Six Sigma Implementation in Production Process in Electronic Company Malaysia

M W D Utami¹, A Ma’aram² and M Hisjam³

¹ Undergraduate Program of Industrial Engineering Department, Faculty of Engineering, Universitas Sebelas Maret, Surakarta 57126, Indonesia
² Department of Material, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Skudai, Malaysia
³ Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret, Surakarta 57126, Indonesia

Abstract. The electronics industry is one of the growing industrial sectors because of the need for electronics industry products continuously increases. This situation of development is driving the fast pace of electronics industry companies in Malaysia to be better prepared to face competition in the era of free trade. The study was carried in an electronic company in Malaysia that produce hard disk components. In this company, the number of defective products is very high which is the average defect (they call it u-loss) in the brushing room for arm body actuator products reaches 0.454% and one type of actuator arm body has reached 0.982% of defect units which means the company loses 65,000.88 RM per year. This study only focused on actuator arm body production in brushing room and aim to determine the dominant product which have the biggest percentage of defect, determine types of defects in the production of selected product, determine the root cause of the biggest defects in the production of selected product in brushing area, and recommend improvements in order to minimize the occurrence of defects in the production of selected product. This research uses Six Sigma in solving problems in the company. This study did not evaluate the results of the Six Sigma implementation directly. Therefore, as an alternative, quality improvement is done through Monte Carlo simulation with several scenarios. If zero defect in actuator arm body production is reached, company can save 65,000.88 RM per year.

1. Introduction

The electronics industry is one of the growing industrial sectors because of the need for electronics industry products continuously increases. This situation of development is driving the fast pace of electronics industry companies in Malaysia to be better prepared to face competition in the era of free trade. All industries, both in the electronics industry and others, should have good quality control. With quality control, product quality will be proper and follow the demand of consumers. Besides, by quality control, the amount of defective material can be minimized so that waste of resources can be avoided. Progress and development of the times change the way consumers look at choosing the desired product. Quality becomes very important in choosing products in addition to the competitive price factor [1]. Product quality improvement to achieve a zero-defect level requires a high cost. A company is stated to be a good quality company if the company has a good production system with
controlled processes. The company can improve the effectiveness of controls in preventing defect through quality control, to reduce the occurrence of waste in terms of material and labor. The study was carried in an electronic company in Malaysia that produce hard disk components. In this company, the number of defective products is very high which is the average defect (they call it u-loss) in the brushing room for arm body actuator products reaches 0.454% and one type of actuator arm body has reached 0.982% of defect units which means the company loses 5,416.74 RM per month or 65,000.88 RM per year only for one sub-type of arm body actuator they produce in the brushing area. This defect products cannot be reworked or repaired and have to be directly removed. If there is no control over this matter, it can result in losses for the company. Some of the losses could longer production time, waste of resources used, operator performance that is getting heavier because they have to work overtime to complete the targets on every shift, so the production process becomes inefficient. From these problems, it is necessary to have a quality control analysis of the defects of the arm body actuator so the company can reduce the number of defects and can improve the quality of the product. This study only focused on actuator arm body production in brushing room. Six sigma analysis were very widely used by researchers to improve many production process quality and productivity. These researchers also have conducted several studies using six sigma analysis as shown in Table 1.

Table 1. Research using Six Sigma Analysis

| No | Title                                                                 | Reference                                                                                     |
|----|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| 1  | Reducing rejections using Six Sigma: a case from Indian automobile component manufacturing industry | Mohit Kaushik, Gaurav Chauhan, K. Mathiyazhagan, Ravindra Ojha, Mayank Kumar, 2019 [2]          |
| 2  | Six-sigma application in tire-manufacturing company: a case study     | Vikash Gupta, Rahul Jain, E. M. L. Meena, G. S. Dangayach. 2018 [3]                             |
| 3  | Quality Improvement In Manufacturing Process Through Six Sigma: A Case Study Of Indian MSME Firm | Sharma, P. Gupta, A., Malik, S. C., Jha, P. C. 2019 [4]                                        |
| 4  | Development of Six Sigma methodology to improve grinding processes: A change management approach | Noori, B., Latifi, M. 2018 [5]                                                                |
| 5  | Perceptive analysis of the quality in health services’ delivery with a Six-Sigma approach | Pérez, P. M. O., Orlandoni, M. G., Ramoni, P. J., Valbuena, V. M. 2018 [6]                    |
| 6  | Using Six Sigma DMAIC to Improve the Quality of the Production Process: A Case Study | Śmętkowska, M., Mrugalska, B. 2018 [7]                                                      |
| 7  | Defect reduction in a capacitor manufacturing process through Six Sigma concept: A case study | Raman, R., Basavaraj, Y. 2019 [8]                                                             |
| 8  | Application of Six Sigma DMAIC methodology in plain yogurt production process | Hakimi, S., Zahraee, S., Rohani, J. 2018 [9]                                                  |

Based on the State of the Art, implementation of six sigma is very important to improve production process in manufacturing company. Fixing the defect problem is very important because the higher number of defect product is the higher the defect product, the higher the business loss of the company. The low defective products produced (even if it can reach zero defects) can make the company can fulfill customer orders on time and the customers can also run their production schedules on time if supplies arrive on time. This study aim to determine the dominant product which have the biggest percentage of defect, determine types of defects in the production of selected product, determine the root cause of the biggest defects in the production of selected product in brushing area, and recommend improvements in order to minimize the occurrence of defects in the production of selected product.
2. Method
This research used Six Sigma to solving problems in the company. The study was divided into several stages, namely define, measure, analyze, improve, and control (DMAIC). This study did not evaluate the results of the Six Sigma implementation directly. Therefore, as an alternative, quality improvement is done through Monte Carlo simulation with several scenarios.

2.1. Define Phase
Define phase includes identifying the problem, calculating the percentage of defects in July 2019, recapitulating production data and defects from all products.

2.2. Measure Phase
Measure phase includes make a Pareto diagram to find products with the most defects, make p control diagrams of selected products, make a Pareto diagram to find out the types of defects that most often occur, determine the Critical to Quality (CTQ), determine the DPMO, Sigma, and Yield (by allowing a shift of 1.5σ), and measure the process capability. The formula for calculating DPMO value is shown at equation (1) [10]. The formula for calculating opportunity yield value is shown at equation (2). The formula for calculating throughput yield is shown at equation 3. Equation 4 shows process capability index calculation (n refers to sigma level).

\[
DPMO = \frac{\text{Total defect}}{\text{Total production} \times CTQ} \times 1.000.000 \\
Y = \frac{\text{Total defect} - \text{Total production}}{\text{Total production}} \times 100\% \\
Y = (1 - \frac{\text{Total n defect}}{\text{Total units checked}}) \times 100\% \\
\frac{DPMO - n \text{ sigma level}}{(n + 1) \text{ sigma level} - n \text{ sigma level}} = \frac{\text{capability index} - \text{capability index} n}{\text{capability index} (n + 1) - \text{capability index} n}
\]

2.3. Analyze Phase
Analyze phase includes analyzing the most dominant defects using Pareto diagrams and analyzing the causes of defects using cause effect diagrams.

2.4. Improve Phase
Improve phase includes the Set DPMO Target and Sigma, make a 5-Why Analysis, verify using the Monte Carlo Simulation. 5 Whys Analysis is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?" Each answer forms the basis of the next question. The "5" in the name derives from an anecdotal observation on the number of iterations needed to resolve the problem. Not all problems have a single root cause. If one wishes to uncover multiple root causes, the method must be repeated asking a different sequence of questions each time.
2.5. Control Phase
Control phase including controlling improvements that have been made by providing several quality control proposals for the company. Without control over the results of these improvements, the repair process will not achieve the expected results.

3. Result and Discussion
The study was conducted in five stages based on the Six Sigma (DMAIC) method used to solve the defect problem, namely the define stage, measure stage, analyze phase, improve phase, and control stage. The data is primary data obtained from the brushing area, as well as through interviews with relevant parties. In this study production data and defect products data are needed on 1st July 2019 – 31st July 2019 as shown in Table 2. The total production during July 2019 was 2,646,069 units and the total defect produced was 15,301 (see Table 3) in which there were 9 types of defect items (products) whose quantities vary each day.

**Table 2. Defect for all Actuator Types Percentage (July 2019)**

| No | Actuator Type | Defect (unit) | Total Production | Percentage |
|----|---------------|---------------|------------------|------------|
| 1  | A             | 3,312         | 464,148          | 0.714%     |
| 2  | B             | 776           | 140,106          | 0.554%     |
| 3  | C             | 3,753         | 727,121          | 0.516%     |
| 4  | D             | 497           | 365,153          | 0.136%     |
| 5  | E             | 4,299         | 437,577          | 0.982%     |
| 6  | F             | 2,261         | 321,725          | 0.703%     |
| 7  | G             | 34            | 35,522           | 0.096%     |
| 8  | H             | 20            | 14,480           | 0.138%     |
| 9  | I             | 349           | 140,237          | 0.249%     |
|    | Total         | 15,301        |                  | 100%       |

**Table 3. Percentage of Production Results (July 2019)**

| Total of Finish Product | 2630768       | 99.422%       |
| Total of defect         | 15301         | 0.578%        |
| Total of Production     | 2646069       | 100%          |

**Figure 1. Pareto Diagram for Defect All Parts Percentage (July 2019)**

Pareto diagram is made with the percentage of defects for each product to find out which products contribute the largest amount of defects. Figure 1 shows that product E is the product with the largest percentage of defects that is 28.096%. So Product E is a product that is the focus of research in quality control. p - Control chart is used to determine the proportion of defects that occurs. This chart is used because the company conduct 100% inspection for every type of product.
Process stability analysis is carried out on each production day where the process stability is calculated as a requirement of calculating process capability. Based on the calculation of stability that has been done using the p-control chart, obtained an average centerline of 0.982% and concluded that the process production is unstable or not under controlled conditions because there are 18 days with \( p \) values that are out of control. Extreme data at 18 days need to be removed to continue calculating process capability.

After eliminating extreme data, the next step is to recalculate the process stability to get the process data that is within limits. Based on the calculation of stability that has been done by using the revised control chart, we get an average centerline of 1.074% and concluded that the production process is stable or in a controlled condition. In control chart, there are some defect numbers that very extreme. This condition is caused by the demand fluctuate. Production depends on the order.

After that, Pareto diagram is used for the second time to sort the type of defect from the largest to the smallest of the Product E production process in July 2019. Making this Pareto diagram aims to determine the priority types of defects that must be handled. Percentage of each type of Defect of Product E can be seen in Table 4. From the table, a Pareto diagram can be generated which can be seen in Figure 4. From Figure 4, the results show that the largest percentage of 3 defects on production line are the bent fantastic, bent at swage pad and bent arm. Based on the number of defects type in Table 4, it can be concluded that the most defects are bent fantail, bent at swage pad, and bent arm. Critical to Quality is the main attribute of consumer needs. CTQ can be interpreted as an element of the process/activity that has a direct effect on achieving the desired quality. The determination of CTQ begins with the identification of the type of defect that can occur in the production of E product. From observations on July 2019, there were 3 types of the largest defects produced, namely 2,155 units of the bent fantail, 1,183 units of bent at swage pad and 654 units of the bent arm. The 3 biggest types of
defects then become Critical to Quality where the 3 defects directly affect the quality to be achieved. Bent fantail is bent in the fantail area either narrows or widens. Bent at swage pad is bent in the swag area either narrows or widens. Bent arm is bent in the arm area either narrows or widens. Defect per Million Opportunities (DPMO) data (see Table 5) occur in fantail bent, bent at swage pad, and bent arm can be done in a way as equation 1 and converting DPMO to Sigma Value Based on the Motorola Concept.

Table 4. Percentage of each type of Defect of Product E

| Type of defect          | Qty   | Percentage | Cumulative |
|------------------------|-------|------------|------------|
| Bent Fantail           | 2155  | 47.22%     | 47.22%     |
| Bent at Swage Pad      | 1183  | 25.92%     | 73.14%     |
| Bent Arm               | 654   | 14.33%     | 87.47%     |
| Scratches at Surface   | 247   | 5.41%      | 92.88%     |
| Dented at Fantail      | 107   | 2.34%      | 95.22%     |
| Bent Tubing Slot       | 98    | 2.15%      | 97.37%     |
| Dented                 | 50    | 1.10%      | 98.47%     |
| Over Cut               | 45    | 0.99%      | 99.45%     |
| Dented at Swage Pad    | 25    | 0.55%      | 100.00%    |

Figure 4. Pareto Diagram of percentage of each type of defect of Product E

Table 5. Calculation of DPMO (Defect per Million Opportunities) and Sigma Value

| Date       | Prod Total | Defect Total | CTQ | DPMO       | Sigma |
|------------|------------|--------------|-----|------------|-------|
| 01/07/19   | 13929      | 150          | 3   | 3589.63    | 4.19  |
| 02/07/19   | 9961       | 101          | 3   | 3379.85    | 4.21  |
| 08/07/19   | 12300      | 130          | 3   | 3523.04    | 4.19  |
| 09/07/19   | 4750       | 63           | 3   | 4421.05    | 4.12  |
| 10/07/19   | 14400      | 152          | 3   | 3518.52    | 4.2   |
| 11/07/19   | 13338      | 132          | 3   | 3298.85    | 4.22  |
| 25/07/19   | 19960      | 213          | 3   | 3557.11    | 4.19  |
| 28/07/19   | 18706      | 201          | 3   | 3581.74    | 4.19  |
Then, the yield value is calculated to determine the percentage of the number of products without defects in the production process. The result of opportunity yield calculation is 98.93%, and for throughput yield is 98.93%. The process capability measurement uses the process capability index to measure the ability of the process to produce products that are following the customer's requirements / expected specifications. This is done because Statistical Process Control is not able to analyze quantitatively a process that is running, but only able to monitor the process that is running. The determination of process capability index value uses the sigma level conversion Table 6.

Table 6. Sigma Level Conversion

| Sigma Level | ± 1.5α | Process capability index | DPMO  |
|-------------|--------|--------------------------|-------|
| 3           | 0.5    | 66.807                   |       |
| 4           | 0.833  | 6.21                     |       |
| 5           | 1.167  | 233                      |       |
| 6           | 1.5    | 3.4                      |       |

This process capability calculation uses the process capability index to measure the ability of the process to produce products that meet customer needs or expected specifications. The criteria for the process capability index [11] are process capability index ≥ 1.5; then the process is considered capable and competitive, 0.5 ≤ process capability index < 1.5; then the process is considered quite capable, but it requires active efforts to improve quality towards the desired target. Companies at this level have the best opportunity to conduct a six sigma quality improvement program, and process capability index < 0.5; then the process is considered incapable and not competitive to compete in the global market. The calculation of the process capability index is obtained from the interpolation results in Table 6 with a sigma value of 4.189. Based on the results of the calculation of the process capability index in July 2019, the process capability index value of 0.896126 is obtained, which means that it is in the range of 0.5-1.49 so it can be considered a sufficiently capable production process. However, improvement efforts are needed to improve quality because at this level the company has the best opportunity to carry out a six sigma quality improvement program.

The determination of the target DPMO and sigma values is carried out in the same month and the amount of production will be shown in Table 7.

Table 7. Determination of DPMO and Sigma Value

| No | Date       | DPMO  | DPMO Target | Sigma | Sigma Target |
|----|------------|-------|-------------|-------|--------------|
| 1  | 01/07/2019 | 3589.63 | 3.40        | 4.19  | 6            |
| 2  | 02/07/2019 | 3379.85 | 3.40        | 4.21  | 6            |
| 3  | 08/07/2019 | 3523.04 | 3.40        | 4.19  | 6            |
| 4  | 09/07/2019 | 4421.05 | 3.40        | 4.12  | 6            |
| 5  | 10/07/2019 | 3518.52 | 3.40        | 4.2   | 6            |
| 6  | 11/07/2019 | 3298.85 | 3.40        | 4.22  | 6            |
| 7  | 25/07/2019 | 3557.11 | 3.40        | 4.19  | 6            |
| 8  | 28/07/2019 | 3581.74 | 3.40        | 4.19  | 6            |
| 9  | 29/07/2019 | 3951.37 | 3.40        | 4.16  | 6            |
| 10 | 31/07/2019 | 3333.33 | 3.40        | 4.22  | 6            |
After obtaining the DPMO value and the sigma value of the potential defects in July 2019, a calculation of the percentage of the DPMO value target and the sigma value can reach 6-sigma. This needs to be done so companies can find out how much improvement should be done to minimize the existing defects. Based on calculations that have been done, the company must reduce the DPMO by an average of 99.905% and increase the average sigma value by 30.183% every month to achieve the target of 6-sigma. If the company can achieve these targets, the company can minimize defects to zero defects because the achievement of defects in the product is under control.

After knowing the percentage of the largest defect types, namely fantail bent, bent at swage pad and bent arm, the next step is to make a causal diagram to find out the factors that cause the potential for bent. This diagram is based on the results of observations and interviews with parties involved in the production process of the Product E.

The first factor is man. The potential cause of the occurrence of bent parts caused by man factor is the operator forcibly pulls the part before the jig opens automatically so that the product parts that are still held by the jig become bent. Besides that, the operator did not install the part correctly so when the brushing going on, the part will be bent. After that, operators became tired and bored because of the repetitive work they should do during work hours. The other potential cause is operators cannot focus on work because of the unsupportive work environment and operators do not comply with Safety Operational Procedure. Operators also lack knowledge of work instructions because they don't understand work instructions' language and lazy to read the instructions.

The second factor is machine. The potential cause of the occurrence of bent parts caused by the machine is the semi-automatic machine suddenly stopped and error due to irregular maintenance, and also the automatic machine suddenly stopped and error caused there is no regular time to check the operation and irregular maintenance. Besides that, the brushing clamp is not up to standard.

The third factor is method. The potential cause for the occurrence of bent parts is caused by the method is the point of quality is not reached because of the point of quality is not listed. After that, defect products may pass into the brushing room because there is no standard checking for bent products on the washing process. is only 1 SOP installed on the wall.

The fourth factor is material. The potential cause of the occurrence of bent parts caused by the material is hard of the raw material (Aluminum Extruded Bar) so it is difficult to do manual rework.

The fifth factor is environment. The potential cause of the occurrence of bent parts caused by the environment is poor air quality because of the dust from aluminum powder residual brushing and high of noise level, 78 dB, because of engine brushing sound. Figure 4 presents a causal diagram of the potential defects that occur in the production.

![Causal Diagram of Potential Defects](image)

**Figure 5.** Cause-effect diagram defect of Product E defect
The high target of sigma value above needs to be addressed by doing the improvement. 5-Why Analysis a tool to make improvements to the E-block palmer defect. 5 Whys Analysis is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. Figure 6 until 14 shows 5-Whys Analysis for each failure mode. Root causes analysis and corrective action plan use the 5-Why Analysis. Based on cause-effect diagram, there are 9 failure mode that occurs as shown in Table 8.

**Table 8. Failure Mode**

| No | Failure Mode                                           |
|----|--------------------------------------------------------|
| 1  | The automatic machine suddenly stopped and error       |
| 2  | The semi-automatic machine suddenly stopped and error  |
| 3  | Point of quality is not reached                        |
| 4  | Defect products may pass enter brushing room           |
| 5  | Operators cannot focus on work                         |
| 6  | Lack of understanding of work instructions              |
| 7  | The operator forcibly pulls the part before the jig opens automatically |
| 8  | Dust from aluminum powder residual brushing            |
| 9  | Brushing clamp is not up to standard                   |

For the first failure mode, the main root cause are irregular maintenance and irregular scrap cleaning. This causes caps of machine radiator become brittle due to heat exposure so coolants cannot regulate the pressure inside the radiator and there are many aluminum scrap that has not been cleaned. The brittle clamps caused by machine usage for 24 hours and become overheated. All this problem make the automatic machine suddenly stopped and error. Temporary countermeasures are giving the machine time to cool down at least 2 hours, conducting regular maintenance every shift change, clean the scrap every shift change, and checking radiator cap every shift change. The final countermeasure or permanent corrective action are making schedule for machine usage (avoid 24 hours usage) and conducting regular maintenance and maintenance checklist.

For the second failure mode, the main root cause are irregular maintenance and irregular scrap cleaning. This causes caps of machine radiator become brittle due to heat exposure so coolants cannot regulate the pressure inside the radiator and there are many aluminum scrap that has not been cleaned. The brittle clamps caused by machine usage for 24 hours and become overheated. All this problems make the semi-automatic machine suddenly stopped and error. Temporary countermeasures are giving the machine time to cool down at least 2 hours, conducting regular maintenance every shift change, clean the scrap every shift change, and checking radiator cap every shift change. The final countermeasure or permanent corrective action are making schedule for machine usage (avoid 24 hours usage) and conducting regular maintenance and maintenance checklist.

For the third failure mode, the main root cause is planner only gives examples of defective locations for QA staff and does not list the quality of the machine operator. Perfect specifications of the product are not given when operators are trained and these things make the operators have lack of clarity of the quality that must be achieved from the supervisor. Of course, the point of quality is not listed. This entire problems make the point of quality is not reached. Temporary countermeasures are planner should give the customer point of quality to the machine operator and always update if there are some changes, point of quality have to list clearly, also QA staffs and machine operators should know the point of quality when trained. The final countermeasure or permanent corrective action are put the point of quality beside Machine SOP and make the point of quality the main course when operator.

For the fourth failure mode, the main root cause is planner only gives examples of scratch for QA staff in washing room, perfect specifications of the product are not given when operators are trained. This things make there is no bending checking and standard checking on the washing process. All this...
problems make defect products may pass enter brushing room. Temporary countermeasures are planner should give the customer point of quality to the machine operator and always update if there are some changes, point of quality (including bent) have to list clearly, also QA staffs and machine operators should know the point of quality when trained. The final countermeasure or permanent corrective action are put the point of quality beside Machine SOP and make the point of quality the main course when operator.

For the fifth failure mode, the main root cause is PPE checking are not held every time the operator entering the room. JSA and PPE symbols only displayed at entrance. This things cause operators does not comply with Safety Operational Procedure and there is no Job Safety Analysis in every machine. So, environmental issue like high decibel of machine (78 dB) and dust of aluminium make operators cannot focus on work. Temporary countermeasures are PPE checking are held every time the operator entering the rooms. (This check is carried out by the supervisor or the authorities) and make Job Safety Analysis for brushing room and every machine in this area. JSA is displayed at every entrance and every work station. The final countermeasure or permanent corrective action are routinely carried out safety inspections and give a warning to the offender.

For the sixth failure mode, the main root cause is many operators do not understand English language, they come from Bangladesh, Nepal, Indonesia, Myanmar, etc. (multinational). SOP only by words not by picture Work instruction and SOP are in English Work instruction hard to read make operators have lack of understanding of work instructions. Temporary countermeasures are make work instructions in 4 languages (Malay, English, Nepali, Bangladesh) and make a clear visual display to give operators knowledge about the work instructions. The final countermeasure or permanent corrective action are work instructions in 4 languages (Malay, English, Nepali, Bangladesh) are printed and put on every work station and clear visual display to give operators knowledge about the work instructions.

For the seventh failure mode, the main root cause is operators do the same job repeatedly that makes operator work in a hurry and out of focus. This is causes operator forcibly pulls the part before the jig opens automatically. Temporary countermeasures are make an sop regarding the technical settings of the machine and install parts with details such as the exact position the part must be placed, the right time to place and retrieve the part and operators may not rush to pick up parts. The final countermeasure or permanent corrective action is change operators with arm robot like automatic brushing machine.

For the eighth failure mode, the main root cause is the dust can fly freely to the air because there are no dust filter in every machine and some of brushing machines do not have covers. The temporary countermeasures are operators must comply with safety procedures by wearing masks and provide a dust filter on each brushing machine and do regular cleaning. The final countermeasure or permanent corrective action is install dust filter.

For the ninth failure mode, the main root cause is clamps are made one by one according to the arrival of new machines and demanded types of products causes clamps that have been made are different. This entire problems make brushing clamp is not up to standard. The temporary countermeasures are ensure the installed jigs meet the standards and conduct appropriate trial for the clamp before used for production. The final countermeasure or permanent corrective action are make a good documentation of machining program to make clamp, so when the new clamp is needed, engineering department can make the same clamp or improved.

Based on existing defect data, Monte Carlo simulations are carried out to imitate the defects produced in the production process system. This simulation calculates random values from an uncertain variable repeatedly. Repeated calculations are used to get the probability distribution of the simulated model. Monte Carlo simulation in this study uses the Companion by Minitab 5.3.0.0 software. This simulation is carried out on the current performance, 1st scenario - 50% solution success, 2nd scenario - 70% solution success, and 3rd scenario - 100% solution success. The success of the solution in question is the reduced type of bent defect. Each simulation is done with iterations 50,000 times. Besides, to know
the capability index of the simulation process given the upper specifications of the DPMO of 6,000 and the lower specification of the DPMO of 0.

Based on the simulation results, it appears that each success will bring a positive impact on the company which can be seen from the increase in the process capability index. Scenario 3 is the best scenario that provides the highest process capability index with a value of 1.2. This proves that the solution will provide quality improvement to the company. But it still depends on the control done to minimize the variations that occur. The purpose of the control stage is to control the improvements that have been made at the improve stage. Without control over the results of these improvements, the repair process will not achieve the expected results. The controls carried out are to monitor and ensure the production process is under controlled conditions by periodically calculating sigma values, record improvement data so that current repair processes can be compared with before. Tools that can be used include check sheets, control charts, and documentation, make and conduct strict supervision at each point of quality actuator arm body production process, and also always update work instructions and points of quality.

The control phase serves to control the improvements that have been made at the improve stage. Without control over the results of these improvements, the repair process will not achieve the expected results and does not run on an ongoing basis. The proposed controls to maintain the continuity of the improve process include reviewing and ensuring production process in controlled condition through calculating sigma value periodically. After that, recording improvement data to compare the before-after result through some tools like check sheet, control chart, and documentation. Make a clear point of quality is very important, and also always updating the work instruction and point of quality.

4. Conclusion
There are 9 types of actuator arm body products in brushing room. Total production on July 2019 is 2,646,069 units and total defect is 15,301 units. Based on Pareto diagram, the product with the largest percentage of defects is Product E, 28.096% which has 9 types of defect. Based on the percentage calculation, the dominant defects are bent fantail (47.22%), bent of swage pad (25.92%), and bent arm (14.33%). These three types of defects have in common the nature of the defect, bending. Based on cause-effect diagram, there are 9 failure modes include the automatic machine and semi-automatic machine suddenly stopped and error, point of quality is not reached, defect products may pass enter brushing room, operators cannot focus on work, lack of understanding of work instructions, the operator forcibly pulls the part before the jig opens automatically, dust from aluminium powder residual brushing, brushing clamp is not up to standard.

Based on 5-Whys analysis, recommended improvements in order to minimize the occurrence of defects in the Product E production in brushing room are holding a regular maintenance schedule for automatic and semi-automatic machine, holding a regular time to check the automatic machine operation, ensuring the installed jigs meet the standards, making a clear visual display to give operators knowledge about quality points that should be reached, making an SOP regarding the technical settings of the machine and install parts with details such as the exact position the part must be placed, the right time to place and retrieve the part. If zero defect in actuator arm body production is reached, company can save 65,000.88 RM per year.

Acknowledgments
This paper is supported by UNS Global Challenge Scholarship and Universiti Teknologi Malaysia. Thank you addressed to Dr. Norizah and Dr. Syed Ahmad Helmi as the person in charge of the research agenda.
References

[1] Pasaribu A 2018 Six Sigma Approach to Control the Quality of Tablet (Case Study: Pharmaceutical Company). *Journal of Management and Leadership*, vol. 1, no 1, pp. 25–32. [Online]. Available: http://jurnal.tau.ac.id. [Accessed Aug. 20, 2019].

[2] Kaushik M, Chauhan G, Mathiyazhagan K, Ojha R and Kumar M 2019 Reducing Rejections Using Six Sigma: A Case From Indian Automobile Component Manufacturing Industry. *International Journal of Services and Operations Management*, vol. 33, issue 1, pp. 69–86. [Online]. Available: www.inderscienceonline.com. [Accessed Oct. 3, 2019].

[3] Gupta V, Jain R and Meena M L 2017 Six-Sigma Application In Tire-Manufacturing Company: A Case Study. *Journal of Industrial Engineering International*, vol. 14, issue 3, pp. 511–520. [Online]. Available: link.springer.com. [Accessed Aug. 20, 2019].

[4] Sharma P, Gupta A, Malik S C and Jha P C 2019 Quality Improvement in Manufacturing Process Through Six Sigma: A Case Study Of Indian MSME Firm. *Yugoslav Journal of Operations Research*, vol. 29, no. 4, pp. 519–537. [Online]. Available: http://www.yujor.fon.bg.ac.rs. [Accessed Aug. 20, 2019].

[5] Noori B and Latifi M 2018 Development of Six Sigma Methodology to Improve Grinding Processes: A Change Management Approach”, *International Journal of Lean Six Sigma*, vol. 9, no. 1, pp. 50-63. [Online]. Available: www.emerald.com. [Accessed Aug. 20, 2019].

[6] Pérez P M O, Orlandoni M G, Ramoni P J and Valbuena V M 2019 Perceptive analysis of the quality in health services’ delivery with a Six-Sigma approach. *Revista Cubana de Salud Pública*, vol. 44, issue. 2, pp. 325 – 343. [Online]. Available: www.medigraphic.com. [Accessed Sep. 28, 2019].

[7] Smętkowska M and Mrugalska B 2018 Using Six Sigma DMAIC to Improve the Quality of the Production Process: A Case Study. *Procedia - Social and Behavioral Sciences*, vol. 238, pp. 590-596. [Online]. Available: www.sciencedirect.com. [Accessed Sep. 28, 2019].

[8] Raman R and Basavaraj Y 2019 Defect reduction in a capacitor manufacturing process through Six Sigma concept: A case study. *Management Science Letters*, vol. 9, issue 2, pp. 253-260. [Online]. Available: http://m.growingscience.com. [Accessed Sep. 28, 2019].

[9] Hakimi S, Zahraee S and Rohani, J 2019 Application of Six Sigma DMAIC methodology in plain yogurt production process. *International Journal of Lean Six Sigma*, vol. 9, no. 4, pp. 562-578. [Online]. Available: www.emerald.com. [Accessed Sep. 28, 2019].

[10] Gasperz, V 2007 *Lean Six Sigma for Manufacturing and Service Industries*. Gramedia Pustaka Utama: Jakarta, pp. 231.

[11] Mc Fadden F R. 1993 *Six Sigma Quality*. Quality Press, pp. 37-42.