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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

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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 | Vacuum 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

4 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

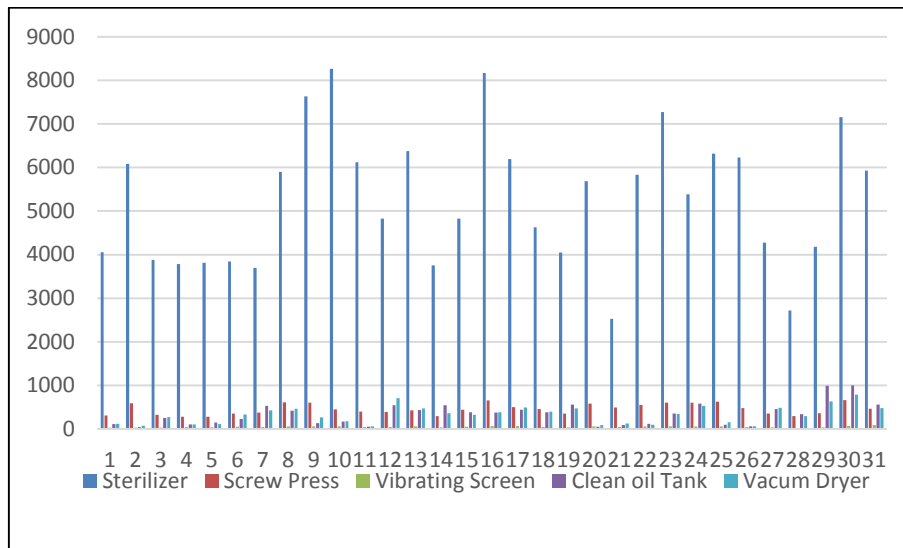


Figure 1. Histogram Types of CPO Production Process Deviations

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

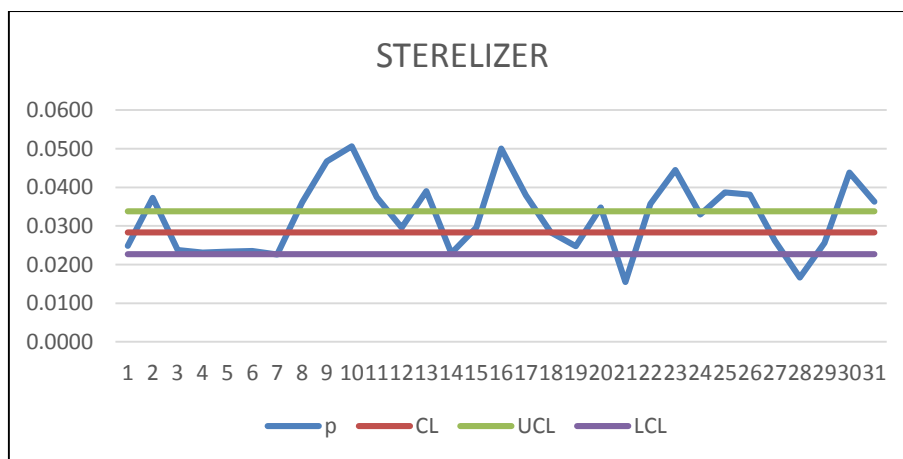


Figure 2. Control Map p Sterilizer

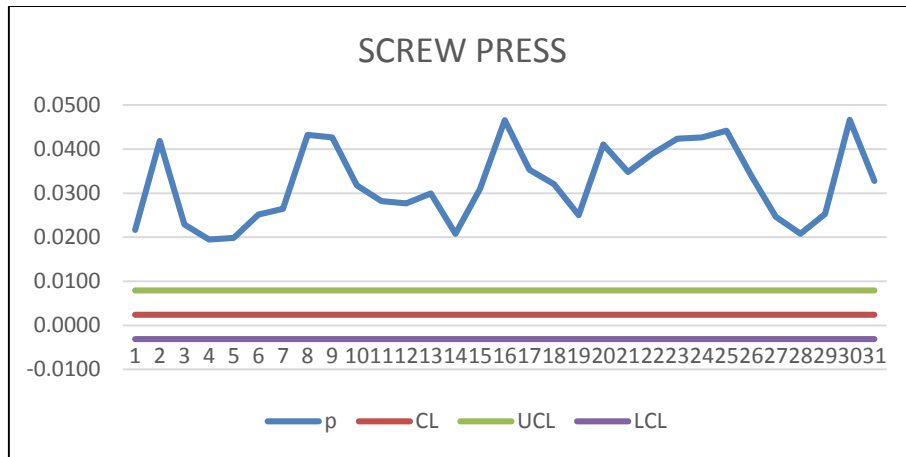


Figure 3. Control Map p Screw Press

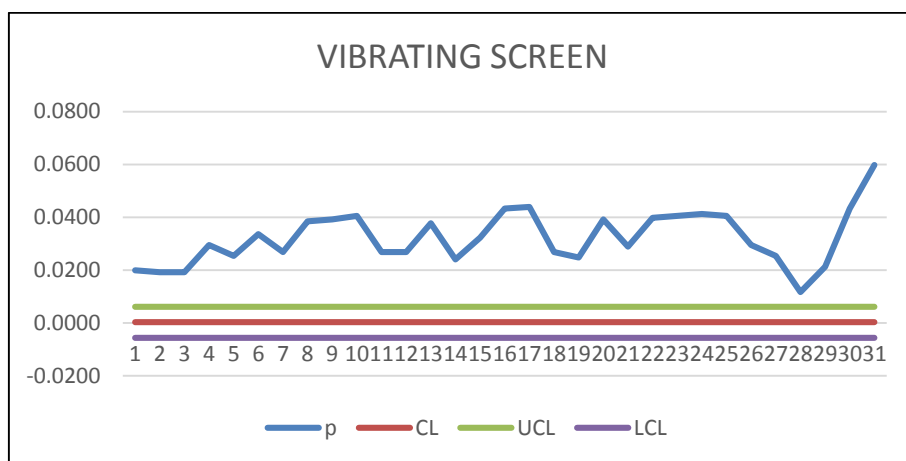


Figure 4. Full Map p Vibrating Screen

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 *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) Diagrama 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%)

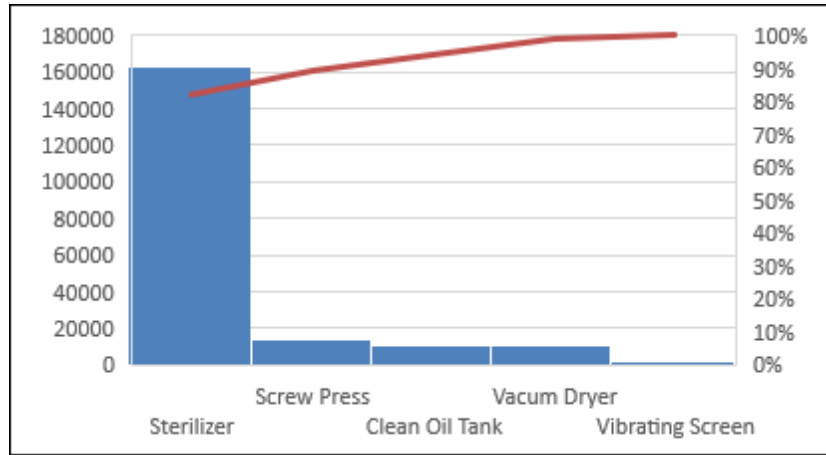


Figure 5. Production Process Pareto Diagram

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.

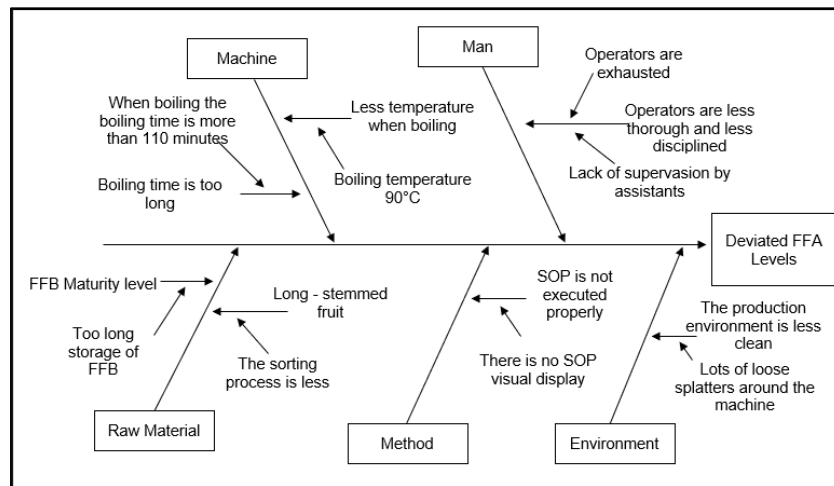


Figure 6. FFA Levels Fishbone Diagram

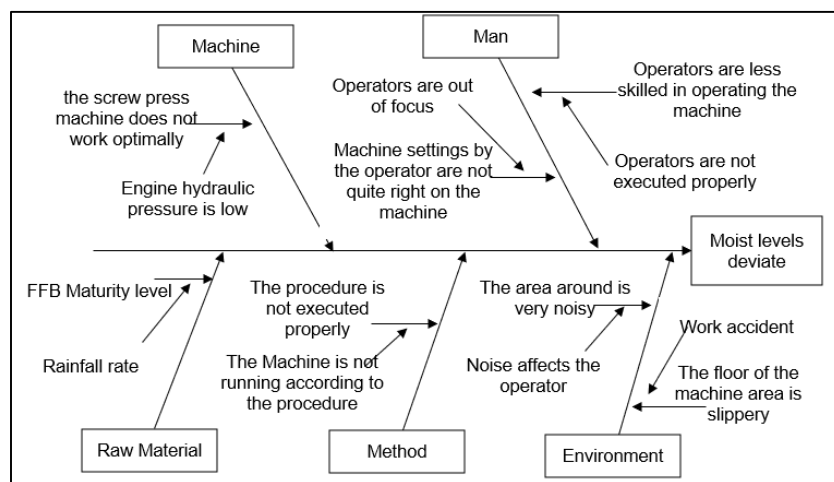


Figure 7. Moist Content Fish Bone Diagram

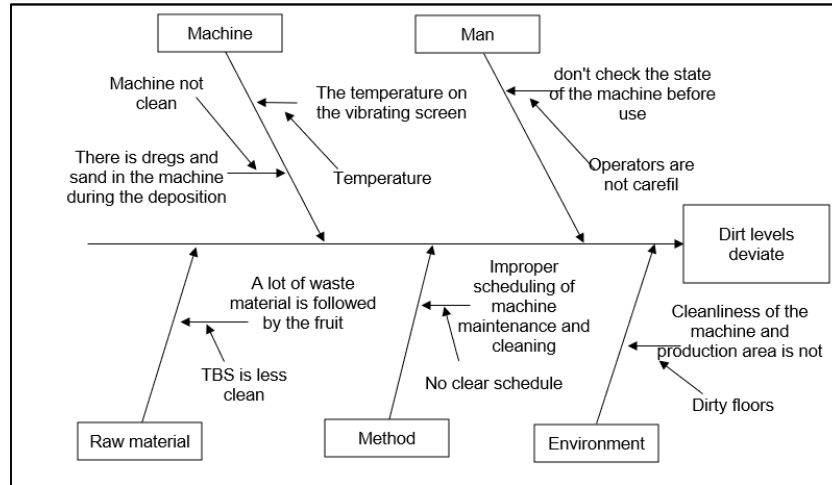


Figure 7. Dirt Content Fish Bone Diagram

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 100°C | Set the sterilizer station temperature to 100°C |

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 100°C.

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