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THE DESIGN AND FABRICATION OF A BRIQUETTE PRESS USING LOCALLY AVAILABLE RAW MATERIALS IN NIGERIA: AN APPROACH TOWARDS BRIQUETTE TECHNOLOGY SUSTAINABILITY IN NIGERIA.

Eze - Ilochi Nkechinyere Olivia [1] and Oti Wilberforce J.O [2]
[1] Evangel University Akaeze, Ebonyi State, Nigeria
[2] Ebonyi State University, Abakaliki, Ebonyi State, Nigeria

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Abstract:
The demand for energy is increasing constantly with the increasing population of the world, and the major source of energy (oil and gas) is limited. This, calls for sustainable energy production and supply such as renewable energy technologies. In this study, a manually operated briquetting machine (a screw press) was designed and fabricated using locally available materials to ensure the sustainability of production and use of briquettes which is a renewable source of energy in Nigeria. The principal parts of the machine are the stirring, screw, compaction chamber and frame. The machine is capable of producing four briquettes (measuring 5cm in length and 7cm in diameter) at a time, as well as creates a central hole on them to aid combustion. The force and compaction pressure of the machine was determined to be 205.80N and 13.4kPa respectively. Performance evaluation of the machine was done by using it to produce maize stalk briquettes. Analysis of the briquettes produced proved the performance of the machine satisfactory. It is hoped that the machine will be useful to small and medium scale briquette manufacturers.

Key words: *Briquettes, Screw Press, Fabrication.*

Corresponding Author:
Eze - Ilochi Nkechinyere Olivia,
Evangel University Akaeze,
Ebonyi State, Nigeria.

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INTRODUCTION:

Energy is the basic need for the economic development of any nation. In Nigeria, the demand for energy is higher than its supply, and it is increasing day by day. Nigerians over depend on oil and gas for domestic and industrial purposes. This makes the price of oil and gas to be increasing constantly, such that most Nigerians cannot afford it. A greater percentage of the ever-growing population of the country has resorted to the use of wood fuel in semi urban and rural areas of the country, this cause global warning, soil erosion and desertification. Compaction of materials (e.g. coal, agro-residues and biomass) for fuel making purposes has been a technology widely used by many countries because it provides renewable source of energy called briquettes. Compaction of these materials for the provision of briquettes will not only provide an alternate source of energy which is renewable, but also help to address the environmental consequences and health hazards associated with the use of wood fuel, and also an effective means of managing agro wastes. A briquette is a block of compressed material that is used to produce heat. Common types of briquettes in use are coal, peat, charcoal, biomass, etc. Briquetting is the agglomeration of fine particles by applying pressure to them and compacting them into various shapes with or without a binder [1]. There is a world acceptance of briquettes and growing demand for briquette plants. Most countries of the world e.g. India, China, Thailand, Japan, Kenya, Malaysia have already adopted this technology. It is yet to get a strong foothold in Nigeria because of technical constrains involved and lack of knowledge to adopt the technology to suit local conditions. The major problem associated with briquette technology in Nigeria is the fabrication and use of briquette press. Some researchers that studied briquettes used hand mould [2,3] single mould [4], among others, in briquetting, making the whole process tedious and boring.

Some researchers used of imported, electrically driven, sophisticated briquetting machines, etc. however, due to lack of technical know how to operate them, problem of electricity in Nigeria, and lack of maintenance, these machines were inefficiently used and were finally abandoned. Provision of cheap and efficient briquette press will help to encourage the production and use of briquettes in Nigeria, hence the need for research on locally constructed briquette press that can produce many briquettes at a time in order to sustain briquette technology in Nigeria. Apparently this will facilitate the maintenance and workability of the briquette press.

Many researchers have reported on the design and fabrication of briquette press. Afonja, (1975) [5] reported on a specially designed briquette machine for briquetting sub-bituminous coal. Ilechie *et al.*, (2001) [6], designed a moulding machine to produce briquettes from palm waste. Inegbenebor, (2002) [7], developed a briquetting machine that can produce for agricultural and wood waste. Osarenmwinda and Ihenyen (2012) [8], also developed a manual hydraulic press. Olorunnisola, (2007) [9], designed and fabricated a prototype briquetting machine in form of die extruder to produce pellets from waste paper plus admixture of coconut husk. Arinola and Osumune, 2013 [10], designed a saw dust briquette machine. Grover and Mishra, (1996), reported that there are two basic types of high compaction technology; the piston press and the screw press. In terms of briquette quality and production procedure, the screw press is superior, the central hole in the briquettes produced by a screw helps in uniform and efficient combustion with significant reductions in smoke. The briquettes from screw press have high density, and are stronger than that from a piston press, making them less prone to breakage which reduces losses during handling. Its maintenance cost is also low, compared to piston press. Therefore, screw press looks to be the most promising technology with its advantages outweighing its disadvantage which is that one briquette is produced at a time [11]. Although there has been a high degree of success with machines from Europe, Japan, India, China, and America, real technology transfer has not really taken place. This rapidly leads to equipment being either abandoned due to high cost of maintenance or operated inefficiently due to lack of technical knowhow. The cost of importing these machines is also high. Local manufacture of briquette press is an important factor in guaranteeing the sustainability of briquette technology, by ensuring that the skills for maintenance are indigenous and hence readily available. In an attempt to overcome these problems and provide a technology which is suited to local manufacture and adapted to local feedstock, a screw press which produces four sizeable briquettes at a time, with a central hole (to aid the combustion process) is fabricated.

Aim of study:

This work is aimed at designing and fabricating a simple briquette press (screw press) from locally sourced materials, which can produce four briquettes at a time as well as create holes in the briquette to aid combustion.

METHODOLOGY:

Design consideration:

The screw press developed in this study was designed based on the following factors:

i. The screw press should be made using locally and readily available materials to ensure their sustainability and easy maintenance. The equipment for the design should also be exceedingly portable and its cost affordable.

ii. The pressure the screw press will exert on the materials should be able to overcome the fibrous and non-friable nature of the materials, and compress them into a whole mass.

iii. The screw press should produce more than one briquette at a time in order to reduce the labour and drudgery associated with the use of traditional moulds (e.g. hand mould) and machines with single moulds.

iv. The screw press should create a central hole in the briquettes to ensure uniform and efficient combustion as suggested by Legacy Foundations (2003) [11].

v. The press should be manually operated, and not electrically operated so that it will not be affected by power failure in Nigeria. This will also make it cost effective as there will not be any cost incurred from buying of fuel or gas.

Machine description:

The machine consists of the following basic components:

The frame: This serves as a support to all other components of the machine. Considerations were given to space, strength and stability, so that any component mounted could be properly supported. It was made with a U channel angle mild steel and serves as support to the thread, stirring (or wheel), and compaction chamber.

The wheel or stirring: This turns the thread or screw as it is being rotated. It is made of a 16mm rod.

The thread: This is also known as the screw. It is attached to the stirring or wheel. As the stirring is rotated clockwise, the thread moves down, compressing the material against the immovable base plate. As the stirring is rotated anticlockwise, it moves up. A nut is used to hold the thread in place.

Compaction chamber: This comprises of an immovable part which contains a base plate and mould, and a movable part made up of transmission rods which are attached to the thread. The transmission rods are held in place by a nut. The transmission rods are made of half inch rods of length 4cm.They go into the materials during briquetting and create holes in them.. The base plate is made of 14 gauge pan mild steel. The base is strong, and does not bend when the thread and stirring exerts pressure during briquetting. The moulds (four) are made of mild steel (18 gauge pan). They measures 7 cm in diameter and 5cm in length. They are placed on the base plate.

Calculation of the pressure exerted by the machine:

The pressure of the machine is calculated as described by Osarenmwinda and Ihenyen, (2012) [8]:

The manual briquetting machine was designed to produce four (4) briquettes at a time.

Total area which the pressure act = number of mould die x cross sectional area of die = $4 \times \pi/4\ d^2$

Where d= diameter of moulding die =7cm =0.07m, π =3.142

$$\text{Total area} = 4 \times \frac{3.143}{4} \times (0.07)^2 = 0.0154m^2.$$

$$\text{Pressure} = \frac{\text{force}}{\text{cross sectional area}},$$

but force = m x a

where m = mass of the thread, driving wheel / stirring, transmission rods(4) and nut holding the transmission rods (kg), a = acceleration due to gravity (9.8m/s).

Mass of thread = 10.3kg, mass of driving wheel/ stirring = 7kg, mass of transmission rods = 550g x 4 = 2.2kg, mass of nut holding the transmission rods = 1.8kg.

Force = (10.3 + 7 + 2.2 + 1.8) x 9.8 = 205.80N

$$\text{Pressure} = \frac{205.80N}{0.01539} = 13.367.46N/m^2 = 13.4kN/m^2 = 13.4kPa.$$

The fabricated screw press is shown in Plate 1.0.

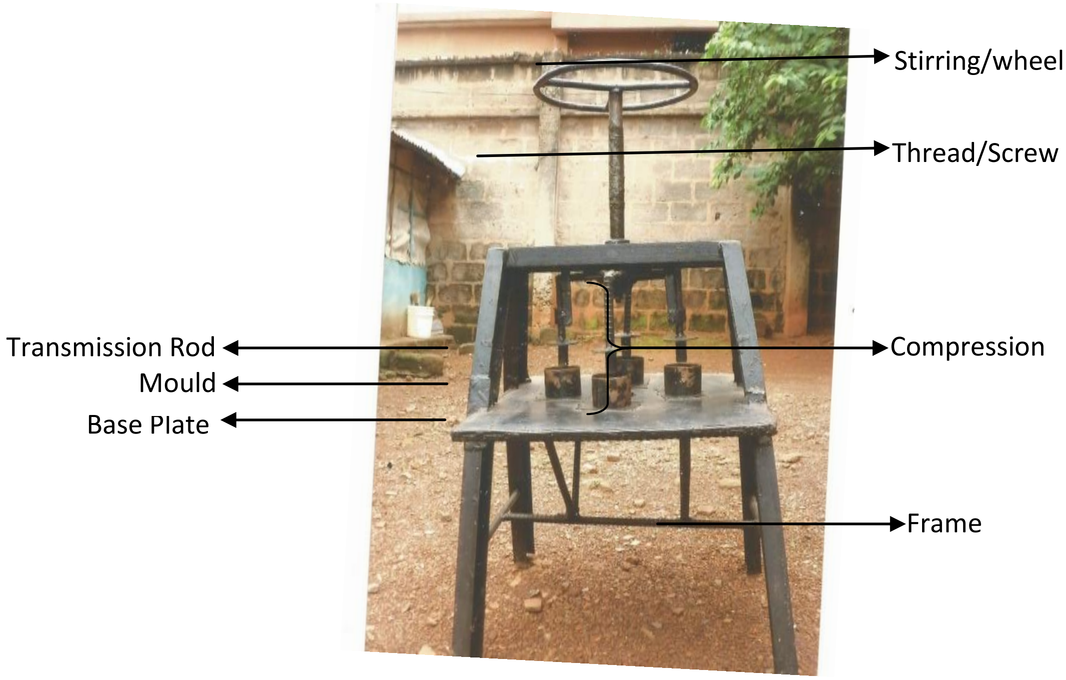

Plate 1.0: The fabricated screw press.

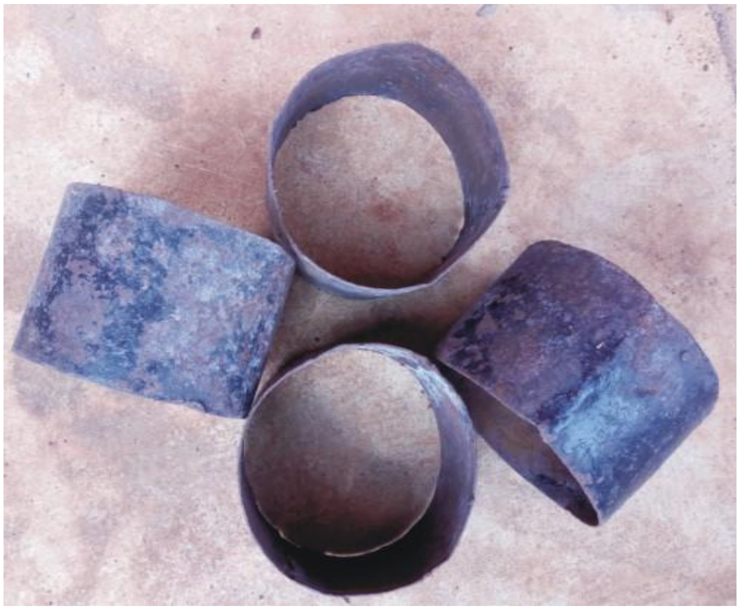

Plate 2: The moulds

Plate 3: The Produced Briquettes

Testing and Evaluation:
The briquette press was tested to ascertain its performance. Maize stalk briquette was produced using cassava starch as binder. The maize stalks were collected from farmlands where maize has been harvested. They were dried under the sun for two weeks. They were cut into very small size so that they can be fed into the grinding machine, ground and sieved into particle size of 3mm. The material was mixed with 20% by mass of starch and fed into the moulds positioned on the base plate in the compaction chamber and rammed until they are full. The stirring or wheel is rotated clockwise to bring down the screw which carries the movable part of the compaction chamber. The transmission rods enter into the materials in the mould and at the same time compresses them against the base plate into a whole mass. The mixture is left to set for 2 mins (dwell time) after which the wheel is rotated anticlockwise, the movable part and screw moving up. The moulds are brought out and the briquettes removed and dried.

Analyses of the briquettes produced:
The densities of the briquettes were determined following the procedures of Tembe *et al.*, (2014) [12]. The calorific value was determined using an Oxygen Bomb Calorimeter Bulk Model XRY-IA. The combustion analysis was conducted to understand the combustion characteristics of the briquette fuel. The ignition time, burning time, water boiling time, moisture content and specific fuel consumption were determined following the procedures of [13,14, 15].

RESULTS AND DISCUSSION:

Table 1: Properties of the briquettes

Density (g/cm3)	0.895
Calorific value (MJ/kg)	21.0
Ignition time (seconds)	14.50
Burning time (minutes)	30.11
Water boiling time (minutes)	19.27
Moisture content (%)	7.48
Specific fuel consumption (g)	0.69

The density result obtained (0.895g/cm3) is higher than that reported by Onuegbu *et al*., (2010) [1], 0.319g/cm^3 for *Pennisetum purpurem* briquettes, and Ugwu and Agbo (2010), 1.65g/cm^3 for palm kernel shell charcoal briquettes. The calorific value (21.0MJ/kg) is comparable to those obtained by Oladeji, (2012) [16], 20.8MJ/kg, 18.6 MJ/kg, 21.8MJ/kg for corn cob, groundnut shell, and mellon shell briquettes respectively. The briquette ignited at 14.50 seconds, and boiled 500ml of water at 19.27 minutes. This value was below that reported by Ugwu and Agbo, (2010) [3], 8 minutes for palm kernel shell charcoal briquettes, although charcoal briquette has a higher calorific value than biomass briquettes. The burning time is 30.11 minutes. The moisture content of the briquette is low, 7.48%, (<10%), showing that it is good for combustibility as reported by Mills, (1998). The specific fuel consumed is 0.69g, and it is comparable to that reported by Olatunde *et al [18]*., 2015, 0.87g for waste paper and groundnut shell admixture.

Performance Evaluation of the Briquetting Machine:

The machine was used to produce maize stalk briquettes succesfully. Four cylindrical briquettes with height 5cm, diameter 7cm, and with a central hole (diameter 2.5cm) on each briquette were produced at a time. The pressure of the machine (13.4kPa) was able to overcome the fibrous and non-friable nature of the materials and compress them into a whole mass. The briquettes produced are of high quality since they proved satisfactory in a briquette stove and can be handled (transportation and storage) easily. Therefore, the performance of the fabricated screw press was satisfactory.

The values of the force (205.80N) and pressure (13.4kPa) of the machine were comparable to 215.3N and 17.5kPa which were obtained from the briquette press fabricated by Osarenmwinda and Ihenyen, (2012).

CONCLUSION:

A screw press briquette machine has been designed and fabricated. This machine has the capacity to produce four briquettes at a time. It was fabricated with materials sourced locally, hence its maintenance and sustainability is assured. This project will provide job opportunity to the unemployed youths as well as alternative source of energy, thereby reducing Nigerian's overdependence on oil and gas. Also, agricultural wastes generated by farmers and food processing industries will be utilized, and wastes will be turned into a useful material.

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