Production Quality Control Analysis in Battery Product Quality Improvement Efforts

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Abstract: Product quality improvement is carried out continuously to reduce defective products. Many factors affect the quality of battery products not in accordance with the desired planning in the production department. Quality control is used to measure the requirements that must be met in forming product specifications according to actual standards. The process of controlling the quality of battery products is used to measure the quality characteristics of the products produced and compare them with the specifications or product quality requirements set by the company, as well as to analyse the quality of the products produced using statistical methods. Analysis of product quality control is able to improve quality improvement. Data patterns from statistical methods show patterns that can be used as a basis for determining battery product standards. Based on the analysis of the data on the factors that affect the cause of product defects, the machine factor has a probability of 66.25%, the human factor has a probability of 27.50%, the material factor has a probability of 3.75% and the method factor has a probability of 2.25%. Improvements in battery product quality control that need to be prioritized are machine and human factors.

1 INTRODUCTION

PT. TBA is a company engaged in the manufacturing industry that produces battery products. These battery products can be used for industrial and motor vehicle purposes. Battery production activities are carried out on Jl. Raya Trosobo Krian-Sidoarjo. Production results are used to meet local and international markets in the form of exports to several countries. After the end of the Covid 19 pandemic, orders for battery products have increased.

Increasing orders from several countries has forced companies to increase battery production, K. Turcheniuk, (2021). In fulfilling the demand for ordering battery products, the company added a lot of new workers. Most of the new workers do not have good skills in the field of battery production so that many reject (defective) products are found. According to Kampker, (2012), the product quality control section pays little attention to the specifications required for the product. According to product standardization that is not going well, the product that has been sent to the customer must be returned to the company and must be re-processed. According to Rahul Panat, VD (2014), the re-production process makes product prices cheaper and has an impact on reducing profits that will be received by the company.

PT. TBA is a company that manufactures batteries. Starting in 2022 the export market will increase, but many buyers complain, because the product quality is not as expected. From the observation results it is known that the data on production defects shows a positive trend (tends to increase).

Analysis of production quality control is carried out by companies in an effort to improve the quality of battery products, Pearn WL, Shu MH, Hsu BM, (2005) . The factors that influence the rejected product are carried out to improve production results. Factors that affect production in producing defective products include humans, machines, methods, materials and the environment. The company conducts analysis and looks for the root causes of the increase in the number of defective products, so that in the coming year it is expected that sales can be increased. According to M. Duquesnoy, (2021), that presumption was that before carrying out the analysis, an evaluation was carried out that the main cause of product defects was due to equipment that needed to

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be repaired, a large number of new workers, and work methods that were not yet well standardized. The company seeks to find out the main causes of defective products by using the cause and effect diagram method.

Based on the problems that occurred in the company, it shows that the increase in the production time period experienced an increase in rejects that occurred even though it was still within control limits. Many factors that affect the cause of product defects when carrying out production activities have not been identified in detail. The company is trying to take action to reduce the number of rejected products which continues to increase. The company strives to be able to fulfil all product requests according to consumer needs.

The company continuously improves the quality of battery products according to the set targets, K o lmel A , (2014) . Many problems occur in improving product quality in accordance with consumer expectations. The research objectives to be achieved are to analyze rejects that occur even though they are still within control limits, find out the factors that cause defective products, and improve production activities in an effort to reduce the number of rejects.

2 RESEARCH METHODS

2.1 Quality

Quality is basically conformity to requirements or requests, suitability for use, continuous improvement or improvement, and something that can satisfy customers. Many also define that quality is the totality of features and characteristics of a product or service that has the ability to satisfy needs, either stated explicitly or impliedly. The term requirements are defined as the specifications stated in the contract as well as the criteria that must be defined beforehand. Quality also means fitness for use. Quality is anything that fulfills a want or satisfies a customer's need.

According to Goodenough J.B., Kim Y., (2009), quality is conformity with market or consumer needs. A quality company is a company that controls market share because its production results are in accordance with consumer needs, resulting in consumer satisfaction. If consumers are satisfied, they will be loyal in buying the company's products in the form of goods or services.

Product quality needs to pay attention to the production process, to guarantee the resulting product is free from defects. According to J. Schmitt et.al., (2014) , there are several dimensions of quality as follows: (a) Performance is the suitability of the product with the main function, (b) Features are product characteristics, (c) Reliability is customer trust in the product, (d) Conformance is the suitability of the product with certain requirements or sizes, (e) Durability is the level of product durability or product longevity, (f) Servicebility is the ease of the product to be repaired, (g) Aesthetics is the beauty or attractiveness of the product, (h) Perception is consumer fanaticism or product reputation

2.2 Factors Affecting Quality

According to Suyadi (2002: 16) product quality is determined by several factors, including: (a) Design, (b) Raw materials, (c) Manufacturing methods or processes, (d) Shipping and packaging methods, (e) Technological developments and service method.
The various levels of quality standard control must conform to the planned quality standard. According to Suyadi (2002: 7) product quality standards can be determined as follows: (a) raw material quality standards, (b) process quality standards, (c) semi-finished goods quality standards, (d) finished goods quality standards, and (e) Standard administration, packing, and product delivery.

The objectives of quality control in general are (a) The final product has specifications in accordance with established quality standards, (b) So that design costs, inspection costs, and process costs become more efficient. According to Kampker , (2012), inspection or checking is an important part of quality control. Inspection includes determining whether inputs or outputs meet company quality standards. The purpose of inspection is to stop processes that cause defective products, stop services (services) that are not useful. Inspections can be carried out at the workplace (floor inspection) or at a central inspection site.

2.3 Quality Improvement Techniques

A causal diagram, also known as a fishbone chart, is a tool for identifying process elements (causes) that might influence outcomes, Sakti A, (2015) This diagram depicts a diagram (shaped like a fishbone) for the everyday quality control problems of a dissatisfied company customer. Each "bone" represents a source of error. The Operations Manager starts with five categories, namely Man (people), Machine (equipment), Material, Method, and Environment referred to as 5M which is the cause.
A fishbone diagram is a method/tool that helps identify, sort, and display various possible causes of

a problem or certain quality characteristics. The fishbone diagram illustrates the relationship between the problem and all the causal factors that influence the problem that occurs.

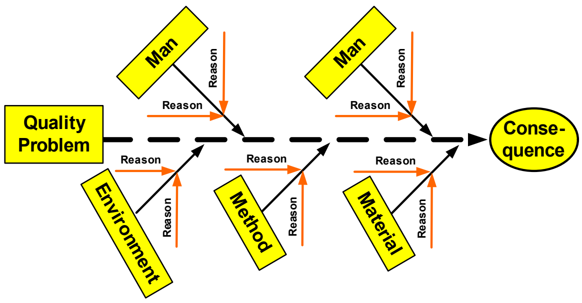

Figure 1: Cause and effect diagram.

The function of the fishbone diagram is to identify and organize the possible causes of a specific effect and then isolate the root causes. The causal conditions that may be carried out in the analysis are to enlarge or reduce the desired result.

The manufacturing industry in production activities greatly benefits by conducting a hypothesis using a fishbone diagram, Shinde, VM (2014). Classic problems that often occur will be more visible including: production delays, high product defect rates, production machines often experience trouble, unstable production line output which results in chaotic production planning, productivity that does not reach targets and customer complaints which keeps repeating.

2.4 Process Capability

Process Capability is the ability of a process to produce a product/service that meets consumer needs/requirements or expected specifications. So process capability analysis is a step that must be taken when carrying out process quality control. Requirements for the implementation of process capability analysis. If we already know how our process is (voice of process), of course we want to compare it with the specifications set by the customer (voice of customer). According to Shinde, VM (2014) , process capability analysis describes process performance in producing products according to the desired specifications. Process capability analysis can be expressed as the probability of producing unsuitable characteristics when the process is in control.

Process capability analysis using the "Process Capability Ratio". A symmetrical process capability ratio has a symmetrical distribution which is calculated by the following formula:

$$Cp = \frac{USL - LSL}{6\sigma} \quad (1)$$

The results of the analysis are known for Cp = process capability, USL = Upper Specific Limit, LSL = Low Specific Limit, σ = process standard deviation value, μ = process average value, if Cp value > 1 means the natural tolerance limit is still within control limits.

2.5 Data Collection

The research was conducted at a battery production company, PT. TBA domiciled in Sidoarjo, research was conducted for 2 months starting from September 1st 2022 to October 30th 2022. Data collection was carried out by observation and interview methods to obtain data about the general description of the company, the production process, the amount of production, and the number of defective products at each stage of work.

2.6 Data Analysis Methods

Analysis of data uniformity is also called data distribution analysis, to determine data uniformity, Zhang ZJ , et.al., (2013) . Data is called uniform if the spread of data does not exceed predetermined control limits, both upper control limits, Rifan Hariri, RA (2013). To find out whether the data is uniform or not, the "P-Chart Diagram" formula is used as follows:

$$UCL = \overline{X} + k\delta \quad (2)$$

$$\overline{X} = \frac{\sum X}{N} \quad (3)$$

$$LCL = \overline{X} - k\delta \quad (4)$$

The control limit of the graph is known from the value of UCL = upper control limit, LCL = low control limit, $\overline{X}$ = average measurement data, k = adjustment constant for the confidence level of the data, if the data confidence level is 99% then k = 3.95% then k = 2 , and below 95% then k = 1. Data distribution is controlled by an X-Chart Diagram as shown in Figure 2. as follows:

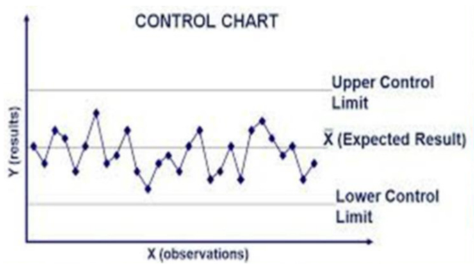

Figure 2: X–diagram.

According to Zhang ZJ , et.al. (2013), the percentage of damage (reject) is analyzed using a pareto chart, if it turns out from the results of the X-Chart diagram the data is outside the control limits, then the data needs to be analyzed using a pareto chart to sort. based on the level of proportion of damage, starting from the highest level of damage to the smallest. According to Rukmana, PW (2015), This pareto plan will help to focus on the more common and significant product defect issues or those that will provide major benefits. The data is processed to determine the percentage of damage which is calculated by the formula:

$$Tk = \frac{\Sigma kj}{\Sigma k} x \; 100\% \qquad (5)$$

The value of Tk = Damage level, Σkj = Total damage of a certain type, ∑k = total damage. If the damage level is Tk ≤ 2.5% = Mild, Tk > 2.5 - 5.0 = Moderate, Tk > 5.0 – 7.5 = High, Tk > 7.5 = extreme.

Causal analysis of a quality problem using a causal diagram. cause and effect diagram is used as a technical guideline for the operational function of the production process to maximize the success value of the quality level. Cause and Effect Diagram or often referred to as a cause and effect diagram.

This analysis is to determine the process potential index or known as Process Capability (Cp) which is obtained by comparing the specification range with the process range with the following formula:

$$Cp = \frac{UCL - LCL}{6\delta} \qquad (6)$$

The analysis is carried out by knowing the value, Cp = symmetric process capability ratio value, UCL = upper specification limit, LCL = lower specification limit, δ = process standard deviation value. If the Cp value > 1 means that the natural tolerance limits are within the UCL and LSL, or within the control limits.

2.7 Research Flow Chart

Research Flowchart to find out the flow of research implementation as shown below:

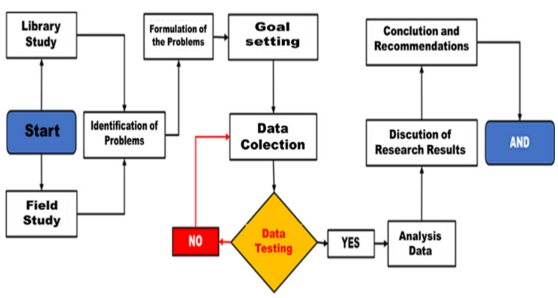

Figure 3: Research flowchart.

Before data analysis is carried out, the data taken from the observations is tested to find out whether the amount of data is sufficient and uniform, as a reference for fact indicators, if the numbers are considered not representative of facts, then additional observation data. added, as well as if the data distribution is not normal or not. If the data is uniform, then data that is outside the control limits is considered defective data and must be discarded and replaced with new ones.

3 RESULTS AND DISCUSSION

Data analysis based on production output obtained from data processing shows that the total production output, including the number of good products and the number of defective products is shown in the following table 1.

Based on the data in table 1. above, it can be concluded that the average production yield is 54,237/month, the average number of defective products is 515 (0.94%)/month. Analysis of the Trend of Defective Products based on data on the number of defective products as shown in the following figure 4.

Based on Figure 4 above, it can be concluded that the average defective product is 0.94%, in terms of the relatively small percentage of defects, but the number of defects tends to form a positive trend (increases every month). Means there is a process change that causes an increase in the number of defects.

Table 1: Production data.

No.	Product Period	Number of Product	Good Product		Product Defects	
			Total	%	Total	%
1	january	33862	33706	99.54	156	0.46
2	February	43754	43457	99.32	297	0.68
3	march	63577	63097	99.25	480	0.75
4	April	56643	56206	99.23	437	0.77
5	may	66325	65772	99.17	553	0.83
6	june	57874	57354	99.10	520	0.90
7	July	45673	45256	99.09	417	0.91
8	August	65276	64662	99.06	614	0.94
9	September	57802	57151	98.87	651	1.13
10	October	62975	62249	98.85	726	1.15
11	November	43826	43233	98.65	593	1.35
12	December	53255	52528	98.63	727	1.37
Total Product		650842	644671	1188.75	6171	11.25
Average Product		54237	53722.58	99.06	515	0.94

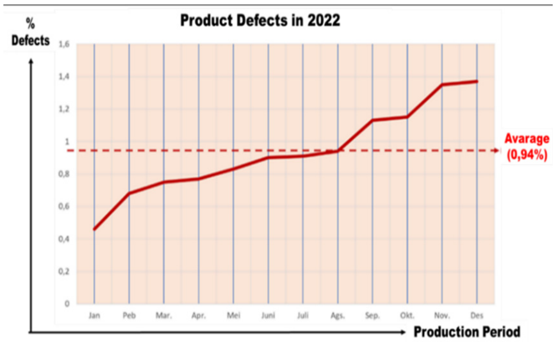

Figure 4: Graph of defective product trends.

Based on Figure 4 above, it can be concluded that the average defective product is 0.94%, in terms of the relatively small percentage of defects, but the number of defects tends to form a positive trend (increases every month). Means there is a process change that causes an increase in the number of defects.

Analysis of Defective Product Control Limits based on data on the number of defective products as in table 1. above, then analysed with an X-Chart diagram as shown in the following figure 5.

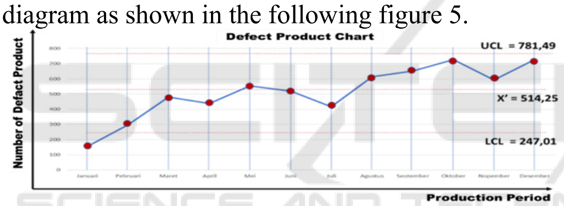

Figure 5: X -chart diagram.

Based on the X-Chart Diagram above, it can be seen that the average number of defective products = 515, Upper Control Limit (UCL) = 781.49 (782), Lower Control Limit (LCL) = 247.01 (248), there is 1 (one) data that is outside the control limits, and the chart shows a positive (increasing) trend. This indicates a continuous change of process equipment which causes product defects. For this reason, product quality control needs to be improved in the production process tool.

Analysis of the Causes of Product Defects based on the fishbone diagram (Ishikawa) is used to explore the causes of defects in detail, the data on the causes of product defects as shown in table 2 below.

Table 2: Causes of Product Defects.

No	Causative factor	Type Because	Score (0–100)	% Score	% Factor Score
1	Man	Untrained	60	15.00	27.50
		No briefing	50	12.50	
2	Ingredients	Not according to specifications	10	2.50	3.75
		Raw material defects	5	1.25	
3	Machine	Breaks frequently	80	20.00	66,25
		Not exactly	90	22.50	
		Rarely calibrated	95	23.75	
4	Method	Not Standard Operational Process	5	1.25	2.50
		No form of activity	5	1.25	
TOTAL			400	100	100

Based on Table 2. it can be concluded that there are 4 factors that cause product defects, namely: the human factor consists of 2 variables that cause many product defects, namely an untrained workforce and no breaving/coordination before work. Material factors consist of 2 variables that cause product defects, namely materials not according to specifications, and raw materials used in defective conditions. The engine factor consists of 3 variables that cause product defects, namely the machine often jams, the machine placement is not precise, and the machine is not calibrated. The method factor consists of 2 variables that cause defective products, namely there is no Standard Operating Procedure (SOP), and there is no work form.

Based on the analysis, it shows that work environment factors do not have much effect on production results. A work environment that meets predetermined standards, so that the workforce is able to carry out production activities properly. The work environment does not affect the use of work equipment and materials used to make battery products.

The Fishbone Diagram is used to explore the causes of defects in detail as shown in Figure 6 below:

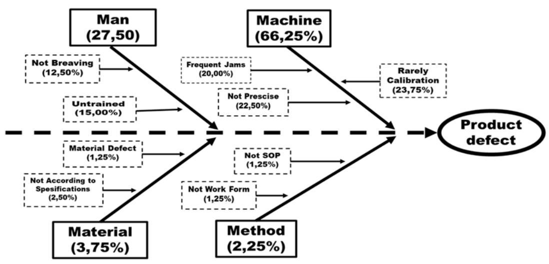

Figure 6: Fishbone Diagram

Today Ishikawa diagram analysis can be concluded that of the 4 causes of product defects the biggest causes are machines with a probability value of 66.25% and humans with a probability value of 27.50%. Improvements are a priority scale in the process of product quality control, it is necessary to increase machines and humans. Machine and human factors have the greatest probability of causing defective products.

Product quality control is carried out by improving machine factors, namely minimizing the occurrence of machine stops when carrying out production activities, setting the machine according to the desired product standard so that production results have a high precision value. The next engine factor improvement is to periodically re-calibrate (calibrate) so that the size of the machine is always precise. Product quality control is carried out by treating the workforce to training and direction from leaders every time they do work in the form of coordination. The human factor requires high work experience so that production results get better by increasing skills, motivation, and selecting foremen who are able to influence subordinates to improve product quality.

4 CONCLUSIONS

The total production yield is 650,842/year with an average of 54,237/month, good products are 644,671/year with an average of 53,723/month, and defective products are 6,171/year with an average of 515/month. Based on the data, it can be seen that total production in 2022 has not been achieved, and every production period (every month) there are always defective products with an average of 514.25 (0.94%). The trend of defective products shows an average percentage of good products at 99.06%, and defective products at an average of 0.94%. Judging from the percentage of defective products of 0.94%, it can still be tolerated, because the tolerance for the number of defective products <2% is relatively small, but the number of defects tends to form a positive trend (increases every month). Means there is a process change that causes an increase in the number of defects

Control of Defective Products from the X-Chart diagram shows the average number of defective products = 514.25 (515), Upper Control Limit (UCL) = 781.49 (782), Lower Control Limit (LCL) = 247.01 (242) , there is 1 (one) data that is outside the control limits, and the chart shows a positive trend (increasing). It was concluded that there was a continuous change of process equipment which caused product defects. For this reason, product quality control needs to be improved in the production process tool.

The biggest causes of product defects are the machine factor with a probability of 66.25% and the human factor with a probability of 27.50%. The product quality control process needs to be improved on machines and humans. Controlling product quality by carrying out machine repairs, namely carrying out repairs and calibrating machines on a regular basis. Product quality control is carried out by treating the workforce, namely training and directing each time they carry out work.

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