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DESIGN AND DEVELOPMENT OF A GRASS GRINDING MACHINE

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ABSTRACT: The search for energy alternatives involving locally available and renewable resources is one of the main concerns of governments, scientists and business people worldwide. This paper focuses on the design and fabrication of a grass grinding machine to facilitate grass grinding as an aid to sustainable energy from biomass in Nigeria. The work further focuses on grinding of elephant grass for generation of energy due to its availability and alternative means of energy generation to fuelwood. The elephants grass was Oven heated to 250ºC, to ensure dryness, the materials for the fabricated machine was sourced locally. They include a 1hp motor, a medium carbon steel Shaft, a SPA rubber melt, a mild Steel bearing, a 255mm by 255mm mild Steel hopper at the top and 125mm by 125mm at the bottom with a thickness of 2mm, a mild steel casing, a mild steel mesh of 4mm and cast iron pulleys. The dried grass is fed into the hopper and the tilted shaft within the casing carries out the grinding and sends it to the mesh which then sieves the ground particle into the receiver for collection. Dried Grass of mass 510.1kg was fed into the hopper and in three minutes the grass was pulverized to a fine particle of mass 43kg. The ground elephant grass can further be converted into pellets and briquettes, which can be used as heating fuel to provide an alternative to wood, biogas etc.

Keywords: Energy Alternatives, Grass Grinding Machine, Generation of Energy.

1. INTRODUCTION

One of the most challenging tasks facing Nigeria just like other developing countries is finding a means of expanding her energy services especially to the rural households, and at the same time addressing the health and environmental consequences of over-dependence on fire-wood for cooking. Irrespective of Nigeria's position as the sixth largest oil producing country, she suffers enormous energy crisis and still employs the use of biomass in the form of wood to meet her energy demands for local use.

Energy no doubt is important to the well-being of humans and to a country's economic development. It is an important input in achieving sustainable development including reduction of poverty. Energy is important to meet our basic needs such as cooking and boiling water. The most common form of energy widely used in Nigeria is biomass in form of wood [1-2].

Biomass is any organic matter that is renewable over time. It is simply a stored energy, and most often refers to plants or plant based materials such as grasses, sugarcane, wood, and wood chippings etc, which are specifically called lignocellulosic biomass. Wood remains the most common source of biomass in Nigeria to date [1].

The overdependence of most Nigerians on wood biomass in meeting their energy demands for heating and cooking purposes has increased the demand for wood through time. With this increase in demand for wood, wood collection has placed a considerable pressure on the forest and consequently this has resulted in deforestation and other environmental consequences.

Deforestation poses a significant threat to lives on Earth due to the fact that burning of wood releases CO_2, a greenhouse gas which facilitates global warming. Hence the need for a more available, affordable, and environmental friendly alternative source of energy for cooking in Nigeria. In this regards grass pulverization and briquetting can be employed as a suitable and a more reliable alternative for wood in accordance with the Nigeria national energy policy: To de-emphasize and discourage the use of wood as fuel [3].

This paper is therefore part of an ongoing work on grass grinding as an aid to sustainable energy from biomass in Nigeria. However this work focuses on the grinding of elephant grass for generation of energy due to its availability and alternative means of energy generation to fuelwood.

2. LITERATURE REVIEW

Survey shows that authors across the globe have developed machines for grinding, cutting and crushing of biomass or solid waste materials/agro residues in Asia, America and Europe, [4-5].

Anand, (2016) [6] showed in the past that manually operated machine has been developed for fodder cutting. The Machine design was baesd on a human powered flywheel or a bicycle drive with speed variation mechanism. Hence, the effort for the process was extensive and unsafe. To overcome these obstacles we have designed a grass grinding mechanism which is safer and effort reducing with minimum power consumption.

Khurmi, (2016)[7] developed a Chaff Cutting Machine which is hay or straw cutting machine that is used for uniform chopping of fodder for livestock to agro industries. In this paper, design and development of grass grinding Machine is presented. The machine is developed gradually from basic machines into commercial standard machine that can be electrically driven to achieve effective grinding of elephant grass. The grass grinding machine is modified for its compactness and to avoid blockage of grass.

Grass is a biomass material readily available in the savannah areas of Nigeria (Guinea forest savannah, made up of plains of tall grasses, Sudan savannah which is the most common across the country with similar but shorter grasses and the Sahel savannah made up of patches of grasses and sand [8].

Generally in Nigeria, grasses are cut and mostly used for feeding live stocks. Often times it is considered a waste regardless of its abundance in the country. Presently, with the advancement in technology, perennial grasses such as elephant grass can be pulverized and pressed into pellets and briquettes and used as a heating fuel to replace or complement fuels made from wood fibers [8].

Energy studies indicate that significant gains in energy return and reduction in carbon emissions can be achieved by using grasses as biomass fuel [9].

Basically, for grasses to be pelletized or turned into briquettes it must undergo a very vital process which is the "grinding process''. To grind simply means to reduce a material to fine particle, in other words grinding means to crush, pulverize or to reduce to powder by friction [10]. Thus a grass grinding machine utilizes the force of friction in reducing grasses to powder.

Grasses more technically known as graminoids are monocotyledonous, usually herbaceous plants with narrow leaves growing from the base. They include the '' true grasses'' of the family poaceae as well as the sedges (cyperaceae) and the rushes (Juncaceae) [10].

3. METHODOLOGY

The conceptual design considerations are based on its mode of operation, material selection, belt size, 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, and the size of the machine.

The conceptual diagram of grass grinding machine is as shown in figure 1. The grass 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. The screw press is driven with a direct coupled drive to the electric motor which is linked to a shaft by means of pulleys. The smooth grinded grass is moved and extruded with aid of a die.
The design parameter calculations for the grinding components include: length of belt, diameter of shaft, the power required to overcome the inertia of the shaft and the screw, and the energy required for grinding.

The length of the V-belt (L) was determined using Eq. (1) as given by Khumi, (2005).

$$L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{1}{4C}(D_1 - D_2)^2 \qquad (1)$$

Where
d_1= diameter of motor pulley, d_2 = diameter of shaft pulley, C = center distance between the two pulleys.

The shaft is designed on the basis of strength, rigidity and stiffness. Khumi, (2005) shows that the shaft diameter can be deduced from;

$$\mathbf{d^3 = \frac{16}{\pi S_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}} \qquad (2)$$

Where, M_t = Torsnional moment (Nm)

S_s = Shear stress

M_t = torsnional moment, Nm

M_b = bending moment, Nm

K_t = combined shock and fatigue factor applied torsnional moment

k_b =, combined shock and fatigue factor applied bending moment

Power requirement: This is given by:

$$Power(P) = \frac{2\pi NT}{60} \quad (3)$$

Where N = speed of rotation and T = torque

$$Torque = \frac{WL}{2} \quad (4)$$

Thus, L =Length of shaft, W = Load.

This concept was adopted after other concepts were evaluated against certain chosen criteria. The criteria for selection were based on the functional requirements of the system, ease of fabrication and the objectives of the grinding machine. In the above concept the shaft housing is tilted at an angle similar to that so that the grasses can slide down during grinding with the help of gravity but relatively less complex and less costly. Energy equation utilized for grinding is given as:

$$E = K_R \left(\frac{1}{d_2} - \frac{1}{d_1}\right) \quad (5)$$

From Rittinger's law of grinding,

E ($J.kg^{-1}$) = the energy required per mass of feed (W/(kg/s)),

K_R = Rittinger's constant,

d_1 (m) = the average initial size of pieces,

d_2 (m) = the average size of ground particles.

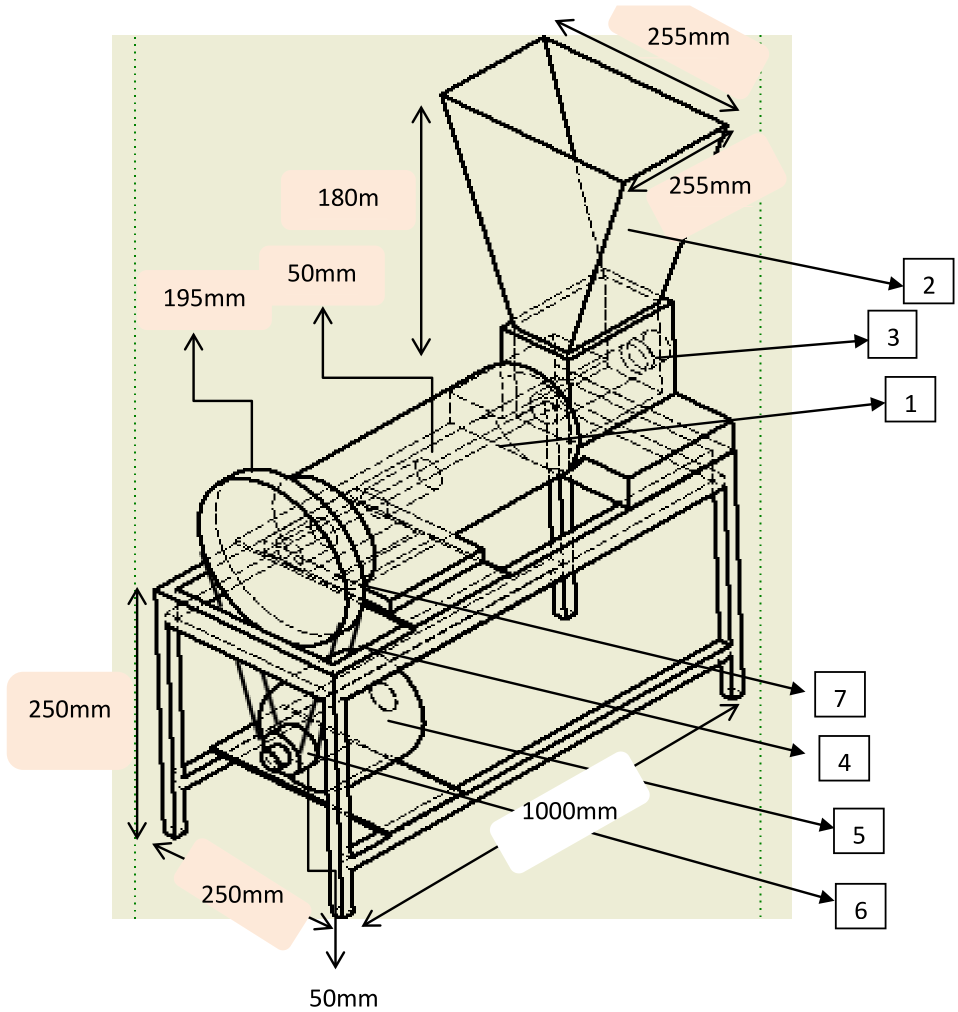

Figure 1. Isometric View of Conceptual diagram of grass grinding machine.

Table 1. Key.

Item No	**Description**
1	Shaft
2	Hopper
3	Sieve
4	Belt
5	Motor
6	Small Pulley
7	Big Pulley

Hopper Design: The hopper is considered as squared frustum made of mild steel as shown in Figure 2.

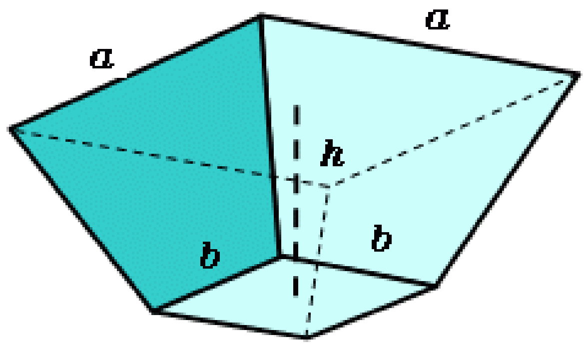

Figure 2. Hopper Design.

The volume of the hopper is given by equation (6),

$$V = \frac{h}{3}[A_1 + A_2 + \sqrt{A_1 A_2}] \quad (6)$$

Where, h = height of the hopper, A_1 = area of the upper base, A_2 = area of the lower base, a = length of the upper base and b = length of the lower base.

4. RESULTS AND DISCUSSION

The grass grinding machine was designed and fabricated as shown in the figure 3 for material crushing of elephant grass used for energy generation. The machine parameters and specifications obtained from the design considerations and theoretical formulations are as provided in Table 2.

Table 2. Machine Parameters and Specifications

S/No	Design Parameter	Specification
1	Volume of hopper	$33.51 \times 10^{12} mm^3$
2	Length of belt	1240mm
3	Power of the electric motor	1hp
4	Diameter of screw shaft	50mm

Figure 3. Fabricated Grass Grinding Machine.

The following results were obtained from dried elephant grass at oven temperature of 250ºC.
Mass of sack = 16.4g
Total Mass = Mass of sack + Mass of Dried Grass.

Table 3. Mass of dried elephant grass at 250ºC at different time interval.

	Sample A	**Sample B**	**Sample C**
Initial Total Mass (g)	526.5	526	527
Total Mass after 1 hour (g)	436.9	462.8	431.8
Total Mass after 2 hours (g)	406.7	428.3	413.8
Total Mass after 3 hour (g)	406.7	427.99	413

510.1kg of the dried elephant grass was fed into the hopper for 2 minutes to pulverize to fine particles of 43kg. The pulverized product was sieved using a sieve size of 4mm to test for fineness of particles. The pulverized particles and the sieved particles obtained are as shown in Figure 4 and 5 respectively.

Table 4. Mass of ground product of grass and time taken to grind.

Mass of dried Grass (kg)	**Sieve size (mm)**	**Mass of grinded grass Before Sieve (kg)**	**Mass of grinded grass after Sieve (kg)**	**Time Taken to Grind the Grass**
510.1	4	62	43	5mins 2secs
445.5	4	58	35	4mins 25sec
402.6	4	55	30	3mins 38secs
308.6	4	48	35	2mins 40secs
270.6	4	45	30	2mins

Figure 4. Sample of an Oven Dried Grass

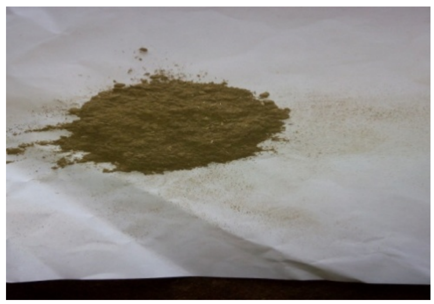

Figure 5. Pulverized Product of Grass

5. CONCLUSION

It can be inferred from the test, result and analysis that the grass grinding machine was effective in not just its ability to grind the elephant grass but also a large variety of grass samples it can grind. The machine is portable by virtue of its size and eases of operation and was fabricated from locally sourced materials making it very affordable for homes and for commercial uses thereby increasing the availability of energy to Nigerians. The pulverized product of grass from the machine will be effectively utilized in the production of briquettes and pellets and used as biofuel to complement fuels made from wood fiber alongside, reducing deforestation and its effects.

The design and fabrication of this machine lays a unique foundation for sustainable energy generation from biomass and hence further research for Nigerians.
Therefore we recommend

- Government to encourage and fund the local production of the machine to further enhance the use of grasses as a viable substitute for wood.
- Cheaper and better production processes for the fabrication of the machine to be researched.
- Government to provide a means of utilizing the end products from the machine such as pellet and briquette stove.

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REFERENCES

[1] United Nations Development Project (2012).Africa Gender and Energy.

[2] World Health Organization (2006) http://www.who.int/heli/risks/indoorair/indoorair/en/).

[3] Iloeje, O. C. (2002). Renewable Energy Development in Nigeria: Proceedings of a National Workshop on "Energising Rural Transformation in Nigeria: Scaling up Electricity Access and Renewable Energy Market Development". Federal Ministry of Power and Steel, Abuja, Nigeria. March 19-20, 2001. pp180. ICEED.

[4] Kishinmoto,S.(1969), "Briquetting of sawdust and other waste materials," proc. Inst. Briquetting and Agglomeration, Sunc. Valley, Idaho, Aug.27th-29th.pp43.

[5] ASTM (1951). Standard for Coal and Coke, pp: 46-51.

[6] Anand K. T. (2016), "Design and Modal Formulation of power Operated Chaff Cutter", International Journal on Emerging Technologies (IJET), vol. 4, p.p. 0975-8364.

[7] Khurmi, R. S. & Gupta, J. K.(2005), "Machine Design". Eurasia Publishing House (PVT) Ltd., RAM Nagar, New Delhi.

[8] Roger, M. R.; Mario, T. F. and Edwin C. A. (2007). Fibre Morphology in Fast Growth Gmelina Arborea Plantations. Madera Bosques, Vol. 13. No. 2. pp 3-13.

[9] Colley, Z.; Fasina, O. O.; Bransby, D. and Lee, Y. Y. (2006). Moisture Effect on the Physical Characteristics of Switchgrass Pellets. Transaction of ASABE. Vol. 49. No. 2. pp 1845-1851.

[10] Earle, R. L. and Earle, M. D. (2004). Size Reduction. Web Edition ed. Unit Operations in Food Processing. The New Zealand Instiute of Food Science and Technology (Inc.).