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Entrepreneurial Skill Development: A Case Study Of The Design And Construction Of Charcoal Baking Oven

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Abstract: This research, concerns the design and construction of a charcoal baking oven using locally available materials as a case study for entrepreneurial development in Nigeria. The baking oven in this work has a rectangular box like shape with a total baking area of 315000mm^2. The oven is used for baking, drying and warming of food e.g cakes, bread, fish, meat etc. It is constructed with mild steel and angle bars. It comprises baking tray, housing frame, charcoal heating tray and baking chamber door. The oven is capable of generating 1488KJ of heat energy. The maximum temperature attainable with the oven is about 500 degree Celsius. The cost of producing one unit of this charcoal baking oven is about fifty five thousand naira only.

Keywords: Entrepreneurship development, Oven, Heat energy, Skills and Charcoal.

I. INTRODUCTION

[1] says Entrepreneurship is concerned with innovation and management. He sees entrepreneur as either a creative innovator that is creating something new that is capable of satisfying consumer's wants or an adaptive innovator who can modify existing or similar products or services for better performance while also engaged in managerial activities of planning, controlling, organizing, directing, and coordinating his business to achieve the objectives of the enterprise. Baking is the process that uses an oven or hotplate to cook a wide range of flour-based foods [5]. According to [13], in free air solid fuels burn at a temperature of only 240^{0}C, which is too low a temperature for perfect reactions to occur, with heat produced through convection being largely lost, smoke particles are evolved without being fully burnt and the supply of air difficult to controlled but by enclosing the fire in a chamber and connecting it to a chimney, draft(draught) is generated by way of pulling fresh air through the burning fuel thereby causing the temperature of combustion to rise to a point of 600^{0}C where efficient combustion is achieved also the enclosure allows the ingress of air to be regulated and losses by convection are almost eliminated. [7] posits that baking requires very high temperature around 250^{0}C which therefore needs a larger amount of thermal energy input and that due to lack of electricity, biomass energy is mostly used for baking in developing countries. There are two categories of ovens: those that are heated internally and those that have a separate heat source [14]. The baking oven in this article is a rectangular box-like structure within which heat is generated and maintained. The oven is usually provided with insulation or lagged to prevent heat loss through the boundary and mostly used for baking, drying and warming needs, making it imperative therefore to design an oven that can be ignited to attain various temperature levels. The thermal energy is generated through conversion of chemical energy and can be utilized for both domestic and industrial purposes. This research paper therefore, takes a look at the design and construction of a charcoal baking oven using locally available
materials. According to [9], Charcoal is a black substance that resembles coal that is used as a source of fuel made from wood that has been burnt or charred, while being deprived of oxygen so that what is left is an impure carbon residue. This design has a little modification when compared to the conventional charcoal baking oven as a case study for entrepreneurial development, particularly adapted for rural areas where there is no electricity as well as natural cooking gas or where both are exceptionally expensive and therefore unaffordable by the populace. This design is meant for domestic use in terms of baking, roasting and drying of food like bread, cake, fish, meat e.t.c. This design could also serve some engineering purpose which include the area of heat treatment of metals. Heat treatment is used to alter mechanical properties of a metal by effecting changes in its microstructure [3].

The main components of the improved design are as follows; the charcoal heating tray, baking chamber door, baking tray, housing frame and a manually operated blower. The operating temperature of the charcoal baking oven ranges from 250^{o}C to 300^{o}C. Thermal heat losses resulting from flow through the wall of the oven to the surrounding are highly reduced by means of lagging. The insulating material precisely, reinforced fibre was used to reduce the amount of heat loss and maintain the temperature within the required range of 250^{o}C to 300^{o}C. The use of the charcoal baking oven is limited to domestic farmers and industries in rural areas and is capable of drying and baking 20kg of bread and farm produce. The charcoal baking oven should be kept in dry environment and away from the rain to avoid corrosion.

According to [8] the most important thing in a bakery is the oven and before obtaining an oven a baker should consider oven prices, fuel availability, and affordability, possible assistance, supply and quality of materials, maintenance requirements etc. The charcoal baking oven was designed to ease and eliminate the stress and drudgery the rural dwellers and industries in rural areas that have no easy access to natural cooking gas and electricity go through during baking and drying food items such as bread & snacks. This design and construction of this oven, therefore becomes significantly imperative for the rural dwellers so as to emancipate them from the crude way of drying & baking with firewood. This will also go a long way to minimize the level of environmental pollution caused by the incomplete combustion characterized with cooking with firewood. This research design in summary therefore seeks to proffer assistance

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to the local and medium scale industries involved in baking and drying business in their quest for a convenient and cheap method of baking. The oven will be useful to the low income earners and medium scale industries in the rural areas due to either the high cost or total unavailability of natural cooking gas in the rural areas. This is in line with [4] position that Entrepreneurship has the ability to raise productivity through various forms of innovations and to create jobs through the formation of new enterprises especially small and medium scale enterprises.

II. MODIFICATION

The traditional baking ovens also refer to as "black-oven" consist of a baking chamber made of fireproof brick, concrete, stone, clay, or cob without insulation and proper ventilation which can be wood-fired or coal-fired with smoke from the burned wood emitting soot on the roof of the oven and consumes about 0.5kg to 1kg of wood per kg of baked wheat flour [2]. Recent charcoal baking ovens designs consist of a box-like metallic structure comprising of the housing frame/casing, baking tray where the food items are placed and heated, the charcoal heating tray where the charcoal is packed, baking chamber's door and charcoal heating chamber's door. The design in this article has been modified by the addition or incorporation of a blower to the various features of the traditional or conventional design. The blower is manually operated to supply air (oxygen) to the charcoal heating chamber in order to constantly keep the charcoal burning in flames. The blower also blows the ashes causing them to move from the charcoal to the ashes tray which is located behind the charcoal heating tray. This process is called FORCED CONVECTION according to [10]. During baking, the heating process is done by a combination of three forms of heat: by infra-red energy that is radiated from the oven walls, by circulating hot air; and by conduction through the baking pan or tray [6]. Naturally, if an oven is fitted with a fan capable of constantly supplying enough oxygen needed for firing the charcoal and thereby increasing the quantity of heat energy flow with minimal heat losses to the surrounding, the rate of heating will increase thereby reducing cooking/baking time. The rate of firing or burning of the charcoal baking oven is controlled or regulated by increasing or reducing the speed of the blower.

III. METHOD OF CONSTRUCTION

The charcoal baking oven is made up of the following main components.

1. Housing frame
2. Baking tray
3. Charcoal heating tray
4. Baking chamber door
5. Charcoal heating chamber door

The description of how each components was made with the material used is given below.

1. Construction Of The Housing Frame / Casing

The housing frame of the charcoal baking oven serves as the warehouse and also as a support for the entire oven components and for whatever food item that is intended for baking. The housing frame is made up of mild steel and angle bar measuring 60mm by 60mm, the angle bar was successfully measured with the aid of scriber and steel rule and cutting was done using hacksaw and cutting disc. The cut out angle bars were joined together with the aid of an electric arc welding machine in order to form a rectangular box-like shape measuring 720mm by 630mm by 720mm in dimensions. See fig 1. Sheet metals made of mild steel of 1.5mm thickness were measured with the aid of steel rule and scriber and cut using cutting disc and thereafter welded to the inner part of the frame. At this point, the body of the metal sheet already welded was then lined with fibre in-between the two metal sheets just welded to prevent heat loss. Another sheet metal of appropriate dimension was cut and thereafter welded to cover the fibre used for lining the body of the inner sheet metal. See fig 1.

2. Construction Of The Baking Chambers

The baking chamber is the portion where the food items are placed during baking. It was made to accommodate three baking trays at a time and lined with angle bars of 60mm by 60mm in three different positions to accommodate three trays at a time. See fig 1.

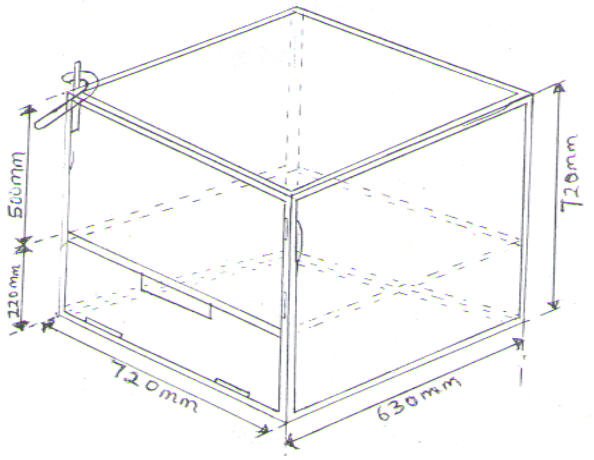

Fig 1: Isometric View of a charcoal Baking Oven

3. Construction Of Baking Trays

The baking trays serves as a means of supporting the food items that are to be baked. The baking trays which are three in number were made of mild steel rod of 3mm diameter. The rods were measured with the aid of scriber and cut with the aid of hack saw and thereafter welded together at intervals of 1 inch with the aid of an electric arc welding machine to form a rectangular box-like trays measuring 720mm by 630mm. See fig. 2.

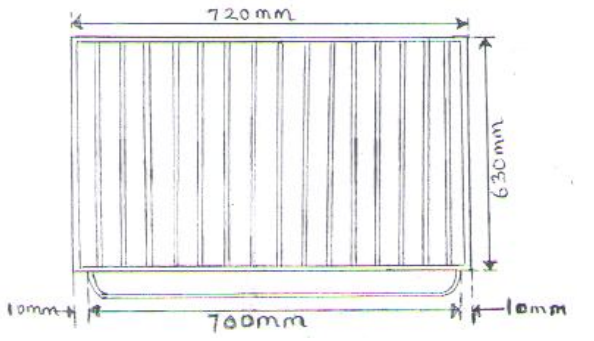

Fig 2: Charcoal Baking Tray

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4. Construction Of Charcoal Heating Tray

The charcoal heating tray serves as a container for the charcoal within the charcoal heating unit or chamber located at the bottom part of the charcoal baking oven housing. The heating tray is made up of a mild steel metal of 2mm thickness. It was measured with the aid of steel rule and scriber and cut with the aid of cutting disc to appropriate dimension of 720mm by 630mm by 220mm and later welded to form a rectangular box-like shape. See fig. 3 for details. The maximum load that can be carried by the tray was determined on the basis of the yield strength of the materials used. The load that produces this stress is a good design parameter for determining the maximum load that the tray can carry. [12] as cited by [11].

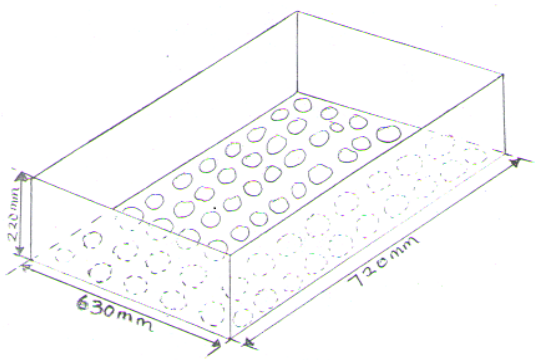

Fig 3: Charcoal Heating Tray

5. Construction Of Baking Chamber Door

The charcoal baking chamber door serves as a means of opening and closing to allow easy feeding in and removal of food items meant for baking and to prevent heat loss from the oven as well as protect the food items from unnecessary interference by unwanted persons. The door frame measuring 720mm by 500mm was made with an angle bar of 60mm by 60mm. Mild steel sheet of dimension 720mm by 500mm was thereafter measured with the aid of steel rule and scriber, Cut with a cutting disc and thereafter welded to the door frame with an arc welding machine. See fig. 4.

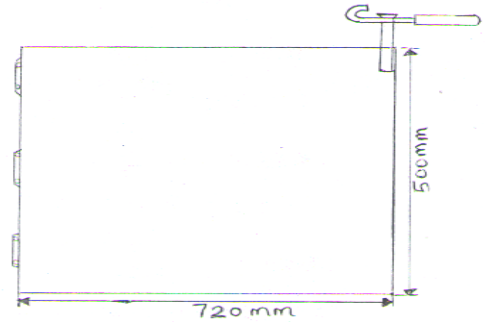

Fig 4:Baking Chamber's Door

6. Assembling Of All Parts

After all the parts were fabricated, they were sequentially assembled in the following order, first the baking chamber door was connected to the housing frame by means of two hinges. See fig.1. The charcoal heating chamber was thereafter fixed to the bottom part of the housing frame as shown in fig. 1. The three baking trays constructed were in turn positioned in the baking chamber one after the other. See fig 1.

7. Finishing Operation

All welded joints were deslagged and thereafter ground and polished to ensure a smooth finish, grinding was done with a hand grinding machine. After grinding, the oven was given a first stage painting with anti-rust paint and then followed by a second stage and final stage painting with a black colour paint.

IV. TEORETICAL DESIGN CALCULATIONS OF THE MAXIMUM HEAT GENERATED IN OVEN(Q)

Maximum Heat Generated In The Oven Q, is given by the equation; $Q = mC_p\Delta T$ [13]

Where:

Q = Maximum Heat generated

m =Total Mass of charcoal used=2kg

C_p= Specific heat capacity of charcoal = 1kJ/kg K

Initial oven temperature, $T_1 = 29^0C$

Final oven temperature, $T_2 = 500^0C$

ΔT = Change in temperature

= Final temperature(T_2) – Initial temperature(T_1)

$=500^0C - 29^0C = 471^0C$

$= 471^0C + 273 = 744$ K

But $Q = mC_p\Delta T$

i.e $Q = 2 \times 1 \times 744 = 1488$KJ

V. TESTING, RESULTS AND DISCUSSION OF RESULTS

1. TESTING

After the construction of the oven, it was tested with 30 loaves of bread at different temperature for ten times. The test was carried out at different temperatures and times and this gave rise to different baking time and different percentage of properly baked bread and burnt bread.

2. RESULTS

TABLE 1: TESTING RESULTS

S/N	Temp ^oc	Time (min)	Quantity of baked bread (%)		
			Properly baked bread	Poorly baked bread	Burnt bread
1	50	85	10	90	-
2	100	75	20	80	-
3	150	60	40	60	-
4	200	45	90	10	-
5	250	40	100	-	-
6	300	30	85	13	2
7	350	20	85	10	5
8	400	15	65	25	10
9	450	13	45	35	20
10	500	10	20	40	30

3. DISCUSSION OF RESULTS

The charcoal baking oven was successfully constructed and tested. From the table above showing the test results, it was discovered that the best temperature for baking bread was 250^oC having baking time of 45 minutes with a result of 100 percent properly baked bread higher than the result gotten from other baking temperatures. Also from the table, we find out that when

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the temperature was at 50^{o}C the percentage of properly baked bread was lower than that of every other temperature, having only 10% of properly baked bread and a whole 90% of poorly baked bread. The testing results of the baking oven showed or proved a high level and efficient performance in terms of baking time and quality of baked food items.

VI. BILL OF ENGINEERING MEASUREMENT AND EVALUATION

S/N	MATERIAL DESCRIPTION	QTY.	UNIT PRICE	TOTAL PRICE
1	1.5mm mild steel	2 sheet	6,000	12,000
2	25 x 25 angle bar	2 length	1,350	2,700
3	35 x 35 angle bar	2 length	1,500	3,000
4	12mm x 11mm rod	1	1,700	1,700
5	Electrode 25mm	2 packet	750	1,500
6	Grinding disc	2	400	800
7	Cutting disc	1	200	200
8	Installation fibre	1 carton	3,000	3,000
9	Hack saw blade	1 piece	150	100
10	Paint	2 pairs	250	500
11	Hinges	2	200	400
12	Filler	2 cup	600	1,200
13	3mm mild steel	½ sheet	5,000	5,000
14	Hand brush	1	100	100
15	Labour cost		12,000	12,000
TOTAL				**55,000**

VII. CONCLUSION

The construction of charcoal baking oven has proved a reliable way of baking. Apart from baking, the oven can also be used to dry farm products like maize, groundnuts and warm food. The charcoal baking oven was designed in a manner such that heat loss is reduced to the barest minimum as well as allow for even distribution of heat for optimal baking performances. It should be noted that the stated cost of production of the charcoal baking oven in this research paper can be drastically reduced with mass production of the charcoal baking oven.

VIII. RECOMMENDATIONS

We wish to recommend that the use of the charcoal baking oven be encouraged for rural dwellers as against the use of firewood by way of the Federal and State Governments going into mass producing it to reduce it cost and by so doing increase it affordability and availability.

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