

Adaptation and Evaluation of Pellet Press Briquette Machine

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ABSTRACT

A good substitute for coal, lignite, and firewood is briquetted fuel made from agricultural leftovers. Compared to loose agro-residues, which have a specific density of 60 to 180 kg/m³, briquettes have a high (1200–1450 kg/m³). Briquettes are formed right where they are made, thus reducing air pollution. In this work, a sawdust and coffee husk briquetting machine is redesigned and built. In this work, briquettes (solid fuels) were made using a screw-type briquetting to compress sawdust and coffee husk at different ratios. An effective densification technique that is suitable for small-scale applications is being adapted by screw press briquetting. The equipment has been modified to generate briquettes at a rate of 187.62 kg per hour. Briquette density, power consumption per kilogram of briquette produced, and calorific value per kilogram of briquette have all been examined in relation to the effect of moisture content in agro-residues and binders utilized. Paper was used as the binding agent, and different biomass binder ratios of 100:10, 100:12.5, and 100:15 were tested to assess the briquette's physical characteristics. The binder level has a big impact on the briquette's physical characteristics. level.

Keywords: Briquette machine; Binding material; Waste biomass; Briquette.

Introduction

Due to a growing global population and burgeoning economies, the need for energy is rising quickly. The over use of non-renewable energy sources as well as other environmental issues including deforestation, environmental degradation, and climate change are all results of this rising energy use [3]. Recent years have seen a rise in interest in the development of renewable energy sources like hydro, wind, solar, geothermal, and bio-energy due to growing concerns about environmental protection, energy security, overexploitation, and rising costs of fossil fuels [1],[2].

Ethiopia relies heavily on traditional biomass for its energy needs, including firewood, agricultural waste, dung, and charcoal. Over 92% of the nation's total energy needs is met by traditional biomass, with the remaining 4% coming from oil, hydro, and geothermal sources [6]. For use in homes, businesses, and industries, biomass is the main energy source. The household sector dominates Ethiopia's energy market, making over 93% of the country's total energy consumption [4],[6]. Ninety-nine percent of the total amount of biomass consumed is used for home purposes, with the remaining one percent going to commercial and public functions. Traditional fuels are the most commonly used for domestic cooking in both rural and urban regions, accounting for 96% of all [3]-[5]. A trade-off in agricultural production results from reliance on biomass energy, as crop residues and animal manure are diverted from farms, where they replenish soil nutrition, to meet energy needs. Additionally, the country's limited biomass and forest resources are anticipated to come under strain from the increased demand for traditional biomass energy uses and a lack of access to modern energy services. In order to create a more effective and environmentally friendly energy source, it is necessary to adopt and promote alternative modern biomass conversion methods. Densification of biomass wastes into fuel briquettes is one of these innovative alternative biomass energy technologies that offer a chance to address the drawbacks of traditional biomass. Briquettes are dense materials

made by compacting loose biomass waste such as sawdust, coffee husk, cotton husk, wood charcoal dust, crop residues, and other solid biomass waste. The densification/briquetting process is the physical conversion of loose, unprocessed raw organic materials into high density fuel briquettes through a compacting process that improves the product's calorific content and combustion efficiency [9].

Briquettes can also be made from any conveniently accessible sort of biomass leftover. This has also helped briquettes become more well-known in many developing nations where biomass is the main source of energy. Briquettes can therefore be regarded as one of the most significant contemporary biomass technologies due to its extensive and varied range of environmental, social, and economic advantages. In the end, widespread use of biomass upgrading technologies in Ethiopia can help to efficient usage of the currently underutilized biomass resources, boosting domestic energy supply, enhancing environmental protection and hygienic practices, and lowering GHG emissions [7],[9].

A procedure that is closely connected to the briquetting procedures yields pellets. The primary distinction is that each machine includes a number of dies arranged as holes bored in a thick steel disk or ring, with die diameters typically up to about 30 mm. Generally to solve the problem related to Briquette producing mechanism, size and to transfer Biomass and agricultural residue (coffee husk, sawdust and corncob) to high densified fuel briquette.

Materials and Methods

Equipments and Ingredient

The material for the briquetting machine depends on how it will be used and how each component of the machine will operate specifically. The tools used in the experiment were a machine, a motor engine, a stopwatch, a caliper, a moisture meter, a digital balance, a sack, carbonized sawdust and coffee husk biomass, water, waste paper, a container, a taco meter, a bomb calorie meter, a furnace, and an oven.

Description of the briquetting machine

The single extrusion worm screw (auger) press briquetting machine was used in the current study. The machine's driving motor, screw, and power transfer system are its main components.



Figure 1. Briquette Machine prototype

The power is transferred from the motor to the screw via a pulley and belts. An engine motor powers the device. Before being added to the machine hopper, biomass must be blended with the addition of a binder that acts as an

adhesive to the mixture. The biomass mixture is dumped into the hopper after the machine is turned on to begin the briquette-making process. The engine's motor, the prime mover, will use a belt to drive a device positioned on a shaft. Every raw material, including biological waste and raw.

Performance evaluation of the machine

On the basis of the sample-based proportion mixture, the briquetting machine was put through testing. Using a weighing balance, the input biomass mass and the output briquette mass were calculated. For each test, the stop watch was used to record how long it took the biomass to be processed into briquettes. Using Eq., the biomass loss was calculated. (1). Using Eqs. (2) and (3), the machine's capacity as well as efficiency were determined.

$$\text{Biomass loss (kg)} = M_i - M_o \quad (1)$$

$$\eta = \left(\frac{M_o}{M_i} \right) * 100\% \quad (2)$$

$$(\text{kg/h}) = \text{BFR} \times 1 \text{ hour} \quad (3)$$

However, $\text{BFR} = (\text{Average mass of output briquette (kg)} / \text{Average processing time (s)})$

where :- M_i , M_o , MC and M_b are the mass of input biomass, mass of output briquette, machine capacity and t, briquette forming rate, respectively.

$$\text{Volume} = L_b \times B_b \times T_b \quad (4)$$

Where:- L_b = Length of briquette, cm; B_b = Breadth of briquette, cm; and T_b = Thickness of briquette, cm



Figure 2. Briquette Machine testing

Sample Preparation

Blending of materials

For the correct binding action, uniform binding material distribution in sawdust and coffee husk particles is essential. The coffee husk and sawdust were manually combined with paper used as blender. Water was used as a medium to help with the mixing process. Three samples—one for each binding agent—were created, each containing a different percentage of binder—10%, 12.5%, and 15%—along with 40% of the base material.

Methods of Briquette production

This study utilized traditional briquette production techniques.

1. In the manufacturing of briquettes, waste paper served as both a binding agent and a source material. For the manufacturing of carbonized sawdust and coffee husk briquettes, waste paper was utilized.
2. Sawdust and coffee husk were used as the primary raw materials in the briquette production. Different ratios of waste paper were added to the chosen raw materials as a binding agent. Samples of sawdust and coffee husk were combined in weight ratios of 100:10, 100:12.5, and 100:15 with a prepared paper binder. The biomass sample and the paper binder had a high moisture level and were thoroughly combined.
3. Composite samples were extracted from manufactured briquettes and subjected to physical and proximate studies for characterization. A standardized method called "proximate analysis" The procedures of the ASTM standard were adopted to obtain the above parameters.



Figure 3. Methods of briquette produce

Results and Discussion

Physical Characteristics of the Briquettes

The machine was used to produce sawdust and coffee husk briquettes successfully. Briquettes produced using 15% waste paper assumed as black-whitish color. The other that produced was black coloration, depending on the quantity of waste material included. Two cylindrical briquettes with length 3.9cm height 3.6cm and diameter 3.6cm, on each briquette were produced at a time. Each briquette weighed in average 29.61 grams.

Performance evaluation of the machine

The modified machine was put to the test using various raw materials (sawdust and coffee husk) and binding materials in various combinations. The performance of the briquette machine was tested at rpm 1000, 1100, and 1200 with binding ratios of 10%, 12.5%, and 15%. The fabricated screw press performed satisfactorily. The modified machine was put to the test using various raw materials (sawdust and coffee husk) and binding materials in various combinations. The briquette machine was found to be the best raw material, and its powder proved to be effective as a binding agent. The altered machine's production capacity was calculated and found to be 187.62 kg of briquettes per hour. To run the equipment, two people are needed. Below are given the specific performance data of briquettes.

Table 1. Production of briquette machine

Test	p_t (s)	m_i (kg)	m_o (kg)	Loss (kg)
1	57	3	2.85	0.15
2	52	3	2.81	0.19
3	48	3	2.78	0.22
4	52	3	2.65	0.35
5	49	3	2.49	0.51
6	46	3	2.83	0.17
7	53	3	2.75	0.25
8	46	3	2.82	0.18
9	58	3	2.38	0.62
10	57	3	2.72	0.28
Average	52	3	2.71	0.29

* P_t -Processing time; M_i -Mass of biomass input; M_o - Mass of briquette output

The average mass of the briquettes produced, according to the table above, was 2.71 kg, whereas the loss was 0.29 kg. Additionally, it took the machine an average of 52 seconds to convert biomass into solid fuel (briquettes). The machine had a capacity of 187.62 kg per hour and a calculated efficiency of 90.3%.

Proximate analysis

Optimum Coffee husk and Sawdust-Binder Blend

A combustion test using a bomb calorimeter is used to calculate the calorific value produced by biomass briquettes. The most crucial factor in assessing the quality of briquettes is calorific value. The best results were obtained using a mixture of waste paper and sawdust with a ratio of 100:12.5, with heating values of 5524.19 and 4806 cal.g⁻¹, respectively. The designed biomass briquetting machine can create excellent briquettes that meet the briquette quality specifications from sawdust. The 100:12.5 blending ratio was found to be the ideal ratio based on the heating value.

Table 2. Proximate Analysis of Briquettes Samples Result

SN	Sample type	Binder Ratio (%)	Moisture Content (%)	Volatile matter (%)	Ash Content (%)	Fixed Carbon (%)	Calorific Value (cal/g)
1.	Coffee husk	B1(15%)	15	51	12	22	4503.5
		B2(12.5%)	14	58	7	21	4337.76
		B2(10%)	13	58	12	17	4806
2	sawdust	B1(15%)	10	59	7	21	5209.1
		B2(12.5%)	10	50	5	35	5524.19
		B2(10%)	10	44	8	38	5249.3

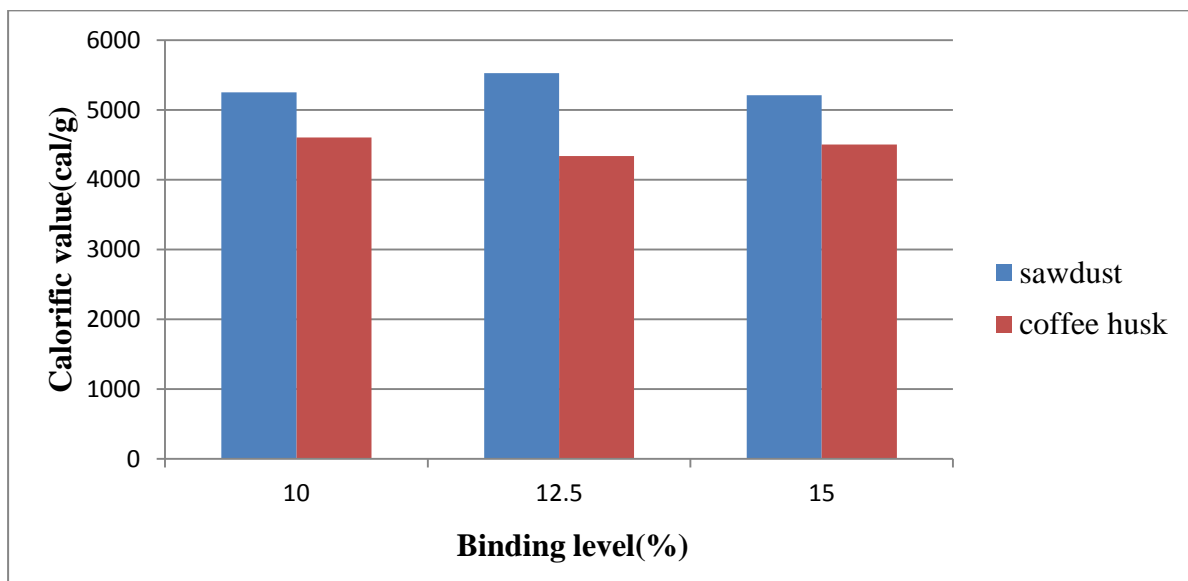


Figure 4. Calorific value tested biomass with binding level

Because they provide a rough sense of the energy values and extent of pollutants released during burning, proximate analyses of fuels are valuable. The percentages of the proximal values of the various contents, as shown

in table 2 and fig. 5, illustrate how the various contents compare to one another. From the figure, it can be seen that sawdust briquettes have a minimum moisture content of 5% as compared to coffee husk biomass and a moisture content of 10% in all binding levels. While sawdust briquettes had a minimum ash content of 5% and a maximum ash value of 12% for coffee husk briquettes, respectively. Coffee husk briquettes had a maximum volatile matter of 58% and a minimum volatile matter of sawdust was 44%. The charcoal briquettes had a maximum fixed carbon percentage of 38% in sawdust and a minimum fixed carbon percentage of 17% in coffee husk.

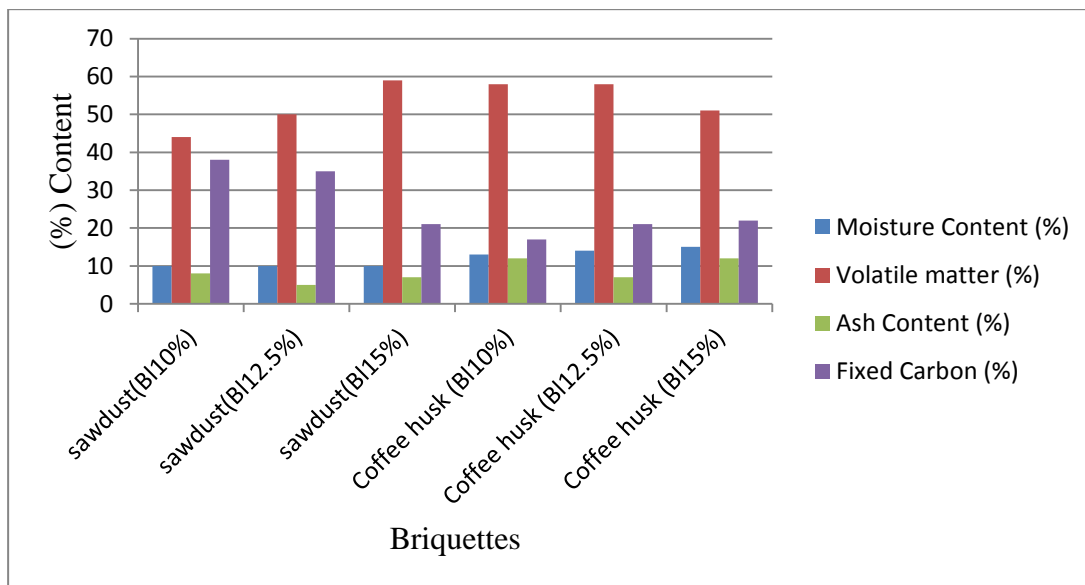


Figure 5. Proximate analysis result

Conclusions and Recommendation

By managing a number of process variables, such as the moisture level of the feed combination, the feed's particle size, and the makeup of the additives supplied to the feed mixture, high-quality sawdust and coffee husk briquettes could be made. Two people are needed to operate a briquette maker. The machine's productivity and efficiency were 90.3% and 187.62 kg/hr, respectively. In this work, a screw-type briquetting was modified, constructed, and tested to create briquettes (solid fuels) using a mixture of sawdust and coffee husk at various mix ratios. The use of a briquetting machine can considerably benefit rural residents, and it has enormous promise as a renewable energy source and a decent alternative to wood.

Production of briquettes from waste biomass helps to increase the mechanism of carbon sequestration through reducing the deforestation rate. The briquetting machine is can be locally made with that can easily be made available in the local small and medium metal fabrication workshops. It is better to use electric motor instead of fuel engine motor for sustainability as a source of power for where electric power is available. Thermal efficiency with combustion behavior of briquette can be done as research to know quality of briquette produced.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this research work.

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