

A Case Study for Potential Process Improvements in the Briquette Industry

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Abstract

This research is about the improvement potential that can be implemented in industrial briquettes. This study will also identify the briquette production process and issues or challenges faced in the briquette industry. A company based in Perak was used to compare this study. The method used in this study is qualitative, namely interview and observation techniques during site visits. Findings from the site visit were compared with those from previous studies. The observation of this company uses rice husk as a raw material to produce briquettes and does not use any binder or additive material. Briquette specifications are produced with strength reaching 1000 kg/cm², a calorific value of 5000 kJ/kg, and a carbon content of 35%. This briquette manufacturing process uses a screw extrusion machine, and the type of screw used is pellets. Several issues and challenges can be taken into account for improvement. Based on the compared results, some observational results have the potential to be improved in this study.

1. Introduction

Briquettes, compacted biomass blocks or logs, are frequently employed as fuel in regions facing fuel scarcity, particularly in the developing world. These versatile briquettes find applications across industrial, commercial, and household sectors, serving purposes such as power generation, steam production in boilers, heating, gasification, and drying processes [1-2]. Their usage aims to replace conventional fuels like coal, wood, and expensive liquid fuels, contributing to environmental sustainability and providing clean energy. Biomass briquettes, derived from materials such as agricultural waste, woodchips, sawdust, and organic waste, present a renewable energy source. Daily waste, including 38,000 metric tons in Malaysia, offers a significant resource for briquette production [3]. This waste, originating from households, restaurants, and schools, represents a valuable recycling opportunity. Malaysia's target of achieving a 40 per cent recycling rate by 2025 reflects the growing importance of sustainable practices in managing waste and promoting environmental responsibility.

The problem statement addresses the fact that the briquette industry faces challenges hindering its growth as a sustainable energy solution. The use of biomass as fuel is problematic due to low bulk density, making handling and storage difficult. Manual fuel feeding is unsafe and leads to efficiency loss. To ensure safety and efficiency, automation of fuel feeding is necessary. The traditional briquette manufacturing process needs improvement with the latest technology. Despite technical limitations, the industry must evolve to stay competitive in an automated world, requiring advancements in production technology [4-6].

In this study, a briquette manufacturing company located in Perak was chosen as the case study location. The research involved on-site visits to observe the briquette production process and conduct interviews with the

company's employees. The case studies primarily concentrated on identifying potential improvements within the company. A comparative analysis was undertaken, from both on-site observations and existing literature, with a focus on material, process, issues, and challenges related to briquette production.

2. Methodology

The methodology involves reviewing previous research papers, conducting a site visit to the selected company to collect data, interviewing workers, and analyzing the data collected. The studies start with a review research paper that follows the objective of the studies. This study conducted a site visit of selected briquette manufacturing companies. The data was collected by interviewing one of the workers based on the objective. The results were recorded and analyzed to compare them with those of a precious research paper to identify potential improvements in the briquette manufacturing process. Fig. 1 shows the flow chart of the methodology.

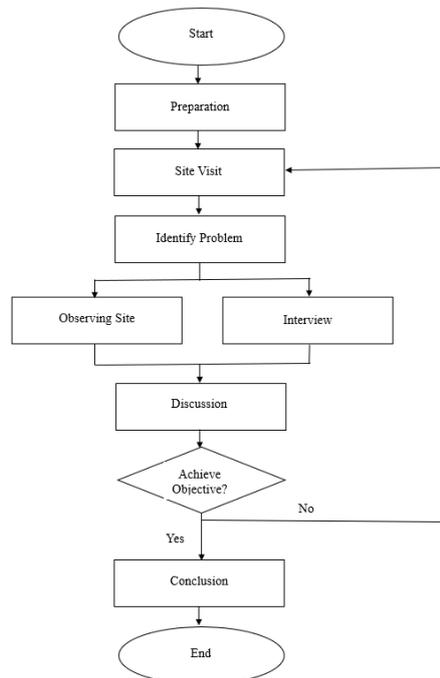


Fig. 1 Flowchart of the research study

2.1 Review Paper

The case study begins with a review of previous research papers to obtain information about the manufacturing process of briquettes, including raw materials, binders, additive materials, and manufacturing processes. As for the raw material, it is the main ingredient to produce briquettes. It's the starting point in the briquette manufacturing process, which can come from material waste sources [8]. Many biomass materials can be used to produce briquettes, such as newspaper, coconut shells, sawdust, palm fronds, and bagasse. Each type of material consists of different properties such as strength, calorific value, carbon content, and ash releases [3-4,7].

In addition, briquettes can also use binder materials to maintain their shape and integrity during handling, transportation, and burning. Not all raw materials used to produce briquettes have strong binding properties. Therefore, these binders are used to further strengthen the binding properties. Among the materials commonly used as binders are starch, clay, molasses, and gum Arabic [8]. Another material that can be mixed is additive material, which helps to improve the quality and specific characteristics of briquettes. Add commonly used additive, such as accelerants to facilitate oxygen absorption, ash-whitening to the appearance of briquettes, and filler to increase volume, density, or volume to reduce manufacturing costs [9-11].

The last information taken for this case study is the manufacturing process that is often used. The briquettes process is also called the densification process. There are a few types of machines available to produce briquettes such as piston press, screw extraction, roller press, and hydraulic press [12]. Each type of machine is used with different suitable pressures to produce briquettes, which differ in properties. Review paper for this study to narrow down to reach the objective and generate ideas and discussion to complete the studies.

2.2 Selection of Briquettes Company

The briquette company for this research is located in Perak. The main product is biomass briquette charcoals are produced from sustainable resources. The selection of this company is the result of a discussion between the two sides, the company's management and the research team consisting of lecturers. The purpose is to discuss to find potential improvements that can be made, especially the quality of briquettes. In line with the company's mission which is to provide good quality industrial briquette charcoal to incinerators and industrial users

2.3 Data Collection

The data collection method is to use qualitative methods, namely interviews and observation techniques. Interviews were conducted with an employee, and observations were made during a site visit. The data collected is consistent with the objectives of this study.

2.4 Data Analysis

Data Collected from interviews and observations during site visits can obtain the processes used by the company. As a result of the site visit, the data taken is analyzed and compared with the results of the review paper to obtain potential improvements that can be made by this company. Among the improvements observed in this study are raw material, binder, additive, manufacturing process, and issues and challenges.

3. Result and Discussion

The site visit and interview outcomes were compared with the literature review to get differences and evaluate the potential improvement in the industry. Furthermore, the site visit and interview specifically addressed the process of manufacturing, the challenge, and the materials employed, including raw materials, binders, and additives.

3.1 Raw Material

The material used to produce briquettes is rice husk in the form of pellets. Rice husk is hard to find because it has high demand outside. The rice husk used is compared with other raw materials as in the review paper (Table 1). In terms of strength, materials that satisfy the specified criteria include coconut shells, with a value of 1500 kg/cm², while other materials register values below 1000 kg/cm². Rice husk exhibits the lowest calorific value among these materials, falling below 10000 kJ/kg. The newspaper has the closest carbon content to rice husk, differing by a mere 2%, with the newspaper containing 37% carbon. Notably, rice husk boasts the highest ash percentage at 15%, surpassing newspaper (13.2%), coconut shells (1.8%), bagasse (3%), sawdust, and palm fronds, each recording 4% ash content.

Table 1 The difference between rice husk and other raw materials

Raw Material	Rise Husk	Newspaper	Coconut Shells	Sawdust	Palm Fronds	Bagasse
Strength	1000 kg/cm ²	500 kg/cm ²	1500 kg/cm ²	500 kg/cm ²	500 kg/cm ²	500 kg/cm ²
Calorific Value	5000 kJ/kg	13500 kJ/kg	14000 kJ/kg	18000 kJ/kg	14000 kJ/kg	17000 kJ/kg
Carbon Content	35%	37%	40%	42%	43%	40%
Ash	15%	13.2%	1.8%	4%	4%	3%

3.2 Briquettes Machine

Screw extrusion is used to produce briquettes. It has 2 types of screws which are for powder and screws for pellets. The pellet-type screw is used as the raw material used is also in the form of pellets. As in the previous paper, other types of machines used are Piston Pressing, Roll Pressing, and Hydraulic Press. The machine's production capacity is contingent upon brand, size, and shape factors, typically falling within the 125 to 500 kg/hour range. Regarding temperature, the acceptable limits span from a minimum of 30 degrees Celsius to a maximum of 250 degrees Celsius. All machine varieties can utilize biomass as raw material, yielding briquettes with dimensions ranging from 50 to 70 mm, as shown in Table 2.

Table 2 Comparison between types of briquette machines

Machine Type	Screw Extrusion	Piston Pressing	Roll Pressing	Hydraulic Press
Production Capacity (kg/hour)	200 to 300	200 to 500	125 to 250	150 to 200
Temperature (°C) Range	150 to 200	100 to 250	39 to 100	50 to 200
Raw Material Compatibility	Sawdust, wood chips, agricultural residue	Coal fines, charcoal, mineral powder	Coal fines, charcoal, mineral powder	Bagasse, straw, miscanthus
Briquettes Size (mm)	50 to 70	50 to 70	50 to 70	50 to 70

3.3 Binder

The binder is used to maintain the shape and integrity of the briquettes. As a result of the visit, the briquettes produced do not use any binder material. Binder materials are compared (Table 3) to see which is more suitable if used for briquettes. Various factors such as concentration, environmental impact, moisture resistance, and ash residue are compared in evaluating four different types of binder materials. While utilizing binder materials provides an option to enhance the form and durability of briquettes, it will increase production costs. Optimal cost-effectiveness is associated with binders featuring low concentrations, and the preference for biodegradable materials is rooted in their environmentally friendly characteristics. Binder materials boasting good moisture resistance and minimal ash residue are deemed preferable for their suitability in the briquette production process.

Table 3 A comparison of binders that can be used

Machine Type	Strach	Clay	Molasses	Gum Arabic
Concentration	4% - 8%	5% - 20%	2% - 10%	5% - 15%
Environmental Impact	Biodegradable	Not biodegradable, but inert and stable	Biodegradable material, low environmental impact	Biodegradable material, low environmental impact
Moisture Resistance	Good moisture resistance	Inherent moisture resistance	Some level of moisture resistance	Some level of moisture resistance
Ash Residue	Low	High	Moderate	Low to moderate

3.4 Additive

The Additive is used to improve the quality of the briquettes. As a result of the visit, the briquettes produced do not use any additive material. Additive materials are compared (Table 4) to see which is more suitable if used for briquettes. Briquette production involves utilizing three additives, each with its designated role and suitability for specific materials. The concentration of these additives is determined by the material choice and the volume of briquettes being generated. The inclusion of additives contributes to a 5 to 10 per cent increase in cost-effectiveness relative to the overall production cost. The decision to incorporate additives in the production of briquettes is guided by the intended purpose for which the briquettes are being produced.

Table 4 A comparison of additives that can be used

Machine Type	Accelerant	Ash-Whitening	Fillers
Description	To burn the briquettes easily and ensure a more efficient burning process.	To increase the quality and appearance of briquettes	To increase volume, density, or volume to reduce manufacturing cost.
Material	Sodium nitrate	Calcium carbonate, lime	Limestone, Clay, Talc
Concentration	3% - 4%	2% - 3%	5% - 20%
Cost-Effectiveness	Increase not exceeding 5% - 10%	5% - 10% in overall production cost	5% - 10% in overall production cost

3.5 Manufacturing Process

The entire process of transforming rice husks into briquettes, from the initial stage to packaging, spans approximately 10 days. Fig. 2 shows the manufacturing process of the briquettes. The journey begins with the reception of a pallet of rice husks, which is then put into a screw press machine to produce the briquettes. Subsequently, the produced briquettes undergo a minimum of 3 days of burning in an oven, utilizing diesel and controlled oxygen flow to achieve a targeted carbon specification of 35%. The carbon content is assessed either by observing the released smoke or, in more modern methods, employing a thermometer. Following the burning phase, the briquettes are taken out of the oven and subjected to a 3-day cooling process within a closed tunnel, followed by an additional 2-day cooling process in an open area. The secondary cooling process aims to ensure complete cooling without the risk of sudden combustion, employing a portable cover to prevent oxygen exposure. Once the second cooling phase concludes, the briquettes are deemed safe for transfer to the packaging area. During packaging, the cooled briquettes weighing 650 kg are placed into bags. Subsequently, the packaged briquettes are dispatched to a third-party company for testing following specified criteria.

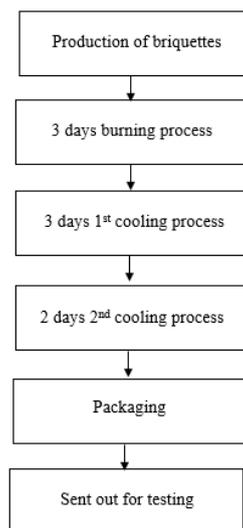


Fig. 2 The process of manufacturing briquettes

3.6 Issues and Challenges

Various issues and challenges were identified (Table 5) during the site visit, mainly related to machinery, the environment, and the workforce. One problem involves the accumulation of tar in the smoke ventilation tunnel due to burning briquettes in the oven. Additionally, there's a concern about the explosion of rice husk waste in the briquette production process. The manual packaging of briquettes, weighing up to 650 kg and transported by forklift, poses another challenge. Lastly, transferring freshly produced briquettes from the machine to the burning cage is also a challenging aspect of the process.

Table 5 *Issues and challenges along with possible solutions*

Issues or Challenges	Description	Possible Solution
Tar that accumulates in the smoke ventilation tunnel	A bad ventilation system causes the smoke that accumulates in the ventilation tunnel to turn into tar that accumulates in one place and will cause it to leak	<ul style="list-style-type: none"> • Burn the tar • Install a ventilation fan to push the smoke toward the tar collection point • The tar that is collected can be refined and sold to agriculture.
The explosion of rice husk waste during the production process of briquettes	Occurred due to a glimpse of powdery rice husks when using a pellet-type screw	Filter rice husk to separate pellets and powder.
The packaging process is done manually	The process of moving it from the cage into the bag is slow	Automatic briquettes filler
Briquettes that have just come out of the machine need to move into the cage	Briquettes are too hot, need to move by hand with 2 layers of glove	Automatic conveyor from machine to cage
The wrong body posture	Low-level conveyor	Raise the conveyor to the level of getting a good body posture

Although the solution can improve efficiency, separating pellets with powder will take time and energy. Additionally, installing ventilation fans, automatic fillers, and conveyors proves costly and requires collaboration with external entities. Consequently, the proposed solution is presented as one among several options, emphasizing the need for thoughtful and strategic long-term planning.

4. Conclusion

In conclusion, the study was able to identify the briquette manufacturing process where screw extraction is used to produce briquettes using rice husk material without using any binder and additive material. In addition, the results of the observation can identify some issues and challenges that occur in the briquette manufacturing industry. The main issue is that the carbon smoke released during combustion does not flow, causing it to accumulate in the ventilation tunnel. As a result of this study, some suggestions have the potential to be improved in the briquette manufacturing industry, either in terms of processes and materials or issues and challenges in the industry.

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