OPTIMIZING PRODUCT QUALITY THROUGH INTEGRATING QUALITY CONTROL METHODS

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ABSTRACT

Industrial developments are currently increasingly competitive, so business people need to produce quality products at affordable prices and be able to meet customer demand in a timely manner. To produce quality products, the production process must really pay attention to and fulfill quality aspects so that it can reduce the number of product defects and wasted production costs. All production process activities that do not have added value must be eliminated, because they have an impact on production costs and company income. In connection with this, industry needs to carry out good quality control in its production process in order to achieve optimal product quality improvement or improvement. A Quality Control System is an effort to improve and enhance the quality, productivity and performance of an industry so that it can achieve optimal results. The Quality Control System aims to utilize all existing assets to improve quality. There are many methods that can be used to improve quality. For this reason, research needs to be carried out to obtain a formula for combining the methods contained in inventory control in order to obtain optimal product quality improvement. The aim of this research is to model a product quality optimization system, to optimize costs and the level of profit obtained. The method used is the PDCA cycle, the Six Sigma method with seven basic tools and the SQC approach, Failure Mode Effect Analysis (FMEA) and 5W + 1H.

Keywords: *Quality Control, PDCA, SQC, Six Sigma, FMEA*

1. INTRODUCTIONN

Industrial development is currently very rapid and increasingly competitive, so every business person must be able to survive in this situation. For this reason, business actors need to pay attention to the quality of the products they produce, so that they can produce quality products at affordable prices and be able to meet customer demand on time.(1,2). To produce quality products, the production process must really pay attention to and fulfill quality aspects so that the number of product defects can be reduced and wasteful production costs can be avoided.(3). All production process activities that do not have added value must be eliminated(1), because it will have an impact on production costs and company income(2). In connection with this, the manufacturing industry needs to carry out good quality control in its production process in order to achieve optimal product quality improvement or improvements.

To overcome these problems, an industry needs to carry out quality control or what is known as a Quality Control System, which is an effort to improve and increase the quality, productivity and performance of an industry so that it can achieve optimal results. The Quality Control System aims to utilize all existing assets to improve quality(2). There are many methods that can be used to improve quality. For this reason, research needs to be carried out to obtain a formula for combining the methods contained in inventory control in order to obtain optimal product quality improvement.

The specific aim of this research is to find a product quality optimization system model, so that it can optimize the production costs incurred and the level of profit obtained.

2. LITERATURE REVIEW

Product quality control is an activity to maintain and direct the quality of the company's products in accordance with what has been previously determined(4). Quality products mean being able to meet customer demands at the right price. Customers will buy products according to their needs, including size, function and price(3). A defective product (reject) is a form of product that does not meet the standards set by the company and is a form of company waste that causes consumer dissatisfaction and must be minimized.(5). Quality control is the development, design, production and service provision of quality products in the most economical manner. The aim is to quickly find out the causes of the production process not running properly and take corrective or corrective action, before the number of defective products produced increases. The ultimate goal of quality control is to serve as an effective tool in reducing product variability(6).

Quality Control Circle (QCC) is one of the instruments for solving company problems, especially those related to product quality. Controlling and improving product quality as an effort to improve or increase the standards and specifications of the products produced so that the products become better in the eyes of customers. By improving this quality, efficiency, effectiveness and productivity will be realized in the production process which can increase the company's competitiveness(7).

The method used in the Quality Control Circle (QCC) to control and improve product quality is to use the PDCA cycle (Plan, Do, Check, Action), which is an improvement cycle. Seven Tools are the basic tools used in Quality Control (QC).

Statistical Quality Control (SQC), is a problem solving technique for monitoring, controlling, analyzing, managing, improving products and processes using statistical methods(8). SQC is used to eliminate causes or deviations that occur in order to meet the production standards implemented by the company(4), is structured and systematic problem solving using statistical tools(9). SQC control uses Seven Tools to improve processes and finishing, product defects can be minimized(10).

Six Sigma is a quality improvement tool based on the use of data and statistics(11). This is a rigorous process and helps to focus on product development and improvement(12), Used to anticipate defects, using the Define, Measure, Analyze, Improve and Control stages.

Failure Mode and Effects Analysis (FMEA) is a structured procedure and method used to identify and prevent as many failures as possible, as well as finding the causes of failure.(9). FMEA is used to obtain the highest RPN value which is a priority in proposed improvements to control quality, search for, identify and eliminate potential failures in the system. FMEA determines risk priorities based on severity, likelihood of occurrence, and likelihood of failure being detected(3). Several steps in creating an FMEA: (a) Identify services/products or processes. (b) List of potential problems that may arise, their causes and consequences. (c) Carry out an assessment of Detection, Occurrence and Severity(13).

3. METHODOLOGYY

The methodology in this research is:

A. Data Collection
1. Product quality specification/criteria data
2. Data on the number of defective products
3. Data on the type of defect
4. Data on the number of products produced

B. Data processing:
1) Determine the level of product defects
   A. Make a Pareto Diagram
   B. Making a Histogram
   C. Making Control Maps
   D. Calculation of sigma level(6):

$$DPMO = \frac{Number\ of\ Defect}{Number\ of\ Unit\ x\ CTQ} \text{ X } 1{,}000{,}000 \ldots. (1)$$

2) Analyzing the causes of defects (Fish Bone Making)
3) Analyze the problem with 5W + 1H and FMEA(13):

RPN = Severity x Occurance x Detection ….. (2)

4) Solutions to the causes of defective products
5) Analysis and creation of a quality optimization system model

In data collection, data will be obtained relating to quality criteria, the number and type of defective products, and the number of products produced. At the data processing stage, from the previously determined quality criteria, Pareto diagrams, histograms, control charts and sigma level calculations are created. From the highest defects, a fishbone diagram is created to analyze the causes of the defects that occur. Then an FMEA calculation is carried out to determine what actions need to be taken first.

The entire data processing process refers to the application of various methods in the Quality Control Circle, namely integrating the PDCA cycle (5W + 1H, and SMART) and Six Sigma which uses seven basic tools in the process as well as Statistical Quality Control (SQC) in the calculation process.

4. RESULTS AND DISCUSSION

Data processing steps use the PDCA cycle, Six Sigma method, SQC, 5W + 1H approach, FMEA method and other methods as a proposal to improve product defect levels so that product quality optimization is achieved.

4.1. Plan and Define

The Plan cycle in PDCA and Define in the Six Sigma stage is basically to identify problems, by using tools: check sheets and histograms to obtain data on the types of defective products and their number.

The histogram diagram image is as follows:

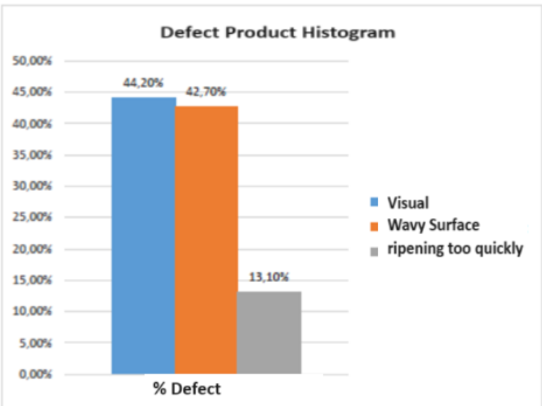

Figure 1. Histogram

From Figure 1, it can be seen that this type of visual disability has the highest percentage of defects, namely 44.2%. Followed by a wavy surface at 42.70% and finally the type of defect that matures too quickly at 13.1%, where this type of defect is the type of defect with the lowest percentage.

4.2. *Plans*and Measure

At this stage, the PDCA cycle remains in the Plan, whereas the Six Sigma method enters the measure or measurement stage. At this stage the calculation process is carried out for the control chart and Six Sigma values. Because defect data is attribute data, the control chart used is the P control chart. The calculation process is as follows:

Based on a calculation process whose results are used to describe a proportion control chart (P-Chart), which is used to determine whether the proportion of product defects is still within control limits or not. Based on this table, P Chart can be depicted as shown in Figure 2.

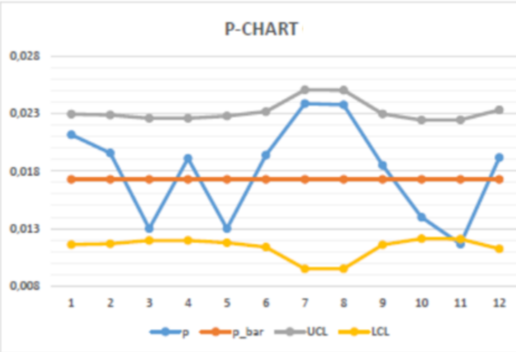

Figure 2. P Chart

In Figure 2, it can be seen that the proportion of product defects is still within control limits, which means that product defects are actually caused by conditions that can still be controlled. However, in reality, product defects still have the possibility to be reduced through possible improvements. For this reason, the calculation process continues with the sigma level calculation. The Six Sigma calculations carried out are as follows:

Table 1. Calculations*Defects Per Million Opportunities*(DPMO) and Sigma Level

Observation	Production Amount (m2)	Total Defects (m2)	DPMO	Sigma Level
1	4,720	100	7,062,147	3.95
2	4,853	95	6,525,173	3.98
3	5,388	70	4,330,611	4.13
4	5,388	103	6,372,185	3.99
5	5,003	65	4,330,735	4.13
6	4,380	85	6,468,798	3.99
7	2,511	60	7,964,954	3.91
8	2,523	60	7,927,071	3.91
9	4,700	87	6,170,213	4.00
10	5,721	80	4,661,190	4.10
11	5,667	66	3,882.125	4.16
12	4,171	80	6,393,351	3.99
Total	**55,025**	**951**		

From table 1. it can be seen that for every square meter in one million the probability or chance of a defect occurring is equal to7,062,147 m2 apart from thatThe product level sigma is in the range of 3.91 to 4.16. To achieve a higher sigma level, improvements need to be made. The next stage, it is necessary to analyze which product defects are the highest, which is still included in the Plan stage in the PDCA cycle, and the Analysis stage in the Six Sigma process.

4.3. *Plan and Analysis*

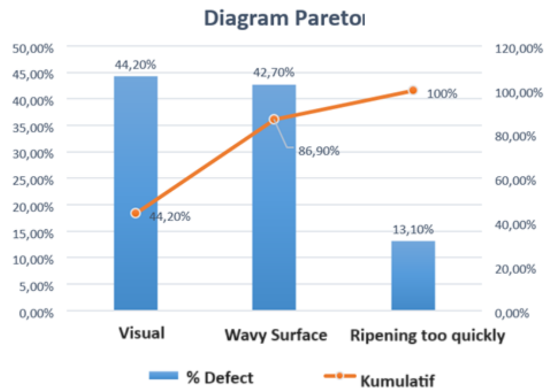

Figure 3. Pareto Diagram of Production Defects

Based on Figure 3, it can be seen that the highest product defects are visual defects, followed by wavy surfaces and the last one is cooking too quickly. The next step is to analyze the causes of the defect. So a fishbone is depicted.

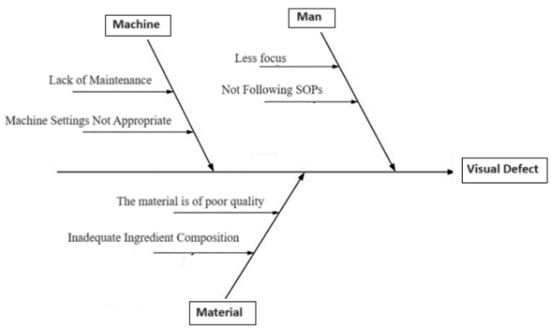

Figure 4. Fishbone Diagram

In Figure 4, it can be seen that the causes of visual defects include human, machine and material factors. For this reason, improvements need to be made to reduce visual defects based on the existing causes. So, the next step is the do stage of the PDCA cycle and the Improve stage of the Six Sigma method.

4.4. *Do*and Improve

At this stage, the FMEA method is applied, where improvements are made to the cause with the highest RPN value. This interprets that this cause is the cause that has the highest impact and frequency of occurrence where the current prevention methods still have little impact.

Table 2. Risk Priority Number (RPN) table

Failure Mode	***Cause***	***Effect***	***Severity***	***Occurrence***	***Detection***	**RPN**
Man	Less focus	Visual Disability	4	5	4	80
	Not Following SOPs	Visual Disability	4	5	4	80
Machine	Lack of Maintenance	Visual Disability	6	6	4	144
	Machine Settings Not Appropriate	Visual Disability	6	6	4	144
Material	The material is of poor quality	Visual Disability	6	7	4	168
	Inadequate Ingredient Composition	Visual Disability	6	6	4	144

Based on table 2, it can be seen that the highest RPN value is 168, which is the cause of the material being of poor quality. An overview of possible improvements and methods that can be used is in the following table, which has been sorted from highest RPN to lowest:

Table 3. Table of Improvements and Alternative Methods Used

No	***Failure Mode***	***Cause***	**RPN**	**Possible Improvements**	**Method**
1	Material	The material is of poor quality	168	Determine material quality criteria Selecting Suppliers	AHP
2		Inadequate Ingredient Composition	144	Conduct trials on the composition of the materials used	Experimental Design
3	Machine	Lack of Maintenance	144	Scheduling Machine Maintenance	Methods in preventive maintenance
4		Machine Settings Not Appropriate	144	Machine settings are carried out systematically	Taguchi
5	Man	Less focus	80	Make clearer and firmer regulations	Making more systematic Personnel Regulations
6		Not Following SOPs	80	There is a reward and punishment system	Making more systematic Personnel Regulations

Table 3 shows the improvements that need to be made based on the causes that result in defective products. In the table, it can be seen that the highest RPN value lies in poor quality materials. To overcome this, there are many things that can be done, but according to what has been described previously, the approach or method that can be done before using the AHP method so that improvements can be made in more detail is to use the 5W+1H method (What, Who, Where, When, Why, and How), namely determining what needs to be done, why it needs to be done, where and when to repair, who made the last repair, how the repair was carried out.

4.5. *Check* and Controls

At this stage a check is carried out to control whether the repairs have been carried out according to the plan. The tool used can be in the form of a check list, to check one by one the items that need to be carried out in repairs, whether they have been implemented or not. If a discrepancy occurs, analysis, evaluation and possible adjustments will be carried out immediately so that improvements can continue to be made. The results of this analysis, evaluation and adjustment will be carried out at the action stage.

Action

At the action stage adjustments are made to several things resulting from the check and control stages. Action can produce standards, preventive steps and required actions based on the results of checks or controls.

Based on what has been described previously, a product quality optimization system model can be created by considering various production factors through integrating various methods contained in quality control. By integrating and combining various production factors, we can optimize the results and production costs incurred which will ultimately increase profits.

4.6. Product Quality Optimization System Model

Table 4. Product Quality Optimization System Model

Cycle	METHOD SIX SIGMA	METHOD OTHER	SEVEN TOOLS	INFORMATION
PLANS: 5W + 1H SMART	DEFINE		1. *Check Sheet* 2. *Run Chart* 3. Histograms	
	MEASURES: Sigma Level Measurement	*Statistical Quality Control*(SQC)	4. *Control Chart*	Measuring product defects are in the control chart or not Measuring the record at what sigma level
	ANALYZE		5. Pareto Chart 6. *Fishbone Diagrams* 7. *Scatter Diagrams*	
DO	IMPROVE	FMEA		Methods for determining which repairs need to be done first
		5W + 1H		The method is applied so that improvements are carried out systematically
		AHP PREVENTIVE MAINTENANCE TAGUCHI Other methods required for repair		Several examples of methods that can be used to make improvements
CHECK	CONTROL		*Check Sheet pareto diagram*,Histograms Control Diagram	Compare the suitability of the improvement plan and reality Compare the situation before and after repairs
ACTION				Standard problem solving solutions
Next, return to PLAN				

Based on table 4, it can be seen that the product quality optimization system model follows the Plan, Do, Check and Action (PDCA) cycle, combined with the Six Sigma method so that it is known at what sigma level, Statistical Quality Control (SQC) is used to carry out analysis related to manufacturing. control chart, then uses the FMEA method to get a decision on which improvements should be made first and in the end will use appropriate methods for the improvements that need to be made. Each cycle uses tools to achieve the goals of each stage of the cycle.

The plan cycle, which is the planning stage, begins with identifying problems according to the principles of What, Who, When, Where, Why and How (5W + 1H) and clear targets that are Specific, Measurable, Attainable, Reasonable and Time (SMART). In this plan cycle, the use of the Six Sigma method is at the Define stage with the tools used are check sheets, run charts and histograms. The next stage in six sigma is Measure, namely measuring whether product defects are at what sigma level and whether they are on the control chart or not. Apart from using the six sigma formula, the tool used is a control chart, where the control chart is made using the Statistical Quality Control (SQC) method. In this cycle, the six sigma stage carried out is analyze, that is, based on the measurement results, an analysis process is carried out using tools including: Pareto diagram, fishbone diagram, scatter diagram. The methods and tools used in this cycle aim to achieve the principle of identifying problems and clear targets (SMART).

In the Do cycle, this is the stage of carrying out improvements according to planning. In this cycle, the improvement stage in the six sigma method is carried out. Other methods used at this stage are FMEA which is useful for determining which repairs must be carried out first based on the RPN value calculation, and 5W + 1H which is useful for more detailed repair directions (usually used in the plan cycle in PDCA). Furthermore, repairs carried out can use appropriate methods, for example the AHP method, preventive maintenance, Taguchi and so on.

In the Check cycle, this is the stage of checking the conformity of the repairs carried out with those previously planned, and comparing before and after repairs. The tools used are check sheets, Pareto diagrams, histograms and control diagrams. This cycle in six sigma is the control stage. At this stage, in-depth control and analysis will be carried out, to ensure whether the improvements made to improve product quality have been carried out, if there are obstacles or problems adjustments will be made.

In the Action cycle, this is the stage of adjusting work standards according to the results of the analysis carried out at the check stage. At this stage, it can produce a work rhythm, rules and work processes that are adjusted to the results of previous analyzes with the aim of improving product quality.

As the name of the cycle suggests, after arriving at the action cycle, it will return to the plan cycle and the stages carried out will repeat with the same case because the problem has not been resolved or even with a new case or problem. In the quality control system, there is the term continuous improvement, where improvements will always be made repeatedly in order to produce a product that is better and better.

5. CONCLUSION

The conclusion of this research is that the resulting product quality optimization system model is needed to provide a sequential picture of the integration of various quality control methods, so that later the use of quality control methods can be more appropriate to produce product quality optimization.

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