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The Application of Six Sigma Framework (Define-Measure-Analyse-Improve-Control) to Improve Product Quality in Water Dispenser Manufacturing Company

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Abstract

This research aims to determine the causes of water dispenser product defects and find the main factors causing defects. This research was conducted in the form of a case study. The data used consists of quantitative data, supported by qualitative data. The analytical method used is Six Sigma, with a focus on the DMAIC method (define, measure, analyze, improve, and control) and sigma values. The population of this research is all water dispenser product equipment. Through observation, interviews and documentation techniques, this research collected data. The data processing method used is DMAIC Six Sigma, with a special focus on the Measure stage. Based on the research results, it was found that the process performance of the water dispenser product was at the level of 4.72 sigma with a DPMO value of 633,732. The most dominant defect occurs in the motor pump. Causes of defects in water dispenser products include human factors (inexperienced operators, errors in reading work instructions, unclear job holders, products not completed on time), materials (parts that do not meet standards, inspection/test equipment that does not function, CBU units that do not conform to standards), methods (products do not meet customer expectations, finished products do not meet standards, inspector operators do not master the use of measuring equipment according to regulations, customer complaints are not handled properly), and environment (hot room conditions, unstable room temperature). The most influential cause and priority for improvement is that customer complaints are not resolved or solutions are sought by the supplier.

Keywords: Six Sigma, DMAIC, FMEA, Sipoc Diagram, Fishbone.

1. Introduction

Current developments in the era of globalization have created increasingly fierce competition for domestic companies. To support Indonesia's economic recovery, the government encourages consumers to choose local products [1]. In addition, the government is committed to carrying out medium- and long-term economic reforms to increase investment and industrial competitiveness [2]. The focus of these reforms includes developing skilled industrial human resources to support the growth and competitiveness of the domestic sector. The target customers for household equipment are those with high incomes, with monthly incomes above IDR 10 million. They tend to buy products such as audio and video electronics, consumer electronic equipment, and smartphones. Currently, the household appliances sector in Indonesia is experiencing rapid growth, with a shift from luxury products to secondary and affordable products [3]. Consumer electronics sales projections show a significant increase, estimated to reach $866 million in 2020, with annual growth of 15.7% from 2020 to 2025. Under these conditions, there is a great opportunity to develop products and services that suit market needs and preferences [4].

Even though the Indonesian electronics industry has great growth potential, there are a number of problems that require resolution. Several factors are impeding the growth of this industry, which the government should seriously support to overcome [5][6]. One of the problems faced is competition for domestic electronic products, which are inferior to imported products, which dominate the market [7]. Apart from that, the lack of basic industries as component suppliers for the electronics assembly industry in Indonesia is also an obstacle [8]. This causes the electronics assembly industry in Indonesia to be highly dependent on component imports, making it less competitive due to risks in the supply chain and exchange rate fluctuations [9]. Despite this, sales projections in the consumer electronics sector show positive growth, with an annual growth rate of 15.7% from 2020 to 2025. However, challenges in the electronics assembly industry, which still relies on imported components, are one aspect of the new competition in the industry. Stable growth every year increases demand from consumers, which encourages competition to maintain product quality and remain competitive in the market [10][11].

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Quality is a crucial aspect that is the main consideration for consumers in choosing a product, apart from the price factor. To create quality products, companies must continuously raise quality standards and make improvements to the entire production process. The level of success of a company can be reflected in its ability to manage production and operational systems effectively [12]. Quality control is the main key to increasing effectiveness in preventing defective products, which in turn can reduce waste of raw materials and labor and increase overall productivity [13][14]. The importance of quality control is very visible in the variation in the number of defects in water dispenser products produced by the company every month, including in May 2022. The existence of different variations in defects every month shows the need to carry out regular repairs to reduce losses due to defective products [15]. Defective products can cause waste of time, increased production costs, and various other problems that companies can face [16][17]. Therefore, companies must continue to implement improvements to the production process to reduce the risk of defective products and increase overall production efficiency [18].

To ensure survival and gain a competitive advantage, companies need to adopt quality improvement methods throughout the product manufacturing process [19]. One methodology that has been proven effective in this case is Six Sigma. This method is designed to identify and reduce factors that cause defects and errors in the production process, with the main goal of reducing defective products and improving overall product quality [20]. Six Sigma also aims to increase customer satisfaction by ensuring that the products produced comply with the desired standards [21]. In addition, Six Sigma can help companies optimize their business processes by reducing cycle times and operating costs, increasing productivity, and achieving higher levels of asset utilization [22]. By implementing Six Sigma, companies can optimize capital investments that have been invested in production and services. This can result in better returns on capital and increase a company's competitiveness in an increasingly competitive market. Thus, Six Sigma is a highly effective approach for continuous improvement and achieving competitive advantage in today's dynamic global market [23].

The Six Sigma method is based on the DMAIC methodology, which is a simple approach to solving problems and improving processes. DMAIC is an abbreviation for define, measure, analyze, improve, and control. This method uses various statistical tools and other process improvement approaches in its steps. DMAIC is used to ensure the successful implementation of Six Sigma in organizations [24]. Several cases have shown that Six Sigma has been successfully applied in various fields, especially in manufacturing. In an effort to ensure survival and competitive advantage, many companies have adopted various quality improvement methods throughout their processes. Six Sigma is one of the most popular methodologies, widely used to reduce defects and poor quality costs, increase customer satisfaction, and increase a company's long-term profitability. By using Six Sigma, companies can continue to adapt to a dynamic business environment and intense competition [25]. By focusing on continuous improvement, companies can ensure that the products and services they produce remain of high quality, meet customer expectations, and maintain their competitive advantage in the marketplace [25].

As a continuous improvement method, DMAIC has become a common approach to problem solving and has been widely applied. However, in facing future challenges, it is necessary to integrate more sophisticated tools and techniques in the application of the DMAIC methodology to continue to improve quality. This approach can be further explored for application in the manufacturing sector and other non-manufacturing sectors. Each company has unique characteristics, so a detailed study is required for proper implementation of the DMAIC approach [26]. Companies need to consider their internal and external conditions, as well as environmental factors that influence the success of DMAIC implementation. The ongoing implementation of Six Sigma projects is an important step in the company's efforts to continuously improve processes, reduce defects, and increase customer satisfaction on an ongoing basis [27]. By combining DMAIC with other innovative technologies and approaches, companies can achieve higher levels of quality and maintain their competitive advantage in a competitive marketplace. This shows that DMAIC is not a static method but rather an approach that continues to develop according to market demands and company needs.

2. Research Methods

This research is a case study that combines various data sources and theories as a basis for analysis. The data used consists of quantitative information about water dispenser production and qualitative data to support it. The analysis method applied is Six Sigma, with a focus on the DMAIC method (define, measure, analyze, improve, and control) and sigma values. The research population includes all Water Dispenser product equipment, with samples taken from the Water Dispenser product database. Through observation, interviews and documentation techniques, this research succeeded in collecting comprehensive and in-depth data regarding research objects related to company production. The data processing method used is product defect analysis using the DMAIC Six Sigma method, with special emphasis on the Measure stage. This research shows that the application of the DMAIC Six Sigma method can help identify the causes of product defects and formulate appropriate improvement strategies. The results of this research contribute to understanding the improvement of the company's production processes as well as providing a basis for developing more effective product quality

improvement strategies. Thus, this research has important implications for companies in their efforts to improve the efficiency and quality of their products.

3. Results and Discussion

A water dispenser is an important device in everyday life, especially at home or the office. The types of dispensers based on gallon location and function provide flexibility for consumers to choose according to their needs. The upper-gallon dispenser makes it easier to replace gallons of water, while the lower-gallon dispenser can provide more practicality in collecting water. Dispensers that combine top and bottom provide wider choices in use. The main function of a water dispenser is to produce hot and cold water, practically making daily activities easier, such as making warm or cold drinks, without the hassle of heating or cooling water manually. In the production process, the rejection process is an important aspect to pay attention to. Rejection at the initial stage, electrical tests, load tests and final inspection indicate that product quality must be maintained properly throughout the production process. Good quality control can help companies produce water dispenser products that are high quality and meet established standards, so that they can maintain consumer trust and increase the company's competitiveness in the market.

CTQ (critical to quality) determination is an important step in the quality control process, where quality characteristics that are important and have a direct impact on customer satisfaction are identified. In the context of water dispenser production, the assembly process is critical because it directly affects the final quality of the product. Successful assembly with a high level of accuracy will produce quality products, meet expected standards, and provide satisfaction to consumers. When a water dispenser product experiences defects, such as what happened to the motor pump, IC cooling system, and PCB pump controller, the finishing process becomes critical. Product quality can be seen in the product's ability to be used without problems or damage. However, when a defect occurs, this process becomes an obstacle because the product must be re-inspected to ensure there are no problems that could affect the final quality. In managing defect problems, it is important to identify the main causes of rejects that occur every month. By knowing the main cause, companies can make appropriate improvements and reduce the number of rejections that occur. This will increase the efficiency of the production process and ensure that the products produced meet the quality standards desired by consumers.

Apart from focusing on motor pump repairs, holistic improvement steps can be taken to ensure overall product quality improvement. One aspect that can be considered is the training and development of employees involved in the production process. By providing proper training, employees can improve their skills in assembling and testing motor pumps, thereby reducing the possibility of defects. Additionally, implementing strict quality control methods can also help reduce defects. By continuously monitoring production processes and conducting regular inspections, companies can identify potential defects early and take the necessary preventive measures. It is also important to evaluate the entire supply chain. Make sure that the raw materials used for the motor pump are of appropriate quality and come from a trusted supplier. By carrying out this evaluation, companies can ensure that every component used in production is of good quality, thereby reducing the risk of defects in the final product. Apart from that, implementing automation technology in the production process can also help improve quality and efficiency. By using automated machines and devices, companies can reduce dependence on manual workers and reduce the possibility of human error in the production process. By taking these steps together, companies can significantly improve product quality and ensure that the products produced meet the quality standards expected by customers.

Based on calculations carried out every month, the average DPMO value of water dispenser products is 639.49, with an average sigma value of 4.72. This indicates that for every one million opportunities, there are around 639.49 chances of defects occurring in the production process. Apart from that, if we take a case example with a total production of 70,219 units and 445 defects, the sigma value for that case is 4.72. With this sigma value, companies can evaluate the performance of their production processes. A higher sigma value indicates that the production process is running better and is closer to the expected quality standards. To remain competitive in the global industry, companies need to make regular improvements to improve the quality of their production. By making continuous improvements, companies can continue to increase the sigma value and reduce the DPMO value so that they can produce higher-quality products that meet the established quality standards. These improvements can be made by conducting root cause analysis of defects, implementing appropriate solutions, and monitoring process performance periodically to ensure the effectiveness of improvements. In this way, companies can continue to improve the efficiency and quality of their production to remain competitive in the global market.

Analysis was carried out on the motor pump as a priority for repair, using a fishbone diagram to identify factors causing defects. The fishbone diagram was prepared based on the results of interviews with related departments, including QC, ISO and production. Based on the research results, several factors that cause defects in motor pumps during the water dispenser production process include material, human, environmental and method factors. Human factors are one of the factors that cause defects in pump motors. This occurs due to a lack of

accuracy in reading work instructions, a lack of operator experience, a lack of clarity on the part of the job holder, work being rushed, and the inspector operator's lack of knowledge in using measuring instruments according to the provisions. This condition causes defects in the pump motor, which results in the pump motor not functioning or damage to this part. To overcome this problem, companies need to make improvements to the factors that cause these defects. This can be done by providing better training and supervision to operators, increasing supervision of the production process, clarifying work instructions, and ensuring the use of measuring tools in accordance with regulations. By making these improvements, it is hoped that defects in the motor pump can be reduced so that the quality of the water dispenser product increases.

In terms of method factors, there are several causes of defects in the pump motor. First, from the supplier's perspective, the motor pump that the QC department receives occasionally does not meet standards or does not operate properly. In cases like this, complaints are usually made to the supplier, but in some cases, solutions from the supplier are not always available. Second, from the consumer side, there are cases where consumers receive products that are not suitable or have defects. This can sometimes be difficult to resolve, and adequate solutions are not always available. Third, there are finished products that do not meet standards, so they cannot be completed on time. Regarding environmental factors, the main obstacle is unstable changes in the temperature of the production room. This causes the room temperature to be too high, which disrupts the production process because the room temperature is not what the production department needs. In terms of material factors, several causes of defects include parts and samples received that do not meet standards, so they cannot be used; test equipment or inspection tools are not available or do not function properly; and CBU units received do not meet standards. Once the factors causing the damage are known, the next step is to carry out a repair plan analysis of these factors using FMEA. FMEA is used to obtain necessary improvements to improve product quality and reduce defects. The analysis that has been carried out on the factors that cause defects in motor pumps is very important to identify the root of the problem and determine appropriate repair steps. By knowing the factors that cause defects, companies can take effective preventive action to reduce these defects and improve overall product quality. FMEA analysis will also help in planning more necessary improvements to ensure that the improvements made have a significant impact on product quality.

To improve product quality and reduce defects, companies can implement the results of the FMEA (failure mode and effects analysis) analysis of the identified factors causing defects. FMEA is a systematic method for identifying potential failure modes in a process or product and evaluating the potential impact of those failures. In the context of water dispenser production, FMEA can be used to analyze the effects of potential failures from factors such as SOPs that are not paid enough attention to, lack of clarity on job holders, delays in product completion, products that do not meet standards, materials and CBU units that do not meet standards, and lack of understanding of inspector operators. regarding the use of measuring instruments. Additionally, companies need to seek improvement proposals for each potential failure mode identified in the FMEA. This improvement proposal must be aimed at addressing the root of the problem that causes defects in the water dispenser product. For example, companies can improve SOP procedures, provide training to job holders to increase their understanding of their duties, improve coordination between parts of the production process to avoid delays, and review material specifications and CBU units used. In addition, businesses must address the main issues they encounter with regards to unresolved complaints or supplier-found solutions. In this case, companies need to improve communication and cooperation with suppliers to resolve complaints quickly and effectively. By implementing improvement recommendations resulting from FMEA analysis and prioritizing improvements based on the RPN (Risk Priority Number) value, companies can reduce product defects, improve product quality, and meet established quality standards, thereby increasing customer satisfaction and the company's competitiveness in the market.

Based on the priority of corrective actions obtained from the highest RPN values, the recommended corrective steps are as follows: First, after the proposed improvements are implemented, it is important to control and evaluate the production process. Calculating the sigma value after improvement and comparing it to the sigma value before improvement serve as the basis for this evaluation. If the sigma value after improvement is lower than before, then it can be said that the proposed improvement was successful. Second, proposed improvements that are proven to be successful need to be standardized and made into a standard operating procedure (SOP). This aims to ensure that the improvements made can be implemented consistently and effectively in all parts of production. Finally, it is necessary to document the proposed improvements and the implementation process. This documentation is important for monitoring and evaluating the effectiveness of improvements on an ongoing basis. Apart from that, outreach to all employees at all levels of management also needs to be carried out so that proposed improvements can be implemented well throughout the company. By following these steps, companies can ensure that the improvements they make not only provide good results in the short term but are also sustainable in the long term. By monitoring sigma values regularly, implementing standardized SOPs, and conducting outreach to employees, companies can continue to improve the quality of their products and achieve higher quality standards.

4. Conclusion

Based on the research results, it can be concluded that the water dispenser product process performance is at the level of 4.72 sigma with a DPMO value of 633,732. The most dominant defect occurs in the motor pump. Causes of defects in water dispenser products include human factors (inexperienced operators, errors in reading work instructions, unclear job holders, products not completed on time), materials (parts that do not meet standards, inspection/test equipment that does not function, CBU units that do not conform to standards), methods (products do not meet customer expectations, finished products do not meet standards, inspector operators do not master the use of measuring equipment according to regulations, customer complaints are not handled properly), and environment (hot room conditions, unstable room temperature). The most influential cause and priority for improvement is that customer complaints are not resolved or solutions are sought by the supplier. Suggestions for improvement to improve production quality and reduce defective products include holding quality meetings with suppliers, providing QC data information to purchasing to evaluate supplier performance, conducting planning evaluations and production meetings according to SOP, informing the engineering department of test results for solutions and improvements, and ensuring supplier commitment to provide materials according to standards. Based on these findings, a number of suggestions are given to improve the quality of defective water dispenser products. Apart from that, this research uses the Six Sigma DMAIC analysis method with various tools such as SIPOC, CTQ, Pareto diagrams, and control maps, as well as determining DPMO and Sigma values using fishbone diagrams and FMEA. For further research, the author is advised to continue the analysis with different tools, such as 5W+1H, affinity diagrams, ANOVA, and others, in order to broaden understanding and deepen the findings that have been obtained in reducing defective products.

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