International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 1, 2020
ISSN: 1475-7192

THE QUALITY IMPROVEMENT TOWARDS MINIMIZING GRILLE BASE PRODUCTS DEFECTS WITH SIX SIGMA APPROACH

Annisa Indah Pratiwi[1], Afif Hakim[2], Murnawan[3]

ABSTRACT---*Quality is an essential part of the company must be fulfilled to provide customer satisfaction. In the industrial revolution era 4.0, quality becomes an indicator of companies in competing with their competitor. The one automotive company in Karawang is processing in improving its product quality, especially in the painting process. The quality condition of Grille Base products have a high enough product defect ratio, namely 42.79% butsu defects (spots), 25.45% hajiki defects (cissing), 18.93% yarn defects (fiber), 4.66% orange peel defects, 4.27% sagging defects, 2.47% gross area defects, 0.68% blister defects, 0.58% thin paint defects, and 0.16% frosted defects (low glossy). The sigma score in the painting process is 2.8 sigmas with 84432.21 DPMO. This condition indicates that it needs immediately improved quality. The concept used is the six sigma approach with the DMAIC cycle (Define, Analyze, Measure, Improve, and Control). This research focuses on increasing the score of sigma in the painting process. FTA use for analyzing the improvements and FMEA identification used to determine the appropriate improvement. The results of improvements result in 2.9 sigmas with DPMO 71008, which means that there are millionth opportunities may facing 71008 products failures.*

Keywords---*Six Sigma, DMAIC, FTA, FMEA, DPMO*

I. INTRODUCTION

Quality is very closely related to the product or production of both goods or services. Quality is the degree of conformity between the product goods or services that agreed. The quality of a product categorized as good quality if the product is processed with a perfect process so that it meets the zero-defect standard. Relate to that case the writer conducted a study about the quality achievement level, especially on Grille Base products.

Quality is a benchmark used to measure the excellence of the product, both goods and services. Customer loyalty will depend on the suitability goods or services with need of the customer, and the more suitable the product with the customer means, the higher the customer loyalty. Therefore, the quality becomes one aspect that must be fulfilled by a company for customers. The high-quality product will give customer satisfaction to the product chosen by the customer. Vice versa, if the company has a low-quality product, it will cause customer dissatisfaction and trigger customer claims which can reduce customer confidence (Oakland, 2004).

[1,2]*Industrial Engineering Department, Buana Perjuangan University of Karawang Indonesia*
Widyatama University[3]
Email: [1.]annisa.indah@ubpkarawang.ac.id
Email: [2.]afif.hakim@ubpkarawang.ac.ic

Based on research conducted by Kifta (2017) about the analysis of welding defect rate and the researcher solve the problem using Six Sigma and FMEA methods in the PT Profab Indonesia company. The results of that study show that by applying the Six Sigma method and using quality tools (FMEA analysis). The company can reduce the defect ratio from 15,5% in October-November 2015 to 2,63% in June 2016. That advancement also improves the performance in the processing stage, namely from an average sigma value of 3,32 to sigma 4,10. According to Devani et al. (2018), who conducted quality improvement research, uses the Six Sigma method with the DMAIC concept. The research was concluded that the types of defects found in packing process, those are bag burst, bag stuck, bag weight outside tolerance, damaged bag, with the biggest defect is bag burst of 72.9% for the 50 kg bag type and 68% for 40 kg bag type which will be prioritized for repairment. Sigma score for 40 and 50 kg bag types is 3,79- 4,13 sigma.

In a production process contain a risk such as a failure or product defects. The condition is the focus of one company in the region, an automotive company which produce the exterior product. Based on production data in the last 3 months, Grille Base products showed a 79.20% product defect ratio, thus affecting productivity performance in the internal painting production process.

Therefore, in this study, the researchers will conduct a quality analysis with a six sigma approach using the DMAIC concept (Define, Measurement, Analyze, Improvement and Control) which aims to improve the current quality. By reducing the product defect ratio, a lot of company profits can be obtained, including increased productivity performance, optimize the production period, and optimize the production cost due to product failure.

II. LITERATURE REVIEW

Quality

Quality is everything that must be fulfilled where the quality depends on the tastes and needs of consumers, but in this case, the amount of money that has been spent also affects to the quality received by the customer. The higher the much money spent, the better the quality that will be accepted. The quality includes physical conditions, function, as well as the nature of a product. (Prawirosentono, 2007).

The Quality of the product must be considered in the manufacturing industry because the production process will affect the products that resulted (Ariani, 2003).

Six Sigma

Gasperz (2002) states that Six Sigma is a vision of improving quality towards the target of 3,4 defect per a million opportunities (DPMO) for each product transaction (goods and services). An effort to achieve the zero defect.

Six Sigma requires an implementation stage. That implementation stage consists of five concepts namely Define, Measure, Analyze, Improvement, and Control (DMAIC) (Syukron, 2013).

Diagram Pareto

The history of the name “Pareto” is taken from the name of an Italian economist who found the evidence that typically 80% of the welfare or prosperity of an area is only controlled by 20% of the population. If this theory is implemented in quality control, this principle can be interpreted as the 20% factor is the cause of the 80% problem. Pareto diagrams ease to identify factors that are more dominant among other factors (Herjanto 2007).

FMEA ***(Failure Mode and Effect Analysis)***

FMEA analysis is a tool to analyze a measurable assessed failure so that it can determine the priority of corrective actions. FMEA provides three criteria for each problem, namely severity, occurrence and detection criteria, with the formula S x O x D = RPN, which is called the Risk Priority Number. The higher the RPN score, the failure must be corrected immediately.

FTA ***(Fault Tree Analyse)***

FTA is used to see the product reliability and show the causal relationship between events. FTA is a simple tool in analyzing the security and reliability of a product. The direct interview or observes of the process is conducted in purpose to build the FTA model. FTA using a tree diagram to show the cause and effect of events (Diana, 2015).

III. Research Method

This study uses the Six Sigma method in analyzing, especially using the DMAIC concept. The basic steps of using the six sigma method with the DMAIC concept consist of five stages namely (Define, Measurement, Analyze, Improvement, Control) the five stages are recurrent stages that form a quality improvement cycle with six sigma.

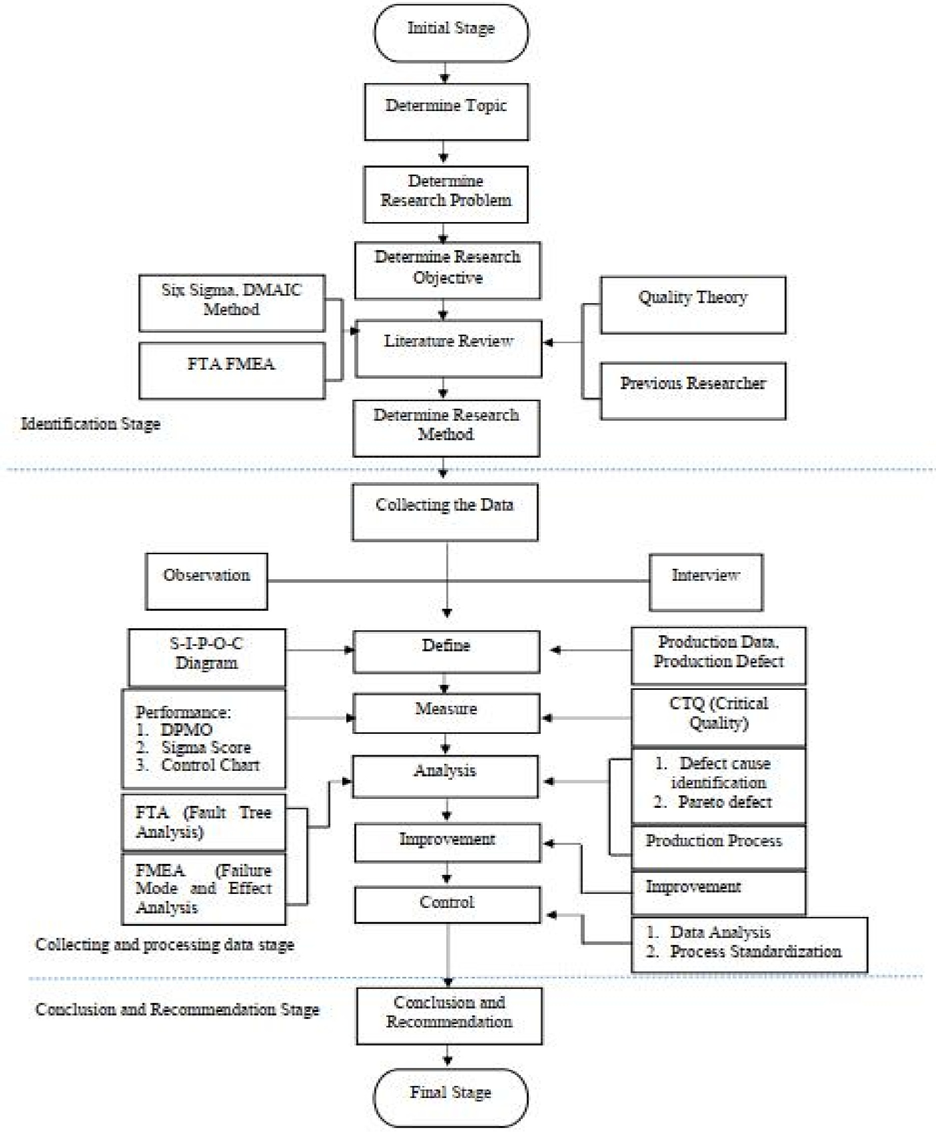

Figure 1. Research diagram

IV. Result and Discussion

Based on the Grille Base product quality data that the defects in the painting process influenced by several factors so that we need a method to improve the product quality. There is the following systematic description that can be carried out through the six sigma with the DMAIC method.

Define Stage

The define stage becomes the initial stage for the DMAIC cycle as an effort to improve quality with the Six Sigma approach. At this stage, several things were identified related to the goals and objectives of the improvements in purpose to improve the quality. This research was conducted on the Grille Base product, which is a product with a painting process.

SIPOC Diagram

SIPOC (supplier, input, process, output, and customer) diagrams explain the process flow in Grille Base products, from material suppliers to customers. This method can ease identification. Then, the implemented SIPOC diagram in the Grille Base product process explained in the following diagram:

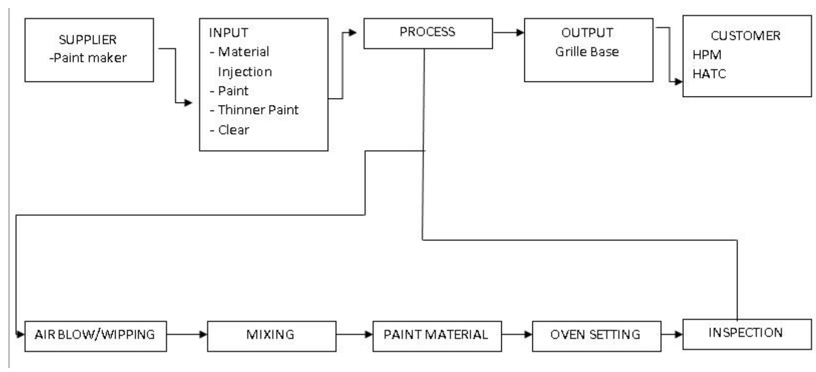

Figure 2. SIPOC Diagram

CTQ (Critical to Quality)

CTQ (critical to quality) are attributes that need to be focused because they correlate with the products that are produced from production. The CTQ identification is developed from customer requirements, and the company determined specifications. The results of the identification show that the CTQ in the Grille Base production process is listed in table 4.2 below:

Table 1. CTQ *(critical to quality)* in *Grille Base* Production

No	Defect types	Description
1	Butsu defects (spots)	Dust particles/paint dust or dirt that sticks to the wet layer and remains when the paint dries.
2	Sagging defects	Painting defects caused by too much paint sticking in the surface
3	Yarn defects (fiber)	Painting process defects caused by dirt in the form of tissues stuck to the coat and left behind when the paint dries. Usually dirt from sozay material.
4	Hajiki defects (cissing)	Painting defects in the form of a crater that opens like a fish's eye after the application of paint.
5	Orange peel defects	Painting defects with uneven surface shape, such as orange peel.
6	Dirty spot	Same as the Butsu defect, the only difference is the size and number of spots.
7	blister defects	Production process defects caused by the crash factors with other objects that cause injury to the product
8	Thin paint	Painting defects caused by the thickness of the paint layer from a predetermined standard

9	Frosted defects (Low glossy)	Painting defect caused by lack of *clear* coating during the painting process

V. Measure Stage

Control Chart "P"

The p control chart is used in analyzing the production conditions of the Grille Base product. This control chart is used to determine the stability of the process and variations of existing data. In the measurement of the stability of this process, it will be presented the proportions score, UCL (Upper Control Limit), LCL (Lower Control Limit) and CL (Center Limit).

Before calculating, it is important to note that the Lower Control Limit (LCL) for the control chart expressed in proportion or percentage is always positive, and it can not be negative. If the negative score is found in the calculation of LCL <0, then LCL = 0 (Gazpersz, 2003: 96). Here are the calculations for the stability of the Grille Base painting process:

a. Calculating $\overline{P}$ Score(*p* bar)

$$\overline{p} = \frac{\Sigma p}{\Sigma n}$$

$$\overline{p} = \frac{3650}{4606} = 0{,}792$$

b. Calculating the *UCL score (Upper Control Limit)*

$$UCL = \overline{p} + 3\sqrt{\frac{\overline{p}\,(1-\overline{p})}{n}}$$

$$UCL = 0{,}792 + 3\sqrt{\frac{0{,}792(1-0{,}792)}{56}}$$

$$UCL = 0{,}955$$

c. Calculating the *LCL score (Lower Control Limit)*

$$UCL = \overline{p} - 3\sqrt{\frac{\overline{p}\,(1-\overline{p})}{n}}$$

$$UCL = 0{,}792 - 3\sqrt{\frac{0{,}792(1-0{,}792)}{56}}$$

$$UCL = 0{,}630$$

d. Calculating proportion score defect in Control Chart "P"

Defect Proportion $\frac{\text{Total Defect}}{\text{Total Production}}$

Defect Proportion $= \frac{39}{56} = 0.69642$

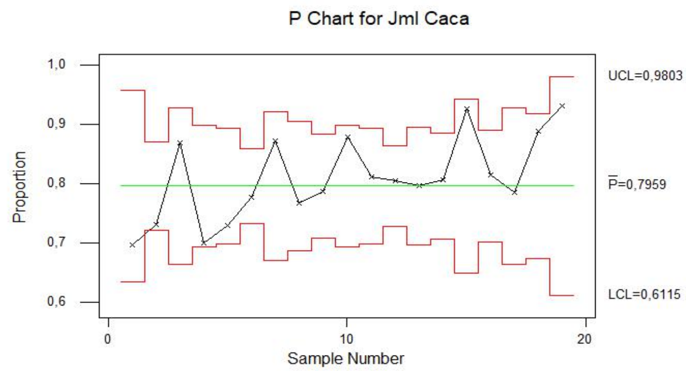

Figure 3. Control Chart p Revised

DPMO score and SQL *(Sigma Quality Level)*

Based on the calculation results, it found that the stability process is still not optimal. That statement comes from the calculation of the sigma level in the painting process, which is at 2.80 sigmas with 88432.21 DPMO scores. This means that per one million opportunities, there can be 88432.21 product defects units. Therefore, it is necessary to improve the process to reduce the number of product defects so that it will increase the level of sigma in the painting process.

***Analyze* Stage**

The third stage in the DMAIC cycle is analysis. In the previous stage, it was known for the DPMO score and the sigma level for the production process of Grille Base painting which is at the 2.8 sigma level. That level indicates that the capability level of the Grille Base painting is not competitive because there are still product failures with 88432.21 DPMO score so that this process is essential to improve the quality of the production process.

Diagram Pareto

In this analyze stage, the Pareto diagram is used to determine the most dominant number of rejects. Based on the Pareto diagram, it will be known the product that has the highest percentage of defects.

Table 2. Pareto Diagram score calculation

No	Defect type	Total Defect	Percentage (%)	Cumulative percetage (%)
1	Butsu defects (spots)	1562	42,79	42,79
2	Sagging defects	929	25,45	68,25
3	Yarn defects (fiber)	691	18,93	87,18
4	Hajiki defects (cissing)	170	4,66	91,84
5	Orange peel defects	156	4,27	96,11
6	Dirty spot	90	2,47	98,58
7	blister defects	25	0,68	99,26
8	Thin paint	21	0,58	99,84
9	Frosted defects (Low glossy)	6	0,16	100,00
Total		3650		

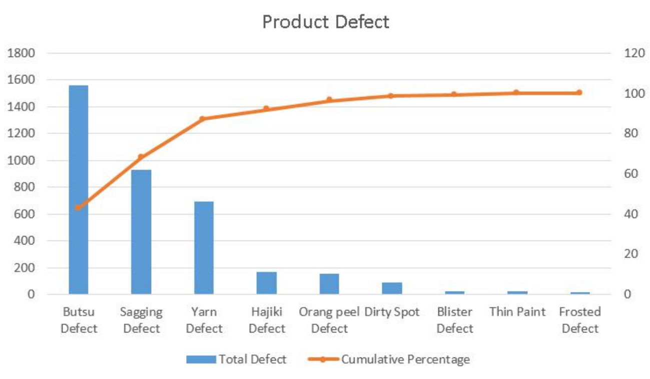

Figure 4. Pareto Diagram

Based on the Pareto diagram above, it can be seen that three types of defects have the highest defect percentage in Grille Base product, namely butsu (spots), hajiki (cissing) and yarn (fiber) defects. The three types of defects have 87.18% cumulative percentage so that the three types of defects are repairment priorities.

Fault Tree Analysis (FTA)

Based on the analysis that has been done previously related to the defect priority that will be got further repairs, then it will be analyzed the causes of the product failure. The factors that may cause failure are human factors, methods, materials, and machines. Based on the SIPOC diagram that has been determined at the define stage, the analysis will be carried out on the processes that exist in the painting production. Here is the fault tree analyze diagram related to by-product failure, which becomes repairmen priority:

Fault Tree Analyze (FTA) Butsu defects (spots)

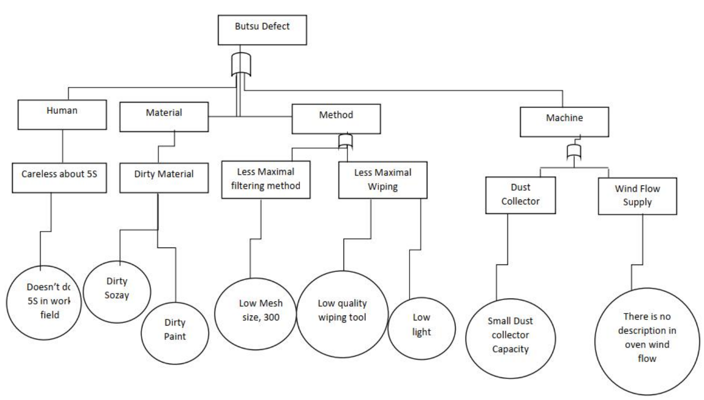

Figure 5. FTA butsu defect (spot) Diagram

Fault Tree Analyze (FTA) Hajiki Defect (cissing)

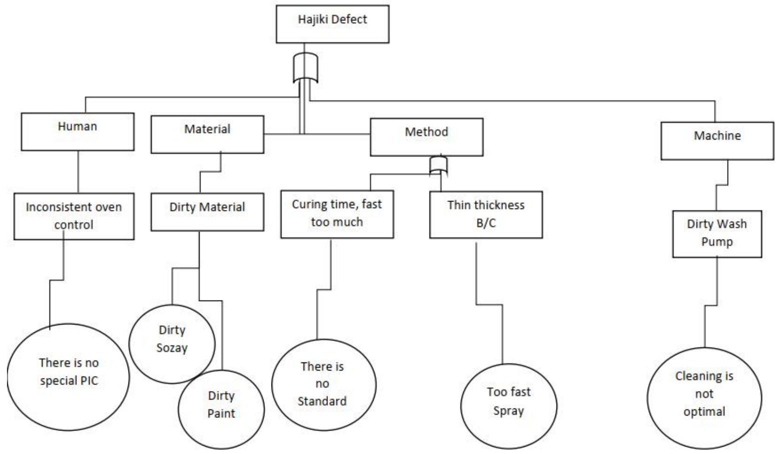

Figure 6. Diagram FTA *Hajiki defect (cissing)*

Fault Tree Analyze (FTA) yarn defect (tissue)

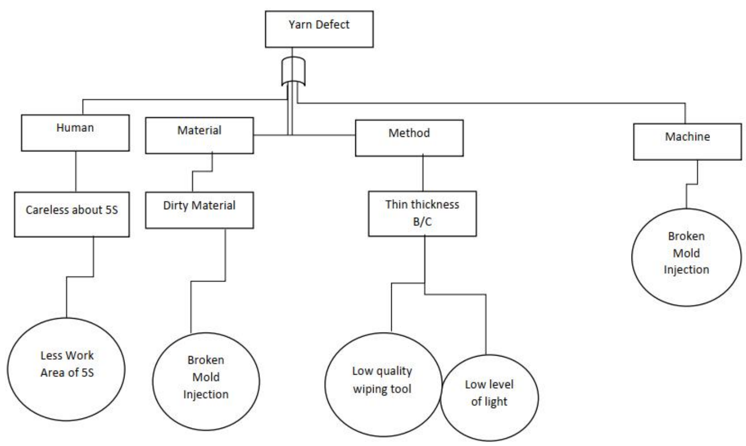

Figure 7. FTA yarn defect *(tissue)* Diagram

Improvement Stage

At this improvements stage, it will be conducted an improvement of the product failure that have been analyzed. The improvements will be conducted based on the priorities that are determined by weighting the score of the potential failure mode. In this case, the tools used are Failure Mode and Effect Analysis (FMEA). Using that analysis, we will measure the score based on the concept of Failure Mode and Effect Analysis (FMEA). Potential failure modes that have an RPN score become a priority for the improvement to improve product quality.

The potential failure modes will be calculated based on the RPN score, as follows:

Table 3. *Failure Mode and Effect Analysis (FMEA)*

Potential Failure Modes	**Failure of potential Effect**	**c c**	**e v**	**The Cause of Failure**	**e t**	**R PN**	**Proposed Improvement**
There is	Cause residual			Broken Mold		24	Repair mold injection

a burry in the material	thread defects			injection		0	
Dirty wiping napkin	Causing the remaining dirt/fiber			Bad wiping fabric characteristics		21 0	Change wiping cloth (Savina type)
Wind Flow (-)	The dirt inside the oven			There is no indicator of wind flow in the oven		19 2	The SOP is made to check the wind indicator periodically
Dust collector capacity is not optimal	Dirt is not filtered out and attached to the product			Small dust collector capacity		18 0	Increase dust collector capacity (temporary with a sticky mat in the area)
Low Light	Dirt on the product is difficult to detect			Low quality of light		16 8	Add standard lighting at 1500 lux
Less optimal filtering	Dirt carried in the paint material			300 mesh size		12 0	Using 500 mesh size
Lacking 5S Concern	Work area contaminated with dirt			There is no control		12 0	A leader up controls 5S
Oven controls are not consistent	Abnormal oven not detected			There is no special PIC yet		72	Made special Cheksheet and PIC
Thin layer thickness	The product reacts quickly in the oven			Not following IK		72	Reeducation IK spray
Curing time is too fast	The product reacts quickly in the oven			There is no standard		72	Created a standard cycle time (study needs to be done)

Based on the analysis results of the improvements that have been identified, the most prioritizing development start from the highest RPN score or 240 RPN. For the improvements is applied in the field in purpose to monitor the results improvements (Jabarullah et al., 2019).

Controlling Stage

This stage is the final step in quality control with the DMAIC cycle approach (Define, Measure, Analyze, Improve, and Control). At this stage, it will be evaluated the improvements result. Evaluation is done by analyzing the results of Grille Base production after repairs.

Data obtained from the results of improvements will be analyzed with a control chart p, in purpose to see the condition in the running process. The steps for the calculation are the same as the initial conditions before making improvements. Here is the following calculation of the process stability after repairs:

a. Calculating $\overline{P}$ score (*p* bar)

$$\overline{p} = \frac{\Sigma p}{\Sigma n}$$

$$\overline{p} = \frac{2205}{3344}$$

$$\overline{p} = 0{,}639$$

b. Calculating the *UCL* score *(Upper Control Limit)*

$$UCL = \overline{p} + 3\sqrt{\frac{\overline{p}\,(1-\overline{p})}{n}}$$

$$UCL = 0{,}639 + 3\sqrt{\frac{0{,}639(1-0{,}639)}{231}}$$

$$UCL = 0{,}734$$

c. Calculating the *LCL* score *(Lower Control Limit)*

$$LCL = \overline{p} - 3\sqrt{\frac{\overline{p}\,(1-\overline{p})}{n}}$$

$$LCL = 0{,}639 - 3\sqrt{\frac{0{,}639(1-0{,}639)}{231}}$$

$$LCL = 0{,}544$$

d. Calculating defect proportion score in control chart p

Defect proportion $\frac{\text{Total Defect}}{\text{Total Production}}$

Defect proportion $= \frac{151}{231}$

Defect proportion $= 0{,}6536$

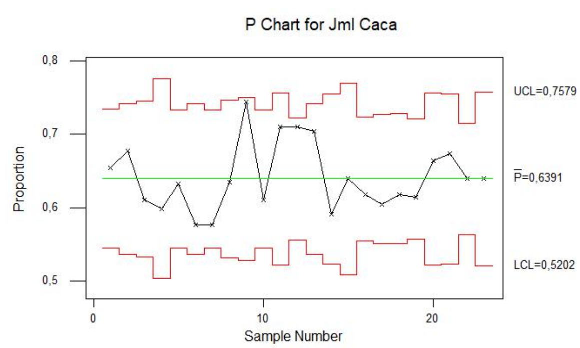

Figure 8. revised control chart p

Furthermore, based on the calculation results of the DPMO score and sigma level, it can understand that after several improvements. There is an increase in the value of the sigma level, namely from the initial condition of the sigma level score namely, 2.8 sigmas with 88432.21 DPMO score and after an improvement to the condition of the sigma score 2.9 sigmas with 71008 DPMO. This means that per one million productions will occur 71008 product failures when viewed from an increase in the sigma score of the Grille Base production process it still needs improvement in purpose to improve product quality.

VI. RECOMMENDATION

After doing the research, recommendations that can be given are it needs control by implementing the proposed improvement given and conducting the measuring repeatedly to control the sigma score. Quality assurance and quality control cannot work if there is no continuous improvement. If kaizen is applied in companies, quality improvement can be achieved so that customer satisfaction can increase.

VII. CONCLUSION

Based on the research conducted, several conclusions can be drawn, as follows:

1. In the Grille Base painting process, several defects occur. The defects with the most significant ratio are butsu defects (spots) by 42.79%, hajiki defects (cissing) by 25.45%, yarn defects (tissue) by 18.93%, orange peel defects by 4, 66%, sagging defect by 4.27%, gross spot defect by 2.47%, blister defect by 0.68%, thin paint defect by 0.58%, and low glossy defect by 0,16%. After calculating the painting process for DPMO score by 88432.21 and converted to a sigma score by 2.8 sigmas.
2. Based on the analysis results of the identified improvements, prioritizing improvement for the highest RPN value is 240 RPN related to injection mold repair. Other improvements include changing wiping cloths, making SOPs for checking wind indicators, increasing dust collector capacity, adding lighting in the wiping area, using a mesh 500 sizes in the mixing process, and making oven-checking checksheets and responsible for controlling 5S conditions in the work area.
3. The results of the implementation of improvements after calculating the level of product quality obtained 71008 DPMO scores if it is converted to a sigma value, it obtained a 2.90 sigma score. When compared with the sigma score before improvement there was an increase in the sigma score in the painting process, from 2.8 sigmas with 84432.21 DPMO scores to 2.9 sigmas with 71008 DPMO scores.

REFFERENCES

[1] Caesaron, D., & Tandianto, T. Application of the Six Sigma Method with the Dmaic Approach in the Bmw X3 Painted Body Handling Process (Case Study: PT. Tjahja Sakti Motor). Research and Application of Industrial Systems and Engineering, 9 (3).

[2] Devani, V., & Amalia, N. (2018). QUALITY IMPROVEMENT OF "X" CEMENT WITH SIX SIGMA METHOD IN PACKING PLANT PT. XYZ Journal of Industrial Engineering, 8 (1).

[3] Ghiffari, I., Harsono, A., & Bakar A., (2013). Six Sigma Analysis to Reduce the Number of Defects in Screen Printing Workstations (Case Study: CV. Miracle). REKA INTEGRA, 1 (1).

[4] Grant, E. L., & Leavenworth, R. S. (1988). *STATISTICAL QUALITY CONTROL, Sixth Edition.* McGraw-Hill, Inc.

[5] Jabarullah, N.H., Razavi, R., Hamid, M.Y., Yousif, Q. A. & Najafi, M. (2019) Potential of Ge-adopted Boron Nitride Nanotube as Catalyst for Sulfur Dioxide Oxidation, Protection of Metals and Physical Chemistry of Surfaces, 55 (4), 671-676.

[6] Kifta, D. A. (2017). ANALYSIS OF WELDING AND TREATMENT DEFECT RATE USING SIX SIGMA AND FMEA METHODS IN PT PROFAB INDONESIA. Journal of Engineering Ibn Sina JT-IBSI, 2 (1).

[7] Putro, W. D., Gutomo, S., & Slamet, A. (2018). Quality Improvement of Production Process with Six Sigma Method to Reduce Product Defects in Partmaster Cylinder Type 2 dp in the Painting Department of PT. Chemco Harapan Nusantara Cikarang. Mechanical Engineering, 12 (2).

[8] Susetyo, J., & Winarni, C. H. (2011). Application of Six Sigma DMAIC and Kaizen as a method of controlling and improving product quality. Journal of Technology, 4 (1), 61-53.

[9] Wahyani, W., Chobir, A., & Rahmanto, D. D. (2013). Application of Six Sigma Method with DMAIC Concept as a Quality Control Tool. Journal of the Adhi Tama Institute of Technology Surabaya, 1-13.

[10] Wahyuni, H. C, Sulistyowati, W. & Khamim, M. (2015). QUALITY CONTROL, Applications in the Service and Manufacturing Industries with Lean, Six Sigma and Servequal. Graha Ilmu Publisher, Yogyakarta.

[11] Widyarto, W. O., Dwiputra, G. A., & Kristiantoro, Y. (2015). APPLICATION OF THE CONCEPT OF FAILURE MODE AND EFFECT ANALYSIS (FMEA) IN PRODUCT QUALITY CONTROL USING THE SIX SIGMA METHOD. Journal of Recavation, 3 (1), 54-60.

[12] Zaldianto, E. (2013). QUALITY IMPROVEMENT IN BREAD PRODUCTION PROCESS USING SIX SIGMA METHOD. Final Project (UIN SUSKA RIAU)