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DESIGN OF GRASS BRIQUETTE MACHINE

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ABSTRACT
In contemporary times, increase in population has placed a huge burden on fuel wood and is now forcing the growing population to engage in deforestation. Of the vast energy resources, non-renewable fossil energy still dominates the consumption chart in Nigeria coupled with its increasing costs which is going beyond the reach of low income earners. In this study, briquette machine design was considered for processing biomass of grass origin. The machine operations include pulverization, compaction and extrusion of the briquettes. Power of 1hp motor is recommended for effective size reduction using a disc plate. The design of the shaft is on the basis of strength, rigidity and stiffness to overcome distributed weight of dried grass stocks. The machine requires a shaft of dimeter 20mm to drive the grinding plate. The dynamic load on the bearing is 8.9kN. The diameter of the screw shaft which is essentially the briquetting screw press, is 40.8mm. The dynamic load on the bearing is 11.42kN, power of the electric motor required to convey, compact and extrude the briquette fuel is 7hp.Resultant fuel briquettes from grass represents a good alternative to fuelwood which can be used for heating, cooking and for firing of boilers either for allied products or for power generation.

Keywords: *Grass, Shaft, Bearing, Biomass, Briquette, Machine*

1. INTRODUCTION
There exist several materials suggesting machine designs or presses for wood briquetting especially in the developed countries of the world. Similarly, significant research from Authors across Asia shows that there is considerable evidence of wood briquetting as well as the use of wood as fuel wood in the rural areas for cooking in an open fire or stove [1,3]. In Sub-Saharan West Africa and the rest of Africa, wood logging is predominantly used for direct combustion and building infrastructures. The subject of wood briquetting is very common, however there exists a considerable number of literature on the use of solid waste and/or agricultural residues for briquettes [7,4,9].

Similarly, Onuegbu [8] examined the production of briquettes from wood and coal. Osarenwinda [9] designed a press for the production of briquette from fillings. In some other undocumented researched efforts, wood shavings (sawdust) were pressed either manually or with hydraulic press to produce briquettes for use in stove. However, there is sufficient literature suggesting the use of grass species for animal husbandry. Odia [5] examined the energy potential dried leaves and agricultural residues. As a follow up on the previous research attempts on biomass fuel, this work is seeking to design a biomass briquette machine capable of converting grass stalk (*Pennisetum purpureum* Shumach and *Panicum maximum* Jacq.) to energy as alternative to fuelwood.

2. METHODOLOGY
The design considerations are based on forces required to drive the shaft, materials and material selection, shaft diameter, throughput capacity, dynamic load on bearing, power of the electric motor required to turn the shaft for effective grinding using the disc plate, diameter of the screw shaft, the dynamic load on the bearing transmitted by the screw shaft, power of the electric motor required to compact pulverized feedstock as well as extrude the resultant briquette from the die. Other considerations include

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the size of the machine, design acceptability based on socio-cultural practices, adaptability of design and fitness for purpose.

Figures 1 represents the conceptual diagram of grass briquette machine. The feedstock is fed through the hopper and to the crushing chamber for material size reduction. The crusher is made of disc plate driven by a direct coupled drive electric motor carrying a shaft and bearings. Feedstock is transported through an auger for grinding and further moved by gravity and collected in a feed barrel. The screw press is driven with a direct coupled drive to the electric motor which is linked to a shaft. Blended and mixed feed is compacted and transported by the screw press and extruded as fuel briquettes with the aid of a die.

The theoretical formulation is based on attempts to produce briquette from dried biomass i.e. perennial grass. Considerations for the grinding components include: power required to convey the dried biomass along the length of the auger, power compensation for friction and other losses during operation and the power required to overcome the inertia of the shaft and the screw. The shaft in this case is cylindrical in shape and made of mild steel thus, the volume of shaft is represented as;

$$V_s = \pi r^2 L \qquad (1)$$

Where r is the radius and L is the length. The mass of shaft is the product of density and volume,

$$M_s = \rho V \qquad (2)$$

The volume of flight,

$$V_f = \frac{\pi(D-d)^2}{4} \times t \qquad (3)$$

Where D, is the screw/conveyor diameter; d, is the shaft diameter and t, thickness

Okafor [6] computed the power to overcome the mass as:

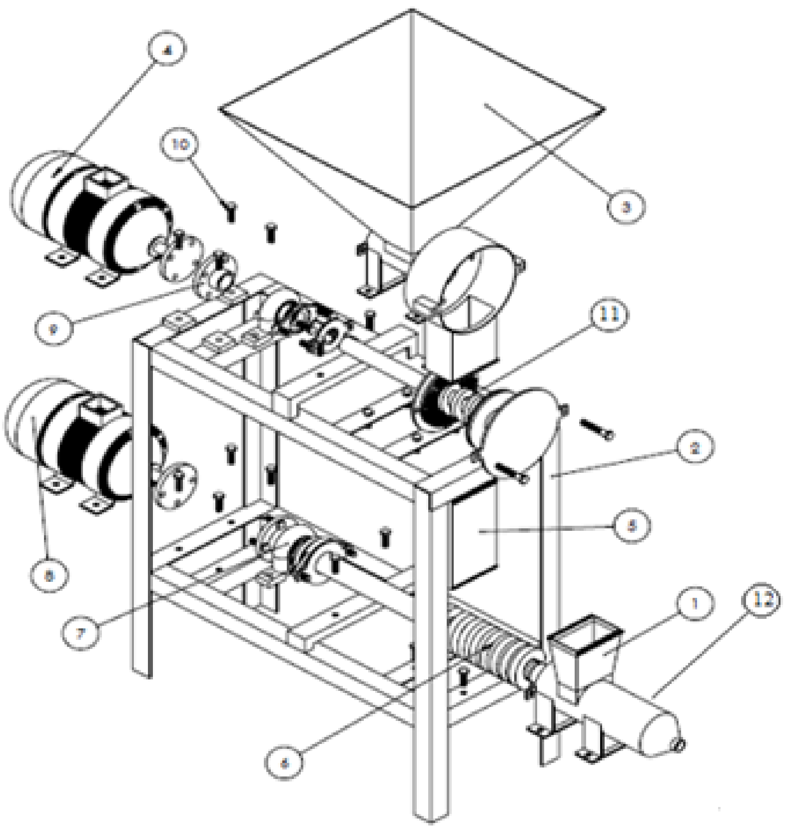
$$power = mgV_m \qquad (4)$$

In (4), the mean peripheral velocity, V_m is given by $V_m = \frac{T_m N}{60}$ where T_m, is the lead of screw and N is revolution per minute of screw.

Similarly, throughput capacity can be computed as;

$$Q = 47.1(D-d)^2 \delta n \psi \rho C \qquad (5)$$

Where D is the outer screw diameter, d is the inner screw diameter, δ is the screw lead, n is the rotational speed, C is the correction factor based on the angle of inclination which is taken as 1, ψ is the filling coefficient of the screw cross section and ρ is the bulk density of the pulverized grass. Figure 2 shows a typical auger used to convey biomass to the grinding plate.



Item No.	Item Description	No. Off
1.	Compression Hopper	1
2.	Frame	1
3.	Feed Hopper	1
4.	AC Motor	1
5.	Linking Duct	1
6.	Screw Press	1
7.	Pillow Block Bearing	1
8.	Reducing Motor	1
9.	Coupler	1
10.	Bolt	1
11.	Auger	1
12.	Compression Chamber	1

Figure 1: Conceptual Diagram of Grass Briquette Plant

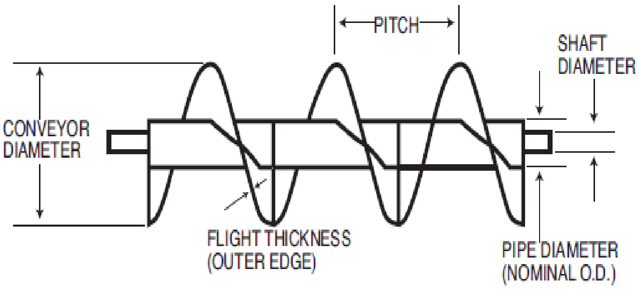


Figure 2: An Auger

Hence the power required to convey the grass can be derived thus;

$$P_2 = \frac{QLWF}{4560} \quad (6)$$

Q, is the conveyor capacity; L is the projected length of the screw conveyor; F_m is the material factor and W is the bulk density. Khumi [2] shows that the force required for actual grinding of the grass is the product of pressure and the surface area of contact. The surface area of the circular disc plate is given by;

$$A = \pi r^2 \quad (7)$$

Again, power can be represented as the product of force and the velocity, where velocity;$V = \omega r$ where, ω is the angular velocity which is equal to that of the shaft,

$$\omega = \frac{2\pi N}{60} \quad (8)$$

The power required to overcome frictional losses can be computed assuming 10% losses due to frictional forces. Essentially, the shaft is designed on the basis of strength, rigidity and stiffness. Okafor [6] shows that the shaft diameter can be deduced from;

$$d^3 = \frac{16}{\pi S_a}\sqrt{[(k_b M_b)^2 + (k_t M_t)^2]} \quad (9)$$

The hopper is considered as squared frustum made of mild steel as shown in Figure 3.

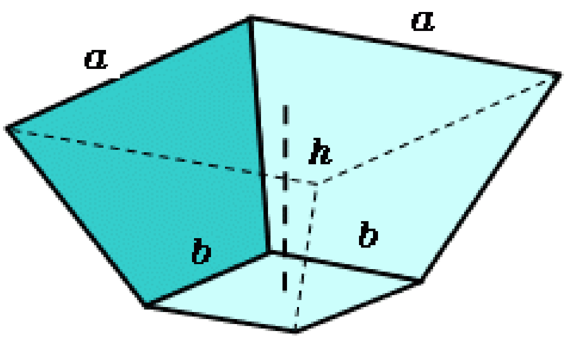


Figure 3: Cross Section of the Hopper

The volume of the hopper is given by;

$$V_h = \frac{h}{3}\left[A + A^1 + \sqrt{AA^1}\right] \quad (10)$$

Where h, is the height of the hopper; a, is the length of the large base; b, is the length of the small base; A, area of the large base and A^1, is the area of the small base

Khumi [2] shows that the basic life of a bearing L_{10}, measured in millions revolution is computed as;

$$L_{10} = \frac{60 \times L \times N}{10^6} \quad (11)$$

Where N, is the speed of the shaft in rev/min

The equivalent dynamic load (F_e) can be represented as;

$$F_e = (xC_rF_r + C_tF_t)S_f \quad (12)$$

C_r is the radial factor, x is the rotational factor, F_r is the radial load, C_t is the thrust factor, F_t is the thrust or axial load and S_f is the safety factor (4). For inner race rotation, x = 1, k = 3 (when ball bearing is used,$k = {}^{10}/_3$ (roller bearing) and C, is the base dynamic load rating in Newton (N).

$$C = F_e L_{10}^{\,1/k} \quad (13)$$

Essentially, the screw power shaft operates both as conveyor and a power element. The screw is welded to the shaft with incremental screw height which provides the compressive force required for briquetting. Design considerations for screw press entails the power to overcome the inertia of the shaft and the screw, the power to convey the pulverized dried grass stock along the entire length of the press and the power to effectively compact the feedstock with little or no binder added.

3. RESULTS AND DISCUSSION

Biomass briquetting machine as shown in Figure 1 was designed for material size reduction (crushing), compaction and extrusion of produced briquette. From the theoretical formulations drawn from the design consideration, the machine parameters and specifications are given in Table 1.

Table 1: Machine Parameters and Specifications

S/No.	Design Parameter	Specification
1.	Diameter of shaft at disc plate	20mm
2.	Dynamic load on bearing	8.9kN
3.	Power of the electric motor	1hp
4.	Diameter of screw shaft	40.8mm
5.	Dynamic load on bearing	11.42kN
6.	Power of electric motor (Screw)	7hp

This means that the machine requires a shaft of diameter 20mm to drive the grinding plate. The dynamic load on the bearing is 8.9kN and the power of the electric motor at the point of grinding is 1hp. However, the diameter of the screw shaft which is essentially briquetting screw press is 40.8mm. The dynamic load on the bearing is 11.42kN and furthermore, the power of the electric motor required to convey, compact and extrude the briquette fuel is 7hp. Whereas Onuegbu [8] examined the production of briquettes from wood and coal using hydraulic press. Osarenwinda and Ihenyen [9] designed a press for the production of briquette from fillings and again, produced briquette using manual hydraulic press.

4. CONCLUSION

A shift from fuel wood to grass species promises a robust prospect for communities to produce domestic size briquette for cooking and heating in boilers and stoves. The most promising areas for development of a grass-based energy industry are the Sub-Sahara African countries like Nigeria. From the process considerations, biomass briquette machine was designed. The feedstock is grass species belonging to the POACEAE family and specifically *Pennisetum purpureum* Shumach and *Panicum maximum* Jacq., also known as Elephant and Guinea grass respectively. The result of this study shows that a screw press can be used to produce briquette from indigenous grass stalk. More so, grass briquette machine is adaptable for converting wood shavings also known as sawdust to fuel briquette for energy generation. The reason is based on similarities in the forces required for size reduction, compaction and extrusion which is very different when compared to solid wood in form of logs or other hard biomass feedstock.

5. REFERENCES

[1] Abakr, Y. A. and Abasaeed, A. E. “Experimental evaluation of a conical crew briquetting machine for briquetting of carbonized cotton stalks in Sudan”. *Journal of Engineering Science and Technology*, 1 (2), 212 – 220, 2006.

[2] Khurmi, R. S. & Gupta, J. K. “*Machine Design”*. Eurasia Publishing House (PVT) Ltd., RAM Nagar, New Delhi, 677-714, 2005.

[3] Mani S, Sokhansanj S, Bi X, Turhollow A.“Economics of Producing Fuel Pellets from Biomass”. *Journal of American Society of Agricultural and Biological Engineers*. 22 (3), 421-426, 2006.

[4] Obi, O. F., Akubuo, C. O. and Okonkwo, W. L. “Development of an appropriate briquetting machine for use in rural communities”. *International Journal of Engineering and Advanced Technology*, 2 (4), 578 – 582, 2013.

[5] Odia, O. O. “Availability of grasses, weeds and leaves as energy resource”. *Journal of Renewable Energy*, 34, 485 – 496, 2009.

[6] Okafor, B. E. “Development of Palm Oil Extraction System”. *International Journal of Engineering and Technology*, 5 (2), 68-75, 2015.

[7] Oladeji, J. T. “Comparative study of briquetting of few selected agro-residues commonly found in Nigeria”. *The Pacific Journal of Science and Technology*, 13 (2), 80 – 86, 2012.

[8] Onuegbu, T. U., Ogbu, I. M. and Ejikeme, C. “Comparative analyses of densities and calorific values of wood and briquettes samples prepared at moderate pressure and ambient temperature”. *International Journal of Plant, Animal and Environmental Science*, 2 (1), 40 – 45, 2012.

[9] Osarenwinda, J. O. and Ihenyen, O. I. “The preliminary design and fabrication of a manually operated briquetting machine”. *Journal of Applied Science and Environmental Management*, 16 (2), 209 – 211, 2012.