DECLARATION

I hereby affirm that this project titled "Design and fabrication of a briquette making machine for selected agricultural waste" is an original work and has never been submitted anywhere else before, neither has it been wholly or partially presented for any other degree. All sources of information have been duly acknowledged by means of reference.

Name of student

20/02/2010

Date

CERTIFICATION

This project entitled "Design and fabrication of a briquette making machine for selected agricultural waste" by Omotainse Peter Olugbenga, meets the regulations governing the award of the degree Bachelor of engineering (B.ENG.) of the Federal University of technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

17/02/2010

Engr. Dr. Agidi Gbabo
Date

Supervisor

18/02/10

Engr. Dr. A. A. Balami
Date

H. O. D, Agricultural and Bioresource Engineering

10-02-10

Engr. Prof. G.O. Chukwuma

External Supervisor
Date

DEDICATION

This Project is dedicated to Almighty God the author and finisher of my faith because of his love, care, support, strength, wisdom, guidance, provision, protection, safety and for seeing me through my degree program. I also dedicate it to my parents Dr. & Mrs. S. O. Omotainse and siblings Tope, Damilola, Tobi and Faith.

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I thank the Ancient of days for his love, grace, mercy and compassion, for he is the one who gave me life, wisdom and understanding to be able to carry out this project. Glory and honour be to His name.

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ABSTRACT

Briquetting is a mechanical compaction process for increasing the density of bulky material. The present study puts forward a machine of simple design which could be manufactured locally in any part of the country and has high productivity. The study presents a detailed design study of the briquette making machine. The prototype was made and tested in Niger state in Nigeria. The low pressure briquette making machine is powered by a hydraulic jack which is easy to operate and thus can be operated by a large range of people. The briquette fuel produced was found to dry in relatively short time due to their size.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

NOTATIONS

The following parameters where used during the design analysis and calculations.

SYMBOL	MEANING	UNIT
P	Pressure	N/m^2
F	Force	N
A	Area	m^2
t	Thickness	m
d	Diameter	m
l	Length	m
V	Volume	m^3
σ_c	Circumferential stress	N/m^2
σ_l	Longitudinal stress	N/m^2
τ	Maximum shear stress	N/m^2
P_{Euler}	Critical load	N
E	Modulus of elasticity	N/m^2
l_e	Equivalent length	m
n	Factor of safety	

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Briquettes are usually made from materials that cost little or no money to obtain, such as old newspaper or partially decomposed plant waste, and can be used as an alternative fuel to charcoal, firewood or coal, and may cost less. Briquetting is one of the several compaction in the general category of densification where a materials is compressed under pressure to form a product of higher bulk density, lower moisture content, uniform size, shape and material properties. Briquetting or biomass densification represents a set of technologies for the conversion of biomass into fuel (Adegoke, 2002). Briquetting is a process that has the objective of concentrating the light energy of agricultural and environmental waste such as wood residues, rice husk, biogases, sawdust, paper, etc., into high density particles of varied forms and sizes known as "briquette". This process eases handling and reduces the costs of transport and storing. When aiming to improve the fuel properties of those, there is a need to eliminate the biomass constituents that are not combustible such as water.

According to Ajueyitsi (2002) briquetting was proposed in Russia in the 1830's by a Russian inventor F.P Veshniakov, who developed a method of producing hard briquettes from waste wood, charcoal and hard coal. One of the most commonly used materials is shredded newspaper. Small wood chips, sawdust and some selected agricultural waste also work quite well. Plant waste can make good briquettes, but it is best to compost the plant waste for a while (two or three weeks) so that it will stick together when it is pressed. Adding a small amount of wood ash to the mix will make the briquette harder and make it burn longer. The addition of manure can

DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE

OMOTAINES PETER OLUGBENGA

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achieve the same effect. After the briquettes are pressed they still remain moist. Therefore it is important to fully dry the briquette before using them. When burning the briquette, they are usually broken apart rather than just burning them whole. Breaking them exposes more surface area of the briquette to burn. (Ajueyitsi, 2002 cited in Ogunrinede 2007)

Briquette making exemplifies the potential of appropriate technology. It saves trees and prevents problems like soil erosion and desertification by providing an alternative to burning wood for heating and cooking. It substitutes agricultural waste like hulls, husks, corn stocks, grass, leaves, food and animal garbage for a valuable resource. It improves health by providing a cleaner burning fuel. This is dramatically true in places like Tibet where yak dung is almost constantly burned in small tents. And in these situations, it also improves agriculture by preserving the dung for pastures and gardens instead of burning them to release smoke (and into people's lungs and eyes). It tackles the problem on both ends by giving a better alternative to firewood (40% more efficient, longer burning, and hotter) as well as helping with reforestation. In addition to providing the above benefits, briquetting engenders many micro enterprise opportunities of making the presses from locally available materials, supplying materials and making the briquettes, selling and delivering the briquettes. (Sustainable Energy, 2003)

Depending on materials used to make the briquettes, they may burn cleaner than coal. By using the briquette it helps to conserve forests and fossil fuel reserves, reduce the amount of waste going to landfill and lower the heating costs, making it a worthwhile investment. Finally, turning "throw-away" materials into a fuel source is attractive because it is a sustainable process. Many different methods and technologies exist for pressing briquettes.

1.2 Statement of Problem

The first "Oil Crisis" showed how vulnerable the oil importing industrial countries had become to the Middle East and South American oil producers who could raise prices further, or limit supplies, on political whim. In 1979 Iran did just that, stopping exports and forcing up prices to well over ten times (Bartholomew *et al*, 2000 cited in Ogunrinede, 2007).

The energy crisis started in 1973 when members of the Organization of Petroleum Exporting Countries (OPEC) took advantage of market conditions to quadruple oil prices, sending shockwave through the world economy. This made values of stock to suffer and also caused inflation to rise to about 25 percent per year in most advance countries. (Ogunrinede, 2007)

Nigeria is not exempted from this crisis and also has its own challenges. According to Adegoke (2002), "Nigeria is passing through an unprecedented energy crisis". He went on to explain that, "non-renewable energy such as kerosene and gas are out of the reach of the common man". He also made mention of the fact that "the supply of electricity, another conventional energy source is epileptic where available or non-available in most part of the country".

The use of fuel wood is creating a human and environmental crisis in developing countries worldwide.

• Half the world's 2 billion fuel wood users face fuel shortages.

• 100 million already experience virtual fuel wood famine. (FAO cited in Ogunrinede 2007)

• In Africa, 40% of energy requirements are met by fuel wood.

• Wood burning creates deforestation, desertification and erosion.

• Many sub-Saharan countries have had over three quarters of their forest cover depleted. (www.paceproject.net)

1.3 Justification of the Project

Developing a machine that produce an alternative source of energy from agricultural by-products in Nigeria that cost little or nothing such as sawdust, rice husk, groundnut husk, etc, will greatly alleviate the problem of energy at the same time preserving the environment, as most people in the rural areas depend mostly on fire wood and charcoal as their source of energy, which constitute a large percentage to the depletion of forest resource, which if not controlled may lead to desertification. Another limitation to the use of fire wood and charcoal is the cost and the time spent in gathering and transporting them, this will be taken care of as briquette will made in areas where needed and are easily transported.

The development of the briquette making machine will serve as a source of wealth generation and job creation, as people will be needed to operate the briquette making machine to make briquette which can be sold to generate income for the operators.

Commercial models of briquette presses are available. However, the consideration should be made that systems built outside of a community are often not as easily replicated or repaired without a trained individual with access to proper resources and services.

1.4 Objectives of the Study

1. Design a briquette making machine.
2. To fabricate a briquette making machine
3. To test the machine.

1.5 Scope of the Study

This project work covers the design, fabrication and performance evaluation of briquette making machine.

CHAPTER TWO

2.0 LITERATURE REVIEW

Environmental issues, present energy crisis, and inevitability of oil depletion are some of the major aspirations for research and development in the work for alternative fuels. Priority programs continually searching for locally available resources especially those that are environment-friendly, economically feasible, and socially acceptable. The use of agricultural waste products is one of several options for replacing or extending the economic life of the country's limited fossil products. (Jorelyn *et al*, 2008)

Biomass energy currently plays a major role in meeting the present energy needs of developing countries. A number of authors have also expressed the view that biomass has the potential to meet the additional energy demands of urban and industrial sectors, thereby making a significant contribution to the economic advancement of developing countries. If this new role is to be achieved within the context of sustainable development, it is important for developing countries to strive towards achieving both sustainable biomass fuel production and the more efficient utilization of biomass. However, in order for biomass to make a significant impact as a fuel there is a need to improve and promote state-of-the-art technologies. Many developing countries produce large quantities of agro residues and domestic waste but are used inefficiently causing pollution to the environment. Our country is no exception as most of our agro residue such as rice husk, maize stalks, groundnut shells, cotton stalks, sawdust, etc, is either burn up or left as environmental hazards. Briquetting technology is yet to set strong foothold in many developing countries because of the technical constraints involved and the lack of knowledge to adapt the technology to suit local conditions, overcoming the many operational problems associated with this technology and ensuring the quality of raw material used are crucial factors in determining it's commercial success (World Bank, 1986 cited in Ogunrinede 2007). Apart from the commercial aspect, this technology is of great importance in the preservation of wood which is obtained from trees which leads to deforestation and later desertification in some developing countries especially in some parts of western Africa.

2.1 History of Briquetting

The compaction of loose combustible material for fuel making purposes was a technique used by most civilizations in the past, though the methods used were not more than simple bundling, baling or drying. Briquetting was proposed in Russia in the 1930's by the Russian inventor F. P. Veshniakov, who developed a method of producing hard briquettes from waste wood charcoal and hard coal (Johannes, 1982 cited in Ogunrinede 2007).

Bowling (1941) noted that an understanding of the structure of the material and their action under pressure is the basis upon which densification processes are established. Fibrous materials are resilient and elastic that mere pressing is not sufficient to retain its pressed state. (Ogunrinede 2007)

Pressing increases the biomass density and generates additional heat that liquefies waxes that cut as additional binders when the product is cooked, since most agricultural waste and residues are light in weight, bulky, irregular in size and shape, and with the relatively high moisture content. These materials are reduced to facilitate drying and increase bulk density, chemical reaction, heat transfer, and handling properties. Pressure, heat, moisture, and size reduction are therefore necessary in the process of making high quality briquettes. In briquetting charcoal, however, binder must be added since their natural binding substances were lost during the charcoal process. (Junge 1981, cited in Jorelyn *et al*, 2008)

Historically, biomass briquetting technology has been in two district direction. Europe and the United States has pursued and perfected the reciprocating ram/piston press while Japan has independently invented and developed the screw technology, although both technologies have their merits and demerits, it is universally accepted that the screw pressed briquettes are far superior to the ram pressed solid briquettes in terms of storability and combustibility, Japanese machine are now been manufactured in Europe under licensing agreement. Worldwide but technologies are used for briquetting of sawdust and locally available agro-residues, although the importance of biomass as substitute fuel for wood, coal and lignite is well recognized, the numerous failures of briquetting machines in almost all developing countries have inhibited their extensive exploitation (Johannes, 1982 cited in Ogunrinede 2007).

At present two main high pressure technologies ram or piston press and screw extrusion machines are used for briquetting while briquettes produced by a piston press are completely solid, screw press briquettes on the other hand have a concentric hole which gives better combustion characteristics due to a large specific area, the screw press briquettes are also homogenous and do not disintegrate easily, having a high combustion rate, these can substitute for coal in most application and in boiler (Biomass Technology Group, 1987 cited in Ogunrinede 2007), briquettes can be produced with a density of 1.2g/cm^3 these can be brunt clean and therefore are eco-friendly and also those advantages that are associated with the use of the biomass are present are present in the briquettes.

2.2 Forms of Briquetting

The compaction of loose combustible material for fuel-making purposes was a technique used by most civilizations in the past. The methods used were no more than simple baling or drying. Industrial methods of briquetting date back to the second part of the 19th century. In 1865, a report was issued on a machine used for making fuel briquettes from peat. Since then there has been widespread use of briquettes made from brown coal, peat, and coal fines. (Ehab, 2004)

Techniques for the conversion of agricultural wastes and residues into energy commodities are being investigated. One alternative technique is briquetting, a process of binding together pulverized carbonaceous matter in pressure moulds, often with aid of binder. The process of making briquette usually consists of crushing, screening, mixing with the binder, and pressing. It is essentially a physical process. Briquetting increases strength, density, handling and transport qualities, and the amount of heat emitted per volume of the biomass. Briquetting is a commercially proven technology in the United States of European countries. Existing machines however are capital-intensive and suitable only for large-scale briquette production. They have complicated parts and accessories and require high power prime movers for their operation. Owing to their high production costs, a large and continuous supply of suitable raw materials and a dependable market of the briquettes are required to make the operation profitable. (Jorelyn *et al*, 2008)

Densification is a method of pre-treating loose, bulky biomass materials and bringing them into a form suitable for use in available combustion equipment. The handling characteristics of material for transport, storage etc. are also improved (Hulscher et al., 1992 cited by Ehab, 2004). The density depends mainly on pressure. In the presses, especially in briquetting without binding agents, external compressive forces are applied and transmitted through the aggregate of the particles, compacting them. Increasing this force will increase the density and the binding forces between the particles (Lindley and Vossoughi, 1989; Clauß, 2002 both cited in Ehab, 2004).

Utilization of agricultural residues is often difficult due to their uneven and troublesome characteristics. The process of compaction of residues into a product of higher density than the original raw material is known as densification. Densification has aroused a great deal of interest in developing countries all over the world lately as a technique for upgrading residues as an energy source. Densification essentially involves two parts, the compaction under pressure of loose material to reduce its volume and to agglomerate the material so that the product remains in the compressed state, the resulting solid is called a briquette if roughly, and it has a diameter greater than 30mm.

Some different models of briquette presses which have already been designed and are being used all around the world include wooden compound levers, hydraulics pistons, car jack presses, and solar or pedal powered versions. Briquetting machines used in the briquetting of the agricultural residues can be broadly divided into three types depending on the die pressure range.

2.2.1 High pressure machines

The first type is the high pressure machines where the pressure reaches values more than 100 MPa. This type is suitable for the residues of good lignin content. At this high pressure the temperature rises to about 200- 250°C, which is sufficient to fuse the lignin content of the residue, which acts as a binder and so, no need of any additional binding material.

2.2.2 Medium pressure machines

The second type of machines is the medium pressure machines, with a pressure ranges between 5 MPa to 100 MPa, which results in lower heat generation (Elmagzoup, 1986 cited by Yousif *el al,* 2006). This type of machines requires in most of the cases the use of an additional heat source to melt the internal lignin content of the feedstock and eliminate the use of an additional binder.

2.2.3 Low pressure machines

The third type is the low pressure machines that work at pressure less than 5 MPa and room temperature. This third type of machines requires the addition of binding materials, and is considered to be the most suitable type for the carbonized materials due to the lack of the lignin material due to the carbonization process and due to the low energy requirement for this type of machines (Abasaeed, 1988 cited in Yousif *el al,* 2006).

Amongst the low pressure type the screw press briquetting machine is said to be most effective because it can generate enough power to be used as an oil press with just a few simple modifications.

2.3 Piston press

The piston press is one of the main high press technologies used for briquetting. The development of the modern type of mechanical piston press started in Switzerland during World War II, based upon work done in Germany in the 1930s. The piston press acts in a discontinuous mode with material being fed into a cylinder, which is then compressed by a piston into a slightly tapering die. The compressed material is heated by frictional forces as it is pushed through the die. The lignin contained in all woody-cellulose materials begins to flow and acts as a natural die. The lignin contained in all woody-cellulose materials begins to flow and acts as a natural glue to bind the compressed material. When the cylinder of material emerges from the die, the lignin solidifies and holds it together, forming cylindrical briquettes which readily break into pieces about 10-30 cm long. The briquettes produced by a piston press are completely solid. The production of these machines is between 25-1800 kg/h, depending on the press canal diameter, the kind of materials pressed, and their properties (FAO, 1990 as cited by Ehab, 2004).

2.4 Screw press

The screw press is another type of mechanical press machine. The earliest development work on screw presses was carried out in the USA in the 1930's. In screw presses, material is fed continuously into a screw, which forces the material into a cylindrical die. This die is often heated to raise the temperature to the point where lignin flow occurs. If the die is not heated, then the temperature may not rise sufficiently to cause lignin flow and binding materials may have to be added. These can be molasses, starch, or some cheap organic materials. The briquettes from screw machines are often of higher quality than from piston units. The screw press is usually sized in the range 75-250 kg/h, though larger machines are available. (Ehab, 2004)

2.5 Roller press

The most standard pellets machines are roller presses with a circular die and cog-wheel pellet principle. Such machines were originally developed for the production of animal feedstuffs. These operate by extruding small pellets of diameter 10-30 mm through a die that has many holes. The extruding mechanism is often an eccentric roller that moves inside the large cylindrical or conical die. Its throughput performance depends on various parameters. The most important of these is the fineness of the pressed materials. The size of the die and its holes also plays a major role. With the cog-wheel pellet principle, the pressed materials are pre-compressed, and then pressed and formed in the press canals in the roller coat. (Ehab, 2004)

2.6 Advantages of briquetting

The briquetting process offers the following advantages:

- The net calorific value per unit volume is increased
- The densified product is easy to transport and store
- Disposal of residue is facilitated
- The fuel produced is uniform in size and quality.

Although there are crops with both higher and lower residue yields, it is reasonable to assume that about 25% of any dry agricultural feedstock consists of residues. These residues are not properly collected or utilized efficiently. The major limitation in utilizing them is their low bulk densities and irregular size, making transportation, handling and storage costs enormous. These limitations can be overcome by compacting and converting the residues into a high density form (FAO, 1990 as cited in Ehab, 2004).

Briquettes can be produced with a density of up to 1.2 g/cm3 from loose biomass with a bulk density of 0.1 and 0.2 g/cm3. When using these briquettes for energy purposes, the optimal density is between 0.9 and 1.2 g/cm3. The briquettes are also affected by the moisture content. Briquettes with a moisture content of less than 18% are constant and durable (Ehab, 2004).

2.7 Forms of briquettes

There are different forms of compressed materials. These forms are cubes, pellets and crumbles. According to Ehab, 2004, ASAE (1991) defined these forms as follow:

• Cubes: An agglomeration of ungrounded ingredients. The configuration of the agglomeration may take any form

• Pellets: An agglomeration of individual ground ingredients, or mixture of such ingredients, commonly used for animal feed

• Crumbles: Pelletized feed reduced to granulate form

The best known forms of the compressed materials are pellets and briquettes. In general there is no difference in properties between them. The small-length pressed materials are called pellets and the coarse materials are called briquettes. The use of briquetting for the conversion of agricultural residues is comparatively recent. Briquetting makes these wastes easier to transport, to handle and to store. It is efficient to use briquettes as an alternative fuel to coal, and additionally this reduces the volume of polluting gases such as sulphur (S) and phosphorus (P) fumes. Increasing the material density through briquetting will increase the energy density. The briquettes are normally cylindrical in shape with a diameter of about 25-100 mm and a length of about 40-400 mm (FNR, 2000 as cited by Ehab, 2004).

The briquetting of biomass has so far posed different problems in different kinds of machines and remains yet to establish a standard procedure for each biomass. The main reason is the changing physico-chemical characteristics of different biomass under different conditions. For the purpose of large scale commercialization, it is highly essential to study the behaviour of each biomass for its application in briquetting. For many years, methods of briquetting have been investigated and it is an established fact that typically very high power levels are required to biomass for its application in briquetting. For many years, methods of briquetting have been investigated and it is an established fact that typically very high power levels are required to form stable high density aggregates. This is true for piston, screw and roller type extrusion processes. This high pressure amounts to high electrical energy consumption and high wear rate of machine parts. Some of the studies made earlier have revealed that the addition of heat benefits by relaxing the inherent fibres in biomass and apparently softening its structure resulting in release of some bonding or gluing agent on to the surface. Reed *et al* as cited by Grover & Mishra, (1995) also observed in laboratory scale experiments that the work requirement for densification can be reduced by a factor of about two by preheating the raw material. The results reported by Sayed *et al* also cited by Grover & Mishra, (1995) have established that the preheating lowers the power input. They have studied power consumption in the screw press briquetting of preheated sawdust at different die temperatures. (Grover & Mishra, 1995)

2.8 Binders

Biological material contains natural cementing agent which may be pectin substances, liquid or other compound, which hold the cells together to form tissues. These substances soften when heated at low temperature. The effect of adding bonding agent is to enhance cohesion and reduce pressure requirements. Binders hold components by both mechanical and chemical adhesion. Bonding occurs when the binder molecules adhere to specific points in the molecular structure of the adherent. A number of binding agent have been tried has additives in briquetting. One of this is the cassava flour. It is made of the tropical root crop cassava. The crop is quite robust, as it can be relatively easily grown in infertile soil. When it is cooked, cassava flour makes an excellent and combustible binder. The cooked cassava flour will be the glue' that holds together the agricultural waste. This cassava flour has a unique property, such as its high viscosity and its resistance to freezing, which make it competitive with other industrial starches. (http://www.bpre.gov.ph/PHIndustry/cassava.htm). Other forms of binders include industrial starch, starch obtain from maize, guinea corn, etc.

2.9 Agricultural waste

Agriculture and forestry activities yearly turn up waste materials. If converted into fuel or industrial energy, such a volume will be equivalent to 60 million barrels of imported crude oil. So far only about 12% of these wastes are utilized for commercial energy (Terrado 1978, cited by Martin et al, 2008). The greater bulk are scattered all over the countryside. In fact, they present disposal problems. Large files of wastes and residues left in the field to decompose also provide excellent breeding grounds for rats and insects pests. More often than not, they are disposed of by wasteful burning if the heat generated by the burning of wastes and residues could be stored and used to supplement the costly fuels, this burning would be justified. The other alternative is to store these wastes off their derivatives and harness their stored energy when needed. The heat value for most agricultural wastes and residues ranges between 4,000 to 8,500 Btu/lb of dry material and are increased to as high as 13,000 Btu/lb if transformed into charcoal. This could easily surpass the 9,000 Btu/lb requirements for coal substitute. (Jorelyn *et al*, 2008). Calorific value is one of the important characteristics of any fuel. It is the amount of heat generated by combustion or the amount of heat released by the combustion of a mass of fuel. Rice hulls are a by-product of the rice industry, with their amount reaching 75 million tons worldwide. In terms of properties they have a unique nature, low bulk density (below 150kg/m3), low water and moisture permeability, low value of equilibrium moisture content, high resistance to the action of harmful fungi, good anticorrosion properties to steel, aluminium and copper. Due to their characteristic properties and chemical compositing the rice hulls have found application in construction, energy production, production of various chemical derivatives, etc. Rice hulls have very low bulk density which makes them hard to transport. Rice hulls are a hygroscopic material, that is, they change their equilibrium moisture content depending on temperature and relative air humidity. Rice hulls are a flammable material that burns with flame. For use as a fuel it is necessary to supply to supply air to the incineration appliances. Their calorific value of 15.3MJ/kg is close to that of wood and other lignocelluloses materials. (*Valchev, et al*, 2009)

2.10 Calorific Value

One of the most important property of a fuel is its calorific value, that is the amount of energy per kg it gives up when burned. According to Barnard, 1985 cited in Sulaiman, 2007, the calorific value of wood and agro-residues can be calculated using the following formula which although originally derived for wood can be used for most agro-residues with little alteration.

Gross or Higher calorific value $(HVC) = 20 \times (1 - A - M)\ MJ/kg$

Where, A = ash content

M = moisture content of the actual fuel

Net or low calorific value (LCV), takes into account unrecovered energy from water vapour from inherent moisture and from the oxidation of hydrogen content, is sometimes used for references purposes especially in industrial applications. In wood and most agro-residues, the hydrogen content is about 6% by weight on the dry and ash free basis, which means that the above formula would be changed as follows

Lower Calorific Value $(LCV) = 18.7 \times (1 - A - M) - 2.5 \times M$

M = moisture content of the actual fuel (MJ/kg)

For material with low ash content and moisture contents between 10% and 15%, like that in most briquettes from wood and agro-residues, the resulting calorific value are HCV 17-18MJ/kg while LCV range from 15.4MJ/kg to 16.5MJ/kg.

Material	Ash content (%)	HCV (MJ/kg) (Oven dry)
Alfalfa straw	6.0	18.4
Almond shell	4.0	19.4
Cassava stem	--	18.3
Coconut husk	0.8	20.1
Coconut husk	6.0	18.1
Cotton stalks	17.2	15.8
Cotton stalks	3.3	17.4
Groundnut shell	--	19.7
Groundnut shell	4.4	20.0
Maize stalks	6.4	18.2
Maize stalks	3.4	16.7
Maize cobs	1.5	18.9
Maize cobs	1.8	17.4
Olive pits	3.2	21.4
Pigeon pea stalk	2.0	18.6
Rice straw	--	15.2

Rice straw	--	15.2
Rice straw	19.2	15.0
Rice husks	--	15.3
Rice husks	16.5	15.5
Soya bean stalks	14.9	16.8
Soya bean stalks	--	19.4
Sunflower straw	--	19.4
Walnut shell	--	21.0
Wheat straw	1.1	21.1
Wheat straw	--	18.9

Table 2.1 Calorific Value and Ash Content of Agricultural Residues (Barnard, 1985 cited in Sulaiman, 2007)

2.11 Briquette Density

Ehab, (2004) mentioned that the primary density (ρ_0) is not constant, even when the same mass is weighed and pressed. That is because of the difference in material structure. These factors always affect the material volume, so that after a certain pressure the material reaches the maximum density (ρ_{max}).

When a material is pressed under axial pressing force, a compact briquette will be produced.

The primary density of the material (ρ_0) is.

$$\rho_0 = \frac{V}{M}$$

Where

M = mass of the material, g

V = volume of the material, cm3

This primary density depends on:

• The way the material is filled into the press form (loose or pressed by a device),

• The structure of the material (the relation between leaves and stem, the content of roots, the resistance to crack etc.),

• The moisture content and the age of the material.

CHAPTER THREE

3.0 DESIGN ANALYSIS AND CALCULATION

3.1 Machine Description

The briquette making machine consists of the following components:

3.1.1 Hydraulic Jack

The machine is hydraulically operated. The hydraulic jack provides the mechanical force that moves the piston up, thereby compressing the material in the compression chamber. The hydraulic jack is connected to a base frame at the bottom and a plate carrying the piston at the top.

3.1.2 Frame

The frame is made from mild steel plates of low carbon steel. Steel plates are very useful in the fabrication of briquetting machines. They were also used in the fabrication of other component of the briquetting machine, such as, the cylinder head cover, the pressure plate, the base plates and lots more.

3.1.3 Pistons

The pistons are used to transfer energy from the hydraulic jack to the compression chamber. The pistons tops were of lesser diameter when compared to the internal diameter of the cylinders, this is allow free movement of the piston and also the create room for fluid to escape during compression.

3.1.4 Compression Cylinders

This is the enclosure where compression takes place. It consists of sixteen cylinders held together in a close enclosure. Each cylinder has its own piston which transfers the compressive pressure at bottom and a heavy metal plate as its covers the entire cylinders at the top. It also serves as a mould since the briquettes are forced to take its shape.

3.2 DESIGN ANALYSIS

3.2.1 Determination of Maximum Shear Stress in the cylinder

A cylindrical vessel or shell may be thick or thin depending upon the thickness of the plate in relation to the internal diameter of the cylinder. The ratio of $t/d=1/20$ can be considered a suitable line of demarcation between thin and thick cylinders. (Rajput, 2006)

In thin cylinders it is assumed that the stress is distributed uniformly over the wall thickness. And thin cylinders are frequently required to operate under pressures of up to 30 MN/m^2 or more, for high pressures as 250 MN/m^2 or more thick cylinders are used. So for this design that the minimum pressure required is far less than 30 MN/m a thin cylinder is used.

When cylinders are subjected to internal fluid pressures the following types of stresses develop:

I. Circumferential stresses that acts tangential to the direction of the circumference of the shell

II. Longitudinal stresses that acts longitudinal to the shell axis

III. Radial stresses acts radially and are too small and can be neglected.

1. Circumferential stress

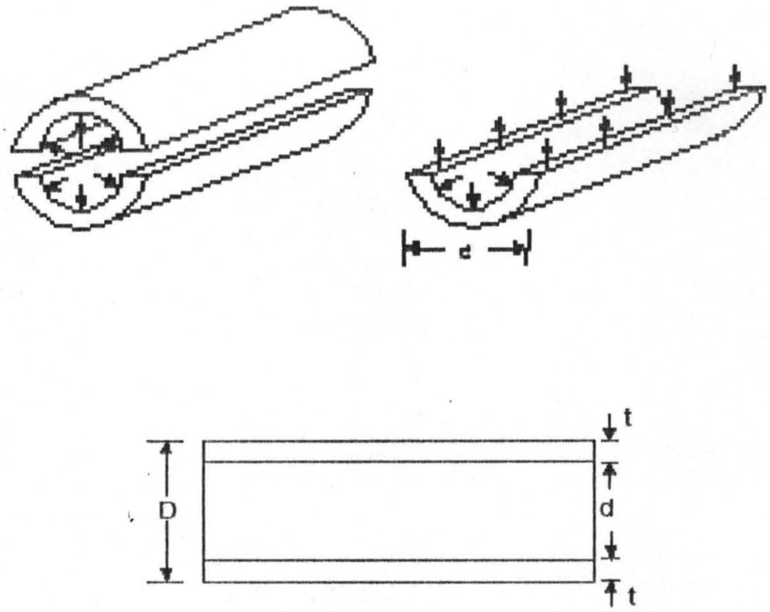

Figure 3.1 Circumferential stresses

From the above figures

l = length of the shell

d= diameter of the shell

t= thickness of the shell

P= intensity of internal pressure

Total pressure along the diameter of the shell,

P=intensity of internal pressure × area $= p \times d \times l$ (3.1)

And circumferential stress in the shell,

$$\sigma_c = \frac{total\ pressure}{resisting\ section} = \frac{pdl}{2tl}$$

$$= \frac{pd}{2t} \quad \text{(of two sections)} \qquad (3.2)$$

II Longitudinal stress

Consider the same cylindrical shell, subjected to the same internal pressure as shown in figure (3.2) (a) and (b).We know that as a result of the internal pressure, the cylinder also has a tendency to split into two pieces as shown in the figure .

Let p= intensity of internal pressure

l= length of the shell

d= diameter of the shell and

t= thickness of the shell

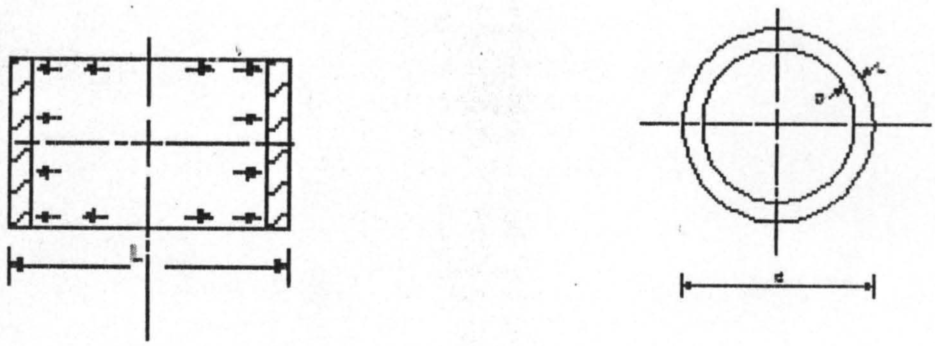

Figure 3.2 Longitudinal stress

Total pressure along the length of the shell

P=intensity of internal pressure × area

$=p \times \frac{\pi}{4}(d)^2$

And longitudinal stress in the shell,

$$\sigma_l = \frac{total\ pressure}{resisting\ section} = \frac{p \times \frac{\pi}{4}(d)^2}{\pi dt} = \frac{pd}{4t} \quad (3.3)$$

This implies that the circumferential stress is twice as the longitudinal stress. And in no case should the circumferential stress greater than the permissible stress in the cylinder material. Since at any point in the cylinder shell there is a set of two mutually perpendicular stresses [circumferential stress (σ_c) and longitudinal stress (σ_l)]

$$\therefore \text{ Maximum shear stress}(\tau_{max}) = \frac{\sigma_c - \sigma_l}{2} \quad (3.4)$$

Since $\sigma_c = \frac{Pd}{2t}$ and (3.5)

$$\sigma_l = \frac{Pd}{4t} \quad (3.6)$$

$$\therefore \tau_{max} = \frac{\frac{Pd}{2t} - \frac{Pd}{4t}}{2} = \frac{Pd}{8t}$$

$$\text{i.e. } \tau_{max} = \frac{Pd}{8t} \quad (3.7)$$

Where , σ_c= Circumferential stress

σ_l= Longitudinal stress

P= Intensity of internal pressure

d= Diameter of the cylindrical shell

t= Thickness of the cylindrical shell

3.2.2 Determination of thickness of cylinder wall

From equation 3.2 and 3.3, we note that

$$\sigma_c > \sigma_l \qquad (3.8)$$

i.e. $\sigma_c = \frac{Pd}{2t}$

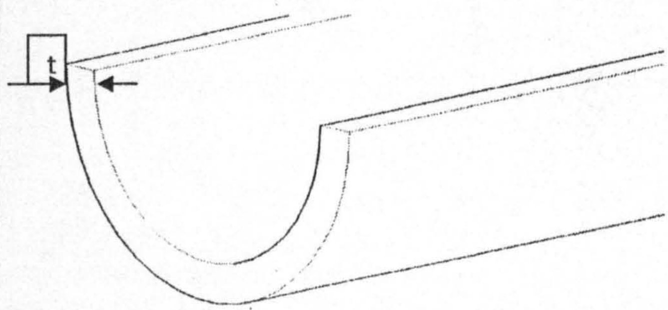

Fig 3.3 Compaction cylinder thickness

But, since σ_c cannot exceed the permissible tensile stress (σ_t)

i.e. $\sigma_c \leq \sigma_t$

$$\therefore \quad \frac{Pd}{2t} \leq \sigma_t \qquad (3.9)$$

$$\therefore \quad t \geq \frac{Pd}{2\sigma_t} \qquad (3.10)$$

3.2.3 Determination of change in cylinder volume due to pressure

Direct strain due to $\sigma_c = \frac{\sigma_c}{E}$

Direct strain due to $\sigma_l = \frac{\sigma_l}{E}$

Net circumferential strain (e_c) = Direct strain – Lateral strain due to direct strain $\frac{\sigma_l}{E}$

i.e. $e_c = \frac{\delta d}{d} = \frac{\sigma_c}{E} - \frac{\mu \sigma_l}{E}$

$= \frac{\sigma_c}{E} - \frac{\mu \sigma_c}{E}$ since $\sigma_l = \frac{\sigma_c}{2}$

$= \frac{\sigma_c}{E}(1 - \frac{\mu}{2})$

$$e_c = \frac{Pd}{2tE}(1 - \frac{\mu}{2}) \quad (3.11)$$

Net longitudinal strain (e_l) = Direct strain – Lateral strain due to direct strain $\frac{\sigma_c}{E}$

i.e. $e_l = \frac{\delta l}{l} = \frac{\sigma_l}{E} - \frac{\mu \sigma_c}{E}$

$= \frac{\sigma_l}{E} - \frac{2\mu \sigma_l}{E}$ since $\sigma_c = 2\sigma_l$

$= \frac{\sigma_c}{E}(1 - 2\mu)$

$$\therefore \quad e_l = \frac{Pd}{4tE}(1 - 2\mu) \quad (3.12)$$

The volumetric strain (e_v)= Algebraic sum of net strains in all axes.

e_v = net longitudinal strain + 2 x net circumferential strain

$$e_v = e_l + 2e_c \quad (3.13)$$

But, $e_v = \frac{\delta V}{V}$

$\therefore \quad \delta V = e_v \times V$

$= (e_l + 2e_c) \times V$

$= [\frac{Pd}{4tE}(1-2\mu) + 2x\frac{Pd}{2tE}(1-\frac{\mu}{2})] \times V$

$= \frac{Pd}{2tE}[\frac{1}{2} - \mu + (2-\mu)] \times V$

$$= \frac{PdV}{2tE}(\frac{5}{2} - 2\mu) \tag{3.14}$$

Where, $V = \frac{\pi}{4}d^2 l$

l = Length of the cylinder

V = Volume of the cylinder

E = Young's modulus for cylinder material

μ = Poisson's ratio

3.2.4 Determination of the compression ratio

Let the distance travelled by the piston be S

Therefore the displacement volume (V_d) = $\frac{\pi}{4}d^2 S$

Since total volume (V) = displacement volume (V_d) + compression volume (V_c)

$V_c = V - V_d$

$$\therefore \quad r_c = \frac{V}{V_c} \tag{3.15}$$

Where r_c = compression ratio

3.2.5 Determination of the mean breaking stress of the piston rod

Let the crippling load (P_c) = $\sigma_c A$

Where, σ_c = Maximum possible compressive stress

A = Sectional area

From Euler's equation

$$P_{Euler} = \frac{\pi^2 EI}{l_e^2} = \frac{\pi^2 EAk^2}{l_e^2} \quad (3.16)$$

Where, P_{Euler} = Euler's equation for critical load

E = Modulus of elasticity

I = Least moment of inertia of section of the rod

l_e = Equivalent length of the rod

A = Area of cross section of the rod

k = Least radius of gyration

Note $I = Ak^2$

From Rankine hypothesis

$$\frac{1}{P} = \frac{1}{P_c} + \frac{1}{P_{Euler}} \quad (3.17)$$

Substituting

$$\frac{1}{P} = \frac{1}{\sigma_c A} + \frac{1}{\pi^2 EA(\frac{k}{l_e})^2}$$

$$\frac{A}{P} = \frac{1}{\sigma_c} + \frac{1}{\pi^2 E(\frac{k}{l_e})^2}$$

$$\therefore \quad \frac{P}{A} = \frac{1}{\frac{1}{\sigma_c} + \frac{l_e^2}{\pi^2 E k^2}}$$

$$\frac{P}{A} = \frac{\sigma_c}{1 + \frac{\sigma_c}{\pi^2 E}(\frac{l_e}{k})^2}$$

$$\therefore \quad P = \frac{\sigma_c A}{1 + a(\frac{l_e}{k})^2} \qquad (3.18)$$

Where, $a = \frac{\sigma_c}{\pi^2 E}$

$l_e = \frac{l}{2}$, since both ends are fixed.

3.2.6 Determination of the equivalent length of the piston rod

If we equate Euler and Rankine formulae

i.e. $P_{Euler} = P$

$$\frac{\pi^2 EI}{l_e^2} = \frac{\sigma_c A}{1 + a(\frac{l_e}{k})^2}$$

$$\pi^2 EI \times \left(1 + a\frac{l_e^2}{k^2}\right) = \sigma_c A l_e^2$$

$$\sigma_c A l_e^2 - \frac{\pi^2 EIal_e^2}{k^2} = \pi^2 EI$$

Since $I = AK^2$

$$l_e^2\left(\sigma_c A - \frac{\pi^2 EAa\, k^2}{k^2}\right) = \pi^2 EAk^2$$

$$l_e^2 = \frac{\pi^2 Ek^2}{\sigma_C - \pi^2 Ea}$$

$$\therefore \quad l_e = \left(\frac{\pi^2 Ek^2}{\sigma_c - \pi^2 Ea}\right)^{1/2} \qquad (3.19)$$

3.2.7 Determination of the thickness of the bottom plate

The bottom plate can be assumed to be clamped at the four corners and the centre is subjected to concentrated loading from the base of the hydraulic jack. The thickness of the bottom plate is given by the formula;

$$\delta = \sqrt{\frac{KFb^2}{Et^3}}$$

$$\therefore \quad t = \sqrt[3]{\frac{KFb^2}{E\delta^2}} \qquad (3.20)$$

Where, t = thickness of the plate

δ = maximum displacement

F = concentrated load

K = constant depending on its length and breath $\left(\frac{b}{a}\right)$

b = breath of the plate

a = length of the plate

E = modulus of elasticity of the plate

$= 0.0225m^2$

$\therefore \quad P = \frac{49050}{0.0225}$

$P = 2180000N/m^2$ or $2.18N/mm^2$

Therefore the compacting pressure is 2.18 *MPa* or 2.18 N/mm^2

3.4.1 Calculation of thickness of cylinder wall

The minimum thickness of the cylinder wall is calculated in order to avoid damaging the cylinder during the compaction process. It can be calculated using equation (3.2),

i.e $\quad \sigma_c = \frac{Pd}{2t}$

Where, d = diameter of the cylinder

P = pressure required for compaction

t = minimum cylinder thickness

σ_c = allowable stress

Allowable stress $\sigma_c = \frac{yield\ strength}{factor\ of\ safety}$

$\sigma_c = \frac{\sigma_y}{n}$

Where, σ_y = yield strength

n = factor of safety

7. The length of the piston is 120mm

8. The piston is fixed at both ends.

3.4 DESIGN CALCULATION

From the data given in the design assumptions, the pressure that the hydraulic jack will produce can be calculated by find the ratio of the force and the area of the pressure plate.

Since, $P = \frac{F}{A}$

$F = mg$

Where, P = pressure required for compaction

A = area of the pressure plate

m = the mass the hydraulic jack is designed to lift

g = acceleration due to gravity

Since, $m = 5000\ kg$

$g = 9.81\ m/s^2$

$\therefore \quad F = 5000 \text{ x } 9.81$

$= 49050N$

$A = 0.15m \text{ x } 0.15m$

$= 0.0225m^2$

$$\sigma_c = \frac{250}{5}$$

$$\sigma_c = 50N/mm^2$$

Let, $d = 35mm$

$$\therefore \quad t = \frac{Pd}{2\sigma_c}$$

$$t = \frac{2.18 \times 35}{2 \times 50} = 0.763mm$$

From the above calculation, the minimum cylinder thickness is 0.763mm but for safety and availability of material, a thickness of 1mm will be used for this design.

3.4.2 Calculation of Maximum Shear Stress in the cylinder

To calculate the maximum shear stress produced in cylinder.

Using the equation

$$\tau_{max} = \frac{Pd}{8t}$$

Let, d = diameter of the cylinder

P = pressure required for compaction

t = minimum cylinder thickness

τ_{max} = Maximum shear stress produced in the cylinder

Where, $P = 2.18N/mm^2$

$d = 35mm$

$t = 1mm$

$\tau_{max} = \frac{2.18 \times 35}{8 \times 1} = 9.54\, N/mm^2$

Based on the above calculations, we can conclude that it is safe to use the parameters used in the calculation of the cylinder for fabrication since the maximum shear stress acting in the cylinder is less than the allowable shear stress.

3.4.3 Calculation of cylinders volume

The cylinders volume is calculated in order to know the value of agricultural waste that it will contain each batch operation. It can be calculated using equation below

$$V = \frac{\pi}{4} d^2 l$$

Where, V = volume of cylinder

d = diameter of cylinder

l = length of cylinder.

Let, d = 35mm

l = 80mm

$\therefore \quad V = \frac{\pi}{4} (35)^2 80$

$V = 76{,}969.02 mm^3$ or $7.6969 \times 10^{-5}\ m^3$

To get the total volume of the machine, we multiply the value of V by sixteen (number of cylinders)

Therefore the volume of the machine = 76,9696.02 mm^3 x 16 = 1.232 x $10^{-3}m^3$

3.4.4 Calculation of the mean breaking stress of the piston rod

Since $I = AK^2$

$$K^2 = \frac{I}{A}$$

$$I = \frac{\pi}{64} \times d^4$$

$$A = \frac{\pi}{4} \times d^2$$

Where, d = piston diameter

$$d = 33mm$$

$$I = 5.82 \times 10^4 mm^4$$

$$A = 855.3mm^2$$

$$\therefore \quad K = \sqrt{\frac{5.82\times10^4}{855.3}} = 8.25mm$$

$$a = \frac{\sigma_c}{\pi^2 E}$$

Let, E = 200 x 10^3 N/mm^2

$$a = \frac{50}{\pi^2\times200\times10^3}$$

$$\therefore \quad a = 2.53 \times 10^{-5}$$

From the equation

$$P = \frac{\sigma_c A}{1+a(\frac{l_e}{k})^2}$$

Where, σ_c= 50N/mm^2

$$A = 855.3mm^2$$

$$l_e = \frac{l}{2}$$

$$l_e = \frac{120}{2} = 60\text{mm}$$

K = 8.25mm

$$P = \frac{50\times855.3}{1+2.53\times10^{-5}\times(\frac{60}{8.25})^2}$$

$$P = 42707.85N$$

3.4.5 Calculation of the thickness of the bottom plate

From equation 3.2.7.1, we know that,

$$t = \sqrt[3]{\frac{KFb^2}{E\delta^2}}$$

Where $K = \frac{b}{a}$

b = 220mm

a = 210mm

∴ $K = \frac{220}{210} = 1.048$

If the maximum deflection δ = 0.3mm

$E = 200 \text{ x } 10^3 \ N/mm^2$

$F = 49050N$

$$\therefore \quad t = \sqrt[3]{\frac{1.048 \times 49050 \times 220^2}{200000 \times 0.3^2}} = 51.7\text{mm}$$

3.4.6 Calculation of the size of welded joints

From equation 3.2.8.1, we have

$$s = \frac{F}{2 \times 0.7071 l\sigma}$$

Selecting an electrode with an allowable stress of $70N/mm^2$ and $l = 20mm$ we obtain

$$s = \frac{49050}{2 \times 0.7071 \times 20 \times 70} = 24.8\text{mm}$$

3.5 Fabrication

The machine component used where mainly constructed from mild steel. Some of the processes involved in the construction are cutting which was done with a hack saw and a bench vice, electric arc welding was used to tack components and permanently joining them after appropriate settings, some holes were drilled using the hand drilling machine, welded joints and other rough surfaces were smoothen with the help of the hand grinder and rusty parts were cleaned with sandpaper before applying paint.

3.5.1 Construction process

The first step was to mark out of the angle iron using a scriber. The marked out irons were out using a bench vice to clap the iron and a hack saw to cut. The procedure was repeated for other

3.2.8 Determination of the size of welded joints

Considering the form of welding used (fillet weld) in joining the columns to the base plate, construction of the compression chamber and the joining of the chamber to the base plate, let the throat thickness be denoted as t, size (or leg) of weld s and weld length l.

$$t = s \sin 45^o$$

$$t = 0.7071s$$

The force in each column is given by the relationship;

F = 2 x treat area x allowable stress (double fillet)

$$F = 2tl\sigma$$

$$F = 2 \times 0.7071sl\sigma$$

$$\therefore \quad s = \frac{F}{2\times 0.7071l\sigma} \qquad (3.21)$$

3.3 DESIGN SPECIFICATIONS AND ASSUMPTIONS

1. Hydraulic jack capacity for this project is 5 tonnes
2. Maximum cylinder diameter = 35mm
3. Length of cylinder = 120mm
4. Number of cylinder 16
5. The dimension of the pressure plate is 150mm x 150mm

component that was to be used in fabrication. The frame was constructed by tacking four angle irons of dimension 25.4x25.4x3mm of length of 300mm each to the base plate of 210x220x12mm in dimension using an electric arc welding machine with BS grade 10 electrodes having an allowable strength of 70MPa. Flat bars were used to join the angle iron at the top. The hydraulic jack (5 tonne) was tag at the centre of the surface of the base plate.

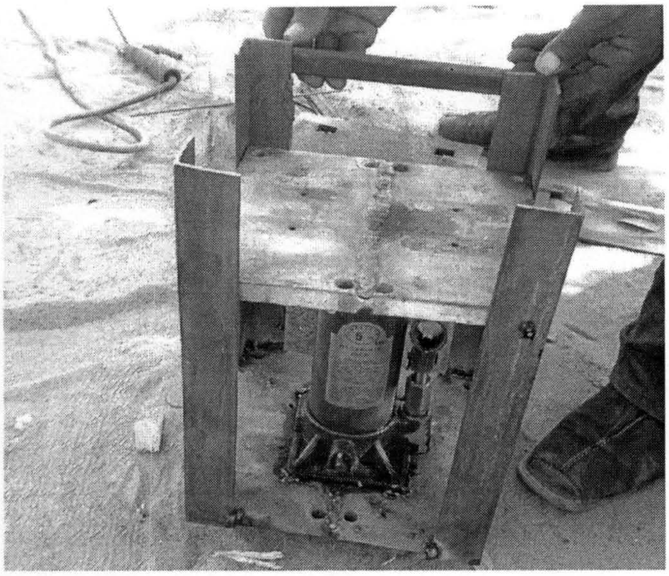

Plate 3.5.1 Tacking of the angle iron to the base plate and flat bar

The top plate was used to guide the angle iron as the flat bars were being tack to the angle iron. The pressure plate was tacked to the top of the hydraulic jack. Four angle irons of length 120mm each and dimension of 75x75x5mm was used to make the compaction block that will house the compaction cylinder, the blocks dimension is 150x150x120mm with a thickness, which can house sixteen cylinders of diameter 35mm perfectly. Angle irons were used to create a sitting base for the compaction block at the top. The compaction block was tacked to the top of the frame as shown in the picture below.

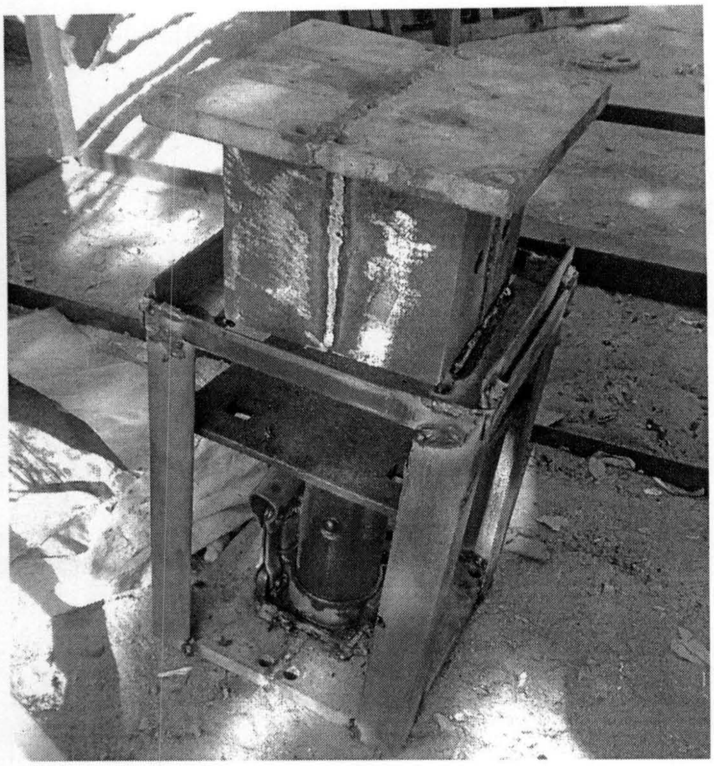

Plate 3.5.2 Components of the machine been assemble

The cover of the compaction has the same specifications as that of the base plate, the cover is fitted in place with the aid of a bolt and nut which is connected at opposite angle sides by a column. The machine was tested to make sure the parts are properly aligned then it was welded together to give a more permanent fill. Sixteen cylinders of 35mm in diameter and 1mm thickness was arranged in block and due to the thin nature of the cylinder they could not be welded or tacked as this may damage the cylinder wall and thus cause hindrance to the movement of the piston. Therefore they were glued with epoxy resin, and due to the compacted sitting arrangement it was firm. The pistons were dropped inside the cylinder to fall on the pressure plate and were not weld either for ease of flow in case of any movement of the pressure plate.

The entire machine was tested as whole to make sure it functioned properly, then the welded joints were grinded and the entire machine was sand papered and then painted.

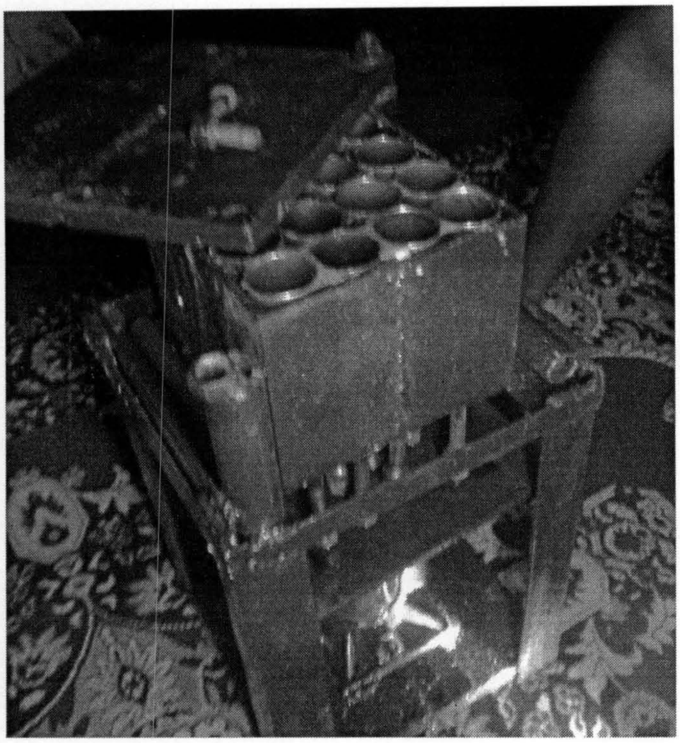

Plate 3.5.3 Assembled machine

3.6 Mode of operation

The agricultural waste should be mixed with the binding material, for testing of the machine both saw dust and rice hull were mixed with the binder. The hydraulic jack is lowered by removing the handle and the valve is slowly released in the counter-clockwise direction so that the jack is lowered to its original position. After which the screw holding the top cover is unscrewed and the top cover is opened, then the mixed agricultural waste and binder is fed into the cylinders and the cover is put back in place and screwed. The valve is then turn clockwise until it is firm with the crimped end of the handle, then the handle is inserted into the pump lever and pumped until the jack becomes hard to pump. It is then allowed for 3 to 5 minutes for water to drain and so the briquette will be fully compacted, the top cover is open and the jack is further pump up to push the briquettes up for easy removal. The wet briquettes are gently removed and placed on a tray to be dried under the sun. The whole process is repeated over and over again for a new batch of briquettes.

CHAPTER FOUR

4.0 Material Selection, Costing and Testing

4.1 Parameters for selection of materials.

During the material selection, materials that meet design specifications which were obtained from the calculations, to avoid failure of the machine components were selected

- **Material properties:** The yield strength of the material selected must correspond to or be greater than that used in the design analysis and calculations.
- **Deteriorative properties:** Such as resistance to oxidation, corrosion or weathering were also considered and are taking care of by painting of the finished work.
- **Manufacturing characteristics:** This includes the material ability to be welded and machined, as most joints are to be made by welding.
- **Cost:** Material cost and manufacturing cost were considered. Relatively cheap materials when compared to other engineering materials that meet the design constraints were considered during selection.
- **Aesthetic properties:** Ability to accept special finishes such as painting.

Considering these parameters listed above and the design calculations done, mild steel plates were used for the base plate, pressure plate, top plate and other components were made from mild steel.

4.2 Material and Labour cost

The cost of a component is usually influenced by its component design, manufacturing techniques and method and the material used in making the component. The cost of fabrication of the machine is grouped into three, namely:

i. Material cost
ii. Labour cost
iii. Overhead cost

4.2.1 Material cost

The material cost is tabulated below.

S/N	Material/ Part	Quantity	Unit price ₦	Amount ₦
1	12mm steel plates	3	1000	3000
2	25.4×25.4×3mm angle iron	½	1500	750
3	75×75×5mm angle iron 120mm in length	4	250	1000
4	½ inch Flat bars	½	500	250
5	35mm pipes, 120mm in length	16	100	1600
6	5 ton hydraulic jack	1	3000	3000
7	Columns	2	500	1000
8	Bolts and nut	2	50	100
9	Piston rods	16	50	800
10	Piston head	16	20	320

11	Epoxy resin	1	800	800
	Total			**₦12620**

Table 4.2 Breakdown of the material cost

4.2.2 Labour cost

Labour cost involves the cost of the machining, cutting, welding and painting. It is taken as 20% of the material cost.

Therefore, labour cost= $\frac{20}{100} \times 12620 = ₦2524$

4.2.3 Overhead cost

The overhead cost includes cost incurred during construction such as transportation, lubrication, as well as other consumables. It is taken at 20% of the material cost.

Overhead cost = $\frac{20}{100} \times 12620 = ₦2524$

Therefore the total cost = 12620+2524+2524= ₦17668

4.3 Machine maintenance

This machine was designed to be basically maintenance free. However the oil level should be kept constant, as too much oil will cause surplus oil to leak from the bottle jack fill pull causing a mess and on the other hand not enough oil will cause loss of power.

The piston head should be kept clean and all remaining waste should be properly cleaned from the cylinder in other to avoid rust and mount in the machine.

The machines should be properly cleaned after each operation.

4.4 Testing

4.4.1 Procedure

After assembling the machine, it was tested using two different agricultural wastes, namely rice hull and saw dust. They were both mixed binders, the ratio of binder used was from 10% to 25% of the total weight of the waste. The amount of water needed to gelatinize the starch ranged from 66% to 100% of the weight of the raw materials.

4.4.2 Mixing

This is the process of coating every particle of agricultural waste materials with a film of binder. It enhances adhesion and produces uniform good quality briquettes. Proper proportions of agricultural waste materials and gelatinize starch were poured into the mixing container. The agricultural waste materials and the binder were mixed thoroughly. The rice hull and the binder were mixed manually and even for the sawdust.

4.4.3 Briquetting

The mixture was converted into finished products using the newly designed machine. Briquetting machine is a simple energy and money saving device made out of locally — available materials used for converting some agricultural waste into briquettes. This was done by pouring the mixture directly into the molder which produced it into uniformed — sized briquettes. These briquettes were produced manually operated. Each batch operation was completed between 10 to 15 minutes.

4.4.4 Drying

The briquettes were placed in trays under the sun for one to two days so it can dry properly, the testing was conducted during the dry season.

4.5 Discussion of results

4.5.1 Compaction ratio

The ratio of compression of the material made into briquettes was based from the depth of cylinder to the height of briquettes that was compressed. Table 4.4 shows the compaction ratios of the briquettes incorporated in the machine. The rice hull compaction ratio was 2:1 and for sawdust 3:1.

The depth of the cylinder was set-up at 80mm with a diameter of 33mm.

Raw Materials (mm)	Depth of cylinder (mm)	Depth of compressed briquette (mm)	Compression ratio of briquette
Sawdust	80	27	3:1
Rice hull	80	40	2:1

Table 4.5 Compaction ratio of the briquettes.

4.5.1 Firmness of the briquettes

This was based on the percentage of binding agent mixed into raw materials. Percentage of binder was equal to the weight of cassava starch or any other binding material per weight of raw materials. From the briquettes formed, it was noticed that the more the binding material the firmer the briquettes that are produced.

CHAPTER FIVE

5.0 Conclusion and Recommendation.

5.1 Conclusion

This project work presents the design of a briquette making machine which was constructed and tested in Minna, Niger state. The design construction was carried out to suit selected agricultural waste with high calorific value and is loose in nature, but it was tested on saw dust and rice hull. The design has been carried out with due considerations of the major factors as applied to the operational characteristics and cost effectiveness. The design proves that with the right amount of binder, the 5 ton hydraulic jack, which is a low source of pressure, is able to compact a wide range of agricultural waste. All these combined together to make the design and construction cheap and the materials used were locally sourced.

The objective of this project was to fabricate and test a suitable briquette making machine which is not to robust, cheap to fabricate due to the availability of fabrication component, easy to operate and relatively maintenance free. The machine was designed and developed was successful as they satisfy these objectives.

5.2 Recommendation.

For further work and research to be carried out on this project work, I therefore recommend that work and research be done on the following areas:

i. It is recommended that further research be carried out to bring about new and improved designs on methods used for briquetting agricultural waste.

ii. That a different sizes and shape of briquettes should be considered to get better surface area and therefore make the drying process faster.

iii. That other source of powering the machine should be explored and considered.

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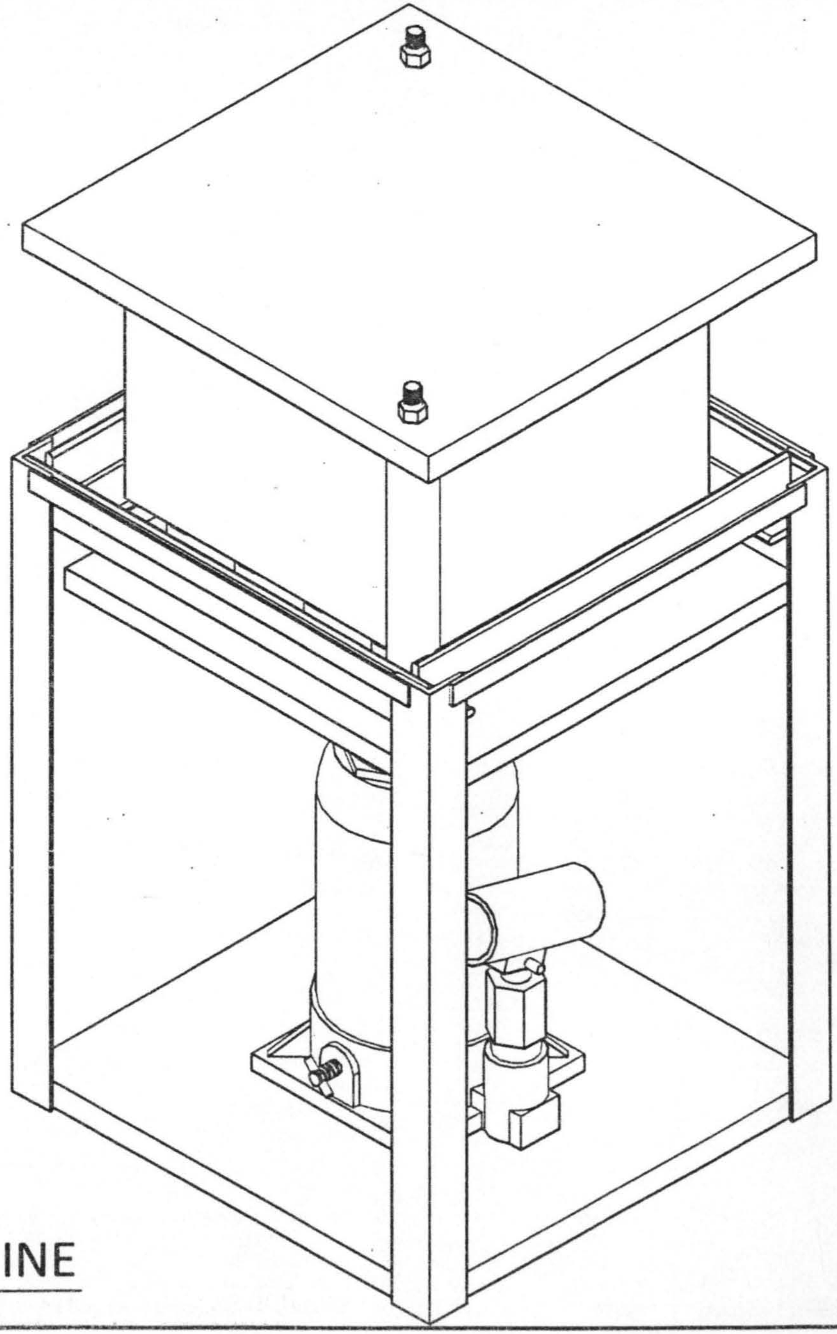
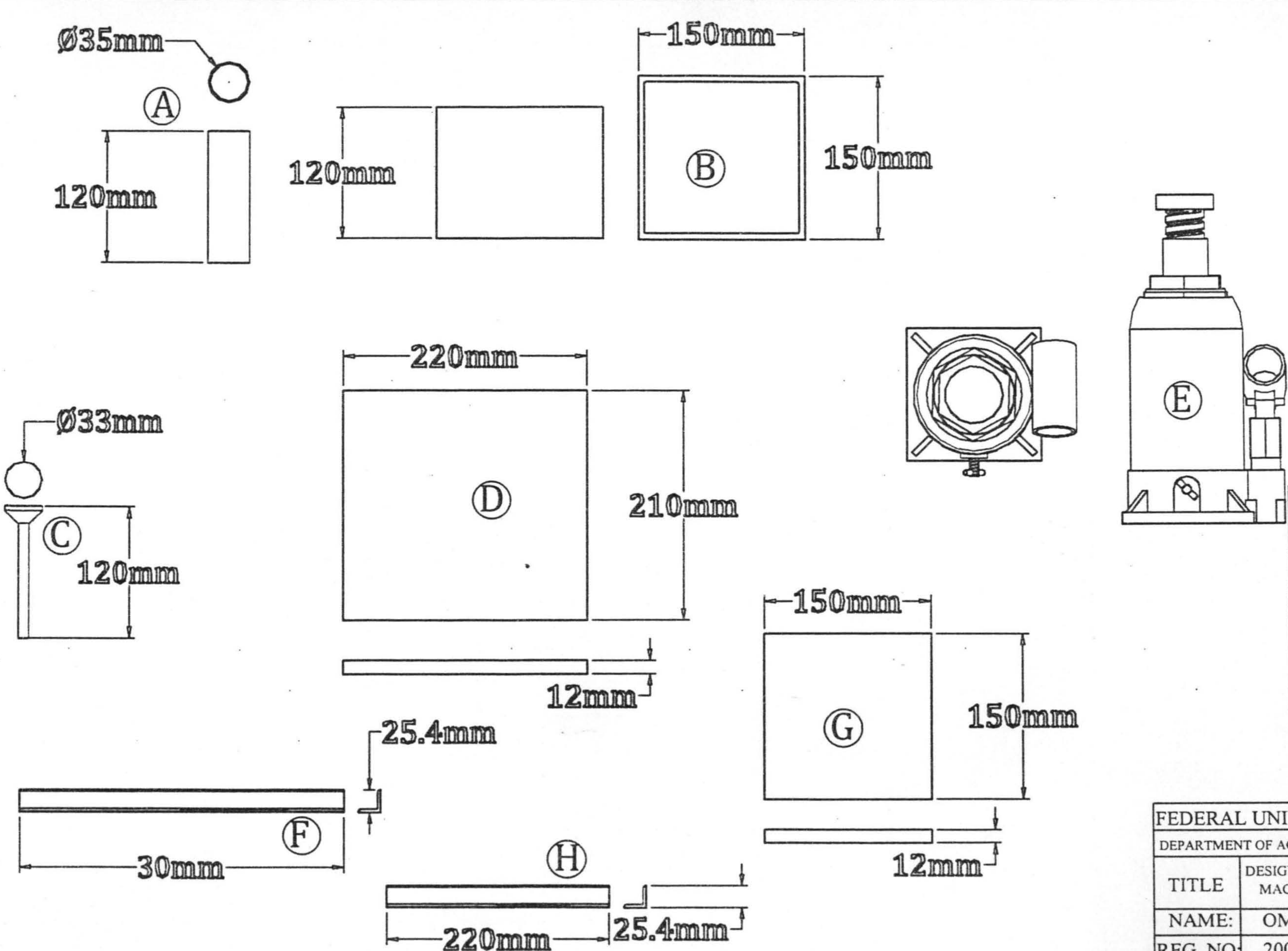


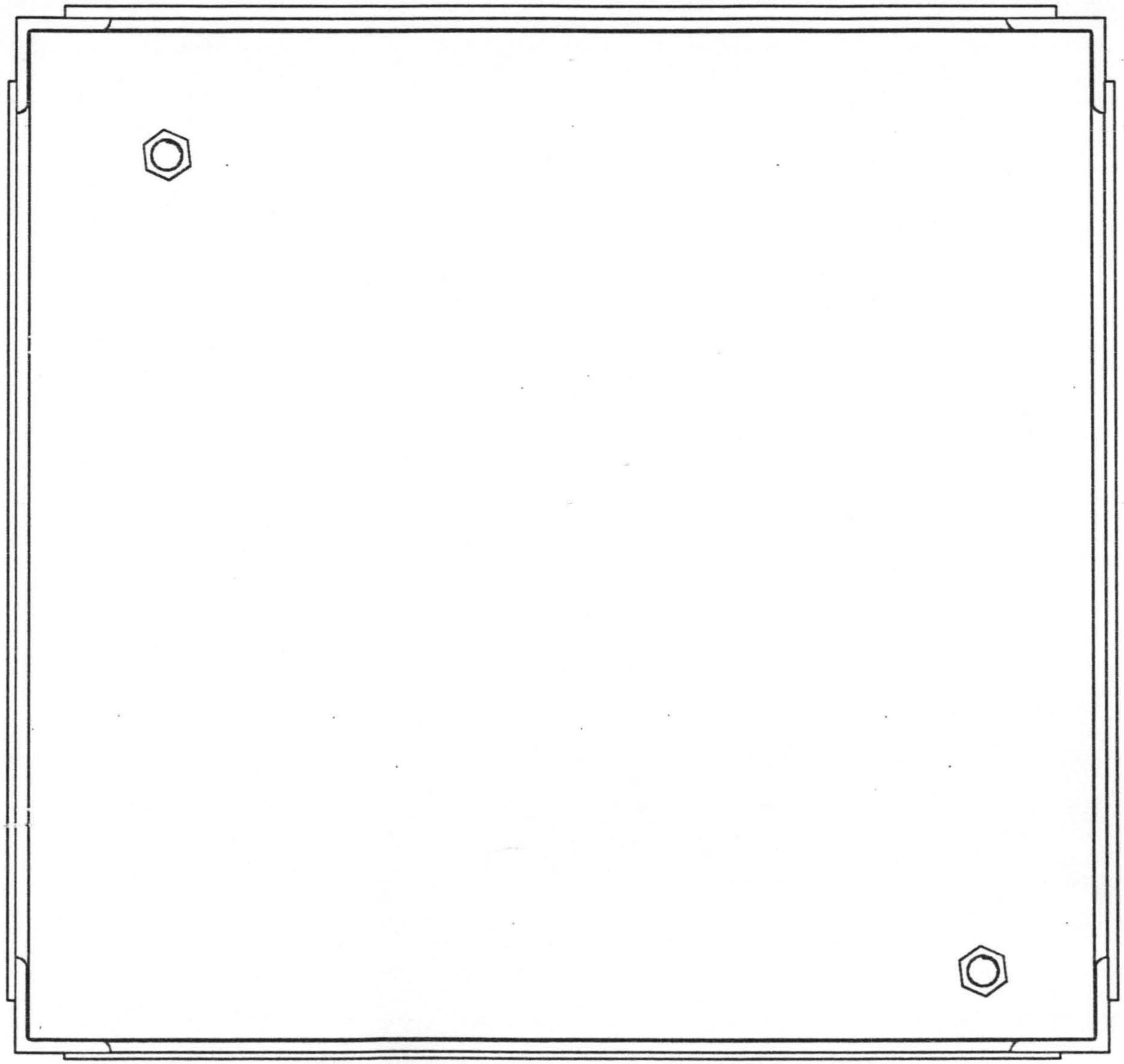
AN ISOMETRIC VIEW OF A BRIQUETTE MAKING MACHINE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA	
DEPARTMENT OF AGRICULTURAL AND BIORESOURCE ENGINEERING	
TITLE	DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE
NAME:	OMOTAINSE PETER OLUGBENGA
REG. NO:	2004/18408EA
SUPERVISOR	ENGR. DR. AGIDI GBABO
DRG NO:	1
SCALE:	1:100 DATE: FEBRUARY 201



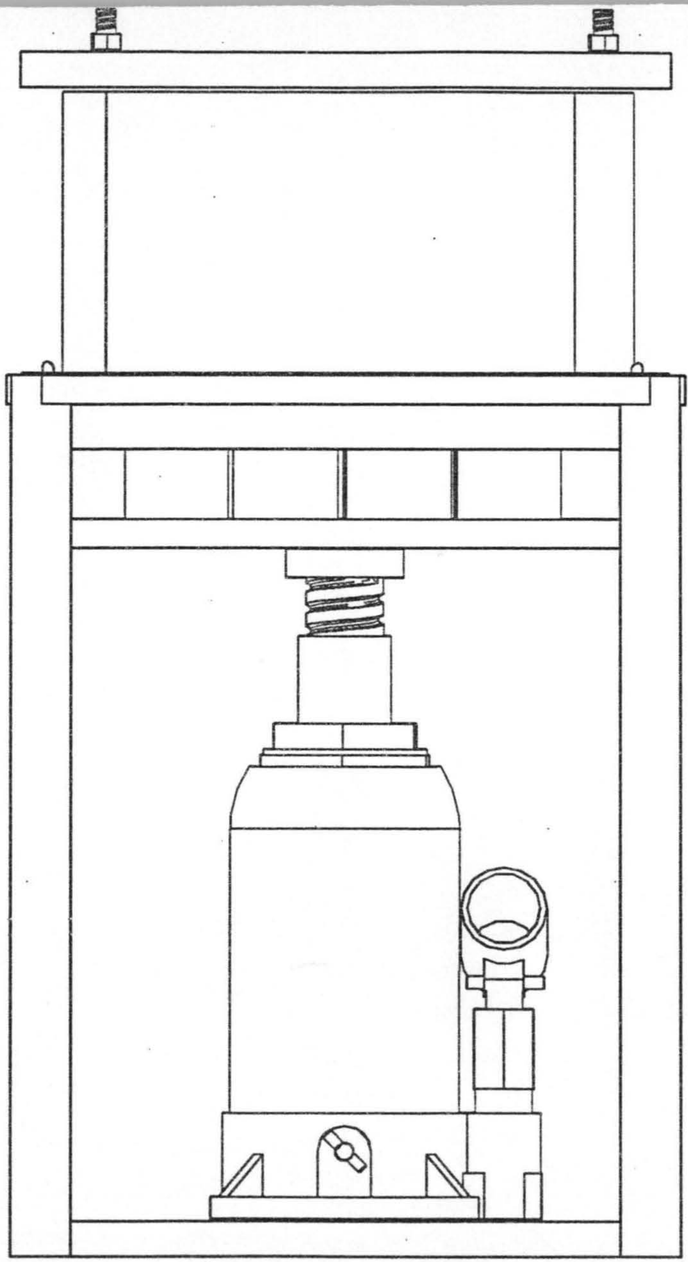
S/No	PART	QTY
A	Cylinder	16
B	Cylinder block	1
C	Piston rod	16
D	Base plate	1
E	5 ton hydraulic jack	1
F	1 Inch Angle iron	4
G	Pressure plate	1
H	1 Inch Angle iron	4

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA			
DEPARTMENT OF AGRICULTURAL AND BIORESOURCE ENGINEERING			
TITLE	DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE		
NAME:	OMOTAINSE PETER OLUGBENGA		
REG. NO:	2004/18408EA		
SUPERVISOR	ENGR. DR. AGIDI GBABO		
DRG NO:	2		
SCALE:	1:100	DATE:	JANUARY 2010



A TOP VIEW OF A BRIQUETTE MAKING MACHINE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA			
DEPARTMENT OF AGRICULTURAL AND BIORESOURCE ENGINEERING			
TITLE	DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE		
NAME:	OMOTAINSE PETER OLUGBENGA		
REG. NO:	2004/18408EA		
SUPERVISOR	ENGR. DR. AGIDI GBABO		
DRG NO:	3		
SCALE:	1:100	DATE:	FEBRUARY 2010



A SIDE VIEW OF A BRIQUETTE MAKING MACHINE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA			
DEPARTMENT OF AGRICULTURAL AND BIORESOURCE ENGINEERING			
TITLE	DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE		
NAME:	OMOTAINSE PETER OLUGBENGA		
REG. NO:	2004/18408EA		
SUPERVISOR	ENGR. DR. AGIDI GBABO		
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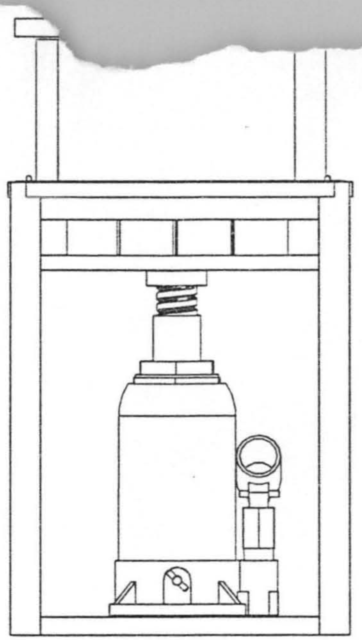
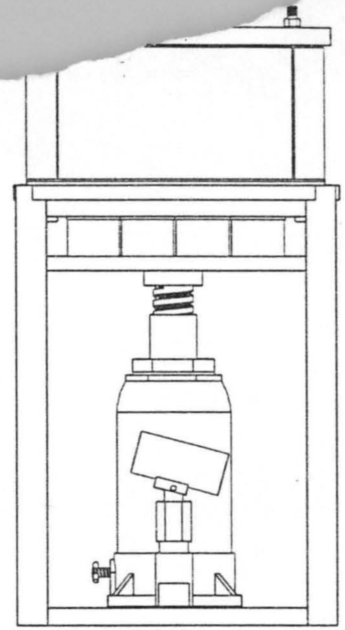
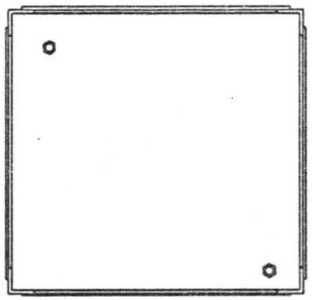
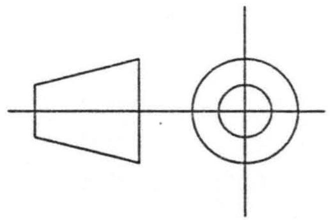
SCALE:	1:100	DATE:	FEBRUARY 2010









A THIRD ANGLE ORTHOGRAPHIC VIEW OF A BRIQUETTE MAKING MACHINE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA			
DEPARTMENT OF AGRICULTURAL AND BIORESOURCE ENGINEERING			
TITLE	DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE FOR SELECTED AGRICULTURAL WASTE		
NAME:	OMOTAINSE PETER OLUGBENGA		
REG. NO:	2004/18408EA		
SUPERVISOR	ENGR. DR. AGIDI GBABO		
DRG NO:	5		
SCALE:	1:100	DATE:	FEBRUARY 2010