Defect analysis on PVC pipe using Statistical Quality Control (SQC) approach to reduce defects (Case Study: PT. XYZ)

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Abstract. Product quality is an important factor affecting the level of development and progress of a company. Statistic Quality Control (SQC) as a quality control tool for production can help companies whether the products produced are still under control or not from the initial process or the final product. The research was conducted at PT. XYZ to find out the causes of defects that occur in the PVC pipe production process. In the research, it is known that the defects that occur are melt, crack and hollow with the majority of defects that occur are melt and crack. By using a Cause and Effect diagram, it is known that the cause of defects occurs due to human, machine, materials and method factors. Solutions for defects that occur are given in the hope that the company will implement the solutions offered to reduce the number of defects that occur in the production process.

1. Introduction

The quality of products (services) is crucial in assessing the performance of each enterprise or organization. The release of effective and high-quality products allows the company to obtain more additional profits and ensures rapid production development [1]. In the current era of technological development, industrial business is considered to be one of the determining factors in a country to develop, both domestically and internationally. The industrial sector has higher competition in fulfilling consumer demand according to the desired specifications [2]. In order to survive in a competitive market, improving the quality and productivity of a product or process is a must for companies [3]. The quality of the company or business and product productivity are the keys to success for the development of the company's production system because quality is the main factor for consumers in choosing products. The quality of a product produced by a company is determined by size and the size is determined by characteristics [4]. Product quality is an important factor that affects the level of development and progress of a company [5]. Quality control is a strategy that companies undertake in facing global competition with other company products. Quality is a characteristic of a product or service that is desired by consumers and is obtained through a process and continuous improvement [6]. To produce quality products, the company must always check and improve in various stages, one of which is the quality control stage. The quality of a product is not something that can be underestimated. Good quality will be produced through a good process and in accordance with predetermined quality standards based on consumer demand [7].

Based on these conditions, it can be seen the importance of maintaining product quality so that it is possible to use Statistical Quality Control (SQC), which consists of analyzing processes, setting standards, comparing performance, verifying and studying defects, finding and implementing
solutions to obtain better improvements. As in the stage of mass productions, statistical process control has a significant contribution in improving quality control [8]. Statistical Quality Control emerged as an alternative to improve and monitor the quality of production, where the control is carried out through an efficient and simple control chart to monitor the average and threshold of the observed characteristics [9]. Several previous studies that have used the SQC method include Nina, et al who conducted research on Statistical Quality Control (SQC) analysis on bread production at Aremania Bakery [10]. Meldayanoor, et al who conducted research on Statistical Quality Control (SQC) analysis as a control and improvement of tortilla product quality at UD. Noor Dina Group [11]. Koyor and Hana who conducted research on quality control of tofu production using the SQC method in UKM H. Musauwimin [12]. Ira who conducted research on quality control analysis using Statistical Quality Control (SQC) at PT. Pratama Abadi Industri (JX) Sukabumi [13].

The research was conducted at PT. XYZ to find out the causes of defects that occur in the PVC pipe production process. According to the results of interviews with the management of PT. XYZ, defects were still found during the production process. This study aims to determine the factors that cause product defects, and later it can become a company reference to reduce the number of defects that occur in the production process.

2. Materials and methods
In this study, there are several steps taken to approach the Statistical Quality Control method so that it can analyse and find the causes of product defects and can improve the quality of PVC pipes.

2.1. Data Collecting
There are two types of data used in this study, namely primary data and secondary data. Primary data is data in a scientific study which is taken directly from the research subject. Primary data were collected based on the results of research on the object of research with work procedures that had been carried out at the time of conducting the research. Data taken in the form of types of defects in products and the number of defects found obtained from direct observations in the field and company reports. Secondary data is data obtained indirectly from sources or research objects. Secondary data were obtained from company-owned reports, books, and scientific journals that support primary data [14].

2.2. Data Processing
Data processing techniques are performed using a Statistical Quality Control approach consisting of histogram, check sheet, scatter diagram, stratification, pareto diagram, cause and effect diagram, and control chart [15].

- Stratification is the process of grouping data into a group that has the same characteristics.
- Check sheet is a form in the form of items to be checked that have been printed in the form with the intention that data can be collected easily and concisely.
- Histogram is a block diagram that is used to show the division of data groups that have been carried out.
- Pareto diagram is a chart containing bar and line charts; Bar charts show data classifications and values, while line charts represent cumulative data totals. The data classification is sorted from left to right according to the order of highest to lowest ranking. The highest ranking is the priority problem or the most important problem to be resolved immediately, while the lowest ranking is a problem that does not have to be resolved immediately.
- Scatter diagram is used to see the correlation of the causes of disability with the types of defects found.
- Control chart is a graph that shows whether the defect found exceeds a predetermined threshold or not. In this study, the control map P is used. The formula used to calculate the threshold is as follows.
3. Results and Discussion

3.1. Stratification

Stratification is used to group data into groups that have the same characteristics. Based on data obtained from the data collection process, three types of defects were found in PVC pipes, namely melting, cracking, and holes.

3.2. Check sheet

Check sheet is a simple sheet regarding the data collection process carried out which is used to determine the number of defects, types of defects, or other information. Check sheet on PVC pipe can be seen in Table 1.

| Period  | Total Production | Melt | Percentage | Crack | Percentage | Hollow | Percentage | Number of Defects |
|---------|------------------|------|------------|-------|------------|--------|------------|------------------|
| January | 85.225           | 1.663| 1.95%      | 1.311 | 1.54%      | 573    | 0.67%      | 3.547            |
| February| 92.884           | 1.987| 2.14%      | 1.270 | 1.37%      | 898    | 0.97%      | 4.155            |
| March   | 86.159           | 1.239| 1.44%      | 1.381 | 1.60%      | 851    | 0.99%      | 3.471            |
| April   | 84.782           | 1.993| 2.35%      | 1.420 | 1.67%      | 957    | 1.13%      | 4.370            |
| May     | 96.956           | 1.964| 2.03%      | 1.280 | 1.32%      | 914    | 0.94%      | 4.158            |
| June    | 97.228           | 1.785| 1.84%      | 707   | 0.73%      | 564    | 0.58%      | 3.056            |
| July    | 92.194           | 1.538| 1.67%      | 1.372 | 1.49%      | 617    | 0.67%      | 3.527            |
| August  | 88.555           | 1.437| 1.62%      | 609   | 0.69%      | 902    | 1.02%      | 2.948            |
| September| 86.368         | 1.734| 2.01%      | 1.337 | 1.55%      | 557    | 0.64%      | 3.628            |
| October | 81.622           | 1.351| 1.66%      | 1.438 | 1.76%      | 589    | 0.72%      | 3.378            |
| November| 84.881           | 1.944| 2.29%      | 773   | 0.91%      | 735    | 0.87%      | 3.452            |
| December| 91.062           | 1.420| 1.56%      | 854   | 0.94%      | 853    | 0.94%      | 3.127            |
| Total   | 1.067.916        | 20.055| 1.88%     | 13.752| 1.29%      | 9.010  | 0.84%      | 42.817           |

Based on the table above, it can be seen that the types of defects starting from the highest number are melted, perforated, and cracked, with a total of 42,817 defects.

3.3. Histogram

The histogram of defects found in PVC pipes can be seen in Figure 1.
Based on the picture above, it can be seen that the type of melt defect is the most common type of defect, followed by the type of defect with crack and hollow.

### 3.4. Pareto Diagram

The Pareto chart is a bar graph and a line graph that illustrates how the data types compare to the whole. The function of the Pareto diagram is to identify the main problems for quality improvement from the biggest to the smallest. The results of making a Pareto diagram using Minitab software can be seen in figure 2.

![Figure 2. PVC pipe pareto diagram](image)

The Pareto principle as the 80/20 rule means that 80% of defects that occur in PVC pipes are caused by melting (46.8%) and cracks (32.1%) which results in 20% of PVC pipe products produced. Melts and cracks have the greatest impact because the cumulative percentages for both are nearly 80%. So that by making repairs at the root of the two defects, it is expected that the defective product level can be reduced.

### 3.5. Scatter Diagram

The scatter diagram is used to see the correlation of the causes of disability with the types of defects found. The scatter diagram for the types of melt and crack defects is shown in figures 3 and 4.
Based on the figure above, there is no linear relationship between the amount of production with melting defects and cracking defects. Based on the calculation, it is found that the correlation between the amount of production with melt defects is 0.308647 which means it has a weak unidirectional relationship. Meanwhile, the correlation between the amount of production and crack defects is -0.305186, which means it has a weak opposite relationship.

3.6. Control Chart

The control map is a graph that shows whether the defect found exceeds a predetermined threshold or not. P chart on PVC pipe production can be seen in Figure 5.
Based on the picture above, it can be seen that there is no number of defects that exceeds the threshold where the entire period is still within the predetermined limit. Then based on the calculation of the capability process, it is known that the Cp value is 95.98%.

3.7. Cause and Effect Diagram

Causal diagrams are used to find the biggest contributing factors for defects found in products. The causal diagram for the types of melt and crack defects can be seen in figures 6 and 7.

Figure 6. Cause and effect diagram of melting defective PVCpipe
Based on the picture above, it can be seen that the causes of disability can be caused by humans, machines, materials, and the methods used. So that improvements can be made to these four aspects.

4. Conclusion

Every manufacturing company must eliminate the causes that could cause production problems. Defects in products can cause the company to suffer material and immaterial losses. Through the Statistic Quality Control approach, types of defects can be found and ways to deal with these disabilities. In PVC pipe production companies, the defects observed were melting and cracking where nearly 80% of defects found were both defects. The causes of defects originating from humans, machines, materials and methods can be overcome in various ways. Both defects can be overcome by recruiting new employees so as to reduce the effect of fatigue on other employees. In addition, regular maintenance can reduce the occurrence of defects. The raw materials used must comply with standards set by the government and it is recommended to use materials of high quality.

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