

PERFORMANCE EVALUATION OF DESIGNED AND FABRICATED DOMESTIC OVEN USING GAS AS A SOURCE OF ENERGY

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Abstract

This practical project is mainly on Performance evaluation of designed and fabricated domestic oven using gas as a source of energy. The oven was designed and was fabricated with housing frame which made up of mild steel and angle bar measuring 60mm by 60mm,. The gas burner was fixed in the stand for baking and the deflector plate placed in the bottom of the baking chamber and the bimetallic thermometer was fixed in the oven and provided with the vent for the removal of humid air. The oven was tested in order to determine its function the model works on natural convection. The oven can be adapted for both domestic and industrial purposes and have been found very useful in bakery industries. The effectiveness was analyzed by baking cake, cookies and muffins. Results showed that the cake was baked in 35 min at a temperature of 120°C it depends on the size of the cake showing higher energy efficiency by reducing the energy, cost and the time of baking.

Keywords: Performance, Evaluation, Design, Domestic, Oven, Domestic Oven, Gas, Energy

Introduction

A domestic oven using gas as a source of energy is mainly use for baking. Thus, a baking oven is the most widely used appliance in home and food service industry. Baking is the oldest and most popular food processing techniques that uses the prolonged dry heat by convection rather that the thermal radiation.. Therefore, an oven can be simply described as a fully enclosed thermally insulated chamber use for the heating, baking or drying of a substance. A gas oven is a domestic oven that is powered by gas. A gas oven is often topped with its own separate cooking unit that includes gas-powered burners. Gas ovens have become more versatile in recent years. When gas ovens were first introduced, they were very basic and did not come in a wide variety of models.

Nowadays, there are many types of oven that can be chosen, with two types of ignition system. Gas ovens are made out of ceramic or stainless steel. Stainless steel models are usually more expensive than ceramics (*Lea, 2017*). Convection oven is one of the more significant developments in commercial cooking equipment. It originated as a modified conventional or standard oven developed to overcome the problem of uneven heat distribution in the cooking cavity to provide more production capacity for a given size (*Sumaila, Alabi and Bamshima 2014*). The convection oven has naturally spawned a vast number of variations based on these attributes in terms of size, technology, capacity and type. Convection oven is also available in gas type model (*Damerow, 2015*). Forced convection gas oven can reduce the cook time significantly on long to cook items and also allow foods to be cooked in short period of time.

Gas uses the fans at the back of the oven to circulate the heated air around in the oven compartment, it distributing the heat more evenly throughout the oven than a regular oven (*Kulla, 2011*).

Gas convection ovens are available in single or multiple burners. Most of the gas convection ovens are indirectly fired and burners are usually located at the bottom of the oven cavity or between the cavity and also the insulated walls. In general, gas convection ovens offer more control over the cooking process than standard ovens. Gas oven has proven to be more efficient and effective than expected. Baking with gas gives a lot of advantages, particularly in this part of the world where electricity power supply is a problem (*Johannes, 2009*). The gas oven can be used both in the rural and urban settlement for small-scale business and also for domestic use. To solve domestic need, a small-scale oven, which can be used at home, is needed and to a large extent a small-scale business can actually emerge and help in providing extra money for the family (*Tong, & Lund, 1990*).

The gas oven is a combination between a gas and an oven in a single device. This provides the best of each device to the modern gastronomy. The gas oven is the perfect option to get the authentic grilling taste with perfect texture and juiciness. The oven is specially designed to cook meat and baking, but is equally appreciated in many different cook styles. It adds a variety of flavors, textures and aromas in all type of meats, vegetables, seafood, pasta and even desserts.

The rate of energy sources price increases every day, globally. To reduce consumer's burden, it becomes sufficiently important and necessary to develop an efficient domestic gas oven through heat transfer analysis and also to design the gas oven using most suitable heat insulation material with appropriate thickness. Research has been done from existing design of gas oven.

The findings can be described below:

- i. Insulation material that been used in the oven make a major changes interms of efficiency.

- ii. Design of the domestic gas oven, the heat insulation materials and their thickness are important criteria to increase the efficiency of gas oven.

Thus, in order to produce an efficient domestic gas oven with minimal trouble and high reliability, a more innovative and systematic development of gas oven is needed. The significance of this project is that in the future, companies that are manufacturing domestic gas oven would be able to refer to this project as a benchmark and will be able to design their own oven with the data that is founded from this project. Companies as well as tertiary institutions would be able to use this research to update the uncertainties when dealing with insulation material or heat transfer analysis and is capable to produce domestic gas oven with high efficiency.

Problem Statement

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- iii. Insulation material that been used in the oven make a major changes in terms of efficiency.
- iv. Design of the gas oven, the heat insulation materials and their thickness are important criteria to increase the efficiency of gas oven.

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Objectives of the project

The aim of this project is Performance evaluation of designed and fabricated domestic oven using gas as a source of energy. To achieve the aim of the project, the following objectives were employed:

1. To design and construct a portable gas oven for baking and drying other foods items.
2. To design and construct an oven that could enhance the working conditions of the bakery that were previously exposed to dangerous smoke and intense heat emission from the existing baking oven.
3. To design and construct a gas oven that could improve on existing baking oven.
4. To design and construct a gas oven that could reduce the baking time and better quality.

Material and Methods

The project started with the research to understand the basic principle of domestic gas oven. The research includes review of different types of oven and how the oven works. There many variation and basic concept in the domestic oven. The construction of a

modern mass production domestic gas oven is relatively very simple concept. The cooking compartment of domestic gas oven consist a pressed steel cavity which is wrapped the thermal insulation material, with a hinged door and a flue gas or a vent. In order to maintain the external surface temperatures as low as possible, the door is usually double glazed with an infrared reflective coating material applied to the inner part of the pane. The air temperature of the gas oven is usually regulated by thermostatic control of the gas supply to the burner.

Therefore, the method used here involves the engineering drawing of the oven, the principle of operation, the design calculation, the material selection and the cost estimate for the developed oven. The gas oven is made up of the following main components.

1. Housingframe
2. Bakingtray
3. Gasheatingtray
4. Bakingchamberdoor
5. Gasheatingchamberdoor

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 gas 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 hack saw and cutting disc (Rajput, 2004). 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 (Stephanel, 1997). See fig1.

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 fig1.

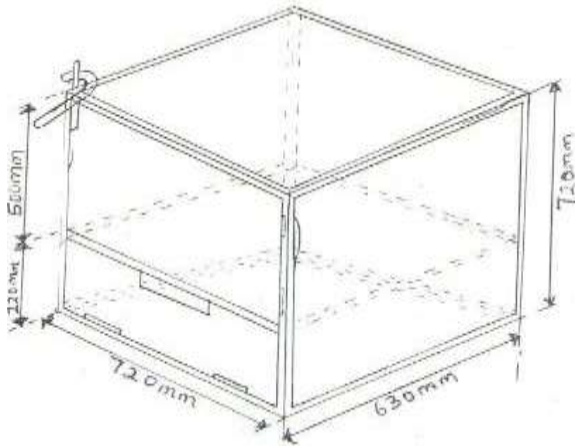


Fig1: Isometric View of a gas Baking Oven

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 (Ozilgen & Heil, 1994). The rods were measured with the aid of scribe 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.

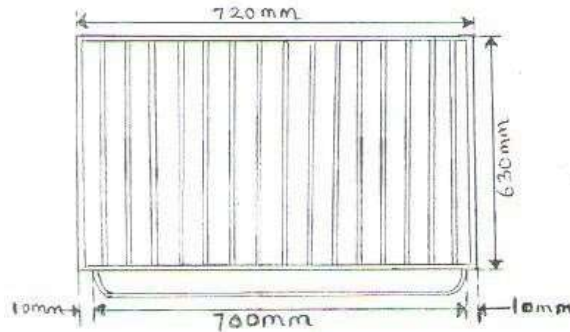


Fig2: Gas Baking Tray

4. Construction of Gas Heating Tray

The gas heating tray serves as a container for the gas within the gas heating unit or chamber located at the bottom part of the gas 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 scribe 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 (Rajput, 2004).. 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 (Fellows, 2000).

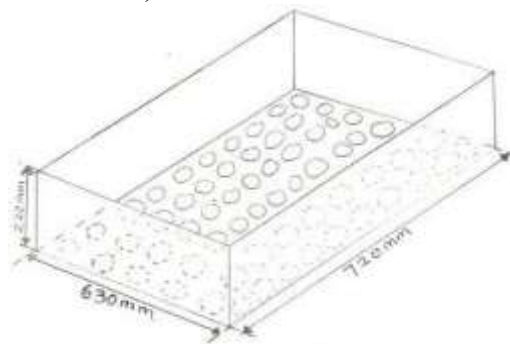


Fig3,2: Gas Heating Tray

5. Construction of Baking Chamber Door

The gas 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 there after measured with the aid of steel rule and scribe, Cut with a cutting disc and thereafter welded to the door frame with an are welding machine. See fig. 3.2.

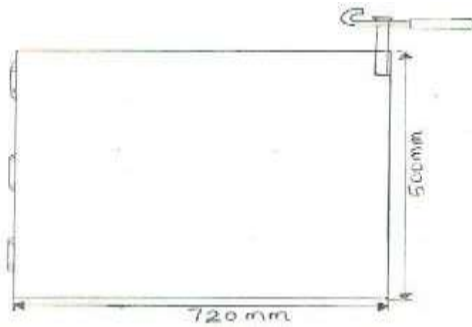


Fig3.3: Baking Chamber's Door

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. The gas heating chamber was thereafter fixed to the bottom part of the housing frame as shown in fig. 3.3. The three baking trays constructed were in turn positioned in the baking chamber one after the other.

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.



Fig. 3.4 Assembly View of the Gas oven

Principle of Operation

The major operational principle of the fabricated gas oven is the process of heat transfer. Heat transfer tends to occur whenever there is a temperature difference, and the ways in which heat may be transferred in the gas oven that is convection. Convection is the transfer of energy from one place to another by the motion of a mass of materials between the two points. Convection occurs when particles with a lot of

heat energy in a liquid or gas move and take the place of particles with less heat energy. Heat energy is transferred from hot places to cooler places by convection (Bitesize, 2014). Naturally, convection occurs when a solid surface is in contact with a fluid of different temperature from a surface. Density differences provide the force required to move the fluid (moisture) in the food. In the oven, the fluid involved is the enclosed air and the burner surface, which provides the solid surface, while the oven walls serve as the solid surfaces (Ray, 1999).

Usually this equipment has a gas inlet through which it is connected to a medium size gas cylinder via a regulator with low pressure flexible hose. The regulator of gas flow rate into the pipeline from the gas cylinder is turned open. With gas in the pipe line, the gas burner is activated by turning on the temperature knob after turned on from the gas cylinder. This creates a gap through which the gas rushes to the nozzle. The gas then passes through the nozzle after which the pressure drops with increased velocity. The low pressure high velocity gas then flows into the burner gas compartment together with the air (oxygen) from the opening created below the oven stand into a channel where it spreads out through the holes around the burner to glow inflame when lighted up by a lighter. The intensity of the heat generated from the flames depends on the amount of gas that is being burnt. The gas flow rate is altered or controlled by the continuous adjustment of the valve (gas knob). The pre – set of the gas regulator has made it possible to obtain a stoichiometric mixture with a constant flow at various level of gas flow rate. This continuous adjustment has therefore provided a wider limitation of range where by the equipment can be operated provided that the temperature gauges still accommodate such (Sumaila, Alabi & Bamshima 2014).

Performance Evaluation

The gas baking oven after fabricated was put to test in order to determine its functionality and the effectiveness through baking some food items like bread and. The ways in which heat may be transferred in the gas oven that is convection Different sizes of dough were baked to examine the effect of dough size on baking time. Figure 4.1 shows the result obtained.

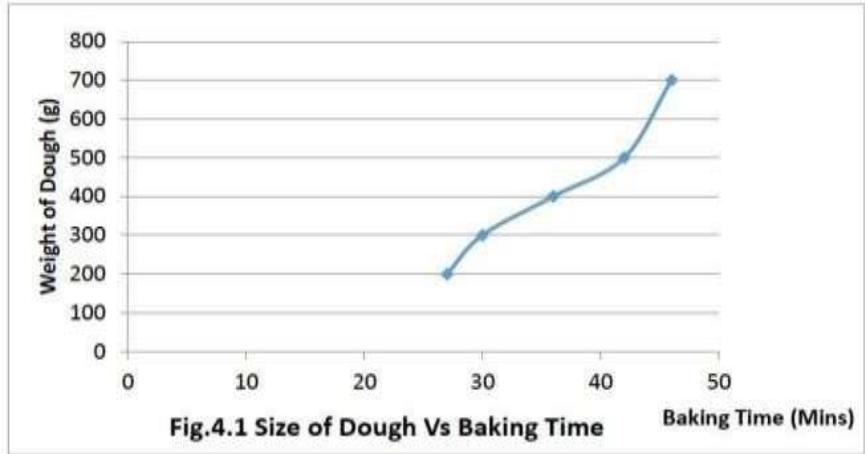


fig 3.5 Size of dough vs. Baking Time

Figure below shows the project methodology for the design of an efficient domestic gas oven:

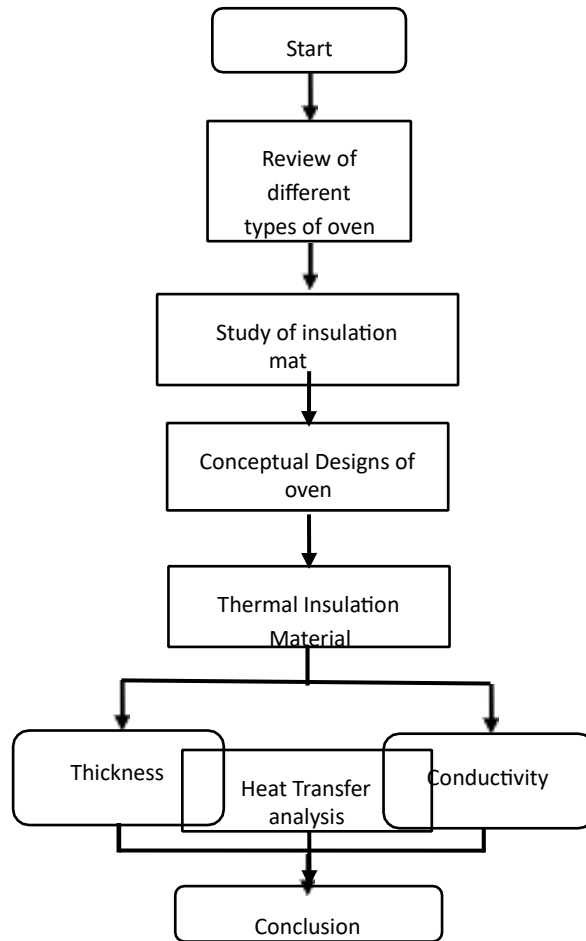


Figure 3.6 Project Methodology (Therdthai, Zhou. & Thomas, 2003).

Discussion

There is sharp increase in baking time as the weight of dough increases. This is quite understandable since as the dough size increases more time is needed for sensible heat to penetrate the dough. It is further expected that was less marginal increase in baking time as the size of dough increases beyond a certain point. Too much heat burns the dough whilst leaving the inside undone. In industrial (large) ovens, baking time can be improved to a large by introducing forced air to increase heat flux within the system. The high efficiency record of 90.7% can be attributed to the 20 per cent allowance for sensible heat transfer considered in the design.

The the fabrication of the designed oven was accomplished and performance of the oven was evaluated the following were deduced from the evaluation: The housing frame is made up of mild steel and angle bar measuring 60mm by 60mm. This system

was incorporated with thermometer for oven temperature measurement and lagged with fiber glass of 40 mm thick.

Average time for baking 300g of dough for bread was 35 minutes while for 400g average time was 37 minutes at temperature range of 170 – 180 degree Celsius. From the graph it shown that as the mass of dough increases, the baking time also increases. Concerning the meat; 1kg each of beef, chicken and fish were used to evaluate the fabricated gas oven at a monitored temperature of 120 degree Celsius. The average roasting time for the beef, chicken and the fish are: 50, 43 and 38 minutes respectively. This shows at same mass and constant temperature fish roasts faster than chicken while beef roasting rate is the slowest. The efficiency of the oven comparing the design baking temperature

Conclusion

The design and fabrication of the gas baking oven has been achieved successfully as well as the performance evaluation of the oven. The materials were carefully selected to meet the needs for their respective parts. The gas baking oven design was made as simple as possible and it had to be operated manually by a spark lighter to provide flames from the burner to the oven chamber. From this study it is evidently clear that the designed gas oven can be better used for the baking of cakes, cookies and all bakery products with good quality parameters like color, texture and taste with good volume for the fermented products and also with reduced preheating time of the gas oven. This in turn consumes much less energy and shortens the baking time, which reduces the overall working cost. This can be used for small entrepreneurs and can be popularized in areas where power cuts are more frequent and power is available only for limited hours. The design and construction of this project has been satisfactorily completed with the capability of providing high performance heat energy for effective baking. The design of the gas baking oven was produced with locally sourced raw materials in its totality, with the exception of bimetallic thermometer, sensor and knobs due to their scarcity.

However, we cannot claim that the gas baking oven is hundred percent efficient, since from the knowledge of thermodynamics, it is impossible for any heat transferring device to deliver heat with a 100% efficiency due to some heat losses. But the designers ensured that a good finish was given to the design and development of the equipment.

Recommendations

To improve the design of an efficient domestic gas oven, it recommended that the following methods should be used:

- i. Build a prototype of domestic gas oven based on this project analysis:** In order to prove that the analysis in this project can increase the efficiency of domestic gas oven, the prototype of domestic gas oven should be build to verify the truth of analysis.

- ii. Expect for mass production singular construction is relatively expensive to produce. Therefore, more fund should be released by the government for mass production of the gas oven
- iii. If precautions are not well carried out, it can result in fire hazard, which is dangerous to life and properties. Serious precaution use be taken when using the gas oven
- iv. Oils and moisture collected on metal surface can end up trying to rust the metal coating if not clean regularly, the product should be keep in cool and dried environment when not in used.
- v. Speed seem to be the key factor and time taken to get to required constant temperature can be wastage of time. Accurate temperature should be maintained in different areas of the baking oven.
- vi. It is also recommend that the use of the gas 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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