DESIGNING A ROTARY SYSTEM BIOMASS CHARCOAL BRIQUETTE MACHINE PROTOTYPE

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ABSTRACT
The global interest in renewable and environmentally friendly energy sources has led to the increasing utilization of biomass-based fuels, including charcoal briquettes. As one of the most abundant and high-quality raw materials in tropical regions, coconut shell charcoal presents a valuable opportunity for sustainable fuel production. However, existing briquette production technologies, particularly those using screw conveyorr systems, still face challenges in terms of production continuity and the need for manual labor during the cutting process. This study aims to design and develop a prototype of a rotary system charcoal briquette machine that integrates a screw conveyor and a cam-based pressing mechanism. The screw conveyor is designed to function both as a material feeder and compactor, feeding the biomass into a rotary die system. The cam-driven press continuously forms rectangular briquettes without requiring additional cutting mechanisms. Analytical calculations were performed to determine the screw conveyor's capacity, power requirement, and extrusion pressure. The designed prototype achieves a production capacity of 2,65 tons per hour using a screw rotation speed of 23 rpm, a screw diameter of 98 mm, and a pitch of 43 mm. The power required to drive the screw is calculated at 0,319 kW, and the extrusion pressure reaches 60,467 Pa. The integration of rotary dies enables a semi-

automatic operation that significantly reduces labor intensity and improves process efficiency. The result is a compact, cost-effective, and practical machine suitable for small to medium-scale briquette production industries, particularly those focusing on coconut shell biomass.

Keywords: *charcoal briquettes, coconut shell, rotary die, screw conveyor, semi-automatic machine*

INTRODUCTION

Charcoal briquettes are a type of biofuel that has gained increasing attention as a renewable energy source for a wide range of applications, including power generation, cooking, and shisha. These briquettes are typically made by compressing biomass materials such as wood, agricultural residues, or coconut shells into uniform shapes that burn efficiently and cleanly. Their widespread use is driven by the need for sustainable alternatives to fossil fuels, especially in developing countries with limited access to clean energy. Currently, charcoal briquettes are widely used as fuel in power generation, food industries (as barbecue charcoal), and for shisha purposes.

The quality standards of these types of briquettes are determined either by user requirements or by existing standards such as SNI or ASTM. For example, charcoal briquettes used in steam power plants must have low ash content. Methods to improve the quality of coke charcoal briquettes through acid treatment, which successfully reduced ash content. Meanwhile, the quality of barbecue and shisha briquettes focuses more on physical properties and the type of biomass used.

These two types of briquettes have become highly profitable commodities due to the abundant availability of raw materials, particularly coconut shells. Many industries have begun producing these briquettes, primarily for export purposes. Recognizing this opportunity, entrepreneurs, supported by research institutions, aim to produce charcoal fuel at the lowest possible production cost while maintaining high production capacity to maximize profit margins. However, to achieve this, the production process must be optimized not only for efficiency but also for consistency and scalability.

Various types of machines have been developed for large-scale charcoal briquette production. Among these, the screw conveyor system is one of the most commonly employed due to its ability to facilitate continuous briquette manufacturing. This system integrates the mixing of binder and charcoal powder with the compaction process during extrusion, thereby streamlining production. Screw press briquetting machines have been shown to produce briquettes with favorable physical properties and high production rates. A study that designed a briquetting machine using this system reported a production capacity of up to 1,020 pcs/h, with a feed rate of 130 kg/h. Despite its advantages, a notable limitation of this system is its imprecise cutting mechanism, which often leads to inconsistencies in briquette size. As a result, manual intervention remains necessary to maintain uniform product quality. This chapter proposes a charcoal briquette machine using a rotary pressing and dies system specifically for coconut shell charcoal. To improve the production efficiency of coconut shell charcoal briquettes in terms of time, labor, and process continuity.

A. DESIGN CONSIDERATIONS FOR BRIQUETTING MECHANISMS

This process involved observing existing charcoal briquette machine designs, particularly those utilizing screw conveyor systems, which were then modified to enhance efficiency and automation. Relevant literature on screw conveyor mechanisms and rotary pressing systems was collected as the foundation for the design process. In this study, the screw mechanism commonly used solely for material conveying is adapted to serve a dual function: as both a material feeder and a compaction system that directs the mixture into the briquette dies. The implementation stages of this research are broadly divided into three main phases, as illustrated in Figure 1.

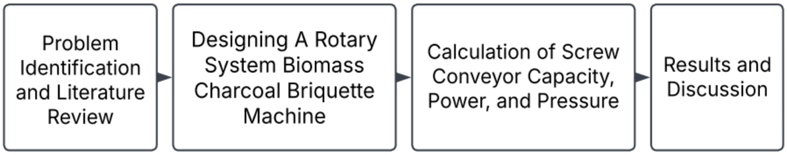

Figure 1. Research Implementation Stages

The main focus of this research is to design and develop a prototype of a charcoal briquetting machine that utilizes a rotary system for the dies process. In addition, the study includes calculations of the screw conveyor's capacity, required power, and pressure.

The capacity of a screw conveyor is defined as the volumetric or mass flow rate of material it can transport within a given time. The theoretical capacity Q of a screw conveyor can be calculated using the following formula given by Khurmi R.S & Gupta J.K (2005) as shown in Equation (1).

$$Q = 60n\phi p\gamma(D^2 - d^2)\frac{\pi}{4} \quad (1)$$

Where,

Q = capacity of the screw conveyor (kg/h)

n = rotational speed of screw (rpm)

ϕ = fill factor or loading efficiency

γ = bulk density of the material (kg/m^3)

p = pitch of the screw (m)

D = outer diameter of the screw (m)

d = shaft daimeter (m)

The screw conveyor's power requirement was determined using Equation (2).

$$P_s = 0.7355ClQ \quad (2)$$

Where,

P_s = ruquired power screw (kW)

C = constant coeficient conveyed material

L = total length of the screw

The pressure in the screw conveyor can be calculated using Equation (3).

$$P = \frac{F}{A} \quad (3)$$

Where,

P = pressure in the screw (N/m^2)

F = force on the screw (N)

A = outlet cross-sectional area (m^2)

B. OPERATIONAL PERFORMANCE AND INDUSTRIAL RELEVANCE

The design outcome of the rotary-based charcoal briquetting machine is illustrated in Figure 2, featuring a compact structure measuring 1500 mm in length, 690 mm in width, and 1080 mm in height. The system utilizes a screw conveyor integrated with a rotary pressing unit, optimized for continuous briquette production without manual cutting.

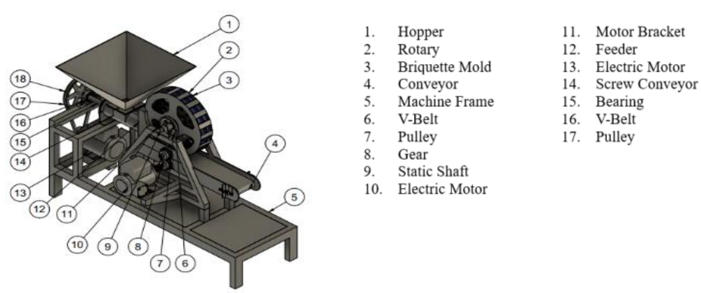

Figure 2. Design of Briquette Machine

Summarizes the main technical specifications of the machine shown in Table 1. The system is driven by a 2 HP electric motor operating at 1400 rpm. The screw conveyor, with a 98 mm diameter and 43 mm pitch, is designed to transport and compress the biomass charcoal into the rotary mold. The shaft diameter of 50 mm ensures mechanical strength during rotation and pressure buildup.

With a calculated capacity of 2,65 tons per hour, the system is capable of meeting medium-scale production demands while maintaining energy efficiency. The screw conveyor requires only 0.319 kW (0.427 HP) to operate, indicating that the machine is suitable for small-scale industries or rural applications with limited power sources.

The pressing pressure is estimated at 60,467 Pa, sufficient to compact coconut shell charcoal powder into briquettes of uniform density and structural integrity. The choice of ST 40 carbon steel for the frame and SS 304 stainless steel for contact components ensures strength and resistance to wear and corrosion, important for handling abrasive charcoal materials and operating under heat and pressure.

Tabel 1. Technical specifications of the rotary system charcoal briquetting machine

No	Description	Spesification
1	Machine dimensions	Length = 1500mm, Wide = 690mm, Height = 1080mm
2	Machine type	Screw conveyor, Rotary system
3	Frame, rotary system and screw conveyor material	ST 40 Carbon Steel & SS 304
4	Main drive	Electric motor
5	Motor speed	1400 rpm
6	Electric motor power for screw conveyor	2 HP
7	Screw conveyor diameter	98 mm
8	Shaft screw conveyor diameter	50 mm
9	Screw conveyor Pitch	43 mm
10	Capacity	265 kg/h or 2,65 t/h
11	Screw conveyor drive power	0.319 kW or 0.427 HP
12	Pressure	60467 Pa or 60.467 N/m^2

C. CHARCOAL BRIQUETTE PRESSING MECHANISM

The briquettes are formed by applying pressure using a press connected to a cam mechanism. The finished briquettes then fall onto a conveyor. The detailed briquetting mechanism can be seen in Figures 3. In this figures, the forming section rotates continuously, which is why the research team refers to this machine as a rotary system. The briquetting components are shown as number 4 (dies), 5 (press), and 6 (press cam).

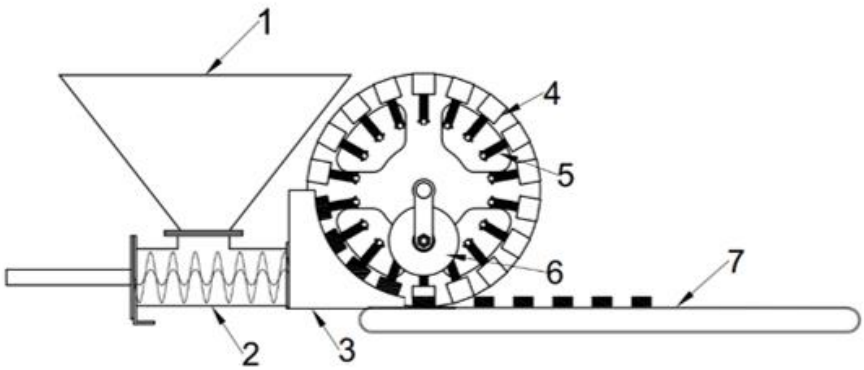

Figure 3. Charcoal briquette pressing mechanism. Component numbers: ① Hopper; ② Screw Conveyor; ③ Feeder; ④ Dies; ⑤ Pressing Rod; ⑥ Press Cam; and ⑦ Conveyor

CONCLUSION

Performance calculations indicate that the machine can produce up to 2.65 t/h briquettes, with low power consumption of 0.319 kW and an extrusion pressure of 60,467 pa. These results demonstrate the machine's high efficiency and suitability for continuous operation with minimal energy use. The machine was designed as a prototype for biomass charcoal briquetting, featuring a rotary system that addresses several limitations of traditional screw conveyor machines. By integrating a screw conveyor with a cam-operated pressing mechanism, the system performs material feeding, compacting, and briquette forming in a fully continuous and semi-automated process. In conclusion, the developed machine offers a practical, energy-efficient, and labor-saving solution for biomass briquette production, particularly using coconut shell charcoal. It supports the broader goals of sustainable energy development. Future enhancements may focus on automation and durability improvements to ensure reliable long-term performance in industrial environments.

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