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The Design and Fabrication of an Improved Diesel Powered Hydraulic Red Brick Molding Machine

Odunlami Samson.A[1*], Orelaja Oluseyi.A[2*,], Adeleke Michael.B[2] Ibrahim, G.W[1,], Olabode Oladele. M[2]

[1.] *School Department of Mechanical Engineering, Fededral Polytechnic Ilaro, Ogun State, Nigeria*
[2.] *School Department of Mechanical Engineering, Moshood Abiola Polytechnic, Abeokuta, Nigeria*

Abstract
Shelter is one of the basic needs of human race. A permanent shelter is referred to as a building. Brick is the smallest unit of a building. The quality of a brick determines the structural viability of a building. Therefore, the production of good quality bricks becomes paramount and great challenge to man, considering other factors like strength, durability, availability of raw materials, cost of production, and transportation amongst others. The quest to solve the problem of affordable housing with local content led to harnessing the readily available red soil in large quantities in developing countries like Nigeria. This need brought the concept of the design and fabrication of Red brick making machine . The major objective of this research work is to is to design and construct red brick making machine with locally sort materials which is more efficient, durable and cost effective when compared with those produced manually or blocks produced with cement. This machine has the following design parameters, having a height of 1700mm with the base dimension of 790mm by 650mm. It was designed to mould four bricks simultaneously. It can be dual powered by electricity or by an internal combustion engine (diesel) and is dual powered (electricity and diesel). The main material used for the fabrication is mild steel. This is due to its good mechanical properties such as machinability, weldability, high tensile strength, availability and low cost. The dimension of the mold inside the core is 150mm x 250mm x 200mm which is segmented into four compartments to produce brick size of 140mm x 230mm x180mm each. The brick has a dimension of 130mm x 220mm x170mm. This machine is incorporated with hydraulic system with a piston rod positioned each of the sides of the travel rail of the machine which will enhance the lifting and lowering of the brick mold with a vibrator imbedded in it to juggle the red clay in the mold cavity to give the desired result after it has been subjected to a rigorous vibration and compression by the vibrator and the rammer in the machine. This machine is capable of producing four bricks simultaneously in 6 minutes.
Keywords: *Design, fabrication, improved, diesel, hydraulic, red, brick, molding, machine*

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I. Introduction

One of the most basic demands of man all over the world is the provision of shelter. For a human to survive and live for the next life opportunities, the provision of shelter is an important requirements shelter consist of some standard living items and conditions which provides room for all other necessities of human rights, Yakubu *et. al.* (2015).one of the most important materials for shelter are bricks and blocks. Brick making is an ancient process Oyedamola *et. al.* (2017). Brick making has evolved since 7000BC and has been found in various places like the Jerusalem and in most developed countries all over the world.

Man uses bricks mainly for the purpose of building, and few other domestic and industrial purposes. In the early thousands of years ago brick were used to construct a lot of buildings and still in existence till this very age of human race. Over 2000 years ago, bricks and stones have been the major building construction materials and the stones are readily available everywhere due to the age of mankind, Afolayan *et. al*(2008). Recently in brick making industries the number of molds determines the quantity of bricks produced at a time. Ever before now, manual process have adopted for brick production. In that process, a lot of time, energy and materials are being wasted resulting to avoidably high cost of production. Ordinarily, a mixture of clay, water (and sometimes kiln for heating) are used to produce bricks. The need for more shelters / buildings becomes imperative as the population of human race increases on daily basis. This brings about the purpose of this research work for the production of adequate quantity and quality bricks to meet the high demand with the aid of an efficient and effective machine which would serve as a major facilitator with minimal human supervision. The machine will be designed such that it will produce more bricks at a time and the time taken will be far less than the manual process. Later the machine was employed in the early 2000's. These machines uses manual

hand lever for the readily mix clay and water, and it takes effort to compress up to 2 to three moulds at a time and impacting on the floor for air trapped in the mixture to escape. The rate of production of bricks became higher due to the designs of the machines. A locally fabricated manually operated multiple brick molding machine was designed and constructed. Putting the machine to test for about 2 hours and the machine was able to produce an average of about 40 bricks Kolawole (2013). Brick making is much more of an art than is usually supposed.

With respect to the quality of building materials, manufacturers of building materials these days have continued experiment with their product to allow for relatively durable and inexpensive materials that will be compliant with these regulations Odusote (2013). A developing country like Nigeria needs to admit this culture too, at least to reduce incessant cases of building collapses in almost all part of the country and promote the economy of the country to a meaningful extent. Poor reinforced concrete steel resulting into collapse of buildings and other major cause of collapse, is fire outbreak Ashby (2002).

The chart below was used to characterize bricks and further refers to ensure that brick making machine is accessible in the market today are excessively costly for individual which is the reason it is just being gotten and used by industries. The chart below was used to explain the classification of bricks based on four (4) standards as listed below:

i. Quality
ii. Usage
iii. Composites
iv. Manufacturing process

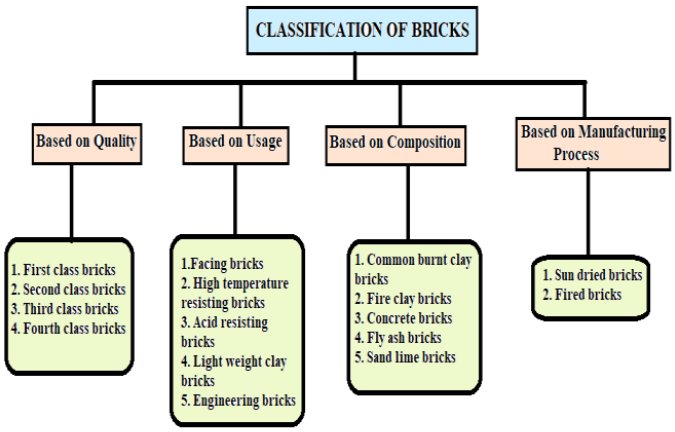


Figure 1 Classification of Bricks Based On Standards.

1.1 Literature Review

1.1.1 Review On Hand Moulding

A brick is a composite material used in construction which in-built consist of several other ingredients The use of hands to shape the mixture of clay, water and other brick production materials into brick and allowing the brick to dry is the earliest method of brick production process. This method is a time consuming method. The production rate is very low because it requires great amount of human effort to mould the brick. The only material needed to make the shape of the desire brick is the mould. Figure 2 shows an example of hand formed brick.

Figure 2 Hand mould bricks

1.1.2 Review On Manually operated Moulding Machine

However, in according to some researchers in the Journal of Engineering Science and Technology review - February 2013, a group of two individuals worked on the design, fabrication and performance evaluation of a manual clay brick molding machine, it produces 80 bricks per hour due to factors such as human efforts introduced and it is highly time consuming. In their review the size of the mould and the shape of the brick were considered. There are four mould compartments. The main significance of the manually operated design was to ensure that the machine can be used in all regions of the country i.e. Rural and Urban regions, Figure 3 also shows an example of manually hand operated machine.

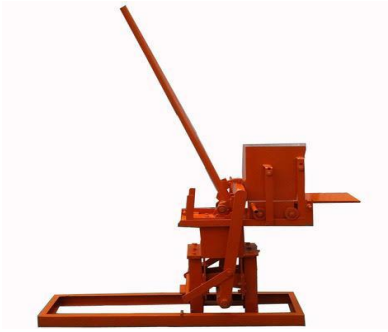


Figure 3 Manually operated brick making machine

1.1.3 Review On Electrical Operated Moulding Machine

Another design which uses electrical power to drive the hydraulic system incorporated with the design was reviewed. Less human intervention is required to operate the machine and it consumes little time during production. The average production rate is 92 bricks per hour. George (2017) stated that these types of brick machines make use of hydraulic systems to compress the brick. It is categorized as a semi-automated system because it still requires a human operator to perform operations on the system. There is no use of vibrator to aid the production process and the manual part is included because the mixture of the red brick clay and water and kiln is done by human and it is been poured in the conical opening located at the top of their machine and it will go down into the mold that has been provided at the bottom of the cone.

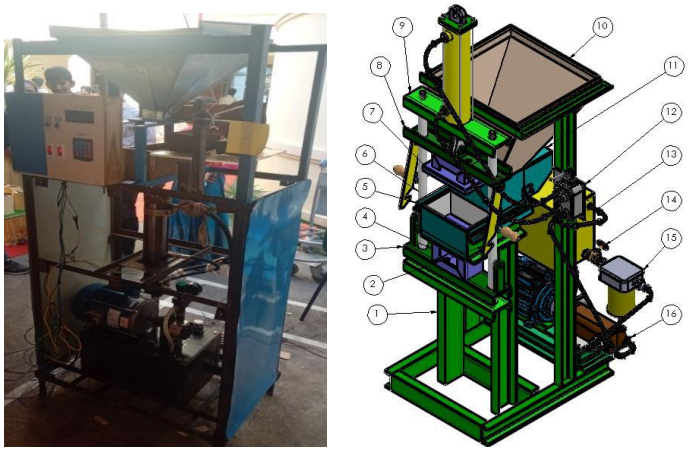


Figure 4 Multipurpose brick and block moulding machine

2.0 Methodology

The early design of the local block making machine is simply the use of mold and human effort extensively, this process involve the use of just a mould and impact of the mold on the earth surface to compact the mixture in the mold and make t easy to remove and form a block. Other latest design that uses a vibration from another electrical device that is, incorporated with a vibrator and also uses electricity to produce the block.

In considering a diesel engine to power a brick making machine and which uses a hydraulic system and a vibrator is a very complex design, but a simpler design can be used with the same features and having the same efficiency. The power supply to this design involved the use of generator or electricity and the hydraulic system also is powered with the aid of electricity supplied by the generator. The figure 5 below shows typical example of red brick making machine, which is incorporated with vibrator and hydraulic system.

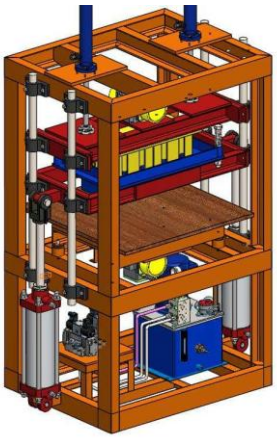


Figure 5 A Hydraulic Red Brick Making Machine

To select a material for an engineering project, there are a lot of factors to be considered which can be, the purpose of the machine, the availability of spare parts, type of operation to be performed by the machine and so on.

2.1 DESIGN ANALYSIS

The machine is \constructed with light materials which will make it easy to be able to convey easily, and it is designed in such a way that it can be dismantled for easy movement. The design analysis of this machine has the following parameter; the height of the machine is 1400mm which has a detachable frame of about 1800mm, the mould cavity for the brick is dimensioned 150x200x250mm, the design of the machine uses hydraulic system to compact and also release the produced bricks. The machine subjects the compressed clay to vibration; this would be as a result of condensing the dry mixed red clay. The resonance and the wavelength along the welded joint and the strength of material is considered in our design. The mass and size of the bricks to be produced at once also will be used to determine the power of the vibrator which will successfully do the work efficiently and provide a good quality brick.

2.2 TABLES/ DESIGN CALCULATIONS

Table 1 **Parameters and measurement table**

S/N	PARAMETERS	CALCULATED/MEASURED VALUES
1	Weight of Brick to be produced at once	19kg
2	Dimension of Mould of Four (4) bricks	60mm x 25mm x 20mm
3	Compressive Force of the Compactor	500N
4	Mass of mould	19kg

DESIGN CALCULATIONS:

$$Stress\ (\sigma) = \frac{Force\ (F)}{Area\ (A)}$$

$$Area\ (A) = \text{Length X Breadth}$$

$$A = 0.60*0.25 = 0.15m^2$$

$$\text{Force} = \text{Mass X Acceleration due to Gravity [mg]}$$

$$\text{Force} = (25 + 50)*9.81$$

$$F = 75*9.81 = 735.75N$$

$$\sigma = \frac{735.75}{0.15} = 4905N/m^2$$

The compressive stress on the plate is **4905N/m^2.**

Due to the use of a vibrator the whole frame will tend to vibrate to but a medium of reducing the vibration from reaching the frame would be installed around the body of the machine where the vibrator will have contact with the frame. This will bring about the consideration of the type of vibrator and the power of the vibrator along with the resonance effect on the material.

M_R (mass of rammer) = 50kg

M_M (mass of mold) = 19kg

M_B (mass of bricks) =19kg

Total mass of the Rammer, bricks and mold T $M_R+M_B+M_M=M_T$

19+19+50=88kg

Minimum force required to vibrate T → $F_t = Tg$

$= 88 * 9.81$

$= 863.24N =$ **0.86KN**

Power required to move 88kg of load. P_{req} for 1 seconds

$$P = \frac{F * D}{T}$$

$$= \frac{863.24 * 1}{1}$$

$$= 863.24watt$$

$$= 0.863KW$$

1 horse power (hp) = 750watt

Vibrator power = 2hp

2hp= 750 * 2 = 1500Watt

For the total mass M_T = 88kg, the capacity of hydraulic system required to lift the rammer, mold and bricks is below 1 ton.

Therefore, the hydraulic system capacity is 10 ton

1 ton = 907.18474kg

Based on the calculations carried out above, it serves as a guide in the selection of the vibrator and the rating of the hydraulic pump selected.

The capacity of the components used is as follows:

VIBRATOR USED: 2hp (single phase)

HYDRAULIC PUMP USED: 3hp (three phase)

2.3 DESIGN CRITERIA

1. **SIZE OF THE BRICK**: Four pieces of bricks are produced at a time and the dimensions were carefully measured to fit in the frame of each mold cavity. The brick size is 25mm x 20mm x 15mm. And the material used for the mould is a 3mm thick mild steel plate that can hold the vibration process and also the brick to maintain good shape.
2. **FRAME OF THE MACHINE**: the frame at which all other components will be mounted on should be a strong and rigid material. A mild steel angle bar of 3mm thickness 3" is used to make the frame of the machine. And the mobility of the machine is also as important, which is why the material used at the base of the machine is a U channel mild steel.
3. **SHAPE OF THE BRICK**: the brick will be produced like an inter lock; there would be a less possibility of using other material to join the bricks together because it would be designed to lock into each other.
4. **CAPACITY OF THE MACHINE DESIGN:** the capacity such that how the machine would be able to withstand all the vibrations was measured and put into consideration during material selection

2.4 MATERIAL SELECTION

In Engineering, the selection of material in manufacturing is the most important task of an engineering design. Materials vary in properties such as Toughness, Strength, Ductility, Corrosion resistance, hardness etc. and all these materials may be selected for their unique properties and other factors such as;

- Availability
- Machine-ability
- Cost of materials
- Properties of materials etc.

Engineering metals are generally alloy, these are metallic materials formed by mixing two or more elements such as Iron and Copper to produce Mild steel etc. Most metals consist of iron element which makes most material ferrous metals and practically magnetic. The design and construction of a diesel powered hydraulic red brick making machine have some specific parts that need some type of a particular type of material to ensure stability of the design.

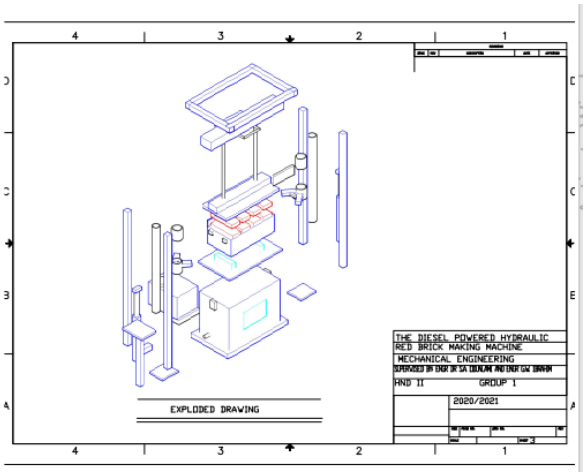
The material selected for the project work is mainly Mild steel. Mild steel differs in sizes, surface textures, and thickness and so on, depending on the work it is to serve or the purpose of its application. Mild steel is selected due to various reasons, the reasons are

1. **Cost of Material**: Mild steel is one of the cheapest materials which is readily available in every part of the country.
2. **Availability**: Mild steel is available for purchase at almost every part of the country
3. **Properties of Mild steel**: the use of substances that leads to corrosion of mild steel is limited here. The use of water is not much in the system

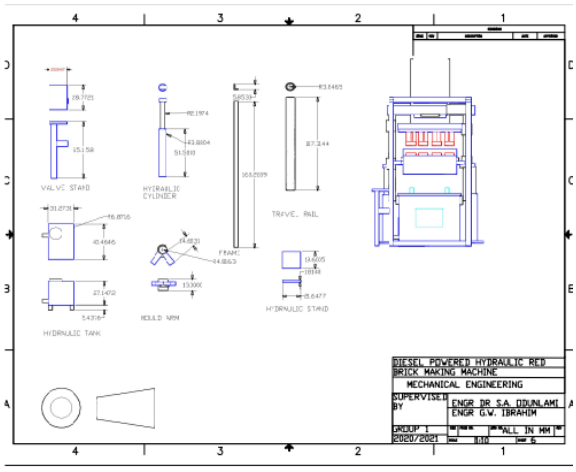
4. **Machinability**: This means the machine can be bent to shapes and cut to sized and also be used to make intricate shapes during construction process.

Other various factors are considered in the selection of material, one of the factors is the weight of the machine. This brick making machine is designed to be able to easily dismantle all the component parts for easy transport and to reduce the weight while transporting the machine.

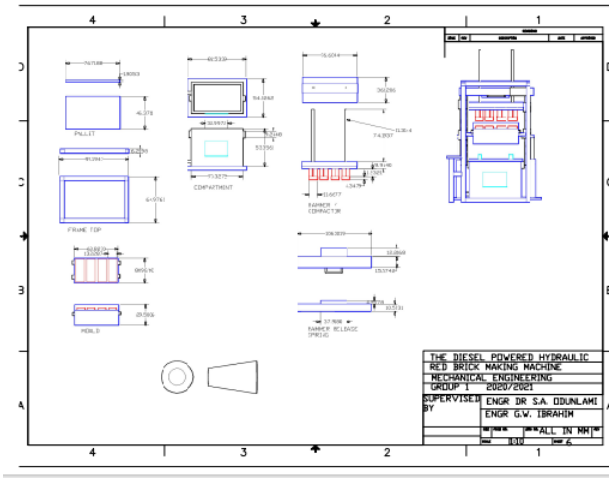
2.5 DESIGN DIAGRAM



(a) Exploded Drawing



(b) Orthogonal View



(c) Part Drawing

Figure 6 (a, b and c) Illustrates the design drawing of the hydraulic brick making Machine

2.6 DRIVING SYSTEM

In every possible way, engineering is solving one problem or the other, so as to reduce human effort in doing specific tasks. There are a lot of machine systems which is used to reduce human effort, and the main purpose of machine is to reduce human effort. Out of all the machine systems we will focus on the Pneumatic system and the hydraulic system. Our main focus is the hydraulic system because it is the one we choose for the design of our machine.

2.7 PNEUMATIC SYSTEM

This is the machine system which uses compressed air to move machine parts. This system makes use of compressor and pneumatic cylinder. Pneumatic system is a fast moving system which operates on a very fast speed. Once it is been actuated, the piston in the cylinder is pushed out. Pneumatic system is used on a light weight machine. The components used in a pneumatic system are as follows;

i. Air compressor
ii. Pneumatic tube
iii. Pneumatic valve

iv. Pneumatic cylinder
v. Push in fitting

2.8 HYDRAULIC SYSTEM

A hydraulic system is the one which uses liquid fluid to move object. A hydraulic system has a lot of working component which are connected through lines. Some of the components are

i. Pump
ii. Hydraulic hose
iii. Hydraulic valve
iv. Hydraulic cylinder
v. Fittings

All the components listed above are the part of the major hydraulic system components.

In relation with our project design the hydraulic system is incorporated in our machine to lift the rammer, the mold and the bricks too. The hydraulic cylinder is mounted at both side of the machine which will move up and down and in process will lift the mold and the rammer together. This will eliminate the manual lifting effort (man power) and also efficiently ease human stress at the end of operation.

The major reasons for selecting a hydraulic system over a pneumatic system are.

i. Pneumatic system is for light weight material
ii. Pneumatic system is too fast for brick operation
iii. Hydraulic system speed is easily controlled and it can lift heavy load

3.0. RESULTS AND DISCUSSION

At this chapter, the results of all the machine components which was put in place with the end result will be looked into. Here are some of the test results carried out on the vibrator and the hydraulic pump.

Table 2. Components incorporated in the machine and results obtained.

Components	Usage	Result
Vibrator	To vibrate the clay and the mold. To ensure even spread of the clay in the mold	Working
Hydraulic	To lift the mold, clay and rammer	Working

The machine was design to be a two way power system i.e. the machine could use electricity and diesel engine of about 7hp and above.

The machine was put to test after all the machine components have been fitted. The test results obtained were shown in table 3 below.

Table 3. **Test of brick quality**

S/N	Test	Mass	Volume	Density	Result
1	Test 1	4.733Kg	$0.0075m^3$	$631.067Kg/m^3$	Fair
2	Test 2	4.200Kg	$0.00375m^3$	$1120.00Kg/m^3$	V. Good
3	Test 3	4.733Kg	$0.00375m^3$	$1262.13Kg/m^3$	Good
4	Test 4	3.980Kg	$0.0075m^3$	$530.667Kg/m^3$	Good
5	Test 5	4.200Kg	$0.0075m^3$	$560.000Kg/m^3$	Fair
6	Test 6	3.980Kg	$0.00375m^3$	$1061.33Kg/m^3$	Good

4.0 DISCUSSION

For any Engineering product to be certified to be fully functional, it must have gone to series of tests, which will prove that the machine is capable of serving its purpose and not only at the point of test but also on a long run. The quality of engineering equipment depends on the result of its constructional purpose and functions.

- The hydraulic system incorporated enhances the efficiency of the machine
- The vibrator is able to vibrate the load precisely without any defect
- This designed and locally constructed red brick moulding machine is a good concept which will enhance brick production rate in Nigeria.

Although, it is believed that there is still room for futures modifications in this design, but this product is very affordable and is believed to ease red brick production generally.

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