

# Use of Six Sigma and Kaizen Methods to Reduce Concrete Iron Defects (Case Study of PT. Hanil Jaya Steel)

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**Abstract** -- Concrete iron produced by PT. Hanil Jaya Steel still has product defects in the form of line defects, village defects, nguping defects and flattened tip defects of 3.22%. The company wants to control the quality of this concrete iron, thereby reducing product defects. This study aims to determine the level of quality of concrete iron and provide suggestions for improvement to reduce disability. The results of this study are the level of product quality during the month of July-December 2017 at the level of sigma 3.9202 with DPMO of 8059.83. In July-December there were several types of concrete iron product defects, namely line defects of 61.873%, kampong defects of 20.3365%, flattened tip flaws of 10.707%, and earning defects of 7.055%. Factors that cause product defects are Human, Machine, Environment. Proposed improvements with the Kaizen method that can be used as a basis for quality improvement efforts, namely at the Seiketsu (maintenance) and Shitsuke (habituation) stages.

**Keywords:** Six Sigma; DMAIC; Kaizen.

## I. INTRODUCTION.

At present, business people in the industry in Indonesia are aware of the ever changing customer orientation towards quality. In the increasingly tight industry competition, companies must be able to survive and compete with similar companies. In competition in the global market only good quality products will always be in demand, because quality is the fulfillment of services to consumers. Quality is the totality of the characteristics of a product that supports its ability to satisfy the specified or specified customer needs. Therefore the role of quality is needed in a company.

PT. Hanil Jaya Steel is a company located in Waru sub-district, Sidoarjo, East Java. The company is engaged in manufacturing that produces concrete iron. In producing concrete iron, there are still defects in the production process. The defects that occur in concrete iron are nguping defects, scratch defects, village defects, flattened tip flaws.

From July to December 2017, there was a defect of deform 19 concrete iron products of 3.22%. From the defects that occur in concrete iron, the company needs to do quality control. With this quality control, the company can reduce the product defect rate. One method of quality control to minimize the percentage of disability is six sigma.

The Six Sigma approach looks at the final product, assesses defects in products and looks for ways to eliminate the causes behind defects. This strategy aims to change the business process, if necessary, to produce the end product without flaw or make changes in the way the product is produced. Six Sigma is a process of measurement, seeing how the results deviate from perfection and how to bring results closer to perfection[1]. Six sigma is deliberate, structure, effective way to develop solutions for sustained improvement[2]. Explores practical solutions for construction performance improvement by applying the six sigma principles. The principles provide the metric required to establish performance improvement goals and a methodology for measuring and evaluating improvement. The proposed approach is expected to achieve more reliable workflows by reducing process variability to fit a desirable range- thereby improving the overall performance through the evaluation of the quality level in current construction operations [3].

The Kaizen approach looks at businesses with a wider lens. The aim is to improve every aspect of the business, create a standard process, improve efficiency and always look for ways to reduce waste. This is a system that always focuses on ways to improve, from beginner to highest level management [1]. Kaizen event is a very effective, proven way to make rapid improvement[2]. Kaizen is a Japanese philosophy and quality management method which involves continuous improvement through small incremental steps over a long period of time. Kaizen philosophy encourages an 'instinct for improvement' throughout the organisation. Improvement is

seen as a 'way of life', not just the application of specific tools and techniques. Senior management commitment is vital for implementing Kaizen across an organisation. Kaizen can be used in the development of TQM [4].

The paper describes a theoretical approach of combining the continuous improvement philosophy of Kaizen with student course evaluation. Furthermore, the author uses evaluation data from two course cycles to describe results from a pilot application. A concept is illustrated for evaluating every single course unit and continuously discussing these results together with the learners. Learners in the pilot courses accepted and welcomed the intense participation and allowed improvements mainly referring to course concept, content (and detail) selection, course material and presentation style. The participation rate declined during the term and was highly influenced by triggers like exam and grade relevance. [5]

As a result of the empirical work the authors proposed a new specific and individualized framework for the public sector called: "Kaizen projects conceptual schemes (KPCS), based on the cycle Plan-Do-Check-Act in order to form a theoretical and practical guide that can serve as a base for local governments seeking to implement Kaizen in their management. [9]

The welding process in pipeline construction takes around 65% in the pipeline replacement project schedule and critical path for the project. From two previous segment, contractor have a reject welding ratio 14% and reject material 7%, so it will be reduce into less than 5% and 3%. The improvement process start from IPO diagram then the problem analyzed using fish bone. The improvement covered manpower skill, manpower certification, and procedure, and then resulted less rework and faster project. These improvements align with BSC Frame; Learning and innovation, Internal Process, Customer, and Financial. [10]

Pere Grima, et al. Have grouped some of the most frequently into four main areas: implementation and organizational aspects, compliance with the DMAIC methodology, statistical tools and techniques and implementation of project improvements and closures (Six Sigma: practice to overcome difficulties (Six Sigma : instructions from exercises to overcome difficulties, Pere Grima, Lluís Marco-Almagro, Sandrine Santiago & Xavier Tort-Martorell [11]. Result shown that lean six sigma and continuous improvement (Kaizen) have positive influence for solving the problem of defect product [9].

Research results on Case Study: Reducing Sampling Time The following case studies illustrate the importance of combining Six Sigma with Kaizen activities. In four-wheel vehicle manufacturers, Black Belts complete Six Sigma projects during the sampling cycle of fully built (CBU) sampling units from cars. The cycle time for sample checking at the beginning of the project is around 24 hours, or three working days. At the end of the project, during the Control phase, time decreases dramatically to around 7.7 hours or one working day, thus reducing two-thirds of the cycle time. (Kaizen with Six Sigma Ensures Continuous Improvement

(Kaizen with Six Sigma Ensures Continuous Improvement) [10].

The paper reviews a large number of papers in this field and presents the overview of various continuous improvement practices demonstrated by manufacturing organizations globally [11].

The study in automotive industry Razmah Mahmoda, with lean six sigma and Kaizen contributes to the advancement of knowledge on methods to reduce defect products. Lean Six Sigma is widely used in many areas such as government, industry, healthcare and education. Big Data which is being collected in ever-increasing amounts due to digital commerce [12].

The study shows the importance of Six Sigma and Lean applications in three of the most important areas in oil and gas: Service quality drilling operations, customer satisfaction, and supply chain. Two successful case study projects are provided with step by step details and are organized around three main parts: the problem, the methodology and the lessons learned. Despite some misconception that some managers have about the implementation of Lean, it will stay the most efficient methodology to apply in the oil and gas business. Success of Lean depends also on top management decisions. [13]

This paper explores how Lean Six Sigma can be applied to accelerate the process of extracting key insights from Big Data and also how Big Data can bring new light and innovation to projects requiring the use of Lean Six Sigma. A case study approach using examples from both manufacturing and the service sector will be used in this research. The results have shown that 55% of employees believe that the philosophy of kaizen is relatively applied in the electricity sector. But there is a ratio of 65% of them think that the administration of the total quality management is the most suitable to be applied in the electricity and water sectors. In addition to that there is a ratio of about 50% see that both methods have achieved better improvements of maintenance in comparison with traditional methods, consequently both methods were successful in the electricity sector for improving maintenance and reducing the cost. [14]

This paper presents a methodology for applying the Lean Six Sigma method on the educational process. After defining defects that have negative influence on the final quality evaluation of higher education and how these defects can be remedied, the Pareto analysis is done, and that is used for establishing a vital minority of the exams that are critical for examination of faculty. The next step is the Statistical Process Control (SPC) analysis that is performed on the exams that are classified as a vital minority in Pareto analysis. Ishikawa diagram shows a relation between considered consequence (small number of passed exams) and all factors that influence this consequence. Based on the results of implementation of the Lean Six Sigma method in the educational process and implementation of all suggested improvements, the comparative overview of Pareto analysis is given for 2009/2010 and 2012/2013 academic year at the Faculty of Mechanical Engineering, University of Niš [15].

Determination of process capabilities for attribute data:

Attribute data is qualitative data that is calculated using a split or tally list for recording and analysis purposes. Attribute data is discrete. If a record is only a summary or classification related to a set of requirements. Examples of quality characteristic attributes are: the absence of labels on product packaging, errors in the administration process of customer savings books, the number of types of defects in products, the number of plywood products that are defective due to colorings, etc.

Defect or disability is a disability to provide what the customer wants. While the defect per opportunity (DPO) is a measure of failure calculated in the six sigma quality improvement program, which shows the number of defects or failures per one opportunity, calculated using the DPO formula. Where the DPO formula is the number of defects or failures found are divided by (the number of units examined multiplied by the number of potential CTQs that cause defects or failure). DPMO is a measure of failure in a six sigma quality improvement program, which shows a failure of opportunity opportunities, to calculate using a formula:

$$DPMO = DPO \times 1,000,000 \quad (1)$$

DMAIC (define, measure, analyze, improve, control)

DMAIC is a process for continuous improvement towards the Six Sigma target. DMAIC is carried out systematically, based on knowledge and facts. This process eliminates non-productive process steps, often focuses on new measurements, and sets technologies to improve quality towards the Six Sigma target.



Fig. 1. DMAIC process (Source: Gaspersz, 2011)

1. Define is the first operational step in the six sigma quality improvement program. At this stage, the most important thing to do is identify the product or process that will be repaired. We must set top priorities about which problems and / or opportunities for quality improvement will be handled first. The best project selection is based on identifying projects that are in line with the current needs, capabilities and organizational goals.
2. Measure is the second operational step in the six sigma quality improvement program. Especially for attribute data can be done using pareto diagrams to find out what potential CTQ is the biggest or highest causing failure.
3. Analyze is the third operational step in the six sigma quality improvement program. At this stage that needs to be considered are several things, namely: determining the capabilities / capabilities of the process, and identifying sources and root causes of disability or failure.
4. Improve is the fourth operational step in the Six Sigma quality improvement program. This step is carried out after

the sources and root causes of quality problems are identified.

5. Control (control) is the last operational phase in six sigma quality improvement projects. At this stage the results of quality improvement are documented and disseminated, best practices that are successful in improving the standardized process and used as standard work guidelines, as well as ownership or in charge of the process, which means six sigma ends at this stage [16].

Kaizen is the Japanese terms KAI and ZEN literally mean “to change” and “ for the better”, and it has come to symbolize continuous improvement.[17].Kaizen can be defined on several levels :

- Aphiosophy of on-going, incremental continuous improvement
- The process of making small incremental improvements on a daily basis
- An attitude within the workforce ,that they have the responsibility to identify and participate in potencial improvements
- A mind –set that as always striving for perfection [2].

Practicals Implications the paper is intended to be equally usefi

UI to both academics and practitioners who are interest on the topic of lean six sigma(LSS).From a pure practical standpoint , the paper provides an overview of the past, present and future trends of LSS as a powerful business strategy and problem solving methodology for all industrial sectors, irrespective of their size and nature.[18]

The implementation of kaizen was carried out using four tools consisting of Kaizen Five Step Plan and Five M Checklist.

1. This Kaizen Five Step Plan (a 5-step plan) is an approach to the implementation of kaizen used by Japanese companies. This step is often called the 5-S movement which is a Japanese initials starting with the letter S. 5-S is a method of structuring and maintaining an intensive work area originating from Japan that is used by management in an effort to maintain order, efficiency, and discipline in work location while improving the overall performance of the company. The advantage of implementing the 5-S is to improve quality and safety / work safety. This can happen because of: reducing time and material waste, increasing production efficiency and productivity, increasing workers' morale and simplifying the work environment.
2. Five M Checklist focuses on the five keys that are seen in each process, namely: Man (operator or person), Machine (machine), Material (material or raw material), Meethods (method), Milieu (environment). Through data collection or brainstorming, it can be assessed how and how much each of the M factors contributes to problem solving or finding solutions.

## II. RESULTS AND DISCUSSION

TABLE I. DEFECT TYPES OF DEFORM CONCRETE IRON PRODUCTS 19 JULY – DECEMBER 2017

| Month     | Nguping (pcs) | Garis (pcs) | Kampong (pcs) | Ujung Gepeng (pcs) | Total Defect (pcs) |
|-----------|---------------|-------------|---------------|--------------------|--------------------|
| July      | 103           | 1097        | 425           | 160                | 1785               |
| August    | 423           | 2452        | 300           | 65                 | 3240               |
| September | 50            | 316         | 120           | 294                | 780                |
| October   | 0             | 720         | 535           | 0                  | 1255               |
| November  | 0             | 0           | 39            | 361                | 400                |
| December  | 50            | 905         | 388           | 70                 | 1413               |
| Total     | 626           | 5490        | 1807          | 950                | 8873               |

### Define Stage

The define phase is the first operational step in the Six Sigma quality improvement program. At this stage, the most important is the identification of the product and / or process to be repaired. The problem that is often faced by this company is the high number of defects that occur in concrete iron products, especially deform type 19. Determination of the research object is focused on the process of making deform type concrete iron products 19 because of the frequent defects. Based on table 1 can be seen the description of the histogram defect that occurs in the type of deform 19 concrete iron products in July - December 2017 can be seen in the picture as follows:

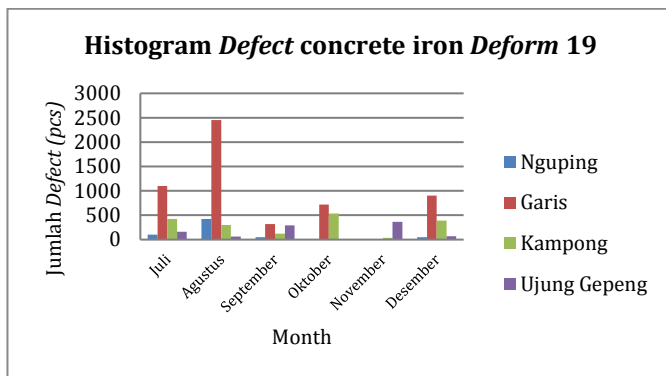


Fig. 2. Histogram Total Types Defect Concrete Iron Deform 19

### Phase Measure

Measure is the second operational step in the six sigma quality improvement program. There are 3 main things that must be done in the measure phase, namely:

- Determine the quality characteristics (CTQ) including eavesdropping, scratch defects, village defects and flattened tip defects
- Determine the biggest defect

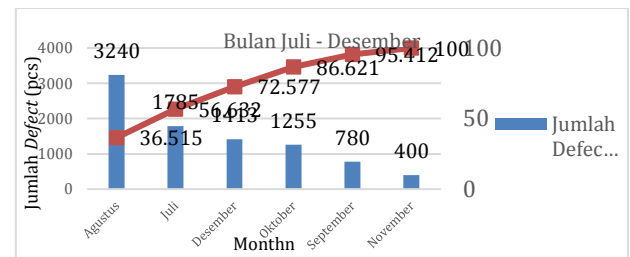


Fig. 3. Diagram Pareto Defect on July – December 2017

Based on Figure 3 can be seen the largest number of defects occurred in August, which amounted to 3240 pcs with a defect percentage of 36.515%. Based on Figure 5 can be seen the largest type of defect that occurs is a line with the amount of 5490 pcs and the percentage of defects of 61.873%

### Phase Analyze

At this stage, identification of the sources of the root causes of defects in the concrete iron production process was carried out. The following is a fishbone diagram showing the root causes of defects in eavesdropping defects as follows:

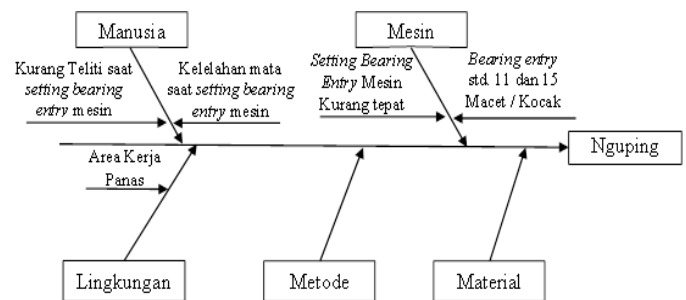


Fig. 4. Causal diagram

### Improve phase

After the sources of the problems have been identified, the next step is to establish an improvement plan (action plan) to reduce the number of defects, the determination of corrective action plans aimed at improving quality. The improvement plan is obtained by means of brainstorming with the company. The implementation of this stage is only a proposal to the company. Where the proposed improvements made can provide input so that the number of defects can be reduced. The improvement is by implementing kaizen using the kaizen M checklist method and kaizen five step plan.



#### a. Analysis Problem with kaizen five M checklist

TABLE II. ANALYSIS OF DISABILITY ISSUES NGUPING WITH KAIZEN FIVE M CHECKLIST

| No | Factor   | Problem  | Problem Solving (Proposed Improvement)  |
|----|----------|--|---|
| 1. | Man      | 1. Eye fatigue when setting engine bearing entry<br>2. Less careful when setting the engine bearing entry  | 1. Providing allowances to workers<br>2. Providing training for refreshing SOP.<br>3. The Head of Production provides more strict direction & supervision of workers. |
| 2. | Machine  | 1. Setting the bearing entry machine is less precise<br>2. Bearing entry STD. 11 and 15 are jammed / funny | 1. Paste / put manual procedures for using the machine around the machine.<br>2. Replace the Std Bearing Entry. 11 and 15 with good.                                  |
| 3. | Mileu    | Hot work area  | Add blower and turbine Roof Ventilator to the production area   |
| 4. | Method   | No cause occurred  | -   |
| 5. | Material | No cause occurred  | -   |

#### b. Improvement with Kaizen Five Step Plan

TABLE III. PROPOSED IMPROVEMENT WITH KAIZEN FIVE STEP PLAN

| Problem   | Kaizen Five Step Plan   |   |  |   |  |
|---|---|---|--|---|--|
|   | Seiri   | Seiton  | Seiso  | Seiketsu  | Shitsuke   |
| Man :<br>1. Eye fatigue when setting engine bearing entry<br>2. Less careful when setting the engine bearing entry  |   |   |  | Providing allowances to workers<br><br>Providing training for refreshing Standard Operating Procedure (SOP) | Get used to working accordingly<br>Standard Operating Procedure (SOP)<br><br>Application of strict punishment when making mistakes repeatedly. |
| Mechine:<br>1. Setting the bearing entry machine is less precise<br>2. Bearing Entry std. 11 dan 15 are jammed / funny<br>3. Roll Guide std. 13 wear out<br>4. Entry std. 13 dies<br>5. std. 14 loop position<br>6. Leaky oil hose<br>7. Roll Guide std. 15 aus | Making machine grouping data in accordance with the type and function in order to change the machine<br><br>Launching machine parts that are vulnerable to damage | Place the manual for machine use procedure around the engine area | Leaning the machine after the production process | Perform regular maintenance of machine  | Get used to always checking machine both before and after the production process is in accordance with Standard Operating Procedure (SOP)      |

#### Control Stage:

Control stage is the last operational stage in the CyclusDMAIC. This study does not exercise control, only limited to proposed improvements.

1. Deform 19 concrete iron production process which has the largest DPMO value in October with 12963 DPMO value and the conversion to sigma value of 3.727 and CTQ (critical to quality) with the highest defect is the type of line defect. So that in October the output of deform 19 concrete iron production has the lowest process capability compared to the other five months.

2. Based on the results of the CTQ root causes there are 3 factors that cause disability categories that affect the production process of deform 19 concrete iron are: humans in terms of fatigue doing work and not careful when checking the condition of the machine and the initial setting of the machine before the production process takes place; the engine in the event that the setting is not right so it experiences some damage such as bearing entry std. 11 and 15 jam / funny, roll guide std. 13 wear, entry std. 13 dies, std loop position. 15 pull, oil hose leaks, roll guide std. 15 wear; environment caused by the temperature of the work area (production room) heat.

3. Of the three factors that cause disability, a proposed improvement is needed to reduce the number of defects in deform concrete iron product 19. Therefore, there is a need for more stringent supervision and control based on the tools for implementing kaizen M checklist and kaizen five step plan in things: give allowance to workers; provide training workers for refreshing standard operating procedures (SOP); accustom workers to work according to standard operating procedures (SPO); the application of strict punishment if the worker makes repeated mistakes; caring for the machine periodically so as not to be damaged or worn out quickly; cleaning the machine after the production process; get used to always checking machines both before and after the production process according to standard operating procedures (SOP); arrangement of air circulation equipment according to needs.

### III. CONCLUSION

Based on research conducted at PT. Hanil Jaya Steel, the following conclusions can be drawn:

1. The quality level of deform 19 concrete iron products in July - December 2017 has a product defect of 3.22% and is at the sigma level of 3.9202 with DMPO of 8059.83. DPMO and sigma values that deform 19 concrete iron products are included in the industry average in Indonesia.
2. To reduce defective production of deform 19 concrete iron products towards zero defects, the proposed improvement is based on kaizen implementation tools to improve product quality, namely: providing training workers for refreshing standard operating procedures (SOP); getting workers to work according to standard operating procedures (SOP); the application of strict punishment if the worker makes repeated mistakes; caring for the machine periodically so as not to be damaged or worn out quickly; cleaning the machine after the production process;

get used to always checking machines both before and after the production process according to standard operating procedures (SOP); arrangement of air circulation equipment according to needs.

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