Design and Fabrication of Simplified Barbecue Machine Using Indigenous Method of Grilled Food in Nigeria

V. E. Aideloje
H. A. Okwudibe
A. Z. Jimoh
A. I. Omoakhalen

ABSTRACT

The need to solve the problem associated with the traditional method of grilling food necessitated the design and fabrication of a barbecue machine, using locally sourced materials in Nigeria. Demand for barbecue food (meat, fish and vegetable) has been in the increase; and there is need to design modern equipment to achieve this purpose. The methodology centres on fuel analysis and design calculation from which dimensions and materials for construction are selected. Solid charcoal was chosen as the fuel for the barbecue machine. The barbecue machine is compact, does not produce smoke yield faster grilling process, and the process is hygienic. The barbecue machine has a maximum temperature of 3030c. The machine is tested using cat fish and the grilling is found to be excellent. The machine cost N 40, 000.00 to be produced.

Keywords: *Barbecue Machine, grilling, cat fish, charcoal fuel.*

INTRODUCTION

A barbecue machine is a metal frame on which meat, fish or vegetable are cooked outdoors over a fire (Gyansah 2012). There are several designs, with most falling into one of the different types which are the gas, charcoal or electric etc barbecue machines (Hale, Hale (Smoky), Lyon S. and Lyon B., 2000). The barbecue machine can also be called the grilling machine, sewing machine or the roasting machine (Ashaolu, 2014).

Grilling (as originally called) has existed in the Americas since pre – Colonial times (http://en.wikipedia.org/wiki/barbecuegrill). The Arawak people of South America roasted meat on a wooden structure called a barbecue Spanish (http://en.wikipedia.org/wiki/barbecuegrill). For centuries the term Baracoa referred to the wooden structure and not the act of grilling, but it was eventually modified to barbecue" (http://en.wikipedia.org/wiki/

V. E. Aideloje, H. A. Okwudibe, A. Z. Jimoh *and* ***A. I. Omoakhalen*** *are Lecturers in the Department of Mechanical Engineering Technology, Auchi Polytechnic, Auchi, Edo State, Nigeria. E-mail: vickycoker2014@gmail.com.*

ISSN: 2141-6745

barbecuegrill). It was also applied to the pit – style cooking technique now frequently used in South Eastern United State (http://en.wikipedia.org/wiki/barbecuegrill). Barbecue is a cooking method that uses dry heat where hot air envelops the food, cooking it evenly on all sides with temperature of a least 1500C (300 0F) from an open flame (http://en.wikipedia.org/wiki/roasting). Barbecue business is very common among the Hausas in Nigeria (Awa, 2015). According to them (the Hausas) it is a very profitable business if you have a good location. This business strives best at night in relaxation spots and busy streets (Awa, 2015). As many people go to these relaxation sports, some business conscious people stand at the corner to provide light meals such as barbecue (grilled) fish meat (Suya) or chicken to go down with the drinks (Awa, 2015). Aside from being located at around hospitality homes, these chefs could be found in busy malls and could be hired to serve in parties or any event (Awa, 2015). It has been a source of income to many people, according to them (the Hausas), it brings big money.

Despite the fact that barbecue business is a very profitable business in Nigeria, the barbecue equipment, which is the life wire of the business are still traditional, in most cases a wire mesh is placed on top of three stones with firewood lit under, or the wire mesh placed on top of a drum and heat supplied by setting fire wood inside the drum. These traditional methods have a lot of short comings, such as production of smoke, the method is unhygienic, heat loss is enormous and it takes a very longtime for grilling process. Hence, the need to solve the problem associated with the traditional method of grilled food necessitated the design and fabrication of a barbecue machine, using locally sourced materials in Nigeria.

METHOD

The methodology centres on fuel analysis and design calculation from which dimensions and materials for construction can be selected. Solid charcoal was chosen as the fuel for the barbecue machine because charcoal is cheap and readily available. Charcoal is a black substance that resembles coal and is used as a source of fuel (Kulla, Ebekpa and Sumaila, 2014). Characterization of fuel is important to search ways and means to optimize the energy consumption, fuel characterization concerns with the “analysis” and “energy content of fuel” (also known as calorific value (Gupta, 2011). Fuel analysis comprises of “proximate” and ultimate analysis, but in this case we were concerned only on proximate analysis.

In the proximate analysis, moisture (m) and Ash (A) content were

ISSN: 2141-6745

determined. Charcoal lumps were bought from Uchi market in Auchi, Edo State; Nigeria and used in carrying out the fuel characterization. A portion of the sample was grinded to a powdered form and was taken to the Department of Science Laboratory Technology of Auchi Polytechnic, Auchi Edo State Nigeria for all the analysis. Washed crucibles were oven dried at 105^0C for an hour to ensure total dryness. They were then transferred into the desiccator to cool for about 30 minutes. The weight of the crucible on the electronic balance was recorded as W_1. Ten grams of powdered charcoal was put into the crucible and the weight of crucible and content were oven dried at 105^0C for 4 hours samples were removed from the oven and dried until a constant weight was obtained. After dryings, the crucible was transferred into the desiccator to cool for about 45 minutes and weighed as W_3. The analysis was carried out in triplicate and the average value was recorded as the moisture content of the charcoal.

Calculations

$$\% \, moisture \, content = \frac{Loss \, in \, weight \, due \, to \, drying}{Weight \, of \, sample \, before \, drying} \qquad ....(1)$$

$$\% \, moisture \, content = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad ....(2)$$

Where

W_1 = Weight of empty crucible

W_2 = Weight of crucible + powdered charcoal before drying

W_3 = Weight of crucible + powdered charcoal after drying

M = % moisture content

% total solid = 100 - % moisture content ………………… (3)

Total solid is the part that is not water.

Table 1: Determination of moisture content for charcoal

Trial	Weight of empty crucible (g) W_1	Weight of crucible+sample (g) W_2	Weight of crucible+sample after drying (g) W_3	Weight of moisture (g)	Percentage weight of moisture (%)
1	22.70	32.70	32.45	0.025	2.5
2	22.70	32.70	32.50	0.02	2.0
3	22.70	32.70	32.51	0.019	1.90

Source: Researcher

The residue left after burning of fuel is known as ash (Gupta, 2011). To determine the percentage ash content, clean crucible was pre-dried in an

ISSN: 2141-6745

oven for 30 minutes at 100^{0}C to assume total dryness. It was then transferred into the desiccator to cool for 30 minutes and weighed on an electronic weighing balance as W_1. A sample of five kilogram of powdered charcoal was weighed into it as W_2. It was placed in a muffle furnace for 4 hours and the temperature was slowly increased to 450^{0}C to avoid incomplete ashing. Sample was ash until it becomes whitish in colour. It was removed and transferred into the desiccator with a tong and cooled to room temperature for an hour. The sample was reweighed as W_3. The percentage ash content was calculated as follows.

$$\% \, ash \, content = \frac{Weight \; of \; Ash}{Weight \; of \; sample \; after \; drying} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$$\% \, Ash \, content = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

% organic matter = 100 - %Ash .... (6)

Table 2: Determination of ash content of charcoal

Weight of empty crucible (g) W_1	Weight of crucible+sample (g) W_2	Weight of crucible+Ash (g) W_3	Ash content (g)	Percentage Ash content
22.72	27.72	22.88	0.032	3.2
22.72	27.72	22.93	0.42	4.2
22.72	27.72	22.96	0.048	4.8

Source: Researcher

To determine of energy content (calorific value) for the charcoal, Ten grams of powdered charcoal were inserted into a bomb calorimeter. The ten grams of charcoal were combusted at constant volume and the rise in temperature noted. The charcoal was placed into the bomb calorimeter which is connected to a light emitting diode and a gas chamber, the bomb calorimeter was switched on for about 45 minutes (by this time the sample energy have been completely exhausted). The energy value was indicated on a meter on a light emitting diode and the reading taken. The calorific value was found to be 0.23kJ/kgk. The modes of heat transfer in the barbecue machine are (1) conduction and (2) radiation.

The conductive mode of heat transfer is the heat transferred through the iron mesh and is calculated from fouriers relation as.

$$Q_c = KA\frac{T_2 - T_1}{L} \times 100 \quad \text{(Rajput, 2004)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

Where

Q_C = Heat transferred by conduction (w),

ISSN: 2141-6745

A = Area of mesh (M^2),
L = Length of mesh (m),

K = Thermal conductivity co–efficiency $\left(\frac{w}{mk}\right) = 59\left(\frac{w}{mk}\right)$

T_2 = Temperature of Hot charcoal (k)
T_1 = Temperature of surrounding (k)

The heat transferred by radiation is the heat transferred across the frustum of the cylinder and is given by Stefan Boltzmann law as:

$$Qrad = \sigma A\left(T_2^{\,4} - T_1^{\,4}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where

Qrad = heat transfer by radiation w,
A = Area of the frustum of the cylinder = (m^2),
T_2 = Temperature of hot charcoal (k),
T_1 = Temperature of surrounding (k)

But: Area of cylinder = $2\pi R(R + H)$ ……………………..…(9)

Areas of frustum of cylinder = $\frac{2\pi R(R + H)}{X} = \pi R(R + H)$ ……………. (10)

Where:

R = Radius of top/bottom of frustum of cylinder,
H = Height of frustum of cylinder

The Brazier

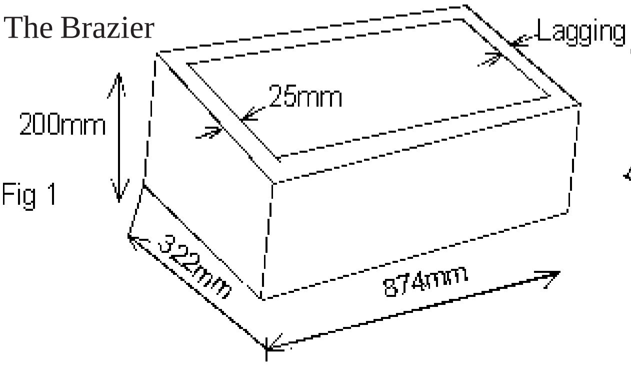

Fig 1

The Cover

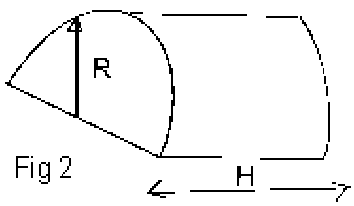

Fig 2

The Wire mesh

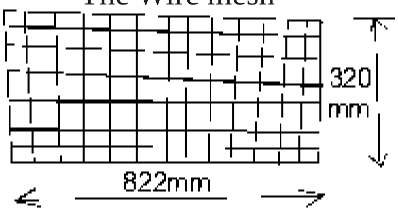

Fig 3

ISSN: 2141-6745