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Analysis of Myristic Acid Quality Control in 3 Plus 1 Fractionated Column Using Six Sigma Method

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Abstract— Each company has the goal of increasing profits by fulfilling consumer demand in accordance with predetermined quality standards. By seeking continuous quality improvement, it can increase product competitiveness with competing products. Myristic acid is a product of PT. XYZ oleochemicals. Based on current quality data, sometimes the resulting myristic acid products do not meet consumer specifications, so they have to be reprocessed, which results in increased production costs. To overcome this, we need a method that can continuously improve quality. The six-sigma method is a production control method that aims to improve product quality through the DMAIC (Define, Measure, Analyze, Improve, and Control) stages. The use of the six-sigma method in this study shows that the critical quality that causes the product not to meet specifications is in the production process, namely those caused by materials, mans, and machines. In addition, measurements show an average sigma level of 3.87, so improvement and control are needed.

Keywords— Six Sigma Method, Quality Improvement, Myristic Acid.

I. INTRODUCTION

Every company has the goal of gaining profits by producing products that meet consumer needs. In order to meet these needs, the company needs to make continuous improvements to the factors that affect the quality of the product to be produced [1]. In addition, improving product quality will increase its competitiveness against competing products [2].

PT. XYZ Medan is a company in the palm oil derivative industry that produces fatty acid and glycerin products. The main raw materials used to produce these products are RBDPS and CPKO.

Currently, one of the company's problems related to quality is the quality of the myristic acid product it produces. Based on the results of the gas chromatography laboratory analysis, it is known that there are a number of myristic acid products that do not comply with the buyer's specifications or are off-spec. Data on production quality conditions every month in 2021 can be seen in table 1.

Table 1: *Monthly production quality data in 2021*

Month	Total Production (Kg)	Total Defect (Kg)	Defect Percentage	Total Product
January	2.140.868	79.606	3,72%	2.061.262
February	2.864.902	89.120	3,11%	2.775.782
March	3.462.906	213.851	6,18%	3.249.055
April	5.023.478	210.813	4,20%	4.812.665
May	5.768.147	342.086	5,93%	5.426.061
June	5.279.164	43.362	0,82%	5.235.802
July	5.249.559	85.098	1,62%	5.164.461
August	6.142.991	164.628	2,68%	5.978.363
September	5.869.297	194.326	3,31%	5.674.971
October	8.873.108	128.302	1,45%	8.744.806
November	5.105.113	81.755	1,60%	5.023.358
December	5.338.984	118.634	2,22%	5.220.350

Based on the data on production conditions in Table 1, it can be seen that the highest percentage of production that does not meet specifications is in March, and vice versa, the lowest percentage is in June.

If the production results do not meet predetermined quality specifications, then the product can be reprocessed, but this will significantly increase costs and

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production time [3]. To overcome this, one method that can be used is Six Sigma.

Six Sigma is one method for controlling and improving the quality of a product through the stages of Define, Measure, Analyze, Improve, and Control (DMAIC) [4]. Six Sigma can be used as a benchmark for industrial system performance; the higher the sigma value achieved, the better the industrial system performance [5]. Previous research on quality control using the Six Sigma method shows that the Six Sigma approach is a successful strategy for improving the quality of dolomite raw materials [6]. In general, the biggest factors causing product defects are people, methods, machines, and materials [7]. The aim of this research is to identify the main causes of non-conforming production in an effort to improve quality.

II. LITERATURE REVIEW

The Six Sigma method is one of the methods used to improve quality by controlling the entire process [4]. In addition, Six Sigma is a comprehensive and flexible system for achieving, supporting, and maximizing processes that focuses on understanding customer needs using facts, data, and statistical analysis and continuously pays attention to setting, improving, and reviewing a process [5]. This method is implemented through several stages known as DMAIC, namely, Define, Analyze, Improve, and Control. Based on the literature [2] [8], the DMAIC stage aims to eliminate unproductive process steps, often focuses on new measurements, and applies technology for quality improvement towards target sigma levels.

Six Sigma is used to anticipate discrepancies or defects by using measurable and structured steps including Define, Measurement, Analyze, Improvement, and Control (DMAIC) [9].

Define

This stage aims to unify the opinions of all teams regarding the project to be carried out. Usually the project is related to the most significant cause of the occurrence of quality variations, which are a source of production failure, and the steps taken are [10]:

1) Define product quality problems that have been determined by the company.
2) Define an action plan that must be carried out based on the results of observation and research analysis.
3) Setting goals and objectives for improving the quality of six sigma based on the results of observations.

Measure

This stage aims to find out how the condition of product quality in the company uses the specified parameters. The measurement phase is carried out in two stages [11]:

1) Analysis of the control chart (P-chart) used for attributes
2) Analyze the sigma level and the defect per million opportunities (DPMO).

Analyze

This stage aims to find the dominant factor and identify the source of the problem. Pareto diagrams and fishbone diagrams are tools that are always used to identify the causes of quality problems [12]. The root cause of the identified problem can be identified by using the 5W+1H method.

Improve

This is the Six Sigma quality improvement stage, which aims to make improvements based on the analysis results measurements (opportunities, damage, current process capabilities), recommendations for improvement proposals, analyzing corrective actions carried out.

Control

This stage aims to maintain the condition of the results of improvement ideas using the latest performance standardization by ensuring the improvement values are disseminated as the next process performance improvement step.

III. RESEARCH METHODS

This research was carried out in several steps.

Step 1. Literature review and field study

The researcher begins the research phase by conducting field studies to find out the existing problems. After knowing the problems that exist in the field, a literature study is carried out. Search for literature according to related study material.

Step 2. Data collection.

Data collection was carried out by direct field observation, interviews with related parties, and document recording.

Step 3. Data processing

Data processing based on Six Sigma with reference to the DMAIC stages.

Step 4. Make conclusions and suggestions.

III. RESULTS AND DISCUSSION

A. Define

At this stage, identification is carried out to determine "critical to quality" (CTQ).

To find out the product's CTQ, the data in Table 1 is further identified to determine the factors of product quality discrepancy. The results can be seen in table 2.

Table 2: *The number of production discrepancies caused by the CTQ factor*

Month	Material (Kg)	Man (Kg)	Machine (Kg)	Total (Kg
January	12.800	16.250	50.556	79.606
February	14.235	13.251	61.634	89.120
March	15.423	14.820	183.608	213.851
April	18.200	18.210	174.403	210.813
May	21.324	12.420	308.342	342.086
June	6.800	12.314	24.248	43.362
July	12.500	16.429	56.169	85.098
August	17.321	23.421	123.886	164.628
September	14.202	25.812	154.312	194.326
October	14.458	23.121	90.723	128.302
November	18.165	22.320	41.270	81.755
December	24.120	16.400	78.114	118.634

Based on the data in Table 2, it is known that the CTQ in this study is in the production process, especially those caused by factors materials, people, and machines.

An explanation for the three CTQ factors can be seen in Table 3.

Table 3: *Critical to Quality (CTQ)*

CTQ	Explanation
Material	Incompatibility of materials resulted in changes in the composition of production
Man	The discrepancy is caused by an input error in the production process set point.
Machine	Non-compliance is caused by damage to the machine or its components.

B. Measure

At this stage, sigma level measurements are carried out. The sigma level can be calculated by first calculating the Defects per Unit (DPU) and Defects per Million Opportunities (DPMO) values.

At this stage, sigma-level measurements are carried out. The sigma level can be calculated based on the Defects per Unit (DPU) and Defects per Million Opportunities (DPMO) values. The sigma level values for each month in 2021 can be seen in Table 4 below.

Table 4: *The sigma level values for each month in 2021*

Month	DPU	DPMO	Sigma Level
January	0,012	12395	3,74
February	0,010	10369	3,81
March	0,021	20585	3,54
April	0,014	13989	3,70
May	0,020	19769	3,56
June	0,003	2738	4,28
July	0,005	5404	4,05
August	0,009	8933	3,87
September	0,011	11036	3,79
October	0,005	4820	4,09
November	0,005	5338	4,05

December	0,007	7407	3,94

C. Analyze

Based on the define and measure stages, an analysis was carried out using the 5W+1H method. The results of the analysis are shown in Table 5.

Table 5: *The results of the analysis using the 5W+1H Method*

		Machine
What	*Q*	What engine often has problems?
	A	Pump Equipment
When	*Q*	When does the engine have a problem?
	A	When running normal production
Where	*Q*	Where is the position of the machine?
	A	On the 0^{th} floor on Pump G12, G13, G15
Who	*Q*	Who operates the machine?
	A	Field Operators and DCS Asst. Supervisor
Why	*Q*	Why the machine is having problems?
	A	frequent shut down and change of product type according to marketing demand
How	*Q*	How to solve the machine problem?
	A	Operation must be in accordance with Standard Operating Procedures, periodic maintenance and production planning according to field conditions
		Man
What	*Q*	What did the operator do so the product was defective?
	A	Field / DCS Operators do not follow the Standard Operating Procedure
When	*Q*	When did this problem occur?
	A	When the initial factory start and normal production
Where	*Q*	Where did the problem occur?
	A	In Pump Equipment and lines that are clog or freeze
Who	*Q*	Who is responsible for supervising the operators and assistant supervisors?
	A	Supervisor / SPT Production
Why	*Q*	Why Field Operator or Asst. Supervisor does not follow the Standard Operating Procedure?
	A	Lack of socialization regarding Standard Operator Procedure so that some operators do not understand well, and need more time to improve their experience.
How	*Q*	How to overcome this problem?
	A	Provide training to field operators or Asst Supervisors regarding Standard Operating Procedures and Supervisors supervise all workers more.
		Material
What	*Q*	What Raw Materials often have problems?
	A	Split Palm Kernel Fatty Acid
When	*Q*	When did the Raw Material not meet specifications?
	A	If there is the addition of new raw materials from production
Where	*Q*	Where are these raw materials stored?
	A	In the temporary storage tank
Who	*Q*	Who checks the Raw Material?
	A	Laboratory personnel and Asst. production supervisor
Why	*Q*	Why is the Raw Material not according to specifications?
	A	Because there is a change of different raw material, so it mixes with the old raw material
How	*Q*	How to overcome these Raw Material constraints?

	A	It is necessary to separate the new raw material in another tank, so that the homogenization of the raw material tank can be maintained and run the agitator continuously.

D. Improve

At this stage, a corrective action plan will be explained to reduce the number of products that do not meet specifications based on the factors that influence them.

Human Factors

1) Prepare all recycling or circulation lines before starting or running operations, both inside the plant and outside the plant, namely from raw material tanks.
2) Make sure all tank product lines and tank conditions have been inspected by the QC laboratory.
3) Coordinate with all parts, mechanical, electrical, instrument, tank farm, and laboratory.
4) Coordinate quickly with leaders and section heads in case of abnormal problems to make decisions for improvement.
5) Do continuous control of process variables so as not to deviate from the predetermined process variables.
6) Regeneration of all personnel is necessary to improve skills according to the job description that has been set.

Method Factors

The method factor is one of the causes of Myristic Acid product defects. Improvements that need to be made to this method factor is that the company makes the right production schedule in a planned manner for each type of product, so that irregular schedules do not occur and disrupt the production process by only relying on pursuing targets.

Machine Factors

1) Perform regular maintenance on all centrifugal pumps and inlet pumps; change spare parts during shut-down so that they work optimally during the production process.
2) Filling with oil, regularly monitoring all Nikiso pumps, and changing spare parts when the life expectancy is reached
3) Make use of original spare parts according to the specifications that have been set by the supplier.
4) Operate the machine according to the procedures of the field operator.

Material Factors

1) Gas chromatography from raw material must be stable during the production process, the addition of raw material to the tank during the production process will cause the GC product to be unstable during the production process.
2) Changing the raw material mode in a small quantity, causing unstable raw material quality according to the specifications that have been set.
3) The raw material does not homogenize as a result of the agitator not being able to run continuously, causing the quality of the production process to be unstable.

Environment Factors

1) Maintain equipment that can cause errors or be unreadable due to sudden heavy rain and strong winds, thus disrupting operational processes.
2) Prohibit unlicensed outside personnel from entering the production process area, to keep equipment in safe operation.

E. Control

These are the control measures taken:

1) Check all machines, especially Nikkiso pumps, the condition of the oil pump, nitrogen, cooling system, and the indication of the TRG lamp to determine pump performance.
2) Perform replacement of pump spare parts at shut down or spare parts that have reached life time.
3) Ordering materials in a timely manner for the replacement of a new pump, which was previously separated into the mechanical rotor and the electrical stator.
4) Maintain a stable, homogeneous raw material so that it does not change in the tank before the plant is running.
5) Changing modes with different raw material tanks used for fractionation so as not to experience changes.
6) Maintain a consistent temperature for the product so it doesn't go out of control limit.
7) Perform DPMO calculations and sigma values periodically each period to determine the ability of the process to produce defect products per one million opportunities.
8) Perform control chart calculations to determine the stability of the process periodically for each period.

IV. CONCLUSION

At the definition stage, it is known that the critical to quality that causes the product to not meet specifications is in the production process, which is caused by materials, man, and machines.

At the measure stage it is known that the average sigma level is 3.87. The highest sigma level is in June, namely 4.28, and the lowest sigma level is in March, namely 3.54.

At the analysis stage, CTQ analysis was carried out using the 5W+1H method. The results obtained are used to find out how to make improvements. Improvements were made in relation to human factors, methods, machines, materials, and the environment. In control, several suggestions are given so that quality conditions are maintained.

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