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DESIGN AND FABRICATION OF A PORTABLE MANUALLY OPERATED SAWDUST BRIQUETTING MACHINE

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Abstract

In Nigeria, furniture making, construction, and cooking compete for woody biomass as their raw material. The utilization of sawdust generated during wood processing for generating thermal energy frees up wood for other useful purposes. However, briquetting is needful, since loose biomass cannot be utilized directly. Low-pressure compaction techniques are preferred for small scale consumers. The need for portable and cheap briquetting machines, therefore, cannot be over-emphasized. The project is concerned with the design, development and fabrication of a briquetting machine for use by small scale customers, possibly resident close to saw mills. A manually operated hydraulic sawdust briquetting machine was designed, fabricated and tested. The machine consists of a cylindrical mold, a piston welded to a 5-ton hydraulic car jack, which drives it, a frame, and a cover plate. The machine worked satisfactorily with an average time of 2minutes and 4 seconds for briquette production. Three samples with different binder content were produced, with calorific values of 83.53, 113.79, and 120.44 J/g, respectively. The machine can be used by small scale consumers to produce briquettes for thermal applications.

1.0 INTRODUCTION

Briquetting is the densification of loose biomass. In utilizing biomass for large-scale fuel applications, the process is indispensable because of its damp and voluminous nature in its elementary form. Biomass densification, therefore, improves it energy density, as well as its handling, transportation, and storage characteristics[1]. Sawdust is waste from wood processing, usually found at sawmills. A large portion of the land at these mills, that could have been useful for other purposes, is taken up by the waste. The off-gassing of sawdust in open storage produces harmful gases like methane and carbon monoxide, compared to what would have evolved from the combustion of wood fuel[2]. Thus, conversion of the wood dust to briquettes seeks to curb solid and gaseous pollution. Furthermore, wood is left for other important ventures such as construction and furniture making, as opposed to energy utilization.

Densification technologies may be classified according to the amount of pressure required to consolidate the loose mass: high-pressure, medium-pressure, and low-pressure compaction[3]. No binder is required in high- and medium-pressure compaction, but the feed material is softened through heat during medium pressure compaction, while the feed material is mixed with a binder in-low pressure compaction."Binderless" compaction technologies offer durable and dense briquettes, but have a high specific energy requirement, high wear rate of parts, and are, therefore, unaffordable for small-scale customers[1]. Therefore, low-pressure compaction may be preferred for domestic purposes. Various work has been published on design and fabrication of manual sawdust briquetting machines. In [4], a manual hydraulic sawdust briquette press was designed,a manual screw press was designed in [5],and a sawdust briquetting machine was also designed in [6].

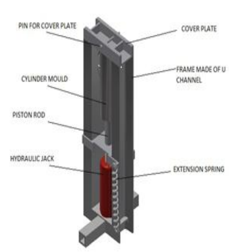
.These designs were very heavy. This necessitates a design which is portable, cheap, as well as produced from locally sourced materials. The aim of this paper is to design and fabricate a briquetting machine that meets these requirements. The subsequent sections highlight the methodology, results and discussion, and conclusion.

2.0 METHODOLOGY

2.1 DESCRIPTION OF MACHINE

A sawdust briquetting machine was designed and fabricated with the following factors being put into consideration: low-cost, portability, fabrication from locally sourced materials, high-pressure during compaction, and manual operation. The machine consists of a cylindrical mold of internal diameter of 70mm and a depth of 190.5 mm, a piston welded to a 5-ton hydraulic car jack, which drives it, a frame, and a stopper. A clearance of 2mm between the piston and the cylindrical mold walls, allow for smooth movement of the piston within the mold, and the escape of water during compaction. Figures 1(a) and (b) contain pictorial and isometric views of the machine.

(a) Pictorial view



(b) Isometric view

Figure 1.The briqueting machine.

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The parts list is shown in Table 1.

Table 1: The parts list

S/N	PART	QUANTITY	DESCRIPTION
1	Hydraulic Jack	1	5 tonnne jack, hydraulic jack
2	Extension spring	1	Hardened steel, chromed spring material
3	U channel	1	Mild steel. 1700 ×80mm, 5mm thick
4	Mild steel plate	1	80 ×109 mm, 6mm thick
5	Mild steel rod	1	Length of rod 264mm, diameter 30mm
6	Mild steel pipe	1	Inner diameter 70, outer diameter 78

The maximum compaction pressure, P,may be estimated using:

$$P = \frac{1000 \times T \times g}{\pi r^2} \quad (1)$$

where, T is the hydraulic jack capacity (tons), πr^2 is the piston surface area (m^2), and, g is the acceleration due to gravity (m/s^2). If, T = 3tons, r = 0.034m, g = 9.81m/s^2, then P is 8.1MN/m^2.

2.2 TESTING AND EVALUATION

The feed material (sawdust) and binder (starch) were mixed in three proportions to give three samples, as shown in table 2, and were compacted with the machine, as shown in figure 2.

Table 2: Briquette samples

S/N	SAMPLES	SAWDUST (g)	STARCH (g)	TOTAL MASS (g)	DENSITY (Kg/m^3)
1	Sample 1	100.8	57.8	158.6	288.3
2	Sample 2	100.8	115.6	216.4	343.5
3	Sample3	100.8	173.4	274.2	386.2

Figure 2: The compaction process

Durability, and calorific tests was carried out on all the samples. In the durability test, the briquette is dropped repeatedly from a height of 1m until it fractures, while the oxygen bomb calorimeter is used to carry out calorific tests.

3.0 RESULTS AND DISCUSSION

The briquetting machine worked satisfactorily. The briquette production time is shown in Table 3, while the durability and calorific test results are reported in Table 4.

Table 3: Briquette production time

S/N	COMPONENT (t_i)	TIME (s)	% OF PRODUCTION TIME
1	Loading (t_1)	38	30.65
2	Compaction (t_2)	53	42.74
3	Ejection (t_3)	33	26.61
	TOTAL	**124**	**100**

Table 4: Durability test

S/N	SAMPLES	NUMBER OF DROPS	CALORIFIC VALUE (J/g)
1	Sample 1	4	83.53
2	Sample 2	7	113.79
3	Sample 3	11	120.44

The calorific value, and durability increase with the binder content, and the total time of briquette production is 2 minutes and 4 seconds.

4.0 CONCLUSION

A manually operated sawdust briquetting machine was designed and fabricated using locally sourced materials. The machine produces a single briquette during thecompaction process, and is portable. It is very cheap to produce, and is, therefore, appealing to small scale customers. Further work should include automation of the hydraulic jack, and the addition of a drier, perhaps, using briquettes produced from the process.

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