Analysis of Quality Control in Assembling Kawachi RN-621 Mosquito Rackets

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Abstract. Along with the current era of globalization and advancements of sophisticated technology, high quality products at competitive prices will be chosen by consumers. This will increase sales of the product, which means increasing market share so that it will increase company revenue. In production activities, problems are always found that ultimately cause defects in a product, especially in mass production. The things that cause disability can be in the form of people, machines, equipment, work environment, work methods, and raw materials. In this study, process quality control methods such as seven tools, Failure Mode and Effect Analysis (FMEA), and new seven tools used to reduce the number of defects in the RN-621 Mosquito Rackets assembly. Errors caused by soldering, ordering and retrieving. This is done to find the root cause of disability and find solutions to minimize errors.

1. Introduction

Competition and technological advances that are rapidly increasing nowadays have brought considerable influence to the industrial world, and business people realize that in a situation of intense competition this is absolutely necessary a reliable strategy so that their products have an advantage. Consumer demand for product quality is accompanied by an increasing number of products and services, causing the competitiveness and endurance of each business is no longer determined by the low cost of the sacrifice, but also determined by the value added of the product through quality improvement. Quality control is one way to improve product quality and make the products produced have competitiveness [5]. Total control of quality as explained by its name is the integration of activities in quality control. People are often confused by the term integrated in the terminology of integrated quality control, namely whether the control is integrated or the quality that is controlled is integrated quality. Quality control is related to the integration of all activities that affect the desired level of quality, whereas integrated quality is the integration of all factors included in the quality dimensions such as size, color, weight, durability, flexibility, etc. in the control of total quality [1]. 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 [11]. Therefore, by achieving a good quality product output, the company has the potential to benefit even progress and recognition from consumers, and the other side of the consumer itself does not feel disadvantaged and feel satisfied with the product consumption [6].
The statistical tools used in the seven tools for quality control are Check Sheet, Scatter Diagram, Fishbone Diagram, Pareto Chart, Flow Chart, Histogram, Control Chart involves the process of checking the production flow then presented in the form of a form to obtain the number of defects in tempeh easily, whereas scatter diagram used to display a pair of numeric data on a Cartesian coordinate system. Fishbone diagram used to identify various causes of a problem. Pareto chart is a chart that displays sequential classifications (priority problems to the lowest). Flow chart used to display the production process flow [7]. In solving or solving a problem there are eight steps that can be taken which are the elaboration of the Plan, Do, Check and Action (PDCA) cycle which is called the eight steps of problem solving as shown in Figure 1 [2].

\[\begin{align*}
\text{Determine the topic} & \quad \rightarrow \quad \text{The problem still exists} \\
\text{Determine the problem} & \quad \rightarrow \quad \text{Standardization} \\
\text{Find the cause of problem} & \quad \rightarrow \quad \text{Research the results} \\
\text{Plan for completion} & \quad \rightarrow \quad \text{Do} \\
\end{align*}\]

**Figure 1.** The eight step problem solving cycle

The main purpose of quality control is to find out to what extent the process and results of products or services are made according to the standards set by the company. The general quality control objectives are:

- The final product has specifications according to quality standards or quality that have been set.
- So that product design costs, inspection costs, and production process costs can run efficiently.
- The principle of quality control is an effort to achieve and improve the process carried out continuously to be analyzed in order to produce information that can be used to control and improve the process, so that the process has the ability (capability) to meet the product specifications desired by the customer [8].

The purpose of quality control by using the seven tools method of this study is to find out the problems that cause errors, the number of errors and look for the factors that cause errors so that improvements can be made in the future.

2. **Theoretical Background**

2.1. *A Quality Approach with Seven Tools*

The intent and purpose of using the seven tools are as follows:

- Know the problem.
- Narrow the scope of the problem.
- Look for factors that are thought to be causes.
- Ascertain factors that are thought to be causes.
- Prevent errors due to carelessness.
- Involved due to repairs.
- Knowing the results that deviate or separate from other results.

The seven quality control tools are:

- Stratification. Stratification is an attempt to group data into groups that have the same characteristics.
- Check Sheet. Check Sheet is a form in the form of items to be checked that has been printed in the form with the intention that the data can be collected easily and concisely [10].
- Histogram. A histogram is one of the statistical methods to organize data so that it can be analyzed and its distribution known [3].
- Pareto Diagrams. Pareto Diagrams are made to find or find out the problem or cause that is the key in solving problems and the comparison of the whole [4].
- Scatter Diagram. Scatter Diagrams are used to see the correlation (relationship) of a continuous causative factor to a characteristic of the quality of the results
- Cause and Effect Diagram. Cause and effect diagram is a diagram that illustrates lines and symbols that show the relationship between the causes and effects of a problem, so that further action is taken to correct the problem [9]
- Control Chart. Control Chart is a chart used to determine whether a process or product quality is in a stable state or not or in other words whether it is still in a controlled state (in accordance with the specification limits) or out of control (outside the specification limits)

2.2. Fault Mode and Effect Analysis (FMEA)
The purpose of implementing FMEA is to prevent problems with the process and the product. If used in design and manufacturing processes, FMEA can reduce or reduce costs by identifying and improving products and processes quickly during the development process.

3. Research Methodology
The data used in this study that has a relationship with the problems of this study are:

- Observation Results Data
- Random Number Data for Simulation
- Data Collection

The data used are observational data and random number data.

| No. | Work Element                                               | Type of Error | Total |
|-----|-----------------------------------------------------------|---------------|-------|
|     |                                                           | X1 | X2 | X3 |            |
| 1   | Assembled 223 J 2000 V capacitors to the main PCB board  | √  | -  | -  | 1           |
| 2   | Soldered capacitors 223 J 2000 V on the main PCB board   | -  | -  | -  | 0           |
| 3   | Assembled capacitor 684 J 400 V 1 to the Main PCB board  | -  | -  | -  | 0           |
| 4   | Soldered capacitor 684 J 400 V 1 on the Main PCB board   | -  | -  | -  | 0           |
| 5   | Assembled capacitor 684 J 400 V 2 to the PCB board       | -  | -  | -  | 0           |
| 6   | Soldered capacitors 684 J 400 V 2 on the Main PCB board  | -  | -  | -  | 0           |
| 7   | Assembled Diode R 400 F 1 to the Main PCB board          | -  | -  | √  | 1           |
| 8   | Soldered R 400 F 1 diode on the Main PCB board           | -  | -  | -  | 0           |
| 9   | Assembled Diode R 400 F 2 to the Main PCB board          | -  | -  | -  | 0           |

The number of work stations formed was 4 work stations and can be seen in Table 2.
Table 2. Division of work centers

| Work Center | Work Element |
|-------------|--------------|
| I           | 2,4,6,8,10,12,14,16,18,20,22,24,26,28,30,32,34,41,43,45,47,49,51,53,55,57,59,61,63,65,67,69,84,85,86,87,89,91,93,94,95 |
| II          | 5,11,19,21,23,25,27,29 |
| III         | 44,42,41,46,52,60,68,87,90,33,50,54,62,91,88 |
| IV          | 70,36,55,92,37,56,38,57,39,58,40,63,64,65,66,71,72,73,74,75,76,77,78,79,80,81,82,83,93,94,95 |

Random Number Data for Simulation

Randomization was carried out for simulations at each work center for one month and can be seen in Table 3.

Table 3. Random number data for every error

| Date       | Sample Number | WC I | WC II | WC III | WC IV |
|------------|---------------|------|-------|--------|-------|
| July 1, 2019 |               |      |       |        |       |
| 1          | 0.603         | 0.665| 0.705 | 0.735  |       |
| 2          | 0.042         | 0.445| 0.336 | 0.260  |       |
| 3          | 0.181         | 0.329| 0.633 | 0.768  |       |
| 4          | 0.516         | 0.009| 0.510 | 0.186  |       |
| 5          | 0.693         | 0.860| 0.513 | 0.171  |       |
| 6          | 0.155         | 0.856| 0.960 | 0.998  |       |
| 7          | 0.680         | 0.348| 0.458 | 0.361  |       |
| 8          | 0.544         | 0.538| 0.717 | 0.772  |       |
| 9          | 0.511         | 0.395| 0.373 | 0.668  |       |
| 10         | 0.551         | 0.631| 0.018 | 0.591  |       |
| 11         | 0.956         | 0.858| 0.568 | 0.640  |       |
| 12         | 0.829         | 0.611| 0.156 | 0.600  |       |
| Etc. until July 31, 2019 |               |      |       |        |       |

4. Result

4.1. Probability Determination

Based on the data that has been collected, a recapitulation of calculations is carried out to find out the number of errors that occur at each work station, this can be seen in Table 4 below.

Table 4. Number of errors at each work station

| Work Center | Type of Error | True | Total |
|-------------|---------------|------|-------|
|             | $X_1$ | $X_2$ | $X_3$ |       |       |
| WC 1        | 0     | 0     | 3     | 96    | 99    |
| WC 2        | 1     | 0     | 1     | 37    | 39    |
| WC 3        | 1     | 0     | 3     | 47    | 51    |
| WC 4        | 1     | 1     | 0     | 91    | 93    |

Then the probability and cumulative probability calculations are performed for each type of error that occurs at each work station.

4.2. Use of seven tools

4.2.1. Stratification. Stratification is a process of classifying the error data from each work station. Grouping is done based on each type of error for each work station. The types of errors that occur are as follows:
X1  = Component Assembly Error  
X2  = Component Soldering Error  
X3  = Tightening Error  

| Work Center | Type of Error | True | Total |
|-------------|---------------|------|-------|
| WC I        | X1 0, X2 0, X3 3 | 96   | 99    |
| WC 2        | X1 1, X2 0, X3 1 | 37   | 39    |
| WC 3        | X1 1, X2 0, X3 3 | 47   | 51    |
| WC 4        | X1 1, X2 1, X3 0 | 91   | 93    |

4.2.2. Check Sheet

| Work Center | Type of Error | Total |
|-------------|---------------|-------|
| I           | X1 0, X2 0, X3 13 | 13    |
| II          | X1 16, X2 0, X3 12 | 28    |
| III         | X1 18, X2 0, X3 47 | 65    |
| IV          | X1 11, X2 9, X3 0 | 20    |
| Total       |               | 45    |

Based on the results of the check sheet, it can be seen that tightening errors (X3) are the most common type of errors, 72 errors, followed by component assembly errors (X1) assembly errors are 45 errors, and finally component picking errors (X2) errors soldering of components is 9 errors. Thus, the total errors in July 2019 were 126 errors.

4.2.3. Histogram. The histogram of the number of errors per work station can be seen in Figure 2.

![Histogram of Error Total](image)

Based on the histogram, it appears that the work station that has the largest total error is WC III with 65 errors.
4.2.4. Pareto Diagram

Table 7. Sorting the number of errors

| Work Center | Error Total | Error Percentage (%) | Percentage of Cumulative Error (%) |
|-------------|-------------|-----------------------|-----------------------------------|
| WC III      | 65          | 51.59                 | 51.59                             |
| WC II       | 28          | 22.22                 | 73.81                             |
| WC IV       | 20          | 15.87                 | 89.68                             |
| WC I        | 13          | 10.32                 | 100.0                             |
| **Total**   | **126**     | **100.0**             | **315.08**                        |

Based on the data in Table 7, above can be made Pareto Diagram shown in Figure 3.

Figure 3. Pareto Diagram

4.2.5. Scatter Diagram. Scatter Diagrams are created to identify possible correlations between quality characteristics and the factors that might influence them. Based on the scatter plot the regression calculations between WC III and WC II are performed as follows.

\[ y = a + bx \]  

Then the regression equation is obtained:

\[ y = 0.7476 + 0.1202x \]

The correlation value between WC III and WC II is

\[ r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}} \]  

\[ r = \frac{27(73) - (65)(28)}{\sqrt{[27(203) - (65)^2][27(54) - (28)^2]}} \]

\[ r = 0.1641 \]

Based on the calculation of the correlation coefficient, it can be seen that the correlation obtained is 0.1641 which means that if an error occurs in WC III it will give a weak influence on the WC II process.
4.2.6. Control Chart. The purpose of making a control chart is to find out whether the process is in control and to monitor variations of the process continuously.

4.2.6.1. Control Chart C. Control chart C illustrates the number of nonconformities or defects in a constant size sample.

![Control Chart WC III](image)

**Figure 4.** Control chart C for work center III

![Control Chart C WC II](image)

**Figure 5.** Control chart C for work center II

Based on the control map C for work centers II and III, it appears that all subgroups are within control limits. Errors per unit that occur are still within the allowed limit.

4.2.6.2. Control Chart U. Based on the control map U for work centers II and III, it appears that all subgroups are within control limits. Errors per unit that occur are still within the allowed limit.

4.2.7. Cause and Effect Diagram. Through the cause and effect diagram, it can be seen several factors that caused errors in WC III and can be corrected for the future.
Through the cause and effect diagram, it can be seen several factors that caused errors in WC II and can be corrected for the future.

**Figure 6.** Cause and effect diagram in WC III

**Figure 7.** Cause and effect diagram in WC II
4.2.8. **Fault Mode and Effects Analysis (FMEA)**. Based on the calculation of the RPN value, it can be seen that for each work station there is the highest RPN value. The following is an explanation of the value of the RPN to the work station.

- **WC III**
  The highest RPN value in WC III is the wrong assembly method, with an RPN value of 336.

- **WC II**
  The highest RPN value in WC II is inaccurate, with an RPN value of 294.

5. **Discussion**

Based on stratification at each work center it can be seen that at work center I there are 3 errors, at work center II there is 1 error, at work center III there are 4 errors, and at work center IV 2 errors occur. Based on the results of the check sheet, it can be seen that the tightening error (X3) is the most common type of error, which is 72 errors, followed by assembly errors (X1) which have 45 errors, and finally the component error taking (X2) is 0 errors. Thus the total errors in July 2019 were 126 errors. Based on the histogram, it appears that the work center that has the largest total error is WC III with 65 errors, and the work center that has the smallest errors is WC I with 13 errors. Based on the Cause and Effect Diagram for WC III shows that the cause of errors in assembling components in WC III is human, that is, it is difficult to distinguish components, raw materials that are easily detached components, the environment ie hot room, lack of lighting, solder smoke odor, work method is soldering method wrong, wrong assembly method, not ergonomic movement, the equipment is inadequate, the solder quality is not good. Cause and Effect Diagram WC II shows that the cause of error in tool installation in WC II is human, that is, it is difficult to distinguish components and is inaccurate, raw materials are easily dislodged components, work methods are incorrect assembly methods and non-ergonomic movements, work environment is lacking lighting, space the smell of solder smoke, the seat is not ergonomic, and the room is noisy, the equipment is inadequate equipment and the solder is not hot.

6. **Conclusion**

The conclusions obtained are stratification shows errors at work stations where errors occur at all work stations. Checksheets show tightening errors (X3) are the most types of errors that is 72 errors, then assembly errors (X1) are 45 errors, and component soldering errors (X2) are 9 errors. Scatter diagram shows the correlation of WC III and II is 0.1641, which means it gives a weak influence on the assembly process in each WC. Cause and effect diagrams on the assembly process of the Kawachi RN-621 Mosquito Rackets are human, material, equipment, work methods, and work environment. The control chart in the Kawachi RN-621 Mosquito Rackets assembly shows that all subgroups are in control and we can also know from FMEA shows that the biggest cause of failure in WC III which has an RPN 336 value which is caused by incorrect assembly method and in WC II which has an RPN 294 value caused by lack of accuracy in assembling components.

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