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Design of Briquette Printing Machine Using QFD for Coffee Waste Utilization

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ABSTRACT IN ENGLISH

The ever-increasing coffee production in West Java generates considerable coffee ground waste, especially from the coffee concentration process by Aroma Kahuripan. This waste has the potential to pollute the environment due to the presence of certain substances in it. This research aims to design a briquette printing machine to optimize the processing of coffee ground waste as part of the circular economic implementation. The research method used is the Quality Function Deployment (QFD) approach to identify user needs, followed by the process of concept development, concept selection, and prototyping. The designed machine uses a frame made of galvanized iron and is equipped with an electric-based drive system. The evaluation results show that this machine can process coffee ground waste into briquettes effectively with low noise levels and efficient maintenance time. This machine is expected to improve the sustainability of Aroma Kahuripan's production through more environmentally friendly waste management and support the concept of circular economy by utilizing waste into valuable products.

Keywords:
Coffee, Coffee Grounds Waste; Circular Economy; Briquette Printing Machine; Quality Function Deployment

1. INTRODUCTION

Coffee is one of the most popular drinks in the world [1]. The drink is made from green coffee beans from the coffee cherry fruit [2]. The high popularity and economic value of coffee make it one of the most recognized plants worldwide [3]. West Java Province is a major coffee bean-producing region in Indonesia. The province is well-known as one of the areas with the best quality coffee production, especially from the Ciwidey, Rancabali, and Gunung Halu regions. Figure 1 is a graph of coffee production in West Java.

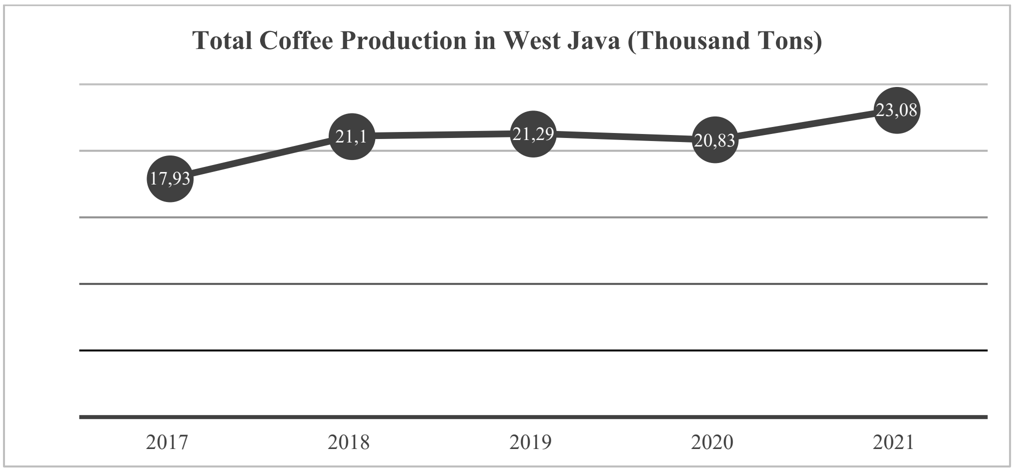


Figure 1 – West Java Coffee Production Data 2017-2021

Based on data from the Central Bureau of Statistics in Figure 1, coffee production in West Java increased from 2017 to 2021, reaching 23.08 thousand tons in 2021 [4]. Recently, coffee consumption has increased rapidly due to widespread urbanization, the emergence of a coffee-drinking culture, and changing consumer preferences [5]. This increase is driven by the high quality of coffee beans produced and the rapid growth in demand from various coffee beverage brands and coffee shops in West Java.

In 2023, Aroma Kahuripan, a ready-to-drink coffee beverage brand, was established through the Student Entrepreneurship Development Program (P2MW). The brand utilizes coffee beans from Ciwidey, Rancabali, and Gunung Halu to produce its main product, coffee concentrate. The production process includes grinding, weighing, and extraction, carried out by two operators according to Aroma Kahuripan's composition standards. Concentration orders by these stores must be made at least three days before the need. Table 1 is demanding data on coffee concentrate for the September and October period of 2023.

Table 1 – Demand Data of Coffee Concentrate for September-October 2023

Month	Week	Demand (g)
September	1	6180
	2	2060
	3	8240
	4	3090
October	1	7210
	2	2060
	3	6180
	4	2060
Total		**37080**
Average		**4635**

Table 2 is aroma kahuripan wet coffee grounds waste data for September and October 2023. This waste comes from the remaining coffee grounds mixed with water during extraction. The waste is only collected in a container and thrown away in the production house area. However, it has the potential to pollute the environment due to the content of harmful compounds such as caffeine, tannins, and polyphenols [6]. Although coffee grounds are classified as organic waste, their disposal in large quantities without proper treatment can have significant environmental impacts. Coffee grounds disposed of in landfills have the potential to undergo anaerobic decomposition, producing greenhouse gases such as methane and CO_2 that contribute to climate change [7]. In addition, the content of bioactive compounds such as caffeine, tannins, and polyphenols in coffee grounds can be phytotoxic, inhibiting plant growth and polluting soil and water if not managed properly [8].

Table 2 - Aroma Kahuripan Wet Coffee Grounds Waste Data for September-October 2023

Month	Week	Coffee Concentrate Production (g)	Coffee Grounds Waste (g)	Waste Percentage
September	1	6414.84	2602	40.56%
	2	2148.58	871	40.54%
	3	8406.86	3423	40.72%
	4	3128.11	1270	40.60%
October	1	7371.71	3001	40.71%
	2	2174.33	881	40.52%
	3	6403.51	2590	40.45%
	4	2153.73	883	41.00%
Total		**38201.67**	**15521**	
Average		**4775.21**	**1.940.125**	**40.64%**

However, coffee grounds also have great potential as an alternative energy source. Through the torrefaction process, coffee grounds can be converted into biochar with a high heating value, making it an efficient and environmentally friendly solid fuel [9]. To solve the coffee grounds problem, it is necessary to apply the concept of circular economy as a solution to manage resources so that they remain functional and do not waste. This approach involves extending the life of products through design innovation, maintenance, reuse, remanufacturing, and reprocessing into new products (recycling) or value-added products (upcycling). The goal is to transform the traditional linear economic system, oriented towards a take-make-dispose pattern, into a circular economy with a take-produce-use-repurpose pattern. This circular economy principle aims to reduce waste and produce new products with economic value [10]. An example of the application of circular economy in waste management is the utilization of plastic waste into reusable building materials [11]. However, not many have applied it to organic waste such as coffee grounds. This research contributes to filling the gap by designing a device that directly converts organic waste into a renewable energy source. Therefore, more optimal management of coffee ground waste is needed so that it can be utilized in useful products without causing negative impacts on the environment, but also supports the principle of circular economy by utilizing organic waste into useful resources.

As an alternative in the management of coffee grounds, a tool or coffee machine can be developed to facilitate the processing of coffee grounds waste. This solution was chosen because, until now, there has been no supporting device for processing coffee ground waste at the Aroma Kahuripan production house. Coffee grounds waste has great potential to be processed into various products, such as in Lego Village Tourism, which utilizes this waste to make traditional bar soap without chemicals, making it safe for the skin [12]. In addition, coffee grounds can also be turned into products such as wallets or bags because they have properties and colors that resemble leather [13]. While innovative, such approaches focus more on the aesthetic or functional value of household products. This research, different from those approaches, emphasizes the energy value through conversion into briquettes as an alternative fuel source. Coffee grounds waste also has the potential to be used as a renewable energy source, such as biomass, which includes materials such as wood, sawdust, straw, seed waste, paper waste, and household waste [14]. One form of renewable energy that can be produced from biomass is briquettes made from organic materials such as coffee grounds, which function as solid fuels. Briquettes can help reduce the use of fossil fuels while sustainably reducing carbon emissions [15]. The production of biomass briquettes from agricultural waste, including coffee grounds, has proven to be an efficient, environmentally friendly alternative energy solution that has the potential to replace fossil fuels on a household and small industry scale [16]. However, the study did not design a printer, so there is still a reliance on manual processes. This study seeks to fill this gap by designing a briquette printing machine tailored to the needs of small-scale users such as Aroma Kahuripan. Besides having economic value, briquettes also have a high calorific content, such as coffee grounds or coffee skins, which contain 6,983 kcal/kg of energy, making them competitive compared to other fuels. Processing coffee ground waste into briquettes requires high effectiveness, one of which is by using a briquette printing machine. The characteristics of briquettes as alternative fuels can vary depending on the main ingredients, particle size, mixture, and percentage of adhesive used. Based on previous research, there is a design of a rice husk charcoal making tool, to increase the selling value of rice husks, which were previously only sold at low prices or discarded [17]. Therefore, the solution is to design a briquette printing machine that suits the user's needs and can produce quality products. With this machine, the processing of coffee ground waste can be optimized, resulting in economically and environmentally friendly briquettes.

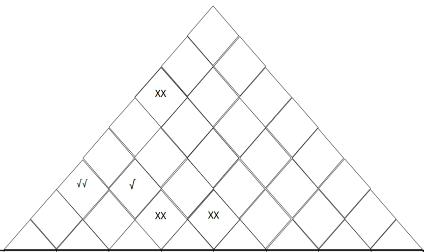
2. METHOD

This research involved field studies and literature studies. Field studies were conducted through direct observation and interviews with two MSME actors, namely the owner of the Aroma Kahuripan coffee business in Bandung, to identify problems in the production process, especially related to the processing of coffee powder waste and the need for a briquette printing machine design; and the owner of a briquette making business, to explore the technical needs in the briquette printing process as a consideration in competitor analysis. The literature study discusses the notion of concept generation as a process of thorough exploration of possible product concepts that can meet customer needs. Concept development includes a combination of external reference searching, creative problem solving within the team, and systematic exploration of the various partial solutions generated. After the concept is designed, the concept selection stage is conducted to select various alternative concepts through a process of gradual elimination to find the most promising concept. This process begins with concept screening, which compares and evaluates concepts based on a number of basic criteria, followed by concept scoring, which assigns weights to each criterion and conducts a more detailed evaluation of each concept. All stages of concept development involve modeling and prototyping as a means to test and refine concepts in terms of technical feasibility, design performance, and user preferences [18].

The design uses the QFD method with the help of the House of Quality (HoQ) tool. The steps taken are to translate information from sources into the HoQ matrix to design specifications that are in accordance with user needs. Then, the concept creation stage is carried out by building a briquette printing machine concept based on the results of the QFD analysis. Furthermore, the concept selection stage is carried out to determine the best concept through concept screening and scoring. After the selected concept is determined, the next step is to develop concept specifications, which include detailed machine specifications and technical responses that still need to be completed. A prototype of the briquette printing machine was then built, followed by a measurement process to complete the unmet technical responses. The measurement results were used to develop the final product specification, which refined the previous specification.

3. RESULT AND DISCUSSION

3.1. House of Quality (HoQ)



Kode	Technical Response / Product attribute	Product dimension	Frame material	Product capacity	Product drive	Product noice	Product maintanance level	Product operation process stages	Mold shape	Importance to Customer	Customer Satisfaction Perfomance	Goal	Improvement Ratio	Sales Point	Raw Weight	Normalized Raw Weight
V1	The product can create various shapes of briquettes							◎	◎	4,00	4,30	4,10	0,95	1,5	5,70	0,06
V2	The product is easy to maintain	○	○				◎	◎		4,10	2,30	3,90	1,70	1,5	10,46	0,12
V3	The product is easy to operate		△		◎		◎	◎		4,20	2,80	3,80	1,36	1,5	8,57	0,10
V4	The product has a sturdy frame material		◎						◎	4,10	4,50	4,30	0,96	1,5	5,90	0,07
V5	The product is easy to move			◎	◎					3,40	1,70	3,90	2,29	1,2	9,34	0,11
V6	The product uses electric power		△	◎	◎	◎	◎	◎		4,30	1,30	3,60	2,77	1,5	17,87	0,20
V7	The product has a low noise level				◎	◎				4,00	1,70	3,50	2,06	1,5	12,36	0,14
V8	The product has low power consumption	◎		◎			△			2,20	2,10	3,10	1,48	1,2	3,91	0,04
V9	The product adjusts to user size	◎								4,40	2,00	4,40	2,20	1,5	14,52	0,16
	Contribution	2,16	1,29	3,15	4,95	3,06	3,82	4,32	1,17							
	Normalized Contribution	0,09	0,05	0,13	0,21	0,13	0,16	0,18	0,05							
	Priorities	6	8	4	1	5	3	2	7							

Figure 2 – House of Quality

Figures 2 and 3 represent the house of quality, consisting of product attributes, planning matrix, technical responses, relationships between components, technical priorities, technical correlations, technical benchmarks, and predetermined targets.

Referring to Figure 2, the product drive system is the highest priority technical response, with a contribution value of 4.95 and a normalized contribution value of 0.20. The results of this study indicate that the use of electricity-based automatic drives is the focus of development.

Figure 3 contains competitive benchmarks, where the circle symbol is a competitor product of PT Arang Nusantara Jaya, which has dimensions of 120 cm × 50 cm × 100 cm with a frame of galvanized angle iron. This machine can produce briquettes in hexagonal (4 cm diameter, 7 cm length) and cube (2.5 cm × 2.5 cm) shapes. Powered by a 26 hp diesel engine, it has a production capacity of 125-250 kg/h, but produces high noise and significant air emissions. In addition, the machine is static and difficult to move. The operation process consists of several manual steps, from installing the mold and refueling, to cranking the machine, feeding the dough into the funnel, and cutting the briquettes after they come out of the mold. The next competitor product is the Asterra machine, which has a triangular symbol, which has dimensions of 100 cm × 80 cm × 100 cm, with a frame made of UNP and galvanized angle iron. This machine is capable of producing cube-shaped briquettes with a size of 3 cm × 3 cm. Its production capacity ranges from 100-200 kg/hour and uses a diesel drive with a power of 8 hp.

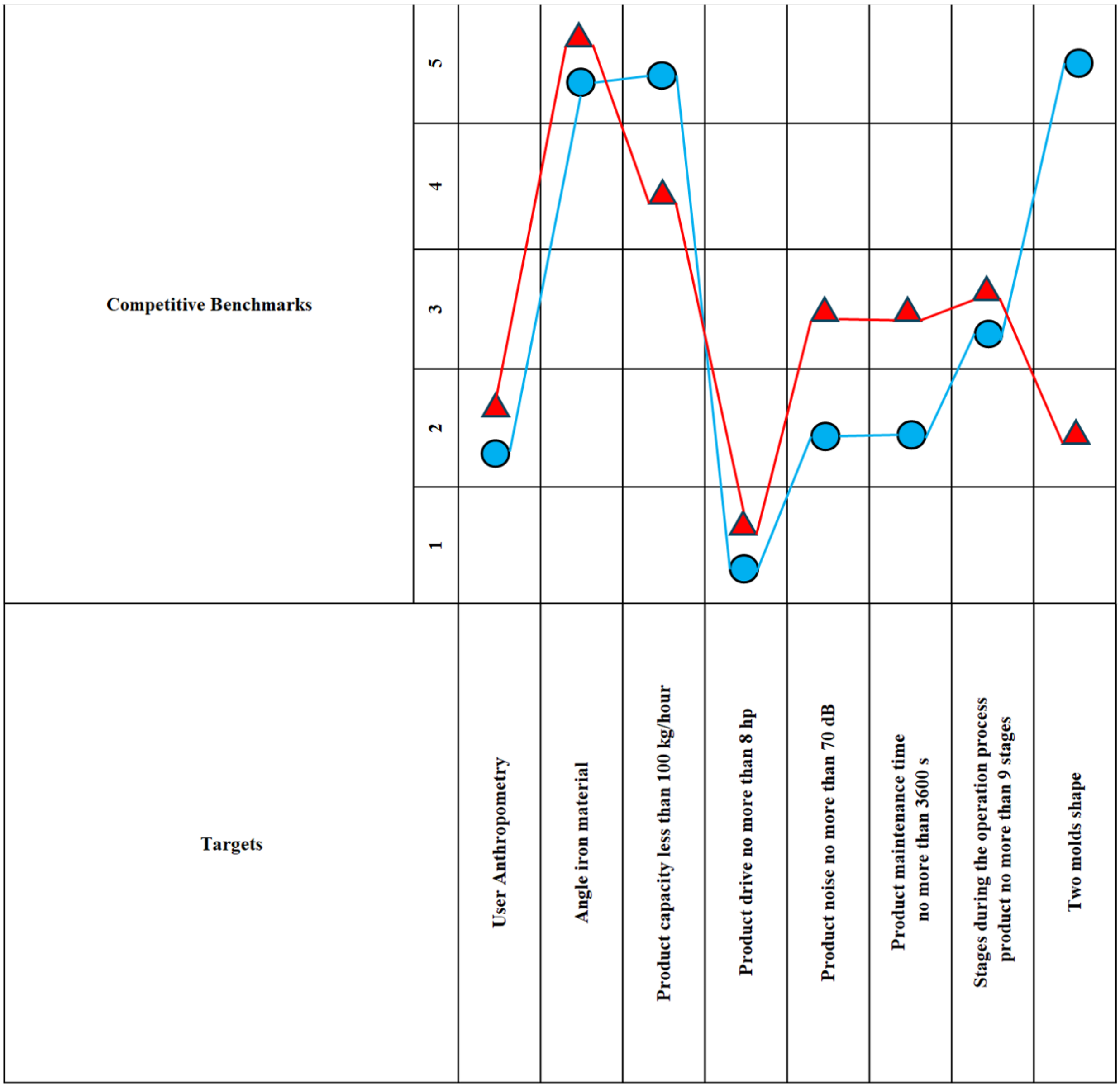


Figure 3 – House of Quality (Continued)

3.2. Concept Generation

In the concept generation stage, the first step in conceptualizing is to clarify the problem by identifying and solving it down into sub-problems [18]. In this research, the problem solution is designed based on user needs, visualized using Blackbox. In the Blackbox, the raw weight becomes the input, while the output is a product that meets the user's needs, as shown in Figure 4.

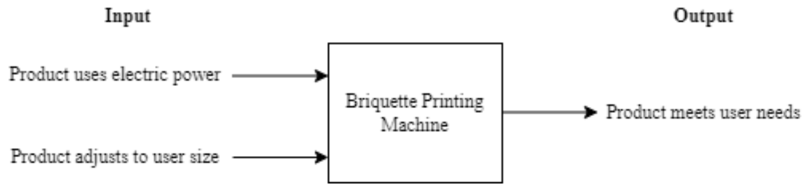


Figure 4 – Blackbox

After the Blackbox was created, the next step was to break down the problem with the briquette printing machine product into several more detailed sub-functions, known as problem decomposition. Subfunctions should be broken down into simple parts for the developers to agree that they are workable. Generally, sub-functions range from 3 to 10 [18]. In this research, the sub-functions are designed based on the primary user needs, including product drive, which uses electricity, and the prioritized technical response part, following frame material, which considers the strength of the material to withstand the load. Product dimensions are adjusted to the size of the user using anthropometric methods. The results of the briquette printing machine product decomposition are visualized in Figure 5, which shows three main sub-functions that are simple and specific.

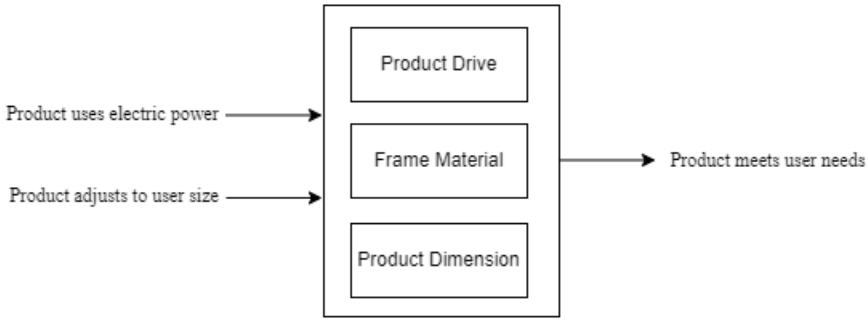


Figure 5 – Product Decomposition

The next stage is to search internally & externally, which is the search for solutions based on the diagram that has been made. An external search was conducted by interviewing two MSME players, namely the owner of the Aroma Kahuripan coffee business in Bandung and the owner of a local briquette business, to explore user needs related to coffee waste processing and briquette printing. A summary of the solution search results is presented in Table 3

Table 3 – Search Internally & Externally

Problem	Option 1	Option 2	Option 3
Product Drive	Dynamo ½ hp	Dynamo 2 hp	Dynamo 1 hp
Frame Material Type	Galvanized angle iron	Stainless steel angle iron	-
Product Dimensions		Length: 0,47 m Width: 0,47 m Height: 1,37 m	

In addition, references from scientific journals, technical articles, and previous studies on briquetting machine design were also used to strengthen the understanding of customer needs. Meanwhile, an internal search was conducted through discussions with the design team and a literature study of the technical specifications of similar machines already on the market, to understand their advantages and disadvantages. After searching internally & externally, the next stage is to design several concepts.

The recapitulation of the resulting concept combinations resulted in six concepts, as shown in Table 4. From the results in Table 4, six exploratory concepts were obtained in accordance with the needs of users or operators in operating the briquette printing machine. These concepts include the selection of the type of product drive and the use of appropriate frame materials.

Table 4 – Recapitulation of Combined Concepts

Concept	Product Drive			Frame Material Type		Product Dimensions
	Dynamo ½ hp	Dynamo 2 hp	Dynamo 1 hp	Galvanized angle iron	Stainless steel angle iron	Length: 0,47 m Width: 0,47 m Height: 1,37 m
1	√			√		√
2	√				√	√
3		√		√		√
4		√			√	√
5			√	√		√
6			√		√	√

3.3. Concept Selection

Concept selection is a stage to evaluate various alternative concepts by considering user needs and other criteria [18]. This process aims to compare each concept's relative advantages and disadvantages to select one or more concepts to be reviewed and developed further. The first stage in the concept selection process is carried out through concept screening, an assessment method based on the conditions set by the researcher or developer. Concept screening uses selection criteria designed to meet user needs. These criteria are usually expressed at a relatively high level of abstraction, including 5 to 10 dimensions, and are subjective. Selection criteria can be seen in Table 5.

Table 5 – Selection Criteria Based on User Needs

Selection Criteria	Product Attributes
Product Features	The product can create various shapes of briquettes.
Ease of Use	The product is easy to maintain.
	The product is easy to operate.
Frame Durability	The product has a sturdy frame material.
Portability	The product is easy to move.
Power Source	The product uses electric power.
	The product has a low noise level.
Energy Consumption	The product has low power consumption.
Product Appearance	The product adjusts to the user's size.

Based on Table 5, there are 7 selection criteria obtained from 9 product attributes. The selection criteria points are determined based on the subjectivity of the researcher, while the product attributes points are obtained from Figure 2 of the house of quality, following user needs. After determining the selection criteria, the next step is concept screening. This process provides symbols to compare various product concepts with competitors' products, such as symbols (+), (-), and (0). The results of the briquette printing machine concept screening process can be seen in Table 6.

Table 6 – Concept Screening

Selection Criteria	Concept						
	1	2	3	4	5	6	(Reference)
Product Features	0	0	0	0	0	0	0
Ease of Use	+	+	+	+	+	+	0
Frame Durability	0	-	0	-	0	-	0
Portability	+	+	+	+	+	+	0
Power Source	+	+	+	+	+	+	0
Energy Consumption	+	+	+	+	+	+	0
Product Appearance	+	+	+	+	+	+	0
Sum "+"	5	5	5	5	5	5	0
Sum "0"	2	1	2	1	2	1	0
Sum "-"	0	1	0	1	0	1	0
Net Score	5	4	5	4	5	4	0
Rank	1	2	1	2	1	2	
Continue?	Yes	No	Yes	No	Yes	No	

Of the 6 concepts listed in Table 6, 3 concepts, namely concepts 2, 4, and 6, are not continued because they have a lower net score than the others. In contrast, concepts 1, 3, and 5, which have a higher net score, were selected to proceed to the development stage. Table 7 shows the 3 concepts carried forward to the further development stage.

Table 7 – Product Concept

Concept	Product Drive	Frame Material Type	Product Dimensions
1	Dynamo ½ hp	Galvanized angle iron	Length: 0,47 m Width: 0,47 m Height: 1,37 m
3	Dynamo 2 hp		
5	Dynamo 1 hp		

The three concepts will be further evaluated through the concept scoring stage to determine the best option. Each concept will be rated using an importance scale from 1 to 5. The assessment will be given by the respondent, where the respondent is a user of a briquette printing machine. While each selection criterion will be subjectively weighted by the researcher. The value of each criterion is then multiplied by the weight to produce a weighted score, and the total score is obtained from the sum of all weighted scores. Criteria such as propulsion and product appearance are given a weight of 20% because they are considered users' primary needs, while others are given a weight of 10%. The results of concept scoring are presented in Table 8.

Table 8 – Concept Scoring

Selection Criteria	Weight	Concept					
		1		3		5	
		Rating	Weight Score	Rating	Weight Score	Rating	Weight Score
Product Features	10%	3	0,3	3	0,3	3	0,3
Ease of Use	10%	4	0,4	4	0,4	4	0,4
Frame Durability	10%	3	0,3	3	0,3	3	0,3
Portability	10%	5	0,5	5	0,5	5	0,5
Power Source	20%	5	1	4	0,8	5	1
Energy Consumption	10%	5	0,5	4	0,4	4	0,4
Product Appearance	20%	5	1	5	1	5	1
Total Score		4		3,7		3,9	
Rank		1		3		2	
Continue?		Yes		No		No	

Based on Table 8, the concept chosen is concept 1. This concept is based on user needs and has dimensions of 0,47 m long, 0,47 m wide, and 1,37 m high. The product frame uses galvanised angle iron material and is powered by a ½ hp electric dynamo. The next step is to conduct a more detailed specification of the selected concept.

3.4. Selected Concept Specification

After passing the scoring stage, the specifications of the selected concept were determined, as listed in Table 9.

Table 9 - Selected Concept Specification

No	Technical Response	Unit	Value
1	Product dimensions	m	Length: 0,47, Width: 0,47, Height: 1,37
2	Frame material type	list	Galvanized angle iron
3	Product capacity	Kg/hour	15
4	Product drive	Hp	½
5	Product noise level	dB	<70
6	Product maintenance time	s	<3600
7	Product operation process stages	list	6
8	Mold shape	list	Cube and circle

Based on Table 9, the main difference between the designed product and the competitor's product lies in the product's dimensions, which are designed according to the user's body size. The material used is a galvanized angle iron. The product's capacity is designed to meet the needs of small-scale users with limited electrical power (VA), so it uses an electric drive with low power. The scoring results show that a dynamo with ½ hp power is the best choice. Based on previous research references, the product capacity was set at 15 kg/hour because a ½ hp dynamo was sufficient to support this capacity [19]. The noise level is designed not to exceed 70 dB, and the maximum maintenance time is 3600 seconds. The operation process is also designed to be straightforward, with only 6 steps, making it easier for users. The product mold is designed according to the need statement and can produce various briquette shapes. The difference with competitors' products lies in the size and shape of the mold, which uses a circular model. After the specifications of the selected concept were determined, the process continued to the prototyping stage.

3.5. Prototype

Prototyping has several advantages, such as cost efficiency, minimizing the risk of failure, and providing an opportunity to interact directly with the designed product [20]. The prototype design of the briquette printing machine is shown in Figures 6, 7, and 8.

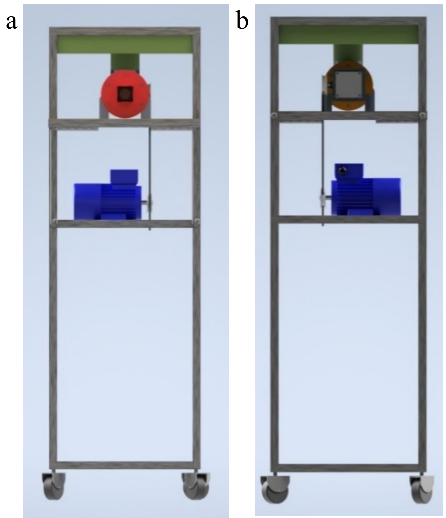


Figure 6 - (a) Product Prototype Design Front View; (b) Product Prototype Design Back View

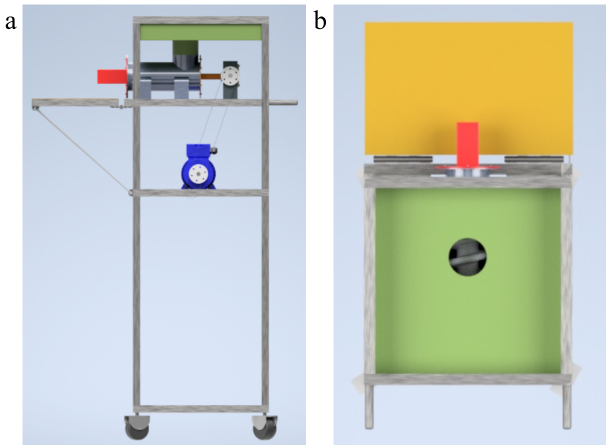


Figure 7 - (a) Product Prototype Design Side View; (b) Product Prototype Design Top View

Next is the design of the 3D prototype of the printing machine product briquettes, as shown in Figure 8.

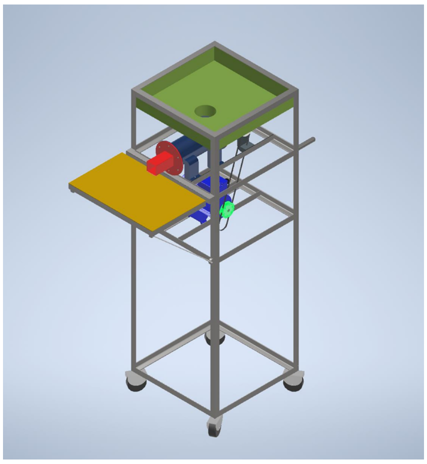


Figure 8 - 3D Prototype Design of Briquette Printing Machine

Based on Figures 6, 7, and 8, this machine is 0,47 m long, 0,47 m wide, and 1,37 m high. The machine frame is made of galvanized angle iron with a 15 kg/hour production capacity. This machine uses a ½ hp electric dynamo connected to a gearbox with a ratio of 1:50. Measurement of noise level and maintenance duration will be carried out after the prototype is completed.

The machine operation process consists of six main steps:
1. Installing the briquette mould by turning the end of the grinder part without tools.
2. Filling lubricant in the gearbox.
3. Connecting the armature cable to the power outlet.
4. Press the switch on button on the dynamo.
5. Feeding the briquette dough into the machine.
6. Cutting the briquette dough from the mould according to the desired size.

This machine is equipped with two types of molds: a cube mold measuring 3 x 3 cm with a length of 10 cm and a circle mold with a diameter of 4 cm and a length of 10 cm. The tray plate, which holds the briquettes after they come out of the mold, has a height of 104 cm, adjusted to the user's elbow height. The tray plate is 40 cm long and 0,47 m wide and equipped with a hook to be folded when not used. To facilitate mobility, the machine has four wheels and two handles adjusted to the width of the user's hand (9 cm), making it easier to move the machine.

After that, enter the model of making a prototype of a briquette printing machine, as in Figures 9, 10, and 11.

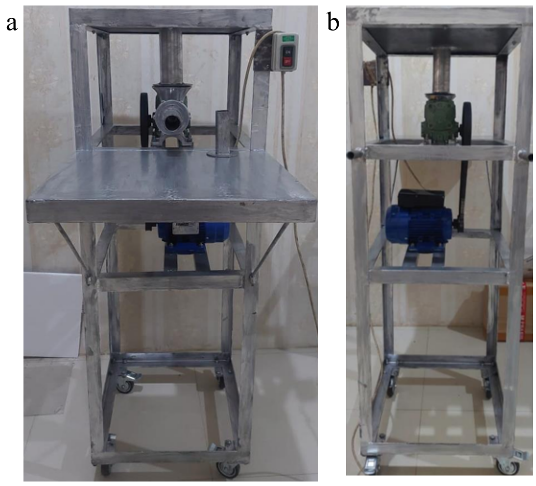


Figure 9 - (a) Product Prototype Front View; (b) Product Prototype Back View

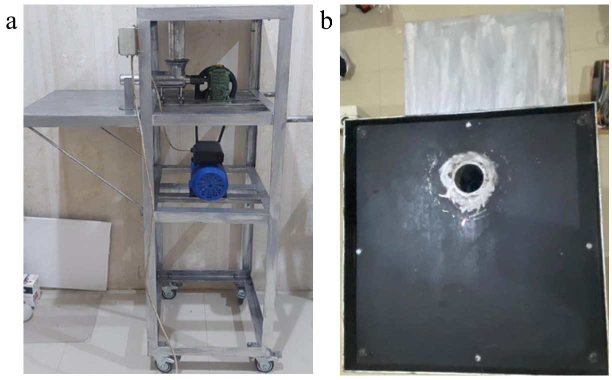


Figure 10 - (a) Product Prototype Side View; (b) Product Prototype Top View

Next is the 3D prototype display of the briquette printing machine product, as shown in Figure 11.

Figure 11 - 3D Prototype View of Briquette Printing Machine

After the briquette printing machine prototype is shown in Figures 9, 10, and 11, the next step is to test the noise level [21]. Noise testing is carried out using a sound level measuring instrument. Each measurement lasts 15 seconds and is repeated five times in no-load and full-load conditions. The test results are shown in Table 10.

Table 10 - Noise Level Measurement Result of Briquette Printing Machine Product

Condition	Distance (m)	Speed (rpm)	Test Duration (s)	Noise Level (dB)	Average (dB)	Overall Average (dB)	Reference Recommendation (Susanto et al., 2021)
No Load	0.5	2800	15	65.4	66.8	65.83	70
			15	66.0			
			15	66.7			
			15	67.5			
			15	68.4			
Full Load	0.5	2800	15	64.5	64.86		
			15	64.3			
			15	64.6			
			15	65.5			
			15	65.4			

Based on the data in Table 10, the engine noise level in both no-load and full-load conditions remains below 70 dB.

The time required to perform engine maintenance is about 1560 seconds. The maintenance process includes checking the condition of the gearbox, dynamo, and belt, as well as cleaning the mold and conveyor screw. After obtaining data on the noise level and maintenance time, the next step is to determine the final product specifications.

3.5. Final Product Specification

After passing through the previous stage, the final product specifications are presented in Table 11.

Table 11 - Final Product Specifications

No	Technical Response	Unit	Value
1	Product dimensions	m	Length: 0,47, Width: 0,47, Height: 1,37
2	Frame material type	list	Galvanized angle iron
3	Product capacity	Kg/hour	15
4	Product drive	Hp	½
5	Product noise level	dB	65,83
6	Product maintenance time	s	1560
7	Product operation process stages	list	6
8	Mold shape	list	Cube and circle

According to Table 11, there is additional information in the form of product noise level that reaches 65.83 dB, and the estimated time required for product maintenance, which is about 1560 seconds.

The design of the briquette printing machine that has been developed generally meets the main needs of users, but there are several compromises and technical challenges that arose during the design process. The use of a ½ hp electric dynamo was chosen to suit the limited electrical power at the household or MSME scale, but this limits the production capacity of the machine to only 15 kg/hour. In terms of ergonomics, the machine is designed with a height of 1.37 meters to match the elbow height of the operator, but this dimension causes limitations in terms of portability and storage in narrow production areas, even though it has been equipped with wheels and handles. The choice of frame material in the form of galvanized angle iron provides resistance to load and corrosion, but results in increased production costs if the machine is to be replicated in large quantities. The provision of two types of molds (cube and cylinder) provides flexibility in product shape but has not been accompanied by in-depth testing regarding the combustion efficiency of each shape. Nonetheless, the user comfort aspect has been well met, characterized by a low noise level of 65.83 dB and a short maintenance time of 1560 seconds. Thus, although the design has covered most of the initial requirements, further evaluation and field testing are still needed to refine the engine's performance and ensure its suitability for real operational conditions.

4. CONCLUSION

This research aims to design a briquette printing machine to optimize the management of coffee grounds waste produced by Aroma Kahuripan. Using the QFD approach, user needs were identified, becoming the basis for concept development and prototyping. The designed machine has dimensions of 0,47 m × 0,47 m × 1,37 m, uses a frame made of galvanized iron, and a dynamo drive with a power of ½ hp. The evaluation results show that this machine can process coffee grounds waste into briquettes with a capacity of 15 kg/hour, a noise level of 65.83 dB, and a maintenance time of 1560 seconds. The use of this machine is expected to support production sustainability through more effective, efficient, and environmentally friendly waste management. In addition, this innovation encourages implementing a circular economy by utilizing waste as an economically valuable resource.

Based on the design process that has been carried out, there are several suggestions regarding the implementation of the product design results of the briquette printing machine for further research, namely considering the improvement feedback provided by related parties, regarding product specifications. Furthermore, conduct an ergonomic analysis to design a briquette printing machine that is more suitable and does not pose a risk of injury or danger to the user. Then, add new features that increase the effectiveness of briquette production, and pay attention to aesthetic aspects in the development of the next briquette printing machine design.

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Conflict of Interest

Dino Caesaron, S.T., M.T., Ph.D., is an editorial team member of IJIES (International Journal of Innovation in Enterprise System).

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