiln, fullness, which is the number of ores that fill the kiln space. The next parameter is the operating temperature, if the operating temperature is too low, the LOI level will be high, that is, when the LOI is >1%, thus reducing the quality of calcine, if the operating temperature is too high it will increase the possibility of clinker formation. The next parameter is the retention time duration, if the retention time duration is also too low, the heat received by the ore will not be evenly distributed so that the moisture content of the ore is not reduced maximally, if the retention time duration is too fast, the potential for clinker will increase and result in a lack of calcine production.

PT. ANTAM Tbk. Southeast Sulawesi UBPN Rotary Kiln III department has a production target of Condition Ore of 60,140 tons or 42,101 tons of calcine (**Figure 1**).

Six sigma is a method that is being developed in today's world. The application of six sigma is expected to reduce failure (damage) in achieving the desired quality goals in increasing the amount of production [8]. Lean Six Sigma is an interesting method used to measure quality and make improvements to improve the quality of goods or services [9]. Lean and Six Sigma integration will improve business and industry performance through increased speed and accuracy [10].

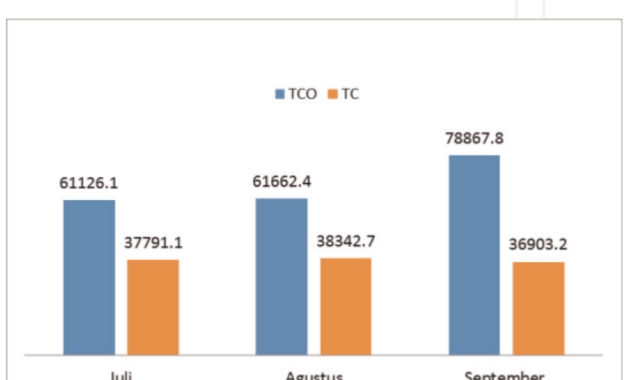

Figure 1.
Production result TCO & TC.

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2. Research methodology

2.1 Time and place of research

The place of research in this writing was conducted at PT. XYZ Southeast Sulawesi on Jalan Jend. Ahmad Yani No. 5, Pomalaa, Kolaka Regency, Southeast Sulawesi. The research was conducted for approximately 1 month start from July – August.

2.2 Data sources

1. Primary data are in the form of production data and breakdown data.

2.3 Data collection methods

2.3.1 Observation

Through this observation technique the author collected data by making direct observations at the Rotary Kiln III department.

2.3.2 Interview

A method for receiving data and information by communicating directly with Rotary Kiln III assistant manager.

3. Results and discussion

3.1 Define

This stage contains data on the flow of the production process starting from the Supplier to the Customer in the Rotary Kiln III section and identifies what wastes are in the Rotary Kiln III section.

From the **Figure 2** above, it explains that the supplier of the Rotary Kiln section is Ore preparation, the input is in the form of ore preparation, the Rotary Dryer input is ore with MC 22 ± 1% and the input ore mixes is an ore + coal condition which will be processed in the production process. The production process is carried out by the drying zone section with a temperature of 250–300°C for 47 minutes, Preheating zone

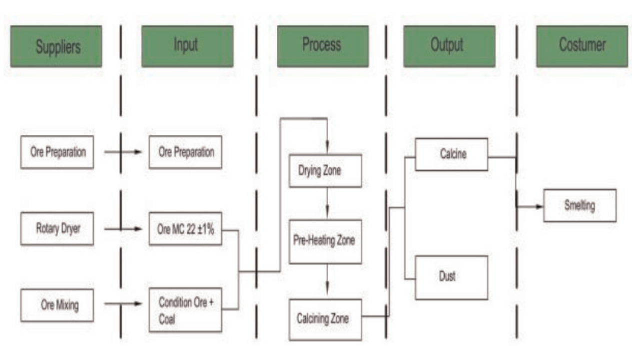

Figure 2.
SIPOC diagram.

No	Month	Sample Rotary Kiln III	Number of Defects	Proportion of Defects	UCL	CL	LCL
1	July	61126.1	1055.2	0.01726268	0.241962411	0.017123	−0.207437061
2	August	61662.4	1142.6	0.01852993	0.243229667	0.017123	−0.206169805
3	September	78867.8	1255.2	0.01591524	0.240614977	0.017123	−0.208784496
	Total	201656.3	3453	0.051707846			

Table 1.
Control chart calculation.

with a temperature of 700–850°C for 47 minutes, and a calcining zone with a temperature of 900–1000°C for 35 minutes. This section removes moisture until the water content is below 1%. Furthermore, the output of the process is in the form of calcine and dust where the calcine will be processed to the next stage, namely the Smelting department. The zones that produce the most defective products are the preheating zone and the calcining zone. Defective products in this section can come from suppliers and originate from the production process itself (**Table 1**).

3.2 Measure

3.2.1 Determination of product control limits

1. Calculating Proportion of Defects

$$P = \frac{\mathrm{np}}{\mathrm{p}} \tag{1}$$

2. Calculating the Center Line (CL)

$$\mathrm{CL} = \dot{\mathrm{p}} \tag{2}$$

3. Calculating Upper Control Limit (UCL)

$$\mathrm{UCL} = \dot{\mathrm{p}} + 3\left(\sqrt{(\dot{\mathrm{p}}\ (1 - \dot{\mathrm{p}})/\mathrm{n}}\right. \tag{3}$$

4. Calculating Lower Control Limit (LCL)

$$\mathrm{LCL} = \dot{\mathrm{p}} - 3\left(\sqrt{(\dot{\mathrm{p}}\ (1 - \dot{\mathrm{p}}))}\right)/\mathrm{n} \tag{4}$$

3.2.2 Calculation of DPMO (defect per million opportunity) & sigma level

The results of the calculation of the DPMO value are used to determine the ratio of defects one per one million opportunities. From the calculation results, the average DPMO value of 5745 means that there is a possibility of 5745 defects that will occur in

Defect	CTQ	DPU	TOP	DPO	DPMO	Sigma
1055.2	3	0.017	183378.3	0.006	5754	4.027
1142.6	3	0.019	184987.2	0.006	6177	4.002
1255.2	3	0.016	236603.4	0.005	5305	4.055
3453		Average			5745	4.028

Table 2.
DPMO Value & Sigma level value.

one million outputs or units of Rotary Kiln III resulting from the Drying Zone process, Preheating Zone, and Calcining Zone. Meanwhile, if converted into sigma value, the value obtained is 4028, which is the achievement of the industry average six sigma level (**Table 2**).

3.3 Analyze

The use of the Fishbone diagram is to see the relationship between the problems faced with the possible causes and the factors that influence it. The Fishbone diagram is an analytical tool used to analyze what happens in the production process resulting in the formation of clinkers (**Figure 3**).

The following is a discussion of the Fishbone diagram and validation of the causes of defects of each type of defect that occurred in the Rotary Kiln III section:

4. Method

The absence of an appropriate temperature standard for each production resulted in the formation of excessive clinker.

4.1 Material

a. A full top bin result in stopping the production process to wait for the top bin to be empty or ready to be filled.

b. The exhaustion of fuel results in the cessation of the production process because the production process is not optimal.

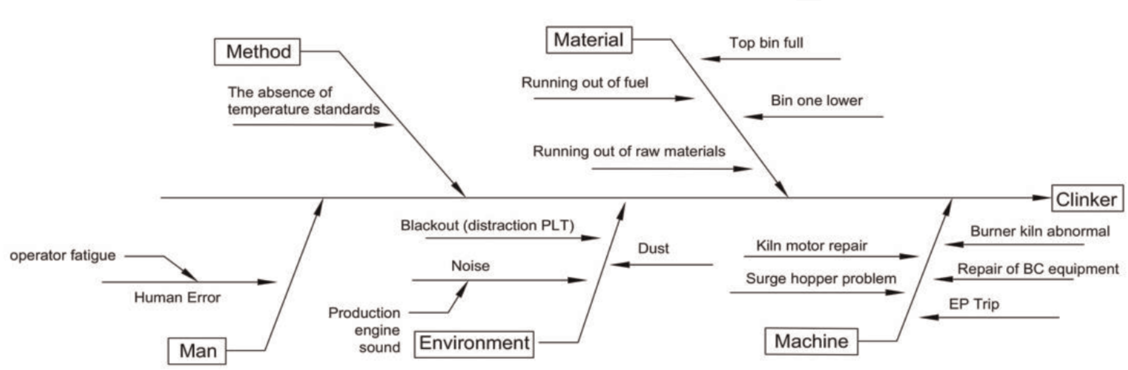

Figure 3.
Fishbone diagram.

c. Bin ore lower occurs due to a decrease in the production process in ore mixing, which result in a halt in the production process at Rotary Kiln III to wait for bin ore to be refilled

d. Raw Material depletion is very rare but this occurs when production decreases or there is a problem with the Rotary Dryer which result in the production process of ore mixing not being carried out.

4.2 Man

Human Error that occurs when the operator is tired and becomes unfocused and causes the error to increase or decrease the temperature during the production process and also the rotation duration of the Rotary Kiln.

4.3 Environment

a. Blackout Blackout (PLT disruption) resulted in the cessation of all production processes that are being carried out in each existing department. This usually happens when there is interference that occurs in the PLT itself.

b. The dust that is generated around the production floor interferes with employee activities at work, because it sometimes interferes with breathing.

c. Noise due to the sound of production machines greatly disturbs the focus of employees in carrying out production activities.

4.4 Machine

a. Abnormal Kiln Burner results in inappropriate combustion fuel and air which results in stopping the production process for checking.

b. Repair of the Kiln Motor is carried out when the kiln rotation does not rotate as specified in the setting.

c. Repair of Belt Conveyor (BC) Equipment resulted in the cessation of material (ore) transportation into the kiln room.

d. Problematic Surge Hopper resulted in the interruption of the production process because checks and repairs had to be done in order to accommodate the production of Rotary Kiln III.

e. Electrostatic Partikel (EP) Trip causes fine dust on the Rotary Kiln not to be caught and enter the production results.

4.5 Improve

Failure Mode and Effect Analysis (FMEA) is used to determine the priority level of the causes of defects that occur [11]. From the Risk Priority Number value obtained from the Severity, Occurrence and Detectability values, it shows that the causes that have the highest RPN value can be made improvements to reduce or even eliminate these defects.

Failure Mode and Effect Analysis (FMEA) is used to determine the priority level of the causes of defects that occur. From the Risk Priority Number value obtained from the Severity, Occurrence and Detectability values, it shows that the causes that have the highest RPN value can be made improvements to reduce or even eliminate these defects (**Table 3**).

The highest RPN value with the cause of the resulting combustion heat is not in accordance with the RPN value of 448. Suggestions for improvements that can be made are scheduling maintenance and scale inspection.

The lowest RPN value caused the disruption of employee activities with an RPN value of 60. Suggestions for improvements that can be made are adding or updating EP.

4.6 Control

For quality control proposals, namely continuous improvement to reduce defective products that arise so that production targets can be increased and as expected. The

Failure Mode	Cause of Failure	Proposed Improvement	RPN
Clinker	The resulting combustion heat is not suitable	Maintenance scheduling and periodic inspections	448
	Lack of checking during maintenance	Maintenance scheduling and periodic inspections	392
	Lack of maintenance	Maintenance scheduling and periodic inspections	343
	Conveyor Belt transports excess material	Maintenance scheduling and periodic inspections	294
	There is no suitable scheduling	Make a schedule to keep the production process running	240
	Incorrect machine settings	Perform checks and set standards for temperature	224
	The amount of dust generated during production	Maintenance scheduling and periodic inspections	210
	Lack of proper checking and scheduling	Set a schedule for periodic checks	200
	Lack of checking	Set a schedule for checking	180
	Poor equipment performance and interruption of the operation process	Inspection of tools that support engine performance at PLT	160
	Lack of scheduling checks	Set a schedule for checking	150
	Reduces employee focus	Implement a sound suppressor	84
	Employees lack focus	Monitor operator performance	70
	Interferes with employee activities	Add or update EP	60

Table 3.
Proposed repair and sequence of causes of failure based on RPN.

implementation of lean six sigma in the company can increase the current sigma value of the company so that the company can strive to achieve a 6 sigma value. The following are proposed controls that can be used to address the root causes of existing problems:

a. Check and clean the machine regularly

b. Creating a check form as a control of machine conditions.

c. Perform periodic machine condition reports.

5. Conclusions and suggestions

5.1 Conclusion

The conclusions obtained after processing and analyzing data are as follows:

1. The average value of DPMO is 5745 with a sigma value of 4028 out of 2570, which means that the capability is good enough, but it is necessary to control the quality so that the resulting product reaches zero defects.

2. To minimize failures that occur, it is necessary to schedule machine maintenance and periodic checks. And by knowing the factors that cause the failure that occurs, the quality will increase so that the production target will be achieved. The most influential factors causing the failure are the Abnormal Kiln Burner, the repair of the kiln motor, and the problematic Surge Hopper.

5.2 Suggestion

Suggestions that can be given to companies to become input for the Rotary Kiln III section in an effort to reduce failed products and control the production process are as follows:

1. By knowing the sigma level on product failure at Rotary Kiln III, it is expected that the company can minimize failed products so that the company's sigma level value can increase and the resulting failed products can decrease.

2. We recommend that the company be able to periodically check machines with a planned schedule so that the production process can be controlled and the expected production targets can be achieved.

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