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Implementation of Six Sigma Method in the Chip Inductor Production Process to Reduce Product Defects; Case Study In PT. XYZ

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Abstract: *Chip inductors are critical components used in LCD displays to support the display of the mobile phone screen at any time switched on. This component is produced by PT. XYZ is a manufacturing company that produces electronic components. The problem company facing now is still found high production costs due to higher production defects resulting from the production line SAV-LPS models so that production becomes ineffective and inefficient. From the main problem above it can be determined the purpose of this research is to obtain the causes of defective products and find solutions to reduce it and also how the effect of improvement to process performance Results of research conducted in the production process are identified core crack become the highest defect product compare to other types of product defects in the production process SEV-LPS chip inductor models. Analysis is given to a product defect with the value of the Risk Priority Number (RPN) which the highest number use for data processing on Failure Mode and Effect Analyze (FMEA) and the concept of Statistic Tools. Further improvement measures are conducted using Six Sigma concepts The results of this research can reduce the number of defects core crack which is one process waste from 0.53 % to 0.23 % and cost savings of US $ 10,474.34 / year, so that production becomes more efficient and effective to produce product with good specification*

Keywords:*DMAIC, FMEA, Six Sigma, Waste*

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I. Introduction

In the era of free zone economic competition as now, each company being sued more innovative to improve the process efficiency. The production process is organized as efficiently as much as possible, with a focus to the quick delivery time, reduced wastage, minimize cost, safety product, that occurred during the process and how to improvement of yield. W. Edward Deming [1] says that a level of quality of the product will effect directlyagainst to the amount of waste and rework that done in process, where waste and rework will add to costs and reduce the profits, thus reducing waste will also have a positive influence on the environment in which we will slightly reduce the energy, consumption and material when product quality more better.

Over the years the development of science occurred very rapidly, the methods used to reduce or even eliminate wastes in the process or activity that happens on the production floor, one of which method is Six Sigma.

Reduction of waste is done to achieve the goal of improvement where less manpower cost, inventory, and able to accelerate time to develop products and able to meet customer demand in the most efficient and as efficient as possible. The types of waste that occurs in the process of manufacturing or services, namely transportation, inventory, motion, waiting, excessive, production processes, and goods damaged [2]. In English, it is known by the term TIMWOOD [3].

The seven wastes was introduced by Taiichi Ono from Japan who work for Toyota and introduced in production system, as known as the Toyota production system [4]. The elaboration of such waste is described in the following section [5] :

1.Waste of transportation – consists of not necessary carriage and transfer.
2. Waste of excess inventory – this includes inventory, namely the excess stock.
3. Waste of movement – the time and energy that is used because the movement does not add value.
4. Waste of waiting – included among other activities waiting of machine running.
5. Waste of excess production – produce exceeds from demand.
6. Waste excess process – all the addition process is not required for the product.
7. Defects – including rework, rework there is no value added.

In the case of production process at PT. XYZ where is a company that produces chip inductor for a variety of electronics products found every month produced waste due to occurring defects of products as shown in table 1.These studies focus on the SEV-LPS product is a chip inductor where daily defective conditions is still high and should be resolve to bring down it. Below is following initial data as a background in this research project :

Table 1. Failure Cost Amount (US$) (Daily defective Jan - May 2017)

PRODUCT	COST AMOUNT
Chip Inductors	85,223

To identify the root cause of the problem "high defective", analysis the root causes described by Causes and effect diagram (Fish Bone Diagram) , also called Ishikawa Diagram [6]:

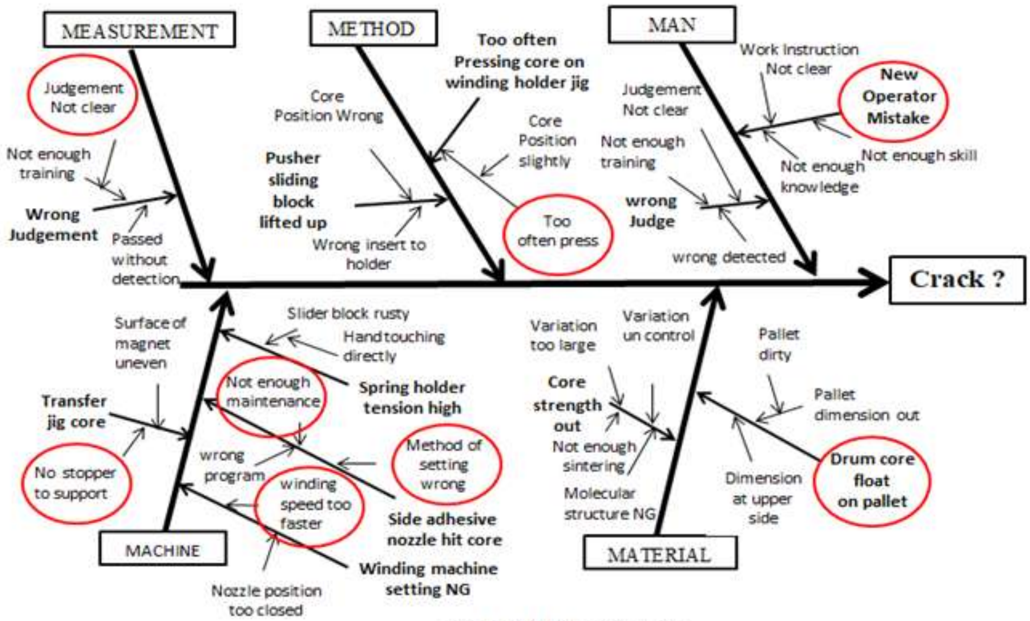

Fig 1.Fishbone diagram

From the identification of problems that is done through the fishbone diagram we find factors that affected to product defects, and formulate the main problems in this research such as :
1. What is a high product defect in the chip inductor production line at PT XYZ ?
2. How to reduce defective products?
3. How influence of handling of defective products against performance of the process?

From the main problems have been formulated as above then it can be determined the objectives of this research are :
1. Get the factors that why the defective product high.
2. To find a solution to reduce product defects.
3. Generate quality achievement of good products and know its effect on the performance of the process.

II. Method Of Research

A series of phases that are used in this research are, define phase, measure phase, analyze phase and improvement phase.

2.1. Define Phase

This phase is carried out to make the explanation easier to understand, making the team charter and determine the problem and give the framework of activity improvement as well as the expectations of what we want to accomplish. This expectation of the research is performed using the calculation of the measurement metric and saving calculation formula.

2.2. Measurements Phase

he objective in this phase is focused on how to collect data and information as accurately as possible that will help to find the real problem to do improvement. From here we will know the actual conditions and how big the expectations are to be achieved.

This phase is also the basic for proceeding to the phase after. In this research will be done internal measurement processes that affected as called the CTQ (critical to customer) that requires an understanding of the causal relationship between the process of performance and value of customers, measure the defective rate and performance level of the current process by measuring the CTQ on defects that are most influential. Tools that can be used to measure the performance of the process is the DPMO and the Sigma Level. Each indicator, identification of defects of the VOC (voice to customer) to CTQ, Attribute GR&R and Strength and Ppk dimension will be achieved and explanation of the type of his defective itself.

2.3. Stage of analysis (Analyze)

The objective of this phase is to obtain data by using statistical tools to identify root causes, make a hypothesis or hypotheses, and prove it. If it has been proven as the root of the problem so that it will proceed to the next phase of the improvement measures. At this stage of the analysis the analysis was carried out to find the root cause of the problem by using fishbone diagrams on each CTQ's most influential and Failure Mode And Effect Analysis (FMEA) to know the priority of improvement by looking at the Risk Priority Number (RPN).

2.4. Improvement Phase

In this phase how to implement or try to implement a solution to the root of the problems that exist. The results that may be obtained from this phase are : actions that have been planned are tested and should be able to reduce even eliminate the root of the problem are already identified. Improvement done to determine corrective actions in order to reduce defective. At this phase it will do improvements prioritized for precedence. Improvement against the most defective effect on the process so that the process becomes more efficient and effective.

2.5. Control Phase

This phase is an evaluation and a plan to keep the improvement efforts have been undertaken by standardizing processes, and also monitoring the improvement measures the results obtained. The results obtained can be shown by doing the calculation saving cost after improvement.

III. Results and Discussion

3.1. Define Phase

From previous data so it can be analyzed that the SEV-LPS type is the highest with the contribution of 43% defective happening at chip inductor model.Required data is chip inductor failure cost amount in total and from this data need to be breakdown in the product size type, and the top defective also note as a supporting data. From the top of the highest defective SEV-LPS model data will be analyzed the cause and do the improvement. This data is as follows:

Product Model	Cost Amount
SEV - LPS	32,155
SEV - 4EF	17,396
SEV - 3GE	10,828
SEV - 6PD	6,282
SEV – GN3	5,351
SEV- LG4	2,320

Table 2. Failure Cost Amount (US$)

Table 3.SEV -LPS Top defective

Top defective	Defective (qty)
Core crack	111,993
Terminal detached	97,098
Core broken	96,173
Terminal gap (uneven)	92,997
Core chip	88,995
Wiring loose	53,990
Terminal gap (back off)	11,993
Others	16,852

Table 4. SEV-LPS Core Crack Defective Rate (Qty)

Defective	Jan-17	Feb-17	Mar-17	Apr-17	May-17
Input qty	1,748,300	3,704,956	4,438,369	4,980,166	5,658,400
core crack	7,901	15,973	25,092	29,937	33,002
	0.45%	0.43%	0.57%	0.60%	0.58%

Production data collected is quality report of January until May 2017 which is the base line data defects as shown in the table below :

Table 5. Base Line Quality Data

	Jan 17	Feb 17	Maret 17	April 17	May 17	Total
Jumlah Produks	1,748,300.0	3,704,956.0	4,438,369.0	4,980,166.0	5,658,400.0	20,530,191.0
Total *cost*	$165,354.21	$350,414.74	$419,780.94	$479,988.40	$545,356.59	$1,960,894.88
Defective qty	7,901.0	15,973.0	25,092.0	29,937.0	33,002.0	111,905.0
Defective rate	0.45%	0.43%	0.57%	0.60%	0.58%	**0.53%**
Defective cost	$ 747.28	$ 1,510.73	$ 2,373.20	$ 2,885.33	$ 3,180.73	$ 10,785.40

Next production-related activities produced each day where the number of products that are generated is explained in the table below:

Table 6. Base Line Productivity Data (Kpcs)

Metric	*Baseline*	*Entitlement*	*Target*
Daily Output	71,000	92,000	100,000

3.2. Measure Phase

Measure is the second phase in the DMAIC cycle. This phase consist of determining breakdown analysis, Identify VOC to CTQ, Problem explanation, Attribute GR&R and Strength and Dimension Ppk will be achieved. From preliminary data need to be classified in any possibility of position core crack. The following data is based on the core crack position :

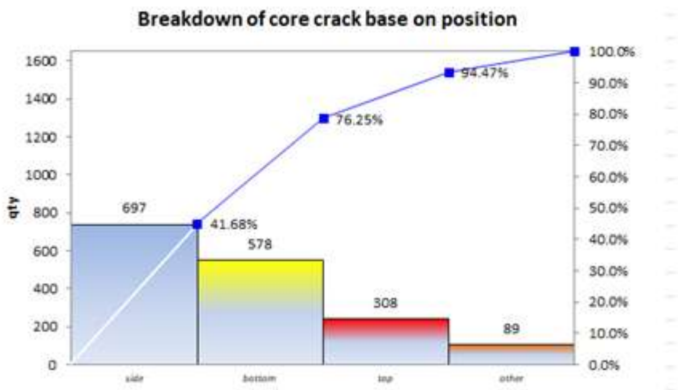

Fig 2. Breakdown of core crack base on position

Base on the graph above, this research focus on reducing core crack defective on side and bottom position due to both of its contribute 76.25% for overall defect. Then the identification of CTQ defects is done by defining a core crack defects and the number of defects that occur during the month of January 2017 until May 2017. Some types of defects that occur is the core crack, terminal detached, core broken, terminal gap (uneven), core chip and other defects. Based on the record the most common defects is core crack. So there is 1 CTQ defect only.

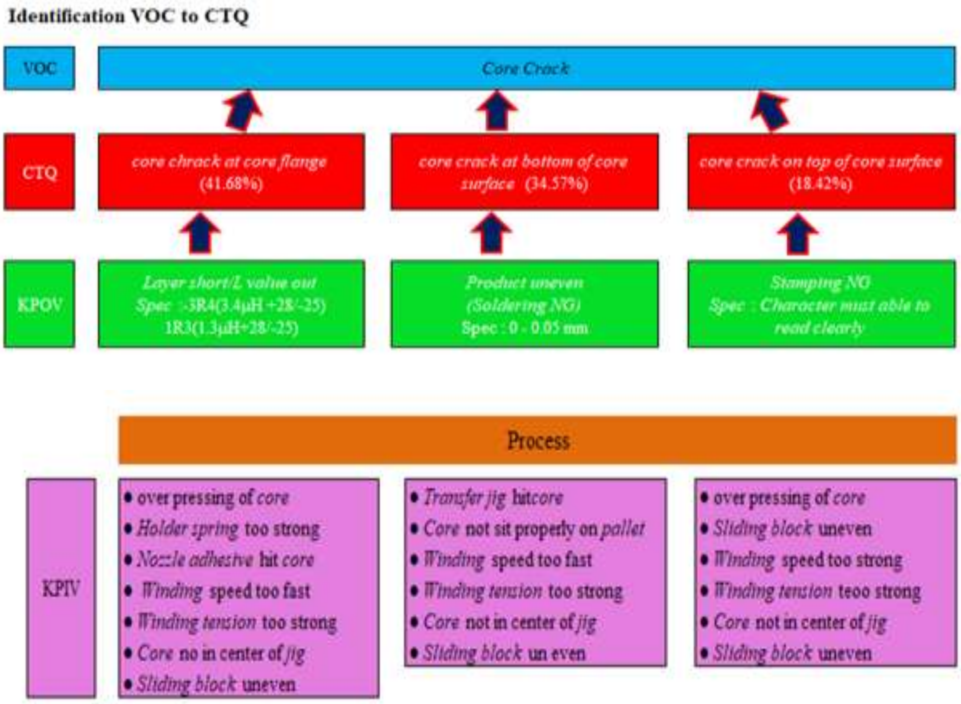

Fig 3.Identification VOC to CTQ

After we know the CTQ defects then the next step is to determine the magnitude of Defects Per Million Opportunities (DPMO) and sigma levels that can be seen in the following table:

Table 7. Calculation of *Sigma*Level of defect waste

Step	Action	Formula
1	No of inspected product	5,658,400
2	No of product lost due to defect	33,002
3	Failure rate = (2)/(1)	0.583
4	No of potential CTQ can create failure	1
5	Opportunity risk failure level each characteristic = (3)/(4)	0.583
6	Possibility of failure per million opportunity = 5*1000000	583,239
7	Conversion DPMO to sigma level	4,00
8	Result	Sigma level = **4,00**

Sigma level of defects indicates that the value is still far away from six sigma level. So it is still very necessary improvement to reach sustainable levels of six sigma.

3.3. Analyze Phase

This phase activities that will be done is to determine of process mapping, Failure Mode And Effect Analysis (FMEA) and calculate the Risk Priority Number (RPN) and perform validation of factors. Based on the fishbone diagram in fig.1 that already explained, we can concluded that the totalprocess mapping are 15 process, possibly of potential problems that can cause the core crack are 2 process i.e. winding processes and external adhesive process (based on the monitoring data of the daily production and quality).
Base on all analysis that was done then the conclusion as following:

Analysis Factor	Analysis Result	Action
1. Winding JIG Holder spring tension too strong	Significant Factor	Necessary
2. Adhesive nozzle hit core during applying adhesive	Significant Factor	Necessary
3. Several times pressing core causes core fragile and create core crack	Significant Factor	Necessary
4. Transfer jig hit core during trasfering core to JIG Holder	Significant Factor	Necessary
5. Drum core dimension at upper limit	Significant Factor	Necessary
6. Winding tesion too strong	Not Significant Factor	Not Necessary
7. Winding speed too fast	Not Significant Factor	Not Necessary

Table 8. Result of Analysis Factor

To know priority of improvement is done by Failure Mode And Effect Analysis (FMEA) and calculate the Risk of Priority Number (RPN) will be explain on the bellow table :

Waste	CTQ	Severity	Causes	Occurance	Improvement Action	Detection	RPN
Defect	Core Crack	4	Winding Jig holder spring too strong	7	1. Replace stronger spring (> 4kg) at winding JIG Holder 2. Control winding holder JIG spring tension about 2 - 4 kgf 3. Implemen monthly checking for spring holder tension	6	168
			Adhesive nozzle hit core during applying process	3	1. Use filler gauge 0.2mm for maintain safety gap nozzle with core during nozzle setting 2. Implement re- setting gap nozzle with core during maching initial run	5	60
			Several times pressing core causes core fragile and create core crack defect	4	1. Kontrol no of pressing minimum 2 x at winding JIG Holder 2. Use JIG to minimize pressing (if core slant after 2 x press, to open the holder jaw have to use JIG)	4	64
			Transfer jig hit core during transfer core to JIG Holder	7	Modify transfer JIG with additional stopper in order to avoid core receive direct press when transfering process	5	140
			Drum core dimension on upper limit	3	Request supplier to maintain core at center limit or in the center below	4	48
			Winding tesion too strong	1	No need improvement	1	4
			Winding speed too fast	1	No need improvement	1	4

Severity Value	1 = None 2 = Very minor 3 = Minor 4 = Very Low 5 = Low 6 = Moderate 7 = High 8 = Very high 9 = Hazardous with warning 10 = Hazardous without warning	RPN = Occur x Sev x Detec
Occurrence	1 = Failure rate ≤ 0.01 per 1000 pcs 2 = Failure rate 0.1 ≤ X < 0.5 per 1000 pcs 3 = Failure rate 0.5 ≤ X < 1 per 1000 pcs 4 = Failure rate 1 ≤ X < 2 per 1000 pcs 5 = Failure rate 2 ≤ X < 52 per 1000 pcs 6 = Failure rate 5 ≤ X < 10 per 1000 pcs 7 = Failure rate 10 ≤ X < 20 per 1000 pcs 8 = Failure rate 20 ≤ X < 50 per 1000 pcs 9 = Failure rate 50 ≤ X < 100 per 1000 pcs 10 = Failure rate X ≥ 100 per 1000 pcs	
Detection	1 = Very very high 2 = Very High 3 = High 4 = Moderately High 5 = Moderate 6 = Low 7 = Very Low 8 = Remote 9 = Very Remote 10 = Almost Impossible	

Table 9.FMEA *(*Failure Modeand Effect Analysis)

3.4. Improve Phase

Improve phase is conducted to determine corrective action in order to reduce defect. In this phase will be done improvement of processes accordance with the root cause of the waste that occurs along inductor production process based on the results of the previous analysis. Before doing any improvement we make sure first that the operators understand well by doing the training, improve the standard of judgement of core crack and done Attribute GR&R test.

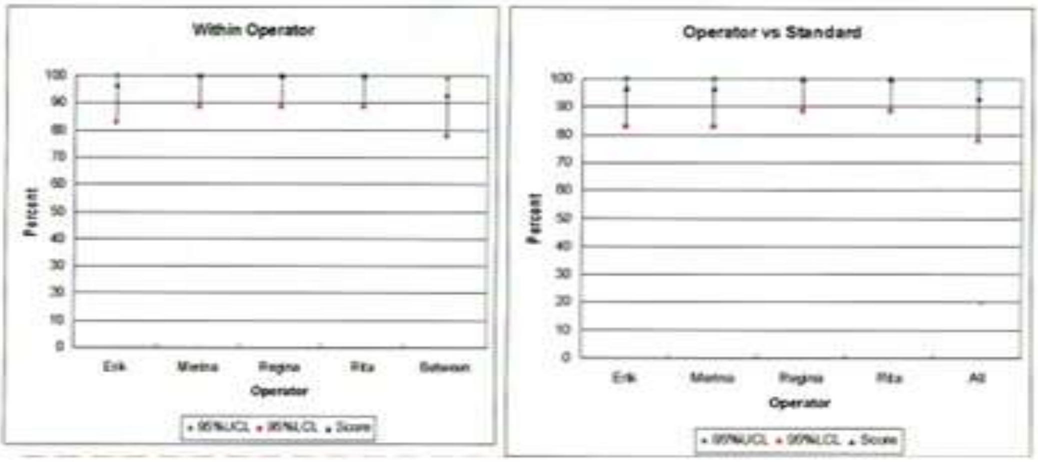

Table 10. Attribute GR&R Test result

3.5. Control Phase

Control is the final step of DMAIC. In this research conducting a review of the operation, check the instruction sheet which is used now and do the calculation saving cost obtained after improvement. Operation instruction of the primary winding process is improved and the adhesive that is the cause of problems that occur are carried out improved in this research.

IV. Conclusion

Based on the results of research that has been done on the inductor production process, here is the conclusion that can be drawn:

1. Reduce the number of defective core crack which is one of waste process from 0.53% to 0.23% and can saving cost US $10, 474.34/year.
2. Addition effect of improvement is process takttime more faster from 0.64 to 0.61 seconds so production becomes more efficient and effective

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