Analysis Roofing Quality Control Using Statistical Quality Control (SQC) (Case Study: XYZ Company)

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Abstract. Quality is a dynamic condition related to products, services, people, processes and the environment that satisfy or exceed expectations. Quality is the main factor for consumers in choosing products. XYZ company is a company engaged in Baja Lembaran Lapis Seng (BJLS) which produces zinc roofing. In order to survive in competitive market, improving quality and productivity of product is must for any company. Based on production on 2019 showed that there were 49,660 defective products out of 824,574 total production meaning that there were 5.95% of defective products that exceeded the company’s tolerance limit of 2%. Many products that defective products that cause repeat activities and losses finished products cause harm to the company. This study reports the application of statistical quality control techniques to ensure roofing quality and to minimize the presence of defective products. The results of the analysis with the P control map show that all data on the number of defects are still in the control limit with a $C_p$ value of 0.9410, which is low improvements the product or process so able to continue to improve the quality of its products.

1. Introduction

In the era of technological development right now, industrial business is considered as one of the key factors in developing countries and manufacturing processes, both domestic and international in the industrial sector having higher competition in meeting consumer demand in accordance with desired specifications. Key of increase a company's competitive advantage depends on the overall quality production process. Good quality will only be obtained if the entire production process is running optimally [1]. Main technique survive in a competitive market, improving product or process quality and productivity is must doing for each company [2]. The quality of a business or company or product quality and productivity is the key to the success of a production system in a company’s production system because the quality is the main factor for consumers in selecting products. The quality of products produced by a company is determined based on certain sizes and characteristics [3]. Product quality is an important factor that influences the level of development and progress of a company [4].

Quality control is a strategy companies do in the face of competition globally with other company products. Quality is a characteristic of the product or service demanded by the user or customer and obtained through measurement of processes as well as improvements to that sustainable [5]. To produce high quality products, then companies must always check and repair in various stages, one of which at the quality control stage. The quality of a product is not an accidental thing. Good quality will be produced through good processes and in accordance with quality standards has been
determined based on consumer demand [6]. XYZ company is a company engaged in Zinc Sheet Steel (BJLBS) which produces flat zinc and corrugated roofing which is adjusted to SNI 07-2053-2006. On the off chance that the consequences of QC tests can't satisfy the acknowledgment models, the aftereffects of examination of the entire arrangement of the estimations on that day must be eliminated or should be re-dissected, and an incomplete or full re-approval of the strategy considered [21].

Roofing is one of the main needs in the field of building construction. At present the public demand for zinc products is increasing due to prices that are classified as standard and suitable for people with middle economic levels. Seeing the condition of population growth which is increasing every year, the need for zinc products will also increase. The increasing demand for zinc products will lead to a level of business competition between companies that produce zinc so that product quality control is needed to face business competition [7].

The increasing demand for zinc products will lead to a level of business competition between companies that produce zinc increasing so that companies are always required to increase customer satisfaction, among others by continuing to improve the quality of the products produced in order to minimize production costs and increase production output [8].

Quality is the main point in the business world, but quality problems in companies are quite complicated, based on record production data zinc production in January - December 2019, there were still many products that did not meet specifications / defective products. Product defect data and zinc production data can be seen in table 1.

Table 1. Data defective product zinc roofing in 2019

| Month     | Production (Kp) | Total Defective (Kp) | Disability Percentage (%) |
|-----------|-----------------|----------------------|---------------------------|
| January   | 83.803          | 4.919                | 5.87%                     |
| February  | 70.277          | 4.083                | 5.81%                     |
| March     | 50.285          | 2.866                | 5.70%                     |
| April     | 49.315          | 2.910                | 5.90%                     |
| May       | 60.195          | 3.678                | 6.11%                     |
| June      | 74.234          | 4.283                | 5.77%                     |
| July      | 62.345          | 3.660                | 5.87%                     |
| August    | 80.564          | 4.745                | 5.89%                     |
| September | 90.358          | 5.412                | 5.99%                     |
| October   | 60.358          | 3.513                | 5.82%                     |
| November  | 92.495          | 5.633                | 6.09%                     |
| December  | 50.345          | 2.965                | 5.89%                     |
| Average   |                 |                      | 5.89%                     |

Based on the data above the average percentage of defects in zinc products in the January-December 2019 period is quite high, namely 5.89% of the total production each month which far exceeds the cumulative defect tolerance limit in the company's quality standards, which is not more than 2% which causes a decline in company profits and decreased productivity. This means that the quality control program implemented by the company is less than optimal. So that the technique may be used is statistical quality control (SQC), which consists of analyzing the process, establish the standards, compare performances and then last verifying and studying deviations that may happened also finding and implementation the solutions, that aim at its improvement. The technique of statistical quality control predicts that a system is subject to changes and variations, evaluating if these parameters are significant. Statistical quality control appears as an alternative to improve and monitoring the quality of roof production, this technique is carried out through an efficient and control chart to monitor the mean and variability of the observed characteristics [9].

Previous research using Statistical Quality Control technique is Irwandhani that using that method to analyze and identify the cause of a defective Shuttlecock Product UD Ardiel Shuttlecock so that can take correction action so that can reduce failure to optimize the production process, improve profit and productivity [10].
Ika Haiyani to solve the problem that occurred during the production process at Liberty Shoes, to find out how to fix it production quality control with (SQC) and Six Sigma and by using that the defect product can minimize by identifying the causes factor of defective from man, method, machine and material [11].

Quality control of the 2-wheel vehicle production torque process at the ABC manufacturing industry in Narsapura, Karnataka, India to eliminate variability and damaged assembly results due to improper process torque. Dial type torque wrench was used as sample data collection. The results of the variability analysis with control charts show that all data are at the control limit and the result of the calculation of the capability process index shows that the value of Cp = 0.5 and the value of CpK = -0.35 means that the process is barely able to meet the standards and the process is not centralized. After analyzing the cause of the damage, it was found that the management in the procurement of lubricants and wrenches from different vendors was not good enough so that the result of the component connection was not good. [12]

2. Literature Review

Quality has become one of the most important factors in consumer decisions in choosing between competing products and services. Understanding and improving quality are key factors that lead to business success, growth, and increased competitiveness [13]. Goetsch and Davis discuss the quality of representing a dynamic state relating to products, services, people, processes and environments that satisfy or exceed expectations [14].

Quality control generally can be defined as a system that maintains the save quality level, through feedback on the characteristics of the product/service and the implementation of corrective actions, if there is a deviation from these characteristics from the specified standards. This general area can be divided into three main subareas that are off-line quality control, statistical process control, and acceptance sampling plans. Quality control is a combination of all the tools and techniques used to control the quality of a product with the most economical costs possible and meet customer requirements [15].

Statistics Quality Control (SQC) as a quality control tool for production can help company whether the product produced is still within the limits of control or not from the initial process of material quality, product process, final product [16]. Melani Anggraini, uses the SQC method to deal with quality problems by conducting quality control at PT Perkebunan Nusantara VII, which produces SIR 20 rubber [17]. SQC is a system developed to maintain the standard of the quality of production, at a minimum cost level by using statistical methods to collect and analyze data [18]. The advantages of the SQC method work based on objective data/facts and not based on subjective opinions [19]. Statistical quality control has seven (7) major statistical tools can be used as a tool to control the quality as Also mentioned by Heizer and Render in his book Management Operations, among others that’s are Check Sheet, histogram, control chart, Pareto Chart, fishbone diagram, scatter diagrams, and design of experiment (DEO) [20].

Concept of Statistical Quality Control (SQC) had been introduced since 1931 by Shewhart in his book on control chart. Dodge and Romig's table for basic acceptance sampling appeared in the next decade. Since this pioneering work many new techniques for process and product control have been proposed and a vast literature on SQC has developed. It is of interest to determine to what extent control charts and sampling techniques, new and old, are being applied in industry.

The function of a quality control tool is to increase the ability to improve processes, so that it will get:

- Increased competitiveness.
- Reducing cost of quality and increasing price flexibility.
- Increase resource productivity.

The most used control charts in statistical quality control are Shewhart (X-bar), Exponentially Weighted Moving Average (EWMA) and Cumulative Sum (CUSUM). Shewhart's chart stands out
with individual measurements for the simplicity of its construction and interpretation applied in situations where the sample consists of a single unit. Shewhart control chart is slow to diagnose small variations in the process, because it's use information from the last sample, ignoring other samples. One way to improve the ability to detect small variations is to collect sample information, such as the cumulative count method. MMEP control charts are used to diagnose minor variations more quickly, gather sequential information, give weight to samples, and give more weight to recent samples. For large variations, MMEP is slower to diagnose variations than the Shewhart chart.

3. Methodology
Hassan Assareh Bayesian Hierarchical Models in Statistical Quality Control Methods to Improve health care in hospital. The reliability of any statistical result in the clinical context is affected by the quality of data being used. In this study we consider application of the well-established statistical tools in industrial quality control program to improve the quality of clinical data in the medical registries. Technical and procedural aspects of acceptance sampling plans and statistical process control tools including control charts and root causes analysis were discussed and translated into a quality control program for clinical data. In this study we use statistical quality control to analyze the level of production quality in the manufacturing industry and to find the causes of quality problems in the production process and to propose improvements.

Data Processing Techniques for the SQC Method using statistical tools that are check sheets, stratification, scatter diagrams, pareto diagrams, histograms, control diagrams and cause and effect diagrams.

- Check sheets are practical tools that are used to collect, group, and analyze data simply and easily. The main purpose of a check sheet is to ensure that data is collected carefully and thoroughly for process control and problem solving.
- Data Stratification is an attempt to group data into groups that have the same characteristics.
- A histogram is a bar graph that illustrates a number of data that is grouped into several classes with certain intervals.
- Pareto diagram by sorting each type of disability from the largest to the smallest. After that the percentage of disability is calculated and the cumulative percentage for each disability is there.
- Scatter diagrams / scatter diagrams are used to see the correlation (relationship) of a factor causing disability associated with a characteristic (type) of the three types of product defects that exist.
- Control Chart is a graphical tool that will illustrate the stability of a work process. Through this description, it can be detected whether the process is going well (stable) or not. In this study used the P attribute control map. to calculate the value of UCL and LCL can use formula.0

\[ CL = \bar{p} = \frac{\sum_{i=1}^{k} n_i \bar{p}_i}{\sum_{i=1}^{k} n_i} \quad (1) \]
\[ UCL = \bar{p} + 3 \sqrt{\frac{\bar{p}(1-\bar{p})}{n_i}} \quad (2) \]
\[ LCL = \bar{p} - 3 \sqrt{\frac{\bar{p}(1-\bar{p})}{n_i}} \quad (3) \]

Cause and effect diagrams are useful for analysis and determining factors that significantly influence in determining the quality characteristics of work output.

4. Result and Discussion

4.1. Stratification
Stratification is the effort of grouping data into groups that have the same characteristics. Based on data obtained from data collection, in this stratification the criteria set are disability in zinc products with four types of disability, namely Scratches, Wrong Milled, White Spots and Black Spots.

4.2. Checksheet

Checksheet is a simple document in the form of inspection sheet which is used to collect data in the form of production processes, items, causes of defective product as well as inspection confirmation tools in real-time and at the location where the data appears. Check Sheet data for zinc products can be seen in Table 2.

| Period     | Production (kp) | Milling Error | Percentage | Scratch | Percentage | Black Spot | Percentage | Mount |
|------------|-----------------|---------------|------------|---------|------------|------------|------------|-------|
| January    | 83.803          | 1.391         | 1.66%      | 2.405   | 2.87%      | 545        | 0.65%      | 578   |
| February   | 70.277          | 1.181         | 1.68%      | 1.722   | 2.45%      | 548        | 0.78%      | 632   |
| March      | 50.285          | 820           | 1.63%      | 1.192   | 2.37%      | 357        | 0.71%      | 498   |
| April      | 49.315          | 853           | 1.73%      | 1.287   | 2.61%      | 345        | 0.70%      | 424   |
| May        | 60.195          | 1.059         | 1.76%      | 1.625   | 2.70%      | 403        | 0.67%      | 590   |
| June       | 74.234          | 1.321         | 1.78%      | 1.967   | 2.65%      | 512        | 0.69%      | 483   |
| July       | 62.345          | 1.116         | 1.79%      | 1.590   | 2.55%      | 424        | 0.68%      | 530   |
| August     | 80.564          | 1.515         | 1.88%      | 2.038   | 2.53%      | 596        | 0.74%      | 596   |
| September  | 90.358          | 1.509         | 1.67%      | 2.485   | 2.75%      | 714        | 0.79%      | 705   |
| October    | 60.358          | 1.068         | 1.77%      | 1.533   | 2.54%      | 380        | 0.63%      | 531   |
| November   | 92.495          | 1.563         | 1.69%      | 2.525   | 2.73%      | 657        | 0.71%      | 888   |
| December   | 50.345          | 876           | 1.74%      | 1.173   | 2.33%      | 362        | 0.72%      | 554   |
| Total      | 824.574         | 14.272        | 1.73%      | 21.542  | 2.61%      | 5.844      | 8.47%      | 7.009 |

Based on the above table, it can be placed on disabilities with the most number until the least is a problem of scratches, milling, white spots and black spots with mount of defective 48.668.

4.3. Histogram

The histogram of defect types in zinc products can be seen in Figure 1.

![Histogram](image)

**Figure 1.** Histogram defective data

Based on the histogram image above, it is found that the highest proportion of defects is scratch defects, then milling, white spots and black spots.

4.4. Pareto Chart

Pareto diagram is used to determine the contribution of each type of disability to disability in a company. The steps taken are to sort each type of disability from the largest to the smallest number of
disabilities. Then calculate the percentage of disability and the cumulative percentage of each type of defective.

![Pareto Chart of Type Defective](image)

**Figure 2.** Pareto chart roofing defective

From the Pareto diagram above, it can be seen that the biggest causes of zinc product defects are scratches (44.3%) and milling errors (29.3%). The cumulative percentage for both types of disabilities reaches 73.6%. Based on the Pareto 80/20 rule where 80% of defective products are caused by 20% of defects, 80% of defects are caused by both types of defects. So as to reduce the number of defective products to the level of 80% enough to control both types of defects. Because if controlling all types of disabilities that occur will be inefficient because it will take time, costs and enormous energy.

### 4.5. Scatter Diagram

Scatter diagram is a tool used to see the correlation (relationship) between the amount of roofing produced with the amount of defects that defect scratch and Milling error. Scatter chart can see in Figure 3 and 4.

![Scatterplot of Production Amount vs Scratches](image)

**Figure 3.** Scatter chart correlation scratches vs production amount
Figure 3 and 4 obtained that there is a linear relationship between the amount of production with the number of disabilities and based on the results of the calculation of the correlation obtained the correlation value of the number of production and scratch defects is 0.9861 and the correlation value of the number of production and milling error is 0.9812, it means that there are significant relationship between the amount of production and disability. Based on this explanation, corrective action is needed to reduce the level of defective despite high production levels.

4.6. Control Chart

The highest types of disabilities are scratches and milled faults. The next step is to conduct an analysis of the amount of zinc product defects using the attribute control map that is the P control map to see whether the number of defects that occur in the product is still within reasonable limits or not.

- Total disability ($\Sigma np$) = 48,668 units
- Total inspection ($\Sigma n$) = 824,574 units
- Total inspection of subgroup 1 (n1) = 83,803 units
- Total disability subgroup (np1) = 4,919 units

The proportion of defective in subgroup 1 it is $P = 0.0587$

The value of UCL = 0.0615 and LCL = 0.0566

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**Figure 4.** Scatter chart correlation milling error vs production amount

**Figure 5.** Control chart P
Based on the picture above it can be concluded that the overall proportion of disability in each subgroup is within the control limits (In Control) so that the calculation of the process capability (CP) quality control in producing non-defective products is equal to:

$$C_p = 1 - \bar{p} = 1 - 0.0590 = 0.9410 = 94.10\%$$

4.7. Cause and Effect Diagram

Cause and Effect Diagram or called the cause and effect diagram is used to analyze and find factors that have a significant effect in determining the quality characteristics of work output or to find out the factors that cause a decrease in the quality of roofing products. Cause and effect diagram can see in Figure 6 and 7.

**Figure 6. Cause and effect diagram scratch**

**Figure 7. Cause and effect diagram milling error**
Based on the picture above it can be seen that human factors, machinery, material and production methods have a high effect on these defects so further corrective action is needed to minimize the level of disability that occurs.

5. Conclusion
Any manufacturing unit or industries must have to eliminate assignable causes for flexible production. Defects had been enhanced by assignable causes and ultimately productivity had diminished day by day till the elimination of assignable causes. Through the root causes analysis assignable causes are detected and it had been eliminated by readjusting the machines, proper work distribution and introducing control charts.

In XYZ company, defects that are observed are scratch defects and rolling errors, repairing scratches can be done by conducting more stringent and routine supervision every day and conducting a briefing before the production process is carried out and also preparing a checklist for machine maintenance procedures and preparing a special schedule for machine maintenance periodically outside the production schedule and for milling fault defects, repairs can be made by installing a support in the form of a buffer to help position the zinc so that it is more evenly and symmetrically. Product defects that occur. Based on the use of the control map as an analysis, it is obtained that all the disability data are still within the control limits. There are recommendations:

- It is expected that the company can implement the proposed improvements given to minimize the number of scratch defects and milling errors in the company while minimizing the loss of production costs.
- Need more systematic division of tasks needs to be developed so that members from each field focus on their responsibilities, especially the formation of inspection and maintenance teams for machinery and equipment.

Acknowledgements
The Authors would like to thank XYZ company for providing the data in this research.

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