FOOD RESEARCH INSTITUTE

A CASE STUDY ON SOME EXISTING BREAD-BAKING OVENS IN ACCRA, GHANA.

by

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S U M M A R Y

A case study was done with the aim of producing a document on the designs, constructions, and other important features of existing bread baking ovens. This followed from an earlier recommendation by Anda, 1982, in a study on bread making in Ghana. This involved a survey in some baking zones of Accra during which some cases of ovens were selected and studied. In all 36 ovens were studied; 85% of which were locally designed and constructed.

The types of ovens found to be used are the wood-fired earth ovens, built with clay-mud in the form of any one of more of unformed mud, burnt bricks, sun-dried bricks and refractive bricks; the wood-fired metallic-brick oven with a metallic baking chamber and a separate burnt-brick fire chamber; the gas-fired brick oven with iron rod shelves; and the various models of metallic ovens which are fired with gas, sawdust, residual oil, electricity; or combinations of some of these.

The ovens are batch types with predominantly peel mode of operation. Limiting features include poor designing, poor (forms of) construction material s, absence of temperature control devices, poor heat distribution; poor insulation and heat retention, discomfort in operation and harmful health impact.

INTRODUCTION

The oven equipment of a bakery may well be considered as the pacesetter or "heart" of its operation. This is just because, it determines the output of the bakery in terms of units of products per hour of production, Anderson, 1970. Because of this, oven designers have always sought to produce the most efficient types of o ovens. In situation where ovens are not well designed and constructed, they tend to have low efficiencies. The consequences are high cost of production.

Naturally, baking exerts a tremendous impact on energy crisis world-wide. It is the single process with the highest energy demand, Tragardh et al, 1980. Owing to the very high adoption of bakery products for consumption for numerous reasons, including their high convenience and nutritional importance, the extent of baking has stressed this impact. Yet still, it is observed that further amounts of energy are consumed by the baking industry as the result of many processing factors. That is, these factors result in more than ideal quantities of energy being consumed during baking, Tragardh et al, 1980. They include the use of imperfect equipment. With the increasing demand for bakery products associated with population growth, increasing cost of production, and the increasing crisis on energy, it is pertinent that preventable wastages of energy are avoided, or minimised. This then calls for the use of better designed and better constructed cooking stoves and ovens, which are more efficient in fuel conversion and conservation; and also the appropriate handling of these equipment. With these, operational losses could be minimised and cost of production.

Already, many different types of ovens are in existence which have lower efficiencies. The improvement of these ovens are desired to cut down the cost of production, and minimise the impact of baking on energy crisis, Andah, 1982.

To be able to effect the improvement it is evident that studies of these existing ovens would be required, so as to identify the various deficiences in their designs. These would then give the functional objectives for research.

This report is on a case study on some existing bread baking ovens in Accra, Ghana. The objectives of the study were:

1. To collect information on the types, designs, construction, operations, maintenance and limitations of the existing commercial bread baking ovens in Accra.

2. To identify the various features that need improvement in these ovens; and

3. To produce a manual that will help in the development of new and appropriate baking ovens, suitable for the local baking industry.

2. LITERATURE REVIEW

2.1 Historical developments of baking ovens

Baking started somewhere around 9000 BC, with the production of primitive flat bread. These were baked by placing layers of viscous gruel of broken grains on hot stones, Stewart and Amerine, 1973; Encyclopaedia Americana; Encyclopaedia Britanica. With time, enclose baking utensils were developed. This made possible the production of thicker baked products. It could be imagined that the next stage from the hot stones was something built over these hot stones to trap the heat; Fance, 1966.

The first ovens were developed by the Egyptians. Earliest known models were cylindrical vessels made of baked clay, tapered at the top to give a cone shape, and divided inside by a horizontal shell-like portions. The lowest section was like fire box, the upper section the baking chamber. The pieces of dough were placed in the baking chamber through hole provided in the top. Remaines from Roman civilization also showed ovens consisting of a simple masonry chambers above fire boxes.

Around 2BC, professional bakers baked in beehive - shaped ovens built with mud and fired by wood. In the latter part of the 18th century, metal ovens appeared both in England and the United States, Encyclopaedia Americana. The first metal ovens were tin boxes for use in fire places.

Baking technology accelerated in the 19th century introducing automation of processes and the replacement of batch processing with continuous operation. There was also the introduction of heat regulation when fuels of gas and electricity became easily controllable. Such operations demanded specially designed and constructed ovens suitable for them; Encyclopaedia Britanica (Macropaedia).

In Ghana, the history and development of baking has not been very much documented. It is however, ascertained that bread and the art of baking were introduced in the country around 1529, by a changing, but nevertheless, an all bread eating series of European nations. The type of ovens used is not known but it is possible that the swish ovens made of mude or bricks, might have developed from a similar existing model.

2.2 Types of Bread Baking Ovens

Many types of baking ovens have been developed the world over. These have been described by many authors; Matz 1960 and 1970; Anderson, 1973, Slade 1971; Fance, 1966, Kudze, 1978. Generally, however, baking ovens can be classified into specific types on two basis, Brennan et al 1969: Firstly by their heating methods, and secondly by their designs. On the basis of the heating methods, two types are described; those indirectly heated by solid fuel, oil, gas, or electricity, and those directly heated by gas, air or electronically, Based on their design also, two broad types are recognised; the batch types and the continuous types. Examples of the batch types are the peel and the draw plate oven, and examples of the continuous types are the multicycle, and travelling ovens, (Fance, 1966; Matz 1960, 1963; Slade, 1971).

Fance, 1966, also classified ovens differently under two broad headings, internally heated and externally heated. The internally heated ovens were sub-divided into those burning solid fuels, where combustion takes plase within the baking chamber itself. In this category are wood or side flue ovens; side flue ovens adopted for gas or oil burning, and those where gas or electricity is used internally. With internally heated ovens in which solid or liquid fuel is burned within the baking chamber, baking cannot take place while the oven is firing. With gas or electric ovens or where the oven is externally heated, the oven remains clean, so that baking is continuous, that is, while firing is still taking place.

In the design and construction of a bread baking kilns for a continuous baking, Kudze rather described two general groups of ovens based on pathway of heat travel. They were updraught kilns and down draught kilns. On the updraught principle, the heat or flames are generated below and travel up the baking chamber. The flame tend to rush unimpeded through the firing chamber. The downdraught kiln might also be called circutous draft kiln. The circutous pathway serves to transmit more heat from the fuel to the wares and to the inside of the chamber and therefore less heat escapes from the chimney; it also enables an even distribution of heat through the oven. Most downdraught kilns require chimney to furnish sufficient draft or pull to draw gas downward. The hot gas or products of combustion travels upwards unless induced by a draft to do otherwise. The products of combustion leave the chamber at or below ground level where their heat can be more conveniently utilised. The hottest part of the flame strikes the top and is radiated or reflected to the floor. In a study on breadmaking in Ghana Andah, 1982, essentially and practically grouped baking ovens used in the Ghanaian breadmaking industry into two; the traditional baking ovens (swish ovens); and the multiple deck ovens. The design of these ovens are well described in a mimergraph report.

Based on these classifications, the commonly known types of ovens used in commercial bread baking are: the peel ovens (e.g. dome-shape swish oven, the side flue oven); the reel ovens, steam tube ovens, draw-plate ovens, hot-air ovens, Vienna ovens, electric ovens; and travelling ovens; the Chinese kilns, Japanese kilns and the Korean kilns; (Matz, 1960, Anderson, 1973; Slade, 1971; Fance, 1966; Kudze, 1978) and the electronic ovens.

* Kudze used the word kiln to describe ovens.

2.3 Designs of Specific Ovens

1. Side-flue Ovens

Built strongly of bricks, the side-flue oven consists of a baking chamber with a flue on one side and a furnace on the other in which the fire is burned. It is internally heated. Combustion takes place in the baking chamber itself, with the by-product escaping by way of the flue and up the chimney. The ovens have a damper built into the flue which is closed when firing is finished, so that the draught is stopped and no heat can escape by way of the chimney. This type of oven is not fitted with a thermometer so that the proper temperature is determined only by the eye and judgement of the experienced master baker. The embers from the firing are cleared out with the aid of scuffle or a rake when the temperature is considered to be appropriate before the baking commences. When the embers are removed, the oven is allowed to 'lie-down' for some time, about an hour, to ensure even distribution of heat, before the baking is commenced.

Firing a side-flue oven is simple. A draught is effected first of all by opening the ash-pit door, pulling out the damper and closing the steam escape trap over the oven stock; after this, the furnace bars are then cleared of ash and clinker. A fire is built up of e.g. paper, wood and coal. The furnace is reloaded a number of times, generally two more times at the start of baking when the furnace has burnt clear. Care in loading should be taken when using coal to ensure that combustion gases released from the roasting coal is ignited to avoid excessive smoke from the chimney. This is done by pushing sufficient white hot coal to the oven end of the furnace to act as ignition to the gases.

2. Reel Ovens

It comprises of a fabricated steel structure with polished metal cladding and trim. The baking chamber is steam-sealed and adequately insulated by mineral wool. A heat resisting glass panel is fitted to the balance door for observation of the oven interior, which is illuminated by special electric fittings.

The reel inside the oven is fitted with metal plates in which is placed bread or cakes, the whole rotating in a vertical plane around a horizontal axis taking two minutes to complete the full cycle. The number of plates depends on the size of the oven. Stopping and starting is electrically controlled by means of a push button.

The oven can be fired by gas, electricity, oil, or solid fuel; Firing is internal with gas and electricity and external when using oil or solid fuel. The gas-fired oven is fitted with an electronic flame failure control, an efficient safety device which ensures that the gas is cut off immediately should the flame be accidentally extinguished.

The oven is quickly heated and the heat is remarkably flexible; working temperatures being easily and quickly attained. The heating efficiency is high, particularly with the internally heated type, for heat losses are at a minimum.

The reel is chain-driven by an electric motor of low horse-power. All types of bread and cakes can be baked. Steam which is usually needed in large amounts can be injected for bread baking.

3. Travelling Ovens

These are automated continuous baking ovens. There are three main types, the swing tray, the tunnel or travelling plate oven, and the controlled tray oven.

The swing tray oven contains an endless chain on which cradle or trays are fixed, into which the bread is placed. The trays move upward and downward and around the oven chamber to complete a cycle. Thus they are loaded and unloaded at the same point. Example are the single-lap and double lap tray ovens. They are generally heated on the hot-air-principle i.e. hot air running through ducts, using as fuel either coke, oil, gas or electricity.

The tunnel ovens are generally of two types; direct heating type and indirect heating type with or without forced circulation of the oven atmosphere. Heating can be by oil, gas or electricity. There are three main conveyors for transferring materials through the baking chamber. These include steel band, grid and oven-mesh belt conveyors. All types are completely automatic in operation and are arranged for easy incorporation into automated production lines.

Indirect heating with natural convection tunnel oven

This comprises of a baking chamber of welded steel plate, insulated with glass wool and based upon a welded and bolted structure of sectional iron clad with polished stainless steel plates at the loading and un - loading ends, and polished aluminium plates around the oven sections. The combination of glass wool and polished stainless steel and aluminium reduce heat loss to a minimum. Stock is conveyed through the oven or a woven wire-mesh belt, the upper stand of which is supported by steel platting and the lower by rollers carried in ball beaming mounted on the based frame. The speed of the carrier is infinitely variable, drive being from an electric motor located under the belt at the loading end of the oven.

Radiator tubes are located in the baking chamber, at the top and also at the bottom, immediately beneath the steel plating supporting the upper top stand of the conveyor belt. These tubers are arranged in groups, one for each section, with delivery and return branch ducts. The return branches are fitted with adjustable dampers permitting the flow of hot gas to each separate section to be regulated by adjustment of a control lever placed on the exterior of the oven. The heat supply source, comprising a centrifugal fan or blower and an oil-fired heater assembly, is mounted on top of the oven at the loading end. Oven heat is supplied by the product of combustion, the gases passing through to another duct back to the heater assembly and admixture with fresh products of combustion, The radiator tubes beneath the top strand of the conveyor are similarly served, the gas flowing to the tubes through different ducts. The hottest gas thus enter the radiator tubes for top and bottom heating on opposite sides of the oven, providing for even heat distribution.

The heater assembly is based on two concentric steel tubes. and inner tube which forms the combustion chamber is lined with refractory brick and houses the oil burner. Spent gases from the heating system are forced by the recirculation fan through a duct into the annular space formed between the two steel tubes. They thus receive heat before being diverted by blades for intimate mixing with the hot combustion products at the outlet end of the combustion chamber; to provide the desired heat supply demanded by the oven temperature. This is controlled by varying the burner output automatically in accordance with pre-set temperature levels. Excess spent gases are vented to atmosphere through an outlet.

A steaming chamber is built into the oven to facilitate the steaming of loaves before baking. Steam is admitted into the chamber through steam pipes, in which are drilled a series of outlet holes.

The heating chamber is segmented into heat zones which can be accurately controlled. Loading is done at one end of the oven and the baked product is unloaded at the opposite end.

The tunnel oven is very simple in design and construction and its long flat hearth or grids gives unlimited flexibility with respect to different pan sizes. It requires the lowest ceiling height. It however, occupies more floor space than any other oven, and has proven difficult to adapt positive automatic unloading devices to it. It is the most expensive type of oven to purchase.

The controlled tray oven has the trays held in a horizontal position during their journey through the oven. This is important for confectionery such as tarts, custards and light sponge goods which would be distorted by a swinging motion.

4. Steam Tube Ovens

Built in 1851, the principle of heating is by an induced pressure on water surface which raises the boiling point and thus the temperature. This is done by a series of tough cold drawn steel tubes approximately 1 5/6 inches in diameter and with abore of about 15/16 inch. Each tube contains about 40% of internal volume of distilled water, and is hermetically sealed.

The tubes, evenly spaced, are placed in rows, one row under the sole and the other just under the crown of the oven. The tubes are tilted back a little so that the lower end are in the furnace. When the fire is lighted or the heat supplied, the heat is conducted through the metal of the tube to the water. Convection currents are set up and the water soon boils at 212°F. The steam from the boiling water cannot escape and the pressure on the surface increases; this raises the boiling-point still further.

As the heat is still being applied it continues to boil at a higher temperature. Eventually the pressure becomes so great that the water boils at 500°F and over. This heat is radiated into the oven and is recorded on the thermometer. The heat is almost the same along the whole length of the tube, even though the heat is applied at the furance end.

Generally the tube ends extend the whole length of the furnace at the back of the oven. In some ovens the tube ends are bent to fit compactly into a smaller furance, resulting in a more evenly heated oven and a greater fuel efficiency.

Firing

If coke is used, the fire is lighted on the bottom row of tube with the ash-pit doors and the dampers opened initially until the fire begins to burn red, when the ash-pit doors are closed and the damper partly pushed in. It is important that the fire be free of accumulated clinker at all times. This will cling to the tubes and act as a barrier to the conduction of heat from the fire to the tubes.

Advantages

1. Continuous baking, hour after hour
2. Clean
3. No fumes in bakery
4. No fuel or ash in the bakery
5. Can be used with eight coke, gas, or oil as a fuel

Disadvantages

1. Higher capital outlay
2. There is a danger of burst tubes when under inefficient control. When the temperature of the tube is 250^{o}F there is a pressure within the tubes of 15lbs, at 400^{o}F it is 235lb and at 500^{o}F it is about 700lb. This potrays how serious a burst tube can be.
3. Regular examination is necessary
4. Time is needed in raising or lowering the temperature.

Whether the ovens are coke, gas or oil fired, the flues and tubes must be kept clean or the efficiency of the oven is lowered. Cleaning is even more important with coke fired ovens because of dust which soon accumulates on the upper rows of tubes and in the flues. The best practice is to clean at regular intervals, for instance, once a week.

5. Drawplate Ovens

These ovens are externally heated, usually by steam tube fired by coke, gas or oil. This type of oven was designed to speed up oven loading and unloading. This speeding up is effected by drawing the plate or oven sole (hearth) out into the bakery, hence the name. In this manner the baked bread is quickly pushed on to metal lined tables and wheeled away. In a similar manner the unbaked bread is wheeled to the plate.in provers and the oven quickly loaded. All bread, whether tin or baked on the oven hearth is placed on "setters" the width of the oven, these are placed into the provers. It is then a simple matter for two men, one on either side of the oven to tilt the setter, so that oven loading takes place a row at a time.

The plate rests on a wheeled carriage. The wheels, which are grooved, fit into metal runners fitted flush with the floor. The plates are easily pulled out and pushed in, passage being effected by counter-weighted doors which are easily manipulated. Single or double-deck ovens are installed if desired or even a single-deck drawplace with a peel oven on top.

6. Hot-air Ovens

These ovens are externally heated, burning gas, oil or solid fuel. The principle of heating is by hot convection currents which circulate in flues and duct between the baking chambers. There is very little flue 'pull' so that hot air circulates slowly.

The newer types, heated by gas, have the burners at the bottom of the oven; they are therefore much more compact and take up less room. In addition there is a greater heat efficiency, for the hot air on cooling is returned and released at a lower level, not as in the older system, at the top before the heat is fully exhausted. There is no flue pull, only the movement of convection currents from the burners round the oven and back to the low level flue. The new ovens of this type are heavily insulated with mineral wool. Hot air ovens are clean in operation, baking can be fairly continuous, and they are safe.

7. Electric Ovens

The electric oven is handy, efficient, easy to handle and maintain, clean and hygienic and has excellent baking qualities. It is practically steam tight, reducing evaporation in baked goods to a minimum. The oven is heated by element enclosed within metal tubes placed in rows in a similar manner to those in a steam tube oven. The oven is insulated against heat loss by radiation. Most of them have tilted soles, are portable and of the peel type, although larger units are also in use.

8. Vienna Ovens

These are used to bake Vienna bread which must be baked in a saturated atmosphere. It is built on a different principle from the other ovens. This is based on the fact that steam is lighter than air and it therefore rises.

The oven sole slopes upward and is in two sections, the first at a more accute angle than the second. This first section is merely to give better access to the baking sole (herewith) on which the bread is placed. The beginning of the baking sole is approximately at the same level as the bottom of the opened oven door, so that all injected steam is trapped within the baking chamber.

There is a flue at the upper end of the baking chamber, in which a damper operated from the front of the oven can be opened towards the end of baking time to allow for the escape of steam. In this way the bread and rolls can finish baking in a dry heat, giving the crisp, dry crust, characteristic of well made vienna bread.

9. <u>The Swish Oven</u>

This is a typical example of the peel oven. It is believed to have been introduced in the country on the introduction of the art of baking; Youngs, 1972.

Essentially it consists of a baking chamber built of bricks of varying types, of mud; with an opening at one face which serve as the mouth for firing, loading and unloading. It also serve as the stack. In its present state, the chamber is normally built on a platform which the experienced builders design to retain high amount of heat for baking, by packing materials like cement blocks, salt and pieces of broken glass to form part of the hearth. Various shapes of this oven have evolved; plates 1 - 6.

Its principle of operation is based on that of the peel oven and it is wood fired, Andah, 1982.

Details on its design and construction are fully described by Kudze, 1978; Capbell Platt, 1979; Opoku, 1984; Biney, 1976 and Armah Jnr. 1980.

2.4 MAINTENANCE OF OVENS

The basic importance of the oven in a bakery has urged oven designers to always aim at making it a reliable piece of equipment, requiring a minimum of maintenance. Anderson, 1970. The fact that ovens will often operate far beyond their normal useful life expectancy of around twenty years is evidence of their rugged, well executed construction. Knowing how an oven is designed, how it is to be operated, which critical points on it require frequent checking and maintenance, along with a good and regular lubrication schedule, will pay important dividends in uninterrupted baking schedules and longevity of equipment.

Anderson, 1970, have described how and why the various parts of the oven should be checked for maintenance, He has also provided a guide for scheduled oven maintenance; using the single-lap direct gas-fired tray oven as an example.

Johnson, 1968, has also described the steps to be followed in oven maintenance or repairs. In his work: improving oven efficiency, he noted that an oven with a record of frequent breakdown is an inefficient one. To prevent such production stoppings, he suggested that a sound preventive maintenance programme should be initiated. A check sheet should be drawn up by a qualified maintenance engineer listing all potential trouble areas for periodic inspections. Further, a record of an oven's preventive maintenance checks should be maintained, following lubrication schedules recommended by the manufacturer. List the date of breakdowns and their causes, and the work or parts installed in the oven.

Johnson further explained that by careful study of these records, certain trends may show up that can be acted upon before breakdown occur. For instance, if it is noted that a certain part fails after a year's service, this part should be scheduled to be changed on a regular basis, and thereby minimize the reoccurance of failure during production. Complete records also can be used to determine what spare parts should be carried on hand.

It is observed that the swish oven is maintained by patching and polishing the cracks on the bodies which generally occur as a result of heating with specially prepared sand and clay mixture, Campbell-platt 1978. The whole body surface of the oven is also regularly glaced with the specially prepared clay mixture. The frequency of this exercise however, depends on the baker; the materials for construction, how well the oven was constructed; and the housing of the oven.

Generally, the following essential points should be observed when using an oven, for higher efficiency (Fance, 1966).

A) Oven fired with solid fuel

1. Understand the construction and the working of the oven. In this may a greater measure of control can be gained.
2. Understand the nature of the fuel that is being used.
3. Keep the fire fans clear so that a plentiful supply of air is available for complete combustion. The flues must be cleaned out regularly so that there is sufficient draught. With adequate supply of air, clinke formation is less and the amount of residual ash is reduced.
4. Plan and give time for obtaining the desired ash is reduced.
5. Replace as soon as possible all burned fire bars and furnace fittings. Failure to do this may result in all the bars buckling and all metal fittings deteriorating, so that all will need replacing.

6. Take care in regulating the draught or the maximum calorific value of the fuel will not be obtained.

7. The quickest way to cool an oven is to close the ash-pit doors, open the damper and the furnace doors. In this way cool air is drawn into the furnace and not through the fire.

8. Study at all times the recommendations of the maker, their advice is always available.

B) Gas Fired

Many of the points emphasized for solid fuel ovens are equally applicable. In addition.

1. Keep a careful check on the air supply, avoiding excessive draught.

2. Burners, jets, valves, etc, must be frequently inspected, kept clean and in efficient working order.

3. All burners should correctly adjusted to maintain heating efficiency.

C) Oil Fired

1. The flame should be inspected at short and regular intervals. A smokeless flame indicates heating efficiency. Smoke shows an excess of oil in the mixture, while the presence of flying sparks indicates an excess of air.

2. Keep all burners clean and properly adjusted.

D) Electricity

1. Have internal elements checked regularly by a competent electrician to ensure maximum safety and efficiency.

2. Pay attention to the use of the switches controlling top and bottom heat for the maintenance of even heating and economic fuel consumption.

It ought to be noted that, the efficiency of an oven or of the fuel depends on correct firing and oven maintenance. These in addition to the inteligent use of the oven will determine the economic efficiency of the oven; Fance, 1966.

2.5 PREVIOUS WORKS ON BAKING OVENS IN GHANA

Research works towards improvement of existing baking ovens and the development of new types have been very little in this country. This may be ascertained from the fact that several hundreds of years after the introduction of the art of bread baking, the swish oven is still the most predominant baking oven in the country. It is observed that, the bakery industry in the country do not have bakery engineers who could have taken the challenges to come out with suitable designs or models. Generally, therefore designing and construction of these ovens have been left to artisans who do not have much knowledge in basic engineering.

A few attempts have however, been made. Campbell-platt, 1979, worked to improve the traditional swish oven. Kudze, 1978, Biney, 1976: and Opoku, 1984 also individually worked to develop new types of ovens suitable for bread.

There seem to have been other works which have not been documented. Currently for instance, better designed ovens are being built which incorporate features like, foundation, chimney ash pits pyrometer, and insulating materials (metal ovens. These features were not in original designs.

With the rate of growth of the bakery industry the increasing cost of bread production, and the impact of baking on the energy crisis in the country however, there is a need for more comprehensive works to update the oven equipment. This should aim at designing and constructing oven equipments which would be more suitable for the local bakery industry more efficient, and economical in terms of fuel use, more safer to use, and more adaptable to modern bakery technology. It should also contribute to meeting demand of bakery products.

3. METHODOLOGY

3.1 Organisation of Study

The survey was carried out with a sturctured questionnaire designed to provide some general information about each bakery and technical information on the ovens. It was pretested in a few bakeries and then reviewed before its implementation.

3.2 Selection of Oven Cases (Sampling)

Thirty-six (36) ovens were randomly selected from 28 bakeries visited in various parts of Accra and its surrounding areas. These areas included Labone, Cantoments, Osu, Kanda, East Legon, Legon, Madina, Kaneshie, Laterbioker shie, Mataheko, Abeka and Dansoman.

Selection of cases were based on uniqueness of design, construction and source of energy. As many different ovens as possible within the project resources were selected for study. The bakeries were identified by their advertising posts, their popularity and with the help of previously visited bakers.

3.3 Data Collection

The questionnaire were filled by the researchers, except in one case. Questions were generally interpreted into the local language, at times with the help of an interpretor. The answers were then recorded in English, going through may be, another interpretation.

A plastic rule, 30cms in length and a metre tape, were used to take dimensions of ovens. Photographs of various models of ovens were taken for illustrations.

4. F I N D I N G S

4.1 General Information About the Bakeries

4.1.1. Ownership of Bakeries

About eighty-nine per cent of bakeries studied are privately owned by individuals, most of whom (about eighty-two per cent) are females between the ages of 26 and 73 years. About sixty-four per cent of these women are of fifty years.

At least twenty-five per cent of the owners have had no formal education; table 1 and 2.

Table I: Age Distribution of Bakers

Age (Years)	Frequency
≤ 30	1
31 - 40	0
41 - 50	9
51 - 60	6
61	6
Not available/Not applicable.*	6
	28

*Refers to the institutionalised bakeries.

Table 2: Formal Educational Levels Attained by Bakers

Level	Frequency	Percentage
None	7	25
Primary (up to standard 7)	7	25
Secondary/Training College	5	17.9
Diploma (in Hotel Management)	1	3.5
Not available/not applicable	8	28.6
	28	100.00

4.1.2. Oven designing and Fabrication

About eighty-five percent of the ovens studied are constructed locally. There are artisans responsible for the constructions. These people, it was revealed in the study, acquire their expertise through experiences as apprentices. The mud ovens are designed and constructed by masons whilst the metal ovens are constructed by mechanics.

4.2 Classification of Ovens

Many different types of ovens are being used in the country. These can be broadly classified by:

- the source of fuel used
- the major construction materials; and
- the mode of operation (loading and unloading).

In practice however, all the three critena need to be used, to describe any particular oven.

4.2.1. Classifiøation by major materials for Construction

This criterion provides the broadest classification. Th broad classes may be described based on the observation of the survey, table 3a.

1. the clay mud ovens; the mud being in the forms of sundried bricks, burnt bricks, refractive bricks and mould (unformed mud). The refractive bricks are imported and usually purchased as rejects from industrial kilns.
2. the metallic ovens; predominantly built with steel plates and iron rods.
3. the metallic - brick ovens. Two models of this are observed; a model of a metallic multiple deck baking chamber with a brick firing chamber attached to its back; and another of a brick baking chamber with iron-rod shelves and steel plate door.

Table 3(a) Materials for Construction of Ovens

Material	No. of Ovens	Percentage
Metal (steel)	17	47.2
Clay Mud:		
Unformed mud	2	5.6
Sun-dried bricks	1	2½8
Burnt bricks (solid and hollow)	11	30.5
Metal - Bricks	2	5.6
Total	36	100

4.2.2. Classification by the source of energy

By the source of energy used in firing, the ovens would be classified as wood-fired, gas, oil - fired, electric and ~~saw dust~~ ovens. A few also combine or use alternatively two sources, as in the gas/electric, electric/oil, and the charcoal/gas ovens.

Fuel wood is the predominant fuel source, used in a little oven 47% of ovens studied. 25% of ovens used liquified petroleum gas (LPG), (they are the gas ovens); and 8% electricity (electric ovens).

Table 3(b): Source of Energy Used for Heating

Energy Source	No. of Ovens	Percent
Wood fuel	17	47.2
LPG*	9	25
Electricity	3	8.3
Residuel oil	2	5.6
Sawdust	1	2.8
Charcoal	(1)	(2.8)
Electricity/Oil	1	2.8
Electricity/Gas	3	8.8
Total	36	100

*In one case encountered, red hot charcoal in coalpots is source of heat in the absence of LPG.

4.3.3 Classification by methods of loading and unloading

Invariably all the ovens are batch types. Predominantly most of them are peel ovens; with a few of drawplate and reel ovens There are yet others which work similarly on the peel principle but due to the dimensions of the ovens do not employ the use of peels. They are easily loaded by hands which could reach the rear of the ovens. These ovens may be described as "semi-peel" ovens.

Table 3(c) provides information on the numbers observed.

Table 3(c): Method of loading and unloading

Method	No.	%
Peel	17	47.22
Draw Plate	2	5.56
Reel	1	2.78
Semi-peel	16	44.44
	36	100.00

4.2.4 Shapes, dimensions and Capacities of Ovens

The shapes, dimensions and capacities of the ovens vary. Generally, the metallic ovens are rectangular in shape and the clay mud ovens are dome. Some of the latter are however, pyramidal or rectangular; table 4; plates 1 - 3. Table 5 shows some peripheral dimensions, and the capacities of some of the ovens studied. Whilst the dome shaped clay-mud ovens measured more in basal diameters than in heights, there seem not to be any regular pattern with the metallic ovens. It could be higher than broader or vice versa; but generally shallow in width. It appears also that generally despite the larger spaces occupied by the clay mud ovens, the metallic ovens possessed relatively higher capacities than them.

Table 4: Shapes of Ovens

Shape	No. Observed	%
Dome	11	30.6
Rectangular	22	61.1
Pyramidal	3	8.3
Total	36	100.0

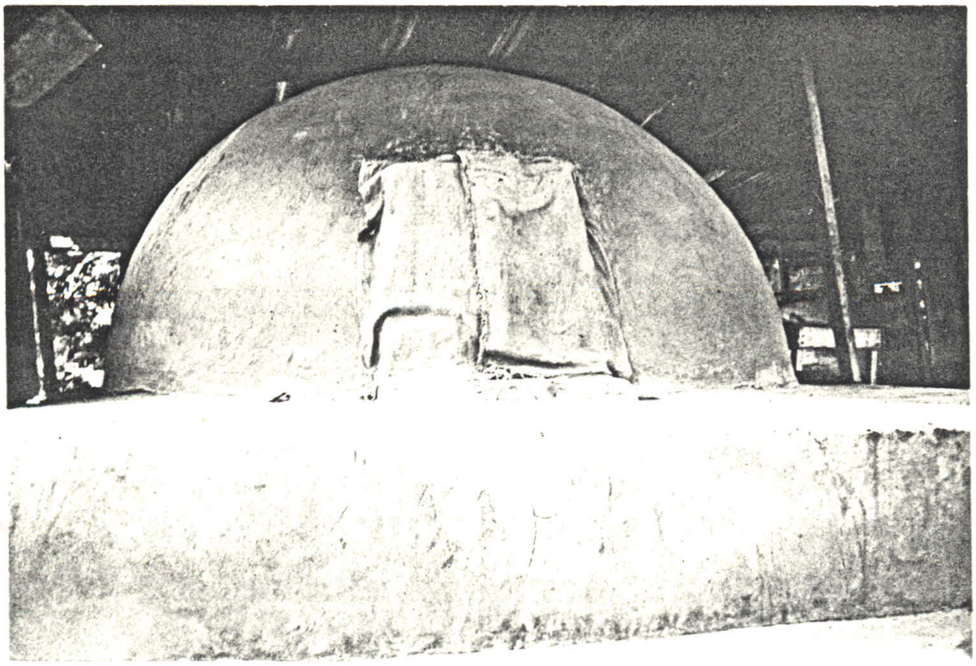

PLATE 1: A model of the clay-mud oven. Note the dome-shape, the foundation (type 2) and the cloth-sealed mouth.

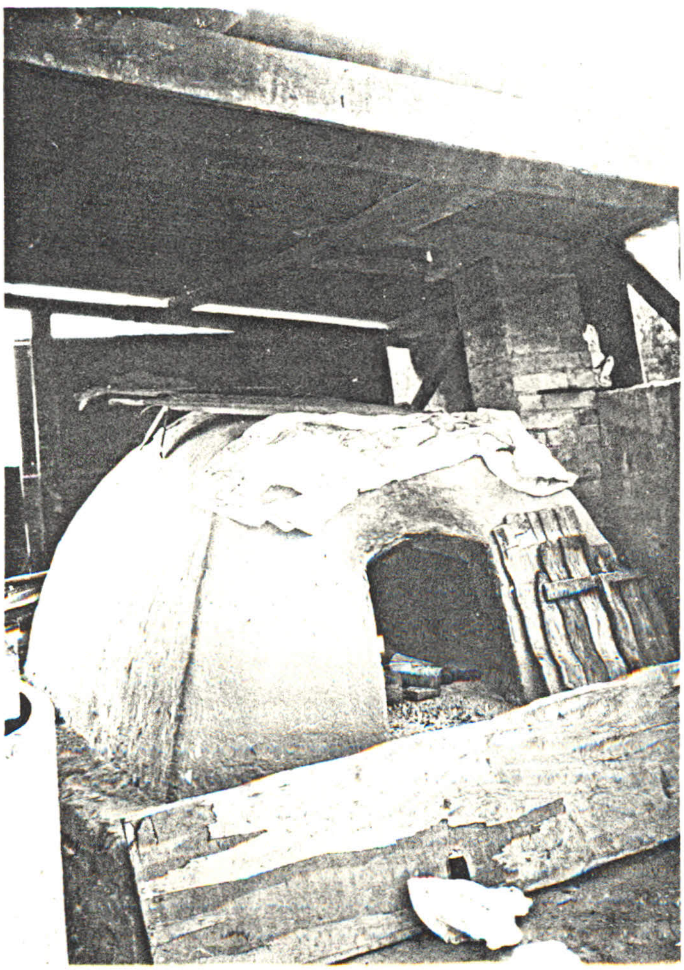

PLATE 2: A model of a clay-mud oven, provided with a chimney

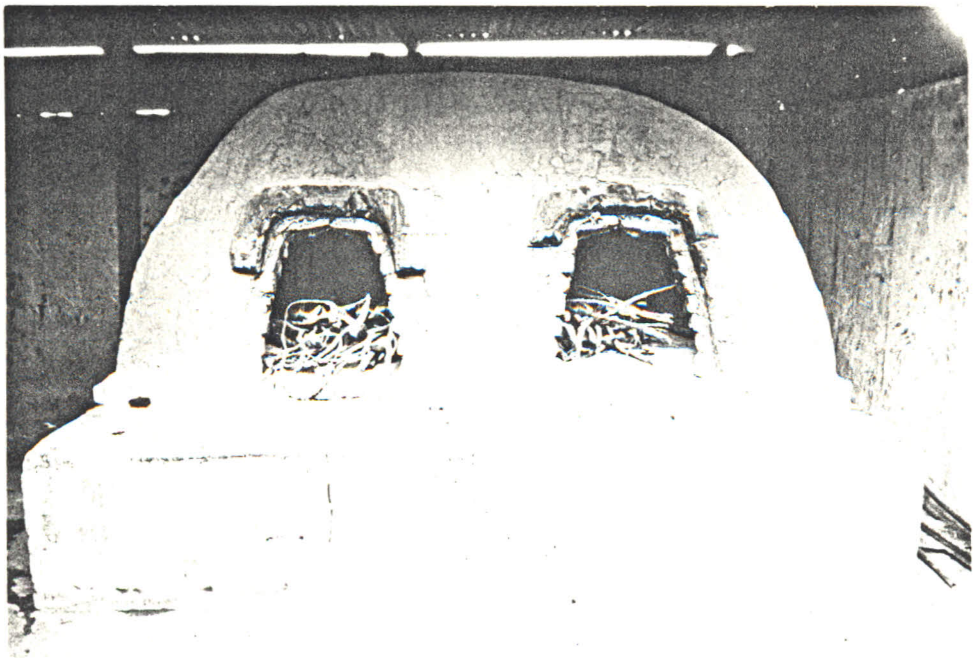

PLATE 3: A model of the clay-mud oven with two entrance the foundation is similar to that of plate I.

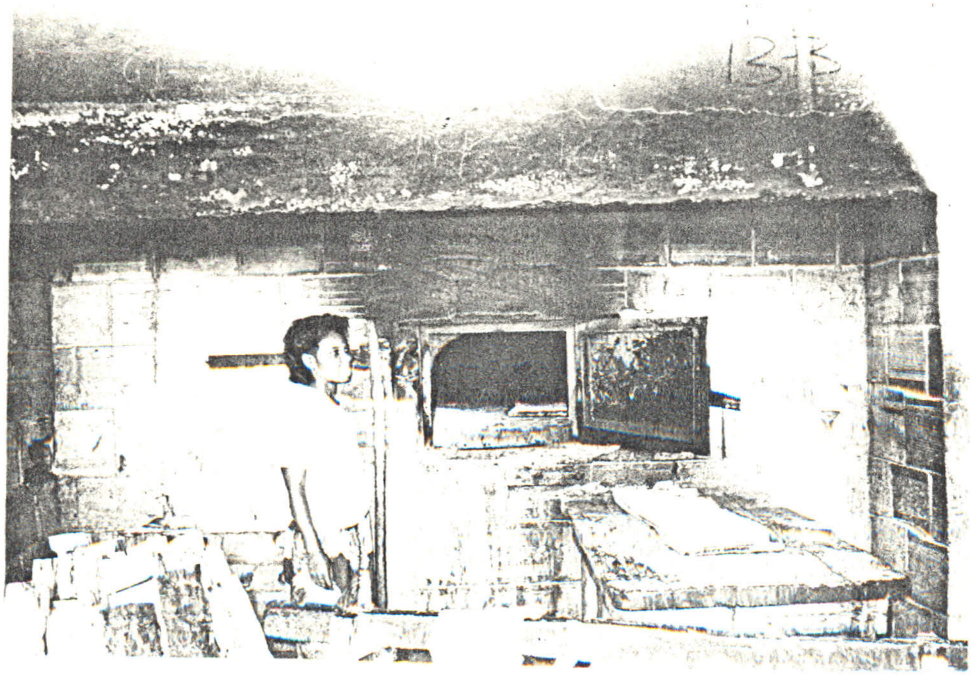

PLATE 4 : A model of the clay-mud oven note the height of the foundation and the continuity of the oven wall with the foundation.

Table 5 Dimensions and Capacities of some Ovens

Shape of Oven	Material used for its construction	Height	Dimensions (metres) Width/basal Diameter	Length	Capacity (Bags of flour baked at a batch) as given by owner on oven
Rectangular	Earth	1.2	2.3	2.8	2/3
"	Metal Earth	1.95	1.8	3.45	2
"	"	1.5	1.25	4.5	-
"	Metal	1.75	1.65	2.05	1½
"	"	1.2	0.9	1.5	½
"	"	1.3	0.6	1.10	½
"	"	1.8	1.05	2.4	-
"	"	1.5	1.10	1.05	-
"	"	1.82	1.15	1.17	1¼
"	"	1.6	1.10	1.60	¾
"	"	1.5	1.2	2.3	-
"	"	1.2	0.8	1.35	-
"	"	-	-	-	2
"	"	-	-	-	3-5
"	"	-	-	-	2
Dome	Earth	0.8	2.1	-	½
"	"	1.2	2.3	-	-
"	"	1.2	1.5	-	⅔
"	"	1.8	3.0	-	-
"	"	1.2	2.1	-	⅔
"	"	1.2	2.4	-	-

4.3 Types of Ovens

An oven may not fall strictly under any one of the classes described. A wood-fired oven can be clay-mud oven or a metal oven, and a peel or a draw plate. Based on the observations of the survey, the types of ovens that are used may be described as:

1. The wood-fired peel clay mud ovens.
2. The wood-fired peel metal brick ovens
3. The gas-fired brick "semi-peel oven with metal shelves.
4. The various models of metallic ovens, which are fired with either gas (LPG) residual oil, saw dust, electricity, charcoal, or combinations of some of them. They are all semi-peel types.

4.3.1 The Wood-fired peel mud ovens

These constituted about 50% of the ovens studied; table 3(b) They consist of chambers constructed of mud and clayey materials. The form of the materials may vary from one oven to another. It may be/mud, sun-dried bricks, burnt bricks or refractive bricks./unframed

Many different shapes of the ovens are found. Generally however, they are dome shaped; table 4, plates 1-3. Individual ovens also vary in dimensions. However, generally, the basal diameters of the dome measure more than the heights (where rectangular, the lengths measure more than both the widths and the heights and where pyamidal the lengths and widths measure similarly, and more than the heights). Table 8 illustrates the dimensions of some of the ovens. Diameters recorded ranged from 1.5 to 3.0 metres, and heights 0.8 to 2 metres.

Some of them are provided with chimney; table 6. In response to the usefulness of the chimney, some respondents indicated that the chimney directs smoke away from the oven chamber and also is used to regulate the heat of the oven. It is however known that it also provides a draught for heat circulation in the oven chamber; Kudze, 1978.

The chambers are provided with small entrances, circular or retangular in shapes, through which the pieces of firewood are loaded in the chamber. These entrances, during baking, are closed with doors which may be completely detached or hinged to a frame at the wall. The doors are made "airtight" by some bakers by covering it with wet jute sacks, during baking, plate 1.

Majority of the ovens are built on raisdd foundations. These according to the bakers aid in the following ways:

1. They prevent the bakers from bending excessively in order to reach the inside of the chambers.
2. They are specially constructed to retain heat for the baking.
3. They prevent seeping of water into the hearth when there are run-offs of water.

The raised foundations project the ovens baking chambers some centimetres above the ground level. The heights vary from 10cms to about one metre.

Some of them are provided with two entrances which maybe adjacently or oppositely placed (see plates 3). The additional entrances are said either to aid loading and unloading, or are equipped with ash pits to be used as entrances for firing.

4.3.1.1. Construction

(a) Foundation

A foundation is the first to be constructed. The construction is differently done, depending on the specification of the owner of the oven, the experience of the builder; and the materials to be used for construction. Materials noted to be used are sand, salt, mud, broken cement blocks, cement, and bricks (any of the types) Campbell-Platt also mentioned broken bottles. Two or more of these materials may be combined in one foundation. The general procedure involved are described below:

They are broadly grouped into three.

1. Sand, mud, stones or broken blocks are heaped at the base for the oven. These are trampled down to be very firm. More additions are made and pressed similarly until the desired height is attained. The edges of the platform may be shaped with pieces of blocks or big stones plate 5.

2. A concrete wall of cement blocks is constructed along a marked area. This may be rectangular or circular,. Generally this area is slightly bigger than the actual base of the oven. The wall is constructed to a desired height. It is then filled in layers with stones or broken blocks, sand or salt and then a single layer of bricks. The brick layer would be in level with the wall. It would form the hearth of the oven. Plate 1 shows this type of foundation. The wall is plastered with cement - sand mixture.

3. Foundations of this type always have rectanuglar bases. A concrete wall of cement blocks is constructed along a marked rectangular base to a height of about 70 to 90cms. Within this wall is marked the actual base of the oven which is circular. Along the circular mark another wall is constructed to the same height of outer wall. The space between the two walls are filled with stones and mortar to the levels of the walls. The base of the circular wall is also filled, in layers, with stones and sand, large quantity of salt and a single layer of bricks (the type used for the chamber construction). The brick layer which forms the hearth is at level with the outer layers. Plate 4.

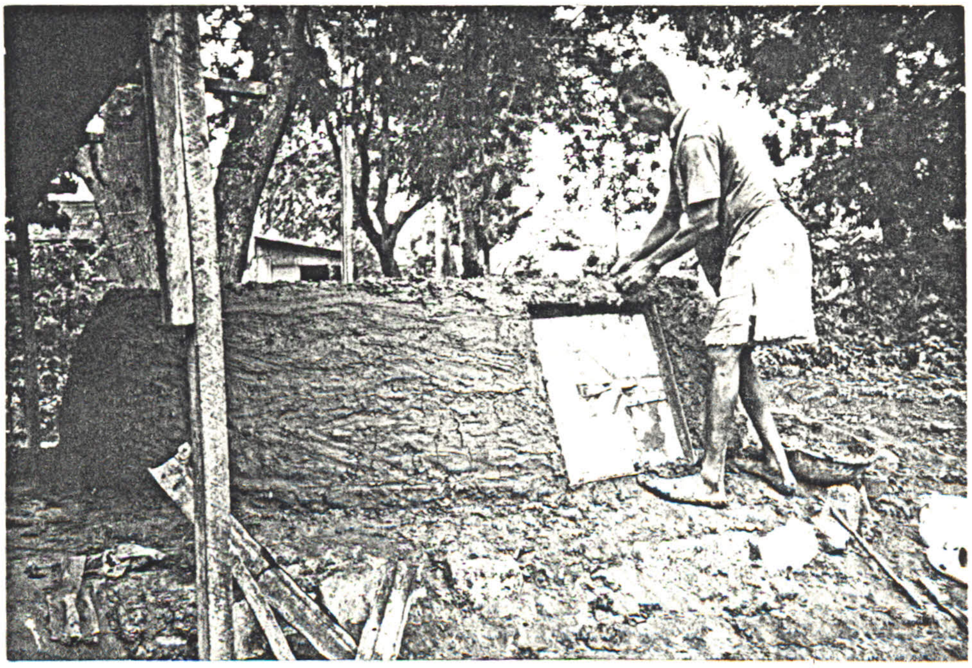

PLATE 5: A clay-mud oven under construction. It illustrates the type of foundation described in type 1 of the text. Note also the inward curving of the walls to form the dome.

PLATE 6: A clay-mud oven which has no shelter. The oven has suffered severely from rains and wind abrasions. There is no foundation.

(b) The Chamber

The chamber is constructed by building along the perimeter of the circular base or a marked base on the foundation, the sides of the oven, The bricks are laid singly and then fixed with clay mud along the perimeter, and layer after layer. A gap is left for the doorway. This is fitted with a frame, which may be a ring (circular) or rectangular, to facilitate the construction; (see plate 5) From a certain height, the bricks are inclined slightly inwards, decreasing the diameter, and giving a gentle curve inwards. Further inclination of the bricks inwards results in the closure of the dome. The outer surface of the walls are then coated with clay, and then polished when dried with a special clay. Chimneys are constructed near the entrance to facilitate the movement of the smoke.

Shelter for the Oven

The oven may be built in a shed specially built for the bakery or in the opening of a compound house and then provided with a shelter The ovens built on the third type of foundations are specially protected in houses built along the outer wall of the foundation. In this way, the actual body of the chamber is not seen from the outside unless one enters the house through a provided window; see plate 4. Yet still there are some which are left in the opening at the mercy of rainfall, and the winds; plate 6.

4.3.1.2 Operation of Oven (firing and baking)

As their names imply, they are all peel ovens; and are all wood fired.

Firing is done by packing pieces of wood, fronds or husks through the entrance near the centre of the hearth. The heap is then set to burn. Burning is continued until all the wood turn into embers. More wood may be added until the fireman realises the temperature is okey for baking. During the survey, a number of ways to assess the heat were revealed:

1. The fireman may fuel the outer surface of the oven with the palm.
2. A piece of dough may be placed on the surface, and then the time taken to bake is noted.
3. The vapour flow from the surface of the oven may be noted. All these depend on the experience of the master baker.

The embers and ashes are drawn out, using a special curved tool. The oven is allowed to "set" for sometime, about 15 minutes, during which temperature equilibriation is thought to occur, and the flash heat is cleared. Leading is then done of the proved dough using a peel. The opening is closed and the bread is baked in the residual heat of the oven; for about 30 minutes. Baked loaves are then unloaded. An oven could be reloaded for baking one or more times without further heating.

A maximum number of 7 times was noted in some of the ovens(the type built on foundation type 3).

4.3.1.3 Maintenance of Oven

Maintenance is regularly/on most of these ovens. It consist/d of polishing the outer surface of the chamber with a special polish some prepared from clay of ant-hill; recoating of scratched surfaces, patching of cracked surfaces, and replacement of broken bricks.

None of the bakers however, had maintenance schedule and with the exception of the surface polishing which seems to be a precentive maintenance, all the other works are done as repairs.

4.3.1.4 Limitations

Even though most of the bakers seem to be satisfied with these ovens, and even prefer them to some metal ovens, a number of limitations are observed in them. These are even appreciated by the owners when they get to know and understand them.

1. Heat control devices: There are no means to regulate heat in these ovens. Even though Campbell Platt introduced a pyrometer in his improved oven, such feature was never observed any where. Meaning it has not been adopted. There is therefore a greater possibility of burning fuel more than ideally necessary.
2. Insulation: Apart from waste of energy by burning more than required, the ovens are not well insulated. Heat is therefore easily lost to the surroundings, and one can realise this when standing within metres of an oven being fired.
3. Capacity: There are no shelves in these ovens; and the areas of the hearths are the only determinants of the ovens capacities. The ovens thus seem to possess very low capacities compared to the spaces they occupy. Campbell-Platt introduced a shelf in his improved traditional oven. This he realised increases the amount of bread baked at a time, using the same amount of fuel. Even though the energy used for one baking in this improved oven would be twice the amount to be used in the shelf-less oven and as such the improved oven could not bake many batches on single heating, it is observed that, time is saved, and the amount of energy lost as a result of poor insulation, with time minimised.

4. Materials for construction: Only in a few cases that refractive bricks were found to have been used for oven constructions. These types of bricks are supposed to be better heat retainers than the others. Some of the bricks, like the sun-dried bricks, and also the mud which seem to be poor heat retainers, were also completely solid, thicker, and therefore tend to dissipate lots of the heat in the baking chambers.

5. Two door system: Much as heat is lost from the walls, the entrances also allow in-flow of cold air which reduces the temperature. Therefore the more the number of openings into the chamber, the faster the oven would cool down and thus the higher the extent of energy wastage.

6. Absence of Controlled Draught: Not all the ovens have chimneys, and dampers to effect draught. Heat distribution within the oven therefore is always poor, concentrating mostly in the upper part near the dome.

7. One Chambered: The baking chamber is the same firing chamber and so baking and firing cannot be simultaneously done. This contributes to the wastage of energy. Products may also be dirtied; and lots of time are wasted in operation.

8. Irregularities in baking: Generally, loaves of dough loaded first are unloaded last, particularlly in the simple or adjacently placed dual entrance ovens. There is therefore high chances of burning or excessive browning of some loaves. Also, because the doors are opaque, oven chambers cannot be seen whilst baking. Bakers depend on their experiences to tell when loaves are ready, as times are not very reliable. Dough can therefore be overbaked, becoming less desirable, and wasting energy.

9. Shelter: The shelter is very important; and it is very well done in most of them. However, where this is lacking, (as in plate 6) the oven is subjected to rains, and air movements which in view of the poor insulation of the ovens may increase energy wastages. Unfortunately the nature of the ovens are such that they demand special shelter.

10. The nature of the oven and how it is operated, it is believed contributes to a number of health problems. Problems mentioned include headaches, fever, barreness, waist/back pain, burns eye defects and abnormal blood pressure.

4.3.2 The wood - fired peel metal brick oven

This consists of a well designed rectangular fire chamber built of burnt bricks, attached to double deck metallic baking chamber at the back. The baking chamber is rectangular. The hearth of the chamber is a plate. The ceiling is equipped with metal tubes which end in the firing chamber. Each chamber is also equipped with a pyrometer which records temperature of the chamber; plate 7. The fire chamber is equipped with an ash pit and a chimney.

4.3.2.1 Construction

Much cannot be said on this oven as the baking chamber is imported. However, the wall is double and either fibre glass or rock wool lagged in between, or vacuumised.

4.3.2.2 Operation

In principle, the metal tubes conduct heat from the firing chamber where firewood is burning into the baking chamber. The baking chamber is well insulated. The air within gets heated and the heat is absorbed by the plate hearth. The temperature thus rises, and at a desired temperature, the oven is loaded. Baking is allowed for about 45 minutes. Many batches can be baked whilst the oven is firing. Loading is done with a peel, plate 8.

4.3.2.3 <u>Maintenance</u>

This is done mostly on the firing chamber. It consist of patching of cracks, and recoating and polishing of surfaces.

4.3.2.4 <u>Limitations</u>

Apart from being a batch oven, the only problem is the control of temperature. It can only be done manually by withdrawing some of the burning firewood.

4.3.3 <u>The Gas-fired "Semi-peel" brick oven with metal shelves</u>

4.3.2.1 <u>Construction Operation and Maintenance</u>

This consists of a rectangular baking chamber constructed with burnt bricks. The chamber is partitioned with metal grid shelves: and is fitted with a metallic plate door; see plate 9. It is fired with gas stored in a cylinder outside the chamber Gas burners are lined at the floor under the lowest shelf. With the aid of a piping system and a valve to control gas flow, the burners are supplied with gas from the outside cylinder.

Construction of the wall is done by firing layers of bricks with clay into the structure desired; and then coating the surface with more clay.

The oven is operated like any other gas oven. Gas is turned on and burners lit. Oven is allow to heat for about 15 minutes with door closed. Loading is then done; and in the semi-peel manner by hand.

PLATE 8: The peel mode of loading being demonstrated in the metal-brick oven.

PLATE 9: A model of the gas-fired brick oven with metallic shelves and door. It also illustrates the semi-peel mode of unloading.

Maintenance is done mainly on the wall. It consists of recoating, patching, and polishing of the surface. Burners are however, occasionally cleaned of soot.

4.3.3.2 Limitations

1) Heat Distribution System

There is no blower to provide draught for heat circulation; and there are no dampers and vents also. Heat is therefore unevenly distributed within the chamber. Because of this loaves have to be rearranged from shelves to shelves to prevent irregular browning. The problem is made more pronounced by the equi-distant positioning of shelves without any consideration of the heat distribution.

2) Heat retention

The walls are not insulated, and there are no special heat retention materials in it. Heat loss to surroundings are therefore inevitable, meaning wastage of energy.

3) Heat regulation

Even though the gas control taps are used to regulate heat outputs, because there are no heat sensors (pyrometers or thermometers), the temperatures of chambers are not known to guide effective regulation. There is thereforeaa likelihood of energy wastage.

4) Opaque Metal Door

The door is opaque and oven chamber can never be seen unless it is opened. This results in frequent openings of the door, causing heat losses.

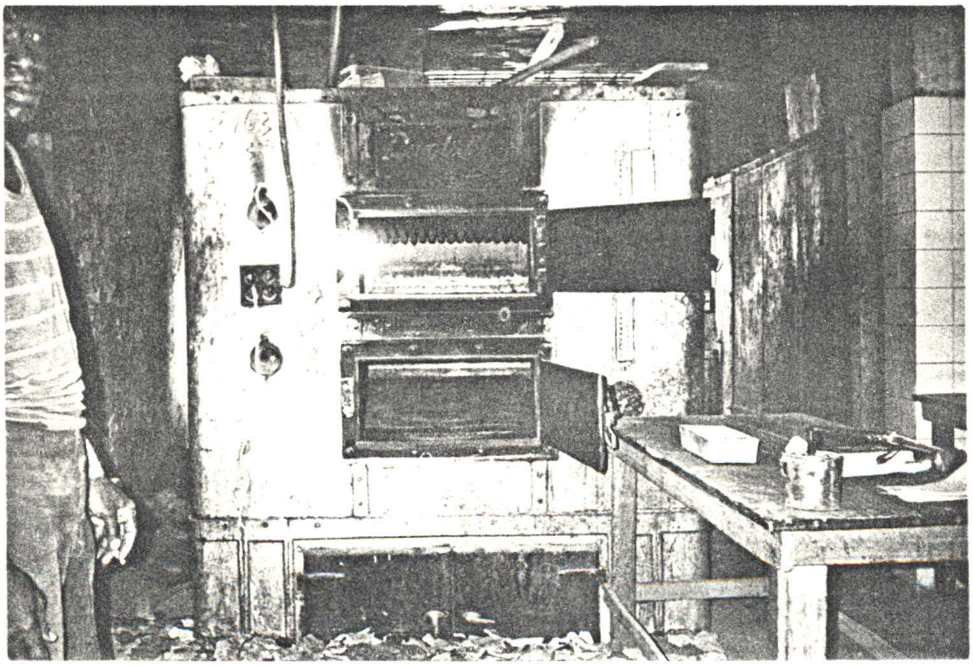

PLATE 7A: The baking chamber of the metal brick oven. The heat conducting tubes could be observed at the ceiling of the upper chamber. There is an external light connection, a timer and also a thermometer.

PLATE 7B: The firing chamber of the metal brick oven. It is provided with a chimne

4.3.4 Various models of the metallic ovens

4.3.4.1 The "Semi-peel" saw dust oven

This consisted of a baking chamber and a separate firing chambe both built of metals. In a typical one observed, the baking chamber is rectangular in shape, provided with grid shelves. There is a hollow at its floor (base), on which are placed several pieces of metal rods (heat conductors). The chamber rests on metal supports, about one metre high. It is provided with a metal door which is completely opaque (no glass window), It has a short chimney directly at the top. There are no heat sensors on it.

Firing chamber is cylindrical in shape, standing directly under the baking chamber. The upper part is opened and the lower end closed but has a bore of about 10cms in diameter. This chamber also rests on supports to about 30cm high. The latter arrangement allows a free flow of air underneath and through the bore at the base of the cylinder into the baking chamber.

(This oven was locally constructed. It was noted to have been designed by the baker for construction), Plate 10.

Much cannot be said about the construction of these and many other metal ovens. A visit to one of the manufacturers revealed that the baking chambers are double walled and lagged with glass wool, to serve as insulators. However, at least an oven was observed which was a single-walled, and realising the extent of heat loss, the baker has constructed a wooden chamber for it; see plate 13. Vent are also provided for most of these ovens, usually at the rear sides.

Firing and Baking

Saw dust is specially moulded into solid masses (loose biquettes, which are firmly packed into the cylindrical firing chamber, leaving

PLATE 10: A saw-dust fired metal oven. Note the rectangula baking chamber, with shelve and chimney; the cylindrica firing chamber; and the hea conducting rods at the base of the baking chamber.

a hollow of the diameter of the bore at the base. To facilitate the latter, a long shaft is fitted through the hole before filling. The two chambers are detached and so the filling is done outside. It is then place in position for firing. The fuel is lit to burn. The baking chamber is closed whilst firing. Smoke leaves through the chimney. The heat from the firing chamber heats up the rods at the base of the baking chamber, which comes into direct contact with the flame. They become red hot. With the draught provided by the chimney the heated air around these rods rises and circulates, heating up the entire chamber. The whole chamber gets heated within thirty minutes of firing; loading is then done. The fuel continues to burn whilst the loaves are baking.

Limitations

1. Heat control: This is very difficult and practically not done with this oven. Extreme cases may be drawing the firing chamber away. There are no heat sensors too in the oven. Fuel wastage in this oven is therefore also inevitable.

2. Shelves: Distribution is done without considering heat concentrations. Inefficient utilisation of energy may thus occur. This is proved by the fact that loaves have to be moved from shelves to shelves whilst baking.

3. Insulation: The firing chamber is not insulated. Heat is therefore lost right from the scratch to the end. The metal nature of the firing chamber may make the heat loss very alarming. The baking chamber it self is also not adequately insulated.

4. Opaque Door: Lack of transparent window in the door means opening the door frequently to inspect the baking products. This facilitates heat losses.

5. More than adequate fuel may be burnt and wasted as temperature for baking is always not known and heat production cannot be regulated.

4.3.4.2 The Semi-Peel Gas Oven

These consist of rectangular metal baking chambers, with gas burners lined at the bases. Plates 11-14 are pictures of some models. These burners are connected to a gas cylinder outside, from which gas is supplied. They are provided with shelves, the numbers which depend on the heights of the ovens and the spacing of the shelves. Generally however, four to five shelves are provided.

They are generally, also vented. Two or three vents may be observed at the rear sides of the ovens. They do not have chmneys.

The dimentions of these ovens vary widely; some are taller than broader whilst others are the opposite. The widths are however, usually shorter, within the reaches of the hands, without peels, table 5.

Generally these ovens are not provided with heat sensors. Heat regulation is however done with the gas flow control taps fitted. Some of them have glass windows in the doors that facilitate the examination of products inside.

These gas ovens are mostly manufactured in the country, appendix I gives the addresses of the manufacturers noted. Plate 14 is a picture of a newly completed oven at one of the factories.

Construction of these ovens are done generally like the other locally manufactured ovens. The only exception is the incorporation of gas burners.

Firing is done like any other gas-fired oven. Loading and unloading is like that decribed in the metal brick semi-peel gas oven.

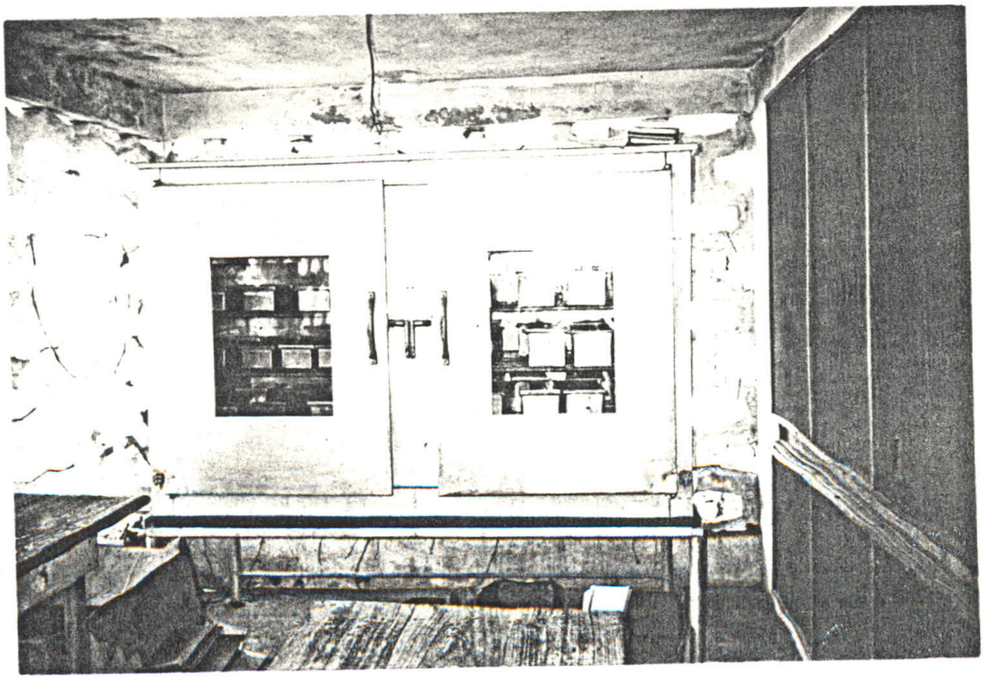

PLATE 11: A model of the gas-fired oven, It is provided with glass-windowed doors, and shelves.

PLATE 12: Another model of the gas oven, also provided with shelves and glass-windowed door. Note the difference in constructions between this and plate 11.

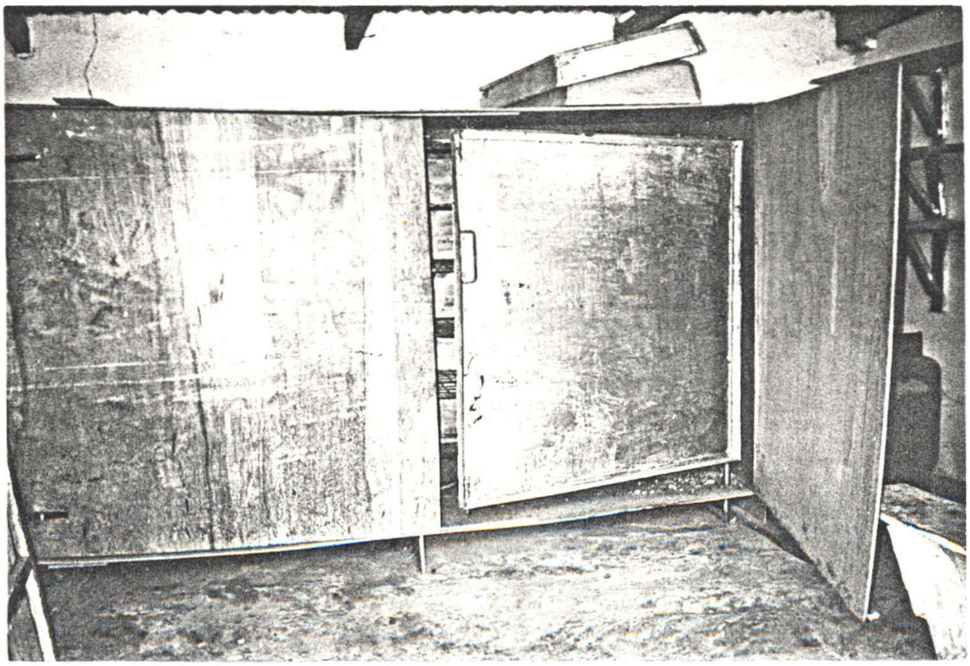

PLATE 13: A gas-fired oven; placed in a wooden cupboard. The cupboard supposed to serve as an insulator.

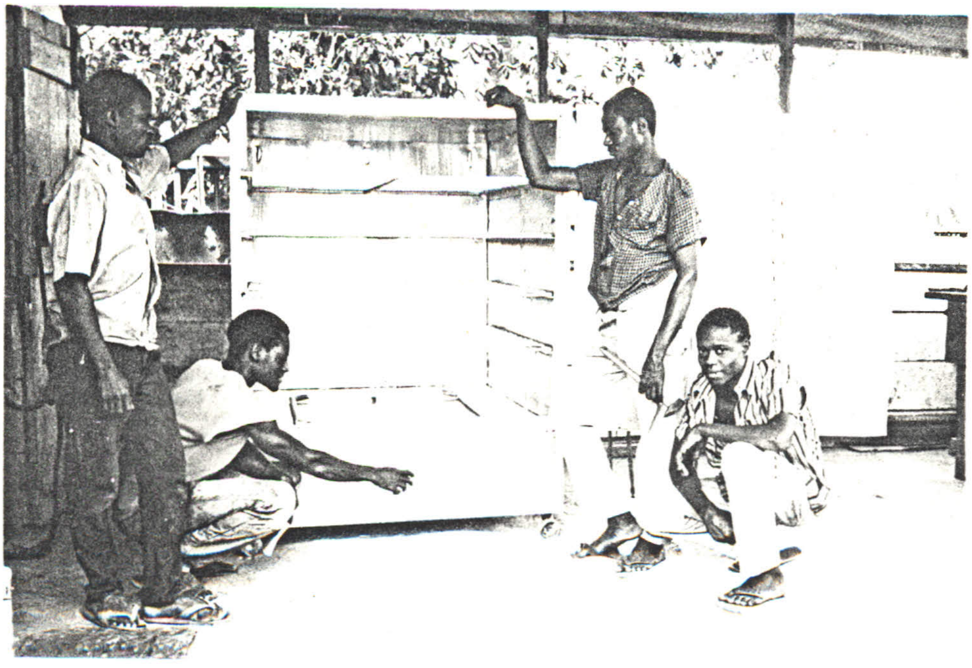

PLATE 14: A newly constructed gas oven at a factory. The three holes at the rear side (top) are the vents.

The limitation of these ovens are also similar to the ones described above. There is the problem of in effective temperature control as they do not have sensors, and insulation is generally poor (plate 13). They are not provided with blowers to ensure proper heat distribution in the oven, and the position of ovens in the houses do not facilitate free flow of air through the oven. Shelves are also poorly spaced and where glass windows are not provided, frequent opening of the door causes heat losses, With the gas control tap however, energy wastage can be minimised. when the baking temperature of the oven is known.

4.3.4.3 The Electric Ovens

A few of these found were imported. The local ones are constructed like the gas ovens, except that instead of gas burners, they have electric elements which produce the heat in the chambers The hearths are generally plates, constructed to retain lots of the heat produced for the baking. Generally they are provided with theremometers (or pyrometers). The models of these oven vary widely; particularly between the imported and local ones. Some are peel, some drawn plate and others "semi-peel". Heating is done by switching on the current, with door closed. Oven chambers heat up, and is indicated on thermometer. At the required temperature oven is loaded. There are generally knobs to control heat output. Plate 15 is a picture of an electric oven.

The few limitation on the local ones are again poor insulation, absence of heat sensers and absence of transparent windows.

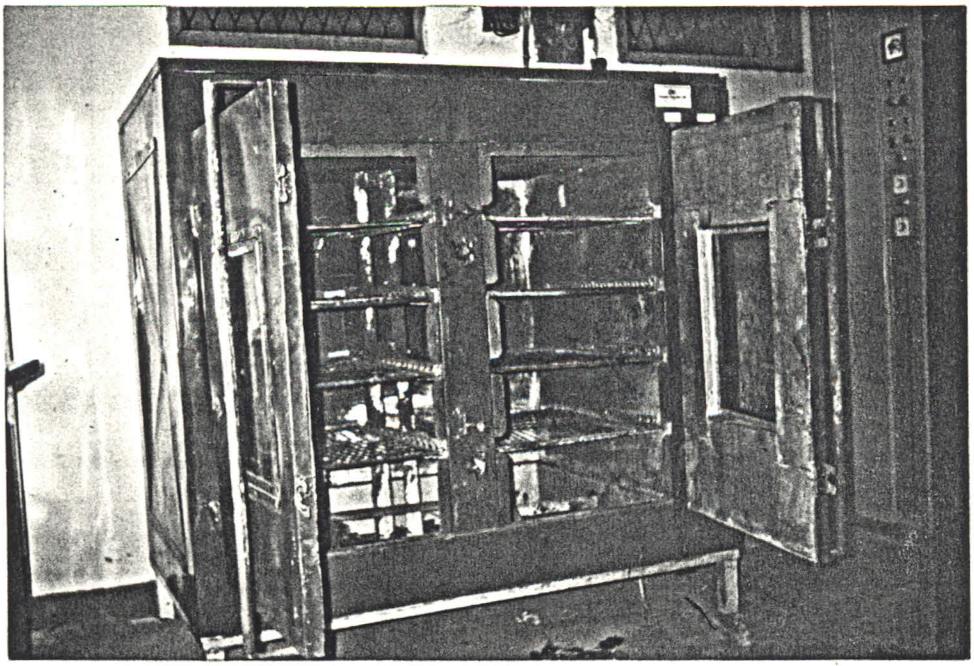

PLATE 15: A model of an electric oven. Locally Constructed

4.3.4.4 The Oil-fired Ovens

Two of these types were observed during the survey. There is the oil-fired reel oven, and the oil fired draw plate oven.

The reel oven consists of a series of shelves each suspended between arms radially disposed from pioneered axles located in the approximate centre of the sides of the oven. Theovens are slowly rotated during the baking cycle so that the shelves describe a cylindrical path. Rotation of the product means that top bottom differences in temperature will not cause product irregulities. Pans can be placed on the shelves as the latter pass a narrow opening in front of the oven. Baked loaves are removed through the same opening.

Firing: An electric motor pumps out oil from a reservier into the burners in a finely sprayed form. The burners are ignited by a step-up transformer. A blower circulates the heat into the baking chamber. Rising temperatures are read on a thermometer attached, and at a required temperature, the oven is loaded. The oven is equipped with start - stop control foot - pedal. There is a safety valve which automatically puts off the fire when oil leakage occurs. It has a chimney and a heat regulating knob. The firing chamber is separate from the baking chamber. See plate 16.

The draw plate oil fired oven, is the other type observed. It is fired similarly like the reel oven. The oven is however, rectangular in shape and smaller in size than the reel oven. It is provided with plate hearths which can be drawn out for loading and pushed in for baking. It has heat sensors, heat regulators, steam connection, transparent windows, internal lights and many advanced features. The oil-fired ovens observed were however imported.

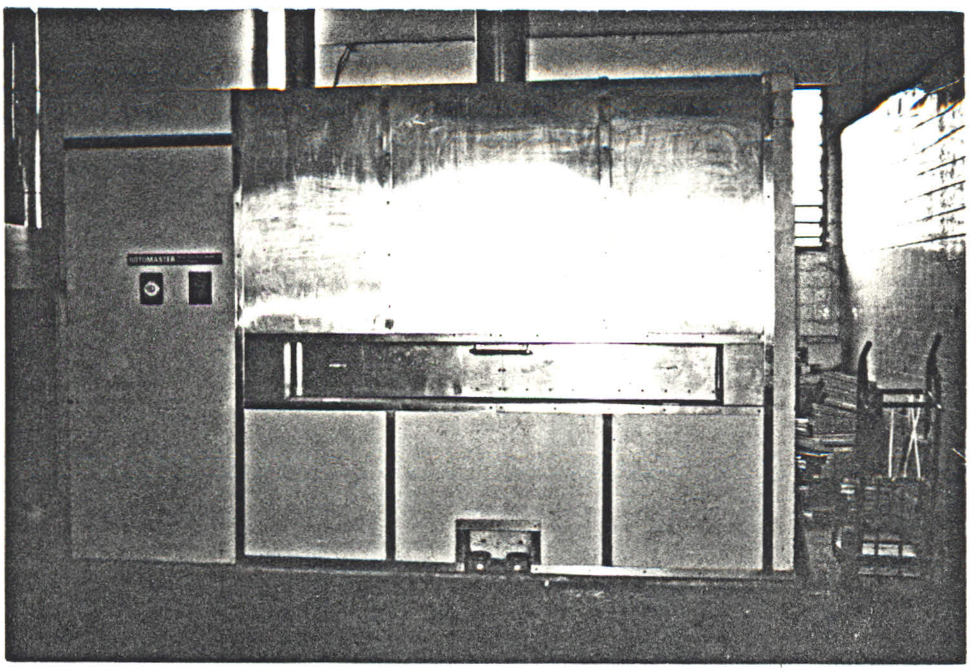

PLATE 16: An oil-fired reel oven. (front view)

4.3.4.5 The Gas-electric and Gas-charcoal Ovens

These are some of the gas "semi-peel" ovens described above. They had been constructed such that they can use any of the fuels described - gas or electricity or charcoal, plates 17.

4.4 Special features observed on ovens

Certain desirable features which are necessary for better oven performance were looked for. Table 6 shows some of the features as observed in the ovens. They were mostly observed in the electric and oil-fired ovens; and they include:

- a temperature recording system
- heat regulating system
- glass window which permits observation of loaves during baking
- multiple shelves for optimum capcity utilisation
- forced draught system (blower, damper or vent)
- timing device

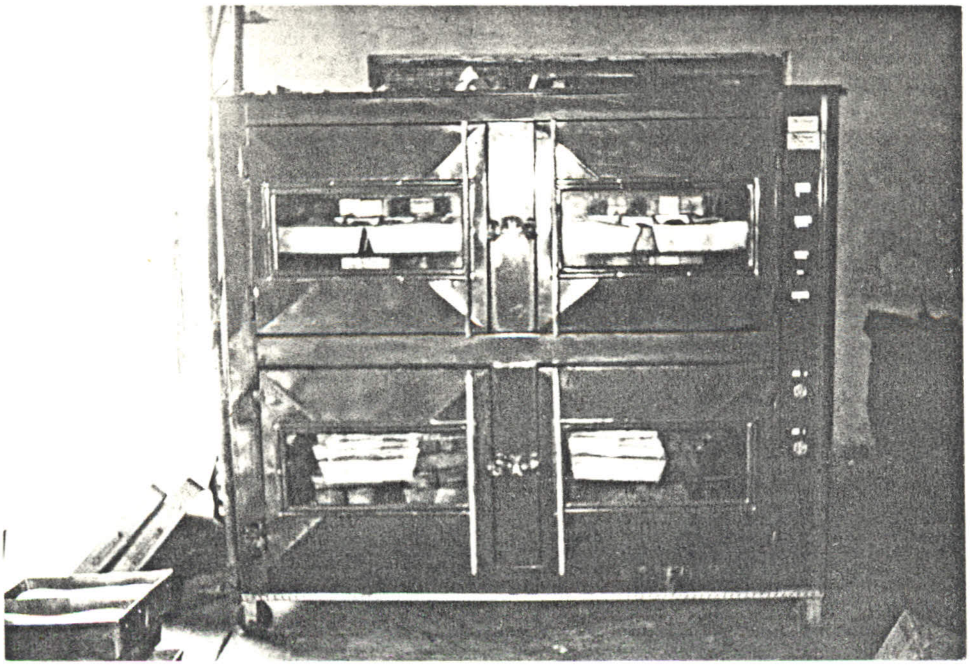

PLATE 17A: A model of the electric-gas ovens.

PLATE 17B: The semi-peel mode of loading being illustrated in the electric-gas oven.

Table 6. Some Special Features observed on ovens

FEATURE	No. of ovens which have Feature	No. of each type of ovens		
1. Thermometer/Pyrometer	11	10	-	1
2. Heat regulator	11	11	-	-
3. Glass door	12	11	-	1
4. Multiple deck (shelves)	19	17	-	2
5. Blower	4	4	-	-
6. Timing device	1	1	-	1
7. Safety device (alarm)	1	1	-	-
8. Heat accelerator	1	1	-	-
9. Steam connections	3	3	-	-
10. Separate fire chamber	3	2	-	-
11. Internal Lighting or light connected to oven body	5	2	2	1
12. Vent/Window	11	6	5	0
13. Raised foundation	15	-	14	1
14. Ash Pit	4	-	3	1
15. Chimney	8	2	5	1
16. Hearth:				
Plate	7	6	-	1
Grids	12	11	-	1
Plastered bricks	17	-	17	-
17. Multiple entrance	4	-	4	-

C O N C L U . I O N

Many different types of ovens are used in the country. Based on their fuel types, major materials for construction, and their mode of operation, these ovens could be described as; the wood-fired peel clay mud oven; the wood-fired brick "semi-peel ovens with metal shelves; and the various models of metallic ovens which are fired with either gas (LPG), residual oil, saw-dust, electricity, or combination of some of them and which are all semi-peel types. Majority of the ovens are privately owned by individuals and are all batch types.

Most of the ovens are designed and fabricated locally, by local experts. These experts are artisans who acquire their expertise through long term experiences of appreticeship They have only limited knowledge in basic engineering as it relates to oven fabrication.

The ovens are generally deficient in designs and constructions. The materials used though locally available are poorly selected. Many features that enhance oven performance are lacking in most of them. These may be summed up as good insulation, heat regulation, and uniform heat distribution systems, and the timing and safety devices. Substantial amount of energy is therefore wasted during operation of these ovens. Furthermore, the designs of the ovens only permit operational practices which contribute to substantial energy losses. For instance, opaque doors and uneven heat distribution in chambers, necessitate frequent opening of doors to inspect products during baking and to rearrange the loaves from shelves to shelves, respectively.

The predominant fuel sources for oven firing are wood-fuel and LPG.

Regular maintenance is done in most of the mud oven; but only in a few of the metallic ovens; oven though the owners do not have laid down maintenance schedules.

It is believed that the nature of some of the ovens exposes users of these ovens to a number of health problems These problems include headaches, fever, barreness, waist and back aches, burns, eye defects and abnormal blood pressure.

RECOMMENDATIONS

1. Studies should be done on the differently designed ovens to evaluate their efficiencies in terms of fuel conversion and conservation, and general performance. Parameters like types of constructing materials dimensions, shapes and the mode of constructions should also be assessed. These should aim at standardising these parameters in the more efficient designs.

2. The standard designs that are produced should incorporate all the necessary features that are needed for the efficient performance of the ovens These include adequate insulation temperature control system, devices to ensure uniform heat distribution, and all other features that limit heat loss in operation practices and ensure maximum safety in operation.

3. It would be appropriate that bakers are introduced formally, through workshops, to these standardised inproved designs that would evolve. They should be taught the appropriate ways of handling them. In this regard it should be borne in mind that most of the bakers have only very little formal education.

4. Oven designing and construction should attract engineers for proper designing and construction. The ever-growing baking industry requires more efficient, more economic and more appropriate ovens to cope up with the demands for baking products in an efficient and cost-effective manner.

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APPENDIX

List of addresses of Local metal oven manufacturers

1. Kadmous Group of Companies
   P.O. Box 5783
   Accra.

2. Mandor Engineering
   P.O. Box 11737
   Accra-North.

3. F.A. Fernybough Memorial Metal Works
   Gas Oven Experts
   P.O. Box 032
   Osu - Accra.

4. G I H O C
   Steel Works
   Tema.