Application of Six Sigma in Quality Control Process at Indonesian Cement Company

Darjat Sudrajat [1*], Hardijanto Saroso [2], Lasmy [3], Maria Grace Herlina [4], Dicky Hida Syahchari[5]

[1,2,3,4,5]*Management Department, BINUS Business School Undergraduate Program, Universitas Bina Nusantara Jakarta, Indonesia*
[1]darjat.sudrajat@binus.edu
[2]hardijanto.saroso@binus.edu
[3]lasmy@binus.edu
[4]herlina01@binus.edu
[5]dicky.syahchari@binus.edu

***Abstract*— An Indonesian Cement Company is facing the number of product's defects in the packing process more than 200.000 bags or sacs annually. It is estimated to cause losses more than one billion rupiahs per year. Therefore, the Six Sigma method was proposed to solve this problem. This study was constitute a descriptive research; whereas based on its strategy, this study was constitute a case study; In addition based on time horizon, this study was constitute a longitudinal study. In the research used DMAIC processes, namely encompasses Define, Measure, Analyze, Improve and Control. The research's results found that the existing process quality of cement packing in the company is out of control. So that the improvement process is needed by eliminating the causes of its. The main cause that must be a priority in its improvement is the machine (belt-conveyor) condition in the cement packing process. The main solution to prevent the occurrence of the main cause namely by checking the machine (belt-conveyor) before and after shift exchange by using a checksheet periodically. By implementing the Six Sigma method, it is hoped that the cement company can reduce or eliminate the existing waste estimated amount of one billion rupiah annually**

***Keywords*—** *Six Sigma, DMAIC Processes, Quality Control, Process Improvement, Cement Packing Process.*

1. Introduction

According to [1] that cement consumption until the end of the third quarter of 2019 in Indonesia grew negatively by 2.2% from the realization of the same period last year to 45.75 million tons. Assuming consumption by the end of the year will remain -2.2%, the utility of cement manufacturers will drop to 61.01% because the installed capacity of cement manufacturers will increase 1.36% or 1.5 million tons this year. With the declining domestic conditions, several producers are trying to enter export markets such as Australia, Bangladesh, Sri Lanka, China, Maldives, Philippines, Timor Leste and Papua New Guinea. According to the Association, export destination countries will increase because domestic manufacturing utility space is still large or equal to 25 million tons.

In connection with that, efficiency of operations activities is very important in improving these companies' competitive advantage. One of operations activities to increase the efficiency such as avoid products' defect due to it will cause waste. Therefore, quality control plays an important role in eliminating the waste. One source of product's defects in the cement production process is the packing process. In a cement company, the number of product's defects in the process more than 200.000 bags or sacs annually. It is estimated to cause losses of more than one billion rupiahs per year. One of tools that can be used to solve this problem is six-sigma. According to [2], Six Sigma constitute a performance management system to execute business strategy. It aligns improvement process through business strategy and business goal metrics. It also refers to a disciplined and data-driven methodology for improving, designing, and managing processes, by focusing on improving business performance and meeting customer requirements.

Some previous researches found that six sigma could be applied in different industries or organizations [3] such as public services [4], small and medium enterprises [5], pharmaceutical [6], higher education [7], Banking [8], machineries [9], automotive [10], etc. This study try to provide tools for improving quality in cement packaging process. The tools will be provided pass through some processess encompasses define the elements of product's defects, the level of product's defects, the main causes of product's defects, the main solution for improvement

in the process, and the tools or framework for controlling further process.

2. Literature Review

Operations management is defined as the systematic design, direction, and control of processes that provide and delivery frim's products and services [11,12,13]. Operations management decisions consist of process, forecasting, capacity planning, locating facilities, facilities and layout, scheduling, inventory, quality, supply chain, motivating and training employees [11,12]. Quality management is one of operations management decisions. Quality is defined as the performance of product or service in fulfilling customer expectations now and in the future [11,12]. It means that the product or service is fit for the customer's use. Fitness for use is related to the benefits received by the customer. Benefits are based on the totality of features and characteristics that determine the a product's or service's performance in satisfying given needs.

The extent to which the product or service successfully fulfills the intended purpose has four aspects which comprise the design, how well the product or service matches the design, ease of use, and after-delivery service [11]. Quality of design is determined before a product is produced. This determination is usually the responsibility of a cross-functional product design team, including members from marketing, engineering, operations, and other functions. Quality of conformance means producing a product to meet the specifications. When the product conforms to specifications, operations considers it a quality product regardless of the quality of the design specifications. Another aspect of quality involves the so-called abilities: availability, reliability, and maintainability. Availability defines the continuity of usability to the customer. Reliability refers to the length of time a product can be used before it fails. Maintainability relates to the product or service recovery after fail performance or delivery. Field service, the last dimension of quality, represents maintenance, repair or replacement of the product after it has been sold. Field service is also called customer service, sales service, or just service. Field service is related to variables such as promptness, competence, and integrity. The customer expects that problems will be corrected quickly, in a satisfactory manner, and with a high degree of honesty and courtesy [12].

Different customers will have different requirements, so a working definition of quality is customer-dependent. Product quality is often judged on nine dimensions of quality namely performance, aesthetics, special design, suitability, serviceability, dependability, endurance, perceived quality and consistency. Whereas service quality is often described using the following dimensions namely consist of responsiveness, reliability, convenience, guarantee, physical evidence, time, expectations, courtesy, and consistency. It was important for management to support various ways in which the quality of the company's product and service can affect the organization and consider it in developing and restoring the quality assurance program. Some of the major areas affected by quality consist of loss of business, liability, productivity and costs.

Six Sigma has at least three meanings, namely as a measure of quality, as a business improvement strategy and a philosophy, and as a problem solving methodology [14]. It constitute a business process to improve quality, reduce costs, and increase customer satisfaction. It is also constitute a comprehensive and flexible system for achieving, sustaining, and maximizing business success by minimizing defects and variability in processes [15]. The term of Six Sigma has several meanings. Statistically, it means having no more than 3.4 defects per million opportunities in any process, product, or service. Conceptually, the term is much broader, refers to programs that desgned to reduce product defect to achieve lower cost and increase customer satisfaction. This is based on the implementation of defect tools and techniques for selecting projects to achieve results of trategic businesss. In the business environment, Six Sigma method has become the main way for improving quality, saving time, cutting costs, and increasing customer satisfaction. The six sigma method can be implemented in design product or service, production or operation, services, inventory strategy, and delivery. It is very important for Six Sigma implementation must relate or align to organizational strategies.

Six Sigma is based on these guiding principles consist of variation reduction is an important aspect; data driven is the methodology, valid measurements; outputs are processed by inputs, modifying and controlling inputs in improving outputs; only a critical few inputs has a significant effect on outputs (the Pareto effect). The DMAIC is a formalized problem-solving process of Six Sigma. It is composed of five steps that can be applied to any process to improve its effectiveness. The steps are [15,16,17]:

1) DEFINE. The first step tries to answer the question 'what is problem ?' Usually, in the process uses some tools such as Stakeholder Analysis; High Level Process Mapping; Suppliers, Inputs, Process, Output and Customers (SIPOC); Voice of the Customer

(VOC); Value Stream Mapping; Afnity Diagram; Kano Model; and Critical-to-Quality (CTQ) Tree. The output of the process encompasses a clear statement of the intended improvement (Project Charter); a high-level map of the processes (SIPOC); a list of what is important to the customer (CTQ) and an understanding of the project's link to corporate strategy and its contribution to ROIC.

2) MEASURE. The second phase has to answer the question 'what are the triggering causes? There are some tools that can be used in this phase encompasses Prioritization Matrix; Process Cycle Effoiciency; Time Value Analysis; Pareto Charts; Control Charts; Ru Charts; Failure Models and Effect Analysis (FMEA).
3) ANALYZE. The third step tries to answer the question 'what are the root causes of the influences on the problem? The tools are used in this step such as Brainstorming; Cause and Effect Diagram; Afnity Diagrams; Contro Charts; Flow Diagram; Pareto Charts; Regression Analysis; and Scatter Plots.
4) IMPROVE. The fourth step will try to answer the question 'what is the solution ?' In the step, the tools are used such as Brainstorming; Flowcharting; FMEA; Stakeholder Analysis; and 5S Method.
5) CONTROL: The fifth step will try to answer the question 'how can we ensure the sustainability improvements? There are some tools that can be used in the process such as Control Charts; Failure Mode Effect Analysis (FMEA) forms; Transition Plans; ROI Formulas.

3. Research Method

Based on problem statement or research questions, therefore, this research constitute a descriptive research; whereas based on its strategy, this research constitute a case study; In addition based on time horizon, this study constitute a longitudinal study [18]. Descriptive study is a study was arranged for collecting data that depict objects characteristics; it is constitute both quantitative (production data, sales data, etc.) and qualitative in nature [18]. It also constitute a method in examining the status of a group of people, an object, a set of conditions, a system of thought or a class of events in the present. The purpose of the descriptive study is to make a systematic, factual and accurate description, painting of the facts, properties and relationships between the phenomena that investigated. Case studies are studies that submit information about certain attractions, events or activities, such as certain business units or organizations; the cases are individuals, groups, organizations, events, or discussions that interest researchers [18]. It was defined as methods or strategies in research to uncover specific cases. There is also another understanding, namely the results of a particular case study. Longitudinal research constitute any research that examines information from many units or cases occure across multiple times (time-series) in order to measure change over time [19,20].

Unit of analysis was used in this study is organization. Source of data was used in his research is secondary data, namely the number of production output and product's defects in the packaging process of a cement firm for period 2017-2019 . Six Sigma tools were used for each phase in this study are as follows [21, 22, 23]:

- Define: Suppliers, Inputs, Process, Outputs, and Customers (SIPOC) dan Critical to Quality (CTQ)
- Measure: Defect Per Million Opportunities (DPMO), Sigma Level, Control Chart, and Pareto Diagram.
- Analyze: Cause and Effect Diagram and Failure Mode and Effect Analysis (FMEA)
- Improve: Brainstorming and Effort Benefit Matrix
- Control: Control Chart and Failure Mode and Effect Analysis (FMEA)

4. Results and Discussion

By using Six Sigma method, the problem-solving process was conducted through phases encompasses Define, Measure, Analyze, Improve, and Control (DMAIC). In the DEFINE process, it were used suppliers, input, process, output and customer (SIPOC) diagram to define the process that cause source of product defect and Critical to Quality (CtQ) diagram to define types of product defects. Based on the diagrams, there were found that source of product defect is cement packing process. Whereas the types of product defects comprises bad stitches, bag gluing, bad raw material quality, bag torn, rejected bag. The defects percentage during 2017-2019 period consist of bag torn 84%, bad stitches 9,3%, bad gluing 4,7%, rject bag 1,7%, and bad raw material quality 0,13%. The product defects caused potential losses for the company estimated amount of 1 billion rupiahs annually.

In the MEASURE process, it were used Defect Per Million Opportunities (DPMO), Level Sigma and Control Chart diagrams. Based on the Defect Per Million Opportunities (DPMO) diagram, the company's DPMO for 2017-2019 cement packing process is 1,756.01 in average with a sigma level of 4.43 and the percentage of overall defective products is equal to 0.87%. The ability of the packaging process, therefore, in the cement company to produce a good quality product (without defects) is 99.13% with a probability of a final product defect of 0.87%. The average (control limit) of the 'p' control chart is at the point 0.00851, while the lower limit of the control chart (Lower Control Limit) is at the point 0.00869, and the upper limit of the control map (Upper Control Limit) is located at the point 0.00888. Based on the "p" control chart, the existing cement packing process is out of control due to of the 36 points, only four points are in the range of the control chart (in-control) while the rest points are out of control. Therefore, the causes of product defects need to be eliminated so that the quality of the further packing process will be in-control entirely. The control chart as in figure 1. Based on Pareto diagram, it was found that the bag torn is the main defect that cause the out of control packing process. The defect covered 81.4% of product defects, then respectively it was followed by bad stitches around 9%, bad gluing around 6.2%, rejected bags around 3.2 and bad raw material quality about 0.1%. Eliminating the causes of the defects, therefore, must be a priority in its further implementation.

In the ANALYZE process, it were used Fishbone (Cause and Effect) and Failure Mode Effect Analysis (FMEA) diagrams. Based on the diagrams, there were found that the factors caused product defects in the cement packing process encompasses machine, environment, methods, people, and materials. The sub-causes of the five factors entirely consist of thirteen causes, namely comprises interlock belt and truck loader, crosswise position of bag on the conveyor, bag stuck, wrong dropping bag, employee fatigue, employee inaccurate and careless, stitches are not strong enough, the quality of raw material decreased, lack of waiting time so the glue is not sticking perfectly, stacking bag in the truck, rush shipping, rainy season, and humidity. Whereas the main cause of product defects is the machine (belt conveyor), where the machine caused the bag torn defect. Therefore, machine maintenance is the first priority in the improvement process of quality control.

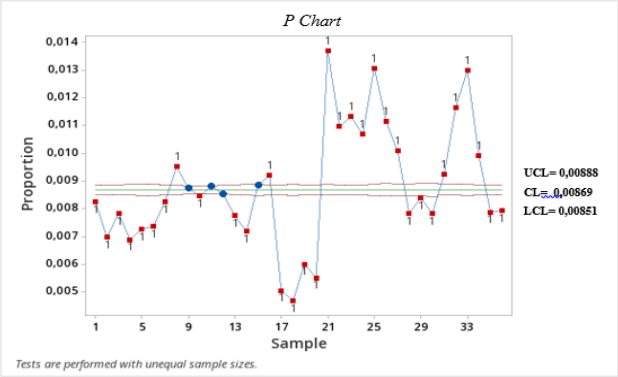

Figure 1. "p" Control Chart

In the IMPROVE process, there were used brainstorming and effort benefit matrix. Based on the tools, there were found that the main solution for reducing the defect level in the cement packing process is checking the machine (belt-conveyor) before and after shift exchange by using checksheet. This step was carried out to ensure that the machine is in good condition for the cement packing process so that it will be able to minimize the product defects. The step also intend to anticipate engine damage, production's obstacles, and work accidents.

In the CONTROL process, it was propose to use the tools that developed in the previous steps to control further cement packing process continually. The proposed ways encompasses perform regular machine maintenance and repair, supervise the receiving process of cement bags supply and packing section employees, and control the packing process (using control chart) continually.

5. Conclusion

Based on the 'p' control chart of Six Sigma method, the existing process quality of cement packing in the company is out of control. So that the improvement process is needed by eliminating the causes of out of control process. The main cause that must be a priority in its improvement is the machine (belt-conveyor) condition in the cement packing process. The main solution to prevent the occurrence of the main cause namely by checking the machine (belt-conveyor) before and after shift exchange by using a checksheet periodically.

In addition, the company needs to make a comparison between before and after corrective actions as an evaluation of quality improvement in the cement packing process so that the company will be able to

eliminate or minimize the number of product defect. By implementing the Six Sigma method, it is hoped that the cement company can reduce or eliminate the existing waste estimated amount of Rp 1 billion annually. Supporting the successful Six Sigma method implementation, therefore, the firm need also to conduct good socialization and coordination, so that this proposal can be implemented effectively and efficiently.

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