



# Application of Kaizen Concept with 8 Steps PDCA to Reduce in Line Defect at Pasting Process: A Case Study in Automotive Battery

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## ABSTRACT

Nowadays in very tight competition age, minimization of defect rate is targeted at all manufacturing production lines including in the process of automotive battery production. The purpose of this study was to reduce the dominant defect rate in the pasting process with Kaizen approach through 8 PDCA cycles. Kaizen implementation involves all parties in the company both management and employees in order to obtain optimal results. The eight cycles performed on Kaizen implementation are (i) Determination of theme, (ii) Targeting, (iii) Analysis of current conditions and problem-causing analysis, (iv) Root cause analysis of the problem, (v) Improvement plan, (vi) Implementation of the improvement, (vii) Evaluate the results, (viii) Standardization. Before Kaizen applied defect rate in the production process automotive batteries of 2.47% with the largest type of defect is plate scrap on the pasting process with a ratio of 2.45%. Kaizen implementation through 8 PDCA cycles implemented during 6 months managed to lower the defect rate to 1.52% or 0.08% better than the target set by the company of 1.60%. Improvements made due to jamming plate interference contributed to a 38 percent reduction in scrap plate in the pasting process.

**Key Words:** Automotive battery, Continuous improvement, Defect, Kaizen, PDCA.

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## 1. INTRODUCTION

Nowadays the industrial sector has an important role in determining the competitiveness of nations in the world. The growth of small, medium and large industries both private companies and state corporation will be one of the supporting in advancing the nation, this is because only companies that have a high competitiveness and smart to take advantage of opportunities that can survive in the globalization era. Currently the quality is one aspect that determines the success of a company because quality is the added value of the product produced by the company, to get a competitive product in the market one of the efforts made by the company is to minimize the defect level at the time of production. Defect is an event where a product or service fails to meet the requirements desired by the customer. This is due to the high competition and the ability of cosmic appraisal of product quality, product quality, and price.

PT XYZ is a manufacturing company in the automotive field which is famous for producing motor and car batteries, until now company already exporting automotive battery product around to 58 countries and 5 continents, while in domestic market the product leading with 40% of market share. as one of the companies that have long been engaged in the Indonesian automotive manufacturing industry which is very prioritize the quality of each product it releases and illustrated in the quality policy of company. In addition to intense competition, lately the company has faced the problem of the high number of scrap in the last 2 years, the increasing trend of scrap figures in the last 2 years.

In the last 2 years there is an increase in the number scrap on the company in the production process. The scrap plates became the largest contributor to the scrap rate 2.45% for plate scrap. This certainly becomes a serious problem because the plate is composed of lead material which is the main component and the most expensive component in the manufacture of batteries so as to potentially cause a decrease in battery quality if the plate scrap passes to the customer, decreased quality and productivity in the next process due to having to wait plate that made again because of scrap, other thing is big enough money value at plate scrap. Corrective actions taken to reduce scrap at previous only limited to addressing the problems that resulted in plate scrap, especially in the pasting area, problem solving is still done by the owner of the area, continued in next year corrective action taken to reduce scrap start involves MDT (Multi-Disciplinary Team) by meeting once a month in a monthly quality meeting to discuss the existing scrap problems, where each area should display the number of scrap every month and speak with team to reduce the number of

scrap. However, from the activities undertaken to reduce the scrap figures it is seen that the action is still not effective because the problem has not found the root of the problem and often the corrective actions performed are not standardized so that the existing activity usually only lasted no more than 1 month later return to the initial condition again.

To solve the problem one of the company's efforts to reduce the number of scrap is by using kaizen method in its production activities to improve every production activity undertaken and save the various expenses incurred in its production activities. Kaizen method is one of the proposed improvement work in accordance with the current company conditions to be implemented by focusing its activities on improving the work system and also the involvement of management to improve the quality of the resulting product. In this research we using kaizen method through Seven Tools and PDCA approach is expected to reduce the number of reject (non- conforming) which is still above 2% from the conforming tolerance limit specified by the department and company in the objective 3 years plan of company management.

## **2. LITERATURE REVIEW**

There are many definitions of quality but none of these definitions can meet with universal recognition. Definition quality as the ability to consistently meet the requirements of the customer [1]. Quality is difficult to define, since it means different thing to different people. On general definition is "degree of excellence" in order to clearly understand what is quality, it is necessary to put the view of some authors to concerning the meaning of quality, this is as the total product and service characteristics of marketing tools, manufacturing tools, engineering tools and maintenance tools through which the product and service in use will meet the expectations of the customer [2]. It is also content that the better quality would lead to the retention of existing customers and in attracting new customers, which in-turn would increase market share of product [3]. One of the quality definition is the degree to make a specific product conform to design or specification [4]. Quality is often the major issue in the market because if we make product with poor quality can be very expensive for both the producing firm and the customer. It is therefore, imperative for every operation manager to ensure that this or her firm to deliver a quality product at the right place, at the right time, and at the right price. Quality is seen as all characteristic and features of a product or service that contributes to the satisfaction of a customer needs [5]. These needs involved a price, safety, available, maintainability, reliability and usability.

Based on our research, in recent years we found that many literature has extensively documented the implementation of lean tools into various manufacturing sectors. Improving quality and productivity to gain a competitive advantage has always been a major issue for most manufacturing industry. Kaizen is a one of quality tools to improving quality and productivity, kaizen is a continuous improvement process which involving everyone, managers and workers alike [6]. Variables that are used to measure the impact of kaizen activities in organization as on human resource, variables include with attitude toward Kaizen events, skills gained from event participation, understanding the need for Kaizen, impact of these events on employee, impact of these events on the work area, and the overall impression of the relative successfulness of these events [7]. If we go back to recent year, we can see that the kaizen philosophy at first adopted in several Japanese businesses after the World War II for improvement of quality and productivity [8]. In the many literature we can see that kaizen is often done for small group activity such as quality circles and/or suggestions made by individual workers on an activity which is used to solve the problem [9]. The concept called kaizen is internationally acknowledged as a solid strategic instrument which allows the enhancement of productivity, quality, efficiency and safety [10]. Kaizen is an underlying principle of lean techniques which have boosted Toyota to the world's number one car maker. Inspired by Japan's success in all sectors especially in manufacturing, many organizations around the world have adopted kaizen philosophy as a way to improve production values while also improving employee morale and safety [11].

Nowadays in the era of competitive market and globalization, the concept and philosophy of quality has emerged as a strategic issue at all levels of the organization and in all industries and services [12]. In the 1960s, Quality Control Circle introduced by kaoru ishikawa in japan, Quality Control Circle is a group of employees consisting of four to twelve employees who come from the same place or work field within the company who voluntarily gather to identify, analyze and solve various problems related to their work and apply them in the company's operational activities. Effective way to apply Quality Control Circle is by using seven tools, this tools used for data processing as well as looking at factors causing product defects. Seven Tools is very easy but effective to use as an improvement tool or graphical problem solving method that generally helps the process between design and delivery process [13]. PDCA Cycle suggests that once the action is planned they must do the plan and then examine and take action based on the results and in addition PDCA has a positive effect on the worker's learning [14].

## **3. MATERIALS AND METHODS**

In this research used descriptive exploratory research type, where in this type of research is on gathering ideas and inputs, especially inputs that are to solve the problem, both widespread or widened and vague problems become focused. The implementation of the PDCA cycle has been found more effective than adopting "the right first time" strategy. Execution of the PDCA cycle means continuously looking for better effects on improvement [15]. This research is about how effectiveness of Kaizen implementation using PDCA concept (Plan, Do, Check, Action) to decrease defect that happened during production process in pasting process.

Data collection methods used in conducting this study using primary data and secondary data. Primary data obtained directly from the object under study to find out the actual events by way of interviewing with the operator, group leader, sub section head and

section head directly in the field. Secondary data in this study compiled in the form of data maintenance activities and data history records in the form of document records damage to the machine on the company as well as from books and other library sources that support the discussion in this study. These data, among others, (i) company production data, (ii) scrap data of production, machine and process specifications.

The population of this research is all the recording data of pasting machine production, while the samples taken in this research is the production record during the period of January 2014 until December 2016. Data processing that has been obtained is analyzed descriptively and explorative that is by arranging data then interpreted and analyzed so as to provide information for problem solving faced qualitatively and quantitatively in accordance with goal that will be achieved that is to answer formulation problem about critical failure that cause scrap at pasting process. Stages of Kaizen implementation conducted in this research are, (i) Determination of theme, (ii) Targeting, (iii) Analysis of current conditions and problem-causing analysis, (iv) Root cause analysis of the problem, (v) Improvement plan, (vi) Implementation of the improvement, (vii) Evaluate the results, (viii) Standardization.

#### 4. RESULT AND DISCUSSION

The first step of kaizen is to apply the PDCA cycle (plan, do, check, action) as a means of ensuring the continuity of kaizen. This is useful in realizing policies to maintain and improve or improve standards. This cycle is the most important concept of the kaizen process (Imai, 2005). There are 8 steps to make this improvement as below,

##### 4.1. Theme Determination

In Figure 1 presented the Pareto of defect rate in company. Before improvement, the scrap rate in the last 2 years has increased especially on plate scrap in the year amounted to 2.47% or 0.65% higher than the scrap target of 1.82%. In figure 1 we can see that the scrap contributor which resulted in the high rate of scrap rate.

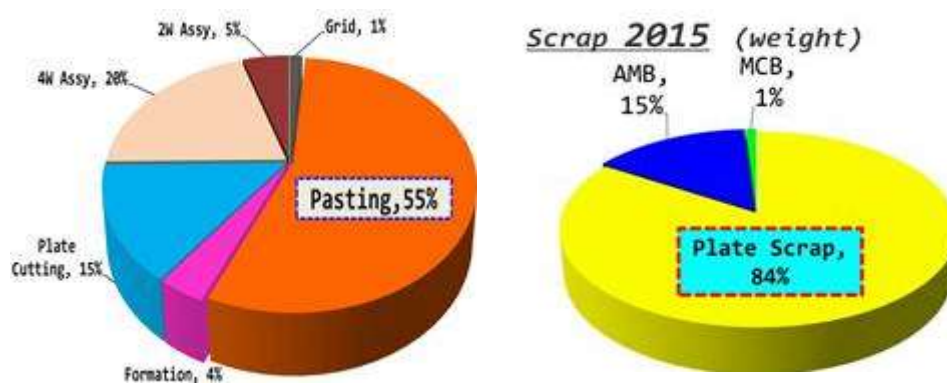


Figure 1. Pareto Scrap Plate (Weight) Before Improvement

In figure 1, we can shown that the scrap plate is the largest contributor scrap rate with 84% of the total scrap, then followed by battery claim of Automotive Battery by 15% and battery claim from Motorcycle Battery by 1%. From above pareto it is seen that 55% plate scrap comes from pasting process and is the biggest scrap compared to other process, then in another process. So the total 46.2% scrap plate comes from the pasting process. Based on the above data it can be seen that the source of the high scrap rate problem before improvement comes from the scrap plate from the pasting process, so it is decided to do the kaizen processed pasting by reduce the plate scrap to reach the scrap target.

Pasting process is the process of sticking paste into the grid in accordance with the desired thick and heavy specifications. Pasting process it self consists of several stages of the process, flow process pasting process starts from the grid into the feeder then transferred into the hopper for the process of sticking the paste into the grid then transferred through the PVC screw and into the oven to remove the water content on the plate where the end result will be unformed plate. Based on the results of the pasting record defect control sheet in pasting process, we can make a pareto to determine the cause of the high number of scrap plate is processed in pasting area.

From the above data it can be seen that the source of the problem that resulted in high scrap ratio before improvement is plate scrap who is main source comes from the pasting process, so it is decided to take the theme "Application of Kaizen Concept with 8 Steps PDCA to Reduce in Line Defect at Pasting Process". The reasons for take this theme are, (i) in accordance with policy management, (ii) is the highest Pareto of the cause of the increase in scrap rate before improvement, (iii) capability and agreement of multi disciplinary team.

##### 4.2. Target Determination

The theme which take for this Kaizen is "Application of Kaizen with Step 8 PDCA Steps to Reduce In Line Defect In Pasting Process". The target to be achieved by reducing the in line defect on pasting process, to make this target should be follow the smart motto (specific, measurable, achievable, reasonable and time based).

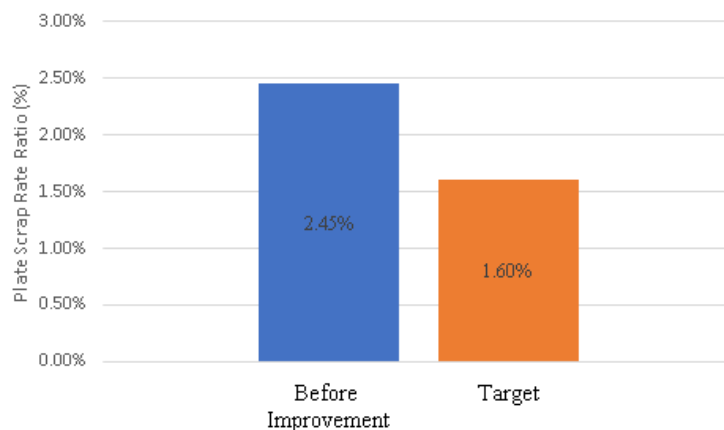


Figure 2. Plate Scrap Target in Pasting Process

From the figure above it can be seen that to achieve the quality improvement plan for 3 years, in targeting the pasting process should be able to reduce the amount of plate scrap produced by 35% it is necessary to achieve the target ratio scrap weight which is equal to 1.60%. The reasons for this targeting are, (i) in accordance with policy management and group management, (ii) it is the highest Pareto of the cause of the increase in scrap rate before improvement, (iii) members ability and agreement to reduce scrap plate minimum 40%, (iv) to achieve the company target in 3 years plan, (v) to get the competitive product in automotive battery market in overseas and domestic.

4.3. Analysis of Current Conditions and Analysis of Problem Causes

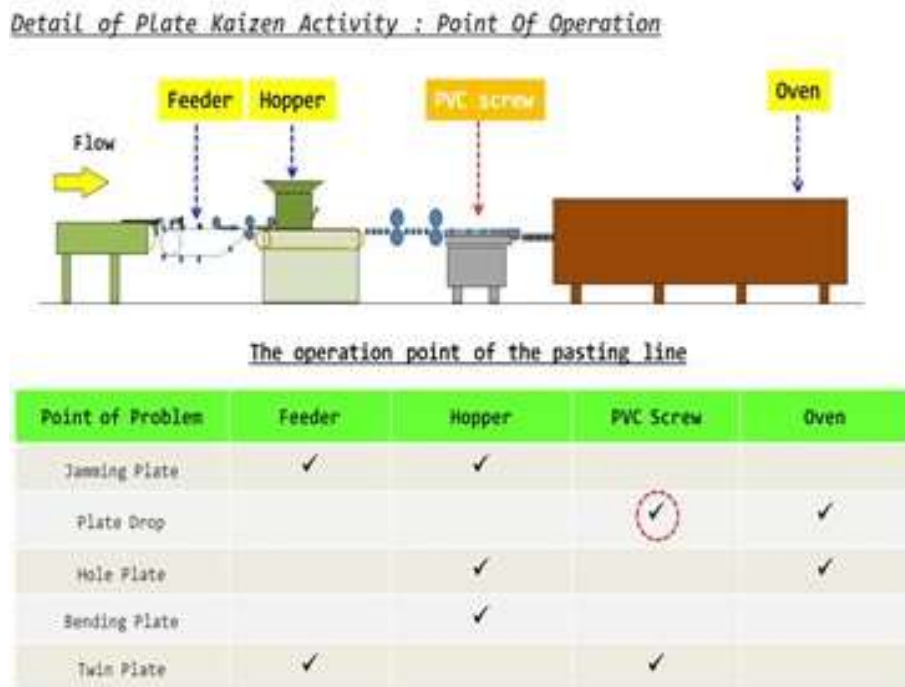
Pasting process is the process of sticking paste into the grid in accordance with the desired plate thickness and plate weight specifications. There are two critical quality in pasting process, (i) paste weight, (ii) visual appearance of plate. In pasting process paste weight controlled by statistical process control to get the good product and for visual appearance now controlled by visual 100% based on visual standard in every line pasting.



Figure 3. Detail Scrap at Pasting Process

Based on the results of analysis, the causes of scrap in the pasting process by doing observations before pasting process to know the effect of hardness of grid to scrap in pasting process, after that observation during running pasting process to know what is potential problem in pasting process. Interviews with some operators, group leader, sub section head and section head at pasting process is needed to know the real cause of problem.

We found there are five main causes of scrap on the plate in pasting process, (i) jamming plate which happened in feeder and hopper process, (ii) plate drop which happened in pvc screw after hopper machine, (iii) plate hole which happened in hopper machine and oven machine, (iv) bending plate which happened in hopper machine, (v) twin plate which happened in feeder and pvc screw.



**Figure 4. Detail of Current Condition of Problem**

**4.4. Root Cause Analysis**

To find out the root cause of the problem in pasting process which resulted plate scrap is used some of analytical tools to know the main cause of problem. Why-Why Analysis method used to find the root cause of the problems to be solved by the team. This method is used because at previous the problem always unresolved, one of analysis why this problem happened again after make some improvement because of the main cause problem in pasting process is unresolved until the root and improvement-improvement which already maked to solve the problem not standardized by improvement team.

There are two problems in the pasting process which resulted in an increase in scrap rate before improvement is jamming plate that occurs in the feeder process stage and the process hopper and plate drop that occurs in the stage of pvc screw process or transfer from roll to flash drying oven. The main causes of scrap in pasting process after we make some analysis and observation because of jamming plate before attached paste to grid in hopper machine, many of plate jamming to roll feeder and make some defect plate which can not be used again or should be scrap. To solved this problem why-why analysis is one of the right analytical tools, this method need some information from multi disciplinary team which have some knowledge and experience in pasting process to make some brainstorming to get some possible causes of the problem untill find out the root cause of the problem



### Why-Why Analysis

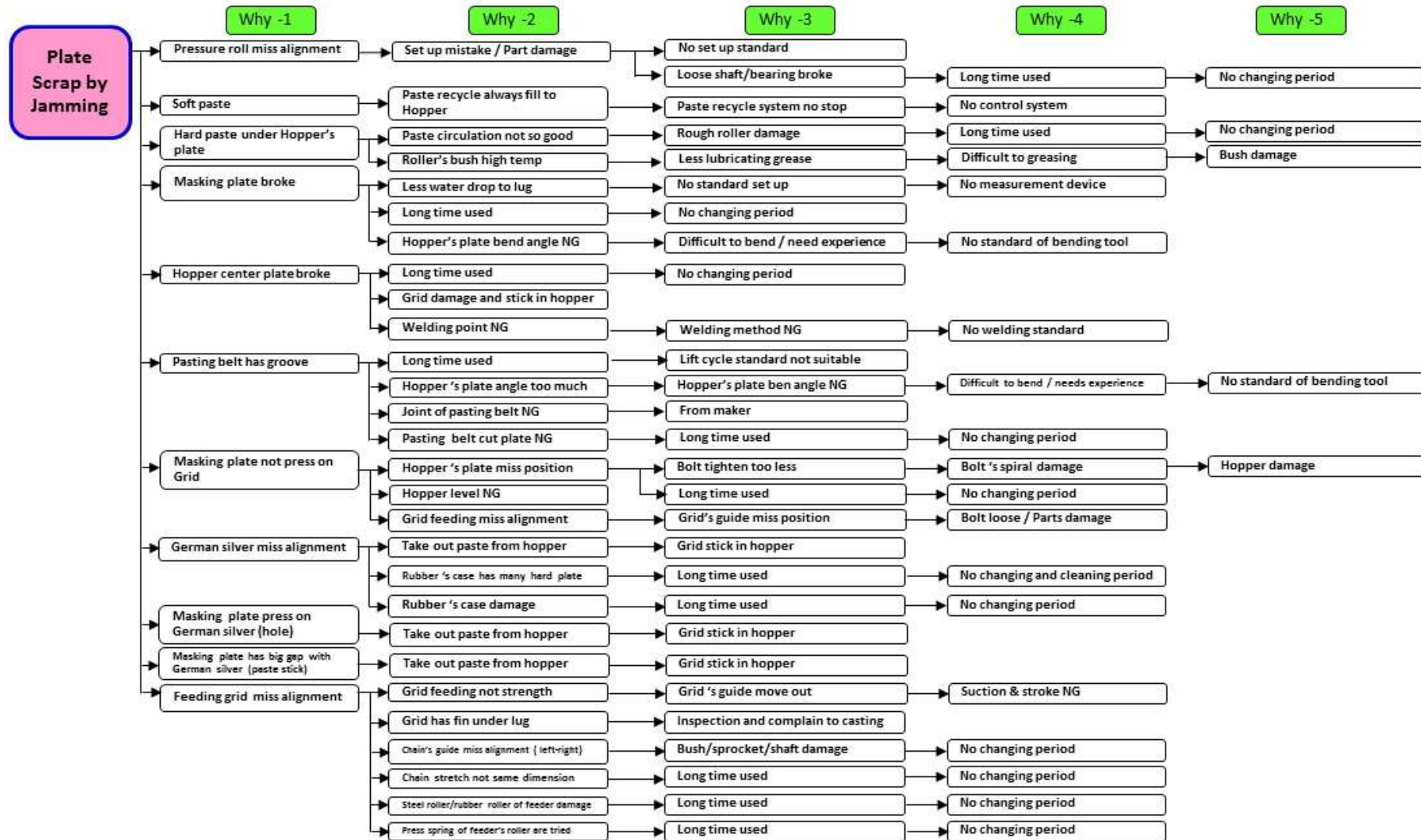
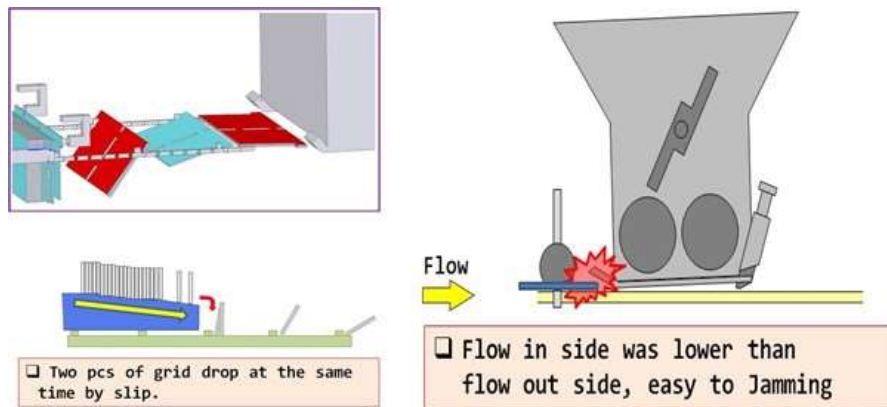


Figure 5. Why-Why Analysis for Jamming Plate Problem in Pasting Process

Jamming plate problems occurs in two stages of the process that is at the time in the feeder and hopper. The jamming plate in the feeder occurs when the grid to be lifted by the vacuum method lifts and falls together due to slip so that the grid becomes stuck and causes damage to the grid that contributes to plate scrap, one of problem is distance between rail to rail is not same.



**Figure 6. Jamming Plate in Feeder and Hopper**

While the jamming plate that occurs in the hopper occurs when the grid has been removed by the method of vacuum hit the trower roll on the front of the hopper because of too small a hopper gap that will be entered by the grid material resulting in causing damage to the grid that contributes to plate scrap this can be seen on the picture above.

#### 4.5. Improvement Plan

Before we make some action to solve this problem first step to action we should be consider about planning, fo an improvement plan for this problem, development planning for kaizen activity schedule to reduce in line defect in pasting process can be seen in table 1,

**Table 1 Kaizen Activity Plan**

DEVELOPMENT PLANNING											ISSUED DATE	REV. DATE															
Title : Reduce Plate Scrap at Pasting Process											05/05/17	05 Mei 2017															
											Page: 1 of 1																
No	DESCRIPTION	PLAN ACT	May-17		Jun-17		Jul-17		Aug-17		Sep-17		Oct-17		Nov-17		Dec-17		PIC	REMARKS							
			I	E	B	N	I	E	B	N	I	E	B	N	I	E	B	N			I	E	B	N	I	E	B
1	Determination of Theme	PLAN																		Team	Reduce Plate Drop at Pasting Process						
		ACT																									
2	Determination of Target	PLAN																		Team	Reduce 30% Plate Scrap						
		ACT																									
3	Analysis of Current Conditions	PLAN																		Team							
		ACT																									
4	Root Cause Analysis Problem	PLAN																		Team							
		ACT																									
5	Improvement Plan	PLAN																		Team							
		ACT																									
6	Implementation of Improvement	PLAN																		Team							
		ACT																									
7	Evaluate The Result	PLAN																		Team	Evaluate every month						
		ACT																									
8	Standardization	PLAN																		Team							
		ACT																									

In total there are 8 steps of improvement plan that will be done related to this problem. To determine the 6 priority improvement plan used 5W 2H method with the cost considerations as cheap as possible for the implementation of corrective action.

All activity to see the detail improvement plan priority can be seen in table 2, from this table we can see that there are 6 priority to make some improvement in pasting process, 3 of which come from the machine factor which cost around US \$308, 2 derived from the method factor which no cost for this improvement and 1 comes from the human factor which no cost from this improvement.

Table 2 Improvement Plan Priority

No	Factor	What	Why	How & How Much	Where
1	Machine	Plate Drop because of Slip when transfer process in pasting feeder	Prevent plate not drop during transfer from feeder to hopper	Trial to modification rail and add point check PM Cost for modification rail @Rp. 1.000.000/machine x 4 = 4.000.000	Feeder Pasting Line 1~4
2	Machine	Plate hit trower roll	Prevent plate not hit trower roll	Standardization machine and additional point check verification using Jig Cost : -	Hopper Pasting Line 1~4
3	Machine	Plate drop because of gap between paster machine with PVC screw	No gap between paster machine and PVC screw	Change part which broken with the new one and standardization again	Pasting Line 1~4
4	Methode	Plate can't flow straight because of roller diameter changed due to long usage	Plate flow with straight and not changeable as well can be standarization roller life time	Changing roller in PVC screw qith adjust roller position in one direction Make a rule for maintenance to changing roller Cost : -	PVC Screw Pasting 1~4
5	Methode	Plate can't flow straight because of no rule for roller position	The existence of rules for roller position	Make standardization for roller position in PVC screw Cost : -	PVC Screw Pasting 1~4
6	Man	Awereness regarding maintenance machine by production operator	Increase awereness of production operator to machine	Trainee about autonomus maintenance as daily check and some item about maintenance machine	Training Room/each loacation

4.6. Implementation of Improvement

The implementation of the improvement begins with the priority set (using the 5W 1H method) which is the improvement that comes from machines, methods and humans. Of the 6 priority improvement plan, the most dominant improvement comes from the machine as much as 4 items, followed by the method as much as 2 items and then humans as much as 1 item as in the explanation below, (i) Plate is jammed due to slip.

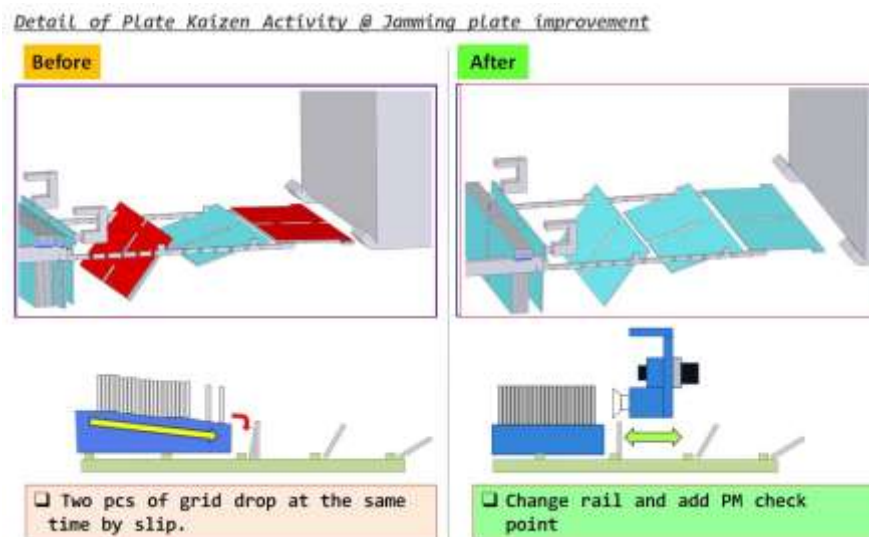


Figure 7. Improvement of Jammed Platen Because of Slip

Before improvement during the process of appointment to the grid from the feeder to the hopper is often 2 pcs grid down at the same time due to slip where one of them due to the decreasing rail design, the grid effect becomes stuck and resulted in damage to the grid being scrap plate.

After the repair by replacing the rails in the feeder and adding point check in the feeder there is a decrease in the processed defect because of the absence of slip plate. The cost to make improvements on the implementation of this improvement is US \$308 to replace the rails in 4 pasting machines that exist or more precisely more specifically on the feeder machine. (i) Plate is jammed because it hit the trower roll in the hopper machine



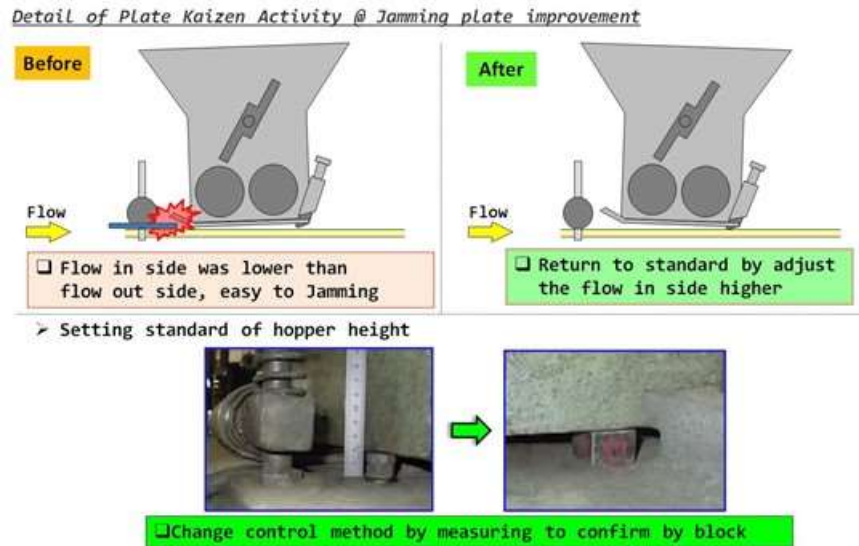


Figure 8. Improvement of Jammed Plate because hit the trower roll

Before the plate repair occurs in the hopper occurs when the grid that has been lifted by the vacuum method hit the trower roll on the front of the hopper due to too small a hopper gap that will be entered by the grid material resulting in grid damage that contributes to plate scrap. After repair by returning the hopper position to the standard with adjust flow on the side of the hopper to be balanced and as a repetitive precautionary measure, for the gap measurement method of the trower roll to the conveyor base is used jig go nogo in accordance with predefined slit design standards.

There is no cost in this improvement due to our method has a workshop to make the jig go nogo and measurements can be made by existing operators on the production floor either during initial start up products or during preventive machines or on daily maintenance controls.

There is no cost at this point of improvement due to the availability of spare parts of the damaged part.

#### 4.7. Evaluation of Results

Based on the results of kaizen implementation to reduce the number of scrap plate, in the pasting process we can see that the effect of the improvements made in it's enough to provide significant results on the decrease in scrap plate as shown in the Figure 9.

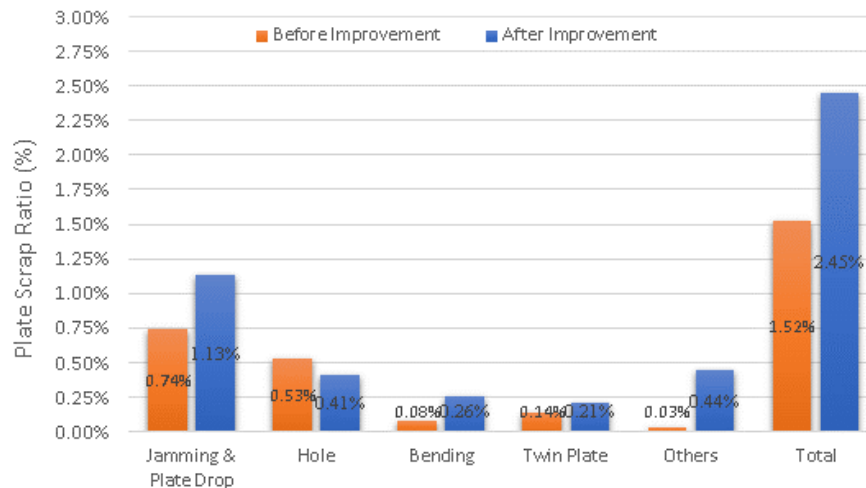


Figure 9. Pareto of Scrap Plate After Improvement

From the graph above shows that the number of plate scrap in 2016 amounted to 1.52% or 0.08% lower than the target of 1.60% whereas when compared with scrap figures in 2015 reached 2.45% means that the steps that have been done improvements, especially by reducing scrap plate due to defect jamming plate and plate drop that dominantly contribute scrap plate in pasting, and this is able to reduce scrap plate of 37.65% in pasting process and from this result many advantages obtained by company either directly or indirectly. Further examination of the results of such improvements and if declared effective, then made standard so that the whole process is done as expected [17].

As for the benefits derived from the decrease of scrap plate, among others, (i) Increased Productivity, (ii) Increased production volume, (iii) Decrease In Process Defect, (iv) Downtime machine, (v) Increased operator awareness level on engine quality and condition, (vi) Improving the quality of products produced, (vii) Improve the safety and morale of workers. The above advantages can be the basis for the implementation of Kaizen in other process stages of battery manufacture and are not only centered on the pasting process but in all stages of battery manufacturing processes.

#### 4.8. Standardization

The success of Japanese companies in improving productivity and quality is because they have a culture and a high work ethic to the application of KAIZEN management system. One such application is the Cultural 5S (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) [16]. Based on above data and after getting good results from the implementation of Kaizen in the pasting process, the next step is to keep the set targets achieved, one of them is to standardize all. The repair activities that have been done, among others, as seen in some pictures in below this,

##### 1. Standardization of Gap from lower roller and Gap Position Chain

The first standardized operating point is a gap on the lower roller and feed roller on the side plate, the gap of the lower roll and the side plate should be kept so that the distance remains zero so as to reduce defects in the feeder process. The second operation point is the standardization of the right and left chain gaps should be maintained in 3 mm.

##### 2. Checking Hopper Height and Checking When Hopper Exchanged

The third operation point is a periodic check of the hopper height as shown in the figure below, periodic refinement of the height of the hopper is intended to avoid defects that occur due to uneven gap between the front of the hopper and the hopper rear is the grid that hit the trower roll resulting in the occurrence of scrap plate. The fourth operation point is checking in parallel when a hopper turn occurs.

##### 3. Standardization Flatness of Pasting Belt

The fifth point of operation is the standardization of the flatness of the pasting belt which must be adjusted according to its level level. Standard pasting belt flatness is intended for the surface level of the hopper with a flat screw conveyor and minimize the potential for plate plunging due to uneven surface pasting belt on the hopper.

All activity for standardization in this case can be seen on Figure 10.

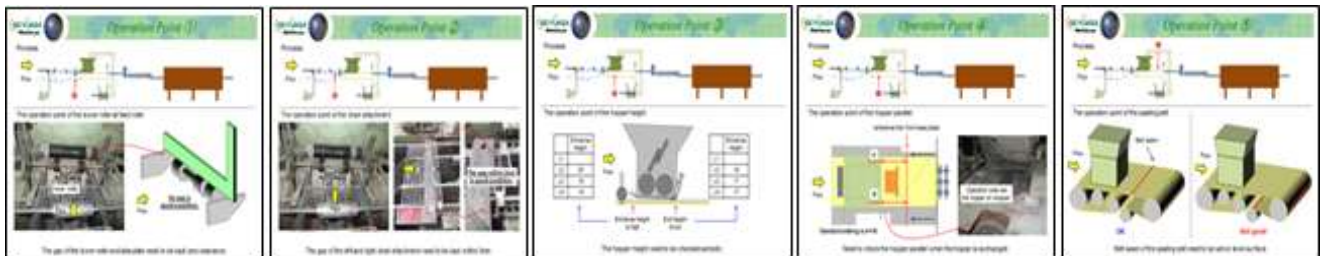


Figure 10. Standardization Activity

Kaizen activity will continue in all process automotive battery, continuous improvement urgent to needed to achieve the target company in 3 years plan to reduce scrap rate under 1%.

## 5. CONCLUSION

Based on the case study in automotive battery it has been concluded that implementation of Kaizen through the steps 8 PDCA are very useful and effective in identifying and removal of defects from the manufacturing process. This paper presents the systematic approach to find the root cause of one of the major defect (jamming plate). Based on the results and discussions regarding the implementation of Kaizen through the steps 8 PDCA to reduce in line defect at pasting process, by applying this method company can reduce plate scrap equal to 38% compared with plate scrap rate after improvement and company is able to achieve the plate scrap target. After achieved this objective Company will further explore how to maintain and care for pasting machine through the implementation of total productive maintenance to maintain and improve the improvement that has been done and will continue the kaizen activity where not only in process pasting but also in all stages of battery manufacturing process such as formation, plate cutting, assembly, wet charging and finish good warehouse.

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