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ANALYSIS OF COFFEE ROASTING PROCESS IMPROVEMENT AT SMALL COFFEE USING SEVEN TOOLS AND TRIZ METHOD

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Abstract

This study aims to improve the quality of the coffee roasting process at Small Coffee, an MSME located in Cikarang, by applying the TRIZ (Theory of Inventive Problem Solving) method and the Seven Tools of Quality Control. The roasting process often faces defects in coffee beans, such as unripe, broken, and burnt beans, which reduce product quality and customer satisfaction. To determine the root causes and influencing factors, the study utilized a fishbone diagram, affinity diagram, and scatter diagram. These tools helped identify critical process inefficiencies and quality issues. Subsequently, the TRIZ method was employed to propose innovative solutions that resolve contradictions in the roasting process without creating new problems. The proposed improvements are expected to enhance process efficiency, lower the defect rate, and ensure consistent product quality. Moreover, the implementation of these solutions provides tangible benefits for Small Coffee and serves as a model for other MSMEs in the coffee industry aiming to boost their competitiveness and long-term sustainability. This research highlights the synergy between systematic problem-solving tools and innovation frameworks in optimizing small-scale industrial processes.

Keywords: ***Coffee roasting, Innovation, Product defects, Quality control, TRIZ***

INTRODUCTION

The coffee industry in Indonesia has experienced rapid growth in line with the increasing public interest in high-quality coffee and a more modern lifestyle. Coffee is no longer just a daily beverage but has become an important economic commodity that can enhance the income of small and medium-sized enterprises (SMEs), such as coffee shops. One of the key factors that determine the final quality of a coffee product is the roasting process, which aims to develop the desired flavor, aroma, and texture.

However, in practice, the roasting process often encounters various obstacles that can significantly affect product quality. Common issues include defects in coffee beans, such as underdeveloped, broken, scorched, or burnt beans, which can degrade the taste and aroma of the coffee and reduce its competitiveness in the market. These defects are typically caused by interconnected factors such as machine condition, human resources, raw materials, work methods, and the surrounding environment during the roasting process (Yanottama et al., 2020).

To address these challenges, a systematic and innovative approach is needed to ensure a more stable roasting process that consistently produces high-quality coffee. One effective method is TRIZ (Theory of Inventive Problem Solving), which aids in identifying contradictions within the process and applying inventive principles to resolve them without creating unwanted side effects. In addition, the use of the Seven Tools—such as the fishbone diagram, affinity diagram, and scatter diagram—is highly beneficial in identifying root causes of defects and understanding the comprehensive factors that influence the production process (Pratikno, 2020).

The implementation of these methods is expected to enhance the efficiency of the roasting process and the quality of coffee products at SMEs like Small Coffee. This allows small-scale industries to compete more effectively in both local and national markets while meeting the quality standards expected by consumers. Moreover, this study aims to provide practical contributions to the development of the SME coffee industry through a systematic and innovative approach that can be adopted by other business actors, thus improving their competitiveness and business sustainability.

By integrating defect cause analysis with TRIZ-based innovative solutions and the Seven Tools, it is expected that the roasting process can be better controlled, defect levels reduced, and overall product quality improved. This approach is not only relevant for the Small Coffee industry but may also serve as a reference for improving coffee production processes in other regions facing similar challenges (Gadd, 2011).

LITERATURE REVIEW

The literature review is a critical component of your research paper, providing a comprehensive overview of existing research and theoretical frameworks related to your topic. This section serves to establish the context of your study by summarizing and synthesizing relevant literature, highlighting key findings, methodologies, and gaps in current knowledge.

In this section, you should:

- Identify and critically evaluate previous studies pertinent to your research question. This includes examining the strengths and weaknesses of earlier work, and how they inform your own research.
- Discuss the theoretical frameworks and concepts that underpin your study, providing insights into how they relate to your research objectives.
- Highlight any controversies, discrepancies, or debates within the existing literature, emphasizing areas where your study contributes new knowledge or perspectives.
- Conclude with a clear statement regarding the gaps in the literature that your research aims to address, setting the stage for your study's significance and intended contributions.

Ensure that the literature review is well-organized, flowing smoothly between topics, and logically leading to your research questions or hypotheses. Proper citations and references are essential to uphold academic integrity and provide credit to original authors.

METHOD

Data collection in this study was conducted through direct observation in the production area of Small Coffee, specifically focusing on the coffee roasting process. The observations were carried out systematically to obtain accurate and relevant data regarding the activities involved in the roasting process, from the initial to the final stages. The collected data consisted of direct observations of the process flow, including various variables related to the quality of the roasting results, such as temperature, roasting time, coffee bean maturity level, and defects appearing on the beans after roasting.

After collecting the observational data, the next step was to identify the types of coffee defects that occurred during and after the roasting process. This identification aimed to determine the defects that could affect the final quality of the coffee product, such as burnt beans, raw beans, uneven color, and off-standard aroma and taste. The identification process was adjusted to the stages of the roasting process carried out at Small Coffee. To assist in the analysis, tools such as the Affinity Diagram and Fishbone Diagram were used. The Affinity Diagram helped group defect data based on similarities and relationships among issues, while the Fishbone Diagram was utilized to trace the root causes of each defect.

Next, in seeking solutions to the identified problems, the TRIZ (Theory of Inventive Problem Solving) method was applied. This method began with identifying contradictions occurring within the roasting process, especially those related to product defects. These contradictions might include conflicts between improving process efficiency and maintaining product quality, or between roasting speed and flavor consistency. Based on these contradictions, the TRIZ method was used to formulate innovative solutions that not only resolve the problems but also avoid compromises that could harm product quality.

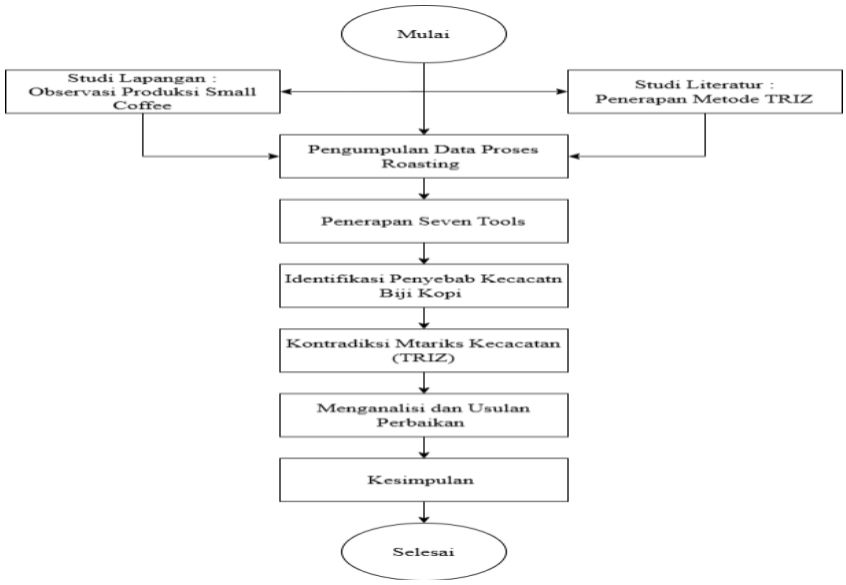

Image 1: Research Flowchart

The implementation of the TRIZ method in this study served as a basis for providing systematic improvement recommendations prioritized according to the main issues causing product defects at Small Coffee. These recommendations were developed based on in-depth analysis of defect data, field observations, and findings from the analytical tools used. The proposed improvements are expected to significantly enhance the quality of the coffee roasting process at Small Coffee, reduce product defect levels, and increase customer satisfaction with the coffee products produced.

RESULTS AND DISCUSSION

The Seven Tools method is a useful aid for mapping the scope of problems, organizing data into diagrams for easier understanding, tracing various possible causes of issues, and clarifying the actual facts or phenomena related to the problem. According to Neyestani B (2017), the seven tools introduced by Dr. Ishikawa are: check sheets; graphs (trend analysis); histograms; Pareto diagrams; cause-and-effect diagrams; scatter diagrams; and control charts.

Table 1. Coffee Bean Success Data

Total coffee beans	Total coffee roasting in week 1	Total coffee roasting in week 2	Total coffee roasting in week 3	Total coffee roasting in week 4	Total successful coffee bean roasting within 1 month
617kg	169kg	135kg	113kg	85kg	502kg

Table 2. Coffee Bean Defect Data

Total defects of all coffee beans	Total coffee defects in week 1	Total coffee defects in week 2	Total coffee defects in week 3	Total coffee defects in week 4
115kg	54kg	23kg	20kg	18kg

The data above shows the total amount of coffee beans purchased in one month, totaling 617 kg, with successful roasting yields of 169 kg in the first week, 135 kg in the second week, 113 kg in the third week, and 85 kg in the fourth week. The total defects obtained amounted to 115 kg, calculated from 617 kg – 502 kg = 115 kg, then 115 ÷ 617 × 100% = 18.64%, which is rounded to 19%. The overall success rate of roasted coffee beans in one month is 502 kg, rounded to 81.36%. During the one-month roasting process, several defects occurred, including black beans, which consistently showed a relatively high defect rate from the first to the fourth week. The researcher then conducted an analysis of several errors that occurred during the roasting process, leading to an evaluation of the roasting machine and the coffee roasting procedures.

Next, the types of defects occurring in the coffee beans after roasting were identified. These defects include various forms of damage or quality non-conformities such as burnt beans (over-roasted), raw beans (under-roasted), uneven color, excessively hard or fragile texture, as well as aroma and flavor not meeting the expected quality standards. To support accurate analysis, defect data were collected based on the average volume of coffee roasted over the course of one month. This approach allowed the researcher to obtain a more representative and stable overview of the actual conditions in the field, serving as a basis for analysis and decision-making.

Data processing in this study was conducted systematically and structurally to gain a deep understanding of the causes of defects in the coffee roasting process. The initial step involved identifying various causes of defects and problems that arose during roasting. This identification was carried out using an Affinity Diagram, an analytical tool that groups information and data based on similarities or logical relationships between elements. Through this process, the researcher categorized the various problems observed into main categories that constitute the root causes in the production process (Fauzan Adzima A, 2023).

After identifying the types and quantities of defects, the next step was to apply the TRIZ method to find improvement solutions for the identified problems. The application of TRIZ in this context began with formulating technical contradictions that are the root causes of defects during the roasting process. These contradictions were analyzed using 39 engineering parameters, which are common parameters in engineering and technology, such as process efficiency, temperature accuracy, time stability, product quality, and others. Each parameter was selected based on the specific conditions observed at Small Coffee.

Once the technical contradictions were formulated, the next step involved constructing the TRIZ contradiction matrix. This matrix is used to match conflicting parameters in the roasting process with 40 inventive principles offered by the TRIZ method as innovative solutions. By referring to this matrix, the researcher could identify suitable principles to resolve contradictions without compromising quality or efficiency. For example, if there is a contradiction between roasting speed and final product quality, TRIZ may suggest solutions such as process segmentation, temperature parameter adjustment, or the development of real-time monitoring methods as improvement approaches (Zakariya Y, 2020).

Therefore, the data processing in this study is not only descriptive of the problems but also analytical and solution-oriented, with the final result being concrete improvement recommendations that can be applied to enhance the quality of the roasting process at Small Coffee and significantly reduce the product defect rate.

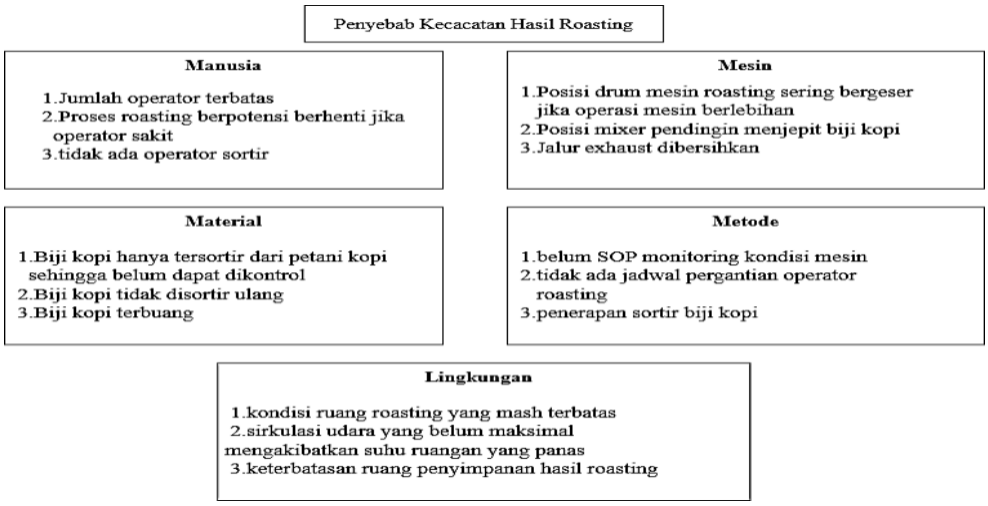

Image 2: Affinity Diagram

Based on Image 2, the diagram illustrates various causes of defects in roasted coffee, categorized into five main factors: Man, Machine, Material, Method, and Environment. Each factor is interconnected and contributes to the final outcome of the roasting process. Issues such as limited operator capacity, poorly maintained machines, unsorted raw materials, non-standard work procedures, and unfavorable environmental conditions can all lead to a decline in roasting quality. Therefore, to improve the quality of the roasting results, comprehensive improvements must be made to each contributing factor, such as increasing the number of trained operators, implementing regular machine maintenance, establishing clear standard operating procedures, and enhancing the workspace and production flow. This approach will help create a more stable and efficient roasting process, consistently producing high-quality coffee.

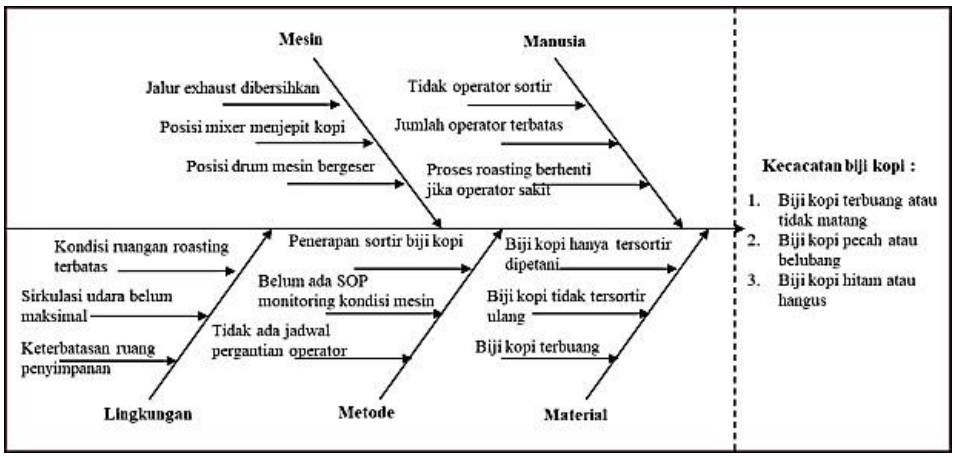

Image 3: Fishbone Diagram

Image 3 illustrates that defects in roasted coffee are caused by multiple interrelated factors, including machine condition, workforce, raw materials, work methods, and the working environment. To prevent coffee beans from being damaged, all of these factors must be addressed simultaneously—for example, by increasing the number of operators, developing standard operating procedures, maintaining machines, and improving the workspace. These improvements are essential to ensure a more stable roasting process and higher quality coffee results.

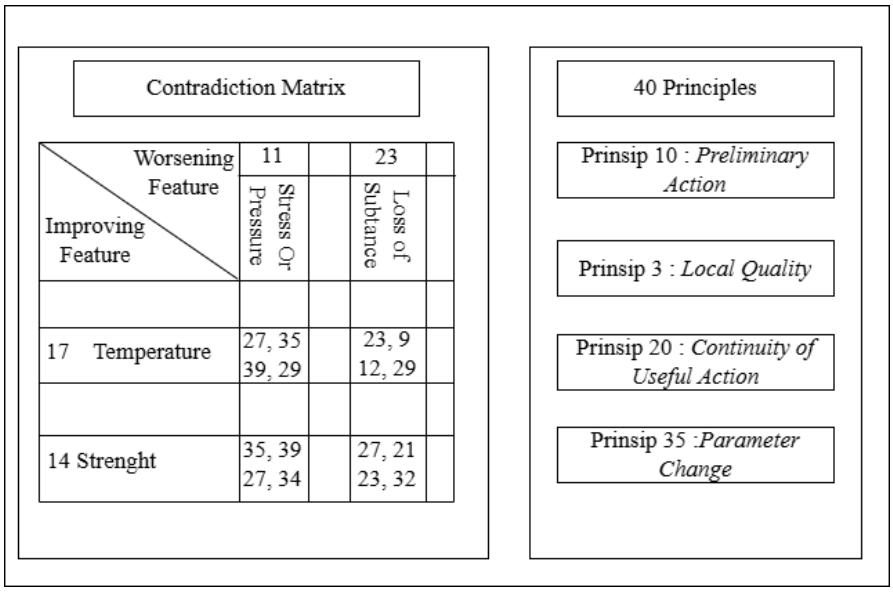

Image 4: Application of the TRIZ Contradiction Matrix

Image 4 illustrates that the TRIZ Contradiction Matrix is a problem-solving tool used to find solutions when two technical aspects are in conflict. We simply select the feature we want to improve (such as temperature or tool

strength) and the feature that deteriorates as a result of that improvement (such as pressure or material loss). The matrix then points to specific TRIZ principles that can be applied to resolve the issue. Each principle offers a creative approach such as taking action in advance, changing parameters, or dividing the process allowing us to solve problems without creating new ones. In the coffee roasting process, this method is highly useful for improving roast quality, equipment efficiency, or flavor consistency without damaging tools or wasting raw materials. With TRIZ, solutions become more systematic and no longer rely solely on trial and error.

Formulating Coffee Roasting Defect Contradictions

At this stage, technical contradictions arising in the coffee roasting process are identified and formulated. These contradictions represent problems that lead to defects in the roasted coffee, which ultimately hinder the achievement of optimal roasting quality. The contradictions referred to here are situations where efforts to improve one aspect of the roasting process inadvertently cause a decline in another aspect. Therefore, each defect or issue identified during the roasting process will be further analyzed to determine:

1. Improving Feature – the parameter or process characteristic that is intended to be improved.
2. Worsening Parameter – the parameter that deteriorates as a result of the improvement effort.

These contradictions will be described in detail in this chapter, based on the types of defects that occur during the coffee roasting process. The aim of this stage is to identify the key technical conflicts that obstruct the roasting process, so they can be resolved through the application of innovative principles from the TRIZ methodology (Grigoryan E, 2020).

a) Contradiction of Defects in Under-Roasted Coffee Beans

Table 4. Results of Contradictions in Defects of Under-Roasted Coffee Bean

NO	Kontradiksi kecacatan biji kopi tidak matang
1	Interaksi operasi drum mesin >< Daya tahan bearing *Strength (14)>< Temperature (17)*
2	Kesesuaian operasi drum >< kerentanan perubahan posisi *Manufacturing precision (29) >< Productivity (39)*
3	Kesesuaian operasi drum >< material yang terbuang *Adaptability (35) >< Loss of substance (23)*
4	Putaran mesin roasting>< daya tahan bering *Speed (9) >< strength (14)*

b) Contradiction of Cracked Coffee Bean Defect

Table 5. Results of Contradiction for Cracked Coffee Bean Defect

NO	Kontradiksi kecacatan biji kopi pecah atau berlubang
1	Sortir material >< waktu yang terbuang *Loss of substance (23) >< Loss of time (21)*
2	Kesesuaian Operasi mixer >< putaran mixer *Manufacturing precision (29) >< speed (9)*
3	Kerentanan perubahan posisi mixer >< kesesuaian operasi mixer *Productivity (39) >< manufacturing precision(29)*

c) Contradictions of Defects in Black Coffee Beans

Table 6. Results of Contradictions in Defects of Black Coffee Beans

NO	Kontradiksi kecacatan biji jopi hitam atau hangus
1	Corong exhaust blower >< kesesuaian operasi blower *Temperature (17)>< manufacturing precision (29)*
2	Kesesuaian Operasi blower >< pengaturan suhu dalam drum *Manufacturing precision (29) >< Temperature (17)*

Contradiction Matrix

a) Contradiction Matrix for Defects in Under-Roasted Coffee Beans

Table 7. Results of the Contradiction Matrix for Defects in Under-Roasted Coffee Beans

Worsening parameter		**21**	**23**
Improving parameter		**Productivity**	**Adaptability**
27	*Reliability*	35, 10, 14, 27	12, 17, 23, 29
39	*Productivity*	12, 27	26, 28, 12, 35
9	*Speed*	13, 12, 27, 14	32, 35, 29, 38

b) Contradiction Matrix for Defects in Cracked Coffee Beans

Table 8. Results of the Contradiction Matrix for Defects in Cracked Coffee Beans

	Worsening parameter	**23**	**9**
	Improving parameter	**Reliability**	**Speed**
12	*Shape*	23, 34, 35, 32	28, 13, 32, 24
26	*Amount of substance*	32, 26, 12, 27	12, 27, 32
30	*Harmful factors acting on Object*	35, 12, 34	21, 13, 35, 28

c) Contradiction Matrix for Defects in Cracked Coffee Beans

Table 9. Results of the Contradiction Matrix for Defects in Black Coffee Beans

	Worsening parameter	**17**	**27**
	Improving parameter	**Reliability**	**Reliability**
18	*Brightness*	35, 39, 38	13, 29, 18, 36
29	*Manufacturing precision*	19, 26	17, 18, 27, 26

Recommendations for Improvement

At this stage, solutions are selected to find the most ideal improvement recommendations based on the inventive principles of the TRIZ method.

Table 10. Recommendations for Improvement

Jenis kecacatan	**Prinsip Triz**	**Deskripsi prinsip**	**Rekomendasi perbaikan**
Biji kopi tidak matang	3	*Local quality*	Menambahkan pasak pada silinder
	10	*Preliminary action*	Memberikan pelumas pada bearing
	26	*Copying*	Menyediakan cadangan bearing
Biji kopi pecah	10	*Preliminary action*	Menyediakan alat sortir otomatis
	24	*Intermediary*	Menambahkan Batangan plastik anti panas
	34	*Discarging and recovering*	Jadwal monitoring perbaikan mixer
Biji kopi hitam	36	*Phase transtitions*	Merubah volume saluran exhaust
	19	*Periodic action*	Membersihkan saluran exhaust.

Figure 4 explains the TRIZ Contradiction Matrix is a tool used to find solutions when two technical aspects are in conflict. We simply select the feature we want to improve (such as temperature or power of the tool) and the feature that is worsened by the increase (such as pressure or material loss). The matrix will show the number of TRIZ principles that can be used to solve the problem. Each principle provides a creative approach, such as taking action early, changing parameters, or dividing the process, so that we can solve the problem without creating new problems. In the coffee roasting process, this method is very useful for improving roast quality, equipment efficiency, or coffee

flavor consistency, without damaging equipment or wasting excessive raw materials. With TRIZ, solutions become more systematic and do not only rely on trial and error.

CONCLUSION

This research shows that an innovative approach combining descriptive, analytical, and solutive methods and the use of various tools such as affinity diagrams, fishbone diagrams, scatter diagrams, and TRIZ contradiction matrices can be used to improve the quality of Small Coffee's coffee roasting process. The main causes of defects, such as unripe, broken, and black beans, were systematically identified through the analysis of the factors involved. The results of the analysis showed that the defect rate reached 19% in one month, indicating that the process should be improved to make the product quality more consistent and stable.

By using TRIZ-based solutions, such as the addition of pegs and lubricants, implementation of standardized procedures, and regular maintenance of the machine, the roasting process becomes more efficient and stable. This reduces the defect rate and improves the quality of coffee flavor and aroma. Improved operator training and implementation of standard operating procedures (SOPs) are also crucial to reduce the rate of human error and ensure that the process runs according to established procedures. This method not only improves the efficiency and stability of the process, but also increases the competitiveness of the product in the local and national markets, and helps the business sustainability of small coffee MSMEs.

Overall, the innovative TRIZ method and the Seven Tools of Quality Control proved successful in finding the main causes of defects and creating systematic and innovative solutions. The method is able to sustainably improve product quality, provide practical benefits for the development of the coffee MSME industry, and can be used as a model for the development of coffee production processes in other places facing similar problems. Therefore, to improve the quality and competitiveness of the small-scale coffee industry in Indonesia, this research emphasizes the use of systematic and innovative approaches.

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