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Analysis of spoilage change over improvements on decorator machines with quality control groups (Pareto and fishbone diagrams)

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Abstract: Every company, including PT, has goals they'd like to accomplish. One of the businesses in the two-piece can sector is CPC. Up until now, PT's goal has been to switch products. The CPC is still not fulfilled; specifically, from January 2022 to May 2023, the product replacement time is still 42 minutes, resulting in the waste of 1043 cans, although the objective was set at 30 minutes for the replacement of the product and 800 cans for spoiling (wasted cans). The current issue is that 800 cans are wasted, and the goal product replacement time is 30 minutes. A quality control group was employed in this study's methodology (Pareto and fishbone diagrams). The primary goal of this study is to identify the underlying cause of the 42-minute product replacement time and the wasted 1043 cans. The analysis's findings demonstrated that the issue of resetting the plate is the one that frequently arises while switching out products. Several underlying causes of the reset plate issue were discovered after additional investigation, one of which was the unclear marking on the plate, which led to imprecise results when the plate was installed on the cylinder. Damages the can printing and necessitates a second plate installation, which wastes time and leads to spoilage. Consequently, a repair plan was created and put into action by changing the plate's markings to make installation easier to understand. This led to a quicker process of replacing the product (41 minutes before repair, 32 minutes after repair), as well as a decrease in the number of wasted cans (850 cans before repair, 828 cans after repair).

Keywords: Altered product; seven tools; quality control group; two-piece can

1. INTRODUCTION

PT. CPC is a manufacturing firm that works in the beverage can industry, or what is widely known as two-piece cans, and is situated in the Bogor region of Cileungsi. The company just manufactures drink cans, which it then gives to clients to fill. Only around 10% of PT. CPC's customers are from outside the country; the company exports to a number of nations, including Brunei, Malaysia, the Philippines, and Mauritius.

Figure 1. Decorator machine

The decorator machine shown in Figure 1 is used for applying can body printing [1]. One of the devices made by PT. CPC is the decorator machine, which uses ink to imprint a picture on the can's

body. The calculator used to determine the indicators generated by PT. CPC is the decorator machine. The process of altering the product or design is one of the many reasons, in addition to machine damage, that might cause the decorator machine to stop operating [2].

Printing plays a critical role in the business since buyers can observe the results immediately. It should come as no surprise that issues with the printing component account for the majority of damage [3] [4]. Numerous cans are wasted during the process of altering this product; these must be sacrificed in order to obtain the ideal settings [5]. Cans that are wasted increase in number as the procedure becomes more complex [6] [7]. Table 1 provides information on how many replacements are made each month, how long it takes on average to complete one replacement, and how many cans are wasted as a result.

Table 1. Data changes from January 2022 to May 2023.

Month	Number of Change Overs (CO)	Average Change Over Duration (minutes)	Average Spoilage Change Over (wasted cans)	% Spoilage	Production Output
Jan-22	35	45	1150	0.12%	34,894,719
Feb-22	30	37	1060	0.06%	52,174,644
Mar-22	26	45	1180	0.11%	53,130,024
Apr-22	40	37	1065	0.19%	29,035,872
May-22	20	38	900	0.04%	22,323,756
Jun-22	33	40	1009	0.08%	43,280,088
Jul-22	39	41	1104	0.10%	41,171,940
Aug-22	29	45	997	0.06%	44,839,788
Sep-22	28	38	1050	0.07%	44,682,354
Oct-22	31	45	995	0.08%	41,373,683
Nov-22	29	43	1005	0.09%	40,320,408
Dec-22	37	41	850	0.01%	31,841,040
Jan-23	35	42	1130	0.12%	39,682,724
Feb-23	27	36	1036	0.08%	35,412,445
Mar-23	31	45	1182	0.09%	40,483,794
Apr-23	23	48	1160	0.07%	28,742,202
May-23	37	41	850	0.10%	32,339,690
	530	42	1043		655,729,171

Table 1 shows the number of replacements performed each month, the average time needed to complete a replacement, and the amount of spoilage that occurs as a result. This information indicates that PT. CPC has a sizable product replacement procedure. The amount of time needed and the ensuing damage nevertheless differed from the 30-minute target with an 800-can spoilage that was set by management. The purpose of the study is to examine how a quality control group approach with seven tools and close attention to detail from the start of the process to the finish can improve the quality and efficiency of changing products on decorator machines. 1. Reducing product damage in the family partners' home industry in the East Lampung district is the research that has been conducted. The goal of this research is to determine the quantity of damaged products and the kind of damage based on the ranking of the number of incidents and factors causing product damage. 2. Quality improvement through the employment of a quality control group; the purpose of this study was to decrease the amount of plastic material wasted by printing defective items on the plastic packaging used for instant noodles.

The novelty of this study is the use of quality control groups (Pareto and fishbone diagrams) to assess spoilage change over repairs on decorator machines in order to identify the underlying cause of the issue of wasted cans and replacement times that have not reached factory standards.

2. METHOD

This method is the stages and steps involved conducting research, namely.

a) Preliminary study

To determine what issues arose during the product replacement process, preliminary investigations were conducted. These included a review of the relevant literature, data gathering, problem identification, and setting the goals of the study. In this pilot project, PT. CPC will also provide preliminary data on the number of wasted cans required and the time required for a single replacement. The study aims to collect 30 minutes for a single replacement and 800 wasted cans. Figure 2 the issues encountered throughout the product replacement process are evident from the preliminary research's findings [8].

b) Create a Pareto diagram.

To determine what factors-lead to issues that arise during the replacement process, a Pareto diagram is created.

c) Analysis of the root of the problem.

At this point, the goal is to identify the primary issues that prevent the target—resetting the plate—from being met. After identifying the primary cause of the issue—which serves as the first point of reference—we utilize information from the January–December 2022 product replacement procedure.

d) Make an improvement plan.

Right now, it serves the purpose of planning any enhancements required to meet the company's goals.

e) Carry out the work plan that has been made.

At this point, it serves the purpose of carrying out the prepared work plan and doing everything necessary to meet the company's goal, which is to replace 800 cans in 30 minutes or less. Return to the repair plan if this hasn't been accomplished, and move on to the next step if it has.

f) Carry out follow-up improvements and standardize.

This stage's job is to standardize the machine's settings when the repairs are appropriate or almost so, such as when the replacement takes 30 minutes and 800 cans are wasted, as determined by the corporation.

g) Conclusion and Suggestions.

At this point, its purpose is to draw conclusions and offer recommendations based on the issues that have arisen, the advancements made, and the conversations required to meet the goals established by the business—namely, a replacement time of 30 minutes and the waste of 800 cans.

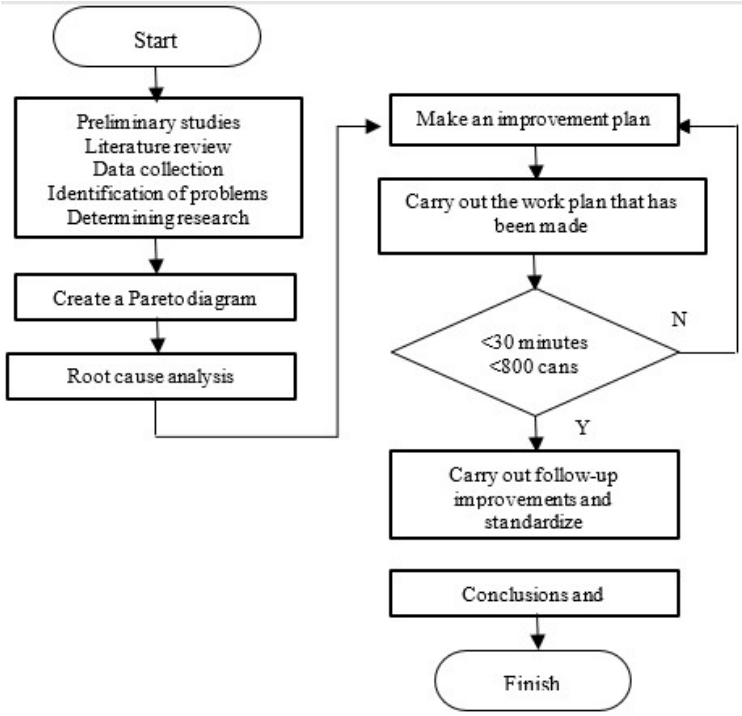

Figure 2. Research method flowchart

3. RESULTS AND DISCUSSION

Changes in the design of the product to be manufactured necessitate the adjustment of the decorator machine, which involves replacing the product [9]. The procedure of changing the cylinder plate involves first installing and positioning it correctly, then applying ink to the plate in the color that corresponds with the intended design to create a clean image and exact color matching the customer's sample [10].

Operator in charge of changing the cylinder plate. The old design's cylinder plate is taken out and swapped out for the new one that will be built. The quantity of colors in the pattern depends on how many cylinder plates are fitted. The "cylinder" plate's ink color needs to match the design to be created and can't contain any other colors. While the ink provides color, the cylinder plate serves as a print to provide an image on the can body.

The purpose of the setting procedure is to modify each cylinder plate's image position. In the meantime, getting pictures that are orderly and not jumbledly stacked on top of one another is the ultimate aim of this setting process.

Printing has a crucial role in the business since consumers can observe the results immediately [11]. It should come as no surprise that printing-related issues account for the majority of damage [12]. To obtain the ideal settings, a large number of wasted cans must be sacrificed during the product's modification process. The number of wasted cans increases with the number of changes made to the process [13]. Table 1 provides an introductory illustration by providing data on the number of replacements performed each month, the average time needed for one replacement, and the number of cans that are wasted as a result.

It is evident from the statistics in Table 2 that PT. CPC's changeover procedure is somewhat extensive. Both the amount of time needed and the harm that results still veer off course. Corrective action is therefore required in order to improve the transition process and make it consistent with the goals set out by the management of the firm.

Table 2. Changeover report for May 2023

Date	Shift/ Group	Design	Durasi CO (menit)	Spoilage co	Problem
1	1/B	Sundrop Ice Ceylon Tea	35	850	Matching Colour
	1/B	Sundrop Chrysanthemum	35	900	Reset Plate
	1/B	Sundrop Orange	35	1,000	Void Pressure
	2/C	Fruit Tea Blackcurrant	45	650	Reset Plate
	2/C	Pepsi Cola PCIB	30	700	Ok
3	1/B	Sundop Milk Coffee	35	750	Reset Plate
	1/B	Sundrop In fresh Lime Juice	35	1,000	Change All Blanket
5	1/B	LP Espe Orange	35	900	Matching Colour
	1/C	LP Espe Strawberry	50	1,000	Reset Plate
6	2/B	LP Espe Grape	40	1,050	Reset Plate
9	1/A	Calpico Soda White	70	1,150	Change All Blanket
	2/B	Calpico Soda Strawberry	35	650	Reset Plate
	2/B	Fruit Tea Apple	30	900	Reset Plate
	2/B	Fruit Tea Maroon	30	900	Reset Plate
10	1/A	Sample Can CPC	15	400	Ok
	1/A	D'best Bird's Nest	60	1,150	Reset Plate
	2/B	LP Espe Guava	50	1,100	Void Pressure
16	2/A	Kingston Mirinda Orange	75	1,050	Reset Plate
	2/A	Pepsi Twist Kingston	35	700	Matching Colour
	2/A	Pepsi Globe Kingston	40	900	Change Plate

Date	Shift/ Group	Design	Durasi CO (menit)	Spoilage co	Problem
17	1/C	Dad's Root Beer Kingston	30	600	OK
	1/C	Kickapoo Joy Juice	25	900	Matching Colour
	1/C	Kingston 7 Up Lemon Lime	60	800	Change Plate
	2/A	Tebs Tea With Soda	40	750	Reset Plate
18	1/C	LP Espe Guava	40	500	Reset Plate
19	1/A	LP Espe Melon	60	750	Matching Colour
23	1/A	Calpico Soda Melon	55	1,000	Reset Plate
	2/C	Fruit Tea Apple	35	650	Matching Colour
24	1/A	Fruit Tea Blackcurrant	20	650	Ok
	1/A	LP Espe Lychee	55	1,100	Reset Plate
27	2/A	Pepsi Cola PCIB	45	1,000	Change All Blanket
29	1/B	Anker Beer	35	850	Reset Plate
30	1/C	Sundrop Coffee Milk	60	850	Reset Plate
	1/C	Sundrop Orange	50	900	Void Pressure
	2/A	Sundrop Soybean	45	1,150	Reset Plate
	2/A	Tebs Tea With Soda	35	800	Reset Plate
31	1/C	Carlsberg Beer	30	500	Ok
Average			41	850	
Total		C/O: 37	1,535	31,450	

A. Data processing and analysis

To identify the source of the issue and implement a solution, data analysis is required in compliance with the problem formulation mentioned in the preceding section.

- Data graphics

Figure 3 shows the CO frequency from January 2022 to May 2023. When observations are made in May 2023, it may be explained that the CO frequency is 37 times higher.

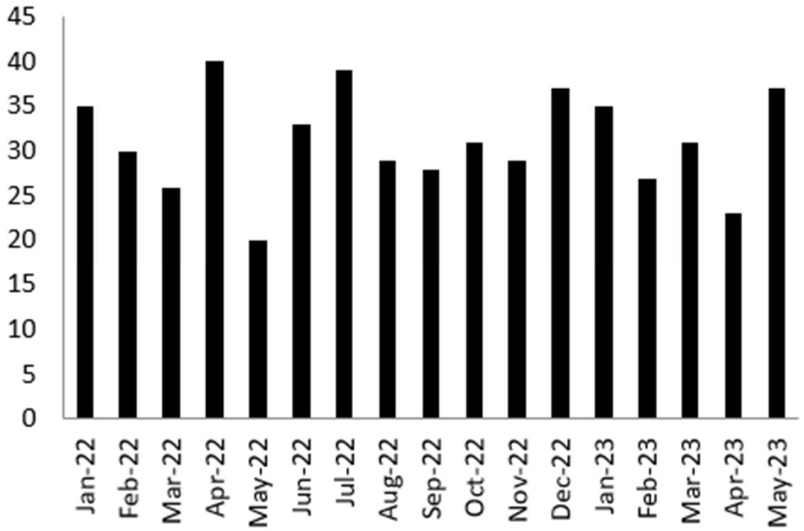

Figure 3. CO frequency from 2022 to May 2023

Figure 4. Average duration of CO from 2022 to May 2023. The average duration of CO was 41 minutes during the time the research was conducted, namely in May. Remedial action is required because the data is still far from the target (red line) of 30 minutes.

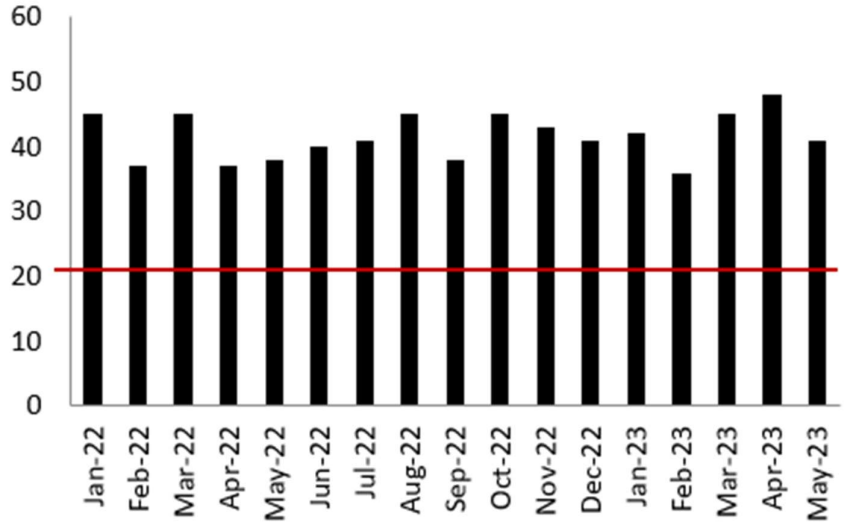

Figure 4. Average CO duration from 2022 to May 2023

Cans of wasted CO are another item that is being studied. Figure 5 shows the average CO damage from 2022 to May 2023. In May 2023, the average damage per CO was 850 cans.

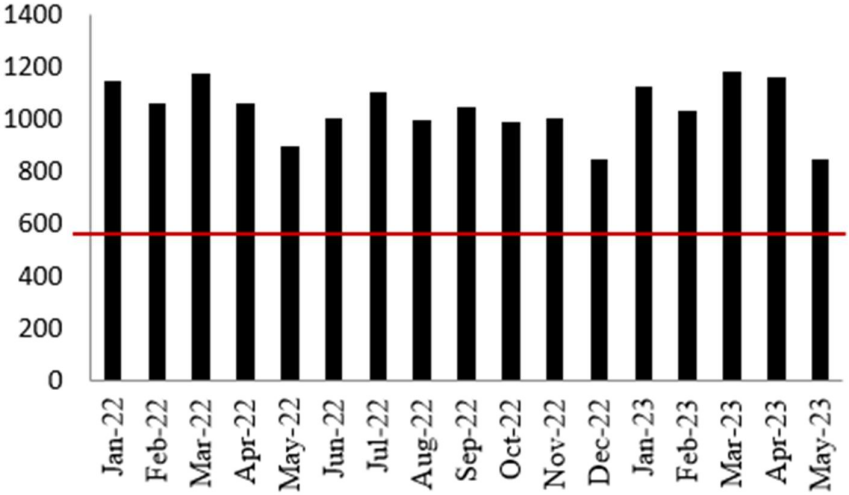

Figure 5. Average CO wasted on cans from 2022 to May 2023

Table 3 provides study material by demonstrating that there were 37 CO processes in May 2023, with an average CO process time of 41 minutes and 850 cans spoiling as a result. Based on these statistics, it can be said that PT.CPC's CO process has to be improved because it is still far from reaching the goal. We will discover issues that lead to the CO process not being on target if we investigate the process more in May 2023 Table 3 lists 32 issues that arose during product changes, with the reset plate (tilted plate) occurring the most frequently (18 times, or 56%). In addition, there are a number of other issues, such as void pressure, matching hue, and others.

Table 3. Current CO problems in May 2023

Problem	Frequency	Percentage %
Reset plate	18	56
Matching colour	6	19
Void pressure	3	9
Change all blanket	3	9
Change plate	2	7

Problem	Frequency	Percentage %
Total	32	100

Figure 6 shows the Pareto diagram for the CO problem. Since the reset plate problem is so prevalent in the diagram—it accounts for 56%—it was decided to address it in the analysis.

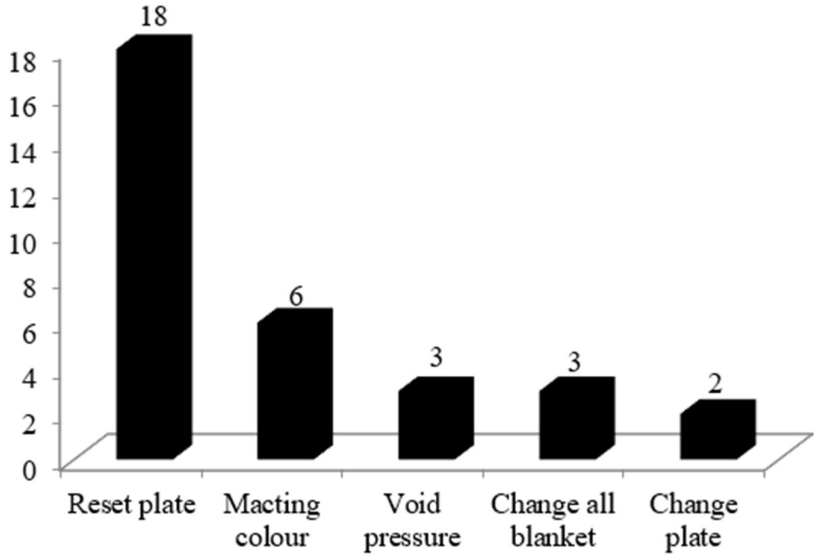

Figure 6. Pareto diagram of CO.

A. Identify the cause of the problem

At this stage, the function is to find out what problems are causing the reset plate problem. The method used at this stage is a cause-and-effect diagram.

B. Cause-and-effect diagram

Previous brainstorming findings are analyzed to determine the underlying causes using cause-and-effect diagrams. After brainstorming, the information is processed into a cause-and-effect diagram, also called a fishbone diagram. When creating this figure, the causes are represented by bones, and the results are represented by fish heads. The discussion's outcomes revealed that the reset plate issue was mostly caused by three things. The three primary factors were machine factors, human factors, and material aspects. To learn more, go to Figure 7.

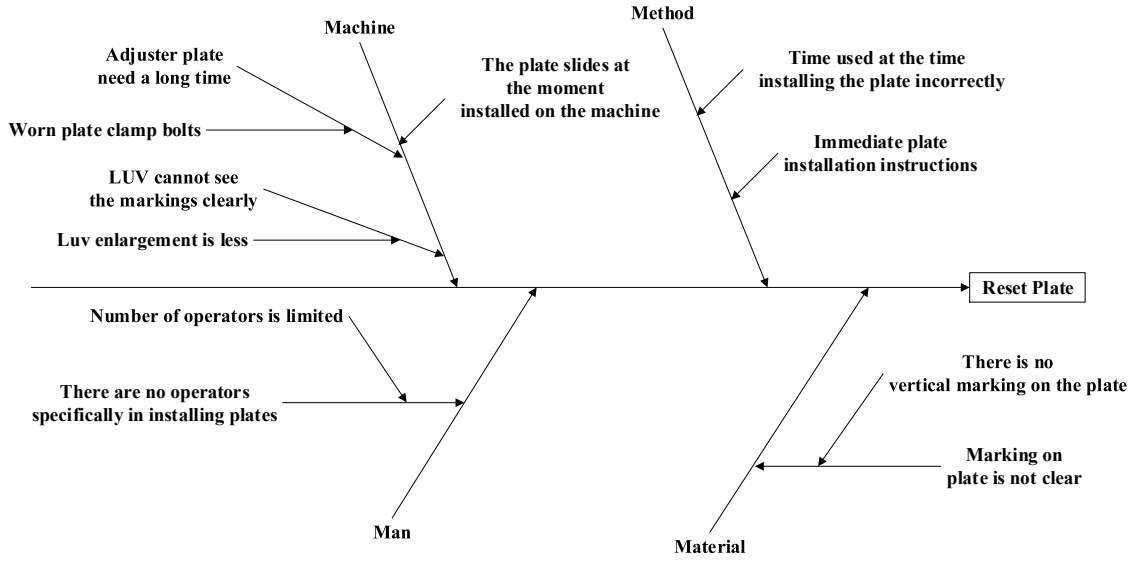

Figure 7. Cause and effect of reset plate problem.

Table 4 contains the root causes of the three primary factors, according to the cause and effect diagram in Figure 7.

Table 4. Identify the causes of reset plate problems.

No	Factor	Potential Causes
1	Man	There is no special operator in installing the plate. There is no training to install the plate.
2	Material	The markings on the plate are not clear. There are no vertical markings on the plate.
3	Machine	Luv couldn't see the markings clearly. There is hilarity in luv. The sliding plate is installed on the machine. Adjusting plate takes a long time.
4	Method	The time used when installing the plate is not correct. Immediate plate installation instructions.

After doing a thorough analysis of the results using a cause and effect diagram, it was discovered that human, material, and machine factors have the greatest influence on the reset plate problem.

1) Human Factors
   Production supervisors are unable to designate operators who are explicitly tasked with installing plates due to the restricted number of operators. The findings are not consistent because anyone can install the plate without the need for a specialized operator.
2) Material Factors
   This material component gives the plate more emphasis. Because there are no vertical markings and only horizontal markings on the current plates, the markings are not very clear. As a result, the operator can only install the left or right plate by feeling instead of having a reference.
3) Machine Factor
   Here, the engine factor is primarily focused on the love employed. Even using a 10x magnification, the Luv utilized is still too hazy to clearly discern the engravings. It takes a lov 20x magnification to get exact findings. Operators encounter challenges when installing plates since many plate cylinders now on the market have worn-out or damaged clamps, which make it challenging to place the plate. Because of this, occasionally when the cylinder is put into the engine, the plate moves.

B. Develop an improvement plan
Based on several factors that have the potential to cause reset plate problems, a plan for proposed improvements will be carried out to reduce these problems in Table 5.

Table 5. Action plan, for Failure Method

Problem	No	Cause	Solution	Implementation Schedule
Reset Plate	1	The original design does not have vertical markings on the plate	Add horizontal and vertical markings to the plate	In the 3rd week of March 2022, the manufacture of plates with new markings will begin
	2	Luv hasn't been upgraded yet	Replacing the luv lens with 20x magnification and increasing the luv position to 3 positions	Week 5 replaces the new luv with 20x greater magnification than before and adds the new luv to 3 positions.
	3	The clamp and adjuster bolts are worn or damaged	Replace the clamp bolt and adjuster plate with new bolts	Week 5 prepares new clamp bolts and adjuster plate for testing

Problem	No	Cause	Solution	Implementation Schedule
	4	The process of recruiting operators to install plates takes a long time	Conduct training for support operators so they can install the plate properly	4th week of June 2023, start of training.

C. Causes of plate reset

- Added horizontal and vertical markings to plates.

Original design plates are devoid of any vertical marks. As a result, operators have trouble putting plates that are really straight. This means that adding vertical markings to the marking plate is a necessary modification. The operator can definitely find the center point of one plate from another with the help of the vertical and horizontal markings on the plate.

1) Replace worn clamps and adjuster bolts with new ones
2) Conduct training for support operators
   Production supervisors are unable to designate operators who are explicitly tasked with installing plates due to the restricted number of operators. All decorator operators are capable of installing plates in the absence of a specialized operator, resulting in inconsistent outcomes. The production department of PT. CPC circumvented this by training supporting operators, as shown in Figure 7, to take over the function of operators installing plates because operator recruiting has not yet been completed.
3) Luv upgrade
   Even with a 10x magnification, the Luv being used is still too hazy to clearly read the markings. This is a result of the improved markings on the plate, which are now smaller in size and intended to be more accurate. To obtain more accurate findings, the luv needs to be updated with greater magnification and made into three positions.

D. Evaluation of improvement results

Following the completion of the improvement process, the implementation phase comes next, which entails assessing the improvement outcomes. A direct evaluation of improvements takes place on the production line. This is due to the lack of available laboratory facilities. On June 19–28, 2023, trials were conducted in production, and the results improved:

1) Replace the clamp and adjuster bolts with new bolts.
2) Plates that are equipped with vertical and horizontal marks.
3) The plate is installed on the clamp cylinder by a support operator who has been specially trained. The test results are shown in Table 6.

Table 6. Change over trial results

Date	Shift/ Group	Plate Cylinder (pcs)	Design	CO duration (minutes)	Spoilage CO	Problem
11	2	4	Pepsi Twist (sodium)	35	1,000	Reset Plate
12	1	6	LP Espe IMP Badak Jeruk	55	1,100	Matching Colour
14	1	5	Mirinda Strawberry (Sodium)	30	800	Ok
15	3	5	Calpico Soda Strawberry (NT)	25	700	Ok
16	1	4	Pepsi Cola (INA)	28	750	Ok
17	2	4	Pepsi Globe (Sodium)	20	650	Ok
19	1	5	Sosro Tebs Tea White Soda	25	750	Ok
20	2	5	Calpico Soda Melon (NT)	40	1,000	Matching Colour
21	1	5	Calpico Soda White Plain (NT)	30	700	Ok
Average				32	828	
Total			C/O: 37	288	7,450	

Table 6 "Design" column displays the product design that will be developed throughout the actual changeover procedure. The length of change over time, which comprises the cylinder replacement, ink

replacement, and setting procedures to produce a high-quality product, is displayed in the "Change over Duration" column [14]. Installing the plate on the cylinder clamp must be done before the changeover procedure is completed [15], Support operators with the necessary training install plates. In the meantime, Table 7 displays the findings of the assessment of the support operator training procedure for placing plates. This data shows that there was a noticeable improvement after three days of training and trying out different plate settings. Before, it took an average of thirty-two minutes for each cylinder to become average. 15 minutes on average per cylinder.

See the "spoilage co" column for the quantity of wasted cans created during the switchover. Concurrently, the "Problem" column details the issues encountered throughout the transition.

Table 7. Results of setting plate exercise

Cylinder	Setting Time Duration (minutes)	
	Before Training	After Training
Cylinder 1	40	20
Cylinder 2	35	15
Cylinder 3	30	15
Cylinder 4	35	13
Cylinder 5	20	10
Cylinder 6	30	15
Average	32	15

Table 7, which the operator placed on the clamp cylinder after utilizing the plate with fresh markings. 828 cans are wasted, and the transition takes 32 minutes on average. In the meantime, out of nine changeover processes, the plate reset issue only arises once.

Table 8 demonstrates that, although still falling short of the aim, the average replacement length and damage it causes have grown (Time: 30 minutes; wasted cans: 800 cans). In the meantime, reset plate issues sharply declined from 49% to 11%.

Table 8. Results of the evaluation of improvements to the changeover process

Reference	Before Repair	After Repair
Average duration of CO (minutes)	42	32
Average CO spoilage (Cans)	1043	828
Problem Reset Plate %	49	11
Setting Plate (minutes/Cylinder)	32	15

3 CONCLUSION

The following conclusion can be drawn from the findings of the data processing and analysis that has been done: It is known from the analysis results during the research that the issue that frequently arises during changeover is plate reset. Following the repair procedures at various locations that result in the reset plate issue, such as: 1) Changing the clamp and adjuster bolts out for new ones Plates that are supplied with vertical and horizontal markings 2) A support operator with specialized training installs the plate on the clamp cylinder. 3) The duration has improved by an average of ten minutes. 4) The company's aim of 800 cans is nearly reached by the average spoilage changes over to 828 cans. 5) The percentage of plate reset issues fell from 49% to 11%. 6) The setting plate took 15 minutes instead of 32 minutes each cylinder.

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