Journal of International Conference Proceedings (JICP) Vol. 6 No. 1, pp. 14-25, March, 2023
P-ISSN: 2622-0989 E-ISSN: 2621-993X
https://www.ejournal.aibpmjournals.com/index.php/JICP

Analysis of Defect Rate Improvement in The Smartphone Assembly Industry Using SPC and DMAIC Approach

Nurfitri Rahmawati[1], Hasbullah Hasbullah[2]
Universitas Mercubuana[1,2]
Jl. Meruya Selatan No.1 Kembangan, Jakarta Barat,11650, Indonesia
Correspondence Email: Nurfitrirahmawati@gmail.com

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE
Rahmawati, N., & Hasbullah, H. (2023). Analysis of Defect Rate Improvement in The Smartphone Assembly Industry Using SPC and DMAIC Approach. *Journal of International Conference Proceedings*, *6*(1), 14-25.

DOI:
https://doi.org/10.32535/jicp.v6i1.2233

Received: 10 February 2023
Accepted: 20 March 2023
Published: 27 March 2023

ABSTRACT

In the current era, business is experiencing very rapid development, one of which is the smartphone assembly industry. With the high demand for smartphones from the public, companies will compete to be able to produce quality smartphones with predetermined standards and specifications. Quality control is needed by the company to maintain the products it produces. It is known that the company's production target is 99.50%. However, this target has never been achieved due to a large number of defect smartphones. Based on calculations using SPC and DMAIC, it is known that most defects are found in production line 1 with the type of smartphone product type B, and the type of defect, namely LTE test fail. For this reason, the research that will be carried out in this study focuses on the LTE test fail defect. The cause of the main problem in this research is machine error. Before the repair, the %p value was 2.6%, and after the repair was carried out by restarting the machine every 2 hours, the %p value was 1%.

Keywords: Defect, DMAIC, Quality, Quality Control, Seven Tools, SPC

INTRODUCTION

In the current era of globalization, business is experiencing very rapid development, especially business in the manufacturing industry. In recent years, the role of the manufacturing industry in Indonesia in the national economy has increased. The Central Statistical Agency said that by the end of 2021, Indonesia's GDP had expanded by 3.69 percent annually, which was higher than the 2.07 percent annual expansion seen in 2020 (Indarto & Naharto, 2022). In order to compete in the global market, every industry must strive to increase productivity in all areas. Therefore it must optimize resources such as machines, people, and materials (Sethia, Shende, & Dange, 2016). There are many manufacturing industry sectors spread throughout Indonesia. The smartphone industry is one of the electronics industries. A smartphone is a sophisticated communication device. Smartphones are versatile gadgets that serve many purposes beyond just making and receiving phone calls; they also make it easy to play games, connect with friends and family, and access useful online services. Smartphones facilitate connection through wireless call services and online mediums like social networking and electronic mail. The presence of a mobile operating system is the most obvious characteristic of a smartphone (Rakib et al., 2022).

With the high demand for smartphones from the public, companies will compete to be able to produce quality smartphones with predetermined standards and specifications. Quality control has the aim of reducing the number of defect or damaged products, maintaining product quality according to predetermined standards, and avoiding defect products that pass into the hands of consumers. It is known that the company's production target is 99.50%. However, this target has never been achieved due to a large number of defect smartphones. The method that can be used for quality control is to use process improvement analysis with the SPC and DMAIC approach.

Based on the background description, the quality of the production process is very important to be implemented in the smartphone industry. Proper production process management can minimize the occurrence of defect products that occur in the smartphone industry. For this reason, research is needed using process capability with the DMAIC approach to pay attention to all process activities starting from the material arrival process to the product packing process.

LITERATURE REVIEW

Quality

Quality is an important indicator for companies to be able to compete during intense competition in the industry. The definition of quality, according to (Domingo & Aguado, 2015), is the ability of a product to be able to satisfy specified or defined needs. As a result of the increasing importance of the global market, quality management is emerging as a key competitive component and a benchmark of success for businesses, regions, and nations. Because the consumer is the ultimate beneficiary of the final product or service, it is the customer who must make the quality determination (Akhmatova, Deniskina, Akhmatova, & Prykina, 2022).

Quality Control

Quality control is a system of verifying a desired degree of product or process quality with careful planning, continuous inspection, use of appropriate equipment, and corrective action if necessary so that quality control is not just maintenance or maintenance of the merits of a product. The goal of quality control is to ensure that final goods and services are consistent with specified requirements, as well as to improve the quality of products that are not yet following predetermined standards and to maintain the appropriate quality as much as possible (Akhmatova et al., 2022). Quality control is a supervisory activity carried out by each component in the company to increase and maintain production so that the products produced are in accordance with the expected product quality standards and as an effort to direct so that quality errors do not occur in the production process (Damayanti, Fajri, & Adriana, 2022).

Seven Tools

Seven tools are tools for solving quality problems and simple statistics that are used for problem-solving (Rasyida & Ulkhaq, 2016).

a. Check sheet
   A check sheet is a tool that allows data collection to be an easy, systematic, and orderly process. This tool is in the form of worksheets that have been printed in such a way that data can be collected easily and briefly (Rasyida & Ulkhaq, 2016).
b. Stratification
   Stratification is a method that divides data into small categories that have the same characteristics. Stratification is an attempt to break down or classify problems into groups or smaller similar groups or become single elements of the problem (Rasyida & Ulkhaq, 2016).
c. Histogram
   Histograms are useful for spotting patterns in data and summarizing information for analysis; they provide a visual representation of the frequency with which various components of a process occur. Histograms are bar charts that indicate the frequency with which individual numbers or other values appear in a larger data collection (Rasyida & Ulkhaq, 2016).
d. Scatter diagrams
   Scatter Diagrams are used to identify relationships that are possible between observed changes in variables that are different. Scatter Diagram is a tool that functions to test how strong the relationship between 2 variables is and determine the type of relationship (Rasyida & Ulkhaq, 2016).
e. Pareto Charts
   A Pareto chart is a type of bar chart in which the bars are arranged in descending order from left to right to highlight the most crucial areas for development. Bar charts and line charts are used to form a Pareto chart. The line chart indicates the total summative data, while the bar chart displays the classification and data values. Data classification is sorted according to ranking order. The highest ranking is the most important issue to resolve soon. Pareto diagrams are used as one of the tools to control quality and help in analyzing data based on categories and patterns of data and problems as a whole (Permono, Salmia, & Septiari, 2022). The Pareto chart aims to determine the most dominant defect problem that causes product quality to decline (Kurnia, Jaqin, Purba, & Setiawan, 2021). Pareto diagrams can be created after improveents are made and then compared with previous conditions (Rohani & Suhartini, 2021).
f. Control chart
   A control chart is a tool in the form of a process control chart to determine the upper control limits and lower control limits for process performance. Control charts are used to measure process performance and sequential or time variability. So that from the data collected, trends in actual process conditions can be detected (Rasyida & Ulkhaq, 2016).
g. Fishbone Diagrams
   An effective method for examining an issue and discovering its root causes is the Fishbone Diagram. Humans, resources, tools, machinery, processes, regulations, and so on are all considered potential sources of a problem's manifestation. Reasons for each class need to be worked out in a brainstorming session. The Cause and

Effect Diagram is also known as a Fishbone Diagram due to its similarity in shape to a fishbone (Rasyida & Ulkhaq, 2016).

SPC (Statistical Process Control)
The goal of statistical process control (SPC) is to use data collected from a process to make adjustments as needed to keep output consistent with specifications. Under SPC, the aim is to maximize the number of usable outputs while minimizing waste. The main methods used in SPC include control charts, incremental improvements, and experiments. Madanhire and Mbohwa (2016). Process control is a step in manufacturing that aims to prevent subpar goods from leaving the production line by monitoring for and correcting any deviations from the ideal process output. Simple Process Control (SPC) relies on the use of control charts, which graph the measured results of a manufacturing process (Shafqat, Huang, & Aslam, 2021).

FMEA (Failure Mode Effect Analysis)
Known failures or flaws of a system, design, process, or service can be defined, identified, and mitigated using the FMEA technique (Özyazgan & Engin, 2013). Mubarok and Ambarwati (2022) add that the function of FMEA is to anticipate the risk of failure. Zyazgan & Engin's study focused on applying the FMEA method to prioritize problems based on their biggest RPN value in order to identify their root causes. A structured method and techniques aimed at identifying and resolving issues are used in the root cause analysis process to determine the primary reasons for a problem (Hunusalela, Perdana, & Usman, 2019). This method has proven to give great results for the manufacturing industry in finding the cause of the problem (Haviana & Hernadewita, 2019). This method is often combined with the FMEA method to find priority problems from the many problems found (Qin, Xi, & Pedrycz, 2020).

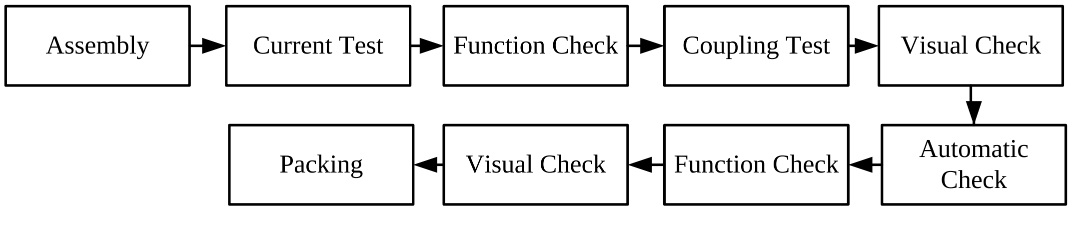
RESEARCH METHOD

The method used in this research is applied research, namely studying a certain aspect related to the problems that will be examined in one of the processes in this research, namely the smartphone assembly process. Then the results are recommendations or proposed improvements to the research problem. The following are the steps in this research.
1. Define: Identify the type of defect and determine the pareto chart.
2. Measure: The process of calculating process capability and % defects
3. Analyze: The analysis process uses a fishbone diagram.
4. Improve: Corrective action by calculating the value of % defects
5. Control: Action control of the proposed improvement

RESULTS

Data Collection
In general, the smartphone production process is divided into several processes, as follows:

Figure 1. Smartphone Production Process



1. Assembly: The process of assembling all smartphone components.
2. Current Test: Testing process to determine the value of the electric current contained in the smartphone.
3. Function Check: The smartphone function is checked through the MMI code.
4. Coupling Test: Testing process to determine the signal value on the smartphone.
5. Visual Inspection: The process of visual inspection of smartphones.
6. Automatic Check/Run-In: The process of testing smartphone endurance, the smartphone will carry out its functions automatically for 4-8 hours non-stop.
7. Function Check: The smartphone function is checked through the MMI code after run in
8. Visual Inspection: The process of visual inspection of the smartphone after Run In.
9. Packing: The process of packing smartphones and accessories into boxes.

The following is smartphone production data consisting of the number of smartphones produced, the number of defect smartphones, the failure rate, and the acceptance rate in 2021.

Table 1. Smartphone Production Data 2021

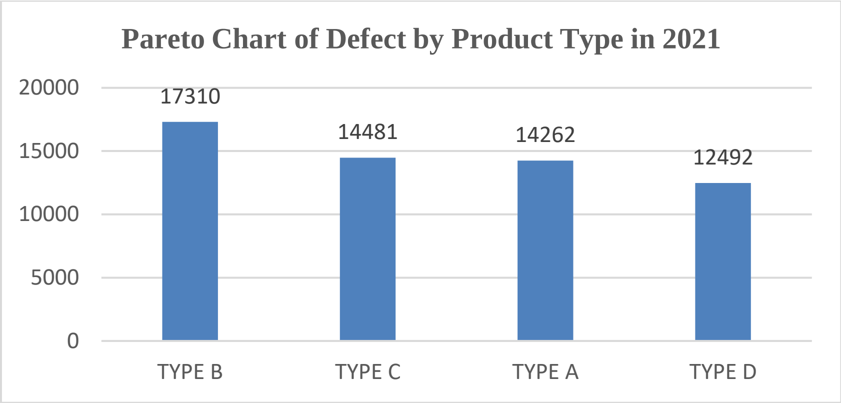
Month	Total Production	Total Defect	Failure Rate	Acceptance Rate
January	100680	4995	4,96%	95,04%
February	103755	5712	5,51%	94,49%
March	110640	6294	4,78%	95,22%
April	101220	6684	6,60%	93,40%
May	88290	4827	5,47%	94,53%
June	90825	4308	4,74%	95,26%
July	96555	4446	4,60%	95,40%
August	90255	4986	5,52%	94,48%
September	85650	4386	5,12%	94,88%
October	81300	4464	5,61%	94,39%
November	90072	4038	4,48%	95,52%
December	93018	4305	4,63%	95,37%
Total	1132260	58545		
Average	94355	4878,75	5,17%	94,83%

Based on table 1 it is known that the total smartphone production in 2021 is 1,132,260 units and the number of defects is 58,545 units.

In this study, analysis was carried out using a Pareto chart. The Pareto chart is divided into 3, namely the Pareto chart based on product type, the Pareto chart based on the production line, Pareto chart based on the type of defect.

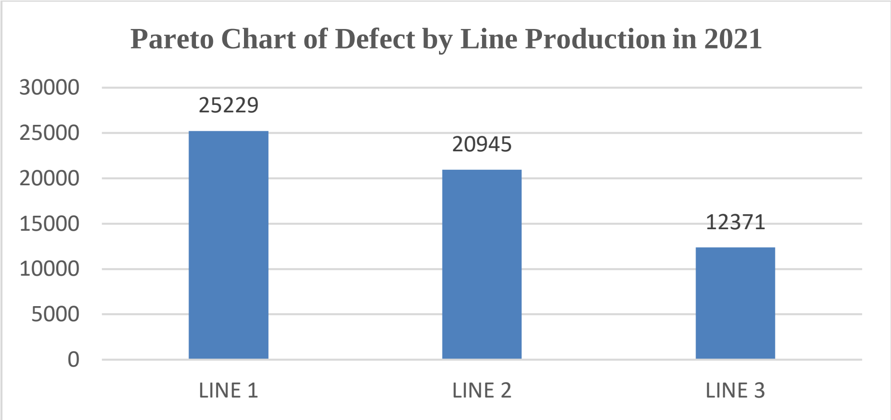
Journal of International Conference Proceedings (JICP) Vol. 6 No. 1, pp. 14-26, March, 2023
P-ISSN: 2622-0989 E-ISSN: 2621-993X
https://www.ejournal.aibpmjournals.com/index.php/JICP

Figure 2. Pareto Chart of Defect by Product Type in 2021



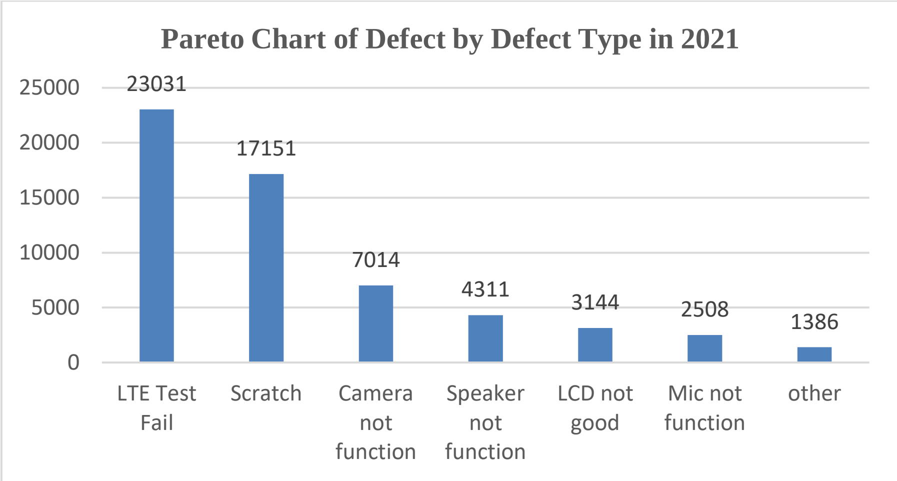
Based on the pareto diagram above, it is known that the biggest defects are found in smartphones with the type B model of 17310 defect units, the second order is the type C model of 14481 defect units, the third order is the type A model of 14262 defect units, the last order is the type D model of 12492 defect units.

Figure 3. Pareto Chart of Defect by Line Production in 2021



Based on the Pareto diagram above, it is known that the biggest defects are in production line 1 with 25229 defect units, the second order is production line 2 with 20945 defect units, and the last order is production line 3 with 12371 defect units.

Figure 4. Pareto Chart of Defect by Defect Type in 2021

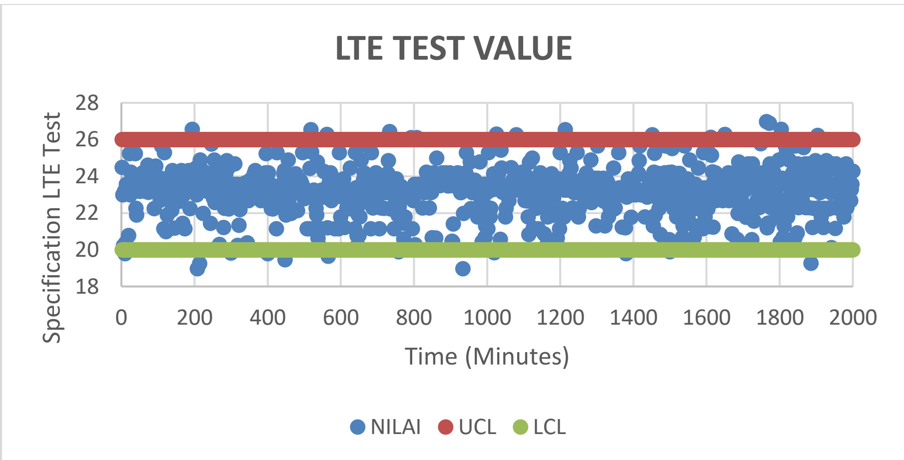


Based on the Pareto diagram above, it is known that the biggest defects are found in the type of LTE test fail with 23031 defect units. The second order is the type of scratch defect with 17151 defect units. The third is the type of camera not function defect with 7014 defect units. The fourth is the type of speaker not function defect is 4311 defect units. Fifth is the type of LCD not a good defect of 3144 defect units, sixth is the type of mic not function defect of 2508 defect units, last order is other types of defects of 1386 defect units.

Data Processing

Based on calculations using Pareto diagrams, it is known that most defects are found in production line 1 with the type of smartphone model type B and the type of defect; namely LTE test fails. For this reason, the research that will be carried out in this study focuses on the LTE test fail defect. Long Term Evolution (LTE) is a name given to a project in The Third Generation Partnership Project (3GPP) which was created to develop Universal Mobile Telecommunication System (UMTS) technology to address future data needs. According to the Standard, LTE provides a downlink speed of 100 Mbps (Karo Karo et al., 2020). For specifications using the standard LTE test applied are 20-26dB. If the LTE test results are not following these specifications, the smartphone unit is said to be defect , and repair or retesting will be carried out.
The following is the LTE Test data displayed in the form of control charts and tables.

Figure 5. LTE Test Value Before Improvement



Based on the graphic image above shows the distribution of 1000 LTE test data for 2000 minutes. There are LTE test values that are appropriate and not following the specifications set by the company.

The following is an example of calculations from the table above.

$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_1-\bar{x})^2}{n-1}$$
$$= \frac{(x_1-\bar{x})^2 + (x_2-\bar{x})^2 + \cdots + (x_{1035}-\bar{x})^2}{n-1}$$
$$= \frac{1393{,}544}{999}$$
$$= 1{,}395$$
$$\sigma = \sqrt{\sigma^2}$$
$$= \sqrt{1{,}395}$$
$$= 1{,}181$$

Based on the LTE test data in the previous table, the following is the calculation of the process capability in this research.

Process capability value Against Standards

$$Cp = \frac{USL-LSL}{6\sigma}$$
$$= \frac{USL-LSL}{6\sigma}$$
$$= \frac{26-20}{6x1{,}181}$$
$$= 0{,}847$$

Based on the calculation above, the Cp value is obtained against the standard of 0.847, which means Cp <1, which means the process is not capable.

Cpk Value

$$Cpk = \min\left\{\frac{USL-\bar{x}}{3\sigma}, \frac{\bar{x}-LSL}{3\sigma}\right\}$$
$$= \min\left\{\frac{26-23{,}162}{3x1{,}181}, \frac{23{,}162-20}{3x1{,}181}\right\}$$
$$= \min\{0{,}801 \,;\, 0{,}892\}$$
$$= 0{,}801$$

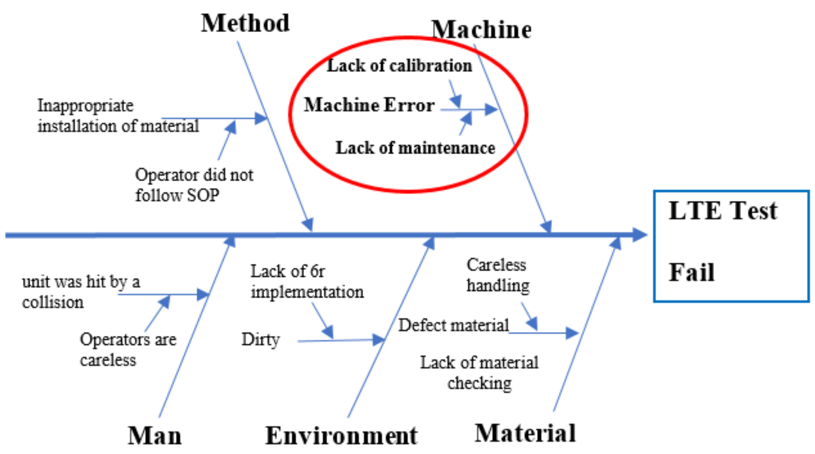
Based on the calculation above, the Cpk value is 0,801, which means Cpk<1, which is the process has not been able to produce the product according to specification. After calculating the Cpk value, the next step is calculating the percentage of defects in the LTE test.

Table 2. Defect Percentage Calculation

No. Sample	Total Defect	Sampling	%Defect
Sample Group 1	2	100	2
Sample Group 2	3	100	3
Sample Group 3	4	100	4
Sample Group 4	2	100	2
Sample Group 5	2	100	2
Sample Group 6	3	100	3
Sample Group 7	2	100	2
Sample Group 8	2	100	2
Sample Group 9	3	100	3
Sample Group 10	3	100	3
Total	26	1000	2,6

Based on the table above, it is known that the 10 sample groups taken obtained a defect value of 2,6%. Based on the pareto diagram that has been prepared, the next step is to find the root cause of the problem with the occurrence of defects using the Fishbone diagram. The analysis is carried out by conducting FGD with related teams who are experts in their fields. The FGD was conducted in the engineering meeting room with the aim of finding the causes of defects and their corrective actions. The following is a Fishbone diagram of the LTE test failure type.

Figure 6. Fishbone Diagram



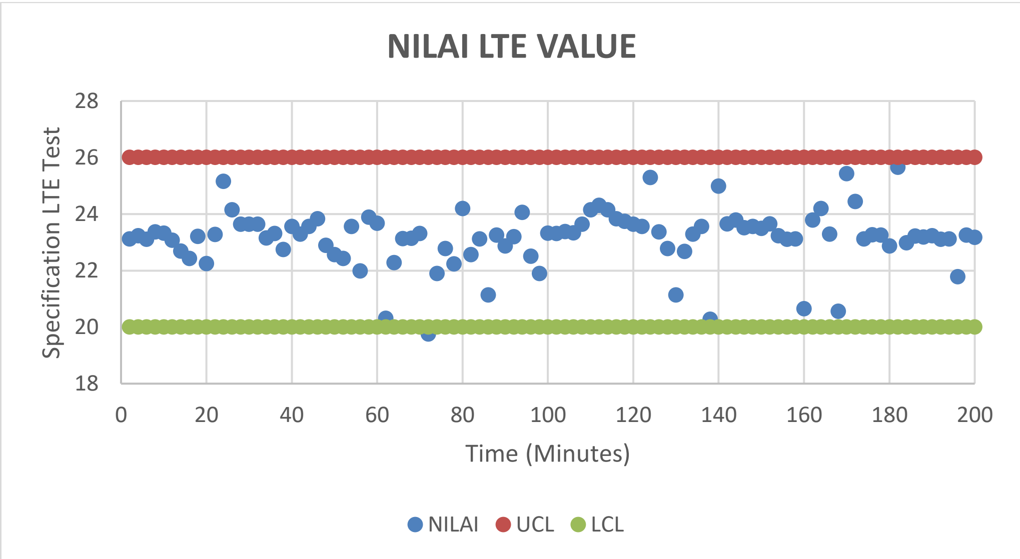
Based on fishbone diagram, identification of the causes of defects that occur in the smartphone assembly industry, which are caused by 5 factors, namely machines, methods, people, the environment, and, materials. On machine factors, namely machine errors caused by lack of maintenance and lack of calibration before using the machine. The method factor is the incorrect installation of the material caused by the operator not following the SOP. In the human factor, the smartphone unit was hit by a collision caused by the operator not being careful when placing the smartphone unit. On the material factor, namely the presence of defect material components before use which is caused by a lack of material checking and careless handling when moving material. The latter is related to environmental factors, namely the dirty environment caused by a lack of implementation of 6r.

Table 3. FMEA

No	Potential Failure Mode	S	Potential Failure Effect	O	Potential Cause of Failure	D	RPN	Rank
1	Defect material	5	Unit out of specification	6	Less of material checking	4	120	4
2					Careless handling	4	120	5
3	Dirty	6	Unit dirty	5	Lack of 6r implementation	3	90	7
4	The unit was hit by a collision	5	Moving component	5	Operator are careless	4	100	6
5	Inappropriate installation of material	6	Component not installed correctly	6	Operator tidak follow SOP	4	144	3
6	Machine Error	6	Inaccurate results	7	Lack of calibration	4	168	1
7					Lack of maintenance	4	168	2

Based on the fishbone and FMEA table above, it is known that the main problem is caused by an engine error. For now, the machine is only restarted every hour of rest time, which is every 4 hours. For this reason, a proposed improvement is given, namely restarting the machine every 2 hours to maintain the stability of the machine. The following is a simulation result of the proposed improvement.

Figure 7. LTE Test Value After Improvement



Based on the graphic image above shows the distribution of 100 LTE test data for 200 minutes. There are LTE test values that are appropriate and not following the specifications set by the company.

Calculation Example:

% Defect = $\frac{Number\ of\ Defect}{Number\ of\ Sample}$

% Defect = $\frac{1}{100}$

% Defect = 1%

Based on the simulation results of the proposed improvements in the form of restarting the machine every 2 hours, a defect percentage value of 0.01% is obtained.

DISCUSSION

This research was conducted to identify the causes of the production defect rate in the smartphone assembly industry and to find out the SPC approach in increasing the acceptance rate in the smartphone assembly industry. The approach used is the DMAIC method. Based on the research that has been done, it is known that there are several defects, namely LTE test fail, scratch, camera not function, speaker not function, LCD not good, mic not function, and other types of defects. These defects cause the company's productivity to be not achieved. The company's target is 99.5% but throughout 2021 this target is not achieved every month. Based on the analysis carried out, the defect was caused by 5 factors, namely man, material, method, machine, and environment.

CONCLUSION

Based on the research that has been done, the conclusion that can be drawn is the identification of the causes of defects that occur in the smartphone assembly industry, which are caused by five factors, namely machines, methods, people, materials, and the environment. On machine factors, namely machine errors caused by lack of maintenance and lack of calibration before using the machine. The method factor is the incorrect installation of the material caused by the operator not following the SOP. In the human factor, the smartphone unit was hit by a collision caused by the operator not being careful when placing the smartphone unit. On the material factor, namely the presence of defect material components before use which is caused by a lack of material checking and careless handling when moving material. The latter is related to environmental factors, namely the dirty environment caused by a lack of implementation of 6r. With the use of the SPC approach, the results of the causes of defects and the presentation of defects for improvement are obtained. After repairs were made, the percentage of defects decreased from 2,6% to 1%. This means that the proposed improvements through the SPC approach help in the process of improving the quality of smartphone production.

ACKNOWLEDGMENT
N/A

DECLARATION OF CONFLICTING INTERESTS
The authors declared no potential conflicts of interest

REFERENCES

Akhmatova, M. S., Deniskina, A., Akhmatova, D. M., & Prykina, L. (2022). Integrating quality management systems (TQM) in the digital age of intelligent transportation systems industry 4.0. *Transportation Research Procedia*, *63*, 1512–1520. doi: 10.1016/j.trpro.2022.06.163

Damayanti, K., Fajri, M., & Adriana, N. (2022). Pengendalian kualitas di Mabel PT. Jaya Abadi dengan menggunakan Metode Seven Tools. *Bulletin of Applied Industrial Engineering Theory, 3*(1), 1-6.

Domingo, R., & Aguado, S. (2015). Overall environmental equipment efectiveness as a metric of a lean and green manufacturing system. *Sustainability, 7*(7), 9031-9047. doi: 10.3390/su7079031

Haviana, E., & Hernadewita, H. (2019). Productivity improvement in the rubber production process using value stream mapping method to eliminate waste. *Operations Excellence: Journal of Applied Industrial Engineering*, *11*(2), 119. doi: 10.22441/oe.v11.2.2019.023

Hunusalela, Z. F., Perdana, S., & Usman, R. (2019). Analysis of productivity improvement in hard disc spare parts production machines based on OEE, FMEA, and fuzzy value in Batam. *IOP Conference Series: Materials Science and Engineering*, *508*(1), 1-6. doi: 10.1088/1757-899X/508/1/012086

Indarto, D. A., & Naharto, E. (2022). Analisis transformasi bisnis PT Kawasan Industri Wijayakusuma (PERSERO). Retrieved from http://etd.repository.ugm.ac.id/penelitian/detail/215363

Karo Karo, F., Nugraha, E. S., & Gustiyana, F. N. (2020). Analisis Hasil Pengukuran Performansi Jaringan 4G LTE 1800 MHz di Area Sokaraja Tengah Kota Purwokerto Menggunakan Genex Asistant Versi 3.18. *AITI: Jurnal Teknologi Informasi*, *16*(2), 115–124. doi: 10.24246/aiti.v16i2.115-124

Kurnia, H., Jaqin, C., Purba, H. H., & Setiawan, I. (2021). Implementation of Six Sigma in the Dmaic Approach for Quality Improvement in the Knitting Socks Industry. *Tekstil ve Muhendis*, *28*(124), 269–278. doi: 10.7216/1300759920212812403

Madanhire, I., & Mbohwa, C. (2016). Enterprise resource planning (ERP) in improving operational efficiency: Case study. *Eco-Industrial Park Development for Harare, 40*, 225-229. doi: 10.1016/j.procir.2016.01.108

Mubarok, A. A., & Ambarwati, S. D. A. (2022). Quality analysis of Black tea products using Fishbone Diagram and Failure Mode and Effect Analysis (FMEA) at PT XYZ. *Journal of International Conference Proceedings, 5*(5), 104-116. doi: 10.32535/jicp.v5i5.2072

Özyazgan, V., & Engin, F. Z. (2013). FMEA analysis and applications in knitting industry. *Tekstil ve Konfeksiyon*, *23*(3), 228–232.

Permono, L., Salmia, L. A., & Septiari, R. (2022). Penerapan metode seven tools dan new seven tools untuk pengendalian kualitas produk (Studi kasus pabrik gula Kebon Agung Malang). *Jurnal Valtech*, *5*(1), 58–65.

Qin, J., Xi, Y., & Pedrycz, W. (2020). Failure mode and effects analysis (FMEA) for risk assessment based on interval type-2 fuzzy evidential reasoning method. *Applied Soft Computing Journal*, *89*, 106134. doi: 10.1016/j.asoc.2020.106134

Rakib, M. R. H. K., Pramanik, S. A. K., Amran, M. Al, Islam, M. N., & Sarker, M. O. F. (2022). Factors affecting young customers' smartphone purchase intention during Covid-19 pandemic. *Heliyon*, *8*(9), 1-11. doi: 10.1016/j.heliyon.2022.e10599

Rasyida, D. R., & Ulkhaq, M. M. (2016). Aplikasi Metode Seven Tools dan Analisis 5w+1h untuk mengurangi produk cacat pada PT. Berlina, Tbk. Retrieved from https://ejournal3.undip.ac.id/index.php/ieoj/article/view/14056

Rohani, Q. A., & Suhartini. (2021). Analisis Kecelakaan Kerja dengan Menggunakan Metode Risk Priority Number, Diagram Pareto, Fishbone, dan Five Why's Analysis. *Prosiding SENASTITAN*, *1*, 136–143.

Sethia, C. S., Shende, N., & Dange, S. S. (2016). A case study on total productive maintenance in Rolling Mill. *International Journal of Scientific Development and Research*, *1*(5), 283–289.

Shafqat, A., Huang, Z., & Aslam, M. (2021). Design of X-bar control chart based on Inverse Rayleigh Distribution under repetitive group sampling. *Ain Shams Engineering Journal*, *12*(1), 943–953. doi: 10.1016/j.asej.2020.06.001