QUALITY CONTROL ANALYSIS OF PACKAGING PROCESS IN MINERAL WATER INDUSTRY USING SIX SIGMA

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ABSTRACT

Product packaging has important role to the producer in order to give consumer satisfaction and convenience. Therefore quality control of packaging process becomes crucial to the producer. One method that can be used is *Six Sigma*, a method of continuous and dramatic quality control to achieve world's class quality which focus on reducing process variation as well as reducing defect until reach the DPMO (*defect per million opportunity)* level using intensive statistics and problem solving tools. The goal of the study is to find out the quality control system conducted by mineral water industry, determine factors that cause defects and measure its effectiveness in product packaging process using achievement of sigma *level.*

INTRODUCTION

Currently, the effect of global economy has reached every corner of the world and increase business competition. Satisfying customer needs and wants become more and more important. Good quality of products, including packaging of the products, has become a requirement in their effort to attract more new customers and to maintain their current customers. This circumstance has led the producers to use consistent quality control of their products.

Indonesian packed mineral water industry start in 1973 with PT. Aqua Golden Missisippi as the pioner. In the 70's the industry has a very slow growth because natural water resources are abundant. The industry start to grow in the 80's when industrial development grow fast along with its polution. The industry have taken hit by monetary crisis. However, until year 2000 the number of producers has reach 100 with 200 brand name (Hendriatna, 2000).

In Indonesian packed mineral water industries, defect in products package is consider as serious problems. For example, usage of below standard heater could produce heat above the limit of 200-230^{o}C that cause leak in the package because the lide could not sealed tight or it just leak because it was to hot. If this defect occurs than the product become waste and increase the overall production cost. These defect products must never get to the hand of customers; otherwise they will be disappointed and switch to use the competitor's product.

One of the quality control methods that popularly use is *six sigma* method. It is a dramatic and continuous quality control method to achieve world class quality. Six sigma is a method to improve production process by focusing on effort to reduce process and product variations while reduce defect (products or service outside specification) until reach the DPMO (defects per million opportunity) level. This methods use intensive statistical and problem solving tools. Most of the process in the industries still in sigma level 3-4.

Implementation of Six sigma method has to be adapted with its inherent condition of the industry. Some company has already have good quality system, but it is still could be improve by using six sigma method, increase in sigma level could be interpreted that the company is reaching the customer satisfaction.

Research Question

1. To determine current product packaging quality system used by companies in Indonesia, case study: PT. Pusaka Kali Agung.
2. To determine the cause of defect in the current product packaging process
3. To understand the implementation of six sigma method in packaging process.

Literature Review

Every part in the company has their own roles to achieve company objective i.e. satisfying customer. The operational department also has important roles to create products needed by customers equipped with all the features to satisfy customers. Fulfill customer needs, wants and tastes to gain customers satisfaction are vital to company's existence.

Quality of products become the key to maintain company existence because they must create products that consistently fulfill the need and taste of customers. Therefore they need a quality management system to solve quality problems. Definition of Quality Management System according to Davis and Goetsch (2003:56) is

> *"The quality management system is composed of all the organization's policies, procedures, plan, resources, process, and delineation of responsibility and authority, all durability aimed at achieving product or service quality levels consistent with customer satisfaction and the organization's objectives."*

Quality control activities are needed to produce good quality products to reduce variations between standard specification with actual products results. Quality control activities have to be conducted thoroughly in the whole process, start in the process of inspection of incoming raw material, during production processes until the last process of packaging end products. Quality control definition according to Fragman (2002:6) is:

> *"Quality control is all operational technique necessary to satisfy all quality requirements. Inclusive in quality control is process monitoring and the elimination of root causes of unsatisfactory product or service quality performance"*

Full commitment to quality will create positive impact and added value for the company to win competition. Products packaging has important role to the company because good design package will give convenience and comfort values to customers. To assure consistent good quality product packaging output, quality control must also apply in the packaging processes.

Definitions of packaging according to Saladin (2002:131) is

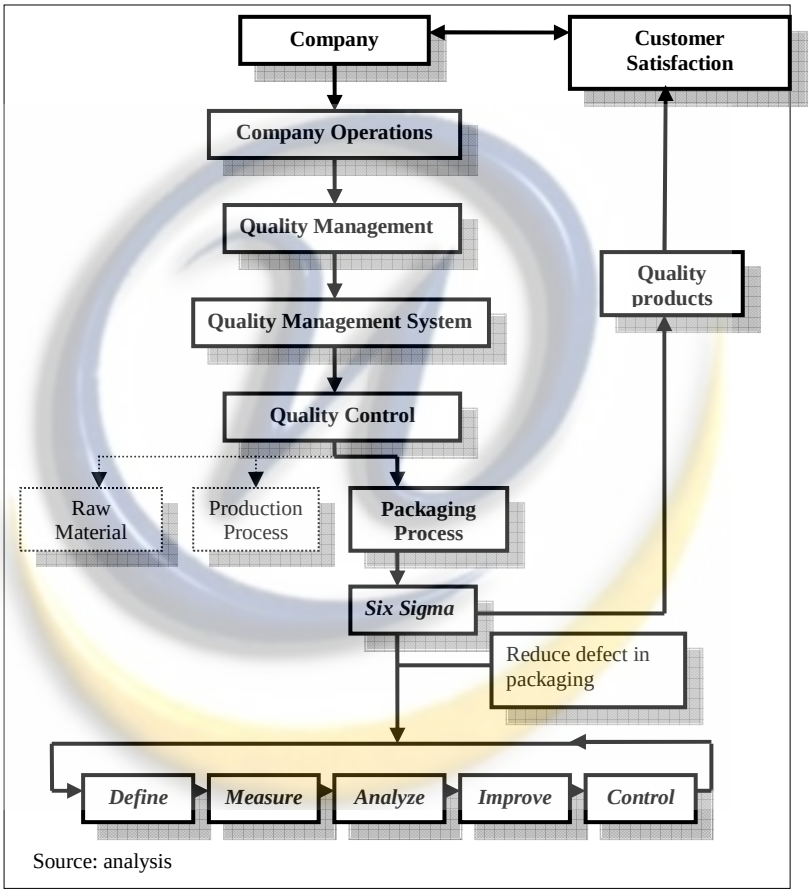
> *"Packaging as the activities of designing and producing the container or wrapper for a product."*

There are several methods of quality control that can be implemented in packaging process. One of them is six sigma method that can give dramatic result. This method first implemented in Motorola in 1986, initiated by one of its engineer Bill Smith with the full support of its CEO, Bob Galvin.

According to Brue (2004) six sigma is a statistical concept that measure a process related to defect at level six of sigma which is only 3.4 defects from a million

probabilities. Six sigma therefore is a management philosophy that focuses to reduce defect with define, measure and improve process.
Problems are identified step by step using six sigma approach. The first step is *define* which is a process of studying the problems so it can be understood. The second step is *measure* by collecting and analyzing data related to the problem. Then in the *analyze* step the root of the problems is identified. In the *improve* step, continuous preventive and corrective action is applied to the process. The last step is *control* which monitors and measure performance to get the result achieved.
Six Sigma method has great benefit especially in reducing product defect in the packaging process and produce consistent good quality product. This method also demands a continuous improvement to have better result.

FIGURE 1: SCHEMATIC



Source: analysis

RESEARCH METODOLOGY

This study use descriptive methods, which tries to discover answers to the questions who, what, when, where and sometimes, how. The descriptive study is popular in business research because of its versatility across disciplines. In not-for-profit corporations and other organizations, descriptive investigations have a board appeal to the administrator and policy analyst for planning, monitoring, and evaluating. In this context, how questions address issues such a quantity, cost, efficiency, effectiveness and adequacy (Cooper, 2003).

Data Collection Method

Author has determined that surveying is the appropriate data collection approach, various means may be used to secure from individuals. Survey was conducted by personal interview (i.e., face to face communication) is two-way conversation initiated by an interviewer to obtain information from a participant.

Author also conducted observation. Observation qualifies as scientific inquiry when it is conducted specifically to describe the researcher objective/question, is systematically planned and executed, uses proper controls, and provides a reliable and valid account of what happened (Cooper, 2003).

Population & Sample

For this study, we took PT. Pusaka Kali Agung as case study sample, out of 100 companies population in the Indonesian packed mineral water industry

PT. Pusaka Kali Agung located in Cirebon, West Java. This company starts the business in 1989 with area of sales in West Java region. As other company in the industry, it has 4 products using "TIRTA" brand as follows:

1. Cup packed of 240ml
2. Bottle pack of 600ml
3. Bottle pack of 1500ml
4. Gallon pack of 19liter

Data used for this study are the production data of Cup packed of 240 ml during period of June 2007.

Data Analysis

There are 3 steps use in processing data analysis, as follows:

1. Explain current quality control system implemented in the packaging process
2. Explain factors that cause defect in the packaging process
3. Explain the quality control system in the packaging process using six sigma method.

To determine which product that will be the subject of improvement process by implementation of *six sigma method*, the study is limited to the product that produces most of defect.

DMAIC (*Define, Measure, Analyze, Improve and Control*) step are conducted as follows:

Define, in this stage problems are identified, customer specification is defined and target is set (reduce defects/costs and time frame). Several steps conducted in this stage are:

1. Set the customer requirement, in order to gain understanding what is really demanded by customer in the product packaging
2. Observe type of defects, in order to understand what type of defects that could occur in the product packaging process.
3. Determine the frequency of each type of defects. In this step calculations are made to determine amount of each defect and by using Pareto Diagram determine frequency of each type of defect occur in the product packaging process.
4. Make IPO (*input-process-output*) diagram to see what factors affecting the process and determine what kind of *output*/target we want from the process.
5. Make Process Flow diagram, to help understand everything that related to the product packaging process and gain understanding which part of the process that can create defects and find out the problems that causing it

Measure, in this stage problems are validated, measurement and analyzing data related to the problems. Several steps conducted in this stage are:

1. Determine DPO (*Defect Per Opportunity*) and DPMO (*Defect Per Million Opportunity*) which is calculated in six sigma quality improvement program,
2. Determine sigma level in the product packaging process.

Analyze, this stage determine which factors that affect the most at process, so when it is improved, it will give dramatic improvement on the process. Steps conducted in this stage is made Cause Effect/Fishbone Diagram to show main factors in more detail which are affecting quality and have impact to the problem studied.

Improve, in this stage ideas are discussed to improve the system based on previous analysis and made an improvement concept.

Control, in this stage the result is monitored and measured to get the result achieved

Data Analysis Technique

In this study data analysis used are Qualitative Data Analysis (an approach using available data and presented it descriptively using tables, graphics and descriptions) and Quantitative Data Analysis (using production data and calculation in form of numbers).

Formulas and tools used in the study:

1. Pareto Diagram is used to determine types of defect in the packaging process and its frequency of occurring.
2. Calculation of defect percentage:

$$\%\ defect\ of\ misalign\ lide = \frac{\sum defect\ of\ misalign\ lide}{\sum total\ defect}$$

$$\%\ defect\ of\ leak\ during\ production = \frac{\sum defect\ of\ leak\ during\ production}{\sum total\ defect}$$

$$\%\ defect\ of\ post\ production\ replacement = \frac{\sum defect\ of\ post\ production\ replacement}{\sum total\ defect}$$

$$\%\ defect\ of\ carton\ box\ leak = \frac{\sum defect\ of\ carton\ box\ leak}{\sum total\ defect}$$

3. IPO (*input-process-output*) diagram is used to study factors which affecting the process.
4. *Process flow* diagram is used to help identify factors which related to packaging process in order to give pictures which part of the process that could led to defects and tracing its cause.
5. Calculation of DPO (*Defect Per Opportunity*) and DPMO (*Defect Per Million Opportunity*)

$$DPO = \frac{\sum defect\ products}{\sum defect\ products\ inspected \times potential\ CTQ}$$

$$DPMO = \frac{\sum defect\ products}{\sum defect\ products\ inspected \times potential\ CTQ} \times 1.000.000$$

Note:
Potential CTQ (critical to quality) = all attributes that very important to consider because have direct relation to customers' needs, wants and satisfaction. CTQ can be an element of product/process or practices that have direct impact to customer satisfaction.

6. Determination of *Sigma value* derived from DPMO to Sigma Value conversion table based on Motorola concept. Sigma value used is the nearest number taken from Sigma Value conversion table.
7. *Fishbone/Cause Effect Diagram* is used to analyze factors which causing defect products.
8. If the causal factors of defect is identified, then corrective and preventive actions is conducted to improve products quality.
9. SOP (*Standard Operating Procedure*) is used and revised to help company achieve the goal/target of quality.

RESULT AND ANALYSIS

Current Condition: Quality Control System in Packaging Process

To maintain products quality, PT. Pusaka Kali Agung implements quality control activities in packaging process in 3 stages:

1. Control of Packaging Raw Material

Raw materials are main factor that affecting the quality of products. If the raw material has good quality or meet the standard than the output products will have good quality too. Therefore, quality control of raw material is implemented at PT. Pusaka Kali Agung. This includes filtering and inspection process to ensure that raw material for packaging such as cup and lide has met the quality requirement.

Figure 2 show the flowchart of raw material control process start form the supplier's shipment to the use of raw material in the production process.

Process start with inspection to incoming raw material from suppliers to check whether the materials meet PT. Pusaka Kali Agung's requirement. Materials that do not meet requirement must not allow to proceeds to the next process. Otherwise it could become an obstacle to the next production process or create a defect product and add another wasted cost. If this defect product is proceeds to the next process unnoticed until end products are produced, then the company has wasted a production cost because defect products must be disposed.

Raw material that passed the quality control inspection was put in the inventory and ready to be used in the next process.

2. Control of Packaging Process

There is no control of packaging process during production process. Control is conducted only by inspection at pre-process and post-process stage. Inspection during packaging process only conducted when there are problems with the production process such as machinery problem. However if there is variation found during packaging process, operators must report it to the production manager.

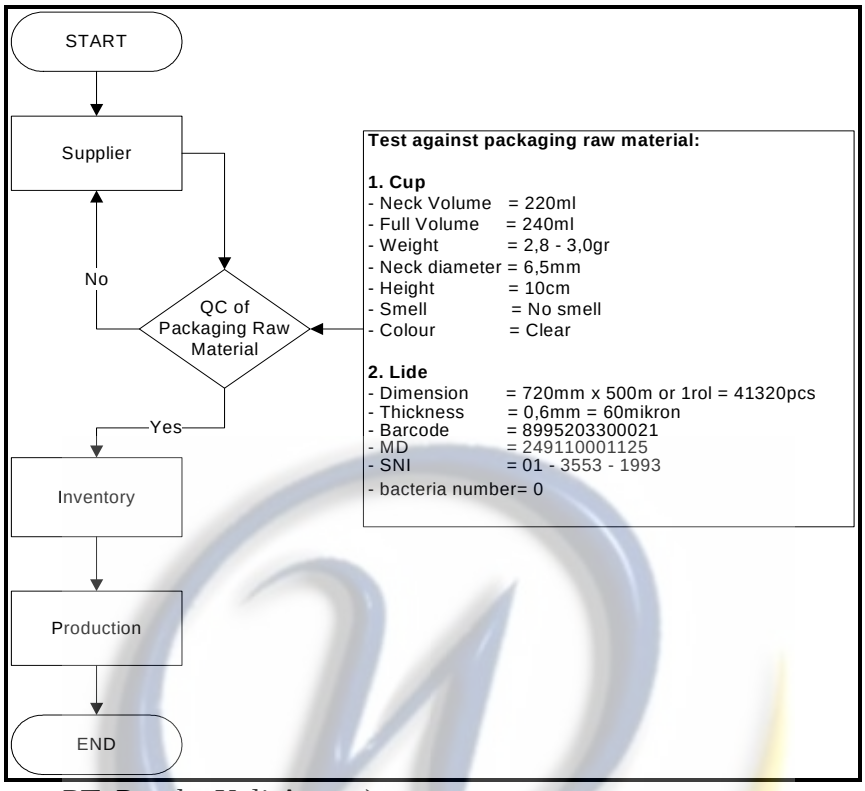
3. Control of Product Packaging

Control at the end product packaging process is conducted through physical inspection activities to the condition of package. The activities are as follows:

a. If there is a defect, whether it is a product defect or a packaging defect, it must be dispose.
b. However, if the packaging defect is repairable, repair can be conducted according to level of defect.

c. Every product that passed quality inspection sent to the inventory before shipped to the customer

FIGURE 2: FLOWCHART of RAW MATERIAL CONTROL PROCESS



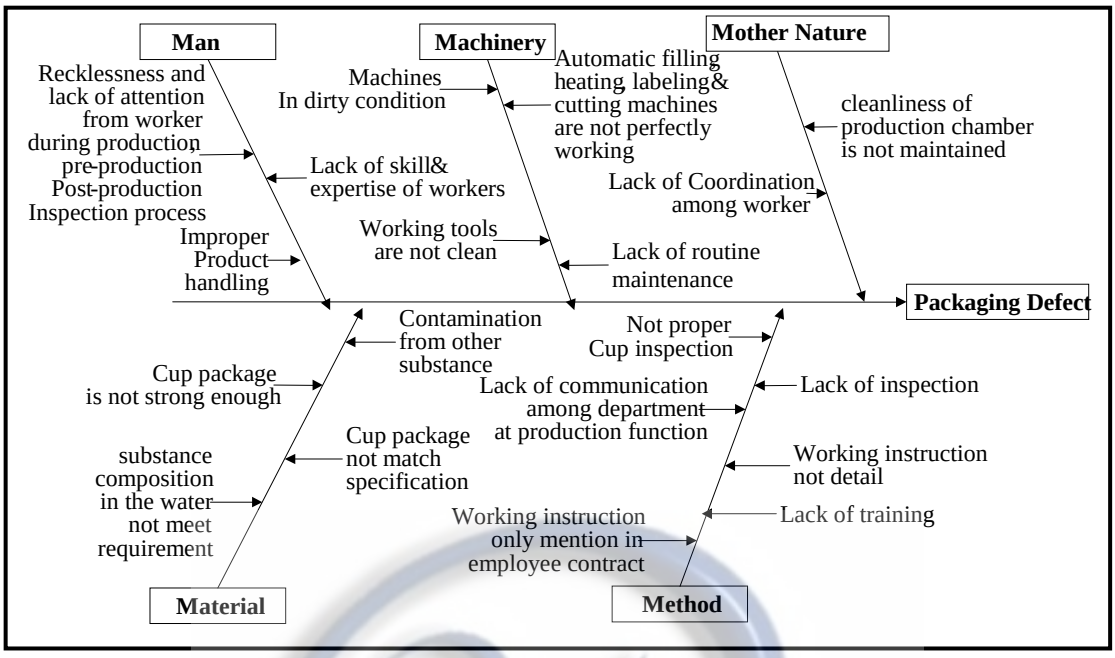
(Source: PT. Pusaka Kali Agung)

Factors which Cause Defect in Packaging Process

Problems face by PT. Pusaka Kali Agung during packaging process activities are categorized into 2 categories, general problems and specific problems. General problems related to raw material, worker and machinery involved in the production process. While specific problems are related to the production process itself.

Figure 3 shows the fishbone diagram made by author to determine main factors which have impact to defect in product packaging process.

FIGURE 3: FISHBONE DIAGRAM for PRODUCT PACKAGING DEFECT



(Source: PT. Pusaka Kali Agung)

Analysis of Quality Control with Six Sigma Method in the Product Packaging Process

Data obtained during the study is the number of production and number of defect on the period of June 2007 from PT. Pusaka Kali Agung. Based on the data a basic concept of six sigma method is established i.e. DMAIC (*define, measure, analyze, improve, control)*. This study is limited only up to the stage of Improve

***Define* step**

In this stage problems are identified, customer specification is defined and target is set (reduce defects/costs and time frame). Several steps conducted in this stage are:

1. Set the customer requirement, in order to gain understanding what is really demanded by customer in the product packaging.
   Based on the identification and interview with the manager of PT. Pusaka Kali Agung, the packaging standard demanded by customers can be narrowed as follows:
   a. Packaging is not leak
   b. Packaging is not dirty
   c. Lide is not defect
   d. Carton box is not leak
2. Observe type of defects, in order to understand what type of defects that could occur in the product packaging process.
   Based on observation, the types of defect occurred are:
   a. Lide Misalign, this defect was caused by improper lide set which make misaligned and did not meet the standard set by PT. Pusaka Kali Agung. Usually caused by operator mistake and uncontrolled machinery operation.
   b. Leak during Production, this product defect is caused by the heating machine in the packaging process that produces heat below or over the standard set by PT. Pusaka Kali Agung i.e. 200^{o}C - 230^{o}C. Under heat will make the lide do not stick tightly and overheat will make the lide melted.

c. Post Production Replacement, this defect occurred when the products are return by the market or customer and must be disposes because it cannot be reprocessed. This kind of defect usually cause by mishandling in shipment or in inventory at the distributors, such as over stacking the carton box exceeded the standard.
d. Carton Box Leak, this defect occurs when the carton is become wet and damaged because of the leak in the cups inside. This usually happen because error in the process of control of leak during production which let defect product packed into the carton box. When this defect occurs, the carton box must be replaced, while the leaked cup must be dispose.

3. Determine the frequency of each type of defects. In this step calculations are made to determine amount of each defect and by using Pareto Diagram determine frequency of each type of defect occur in the product packaging process.
   In the Table 1, data of production and defect of Cup product is shown for production period June 2007

TABLE 1: DEFECT DATA of WATER CUP 240ml of JUNE 2007

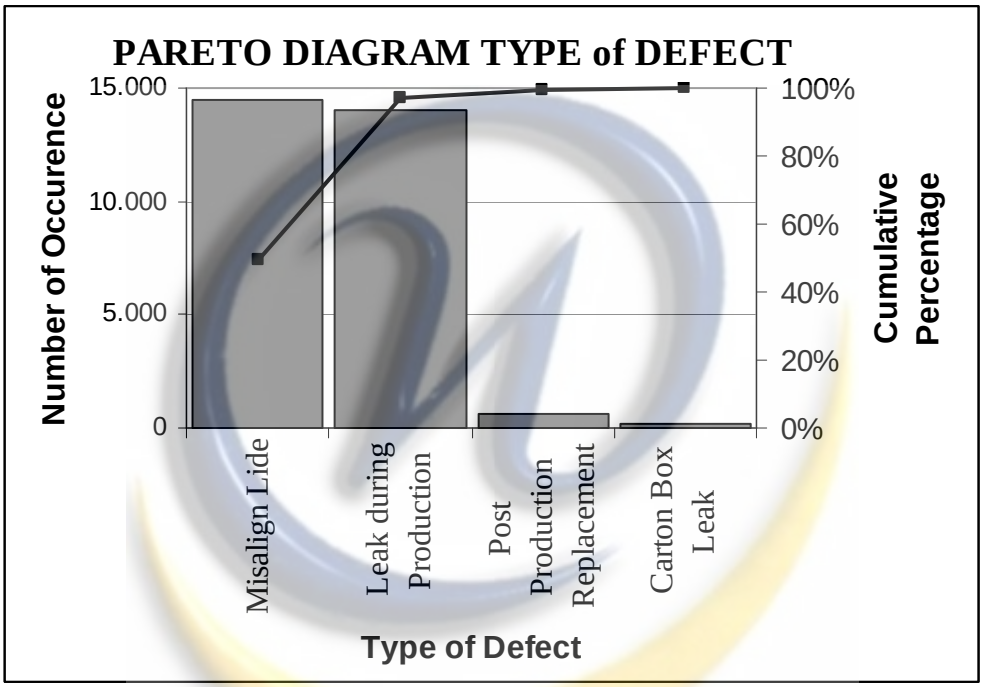
No	Production Date	Number of Production	Type of Defect				Total Defect
			Misaligned Lide	Leak during Production	Post Production Replacement	Carton Box Leak	
1	1	172368	1486	661			2147
2	2	74256	1280	280	12		1572
3	3	124752	117	270			387
4	4	206544	93	405		13	511
5	5	236688	1501	553	107	14	2175
6	6	294144	1817	402	38	8	2265
7	7	225216		253			253
8	8	314880	947	630		4	1581
9	9	185232	1216	700	37	5	1958
10	11	242496	982	595	23	5	1605
11	12	239952	150	458	23		631
12	13	299968	495	490	23	8	1016
13	14	238944		228	34	3	265
14	15	113348	210	467	10	6	693
15	16	216816	225	445	28		698
16	18	241968	1078	749		6	1833
17	19	251664	126	330	14	24	494
18	20	231696	320	515	14		849
19	21	235968	30	665	36		731
20	22	213696		585	12		597
21	23	223344	240	486	40	3	769
22	24	223584	186	165	15		366
23	25	320112	26	373	11	9	419
24	26	263848	514	534	42	14	1104
25	27	289488	465	1139	40	8	1652
26	28	323088	794	1095	10	8	1907
27	29	309024	154	380	8	30	572
28	30	264720		159		33	192

No	Production Date	Number of Production	Type of Defect				Total Defect
			Misaligned Lide	Leak during Production	Post Production Replacement	Carton Box Leak	
Total		**6577804**	**14452**	**14012**	**577**	**201**	**29242**

(Source: PT. Pusaka Kali Agung)

Using data at table 1, a Pareto Diagram is made to determine type of defect occurs and its occurrence frequency in order to determine priority of problem solving. The Pareto diagram is shown in Figure 4.

FIGURE 4: PARETO DIAGRAM TYPE of DEFECT (JUNE 2007)



4. Set Priority for Six Sigma Implementation.
   Based on the Pareto diagram above, priority analysis for handling defect problem is conducted. The Pareto diagram can be transform into a table of percentage and cumulative percentage as shown in Table 2.

TABLE 2: PERCENTAGE of DEFECT (June 2007)

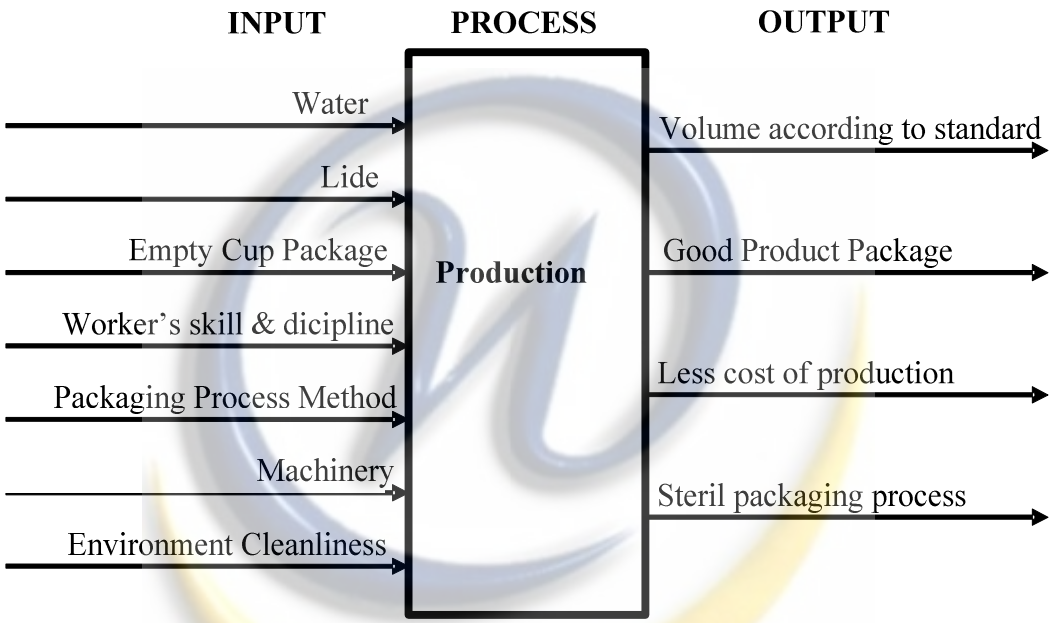
Type of Defects	Total	Percentage	Cumulative Percentage
Misaligned Lide	14452	49.42%	49.42%
Leak during Production	14012	47.92%	97.34%
Post Production Replacement	577	1.97%	99.31%
Carton Box Leak	201	0.69%	100.00%
Total	29242	100.00%	

From table 2, we conclude that the most dominant cause for defect is Misaligned Lide because overall it caused 49.42% of defect.

Misaligned Lide will make the brand on the package is cut or cannot be seen and cannot be sell to the market. Therefore the priority for implementation of six sigma method is to reduce defect caused bay misaligned lide on the 240ml Cup product.

5. Make IPO (*input-process-output*) diagram to see what factors affecting the process and determine what kind of *output*/target we want from the process. Generic IPO diagram have standard input called 6M (*Manpower*, *Method*, *Material*, *Measurement*, *Machine*, and *Mother Nature*). While standard *Output* usually in term of cost (cheaper), time (faster), and quality (better). The IPO diagram for this study is shown in Figure 5.

FIGURE 5: INPUT-PROCESS-OUTPUT DIAGRAM PACKAGING PROCESS of 240 mL CUP



Factors that affecting the output of Cup 240ml are as follows:
Water; poor water quality will resulted poor the product.
Lide; good quality lide will have positive impact to the product while poor quality will have negative impact.
Empty cup package; Cup quality must be carefully inspected to know exactly its condition and strength.
Worker's skill and discipline; unequal level of skill and discipline will vary the performance of the worker which resulted in inconsistent product quality. Negligence or human error while operate packaging process or inspect incoming raw material could resulted in defect as well as physical factor of the workers such as fatigue.
Method and production process; improper method and production process will resulted in inefficiency because defect can be detected after the final products are produced, not prevented. Proper method and production process alone also not consistently operated; otherwise probabilities of defect will increase.
Machinery; as supporting factor in manufacturing, machinery has role to help finished the job faster and standardized. However, machinery needs proper and regular maintenance to keep consistent output.

Cleanliness of working environment, working environment must be maintain in order to prevent contamination to the material as well as provide comfortable working areas.

6. Make Process Flow diagram, to help understand everything that related to the product packaging process and gain understanding which part of the process that can create defects and find out the problems that causing it.

   There are 3 processes in production of drinking water in 240ml cup package as follows:

   a. Early Process

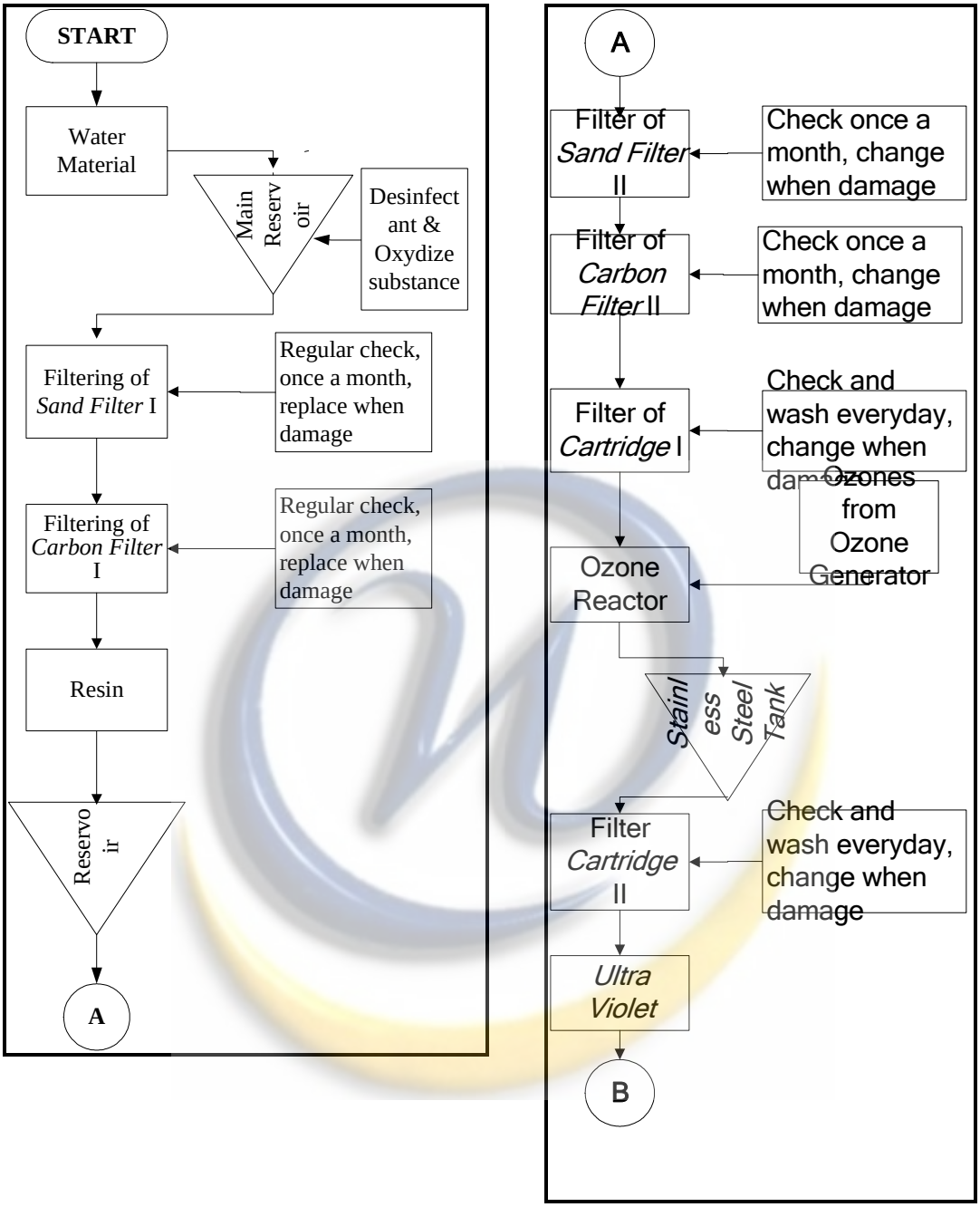
   The process starts with the water pumping into the main reservoir, where it is going to be disinfected and oxidize. After that the water pumped into process of filtering through *Sand filter* I (quartz sand) to reduce or eliminate particles that can disturb the next process. Then through the *Carbon filter* I (active carbon) to reduce remaining *chlorine* and absorb disturbance particle. After that the water go to the resin. Next step is the inspection to the resin result. If the result is good then the water allowed to flow to the next reservoir before start the next stage of process. The filters are regularly checked, once a month, and replace when necessary.

   b. Production Process of Drinking Water in 240 ml Cup Package

   Water from the reservoir is pumped to second filtration i.e. Sand Filter II and Carbon Filter II, in order to reduce remaining chlorine and to absorb other disturbance substance. These free chlorine water then are filtered by cartridge to remove solid substance. Then it pumped into Ozone Reactor tank to be mixed with ozone produce by the ozone generator in order to be disinfected. These sterilized water then pumped to a stainless steel tank. The next process is pumps the water to a second cartridge filter. After that the water is pumped through ultraviolet light to remove excess ozone so that the ozone will not affect the water taste. From the ultraviolet process, the water filled into the filler machine reservoir. The water is now ready to put into package through filler machine.

   Figure 6 show Process Flow Diagram for the early process and production process in the production of drinking water in 240ml cup.

FIGURE 6: PROCESS FLOW DIAGRAM of
EARLY PROCESS & PRODUCTION PROCESS



(Source : PT. Pusaka Kali Agung)

c. Packaging process of Drinking Water in 240 ml Cup Package

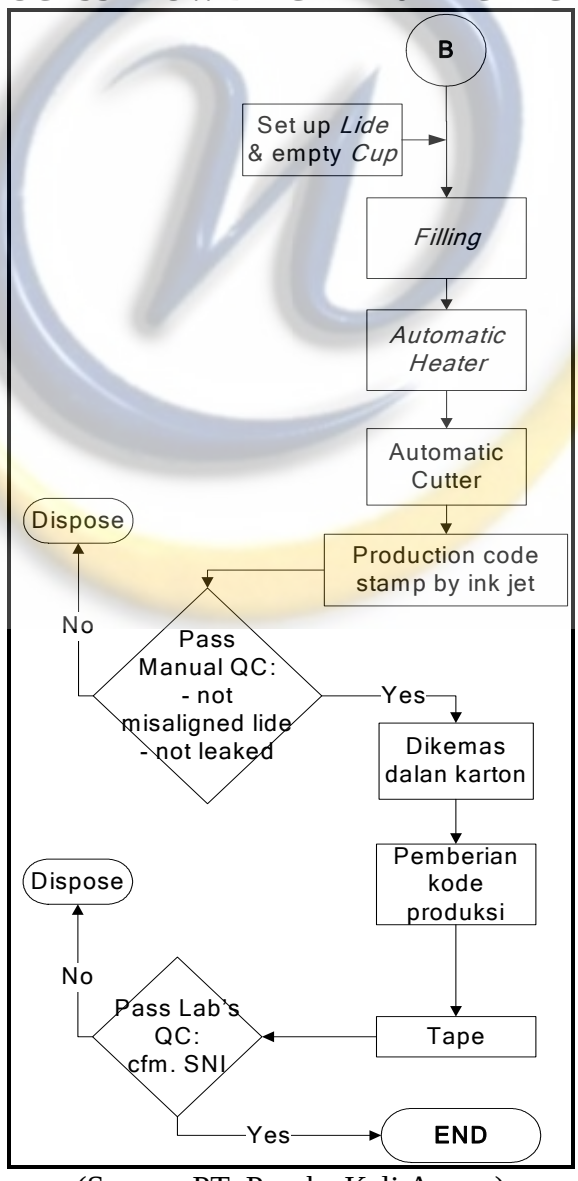
The packaging process is done by Unit *Cup* machine. This unit produces drinking water in form of *Cup* volume 220 ml/ 240ml with the capacity of 400 Box/jam continuously on conveyer.

Before start the process, empty Cup package is line-up in the rack and the lide is set to be drop exactly on Cup's top package. The filler machine reservoir is filled with processed water. Filler volume is set according to the volume of the cup used (240 ml or 220 ml).

Once the process begin, empty cup package will be dropped automatically and fill with water, the lide will close the cup and then heading to the automatic heater

with temperature of 200^0C – 230^0C. The *lide* will be sealed tightly by the heat and then automatically cut by cutting machine. Lide excess is hooked to a roll to prevent it fall to the filler machine. Sealed cup will be stamped the production code through the ink jet, then carry by the conveyor to be pack in carton box.
Cup products will be inspected and selected manually, those passed the requirement of the company will be pack in carton box of 48 cups. The carton box also stamp the production code and than seal by tapes. The cup must not have misaligned lide and not leaked. Otherwise, it will be separated to be disposed later.
Before went to the inventory, samples of production is taken to have a series of quality test to ensure the product meet the company's standard (pH level, Smell, Taste) and SNI (National Standard of Indonesia). If the sample is passed the quality test, then the cups ready to put to the inventory before shipped to the customers.
Figure 7 show Process Flow Diagram for the packaging process in the production of drinking water in 240ml cup.

FIGURE 7: PROCESS FLOW DIAGRAM of PACKAGING PROCESS



(Source: PT. Pusaka Kali Agung)

***Measure* step**

In this step problems are validated, measurement and analyzing data related to the problems. Several steps conducted in this stage are:

1. Determine *Critical to Quality* (CTQ).
   Critical to Quality (CTQ) is all attributes that very important to consider because have direct relation to customers' needs, wants and satisfaction. CTQ can be an element of product/process or practices that have direct impact to customer satisfaction.
   In the cup packaging process, CTQ is determined based on how well the products meet the specifications from customer. Customer will not satisfy if the products which they received do not meet their demand specification
   Based on the observation during the study, the defects occur are as follows:
   a. Misaligned Lide
   b. Leak during Production
   c. Post Production Replacement
   d. Carton Box Leak:
   So the potential CTQ which could create defect (number of CTQ characteristic) are four.
2. Determine DPO (*Defect per Opportunity*), DPMO (*Defect per Million Opportunity*) and *Level Sigma* at PT. Pusaka Kali Agung.
   Based on inspection during period of June 2007 we gather data that there are **29.242** defects out of **6.577.804** cups produced. After defect frequency is known than we calculate the DPO, DPMO and *level sigma* at PT. Pusaka Kali Agung to be used as performance baseline in six sigma project. The result is shown in Table 3.

TABLE 3: DPO, DPMO and SIGMA CAPABILITY CALCULATION of PACKAGING PROCESS of DRINKING WATER in 240ML CUP

No	Date	Number of Production	Number of Defect	Potential CTQ	DPO	DPMO	Sigma Value
1	1	172368	2147	4	0.00311398	3113.98	4.23
2	2	74256	1572	4	0.0052925	5292.50	4.05
3	3	124752	387	4	0.00077554	775.54	4.66
4	4	206544	511	4	0.00061851	618.51	4.73
5	5	236688	2175	4	0.00229733	2297.33	4.34
6	6	294144	2265	4	0.00192508	1925.08	4.39
7	7	225216	253	4	0.00028084	280.84	4.95
8	8	314880	1581	4	0.00125524	1255.24	4.52
9	9	185232	1958	4	0.00264263	2642.63	4.29
10	11	242496	1605	4	0.00165467	1654.67	4.43
11	12	239952	631	4	0.00065742	657.42	4.71
12	13	299968	1016	4	0.00084676	846.76	4.64
13	14	238944	265	4	0.00027726	277.26	4.95
14	15	113348	693	4	0.00152848	1528.48	4.46
15	16	216816	698	4	0.00080483	804.83	4.65
16	18	241968	1833	4	0.00189385	1893.85	4.39
17	19	251664	494	4	0.00049073	490.73	4.79
18	20	231696	849	4	0.00091607	916.07	4.61
19	21	235968	731	4	0.00077447	774.47	4.66

No	Date	Number of Production	Number of Defect	Potential CTQ	DPO	DPMO	Sigma Value
20	22	213696	597	4	0.00069842	698.42	4.69
21	23	223344	769	4	0.00086078	860.78	4.63
22	24	223584	366	4	0.00040924	409.24	4.84
23	25	320112	419	4	0.00032723	327.23	4.90
24	26	263848	1104	4	0.00104606	1046.06	4.57
25	27	289488	1652	4	0.00142666	1426.66	4.48
26	28	323088	1907	4	0.0014756	1475.60	4.47
27	29	309024	572	4	0.00046275	462.75	4.81
28	30	264720	192	4	0.00018132	181.32	5.06
Total		**6577804**	**29242**	**4**	**0.00111139**	**1111.39**	**4.55**

(Source: Analysis)

Note**:** *Sigma* value taken is the nearest value from the Sigma Value Conversion Table.

From the calculation in Table 3 we conclude that packaging process for 240ml Cup at PT. Pusaka Kali Agung have good capability. Using DPMO value of 1111.39 and capability of 4.55 sigma as performance base line to a six sigma project could be set toward zero defects. With current capabilities, PT. Pusaka Kali Agung is comparable to US average industries capabilities (2002) of 4 sigma. Therefore, this company must improve its capability to reach sigma level 5 to 6 to be in average capabilities of world class' industries.

Based on table 3, we made DPMO and Sigma capabilities graphic shown in Figure 8 & 9.

FIGURE 8: DPMO PATTERN

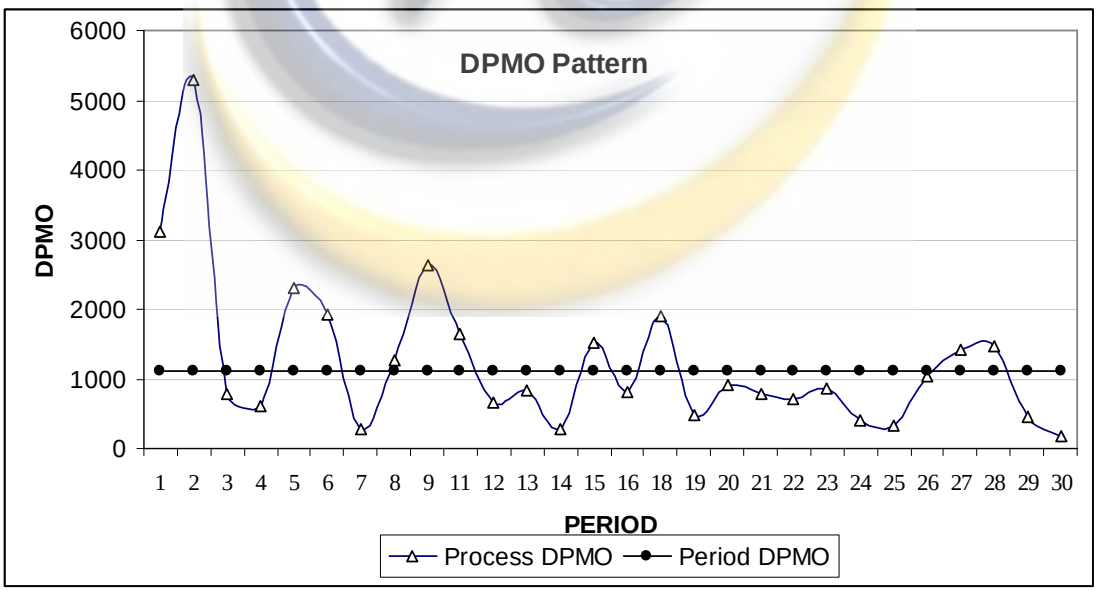
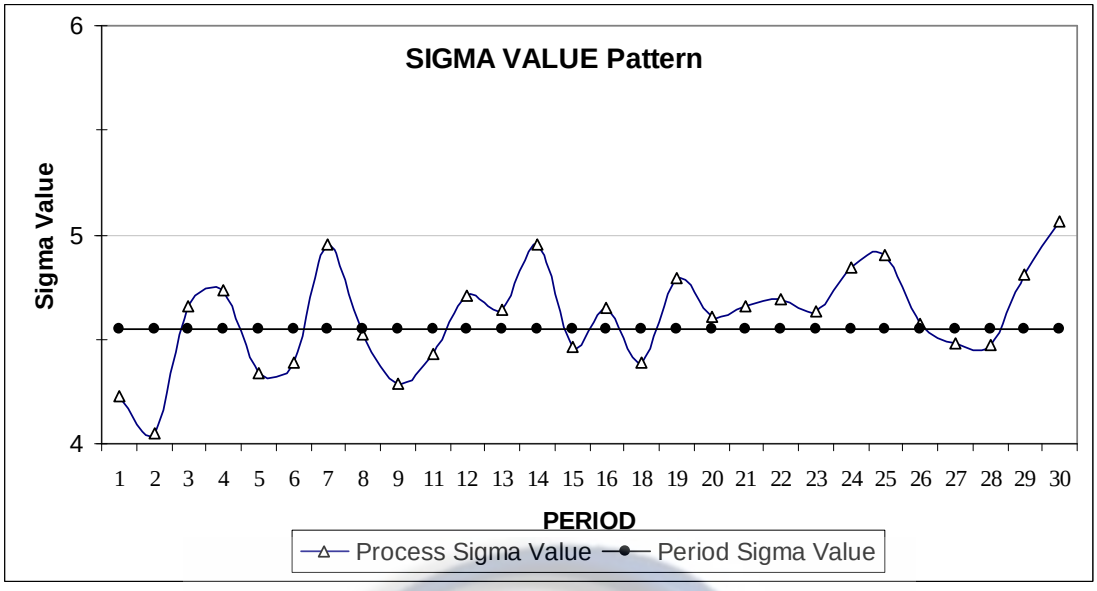


FIGURE 9: SIGMA CAPABILITIES PATTERN



(Source: analysis)

As shown in Figure 8 and 9, we derived that the DPMO and Sigma from the packaging process of 240 ml cup is fluctuate during production period. It means that the packaging process was not properly conducted. Sigma level should be have a tendency to increase if the company doing continuous improvement. If the packaging process could be controlled then the DPMO pattern will decrease and sigma level pattern increase.

***Analyze* step**

At this stage, which factors that affect the most at the process is determined, so when it is improved, it will give dramatic improvement on the process. Steps conducted in this stage is made Cause Effect/Fishbone Diagram to show main factors in more detail which are affecting quality and have impact to the problem studied.

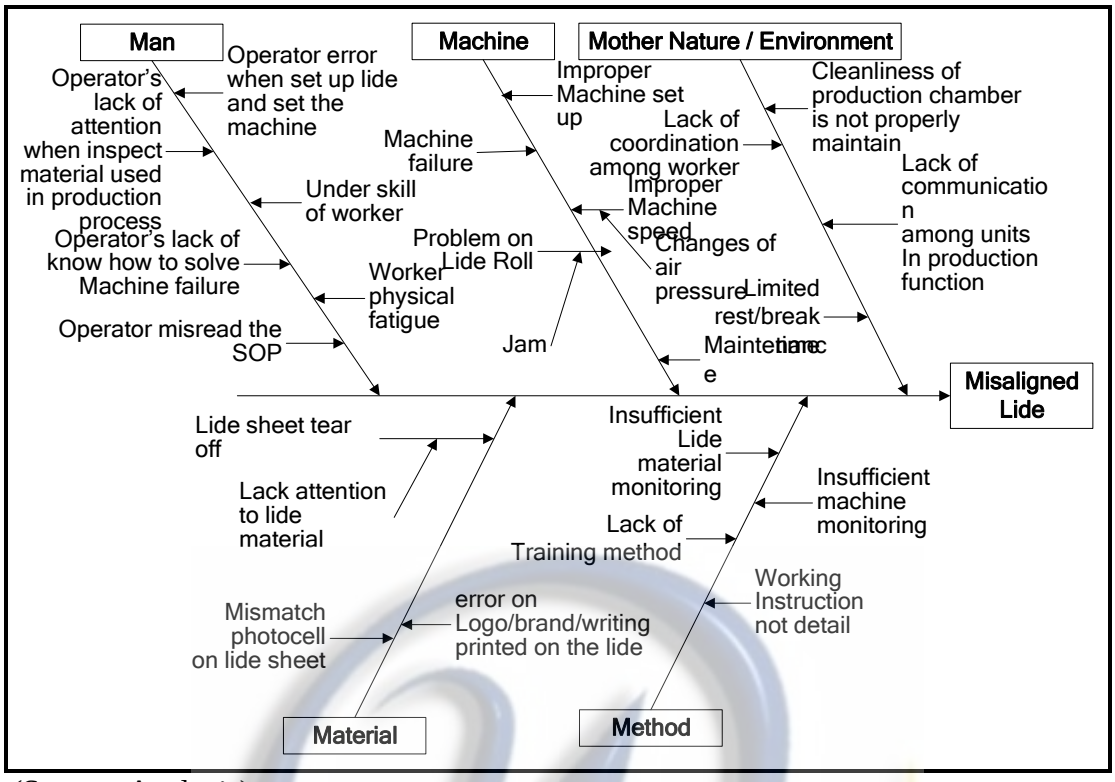
We made fishbone diagram (Figure 10) to show factors affecting the packaging process of 240 ml cup which cause misaligned lide base on finding during the study.

***Improve* step**

In this stage ideas are discussed to improve the system based on previous analysis and made an improvement concept. Make experiment to monitor results and new SOP (*standard operating procedure*) if the result is good

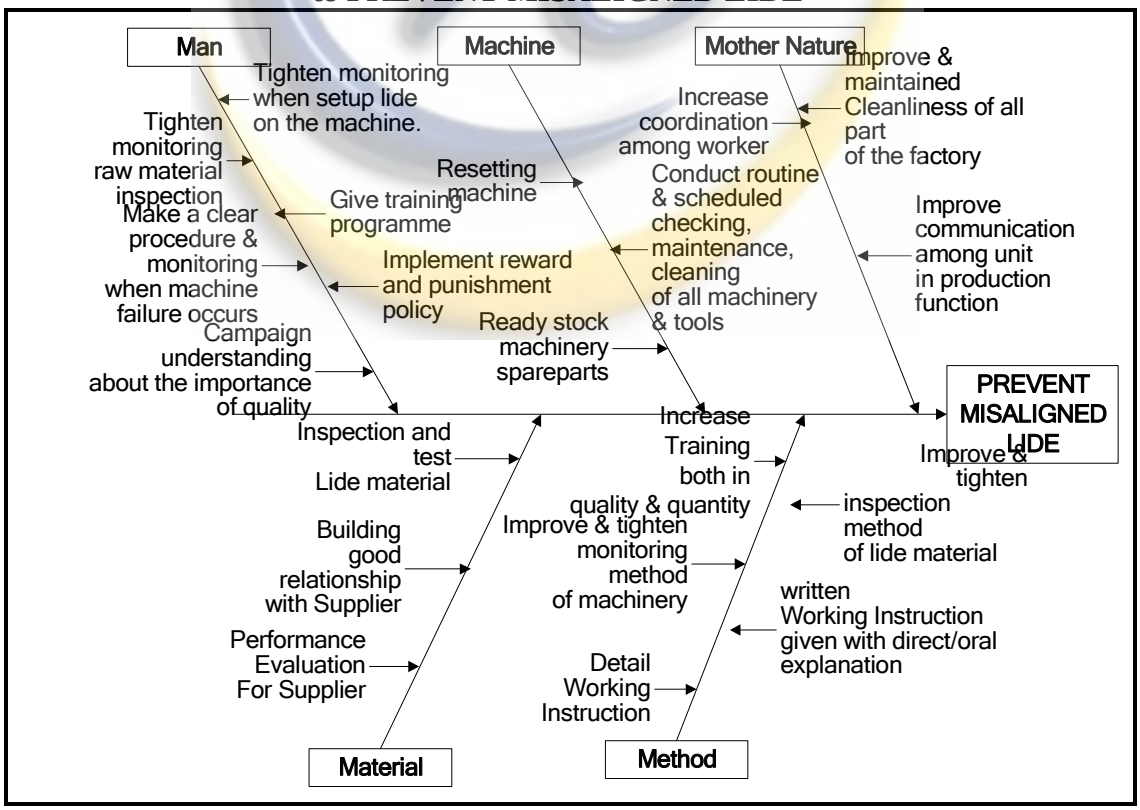
1. Improvement to Man, Material, Method, Machine, and Environment
   Based on the result from *Analyze* step, an improvement concept is proposed. In this proposal we made improvement to factors known as 5M to reduce misaligned lide defects in order to increase its sigma capability.
2. Make *SOP (Standard Operating Procedure)*
   A new SOP was proposed based on interview with the quality control department and observations during the study is shown in Table 4.

FIGURE 10: FISHBONE DIAGRAM of MISALIGNED LIDE



(Source: Analysis)

FIGURE 11: FISHBONE DIAGRAM of IMPROVEMENT to PREVENT MISALIGNED LIDE



(Source: Analysis)

TABLE 4: SOP for PACKAGING 240 ml CUP

No.	PROCEDURE
1	1. Set and line up empty cup on the rack 2. Put lide sheet on the machine 3. Set the lide so it will be dropped exactly above the cup 4. Monitor to prevent variations.
2	1. Fill the filling machine reservoir 2. Set the filling volume according to the cup used 3. Monitor to prevent variations.
3	1. Give production code and expire date using inkjet to the cup 2. Monitor this process to prevent variations.
4	1. Start automatic *heating* process with heat standard of 200^0C – 230^0C. 2. Monitor this process to prevent variations.
5	1. Start cutting process with automatic cutting machine 2. Monitor this process to prevent variations.
6	1. Pack manually cup into carton box, 48 cups each box 2. Monitor this process. If defect found (leak cup or misaligned lide) separate it to be dispose later
7	1. Give production code and expire date to the carton box 2. Seal the carton box using seal tape.
8	1. Take sample of production to be sent to the Lab for Laboratorial test for quality control and make sure the products meet the company requirement and SNI (National Standard of Indonesia)

(Source: Analysis)

CONCLUSION AND DISCUSSION

Implementation of quality control in PT. Pusaka Kali Agung is good still can be improve because there was still a number of defect occurs. Quality control in packaging process has been set to comply to government regulation. In order to maintain quality of its product the company implement quality control activities in 3 stages : quality control to raw material, quality control to the production process and quality control to product packaging.

Based on observation during the study the company still facing problem in packaging process activity involving factors : material, man, machine, method and environment.

Using six sigma method (DMAI) to we have result as follows:

In ***Define*** step the dominant cause of defect is determined to be *misaligned lide*. It contribute of **49.42%** of total defects. While other type of defects result are *leak during production* **47.92%,** *post production replacement* **1.97%** and *carton box leak* **0.69%**. From ***Measure*** step we find that product packaging process of cup 240ml in the period of study has **DPMO** value of **1111.39** and *sigma* sigma capability of **4.55 *sigma,*** which shows that the company's performance has reach US industry average (2002) of 4 sigma. However, it also show that its DPMO value is fluctuate and not stable. Base on ***Analyze*** step result, we find that factors cause the *misaligned lide* defect are combination of human, material, machine, method and environment factors. In the ***Improve*** step we proposed an improvement concept to those factors.

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