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Analysis of Phonska Fertilizer Product Quality Control Using Seven Tools Method With Fmea: A Case Study

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Abstract

This study aims to analyze the quality control of Phonska fertilizer products at Phonska Warehouses II and III of PT Petrokimia Gresik using the Seven Tools and Failure Mode and Effects Analysis (FMEA) methods. Seven Tools are used to identify and map the root causes of production defects through Pareto diagrams, cause-and-effect diagrams, and control charts, while FMEA is used to measure and mitigate potential failures in the production process. The study was conducted during the period April to October 2024 with product defect data collected and analyzed. The results showed that the main defects were no coating oil (34%) followed by mesh (29%), caking (24%), and no color pigment (13%). The implementation of corrective steps based on Seven Tools and FMEA has proven effective in reducing product defects to increase production efficiency and the quality of Phonska fertilizer.

Introduction

In the industrial era 4.0, scientific progress is developing very quickly, encouraging the birth of various new technological innovations so that competition between companies becomes more competitive every year (Putri et al., 2023). This development has an impact on increasing levels of competition in the industrial world, both at the national and global levels. Every industry is required to continuously compare and evaluate itself with other sectors, especially those operating in similar business fields, in order to remain competitive. In this condition, product quality is one of the key factors in maintaining a company's competitiveness amidst global challenges. Quality products are not only able to win the hearts of consumers but also provide significant competitive advantages, especially for strategic industries such as fertilizer (Atikah et al., 2024). The quality of the products produced by a company is determined by certain measures and standards that have been set by the company (Shiyamy et al., 2021; Litvinenko et al., 2022; Psarommatis et al., 2022).

Food needs and national economic growth greatly influence the development of Indonesia, so the fertilizer industry is very important for the agricultural sector (Gürçam & Mukhlis, 2022). Most of the fertilizer production in Indonesia is managed by State-Owned Enterprises (BUMN) in the form of *holding companies* . From time to time, the national fertilizer industry has been dominated by BUMN companies that are tasked with meeting the need for large amounts of fertilizer to support the agricultural sector. Some BUMN fertilizer producers include PT Pupuk Sriwijaya (Pusri) which produces and markets Urea fertilizer and other chemical products; PT Petrokimia Gresik which produces Urea, ZA, SP- 36/26, Phonska, DAP, NPK, ZK fertilizers, as well as organic fertilizers and other chemical products; PT

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Pupuk Kujang with Urea, NPK, organic fertilizers, and other chemical products; PT Pupuk Kaltim which produces Urea, NPK, organic fertilizers, and other chemical products; and PT Pupuk Iskandar Muda which produces Urea fertilizer and other chemical products (Ruminta, 2021; Bakhtiar & Aini, 2023).

Fertilizer is a chemical compound and a source of nutrients that are important for the metabolic process. The selection of fertilizer types must be in accordance with the needs and refer to existing standards. Several types of fertilizers produced by PT Petrokimia Gresik, such as Urea fertilizer (SNI 02-2801-1998), Phonska Plus fertilizer (SNI 2803-2012) and NPK Compound fertilizer (SNI 02-2803-2000) have hygroscopic properties, which are very important in determining the storage capacity and handling of their storage. Hygroscopicity is a property of fertilizer related to its ability to absorb or bind water vapor from the free air (Mansyur et al., 2021). Fertilizers that have hygroscopic properties will easily melt if placed in an open place. Therefore, this type of fertilizer should not be stored for too long and must be stored in an airtight room/container. If the fertilizer is stored in a warehouse/room with high humidity, the fertilizer will melt or clump quickly, and this will affect the quality of the fertilizer being marketed (Sari et al., 2017).

PT. Petrokimia Gresik is the most complete fertilizer producer in Indonesia. The types of fertilizers produced include ZA fertilizer, Urea, Phosphate fertilizer (SP-36), NPK fertilizer, and petroganik. The non-fertilizer products produced consist of ammonia (NH3), sulfuric acid (H2SO4), phosphoric acid (H3PO4), Aluminum fluoride (AlF3), purified gypsum, and hydrogen gas (H2). Units Phonska I, Factory II, PT. Petrokimia Gresik produces NPK fertilizer under the name Phonska with a capacity of 450,000 tons/year. Phonska fertilizer is useful for increasing soil nutrients in helping the vegetative and generative growth of plants. Fertilizer Phonska is produced using the chemical reaction route method, which includes the stages neutralization reaction, granulation, drying, sieving, cooling, and coating. Calculation of mass balance in the manufacture of Phonska fertilizer, using materials raw materials including ammonia, H3PO4, H2SO4, KCl, ZA, filler materials, and coatings with a total of 557,307.313 kg/hour. The product produced is phonska fertilizer with a content of 15% N, 10% P2O5, and 12% K2O as much as 433,448,190 kg/hour with production efficiency of 77.78% and energy efficiency of 85.94%. Before the Phonska fertilizer at PT. Petrokimia Gresik is marketed, the Phonska fertilizer must pass the Analysis content test in the Laboratory so that later the Phonska fertilizer circulating to farmers is guaranteed quality (Ramadhan & Devi, 2024).

PT Petrokimia Gresik, as one of the largest fertilizer producers in Indonesia, has a strategic role in supporting the national agricultural sector (Gynastiar, 2024; Putra et al., 2024). In facing increasing market demand and increasingly competitive competition, companies are required to maintain and improve the quality of their products, including Phonska fertilizer. However, complex production processes can cause product defects, such as grain size discrepancies, color changes, and the presence of foreign objects. These problems not only result in financial losses, but can also damage customer trust in the company. Therefore, a systematic and effective quality control approach is needed to minimize the number of product defects and reduce the risk of failure.

Table 1. Production Defect Data

Month	**Total Production Defects (tons)**				**Average**
	Without Coating Oil	**Mesh**	**Caking**	**Without Color Pigment**	
April	550	955.45	606,243	100	552,9233
May	303	305.48	200	250	264.62

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June	588.7	500.2	360.77	227,613	419,3208
July	1267.5	271.98	822.9	276	659,595
August	628	478.4	495	259	465.1
September	544	484.02	343	271.17	410,5475
October	185	410,674	20	160	193,9185

Source: Internal Data of PT Petrokimia Gresik

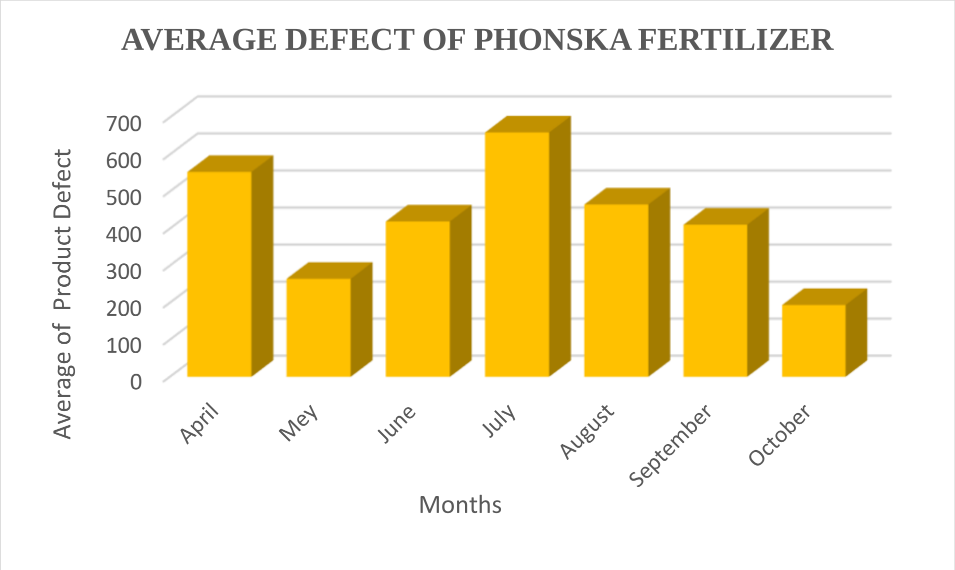

Figure 1. Phonska Fertilizer Product Defect Diagram

The urgency of implementing this quality control method is based on the need to increase the efficiency of the production process and meet established quality standards. With a structured approach, PT Petrokimia Gresik can identify the main sources of product defects, provide repair solutions, and optimize operational performance. In this research, the Seven Tools method was used to map and analyze types of product defects as well as the Failure Mode and Effects Analysis (FMEA) approach to identify risks and determine priorities for corrective action. The problem solving plan in this research involves analyzing historical product defect data using Seven Tools to identify significant defect patterns. Next, FMEA is applied to analyze the main causes of defects and provide priority recommendations for improvement. The results of this analysis will be used to design more effective quality control strategies. The aim of this activity is to minimize the number of defects in Phonska fertilizer products, increase the efficiency of the production process, and reduce the risk of failure which could be detrimental to the company. This research also aims to make a real contribution in increasing the competitiveness of PT Petrokimia Gresik in the national and international fertilizer market. The hypothesis developed in this research is that the integrated application of the Seven Tools method with the FMEA approach can significantly reduce the number of product defects and the risk of failure, while improving the quality and efficiency of the Phonska fertilizer production process at PT Petrokimia Gresik.

Quality

Product quality is a measure or level of excellence or adequacy of a product in meeting or exceeding consumer expectations. Product quality greatly influences consumer perceptions of the brand and can be a key factor in building customer trust and loyalty (Diputra & Yasa, 2021; Rahmat & Kurniawati, 2022).

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Quality Control

Quality control is a technique that is carried out starting from the stage before the production process, while the production process is running, until the production process ends (Amin et al., 2019). The aim of quality control is to be able to produce products in accordance with the desired and planned standards, as well as improve the quality of products that do not comply with predetermined standards and maintain appropriate quality as much as possible (Pramana et al., 2021).

Product Defects

The existence of a defective product indicates the need to analyze quality control efforts, find the cause of the defective product, and find appropriate repair solutions (Prasetyo & Safitri, 2024). Defective products are product units that due to their physical condition cannot be used as final products, but can be repaired and then sold in the form of final products (Dasmasela et al., 2020). Defective products are products that are not fit for consumption and do not meet the safety requirements consumer (Wahyudi et al., 2022).

Seven Tools

The Seven Tools method is a statistical tool to find the root causes of quality problems so that quality can be controlled (Hairiyah et al., 2020). Seven Tools basically has seven control tools including flowchart, checkseet, histogram, Pareto diagram, control chart, scatter diagram, fishbone (Burhanudin & Cahyana, 2024).

FMEA

FMEA prioritizes failure modes based on the assumption that the higher the failure mode RPN, the greater the risk for product failure (Fernandi, 2022). The FMEA technique was chosen as a strategy to identify and measure the causes of problems because FMEA has the benefit of ensuring final results are in accordance with decisions, and focuses on helping to distinguish and eliminate error modes, as well as providing suggestions for improvement (Prasetyo & Safitri, 2024).

Methods

This study uses a case study approach to analyze the quality control of Phonska fertilizer products at PT Petrokimia Gresik, focusing on Phonska Warehouse II and III. The main methods applied are Seven Tools and Failure Mode and Effects Analysis (FMEA). Seven Tools is used to identify the main causes of production defects through statistical tools such as Pareto diagrams, cause-and-effect diagrams, and control charts. This method allows for structured analysis to map problems and determine improvement priorities. Meanwhile, FMEA is applied to identify and measure potential failures in the production process, based on three main dimensions: severity, occurrence, and detection level. This approach aims to systematically mitigate the risk of failure and improve product reliability. The research process involved data collection from April to October 2024. Product defect data was analyzed to identify patterns and root causes, which were then used to formulate improvement measures. The research was conducted in close collaboration between the research team and PT Petrokimia Gresik staff to ensure the implementation of effective and relevant methods to operational conditions. The expected results are a reduction in the number of product defects, increased efficiency of the production process, and improved quality of Phonska fertilizer in accordance with company standards. Thus, this research provides an important contribution to quality control and company competitiveness in the fertilizer industry.

One of the main challenges in quality control is workers' lack of understanding of the changes implemented in the quality improvement process. In practice, some workers may not fully understand the importance of the Seven Tools and FMEA, and how these methods can help

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reduce product defects. This lack of understanding can fuel resistance to change, especially if workers feel that new procedures add to their workload without clear benefits. For example, in using Pareto diagrams to identify major defects in Phonska fertilizer, some workers may overlook the importance of accurate data collection. As a result, the analysis becomes less effective because the data used is invalid. To overcome this challenge, training and effective communication need to be carried out, so that workers understand the benefits of the methods applied and feel involved in the improvement process. This approach can reduce resistance and increase worker participation in quality control efforts.

Implementation of Seven Tools and FMEA also faces potential resource constraints, such as limited budget, available time, and equipment availability. In the case study at PT Petrokimia Gresik, time and budget limitations can affect the effectiveness of data collection and analysis. The process of collecting defect data from April to October 2024 at PT Petrokimia Gresik takes quite a long time and requires significant manpower allocation. This time constraint can affect the smooth operation of the company, because employees involved in data collection must divide employee attention between daily operational tasks and data collection activities. This data collection must be done consistently to obtain accurate results, but this requires a significant allocation of time from the workforce. In addition, companies must ensure that the data collection process does not interfere with daily operations. In some cases, data collection can be delayed due to limited workforce who also have to carry out other operational tasks. From a budget perspective, limited funds can affect the implementation of quality improvement programs. The costs incurred for employee training in understanding the use of Seven Tools and FMEA, as well as the costs of procuring analysis software, can be a burden for the company. Without adequate budget allocation, the process of employee training and purchasing supporting equipment can be hampered, which ultimately affects the results of data analysis.

Apart from that, limited equipment for measuring and monitoring processes can also be an obstacle. One of the important tools in Seven Tools is the Pareto diagram and control chart, which require special software to create quickly and accurately. If a company does not have adequate software, the process of creating diagrams and data analysis must be done manually, which takes more time and increases the risk of human error in calculations. For example, in the process of identifying the types of defects that occur most frequently, companies need a Pareto diagram to determine improvement priorities. If the diagram is created manually using a regular worksheet, the data collection and processing process becomes more complex and takes longer. As a result, quality improvement efforts that should be carried out quickly become hampered. The solution to overcome these obstacles, PT Petrokimia Gresik can consider employee training in stages to reduce the budget burden, employee training in the use of Seven Tools and FMEA can be carried out in stages. Companies can start by training a small number of employees who can then share their knowledge with other colleagues through internal training sessions. In addition, allocate part of the budget for investment in software that supports the creation of Pareto diagrams, control charts, and FMEA analysis. This software can help speed up the data analysis process and reduce the risk of human error.

Results and Discussion

Seven Tools

Checksheets

A check sheet or inspection sheet is a data collection sheet used to monitor an activity within a certain period. The results of data according to the check sheet can be seen in table 1.2 :

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Table 2. Production data and production defects checksheet

Month	Total Producti on (tons)	Total Production Defects (tons)				Total Number of Defects	% Disabled
		Without Coating oil	Mesh	Caking	Without Color Pigment		
April 2024	27956	550	955.45	606,243	100	2211.69	7.91
May 2024	22138.5	303	305.48	200	250	1058.48	4.78
June 2024	38191	588.7	500.2	360.77	227,613	1677.28	4.39
July 2024	42295	1267,5	271,98	822,9	276	2638,38	6,24
Agustus 2024	40750	628	478,4	495	259	1860,4	4,57
September 2024	35917	544	484,02	343	271,17	1642,19	4,57
Oktober 2024	53477	185	410,674	20	160	775,674	1,45
Total	260724.5	4066.2	3406.20	2847.91	1543.78	11864.1	33.91

Source : PT Petrokimia Gresik

Histogram

A histogram or bar chart that shows the degree of variation in data measurements.

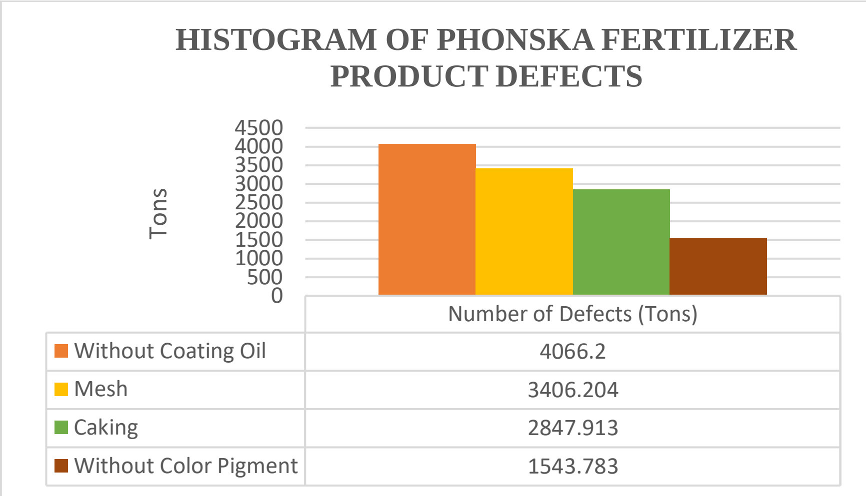

Figure 2. Histogram

Defects in the context of production quality refer to products that do not meet the standards set by the company. At PT Petrokimia Gresik, defects can be products that do not have a protective oil layer (coating oil), mesh defects, caking, or products without the appropriate pigment color. In the context of Phonska fertilizer production at PT Petrokimia Gresik, defects can reduce product value and affect customer trust in the brand. If defects are not handled well, companies risk financial losses and loss of market share. Therefore, identifying the type of defect, the main cause, and corrective steps are very important to maintain product quality and the sustainability of company operations. Based on the results of the histogram above, it can be seen that PT Petrokimia Gresik has 4 types of defects along with the number of defects, namely 4066.2 tons of defects without coating oil, 3406.204 tons of mesh defects, 2847.913 tons of caking defects, and 2847.913 tons of defects without pigment colors as many as 1543,783.

One type of defect found at PT Petrokimia Gresik was a defect without oil coating, which was the most dominant defect with a total of 4066.2 tons. Coating oil functions to coat fertilizer granules so that they do not clump and maintain product stability during storage and distribution. Defects without coating oil are considered critical because without this protective layer the product is at risk of experiencing more rapid clumping (caking), which makes the product difficult for customers to use and reduces physical and visual quality, which can reduce customer confidence. To understand the broader impact of non-oil coating defects, it is important to identify the root cause. Potential causes may include errors in the coating

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process, inappropriate quality of raw materials, or changes in production process parameters. Once the root cause is identified, corrective steps such as process adjustments, quality control improvements, or operator training can be taken to reduce the defect.

Temporal analysis is critical in understanding defect patterns that occur over time. By analyzing defect data on a regular basis, companies can identify trends, seasonal patterns, as well as specific periods where defects tend to increase. From the data above, it can be seen that defects without oil coating are the defects with the highest number. It is important to analyze whether the number of these defects increases over time, as well as what factors influence the fluctuations in the number of defects. An increase in defects may occur during times of high volume production, when stress on machines and operators increases, or when the quality of raw materials changes. By analyzing temporal data regularly, companies can take proactive action to reduce defect rates. It is found that defects without coating oil increase during a certain period, companies can increase quality control during this period or carry out additional inspections on machines and raw materials. In this context mesh defects may increase when certain filter machines are used, while caking defects may increase during the rainy season if the air humidity is higher than normal.

Defects that occur in large numbers can affect customer perceptions of PT Petrokimia Gresik products. If customers receive a product that is caking or does not have an adequate protective coating, they may experience difficulty using it and consider switching to another supplier. Therefore, temporal analysis of defects and corrective steps taken based on such analysis are essential to maintain product quality and customer satisfaction. Based on histogram analysis, companies can identify corrective steps that need to be taken to reduce the number of defects. Some actions that can be implemented are optimizing the coating oil coating process, where companies need to ensure that the coating machine works optimally and the coating oil material used is of high quality. The second is by carrying out regular machine maintenance, because machines that are not maintained can increase the risk of defects. The third is monitoring the quality of raw materials because changes in the quality of raw materials can affect the stability and effectiveness of the final product. The fourth is by developing a real-time monitoring system, because this system can help companies identify defects quickly and take immediate action before defects increase. The fifth integrates operator training to increase understanding of the importance of coating oil in the production process. Sixth, by conducting regular quality audits of raw materials to ensure the materials used meet standards. By implementing these steps, PT Petrokimia Gresik can reduce defect rates, improve product quality, and maintain customer satisfaction.

Control Chart

The proportion of defects in a data production process is determined using a control chart p. The P control chart is used for samples that are not constant.

Table 3. Defect Proportion Value Without Coating Oil

Month	**Without Coating Oil**		**Proportion (p=d/n)**	**3σ**	**UCL**	**LCL**	**CL**
	Observation (n) (ton)	**defect**					
April 2024	27956	550	0.0197	0.0022	0.0178	0.0134	0.0156
May 2024	22138.5	303	0.0137	0.0025	0.0181	0.0131	0.0156
June 2024	38191	588,7	0,0154	0,0019	0,0175	0,0137	0,0156
July 2024	42295	1267,5	0,0300	0,0018	0,0174	0,0138	0,0156
Agustus 2024	40750	628	0,0154	0,0018	0,0174	0,0138	0,0156
September 2024	35917	544	0,0151	0,0020	0,0176	0,0136	0.0156

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Oktober 2024	53477	185	0.0035	0.0016	0.0172	0.0140	0.0156
Total	**260724.5**	**4066.2**	**0.0156**				

Based on the defect data without oil coating, a graph will be produced as shown in the image below:

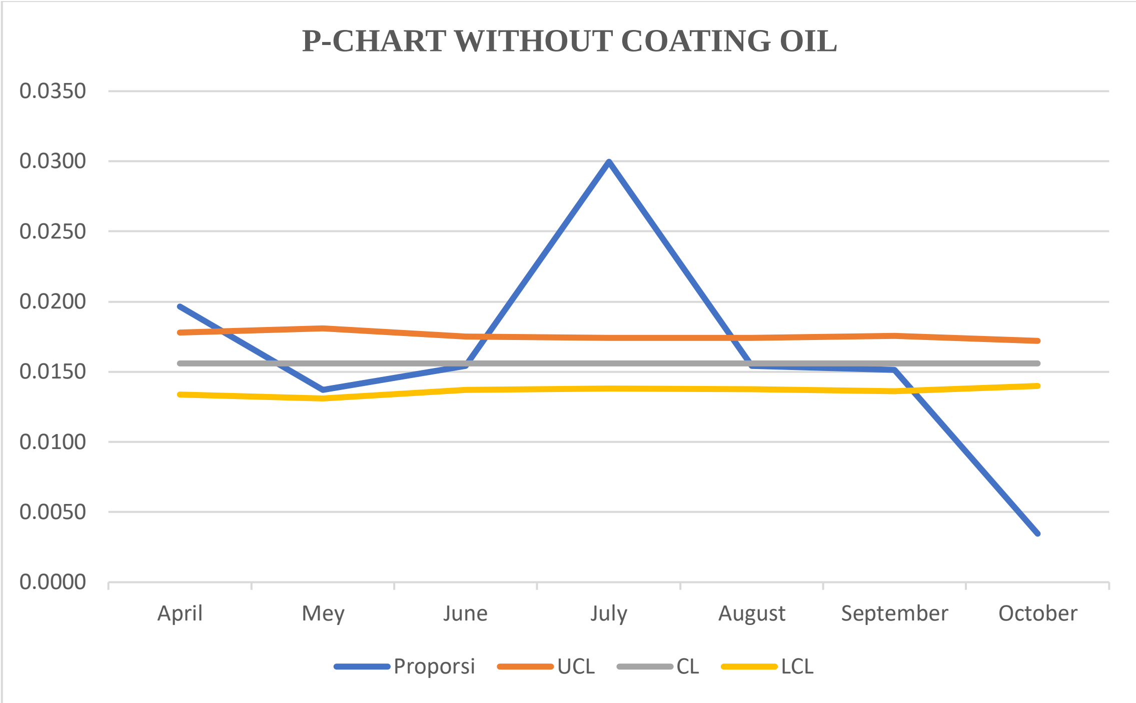

Figure 3. Control Chart Defect Without Coating oil

On the P control chart used to measure the proportion of non-conformity of the inspected phonska fertilizer product, the *pp* value is obtained from the division between the number of product defects ∑d by the number of observations ∑n, which produces a value of 0.015596 where this value also has a role as LK. It is also known that for LKA each observation has a different value, where the LKA value is obtained from the addition of the *pp* value by 3σ. The LKB value is also the same where each observation has a different value, where the LKB value is obtained from the subtraction of the *pp* value by 3σ.

Table 4. Defect Proportion Value Mesh

Month	Mesh		Proportion (p=d/n)	3σ	UCL	LCL	CL
	Observation (n) (ton)	Total defect					
April 2024	27956	955.45	0.0342	0.0020	0.0151	0.01103	0.0131
May 2024	22138.5	305.48	0.0138	0.0023	0.0154	0.01077	0.0131
June 2024	38191	500,2	0,0131	0,0017	0,0148	0,01132	0,0131
July 2024	42295	271,98	0,0064	0,0017	0,0147	0,01141	0,0131
Agustus 2024	40750	478,4	0,0117	0,0017	0,0148	0,01138	0,0131
September 2024	35917	484,02	0,0135	0,0018	0,0149	0,01127	0,0131
Oktober 2024	53477	410,674	0,0077	0,0015	0,0145	0,01159	0,0131
Total	**260724,5**	**3406,204**	**0,0131**				

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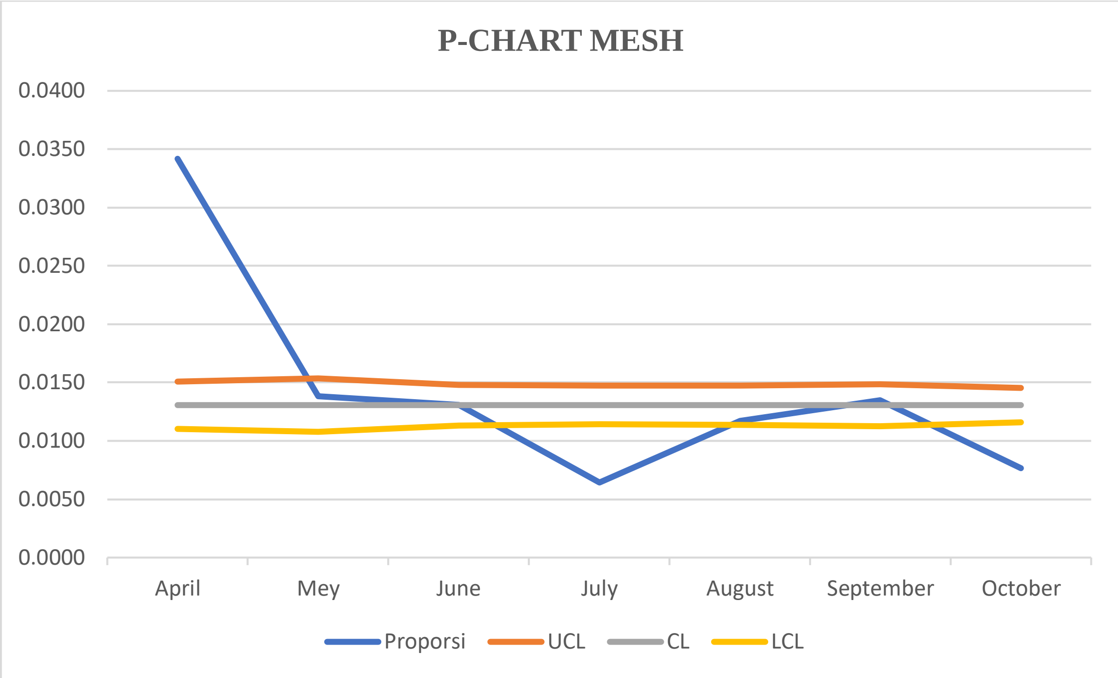

Figure 4. Control Chart Defect Mesh

On the P control chart used to measure the proportion of non-conformity of the inspected phonska fertilizer product, the *pp* value is obtained from the division between the number of product defects ∑d by the number of observations ∑n, which produces a value of 0.01306 where this value also has a role as LK. It is also known that for LKA each observation has a different value, where the LKA value is obtained from the addition of the *pp* value by 3σ. The LKB value is also the same where each observation has a different value, where the LKB value is obtained from the subtraction of the *pp* value by 3σ.

Table 1.5 Defect Proportion Value Caking

Month	**Caking**		**Proporsi (p=d/n)**	**3σ**	**UCL**	**LCL**	**CL**
	Pengamatan (n) (ton)	**defect**					
April 2024	27956	606,243	0,0217	0,0019	0,0128	0,0091	0,0109
May 2024	22138,5	200	0,0090	0,0021	0,0130	0,0088	0,0109
June 2024	38191	360,77	0,0094	0,0016	0,0125	0,0093	0,0109
July 2024	42295	822.9	0.0195	0.0015	0.0124	0.0094	0.0109
Agustus 2024	40750	495	0.0121	0.0015	0.0125	0.0094	0.0109
September 2024	35917	343	0.0095	0.0016	0.0126	0.0093	0.0109
Oktober 2024	53477	20	0.0004	0.0013	0.0123	0.0096	0,0109
Total	**260724,5**	**2847,913**	**0,0109**				

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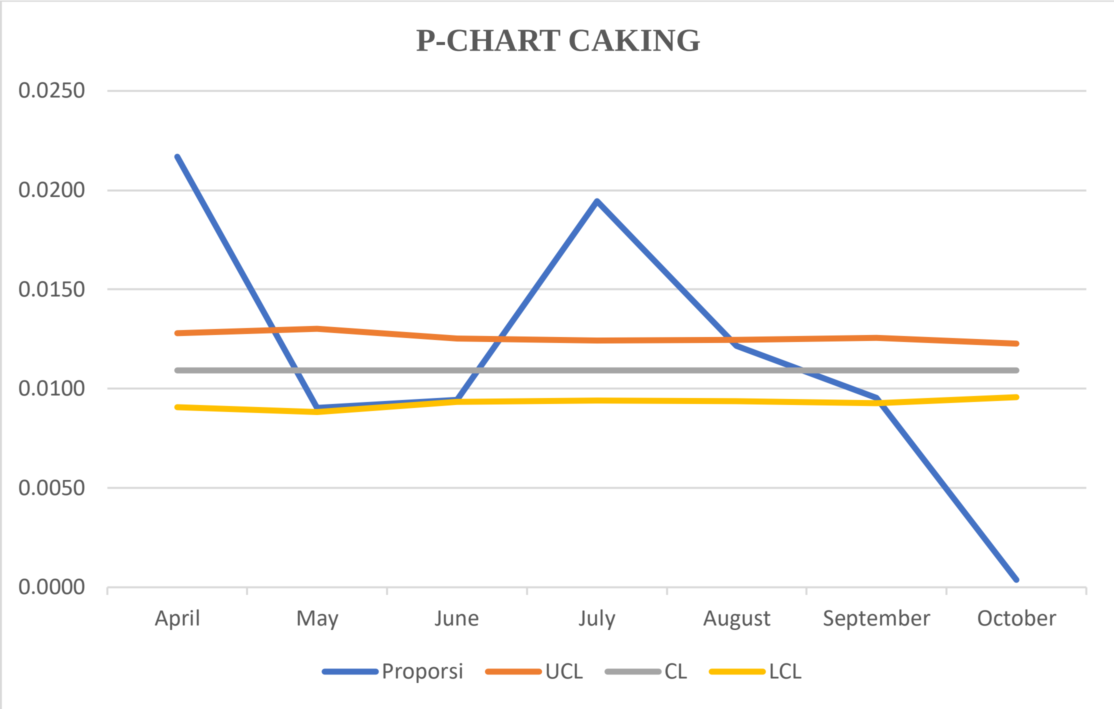

Figure 5. Control Chart Defect Caking

On the P control chart used to measure the proportion of non-conformity of the inspected phonska fertilizer product, the *pp* value is obtained from the division between the number of product defects ∑d by the number of observations ∑n, which produces a value of 0.01092 where this value also has a role as LK. It is also known that for LKA each observation has a different value, where the LKA value is obtained from the addition of the *pp* value by 3σ. The LKB value is also the same where each observation has a different value, where the LKB value is obtained from the subtraction of the *pp* value by 3σ.

Table 1.6 Defect Proportion Value Without Color Pigment

Month	**Without Color Pigment**		**Proportion (p=d/n)**	**3σ**	**UCL**	**LCL**	**CL**
	Observation (n) (ton)	**Defect**					
April 2024	27956	100	0.0036	0.0014	0.0073	0.0045	0.0059
May 2024	22138.5	250	0.0113	0.0015	0.0075	0.0044	0.0059
June 2024	38191	227,613	0.0060	0.0012	0.0071	0.0047	0.0059
July 2024	42295	276	0.0065	0.0011	0.0070	0.0048	0.0059
Agustus 2024	40750	259	0.0064	0.0011	0.0071	0.0048	0.0059
September 2024	35917	271,17	0.0075	0.0012	0.0071	0.0047	0.0059
Oktober 2024	53477	160	0.0030	0,0010	0.0069	0.0049	0.0059
Total	**260724.5**	**1543,783**	**0.0059**				

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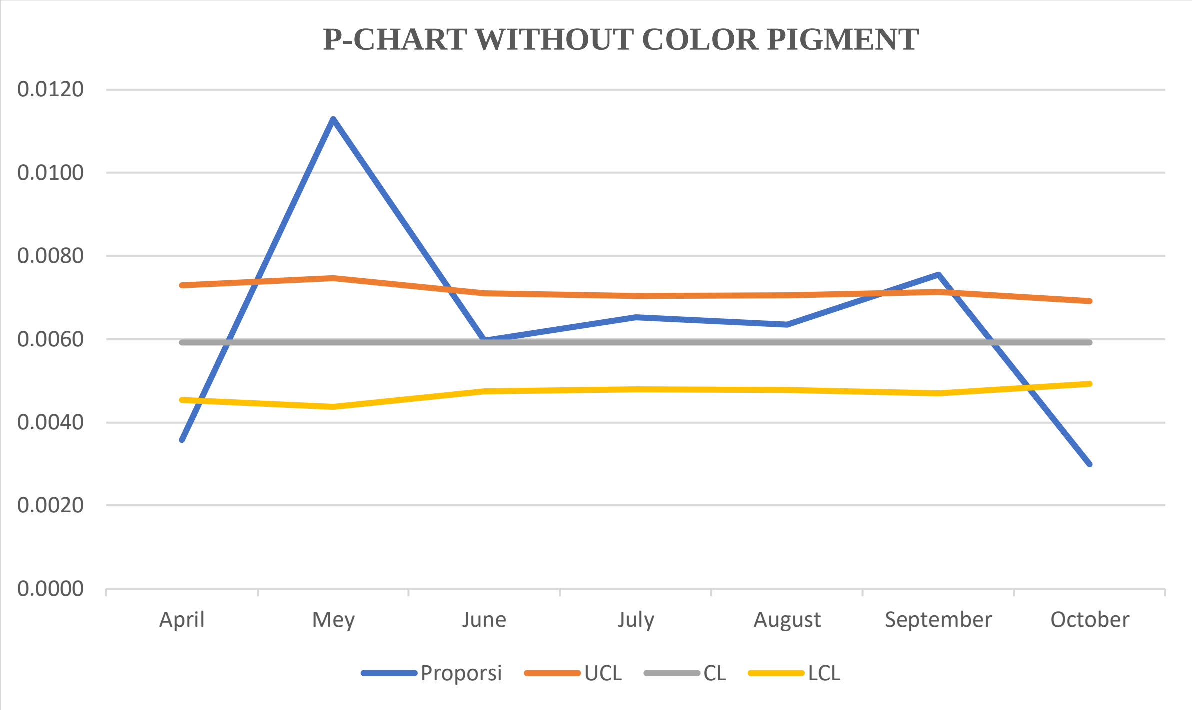

Figure 6. Control Chart Defect Without Color Pigment

On the P control chart used to measure the proportion of non-conformity of the inspected phonska fertilizer product, the *pp* value is obtained from the division between the number of product defects ∑d by the number of observations ∑n, which produces a value of 0.00592 where this value also has a role as LK. It is also known that for LKA each observation has a different value, where the LKA value is obtained from the addition of the *pp* value by 3σ. The LKB value is also the same where each observation has a different value, where the LKB value is obtained from the subtraction of the *pp* value by 3σ.

Pareto Chart

Pareto diagrams are bar graphs that are often used as an interpretation tool to order each type of defect from largest to smallest. After that, the percentage of defects is calculated and the cumulative percentage can be seen in table 1.7.

Table 7. Results of Calculation of Dominant Defect Identification

No	Types of Defects	Number of Defects (Tons)	Disability Percentage (%)	Cumulative Percentage (%)
1	Without Coating oil	4066.2	34%	34%
2	Mesh	3406,204	29%	63%
3	Caking	2847,913	24%	87%
4	Without Color Pigment	1543,783	13%	100%

Based on Table 7, a Pareto diagram is then created. Figure 1.7 is a Pareto diagram.

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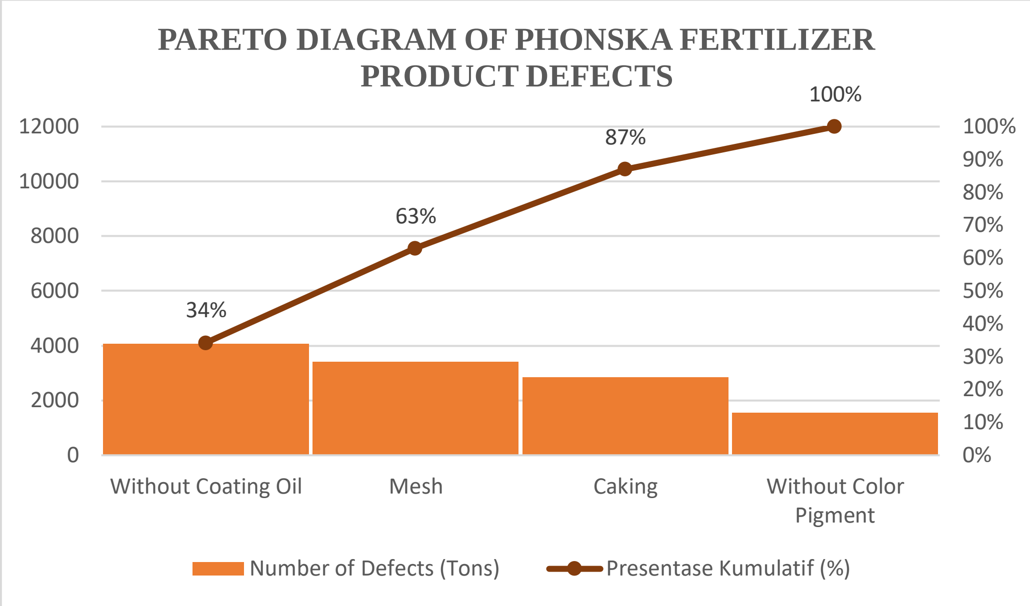

Figure 7. Pareto Diagram

Based on the Pareto diagram above, it can be seen that the highest number of non-conformities in Phonska fertilizer products is in the form of no *coating oil.* with a percentage of 34%, then *the mesh defect* with a percentage of 29%, then followed by *the caking defect* with a percentage of 24% and *Defect* without color pigment with a percentage of 13%.

Fishbone Diagram

The fishbone diagram is used to identify the factors that cause defects. The following are the factors that cause defect.

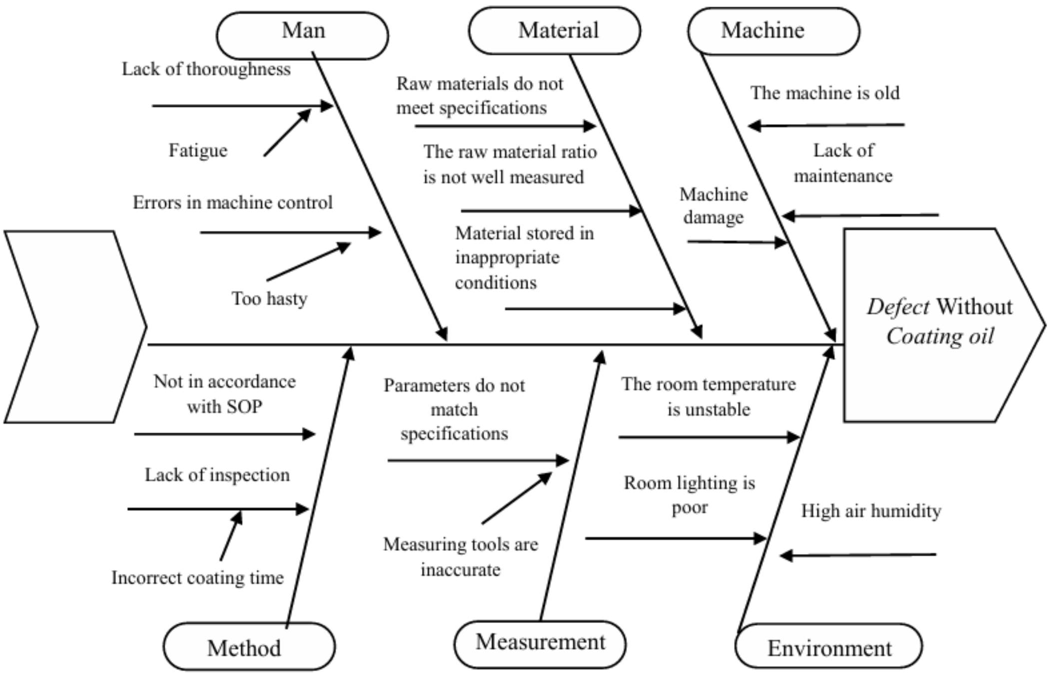

Figure 8. Fishbone Diagram Defect Without Coating Oil

Phonska fertilizer product defects without coating oil are caused by six main factors: humans, materials, machines, methods, measurements and work environment. Human factors include lack of accuracy and operator training. Materials related to raw material quality and contamination. Machines that are not maintained or worn out also affect the coating results.

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Non-standard methods, measurement errors, and unfavorable work environments, such as high humidity and poor lighting, are also the main causes of product defects.

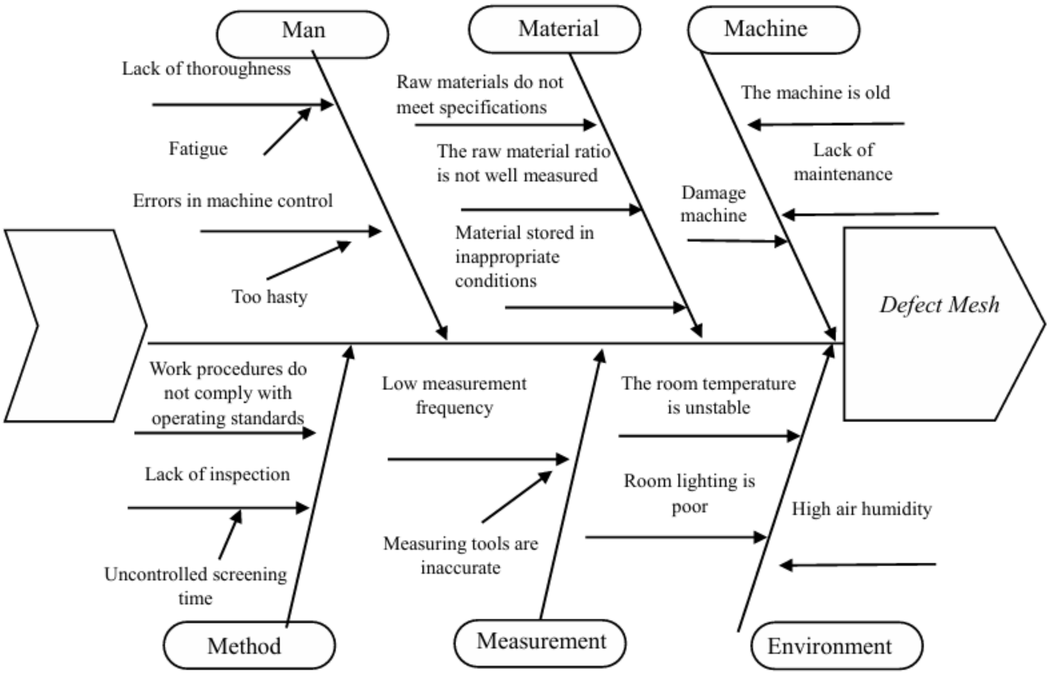

Figure 9. Fishbone Diagram Defect Mesh

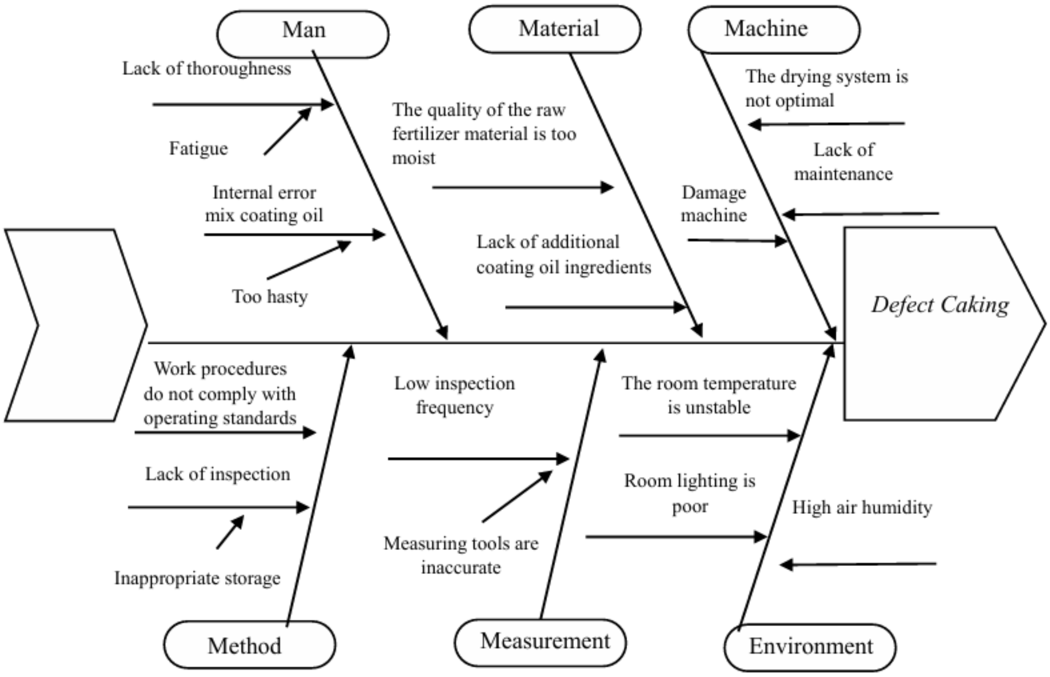

Figure 10. Fishbone Diagram Defect Caking

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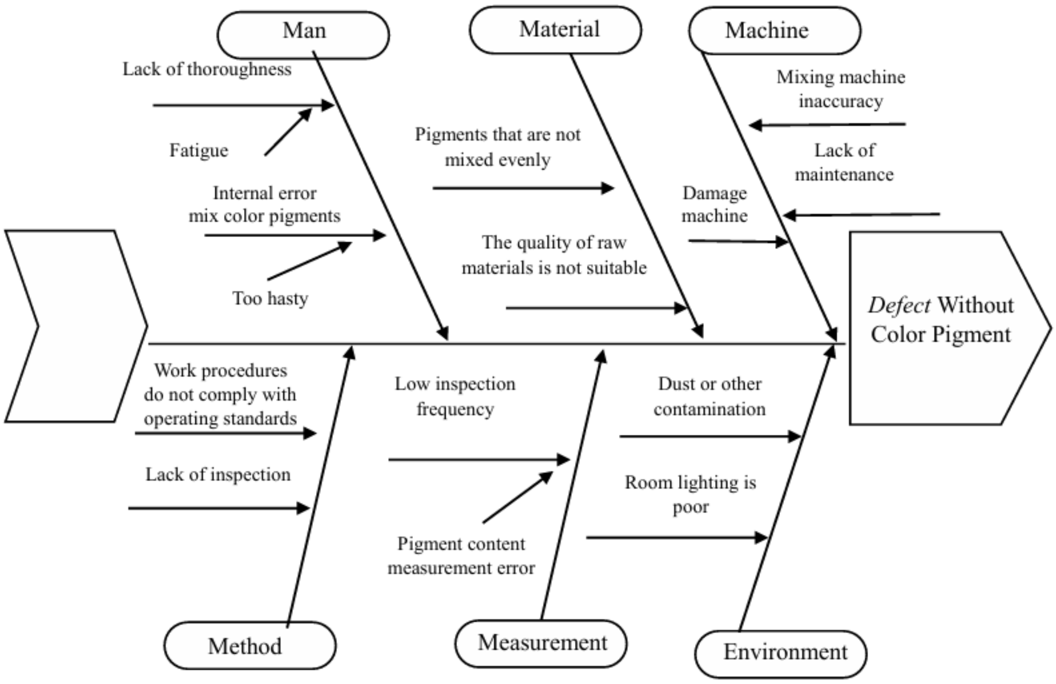

Figure 11. Fishbone Diagram Defect Without Color Pigment

Flowchart

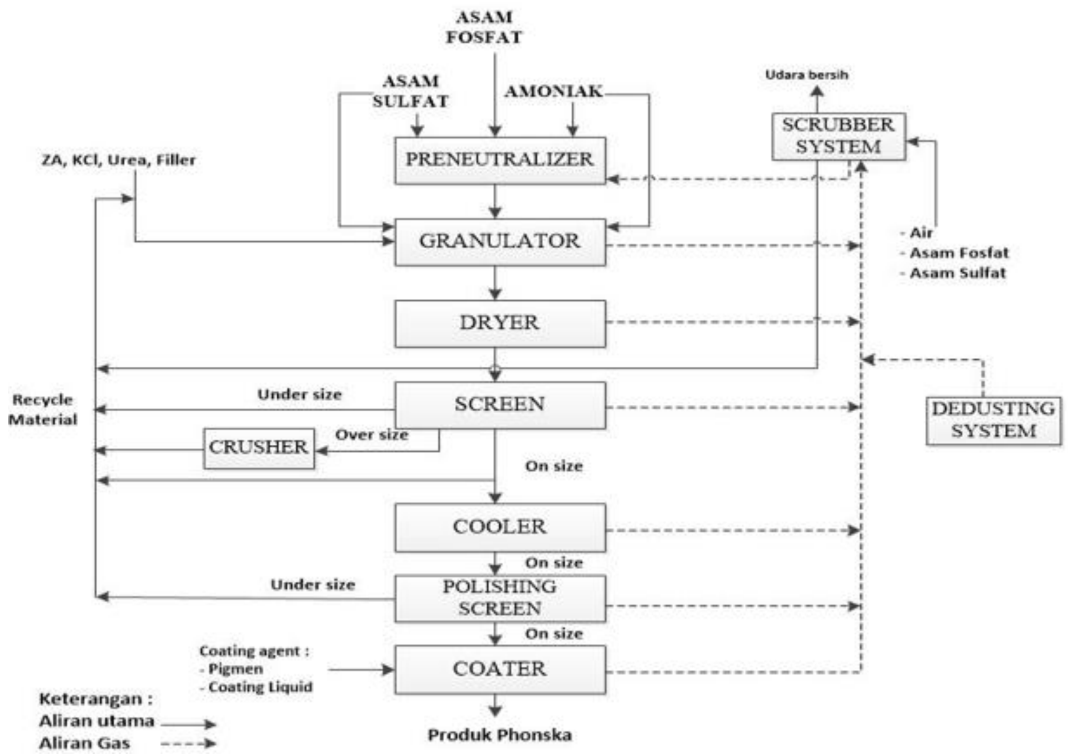

Figure 12. Flowchart for Making Phonska Fertilizer

Scatter Diagram

Scatter diagram is used to show the relationship or correlation between two measurements of defect-causing factors related to a characteristic. Based on the Pareto diagram, the dominant order of defects is defects without *coating oil* , *mesh* , *caking* , without color pigment.

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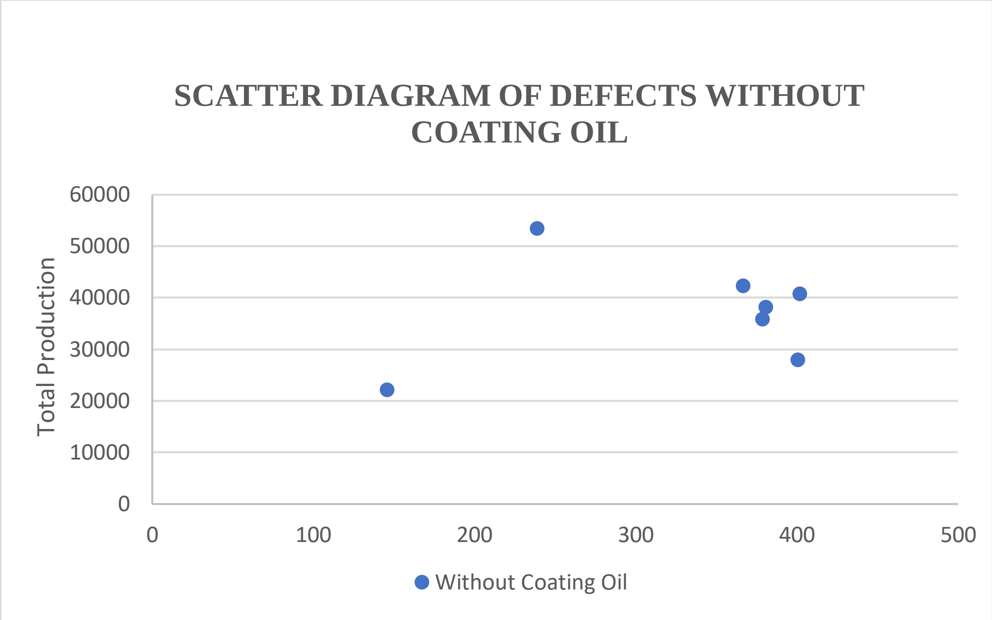

Figure 13. Scatter Diagram Without Coating Oil

Based on the results of the scatter diagram above, it can be seen that the type of defect without *coating oil* can be concluded that between variable X, namely the quantity of defects without *coating oil* of Phonska fertilizer and variable Y, namely the amount of production, there is no correlation, meaning that the amount of defect quantity without *coating oil* does not have an impact on the high amount of production. This happens because the distribution of points in the scatter diagram above moves randomly.

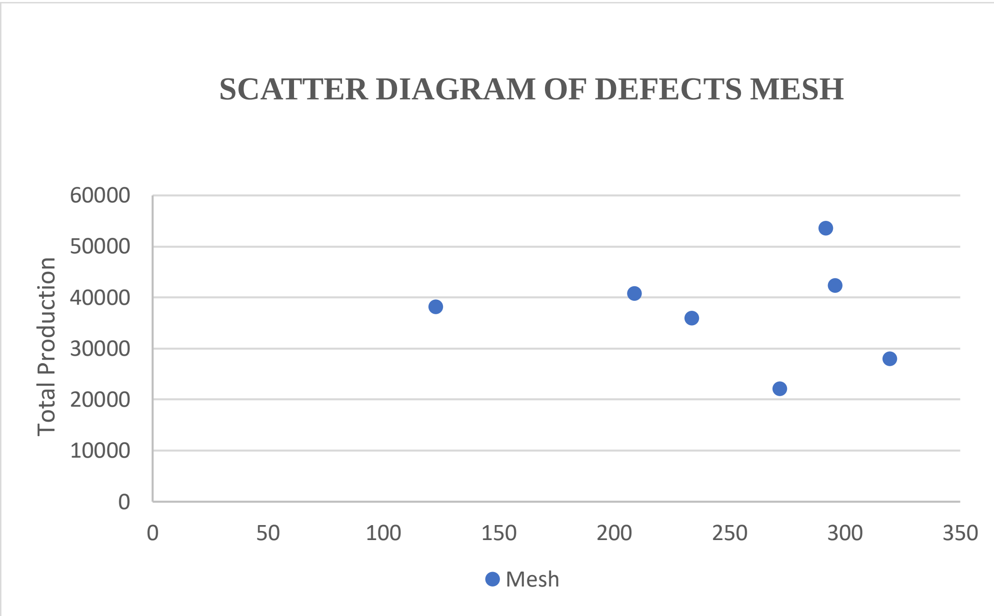

Figure 14. Scatter Diagram Mesh

Based on the results of the scatter diagram above, it can be seen that the type of *mesh defect* can be concluded that between variable X, namely the quantity of Phonska fertilizer *mesh defects* and variable Y, namely the amount of production, there is no correlation, meaning that the amount of *mesh defects* does not have an impact on the high amount of production. This happens because the distribution of points in the scatter diagram above moves randomly.

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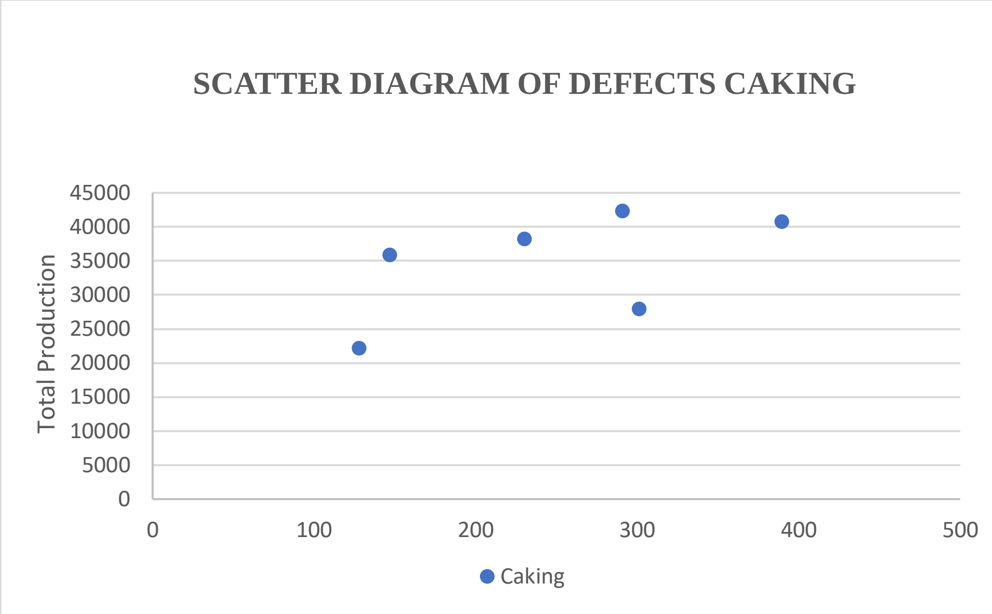

Figure 15. Scatter Diagram Caking

Based on the results of the scatter diagram above, it can be seen that the type of *caking defect* can be concluded that between variable X, namely the quantity of *caking defects* of Phonska fertilizer and variable Y, namely the amount of production, there is no correlation, meaning that the amount of *caking defects* does not have an impact on the high amount of production. This happens because the distribution of points in the scatter diagram above moves randomly.

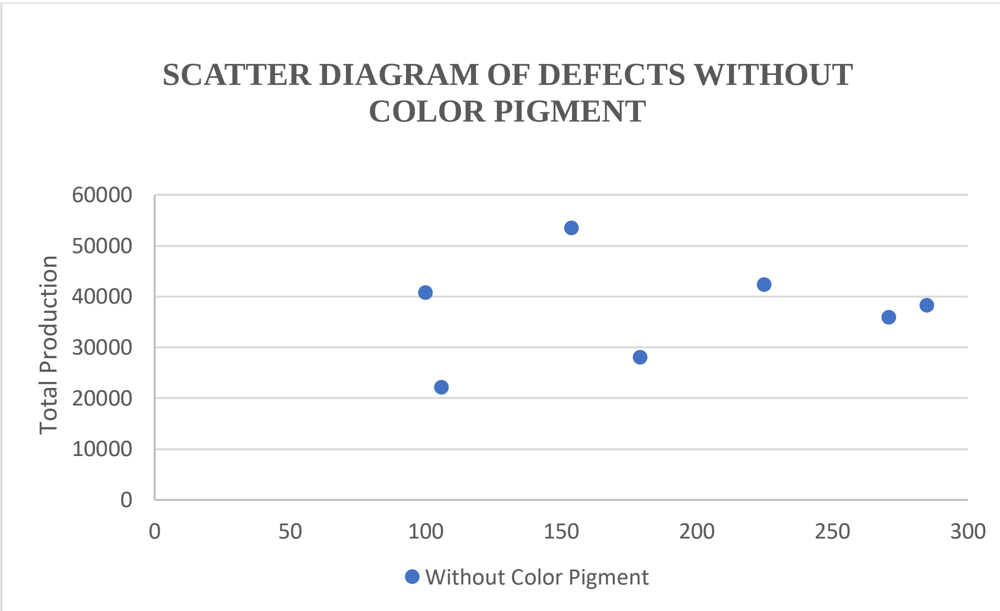

Figure 15. Scatter Diagram Caking Without Color Pigment

Based on the results of the scatter diagram above, it can be seen that the type of defect is without color pigment. it can be concluded that between variable X, namely the quantity of defects without color pigment of phonska fertilizer and variable Y, namely the amount of production, there is no correlation, meaning that the amount of defects without color pigment does not affect the high amount of production. This happens because the distribution of points in the scatter diagram above moves randomly.

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FMEA

Table 8. RPN (Risk Priority Number)

Potential Failure Mode	Potential Effect of Failure Potential	S	Cause	O	Current Control	D	RPN
Without Coating oil	Defects in the form of the absence of an oil coating layer on the product can cause moisture to enter the fertilizer granules, which have the potential to clump and be difficult to apply. This affects the quality and effectiveness of fertilizer in the field.	2	Uneven coating process	4	Periodic training is carried out for operators to ensure proper application of coating procedures	2	16
			Screw feeder speed mismatch	7	Preventive maintenance is carried out to ensure the speed variator functions properly and is free from mechanical damage	7	98
			Oil coating machine that is not functioning optimally	2	Machine inspection and maintenance are carried out regularly before and after use	5	20
Mesh	Defects in the mesh, namely fertilizer particle sizes that do not meet standards, can cause fertilizer to spread unevenly on agricultural land. This reduces the effectiveness of fertilizer application but can still be improved in the production process	4	Mismatch in granule size on vibrating screen	2	Routine checks and calibrations are carried out on the vibration system to ensure vibration stability	5	40
			Blockage in Screen Feeder 9F-301 A/B/C/D)	6	A routine inspection schedule is carried out on the condition of the mesh screen to ensure there is no accumulation of material or damage to the fertilizer	3	73
			Damage to the crushing mill or crusher	6	Carry out regular checks and ensure there is no wear or damage that could affect	4	96

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Potential Failure Mode	Potential Effect of Failure Potential	S	Cause	O	Current Control	D	RPN
					screening efficiency and replace worn crusher chains before they become damaged		
Caking	Defects in the form of caking or clumping can cause difficulties in applying fertilizer and reduce the quality of its distribution. Clumped fertilizer needs to be re-crushed before use, but this defective product remains unmarketable	7	Storage warehouse conditions are not controlled	6	Implementation of standardized storage procedures and routine monitoring by warehouse staff	5	210
			The process of cooling fertilizer after production is not carried out optimally	4	Routine checks are carried out to ensure the cooler fan is functioning optimally and real-time temperature monitoring	3	84
			Lack of use of additional coating oil ingredients	2	Strict checking of raw material composition before production to ensure compliance with standards.	2	28
Without Color Pigment	Defects in the form of the absence of color pigments in fertilizer can confuse customers in recognizing the product and give the impression that the product does not meet standards. However, this does not affect the main function of fertilizer	5	Lack of operator training in managing fertilizer coloring	2	Direct supervision by the operator at the mixing stage to ensure the pigment is mixed evenly	3	30
			Color pigments are not mixed perfectly because the mixing time is too short	6	Use of automatic timer to set the right mixing time	3	90
			The mixing or pigment injection system on the machine is damaged so the color is uneven	4	Routine maintenance and periodic checking of the pigment mixing and injection system	2	40

Source : PT Petrokimia Gresik

Table 9. RPN (Risk Priority Number) Recap

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Number	Failure Mode	RPN
1.	Storage warehouse conditions are not controlled	210
2.	Screw feeder speed mismatch	98
3.	Damage to the crushing mill or crusher	96
4.	Color pigments are not mixed perfectly because the mixing time is too short	90

Source : PT Petrokimia Gresik

Seven Tools method is a series of statistical tools used to analyze and solve problems in product quality control. These seven tools include checksheets , histograms, control charts, Pareto diagrams, fishbone diagrams, flowcharts , and scatter diagrams. Checksheets are used to collect and record product defect history data obtained from the company systematically with a total production in that period of 260,724.5 tons and a total defective product of 11,757.1 tons . The histogram provides an overview of the data distribution. PT Petrokimia Gresik has 4 types of defects along with the number of defects, namely defects without coating oil as much as 4066.2 tons, mesh defects as much as 3406.204 tons, caking defects as much as 2847.913 tons, and defects without color pigment as much as 1543.783. Control Chart monitors the stability of the process over time . The P control chart shows points outside the control limits in July and October for various product defects, such as no coating oil , mesh , caking , and no color pigment. The proportion of nonconformities is calculated based on the number of defects and observations, with LKA and LKB calculated using 3σ. These deviations indicate problems in quality control, so further analysis and corrective actions are needed to improve product quality and reduce the risk of failure . Pareto diagrams are used to identify major problems by sorting the frequency or impact of the problems, so that efforts can be focused on the most significant problems. It can be seen that the highest number of nonconformities in Phonska fertilizer products is in the form of no coating oil with a percentage of 34%, then the mesh defect with a percentage of 29%, then followed by the caking defect with a percentage of 24% and Defect without color pigment with a percentage of 13%. Cause-and-effect diagrams (fishbone) help find the root cause of the problems that occur. F lowcharts visually describe the process flow to facilitate identification of potential problems. Finally, scatter diagrams are used to see the relationship between two variables. The combination of these tools allows for in-depth analysis of the causes of defects and variability in the production process, and helps in decision making for quality improvement.

This research uses the Failure Mode and Effect Analysis (FMEA) method to determine the priority scale of product defects that require quality improvement through appropriate improvement proposals. Based on the results of FMEA analysis, some of the highest RPN values were found for various types of product defects. In the defect without coating oil, the highest RPN value of 98 is caused by a mismatch in the screw feeder speed in the fertilizer making process. The proposed improvement is to carry out preventive maintenance to ensure the speed variator functions properly and is free from mechanical damage. Furthermore, defects in mesh have the highest RPN value of 96, which is caused by damage to the crushing mill or crusher. Recommended repairs include regular checks to ensure there is no wear or damage affecting screening efficiency, as well as replacing worn crusher chains before they fail. For the caking defect, the highest RPN value reached 210 due to uncontrolled storage conditions. The proposed improvements involve implementing standardized storage procedures as well as regular monitoring by warehouse staff. Lastly, the defect without color pigment has the highest RPN value of 90 due to the color pigment not being completely mixed because the mixing time is too short. To overcome this, it is recommended to use an automatic timer to set the optimal mixing time.

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Conclusion

Based on the results of interviews and observations obtained, it can be seen that the study shows that the level of defects in Phonska fertilizer products at Phonska Warehouses II and III of PT Petrokimia Gresik has a certain pattern that can be grouped based on the type of defect such as without coating oil, mesh, caking, without color pigment. The method that can be used in analyzing the causes of Phosnka fertilizer defects in Phonska II and III Warehouses of PT Petrokimia Gresik by applying the Seven Tools method has successfully identified the root causes of product defects through a systematic approach using tools such as checksheets, histograms, control charts, Pareto diagrams, fishbone diagrams, flowcharts, and scatter diagrams. The results of the analysis show that most product defects are caused by human factors due to lack of supervision and environmental factors due to uncontrolled warehouse conditions. The application of the Seven Tools method has proven effective in identifying and addressing the root causes of product defects, thus contributing to reducing the level of defects and increasing the efficiency of the overall production process. However, there are several aspects that still require attention, such as improving quality control and routine equipment maintenance.

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