International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 6 ǁ June 2023 ǁ PP. 513-521

Crude Palm Oil (CPO) Quality Control Using Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA) Methods at PT. XYZ

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Abstract
PT. XYZ is a company engaged in oil palm plantations for the processing of Crude Palm Oil (CPO). The company has set CPO quality standards. But what is happening now is the high percentage of CPO quality that is not by the specifications of the established quality standards. The purpose of this study is to identify the causes of the high percentage of nonconformity in CPO quality using the methods of Statistical Quality Control and Failure Mode Effect Analysis and make suggestions for improvement. The results of data processing obtained the cause of the high percentage of CPO quality discrepancies are operators are less careful and disciplined, SOPs are not carried out properly, boiling time, less temperature. The company's recommendation is to conduct training for operators and set the boiling time to 102 minutes and the sterilizer station temperature to 100°C.

Keywords: *Quality Control, CPO, SQC, FMEA*

Date of Submission: 13-06-2023 Date of acceptance: 28-06-2023

I. INTRODUCTION

Product quality control is a very important factor for the industry because good quality control and continuous application can quickly detect abnormalities so that corrective and anticipatory actions can be taken immediately [1]. Quality control can be interpreted as a method of controlling a product's features, totality, and characteristics related to the product related to the results of the product's ability to meet consumer needs [2]. Quality standards include raw materials, production processes, and finished products [3]. Quality is expected to be an indicator of success in engineering and reduce product variations, quality will have an impact on increasing profitability [4]. Quality is expected to be an indicator of success in engineering and reduce product variations, quality will have an impact on increasing profits [5].

PT. XYZ which is engaged in Oil Palm Plantations in Pasangkayu Regency, West Sulawesi Province (Sulbar), is a subsidiary of PT. Astra Agro Lestari (AAL) Group Tbk Area Celebes 1 (C1). Operated in 1995, with a land area of 7,101 hectares. Being one of the companies that produce the largest *Crude Palm Oil* (CPO) in the West Sulawesi region. *Crude* palm oil (CPO) is oil synthesized in palm fruit until it is 22-24 weeks old after fertilization [6]. The factors that determine the quality of CPO are free fatty acid content, water content, and dirt content.

Average CPO production capacity at PT. Letawa every month is 67,878 tons/month or 200 tons/day or 1.21% while the company standard sets >1% who experience non-compliance. CPO that does not comply with the specifications is 826 tons/month with the type of discrepancy, namely free fatty acid content with a percentage of 3.37%, water content 0.27%, and rotten content 0.030%. The standards set by the company for CPO quality standards with a free fatty acid content of 2.5%, water content of 0.20%, and dirt content of 0.025%.

Statistical Quality Control (SQC) and *Failure Mode Effect Analysis* (FMEA) methods are used to determine product nonconformity and control the level of product non-conformity. Where the method can be applied to PT. Letawa in improving product quality with the application of SQC and to overcome nonconformity problems can apply the FMEA method.

Statistical quality control is a statistical technique needed to guarantee and improve product quality [7]. This makes it possible to make a decision as to whether to bear the costs of many defective products and save on inspection costs, or vice versa [8]. While FMEA (*Failure Mode and Effect Analysis*) is a technical analysis that if done correctly and at the right time will provide great value in assisting the decision-making process of engineers during design and development [9]. The creation of FMAE aims to identify and assess the risks

associated with potential failures [10]. The advantage of the FMEA method compared to other methods is that it can take priority actions and steps taken by looking at the effects of failure of each production process so that the company is easier control the production process and minimize defects [11]. By paying attention to the causes of disability that occur, control can be carried out on the causes of disability carried out by workers in order to minimize the risk of disability [12].

Based on the above problems, the purpose of this study is to identify the causes of the high percentage of CPO quality discrepancies based on the *Risk Priority Number* (RPN) value and provide suggestions for improvement.

II. RESEARCH METHODOLOGY

2.1 Place and Time of Research

This research was conducted at PT. Letawa is located in Makmur Jaya Village, Tikke Raya District, Pasangkayu Regency, West Sulawesi Province, with a research period of one month.

2.2 Data Type and Sources

Qualitative Data, namely data obtained from companies in the form of information both orally and in writing. Data in the form of *crude palm oil* (CPO) production process flow data in the form of an overview of CPO at PT. Letawa.

Quantitative Data is data obtained from companies in the form of numbers. The data is in the form of data on the amount of production and data on the type of non-conformity in *crude palm oil* (CPO) production at PT. Letawa.

2.3 Data Processing Methods

This study used two methods, namely SQC and FMEA. Where the first stage is to determine the *check sheet*. *Check sheets* help analysts find information or patterns that can be used for further analysis [1]. Second, create a histogram that shows the visual distribution of data or how often different values occur in a data set [13]. Next, create a control map. *The Control Chart* is created in such a way that new data can be compared quickly with previous data [1]. After that, make a Pareto chart which is a special bar graph and is commonly used to interpret in determining the frequency or level of importance depending on various problems or causes [1]. And next, make a fishbone diagram. This diagram illustrates the relationship between problems or consequences with the factors that cause them so that it is easier to handle because it can clearly describe the various causes of defects in the product [13]. And the last one calculates the RPN value. The RPN value can be determined by multiplying the severity, occurrence, and detection values that have been obtained previously. The highest RPN value is prioritized in providing recommendations [14].

III. RESULT AND DISCUSSION

3.1 Statistical Quality Control (SQC)

1) Check Sheet

Table 1. CPO Production Check Sheet *Data* for October 2022

No.	Date	Total Production (Ton)	Types of CPO			Production Process					Total of Production Deviations (Ton)
			FFA (Ton)	Moist (Ton)	Dirt (Ton)	Sterilizer	Screw Press	Vibrating Sscreen	Clean oil tank	Vacum Dryer	
1	10/1/2023	169398	4269	305	34	4054	305	29	105	115	4608
2	10/2/2023	178439	6192	589	36	6087	589	28	45	68	6817
3	10/3/2023	140067	4384	322	36	3877	322	28	245	270	4742
4	10/4/2023	136942	3971	274	49	3781	274	43	97	99	4294
5	10/5/2023	139583	4062	279	42	3815	279	37	145	107	4383
6	10/6/2023	160881	4392	354	55	3841	354	49	226	331	4801
7	10/7/2023	155127	4638	372	45	3692	372	39	526	426	5055
8	10/8/2023	191276	6774	609	61	5899	609	56	419	461	7444
9	10/9/2023	230912	8013	600	65	7634	600	57	127	260	8678
10	10/10/2023	248575	8601	447	65	8265	447	59	166	176	9113
11	10/11/2023	189141	6223	397	47	6123	397	39	51	57	6667
12	10/12/2023	185456	6064	389	45	4830	389	39	539	701	6498
13	10/13/2023	221770	7274	421	60	6381	421	55	428	470	7755
14	10/14/2023	146449	4642	293	40	3751	293	35	539	357	4975
15	10/15/2023	198674	5523	437	52	4827	437	47	379	322	6012
16	10/16/2023	234017	8916	655	68	8170	655	63	369	382	9639
17	10/17/2023	198961	7123	497	66	6196	497	64	438	491	7686
18	10/18/2023	161250	5402	452	42	4629	452	39	382	394	5896
19	10/19/2023	146502	5054	352	42	4046	352	36	557	467	5448
20	10/20/2023	175203	5817	578	63	5687	578	57	51	85	6458
21	10/21/2023	114052	2737	490	46	2529	490	42	87	125	3273
22	10/22/2023	210983	6034	549	65	5831	549	58	117	93	6648
23	10/23/2023	229564	7966	597	64	7275	597	59	351	346	8627
24	10/24/2023	240312	6488	601	65	5386	601	60	580	527	7154
25	10/25/2023	222242	6556	622	64	6320	622	59	91	150	7242
26	10/26/2023	184122	6334	479	50	6228	479	43	59	54	6863
27	10/27/2023	173510	5205	347	43	4278	347	37	453	480	5595
28	10/28/2023	121857	3339	292	23	2719	292	17	337	289	3654
29	10/29/2023	197909	5799	356	36	4183	356	31	991	629	6191
30	10/30/2023	234682	8941	657	68	7159	657	63	998	784	9666
31	10/31/2023	242809	6969	461	92	5931	461	87	560	478	7522
Total		**5779665**	**183703**	**14076**	**1628**	**163424**	**14076**	**1455**	**10458**	**9994**	**199406**

Source: Primary Data,2022

Based on the results of data processing using check sheets, can be obtained from the results of CPO production produced by PT. Letawa during October 2022 was 5779665 tons. Total production with the amount of CPO production deviation of 199406 tons where the type of CPO deviation at FFA levels is 183703 tons, FFA levels most occur at sterilizer stations and vibrating screens. At a moist level of 14076 tons, moist levels of aging a lot occur at screw press stations and clean oil tanks. At dirt levels of 1628 tons, dirt levels occur most at vacuum dryer stations. For the amount of CPO quality discrepancies at each CPO production process work station, namely at the sterilizer station amounting to 163424 tons, at the screw press station amounting to 14076 tons, at the vibrating screen station amounting to 1455 tons, at the clean oil tank station amounting to 10458, and at the vacuum dryer station amounting to 9994 tons.

2) Histogram

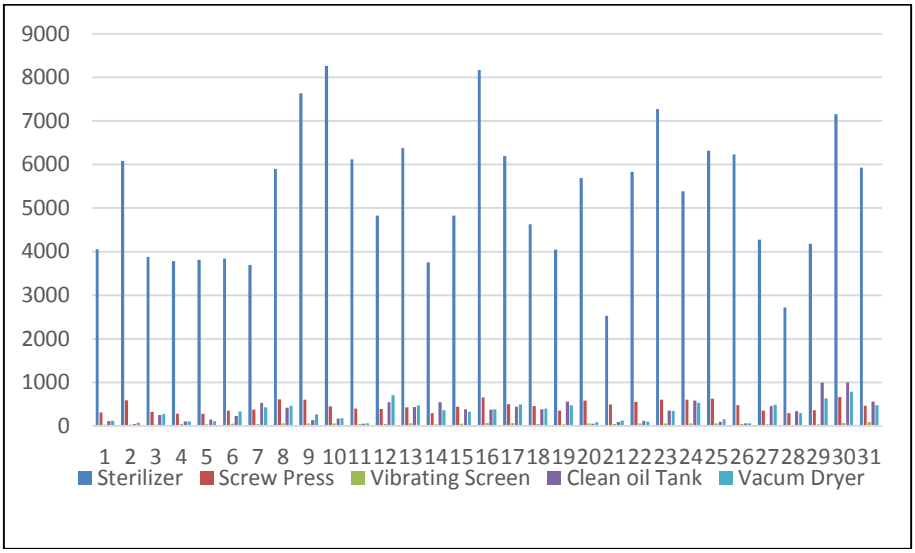

Figure 1. Histogram Types of CPO Production Process Deviations

Based on the results of data processing using the control p *sterilizer map graph*, it can be seen that the data processed 17 points are outside the lower and upper control limits. From the results of the graph analysis on the p *screw press control map*, it can be seen that the data processed by all points is outside the lower and upper control limits. From the results of the graph analysis on the p *vibrating screen control map*, it can be seen that the data processed by all points is outside the lower and upper control limits. From the results of the graphic analysis on the control map *of the p clean oil tank*, it can be seen that the data processed there are 27 points outside the upper control limit. From the results of the graphic analysis on the p *vacuum dryer control map*, it can be seen that the processed data has 28 points that are beyond the limits of upper control. So it can be said that the CPO production process is produced by PT. Letawa in October 2022 still needs improvement. Due to the high and irregular fluctuation points that indicate the production process is still experiencing deviations.

3) Control Map

Analysis of the CPO production process using a control map, namely the control map p. The results of the data calculation are obtained as follows.

Center Line = 0.0283
Upper Control Line = 0.0338
Lower Control Line = 0.0228

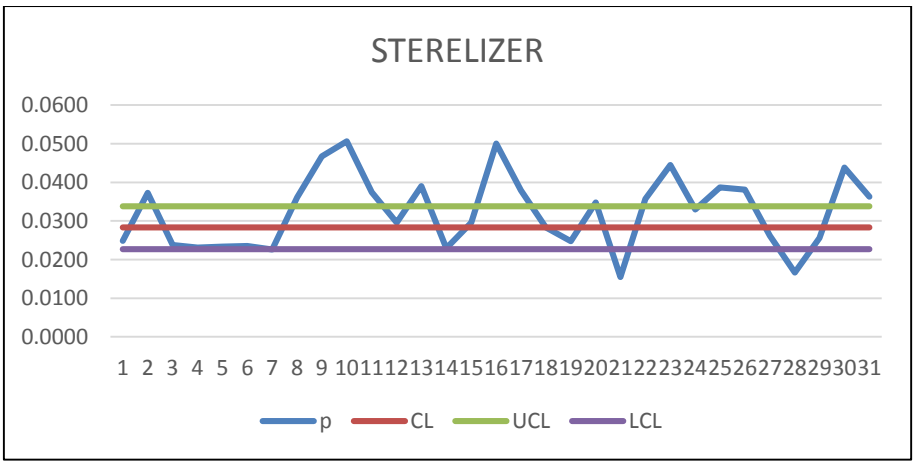

Figure 2. Control Map p *Sterilizer*

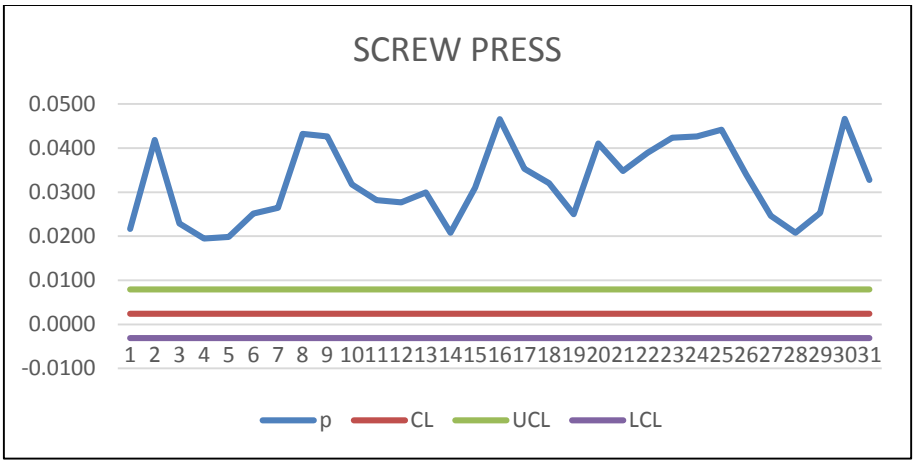

Figure 3. Control Map p *Screw Press*

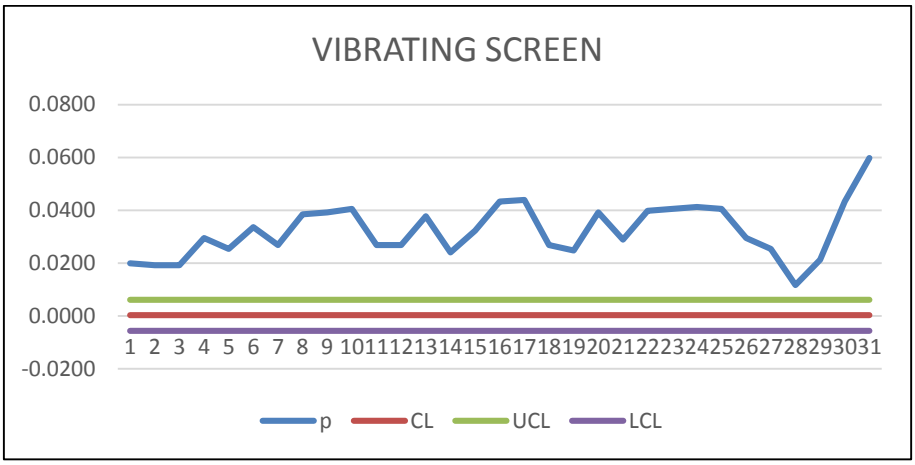

Figure 4. Full Map p *Vibrating Screen*

Based on the results of data processing using the control p *sterilizer map graph*, it can be seen that the data processed 17 points are outside the lower and upper control limits. From the results of the graph analysis on the p *screw press control map*, it can be seen that the data processed by all points is outside the lower and upper control limits. From the results of the graph analysis on the p *vibrating screen control map*, it can be seen that the data processed by all points is outside the lower and upper control limits. From the results of the graphic analysis on the control map *of the p clean oil tank*, it can be seen that the data processed there are 27 points outside the upper control limit. From the results of graphic analysis on the p *vacuum dryer* control map, it can be seen that in the processed data 28 points are outside the upper control limit. So it can be said that the CPO production process is produced by PT. Letawa in October 2022 still needs improvement. Due to the high and irregular fluctuation points that indicate the production process is still experiencing deviations.

4) Diagrma Pareto

A Pareto diagram is a bar chart connected to a line chart. This bar chart shows the grouping of data while the line chart depicts the cumulative data results [15]. Based on the results of data processing using a Pareto chart, it can be seen that the largest CPO production process in October 2022 was in the *sterilizer* process (81.95%), then in the *screw press* process (7.05%), then in the *clean oil tank process (5.24%), and in the* vacuum dryer process (*5.01%), and the smallest CPO production process was in the* vibrating screen process *(0.72%)*

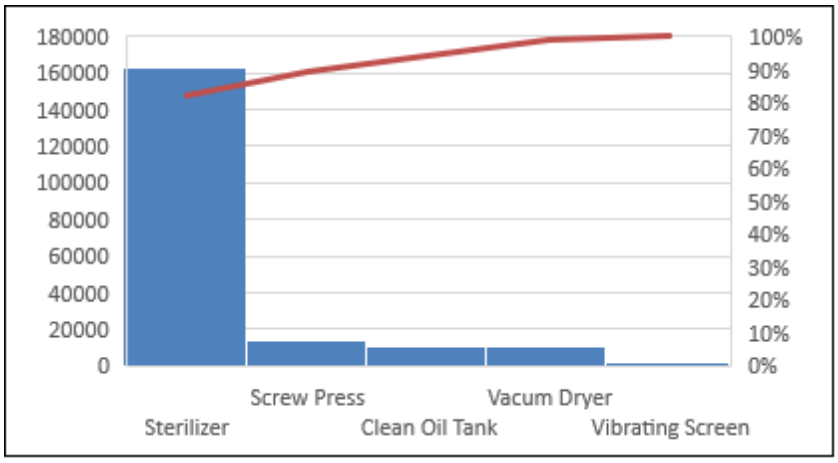

Figure 5. Production Process Pareto Diagram

5) Fishbone Diagram

To find out the factors that cause deviations, research is carried out on the main factors, namely raw materials, machines, people, methods, and the environment.

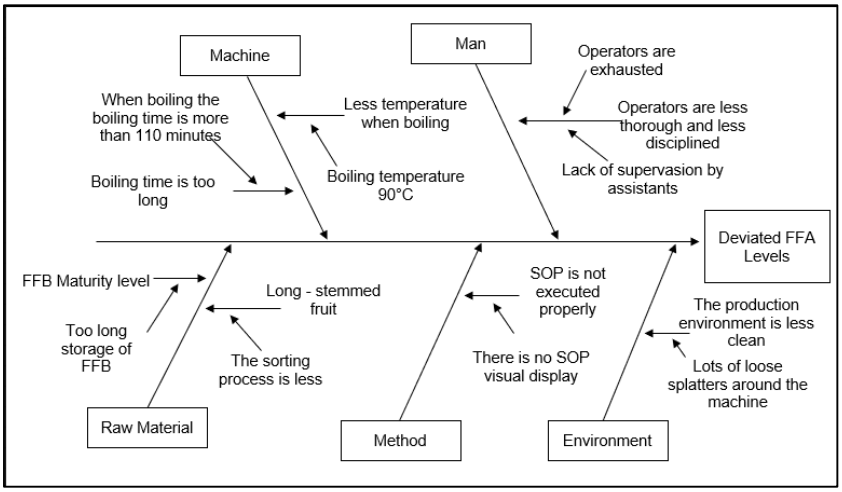

Figure 6. FFA Levels Fishbone Diagram

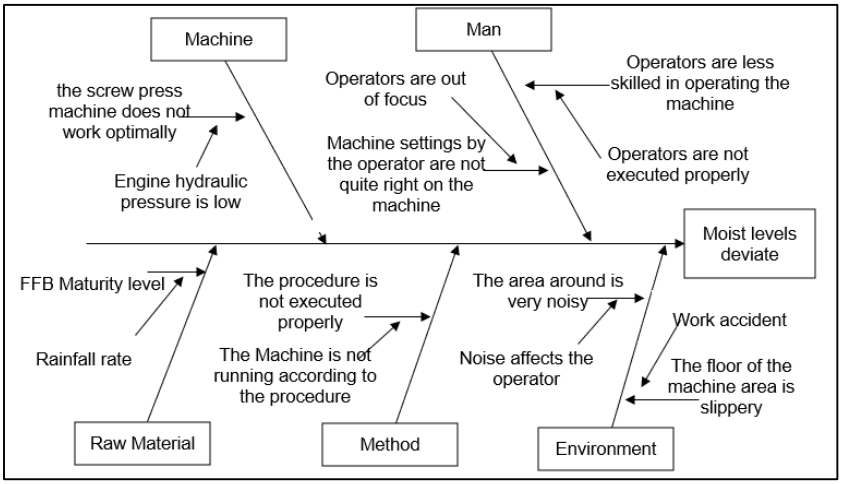

Figure 7. Moist Content Fish Bone Diagram

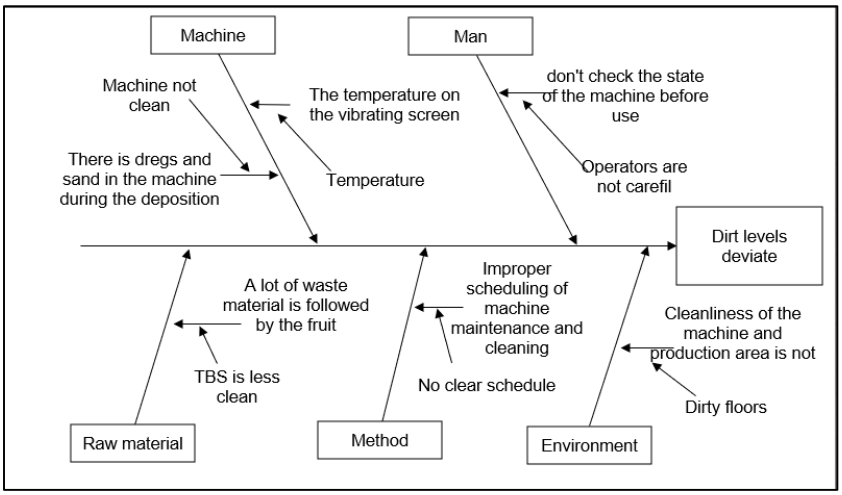

Figure 7. Dirt Content Fish Bone Diagram

3.2 Failure Mode Effect Analysis (FMEA)

Table 2. Table FMEA

Failure Method	Failure Effect	(S)	Cause of Failure	(O)	Detection Method	(D)	RPN	Complete Failure
FFB maturity level	Overripe fruit will cause high FFA levels	8	The fruit does not meet standard operating procedures	10	Check	3	240	
			FFA levels increased	9	Check	3	216	
Boiling time	The length of boiling time will increase FFA levels	8	Fruit will pile up on the ramp	6	Supervised	7	336	
Less temperature	FFA, Moist, and Dirt levels increased	8	As a result of many problematic machines	8	Check	5	320	
			FFA, Moist, and Dirt levels increase	9	Check	2	144	
Operators lack thoroughness and discipline	Production process not by SOP	9	As a result of many problematic machines	8	Improvement made	4	288	13
			Wasted lots of production time	7	Check	7	441	
SOPs are not executed properly	As a result of the result not matching the specifications	9	The occurrence of production repetition	6	Improvement made	8	432	
			Production costs will increase	7	Check	5	315	
Production environment	As a result, the operator does not work optimally	6	The Occurrence of work accidents	7	Supervised	4	168	
			Hinder the production process	5	Supervised	7	210	
Hydraulic press machine low pressure	The press machine does not work optimally	8	Fruits are not optimally depressed	6	Check	4	192	
			The oil produced is reduced	7	Check	3	168	
			Total RPN				3470	

Kritikal RPN = Total RPN/ Total Failure = 3470/13 = 266,92.

Thus, the main causes of failure to increase FFA, *moist, and* dirt *levels are caused by operators not being careful and disciplined, SOPs not being carried out properly, boiling time, less temperature with RPN values of 441, 432, 336, 320, 315, and 288, respectively*.

3.3 Proposed Improvements

Table 3. Proposed Improvements

No.	Proposal	Explanation
1.	Conduct training for operators in providing accuracy and discipline	Rigor and discipline can be provided from training and development by providing an understanding of discipline and research. Maximum work discipline from the workforce will directly impact productivity which brings results not only to the company but also to employees. This will affect the work performance of employees which will ultimately improve careers for the workforce concerned.
2.	Conduct training for operators so that they can run production process machines by SOPs	Training is an effort to reduce or eliminate the gap between the ability of employees and what the company wants. This effort is carried out by increasing the workability of employees by increasing knowledge and skills and changing attitudes. One way is to hold training. Lack of knowledge of existing rules, procedures, and policies is the most common cause of disciplinary action. One effort to overcome this is that the leadership should provide an orientation program to new employees on their first day on the job.
3.	Set the boiling time for 102 minutes	In determining the cycle time during boiling by dividing 2 large parts. The first time to go in and out of the calibration stew is 24 – 25 minutes. Both times are below steam, with an entry time of 24 minutes in 78 minutes. With a time position of 78 minutes for 4 sterilizers, a pause between sterilizers will be obtained of 19-20 minutes. This is very possible because the peak position does not collide with steam needs.
4.	Set the *sterilizer* station *temperature* to 100ºC	Set the *sterilizer* station *temperature* to 100ºC

IV. CONCLUSION

From the results of the analysis and discussion, it can be concluded that:

1. The high percentage of CPO quality discrepancies based on RPN values, namely operators are less careful and disciplined, SOPs are not carried out properly, boiling time, *and temperature* is less with RPN values of 441, 432, 336, 320, 315, and 288 respectively.
2. The proposed improvement of CPO quality discrepancies to reduce the percentage of non-conformities is for companies to conduct training for operators in providing accuracy and discipline. As well as being able to run production machines by SOPs. Set the boiling time for 102 minutes and *the sterilizer* station *temperature* to 100ºC.

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