Original Research Article

Design and Construction of Electric Fish Smoking Kiln Using Locally Available Composite Materials

Abstract

The design and construction of low cost electric fish smoking kiln was undertaken with the aim of improving the existing ~~fish smoking~~fish-smoking kiln. The newly constructed kiln was made using locally available composite materials and technologies sourced locally. The kiln consists of smoking kiln chamber, heating elements, a variable thermostat, lagging materials of insulating clay wall and metal frame made of angle iron on which the fish tray, oil collector pan were assembled. The production cost of the electric ~~fish smoking~~fish-smoking kiln is one hundred thousand naira compare with mechanical ones that cost within the range of three hundred thousand and four hundred thousand naira excluding transportation charges.

Keywords:

Comment [p1]: How durable overtime especially with tendency to disintegrate in the face of constant heating and cooling?

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1.0 INTRODUCTION

Fish is an important source of food and income to many people in developing countries. In Nigeria, most people depend wholly or partly on the fisheries sector for their livelihood. In recent time, many individuals and cooperatives are going into small and big scale fish farming (Adewuyi. 2010). Fish is an extremely perishable food item (Agbon *et al.,* 2002). Soon after death, fish begins to spoil. In the healthy live fish, all the complex biochemical reactions are balanced and the fish flesh is sterile. After death however, irreversible change that results in fish spoilage begins to occur. The resultant effect is the decomposition of the fish (Akinola *et al.,* 2006). Various factors are responsible for fish spoilage. The quality of capture is important at determining the rate of spoilage. Notably are the fish health status, the presence of parasites, bruises and wounds on the skin and the mode by which the fish was captured. The caught fish quality depends on the handling and preservation of the fish received from the hands of the fishermen/fisherfolk after capture.

The handling and the preservation practice after capture affects the degree of spoilage of the fish (Akinneye *et al.,* 2007). The quality of the freshly caught fish and its usefulness for further utilization in processing is affected by the fish capture method. Unsuitable fishing method does not only cause mechanical damage to the fish, but also creates stress and the ~~conditions which~~conditions, which accelerate fish deterioration after death. Fish is highly susceptible to deterioration without any preservative or processing measures (Okonta and Ekelemu, 2005).

Emokpae (Year) reported that immediately the fish dies, a number of physiological and microbial deterioration set in and thereby degrade the fish (Delgade *et al.,* 2003). Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries (Al-Jufaili and Opara, 2006). Improper processing especially with rudimentary smoking kilns can also negatively impact the amino acids profile and other mineral constituents of the fish.

In order to improve on these methods, several technological approaches has been reported, including harnessing the solar energy for fish drying, the use of electric heaters (Akinola, *et al.,* 2006), and the use of smoking kiln (Ikenweiwe, 2010). This present study is aimed at designing and construction of a cost effective locally made electric fish smoking kiln. This study was carried out to design and construct a cost effective locally made electric fish-smoking kiln using materials sourced locally.

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2.0 Study Area

Comment [p2]: I guess this should be part of research methodology

Lake Kainji was formed by damming the river Niger at Kainji Island. The dam was closed on 2nd August, 1968 and the reservoir created behind it has a surface area of 1,120km^2 at maximum-recorded level. The lake is 137km long and 24km wide (Welcomme, 1972). Kainji Lake is in the Guinea savannah vegetation zone of the ~~north-western~~northwestern Nigeria. Kainji lake is located between longitude 9^0 20' and 10^0 55' East and latitude 4^0 22' and 4^0 45' North. It has a length of 134km, a maximum width of 21.1km and a maximum depth of 60meters. It has a surface area of 1270 km^2 and a mean annual water temperature of 27.85^{0}c after construction (Abiodun, 2002), and catchment area of 1.6× 10km^2. The river Niger has two flood regimes, the black floods and white floods. Although the primary aim of the impoundment is to generate ~~hydro-electric~~hydroelectric power. The lake also offers opportunities for developmental projects like irrigation farming, fisheries and navigation. Kainji Lake has its source from Futa Jalon in Niger Republic and from local rivers around the lake basin. It takes three to four months for the water from Futa Jalon to get to Kainji Lake especially the southern basin (Ogundana, 2013).

Comment [p3]: Created after closure please

Comment [p4]: 137km long and 134km in length which is the correct. Please resolve the ambiguity.

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3.0 RESEACH METHODOLOGY

Research Materials

The materials used to construct the electric ~~fish smoking~~fish-smoking kiln ~~includes:~~includes 1.5mm flat mild steel sheet, angle bar of 2.54cm thickness. The electrical components (2000 watts capacity heating elements, 1.5mm wire, switch, and thermostat) were sourced from Owode Onirin Market Lagos, Nigeria. Mortar to build the kiln wall was formed from ~~ant hill~~anthill clay (sourced from New Bussa, Nigeria).

4.0 Result

Comment [p5]: This section should be part of methodology. Take note, you may not have results but I think your result is the innovation generated. Insert pictures under results section and provide brief explanation for the workings/efficiency of the developed kiln.

Kiln capacity (Volume):

The volume of a flat top kiln, V_k was calculated using Eq. 1 (Ward, 2015).

V_k = w × h × d .... (1)

Where W = width of the electric fish smoking kiln = 0.80m

h = height of the electric fish smoking kiln = 0.2m

d = depth of the electric fish smoking kiln = 0.76m

V_k = 0.80 × 2 × 0.76 = 1.22m³

Cross-Sectional Area of the Kiln's heating Chamber

The interior cross sectional area of the kiln was computed using Eq. 2:

Area = Length × Width ..... (2)

Surface Area = 80 × 76 = 608cm²

Surface Area = 20 × 76 = 152cm²

What is the CSA?

Element Surface Load

The surface load of an element estimates the wear or deterioration during a given ~~period of time~~period and it is measured in watts per square centimeter (W/sq. cm) (Olsen, 2001).

Element Surface Load = power/ surface area ..... (3)

Element surface Load = 2000/608 = 3.290 w/sq.cm

Electric Kiln Power (Kilowatts) Requirement

The required power for power (in kilowatts) of the electric kiln is a function the kiln's volume temperature and the time required to reach the temperature (Olsen, 2001). Kiln voltage depends on the local power voltage. The voltage supply from Kainji ~~hydro electric~~hydroelectric station is 240V in New Bussa, Nigeria. The rate of the resistance element used is 2KW.

Thus:

P = IV ..... (4)

Where p = power, I = current and V = voltage

Voltage = 240v, power = 2000watts

Current = 2000/240 = 8.33amps

Resistance of the Electric Kiln Element (R)

Resistance is given according to ohms as:

$R = \frac{v}{L}$ ..... (5)

Where V = voltage, I = current,

Therefore; R = 240/8.33 =28.8Ω

Smoke Chamber Volume Design

The volumetric capacity of smoke chamber in figure 2 was calculated in relation to the volume of ~~saw dust~~sawdust it occupies. The chamber was separated from the heating chamber by perforated clay partition.

VP = L × b × h ..... (6)

Where; L = length of smoke chamber = 0.66m

b= width of smoke chamber = 0.26m

h= height of smoke chamber = 0.18m

VP = 0.66 X 0.26 X 0.18 = 0.0309 m^3

Fish Tray Design:

~~The~~The volumetric capacity of each fish tray was calculated in relation to the volume of fish it occupies. Each tray was designed to contain 10 kg of fish per unit operation. In the designing of fish tray volumetric capacity, the shape of the compartment was designed to be rectangular. Lengths and breadth of the tray were assumed to be the same 0.75m, while the height was selected as 0.045m.

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5.0 Results and ~~D~~discussion

Please compare your design with the work of others. What were the things your team did differently that set your design apart from others? It is important to include it here.

The fish kiln built with ~~ant hill~~anthill clay to enable sustainability of heat within the heating chamber having an iron frame structure inside the clay wall with structural dimension of 0.92 x 0.76 x 1.24m. The electric heater is sited at the center wall inside the kiln and oil collecting pan is below the heating chamber which collects the fish oil extracted during drying. The right side of the chamber has a structure for smoking drawers separated from the heating chamber by a perforated clay wall that supplied smoke into the heating ~~chamber which~~chamber, which has a rectangular shape. There are provisions for eight rails of wire mesh trays in the chamber; each tray rests on the structure frame.

The kiln door was fabricated with galvanized iron having a thick cover lagged with ~~fibers which~~fibers, which minimize heat loss from the kiln system. Temperature control meter was installed to control heat generated in the kiln system. At the upper most point of the kiln, an opening (chimney) was provided for exit of excess heat and pressure in the kiln system.

Resistance Heating Element

The heating element used for the construction of the kiln is manufactured by Kenton incorporated with capacity of 2000watts, two elements pieces were installed and connected to an electric power source.

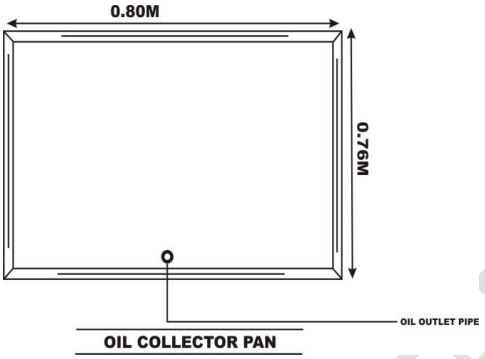
Mortar Paste

Mortar paste was composed from admixture of ~~ant hill~~anthill clay, rice dust and water. It was used for constructing kiln's wall, base and cover.

Comment [p6]: What inform the admixture of rice dust?

Material Selections

The materials selections for this research work were mild steel; the reason for choice of mild steel is its corrosion resistant property, strength durability and cost effectiveness. Basic drawing tools and computer software were used for the design work. The materials used for construction includes; Angle iron, Temperature control meter, Wire, Sawdust, Heating element, Insulating wool and fish species.



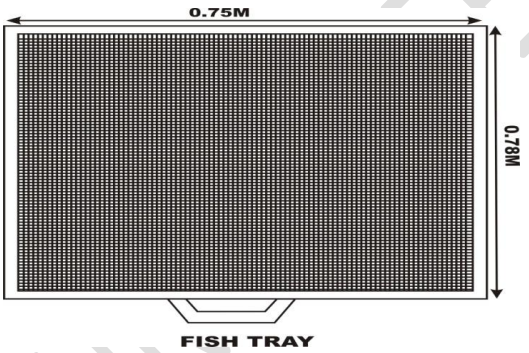


Figure 1: Oil Collector pan **Figure 2: Fish Tray**

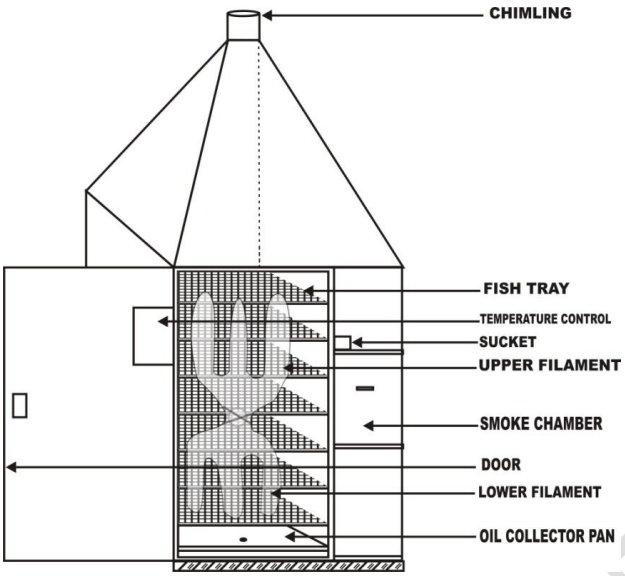


Figure 3: Schematic Diagram of Electric Fish Smoking Kiln

Plate 1: Kiln Wall under Construction

Plate 2: Electrical Fish Smoking Kiln Structure.

6.0 CONCLUSION

The materials used to construct the electric ~~fish smoking~~fish-smoking kiln to accommodate 70 – 80Kg were sourced locally. The construction design is simple and provided avenue for easy

maintenance and replacement of heating elements and further modification on the kiln. This kiln is simple to operate, cheap to maintain and the heat generated inside the smoking chamber is up to 350°C. The cost of the electric ~~fish smoking~~fish-smoking kiln is about #200,000.00k which would be profitable and reliable if all the necessary environmental factors are observed, to Kainji lake artisanal fish processor. Although there is wealth of theoretical and practical knowledge of fish kiln, this knowledge is applied irregularly or wrongly; designers and builders make avoidable mistakes owing to inadequate appreciation of local content (materials) to produce cheaper and highly efficient machineries.

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