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Enhancing Product Design Performance and Efficiency: A Case Study on Coffee Bean Peeling Machine

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ABSTRACT

This paper presents a methodology that integrates Quality Function Deployment (QFD), Value Engineering (VE), and Lean principles to prioritize control tests in product design. The objective of this research is to identify and address the problems associated with the coffee bean hulling machine and propose improvements to enhance its performance and service life. The study was carried out at a manufacturing company specializing in production machines. The House of Quality (HoQ) matrix was developed to prioritize the improvement areas. Meanwhile, the Value Engineering method was employed to propose alternative components considering cost and performance factors, and prioritizing them with a lean approach. The results of the research indicate that the integration of QFD and Value Engineering successfully articulates consumer needs into technical characteristics and provides concrete improvements. Proposed improvements include using a steel blade material, optimizing the transmission, and adding a magnet to the hopper to prevent metal particles from entering the machine, and implementing design changes for improved performance and efficiency. The integration of QFD and VE allowed for the optimization of functionality and cost, ultimately enhancing the value of the product for consumers and reducing manufacturing costs.
Keyword: *Component Optimization, Customer Feedback, Product Design Improvement, Quality Function Deployment, Value Engineering*

ABSTRAK

Artikel ini menyajikan metodologi yang mengintegrasikan prinsip-prinsip *Quality Function Deployment* (QFD), *Value Engineering* (VE), dan *Lean* untuk memprioritaskan pengujian kontrol dalam desain produk. Tujuan dari penelitian ini adalah untuk mengidentifikasi dan mengatasi permasalahan yang terkait dengan mesin penggilingan biji kopi dan mengusulkan perbaikan untuk meningkatkan kinerja dan masa pakainya. Penelitian dilakukan pada perusahaan manufaktur yang mengkhususkan diri pada mesin produksi. Matriks *House of Quality* (HoQ) dikembangkan untuk memprioritaskan area perbaikan. Sedangkan metode *Value Engineering* digunakan untuk mengusulkan komponen alternatif dengan mempertimbangkan faktor biaya dan kinerja, serta memprioritaskannya dengan pendekatan lean. Hasil penelitian menunjukkan bahwa integrasi QFD dan *Value Engineering* berhasil mengartikulasikan kebutuhan konsumen ke dalam karakteristik teknis dan memberikan perbaikan nyata. Usulan perbaikan meliputi penggunaan material bilah baja, optimalisasi transmisi, dan penambahan magnet pada hopper untuk mencegah partikel logam memasuki mesin, serta penerapan perubahan desain untuk meningkatkan kinerja dan efisiensi. Integrasi QFD dan VE memungkinkan optimalisasi fungsi dan biaya, yang pada akhirnya meningkatkan nilai produk bagi konsumen dan mengurangi biaya produksi.
Keyword: Optimasi Komponen, Umpan Balik Pelanggan, Perbaikan Desain Produk, , Quality Function Deployment, Value Engineering

1. Introduction

In today's product design landscape, prioritizing customer needs and demands is paramount. Designing and producing new products that align with customer expectations necessitates a strategic plan to ensure the product's desired capabilities while maintaining competitive costs. Integrating tools like VE and QFD is essential for achieving this objective. Efficient cost management practices, such as target costing, play a crucial role in enhancing the capabilities of the designed model. QFD plays a pivotal role in identifying customer needs and aligning them with engineering requirements to streamline the product design process and minimize the need for design change [1]. The design of a product involves a multifaceted process that requires careful consideration of various factors, including quality, functionality, cost, and sustainability [2]. Integrating QFD and VE to achieve optimal product design has been recognized as a powerful approach [3]. This combination method allows for a structured and systematic product design evaluation, ensuring that it meets customer needs while minimizing costs and environmental impact [4].

QFD is a methodology that focuses on translating customer requirements into product characteristics, ensuring that the final product meets customer expectations [2]. On the other hand, VE is a strategy that assesses the performance, noise, quality, safety, and compatibility of systems to deliver necessary functionalities at the lowest life cycle cost [5]. By integrating these two methods, designers can create products that not only meet customer needs but also reduce costs and environmental impact [6].

Recent studies have highlighted the benefits of combining QFD and VE in product design. For instance, a study on the integration of QFD and VE for designing a Texon cutting tool demonstrated the effectiveness of this approach in improving product quality and reducing costs [7]. Another study on the application of QFD and business model canvas (BMC) for furniture development showed how this integration can lead to better product design and reduced production costs. In the context of the construction sector, VE is particularly important due to its significant impact on greenhouse gas emissions. By integrating QFD and VE, designers can create sustainable and cost-effective solutions that contribute to a more environmentally friendly construction industry [8]. Designing products that meet customer demands while ensuring optimal performance, quality, and cost efficiency is a crucial challenge in today's competitive market [5]. To address this challenge, various product design and development techniques have been developed, including QFD and VE. QFD is a structured methodology that sets targets for product characteristics to ensure optimal customer satisfaction [4]. On the other hand, VE is an organized strategy that assesses the performance, noise, quality, safety, and compatibility of systems to deliver necessary functionalities at the lowest life cycle cost [1]. The integration of QFD and VE is particularly effective in improving product quality and reducing development costs [3]. To maintain customer trust, Company X strives to design products at a low cost while maximizing their functionality. The company prioritizes customer satisfaction through high-quality products, timely delivery, and comprehensive attention to customer needs. As a private company in the manufacturing sector, specializing in industrial machine workshops and adopting a Make to Order production system, it can meet customer orders based on designs, allowing products to be tailored to customer preferences. Company X has produced five units of coffee bean husking machines [13]. These machines are designed to remove or separate coffee bean husks from the beans. Operating the machine is straightforward: simply feed the coffee beans into the machine, and it will start grinding and rotating clockwise. During the coffee bean husking process, several issues arose based on a preliminary questionnaire distributed to users of the coffee bean husking machines to gather several problems, such as dull blades, the shaft of the husking machine experiencing slippage when used at maximum capacity, and the husking blade being damaged due to the entry of small metal particles [14].

These issues resulted in incomplete separation of coffee beans from their husks, increasing processing time, cost, and labor. This led to the question of how to address these problems: how to resolve issues with the coffee bean husking machine? and how to propose improvements to the coffee bean husking machine after applying the QFD and VE methods?

This research aims to address the issues that have occurred at Teknologi Tepat Guna through the application of the QFD method with VE.

This article proposes the integration of VE and QFD to emphasize that merely presenting different alternatives for a function is insufficient; customer opinions on these alternatives must also be taken into account. Recognizing the importance of optimizing cost management in manufacturing new products, this

study aims to provide an integrated approach leveraging three reliable and efficient models, including QFD and VE. Despite their strengths in cost optimization, each of these models has its limitations

QFD is a comprehensive concept that facilitates the translation of customer requirements into the appropriate Technical Attributes (TAs) at each stage of product development and production. Several researchers have explored the integration of cost considerations into the House of Quality (HOQ) offering a valuable tool for cost management during the design phase [15]. Mathematical modeling has also been employed to incorporate cost into QFD planning, with various articles highlighting successful experiments in this area. Originally conceived to gather and analyze customer opinions for developing higher-quality products that meet or exceed customer needs, QFD serves key functions in product development, quality management, and customer need analysis [16]. Conversely, VE plays a crucial role in optimally allocating resources based on the importance level of product functions. In the context of QFD, VE serves as a foundation for synthesizing or prioritizing critical Quality Control (QC) items listed in the HOWs row of a QFD matrix. The VE process commences with analyzing the "as-is" process flow-charts to identify opportunities for enhancing QC items and process areas. While QFD ensures the design of the "right product," VE focuses on achieving the "right product design" through an optimal approach. By applying VE to a project or product, all potential alternatives for satisfying the required functions are thoroughly considered, with the best alternative selected based on customer preferences and associated costs [17].

A critical component of any research endeavor is the literature review, which involves evaluating and analyzing relevant literature to identify potential research gaps that can enhance the field of study. Extensive literature reviews were conducted using various databases focusing on knowledge sharing, transfer, and flow. The authors consulted papers from reputable databases such as Web of Science (WoS) and ProQuest, which host a wide range of well-known publications [18].

Gunnam & Eneyo [9] explores the integration of QFD and VE in smartphone design and cost management. It emphasizes the significance of considering cost in product development, outlines the benefits of using QFD and VE, and presents a case study on the Samsung Galaxy Note 3 to demonstrate how VE techniques can be employed to reduce component costs effectively. Through calculations of various coefficients, the study identifies key components like touchscreen glass, processor, non-electric parts, and supporting materials to achieve cost reduction in smartphone components for improvement, aiming to enhance smartphone design, reduce costs, and align with customer requirements. This approach helps in achieving cost reduction while enhancing the quality of components in smartphone design.

Ishak et al. [5] discussed the integration of QFD and VE in improving product quality. It emphasizes the benefits of using these methods in product design and development, highlighting cost-effectiveness, customer focus, and competitiveness in the market. The integration of QFD and VE has been shown to lead to better decision-making in product planning and design, resulting in increased customer satisfaction and cost efficiency across various industries. The integration of QFD and VE can help companies improve product quality and reduce costs by determining what customers want through QFD and identifying functions of products and services to provide functional needs at a low cost through VE. This integration allows companies to deliver high-quality products, reduce costs, and balance customer satisfaction, cost, and functionality of the product.

Pardosi & Susilawati [1] focused on the development of a betel nut peeler machine in Petaling Village, Keritang Sub-district, using QFD and VE methods. The design process involved identifying user needs, creating a planning matrix, evaluating concepts based on various attributes, and selecting the optimal design alternative. The final machine design includes components like a gearbox, electric motor, hopper, and protective cover, aiming to enhance productivity and quality in the betel nut peeling process in Indonesia. The betel nut peeler machine design process was carried out by gathering data and information about the machines desired by the community using QFD and VE. The machine was designed to be simple to use, efficient, and responsive to the community's needs. The VE approach was used to uncover effective costs to deliver good quality, appearance, or features, aiming to improve product quality, lower costs, boost efficiency, and reduce risk. The key attributes considered during the evaluation of design concepts for the betel nut peeler machine were security, convenience, ease of use, low price, not easily damaged, easy to move, pleasing to the eye, and a minimalist size. By using the machine, the production of betel nut peeling is expected to rise significantly, leading to higher productivity levels. Additionally, the machine is designed to produce completely peeled betel

nut seeds, which enhances the quality of the final product, resulting in higher selling value and improved welfare for the community.

Muhammed & Alawaed [3] discussed the application of QFD and VE in enhancing the product design of a Texon cutting tool in the footwear industry. Through survey research with operators in Indonesia, the study identified operator complaints, customer needs, technical characteristics, and their relationships. The results emphasized the importance of material type and strength in addressing technical challenges. Additionally, the integration of QFD and VE aimed to reduce costs, increase product value, and enhance customer satisfaction. The key technical characteristics highlighted in the research on the Texon cutting tool design were the coating material of the handle, blade material, rod material suppressants, color of the tools, the shape of leg braces, the thickness of session frame, the thickness of the anvil cutter, the thickness of the blade, additional functions, and durability. This integration allowed for the optimization of functionality and cost, ultimately enhancing the value of the product for consumers and reducing manufacturing costs.

Karimi & Jafari [10] studied on developing a new product, the concrete sleeper, by integrating Target Costing, QFD, and VE. A mathematical model is created to optimize cost management, aiming to maximize customer satisfaction while minimizing costs. The study highlights the importance of target costing and VE in product development, showing that the concrete sleeper provides higher customer satisfaction compared to wooden sleepers. Specific technical properties are identified to meet customer needs and reduce manufacturing costs effectively. The study optimizes cost management for the new product, the acicular concrete sleeper, by proposing a price of 1500 Tomans for target costing, which allows for a cost reduction of 1500 Tomans per meter from the current price of the sleeper. Additionally, mathematical modelling and solving based on parameters from Railway Engineering and Production Engineering working groups in Lingo software resulted in a target cost reduction of 1500 Tomans per meter of the sleeper.

Hidayat et al. [11] focuses on adding value to crispy peperek fish products (a processed seafood product) by using QFD and VE methods. The objectives were to develop a value-added crispy peperek product based on customer needs, identify technical requirements using QFD, and analyze the added value using VE. Through surveys, 16 key product attributes (e.g. fresh, savory, crunchy, tasty) and 7 packaging attributes (e.g. sealed, clear plastic, attractive design) were identified based on customer needs. QFD analysis showed the most important technical requirements were using quality materials, cleaning the fish thoroughly, and minimizing leftover oil for the product, and having tightly sealed, durable packaging. The chosen design from the VE analysis was crispy peperek with original flavor, polypropylene plastic packaging, medium size, and 100-125g net weight per pack. This design was found to add IDR 4,692 value per pack, with a 46.92% profit rate compared to selling raw fish.

Pardosi & Susilawati [1] discussed the design of a goat food processing tool using the QFD method. Goat farming is prominent in Indonesia, and an important aspect is feeding the goats efficiently. Currently, most goat breeders still prepare feed manually, which is time-consuming, hazardous, and can affect the quality of the feed. The researchers interviewed three goat breeders in Rejodani District to understand their needs related to goat feed preparation. From the interviews, they identified four main needs: sufficiency, worker health and safety, effectiveness, and consistency of the feed output. Using QFD, the customer needs were translated into technical requirements like automatic mixing, blade design, production volume, dimensions, anthropometric factors, and safety features. Three concept designs were generated and screened, with two being combined into a final proposed design incorporating all the technical requirements. The final design was validated by the three respondents, who agreed that it met their needs for an efficient and safe goat feed preparation system.

Perdana et al. [8] described the development of an aluminum frame product for residential and office buildings using QFD and VE methods. PT KSN, an aluminum frame supplier, faces challenges in meeting various consumer demands with non-standard jamb product designs, resulting in high modification costs. QFD is used to translate consumer needs into technical specifications, while VE aims to streamline the product development process. Key technical specifications identified include developing sliding door protrusions, glass bead shapes, wind pressure testing, adding gasket material, adjusting glass grove width, adding window security material, leak testing, noise testing, layered protection, and pallet shipping. The conclusion is that frame design according to consumer desires is needed to compete with affordable, quality competitors. By using QFD and VE methods, the installation of glass with gaskets and without sealants makes the process more efficient, easy and safe.

Gavareshki et al. [12] presented a methodology that integrates QFD, VE, and lean approach for prioritizing control tests in product design. The key aspects are: The methodology converts customer requirements into control requirements using the four matrices of QFD (product planning, product design, process design, and process control). The control requirements are then converted into control tests. VE technique is applied to weight control tests. Finally, the lean approach is used to prioritize the weight control tests by assessing indices, sub-indices, and specifications to create added value. A numerical application is demonstrated for designing a bullet-head drill used in the oil and gas industry. The results show the proposed integrated methodology can effectively identify and prioritize control tests, while a survey validates its applicability, successful implementation, and effectiveness in increasing organizational productivity through qualified product design.

Ginting et al. [7] evaluate the design of a Texon cutting tool using the integration of Quality Function Deployment (QFD) and Value Engineering (VE). This study argued that the integration of QFD and VE could significantly improve the product design of the Texon cutting tool. Attributes were identified through a series of questionnaires and brainstorming sessions with operators and experts. The QFD process helped to prioritize these attributes based on customer needs and expectations, while VE was used to explore cost-effective alternatives for materials and components that could meet the desired quality without increasing the manufacturing costs. The study identified the most critical attributes and technical characteristics that needed improvement. By applying VE, the researchers found cost-effective alternatives for materials without sacrificing the quality of the product. The final product design was expected to increase customer satisfaction and reduce production costs for the manufacture

2. Method

This research aims to investigate the production process of the Coffee Bean Peeling Machine, a product manufactured by CV. Teknologi Tepat Guna. The study employed a quantitative approach with a survey method to analyze data related to the production process of Coffee Bean Peeling Machines at CV. Teknologi Tepat Guna while focusing on statistical analysis of numerical data. The research method used was a survey, which involved a causal relationship between independent and dependent variables. Data collection involved both primary (direct observation, questionnaires) and secondary data (company and employee data). Various data collection techniques were employed, including observation, questionnaires, interviews, and literature studies.

Meanwhile, the primary objectives of this research are to design and develop a high-quality coffee bean processing machine that meets the needs of coffee users, to identify the key technical characteristics and critical parts of the machine and to evaluate and select the best alternative for the machine's components based on criteria such as durability, cost, and ease of maintenance

3. Result and Discussion

3.1. Result

3.1.1. Data Processing

This chapter discusses the analysis collecting feedback from users of the product through both open-ended and closed questionnaires with a focus on the methodology used to collect and analyze this feedback to improve product design. The open-ended questionnaire allowed users to provide detailed responses about their experiences and opinions, while the closed questionnaire offered structured data with predetermined answer options. From these questionnaires in tabular form, detailing the product attributes such the validity testing ensured that the questions were appropriate for the study, and the reliability testing confirmed that the questionnaire an open-ended questionnaire was distributed to five users of the Coffee Bean Peeling Machine produced by CV. Teknologi Tepat Guna to gather detailed feedback. The questionnaire aimed to evaluate product quality, identify areas for improvement, and gather insights for future product development. The results of the open-ended questionnaire are summarized in Table 1, which lists the product attributes based on user feedback that was consistent in measuring the intended data.

An open-ended questionnaire was distributed to five users of the Coffee Bean Peeling Machine produced by CV. Teknologi Tepat Guna to gather detailed feedback. The questionnaire aimed to evaluate product quality, identify areas for improvement, and gather insights for future product development [19]. The results of the open-ended questionnaire are summarized in Table 1, which lists the product attributes based on user feedback

Table 1. Open Questionnaire Recapitulation

Name	Question Attributes				
	1	2	3	4	5
Respondent 1	600 kg/hour	Diesel	Iron Plate	Stainless steel	Sprockets
Respondent 2	500 kg/hour	Diesel	Iron Plate	Aluminum	Dual belt
Respondent 3	600 kg/hour	Electricity	Hollow Iron	Stainless steel	Gear reducer
Respondent 4	600 kg/hour	Diesel	Iron Plate	Stainless steel	Dual belt
Respondent 5	400 kg/hour	Electricity	Iron Plate	Aluminum	Dual belt
Mode	600 kg/hour	Diesel	Iron Plate	Stainless steel	Dual belt

Meanwhile, based on the results of the recapitulation of the open questionnaire above, Table 2 presents the product attributes in detail, including the machine's capacity, main drive, frame material, blade material, and transmission type.

Table 2. Product Attributes of Coffee Bean Peeling Machine

No.	Product Attributes
1	The capacity of the coffee skin peeling machine is 600 kg/hour
2	The main drive of the coffee skin peeling machine is diesel
3	The material of the coffee skin peeler frame is iron plate
4	The material of the coffee skin peeler blade is stainless steel
5	The transmission of the coffee bean peeling machine is dual belt

A closed questionnaire with predetermined answer options was also used to collect structured data from the product users. This data provides clear information about user satisfaction, problems encountered, and preferences for product features. The closed questionnaire results are summarized in Table 3, which shows the responses of the five users to each question attribute.

Table 3. Closed Questionnaire Recapitulation

No.	Attributes				
	1	2	3	4	5
1	3	5	5	5	5
2	1	2	3	4	4
3	3	5	3	5	4
4	5	4	4	5	5
5	3	4	4	4	4

The questionnaire data underwent validity testing using the Method of Successive Intervals (MSI) to convert ordinal answers to an interval scale. The standard normal density function was used to calculate density values for each Z value, and Scale Value (SV) was determined for each scale. The Pearson correlation coefficient (r) was calculated for each question attribute, and the results showed that all attributes exceeded the critical value at a 5% significance level, indicating that the questionnaire data is valid [20]. The questionnaire's reliability was assessed using Cronbach's Alpha formula, which resulted in a reliability coefficient of 0.7766. This value is greater than the critical value of 0.632 at a 5% significance level with five respondents, confirming the questionnaire's reliability in measuring the correctness of the data collected. From the data processing, it can be concluded that both the open-ended and closed questionnaires used in the study are valid and reliable tools for evaluating the Coffee Bean Peeling Machine and that the data collected provides valuable insights for product improvement and future development [21].

3.1.2. QFD Phase 1

This chapter outlines the initial steps of the QFD process for developing a coffee bean hulling machine including the details of the process of identifying consumer needs, translating them into technical product characteristics, and prioritizing improvements based on consumer preferences [22]. The process begins with identifying consumer needs through an open-ended questionnaire, focusing on aspects such as capacity, drive, colour, material, and net weight. The importance of these attributes is determined using mode values from a closed questionnaire. A Planning Matrix is created to measure consumer satisfaction and calculate the

Improvement Ratio for sales points, while absolute and relative weights assess the importance of each variable [23].

Technical characteristics of the product, including Strength, Ease of Maintenance, Product Colouring, Structural Durability, and Comfort of Use, are determined through interviews with supervisors. The degree of relationship between these technical characteristics and consumer desires is represented in a relation matrix using a scale (9, 3, 1, 0) to determine the relationship score. The House of Quality (HoQ) Phase I Matrix is constructed, calculating performance measures like difficulty, importance, and estimated cost based on the weighted relationships among technical characteristics [24]. This matrix guides product development, considering the relationship between technical characteristics and critical parts, as well as difficulty, importance, and estimated cost (Fig. 1).

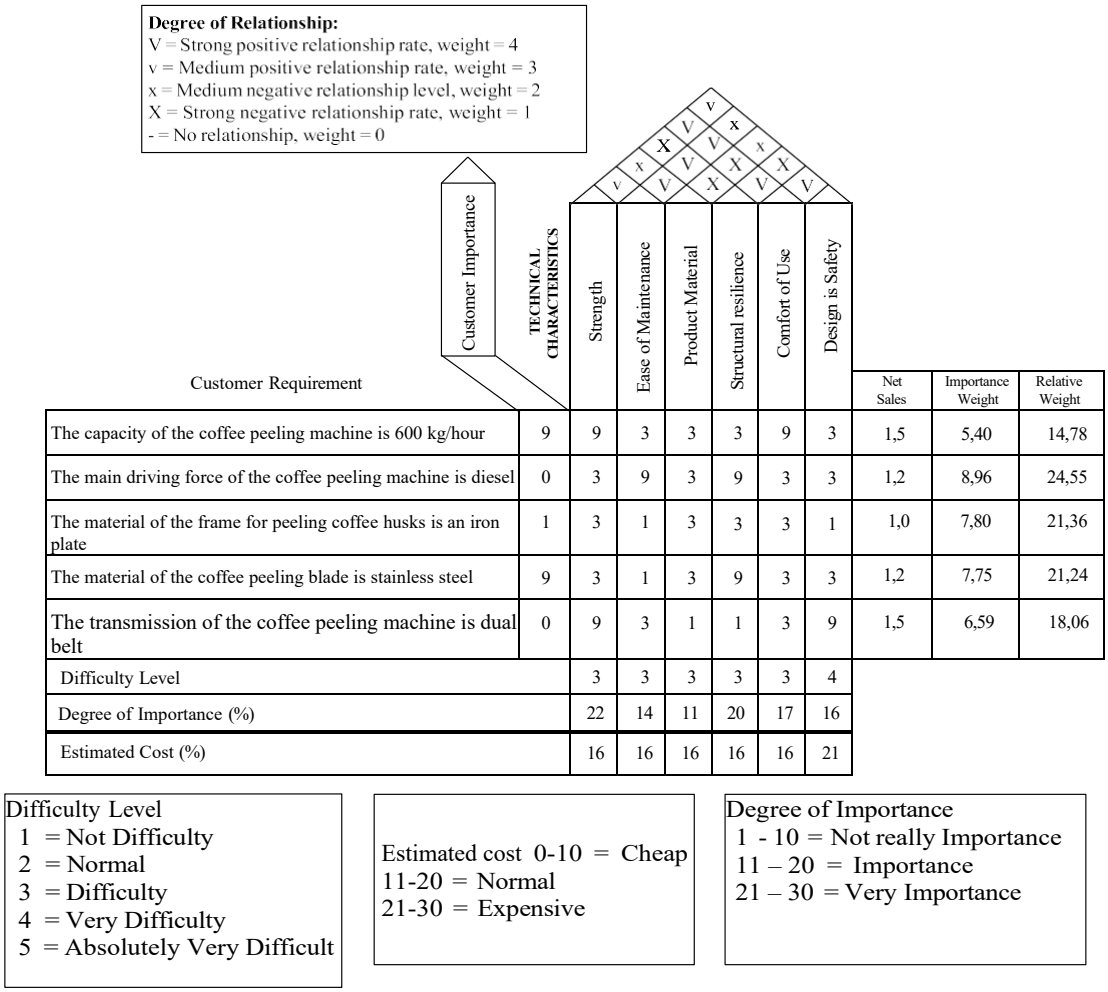


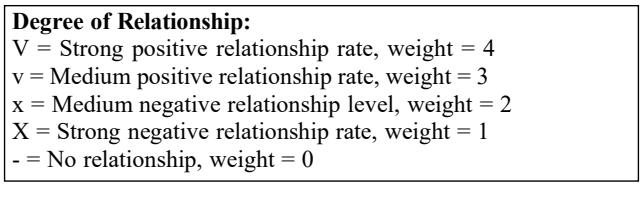
Figure 1. House of Quality Matrix Phase I Coffee Bean Peeling Maching

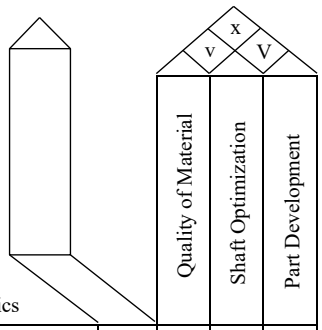
The figure 1 above likely illustrates the HoQ Phase I Matrix, showing the relationship between consumer needs and technical characteristics, as well as the performance measures.

3.1.3. QFD Phase 2

The second phase of QFD continues the development process by prioritizing technical characteristics based on the results of QFD Phase I and identifying critical parts of the product [25]. The relationship between technical characteristics and critical parts is assessed and scored. The critical parts analyzed include Blade Quality, Shaft Optimization, and Product Part Development. The final step is creating the House of Quality Phase II matrix, which includes the calculation of HoQ performance measures based on difficulty, degree of importance, and estimated cost [26].

In this process, the technical characteristics that had been identified as priorities from QFD Phase I became the main focus. The parts considered critical to the product, namely Blade Quality, Shaft Optimization, and Product Part Development, were analyzed through interviews and discussions. Furthermore, the relationship between technical characteristics and critical parts was assessed and scored according to the level of relationship. Fig. 2 mentioned in the summary may contain additional details about the priorities and technical specifications for the development of the coffee bean peeling machine based on the results of the House of Quality Phase II matrix formation process.





Technical characteristics

Strength	3	9	9	9
Ease of Maintenance	4	3	9	3
Product Material	3	3	1	3
Product durability	3	1	3	1
Comfort of Use	4	3	3	3
Design is safety	3	9	3	9
Difficulty Level		5	5	5
Degree of Importance (%)		28	28	28
Estimated Cost (%)		33	33	33

Estimated cost 0-10 = Cheap
11-20 = Normal
21-30 = Expensive

Degree of Importance
1 - 10 = Not really Importance
11 – 20 = Importance
21 – 30 = Very Importance

Difficulty Level
1 = Not Difficulty
2 = Normal
3 = Difficulty
4 = Very Difficulty
5 = Absolutely Very Difficult

Figure 2. House of Quality Matrix Phase II Coffee Bean Peeling Machine

The results of the House of Quality Phase II show that all critical parts, namely Blade Quality, Shaft Optimization, and Part Development have the same difficulty level value of 5. This means that all critical parts are a priority for improvement of the animal feed mixer machine.

3.1.4. Value Engineering

1. Information Stage

In this stage, component data from the initial product design is gathered to support analysis and comparison during the creative phase of value engineering [27]. The components that need improvement are identified, specifically the blade and transmission optimization. The information includes the product name, quantity, price, and description. The focus is on improving the quality of the blade and optimizing the transmission of the coffee skin peeling machine. The document lists specific parts that need engineering attention, such as the blade shaft and transmission, due to issues with durability and grip power, respectively.

2. Analysis Stage

In this stage, a FAST (Functional Analysis System Technique) diagram is used to identify the functions of each component and their relationships within the product or system [28]. The diagram helps in evaluating the contribution of each component to the basic and additional functions of the coffee skin peeling machine, aiming

to make the product more effective and efficient. This diagram helps illustrate the relationship between basic and additional functions of a product or system, aiding in evaluating and improving effectiveness and efficiency. The FAST diagram for the coffee skin peeling machine highlights the continuous functions that occur during its operation, including stabilizing the capacity, generating rotation, and separating the coffee beans from their skin.

3. Creative Stage

The goal of this phase is to generate alternative substitutes for the machine's components that offer a low or equivalent price and increased functionality compared to the existing components [29]. Based on the Quality Function Deployment phase II, the components identified for engineering improvements are the blade shaft and transmission. For the blade shaft, the preferred alternative is Stainless Steel due to its high durability and resistance to rust. For the transmission, the most preferred alternative is the Dual Belt due to its ability to maintain torque stability and silent operation. To facilitate the selection of the best alternative, criteria for the product's constituent materials are established.

4. Evaluation Stage

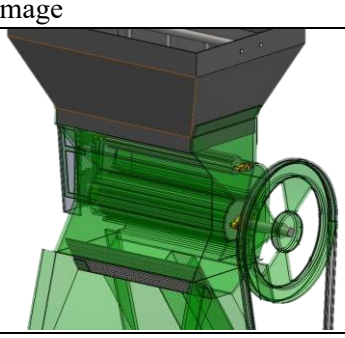
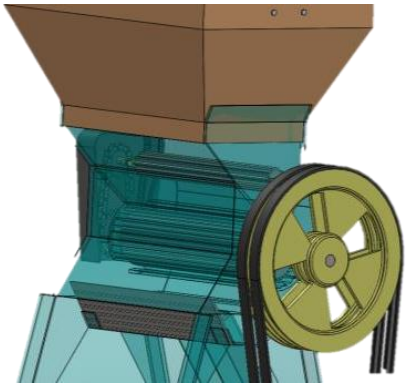
The Evaluation Stage in the Value Engineering process for the coffee skin peeling machine involves selecting the best alternative from the options generated during the Creative Phase [30]. This selection is based on an analysis of the advantages and disadvantages of each alternative, using a matrix that compares them against specific criteria. Each alternative is given a number one (1) for alternatives better than other alternatives and a number zero (0) for alternatives less good than other alternatives. The criteria for assessment are durability, cost savings, and ease of obtaining materials, each given a weighting and ranking to reflect their priority.

The evaluation results show that the best alternative for the blade shaft is Stainless Steel, and for the transmission, it is the Dual Belt [31]. These alternatives are chosen based on their ability to improve the performance and efficiency of the coffee skin peeling machine. For the blade shaft, stainless steel is determined to be the preferred alternative due to its high durability and cost savings, outperforming aluminum and carbon steel. For the transmission, the dual belt is selected as the best alternative due to its durability and ease of obtaining components, although it is less favorable in terms of cost savings compared to the manual option. The Evaluation Stage concludes with a matrix analysis that combines the weighted scores for each alternative, leading to the selection of stainless steel for the blade shaft and the dual belt for the transmission as the optimal choices for improving the coffee skin peeling machine.

5. Development Stage

The Development Stage of Value Engineering provides recommendations for quality improvements based on the findings from the previous stages [32]. The improvement phase involves implementing the selected alternatives to improve the performance and efficiency of the coffee skin peeling machine. For the blade shaft, the repair involves using a blade with high durability and longevity. For the transmission, the repair involves replacing the single belt with a dual belt to increase traction and durability. Table 4 is provided for the transmission component, suggesting the replacement of the single belt with a dual belt to increase traction and durability. The use of a dual belt is expected to improve the efficiency and accuracy of the coffee skin peeling process and extend the machine's operational life. In summary, the Development Stage concludes the Value Engineering process by proposing specific design changes to enhance the coffee skin peeling machine's performance, durability, and efficiency, based on the evaluations conducted in the previous stages [33].

Table 4. Comparison of Actual with Proposed Repair of Transmission Components

Improvements	Component	Image	Specifications	Description
Transmission	*Single Belt* (Actual		*Row*:1 Diameter: 10 inch Material: *Cast Iron*	Replaced the 1 *row pulley* with a 2 *row pulley* to increase traction and durability.
Improvements	Component			
				(Qadafi, M. 2022)
	Double Belt (Usual)		*Row*:2 Diameter: 10 inch Material: *Cast Iron*	

Actual	Proposal
	
Capacity = 600 kg/hour	Capacity = 600 kg/hour
Main drive = diesel	Main drive = diesel
Frame material = iron plate	Frame material = iron plate
Blade material =	Blade material = stainlees steel
Transmission = one belt	Transmission = dual belt
Add additional specs	Add additional specs
	Addition of magnets to the hopper

The Quality Function Deployment (QFD) method analysis successfully identified consumer needs, translated them into product technical characteristics and specifications, and provided recommendations for improvements to the coffee bean hulling machine. This method helps in prioritizing technical characteristics that need to be improved to meet consumer preferences, such as structural strength and durability. In addition, QFD also identifies critical parts that require improvement, making it possible to focus on areas that require the highest attention [34].

The value engineering method was successful in evaluating and selecting replacement components that were more optimal in terms of cost and function for the development of a coffee bean hulling machine. By identifying critical components in need of improvement, such as the blade shaft and transmission, and proposing alternative components considering cost and performance factors, the method provided a solid foundation for efficient and effective product improvement [35].

As such, both methods have made valuable contributions to the understanding of consumer needs, identification of areas of improvement, and development of solutions that can improve the quality and efficiency of the coffee bean peeling machine. This case study of product improvement design for a coffee bean hulling machine illustrates the results of applying both methods. The proposed improvements included replacing the existing blade shaft with a version made of stainless steel to improve durability and structural strength. In addition, the single pulley transmission originally used was replaced with a double pulley transmission to improve the machine's grip and durability [36].

5. Conclusion

This research paper focuses on the production process of the Coffee Bean Peeling Machine and aims to address the issues faced by CV. Teknologi Tepat Guna through the application of the Quality Function Deployment (QFD) method with Value Engineering (VE). Integrating Quality Function Deployment (QFD) and Value Engineering (VE) in product design is crucial for improving product performance, durability, and efficiency while reducing costs. The study demonstrates the effectiveness of this integration in various industries, such as designing a coffee bean peeling machine and a bullet-head drill. By using QFD to determine customer needs and technical characteristics and VE to propose design changes and material substitutions, the integration optimizes functionality and cost, ultimately enhancing product value and customer satisfaction.

The research methodology involves the collection of both primary and secondary data through direct observation, questionnaires, interviews, and literature studies. The primary objectives of the research are to design and develop a high-quality coffee bean processing machine, identify key technical characteristics and critical parts, and evaluate and select the best alternatives for the machine's components based on criteria such as durability, cost, and ease of maintenance.

The findings of the research provide valuable insights for product improvement and future development. The selected alternatives for the coffee skin peeling machine include using stainless steel for the blade shaft and a dual belt for the transmission. These alternatives are chosen based on their ability to improve the performance and efficiency of the machine.

Future recommendations include continuing to apply the integrated QFD and VE approach in product development to meet evolving customer needs, reduce manufacturing costs, and enhance product quality. The study emphasizes the importance of selecting the best alternatives based on criteria such as durability, cost savings, and ease of obtaining materials, as demonstrated in the evaluation stage of the Value Engineering process. In terms of development, the paper suggests implementing specific design changes, such as using stainless steel for the blade shaft and a dual belt for the transmission, to enhance the performance, durability, and efficiency of products like the coffee skin peeling machine. These improvements aim to address technical challenges, increase product value, and improve customer satisfaction. Further research and application of the integrated QFD and VE methodology can lead to continuous product enhancement and cost optimization in various industries.

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