Development of a Simple Briquettingmachine for Small Scale Application

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Abstract **- Human waste, agricultural waste and animal waste will always be available in abundance as long as living upon the surface of the earth is permissible. This will certainly constitute some form of nuisance if not effectively managed and utilized. Briquetting is one useful way to manage the rubbish generated by human and their activities on the earth surface, especially in this generation where the desire for energy is ever in geometric progression. Briquetting is a method of compacting the wastes into a single solid rod or brick with the use of briquetting machine. This briquettes are utilized as alternative source of energy for cooking and general thermal energy supplement. Consequently, a manually operated simple briquetting machine was designed and fabricated. The machine is made from locally available materials. The assembling was done through welding and machining processes. The simplicity and performance evaluation of this machine justify its efficiency, ease of operation as well as suitability for small scale production of briquettes.**

Keywords: Briquettes, Briquetting machine, Alternative energy, Small scale briquetting.

INTRODUCTION

Briquettes are made from waste. Materials such as old newspapers, partially decomposed plant, wood etc. are made to function as alternative fuel to charcoal and fire wood.Briquetting is a process where some type of material is compressed under high pressure(Grove, 1995).Depending on the materials, methods and procedure of making these briquettes, they can burn cleaner than coal. Turning useless materials into a fuel source is attractive because it is a sustainable process(Denholm, 2007). Many different methods and technologies exist for pressing briquettes. Though each method has its own unique advantages and disadvantages, the method, technology or the machine used plays a significant role in the quality of the briquette produced. This paper describes the development of a briquetting machine for small scale application. The machine can be used by small scale entrepreneurs for small entrepreneurial community groups and business people. Compaction of the products from the machine was aided by using starch as binding agent for fastening its particles.Using fuel briquette reduces the use of firewood, charcoal, thereby saving money and time and also putting less pressure on forest products. Income and employment opportunities are generated from briquettes production and sales. When the rubbish on the streets isused up as raw material for briquetting the environment becomes cleaner and the health standard of the community is improved.

Briquetting is a process of compaction of residues to products of higher densitythan the original raw material. In developing countries such as Malaysia, Philippine andThailand,biomass briquettes are mostly carbonized to get briquetted charcoal. (Bhattachanya,2002). Usually binders are added to act as fastening agent. Briquetting is a step by step process of collecting, blending, mixing, compacting and drying. Essentially, briquetting will save trees, prevent negative health effects in places that burn only dung (and save the dung for fertilizer) as well as creating many micro-enterprise possibilities.

Young (1994) reported successful briquette with 10-16% clay binder. Ajueyitsi (2002) also produced briquette with 4-6% starch binder.

A popular biomass briquette emerging in developed countries takes wastes products, such as sawdust, compresses it and then extrudes it to make a reconstituted log that can replace firewood. It is a similar process to forming a wood pellet but on a larger scale. The extrusion production technology of briquettes engages extrusion screw on wastes (straw, sunflower husks, buckwheat, etc.) or finely shredded wood waste (sawdust) under high pressure when heated from 160 to 350 C °. The quality of such briquettes, especially heat content, is much higher comparing with other methods like using piston presses.(Wikipedia, 2013)

Sawdust briquettes have developed over time with two distinct types: those with holes through the centre (plates 2&3) and those that are solid (plate 3). Both types are classified as briquettes but are formed using different techniques. A solid briquette is manufactured using a piston press that compresses sandwiched layers of sawdust together. Briquettes with a hole are produced with a screw press. The hole is from the screw thread passing through the center, but it also increases the surface area of the log and aids efficient combustion.

According to Manny and Paddy (2009),North India biomass briquette consumption has seen new dimensions. Many companies like Nishant Bioenergy and Ekta

Bioenergy in Rajasthan are leading in the briquette supply and manufacturing. The contribution of briquetting production and sales to the economy of those nations are quite magnificent and cannot be over-emphasized.

This paper discusses the construction of a simple briquetting machine using a screwed-drive fitted with a compacting disc to compress waste materials like sawdust, rice husk, and straw into a briquette of a solid form that will serve as alternative to conventional fuel. The mold compacting chamber is designed to produce only cylindrical shape briquettes. The machine is manually operated. It is vertically framed with power screw at the top, which when turned anticlockwise will feed downwards to compress the briquette inside the compression chamber located at the middle of the vertically framed body. When tuned clockwise, the power screw causes the ejection of the briquette with the aid of the connecting rod attached to the power screw which is joined with the ejection pipe as the power screw moves up.

DESIGN CONSIDERATION AND ANALYSIS

The design considers the production of cylindrical briquettes with the following dimensions: diameter (d) = 70mm,r = d/2 = 35mm;height (h) = 150mm

Surface Area of the chamber $A = 2\pi r(h + r)$ --------- equation 1

$$A= 0.406m^2$$

Total mass used = 8.5kg

Weight = mg--equation 2

Where g is the acceleration due to gravity = $9.81m/s^2$

$W = 83.39N/m^2$

The maximum pressure due to the weight of briquette is calculated from the simple equation of Pressure

$$= \frac{force\ or\ weight}{Surface\ Area}$$

mass of briquette material sample thatfilled up the compression column chamber is measured to be 167.2g

i.e. Mass (m) $= 1.672 \times 10^{-1}$ kg

Weight (W) = mg =1.64N

The circular surface area under the influence of the compaction pressure given by

$$A = \pi r^2, \text{ but diameter } d = 50mm$$

$$A = \pi(0.05/2)^2 = 1.96375 \times 10^{-3} m^2$$

The pressure exerted due to the weight of the briquette = $\frac{1.64}{1.96375 \times 10^{-3}}$=835.14N/$m^2$

The capacity (C)of the compression chamber = $\pi r^2 h$, where h is length of compaction chamber.

$C= \pi (0.025)^2 \times 0.160 = 3.142 \times 10^{-4} m^3$

Volume of cylindrical briquette $V = \pi h_2 (R^2-r^2)$

The height to which the base plate is raised during compression = 60mm

The height of the compression chamber = 160mm

:- h_2= 160m – 60mm = 100mm = 0.1m

$V = 0.1\pi[(0.25)^2-(0.1)^2]=1.65 \times 10^{-2} m^3= 16.5cm^3$

The mass of the compression bar is4.3kg. This serves as additional weight with the weight of the respective masses used in the analysis.The compression bar was filled to the brim with briquette materials.The briquette was then compressed and the following results were obtained.

Table 1: Determining the weight for minimum compression of briquettes

Mass (kg)	24.3	44.3	64.3	84.3
Height (mm)	82.0	75.0	77.5	61.0

Further addition of masses to 84.3kg does not have any corresponding reduction in the height.

Weight = = 84.3 x 9.81 = 826.983N

Recall that cross sectional area $A = 1.96375 \times 10^{-3} m^2$

Therefore pressure applied $= \frac{826.983}{0.00196375}$= 421124.38N/$m^2$.

The minimum pressure applied on the biomass material in the mold chamber = 421124.38N/m^2

Lead Screw Design: The lead screw is the screwed shaft that transmits the applied force to compress the briquette in the chamber.

Lead screw pitch Þ = 5.5mm, Mean diameter d = 50mm, Helix angle = α is given by

$\tan ά = p/\pi d$ Osarenmwinda and Ihenyeh (2012).

$\tan ά = \frac{5.5}{\pi \times 5o} = 0.0350095$

$ά = \tan^{-1} 0.0350095$

$= 2.01^0$

The coefficient of friction between the plate and the compression chamber is chosen to be 0.12. (Khurmi and Guptal, 2005).

Friction angle β is given by$\beta = \tan^{-1} 0.12= 6.84^0$

Force required to turn the screw F = W tan (β - ά)= 826.983 x tan (6.84 - 2.01)= 69.88N

The Torque (T) required to turn the lead screw is determined byT = Fr

Where r is the mean radius of the screw i.e. mean diameter/2r = 0.025

T= 69.88 x 0.025 = 1.747 Nm

Efficiency E=ideal effort/actual effort = $w \tan ά$ / wtan(ά + β) X 100%

E= W tan2.01/tan(2.01 + 6.84) X 100% = 0.2249 x100 = 22.49%

Materials and Methods: The Compression plate:3mm thick mild steel was machined into a circular shape for easy of passage into the circular chamber during briquette compaction. Through cutting, drilling and machining, the plate originally 75mm x 75mm was reduced to a circular plate with 15mm internal diameter and 49.5mm external diameter plate.

Compression Chamber: Manufactured from a cylindrical pipe of diameter 50mm and 4mm thick. It was measured and marked out to 160mm long, but was cut above the 160mm mark in order to be machined (turn) on the lathe for better precision.

The Lead Screw: The lead screw was machined (turn) on the lathe at the base to accommodate the lead screw socket. The screw with major diameter 45mm and minor diameter 40mm was groove to depth of 4mm.

Lead Screw Socket: This is a bar of 70mm by 40mm bored to 40mm by 34mm and a hole of diameter 7mm was drilled of the side of the bushing, which was tapped to accept a lock for the lead screw.

Top Beam C support channel for the lead screw: U bar is made of mild steel materials with its carbon content ranging from 0.15% to 0.3%, making it tough to withstand normal loading. Bazor and Lambert, (1984). 4 "U" channel was measured, marked and cut to a sizes. The center hole for the female part of the lead screw marked and rough cut with an arc welding machine and later filed to the exact size. Middle Beam (support channel for the compression channel). The 4 "channel bar was cut to 240mm long, while the hole of diameter 40mm for the compression chamber was measured, marked and rough cut with arc welding machine and later filed to that exact 40mm diameter. The centre of the channel was drilled to 10mm for the injection rod passage**.** Bottom Beam (support channel for injection pipe) it is a 4 channel bar, which was cut to 2 feet long, while the 18mm diameter for the stopping nut to pass through was drilled at the center of the channel.

Ejection Support Bar: The flat bar of 5mm thick was measured, marked, cut and filed to a rectangular bar of 20mm by 300mm, while the whole for the rod to form the center hole of the briquette was drilled to 15mm diameter.

Ejection Mechanism: The ejection of the briquette from the compression chamber is done with a simple mechanism including the following links; the ejection pivot rod, ejection lift bar, ejection rod mover and two ejection rods.

Assembly: The female part of the lead screw was welded to base bored on the support channel for the lead screw to the guided and for ease of rotation. The support channels were welded to the frame bar. The compression chamber was also welded to the middle of the support channel. The two holes of diameter 16mm spaced at 140mm apart was drilled on the ejection support channel bar to locate the ejection rods. The two ejection rods were later held together at their base by ejection rod mover by welding.The ejection bar of 20 x 4 x 160mm was bolted to the ejection rod mover connecting the two ejection rods at the center pivot. This is connected to the ejection lift bar by a bolt and the lift bar is welded to a pivot fixed with the ejection rod. Finally a pivot rod is passed through the pivot pipe fixed to the ejection rod for lifting the compressed briquette out of the compression cylinder.

Finishing Operation: Finishing jobs involved grinding, filing, polishing and painting of the machine surfaces to make the assembly neat and most importantly to prevent rust and corrosion.

Maintenance: The maintenance of this simple briquetting machine includes regular cleaning after use, tightening of nuts and bolts and replacement of worn out parts.

Testing: The compacted briquettes were very solid (plate 2). The machine compressed rice husk to a density of $480kg/m^3$, sawdust to $600kg/m^3$ and maize stalk to$750kg/m^3$. The design uses the opposite turning of the lead screw to eject the compacted briquettes. Thus it makes ejection process slower and fragile in order not to damage the compressed lump. The time taken for production of a briquette was 8minutes for the briquettes of good quality.

RESULTS AND DISCUSSION

For the same volume of different materials, different heights of compression were produced by the machine. Out of the three materials that were tested, rice husk has the least densityfollowed by saw dust and then maize stalk in that order. All the three products were very strong as they did not break under compressive load of 20kg. On combustion, the briquette from the maize stalk provided more energy due to its highest density out of the three samples tested. The machine produced a briquette in 4minutes. Therefore an entrepreneur who operates the machine five hours a day will produce above six dozens in a day. The machine is therefore very suitable for domestic and small scale enterprise application. Apart from the fact that it can be stored inside the house without fear of explosion unlike other fossil fuels, the products of this machine also burns better than kerosene and gives less amount of carbon sooth on burning

RECOMMENDATION

The design of the machine should be replicated and made available for the cities and the communities where refuse disposal and recycling is difficult. However it is observed that the amount of briquettes produced by this machine per man-hour is low regarding the enormity of waste material available for briquettes production. Therefore further developments ofthis machine should focus more on products multiplicity, increased machine speed and performance.

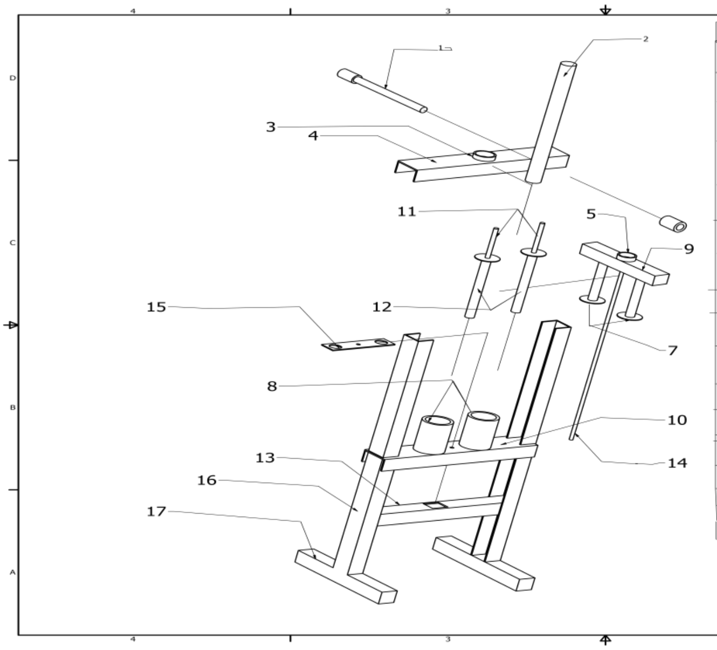
CONCLUSSION

The design of a simple briquetting, using power screw in transmitting the compressional force simplifies briquetting to the lowest ebb. It can be manually operated by any class of people, with or without formal education. It does not require the use of any form of ancillary source of power like electricity or diesel and petrol. The materials for its construction are available locally. The machine can also be easily transported to site without difficulty as a result of its compact size and flexibility of assemblage. The abilityof the compression chamber to be replaced to suit the design of different shapes of briquettes is a plus. The U channel bar provides optimum rigidity and stability. The simple briquetting machine will go a long way in reducing greenhouse gas emission resulting from waste burning and poor waste management.

REFERENCES

(1) Abubakar, A. (2003), Employment Creation in Agro-Allied Sub-Sector, CBN Bulleting 27(4): pp 7-9
(2) Ajueyitsi, O.N.A. (2002), Evaluation of Coal briquettes as a Source of Domestic Cooking Fuel. M.Eng Thesis, Mechanical Engineering Department, Federal University of Technology, Akure
(3) Battachanya, S.C. (2002). A Global Review with Emphasis on Developing Countries, Paper Press In First World Pellets Conference, Stochholm, Siveden.
(4) Bazor, Z. and Lambert, F. (1984), Mechanical Properties of some fill materials for ceramic conservation, International Council of Museum Committee for Conservation Preprints, 7th Triennial Meeting, Copenhagen Paris, Icon. 84.20.1-4
(5) Denholm, P. (2007): The Potential of Solar Water Heating to reduce Fossil Fuel Use and Green House Emissions in the USA, National Renewable Energy Laboratory Vol.41157
(6) Goodger, E.M. (1980): Alternative Fuels, Chemical Energy Resources: Macmillan, London Publisher
(7) Grooves, D. P. (1995), “Briquetting of Wood and Agro-Residue”, Wood Energy News, 10(3): pp. 12-14
(8) Khurmi, R. S. and Guptal, J. K. (2005), A Textbook of Machine Design,S. Chand & Co Ltd,5th Edition,
(9) Manny and Paddy(2009): “With Green Power Comes Great Responsibility” -EIA Renewable Energy of Solar Thermal Collector 20091009
(10) Osarenmwinda, J.O. and Ihenyeh, I.O. (2012): “The Preliminary Design and Fabrication of Manually operated Briquetting Machine”, Journal of Applied Sciences and Environmental management, Vol. 16 (2), pp. 209-211
(11) Olorunnisola, A.O. (2007),“Production of Fuel Briquettes from waste paper and coconut Husk Admixtures”, Agricultural Engineering International E-journal, Manuscript, EE06 006, Vol. 8
(12) Wikipedia (2013): The Free Encyclopedia http://en.wikipedia.org/wiki/briquette assessed January, 2014

APPENDIX



S/N	ITEMS	DESCRIPTION	QTY	MATERIALS
1	TOMMY BAR	24D X 300bar	1	M.Steel
2	POWER SCREW SHAFT	M60 X 5.5 X 600	1	M. Steel
3	SCREW LOCK		1	M. Steel
4	POWER SCREW SUPPORT BAR		1	M. Steel
5	BUSHING		1	M. Steel
6	COMPRESSION PLATE		4	M. Steel
7	COMPRESSION PIPE		2	M. Steel
8	COMPRESSION CHAMBER		2	M. Steel
9	COMPRESSION BAR		1	M. Steel
10	COMPRESSION SUPPORT BAR		1	M. Steel
11	COMPRESSION ROD		2	M. Steel
12	EJECTION PIPE		2	M. Steel
13	EJECTION SUPPORT BAR		1	M. Steel
14	EJECTION ROD		1	M. Steel
15	EJECTION PLATE		1	M. Steel
16	FRAME SUPPORT		2	M. Steel
17	BASE BAR		2	M. Steel

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Fig 1: Assembly Drawing of Briquetting Machine

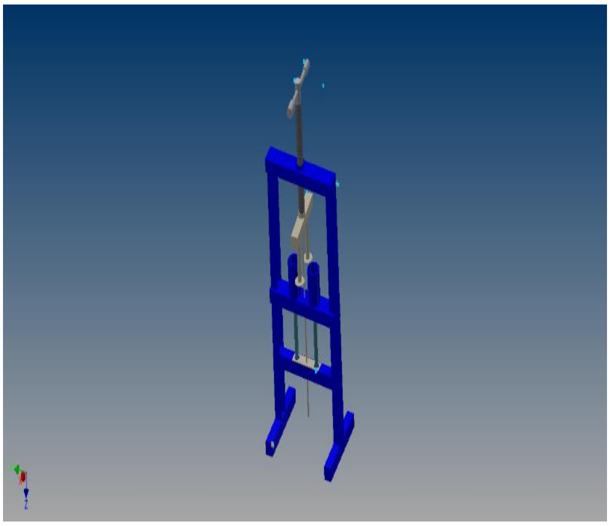

Plate 1: 3-D viewof the briquetting machine Plate 2: Picture of Machine

Plate 2: Picture of Samples of briquettes produced