DEVELOPMENT OF GAS BOY MEDICAL INCINERATOR AS A SUBSTITUTE FOR PLACENTA PITS IN HOSPITALS IN GHANA

P. S. Kwawukume
Department of Industrial Art
Kwame Nkrumah University of science and Technology,
Kumasi, Ghana

ABSTRACT
A high temperature medical incinerator of 0.4cu m capacity was designed and built with specially manufactured refractory bricks and high temperature bauxite mortars with local gas burners rated at 158Kilojoules(150 B.T.U.) High pressure regulators were fitted onto the 52kg gas cylinders to enable the delivery of high gas pressure to the burners for quick combustion. The stench that emanates from the burial of placentas, limbs etc especially after rainfall, are unbearable and awful within most hospital environments. A solution has been found in the engineering of all- in- one medical gas boy incinerator with quick rise in temperature and even distribution of heat, with drying and firing cycles and can be recharged at elevated temperatures. Steady states of heat transmission through the multi-layer wall of the incinerator was calculated which shows low escape of heat through the walls thereby enhancing maximum heat retention which is available in reducing the medical wastes into their mineral constituents which are essentially stench free ashes.

Keywords: *Medical waste, Heat transmission, refractory components*

INTRODUCTION
Hospitals in Ghana have been caught up with the dilemma of disposal of medical waste in a safe manner. Various methods have been adopted by these Hospitals for the disposal of waste for example, burial, treatment with chemicals, mixing with domestic refuse and careless dumping in overgrown environment by mothers etc. These methods of disposal have proved extremely unhygienic and at times scavengers manage to excavate the buried waste and scatter them all over in the most unhygienic manner. The stench that emanates from the burial of placentas, limbs etc especially after rainfall are unbearable and awful within most hospital environments.

Reduction of placentas, limbs and pathological wastes into harmless ashes by incineration in a gas boy incinerator has proved to be another source of safe disposal of waste in hospitals. These wastes have high water content and needed to undergo very decisive and fast dry-

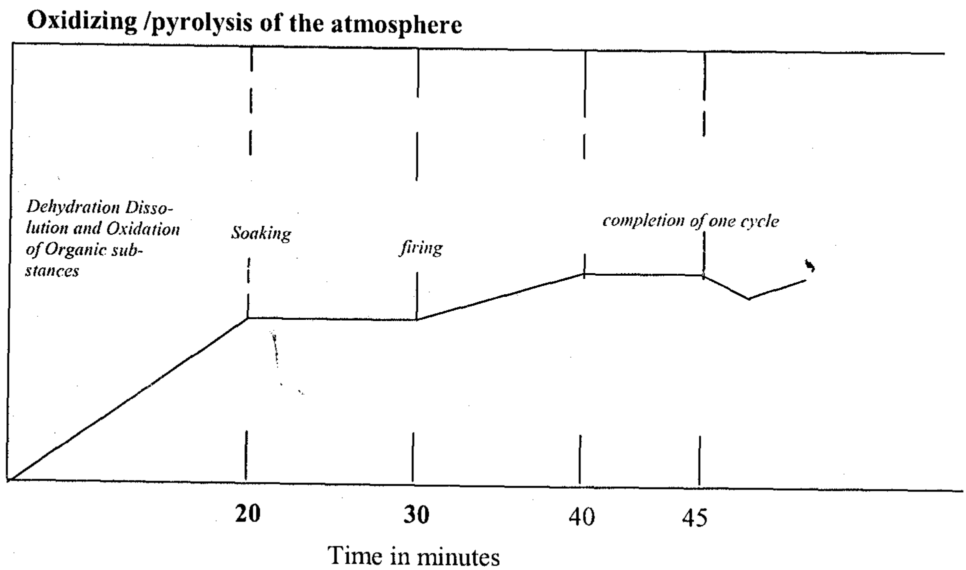


Fig 1: Incineration Curve for Gas boy medical waste Incinerator

ing and eventually high firing regimes to enable heat to convert them into harmless ashes in a single rapid oxidation.

In Ghana, there is now a serious topical issue about health care management. This has come about due to the awareness that a higher source of infection could start from careless handling of medical waste. A survey of hospitals in Ghana has revealed inadequate waste treatment facilities. Environmental Protection Authority. (2002a). The result is for example, amputated parts find their way mixed up with public refuse Environmental Protection Authority (2002b).

Scavengers visit waste dumps and collect items such as syringes, which are sold for use as rollers for the hair.

Animals feed on discarded human tissue from hospitals. Foetal parts are dumped into public drains, which eventually find their way into town refuse. Some hospitals parcel placentas for mothers to be sent home and are usually dumped in over grown environments.

The lists of possible treat of diseases emanating from such practices are endless. Wastes generated from veterinary services, research facilities, funeral homes, mortuaries and practitioners of traditional and alternative medicine pose serious dangers as well to our health due to the mode of disposal. Strange diseases that keep coming up could be traced to such willful practices as a result of lack of proper disposal facilities.

In this paper, an attempt has been made to engineer high temperature gas operated medical waste incinerator with ceramic thermal heat approach capable of turning into ashes wet medical wastes in a short time and with low energy cost for Hospitals in the country. This design concept of waste disposal is of immerse benefits to Hospitals that are using them on trial basis in the country.

DESIGN CHARACTERISTICS

The following quantities are the essential parameters used for the design of the incinerators and in achieving efficient combustion characteristics and fast built up and maintenance of high temperatures.

1. Heat generated from fuel
2. Volume of air (Nitrogen + Oxygen) necessary to completely burn the fuel.
3. Volume of gas generated through combustion.
4. Heat loss through the incinerator walls and calculation of temperature in each section leading to energy saving gas boy incinerators.

The figures obtained from 1and 2 were used to design the atmospheric burners and the figures obtained from (3) were used to calculate and determine the sizes of the flue and the chimney

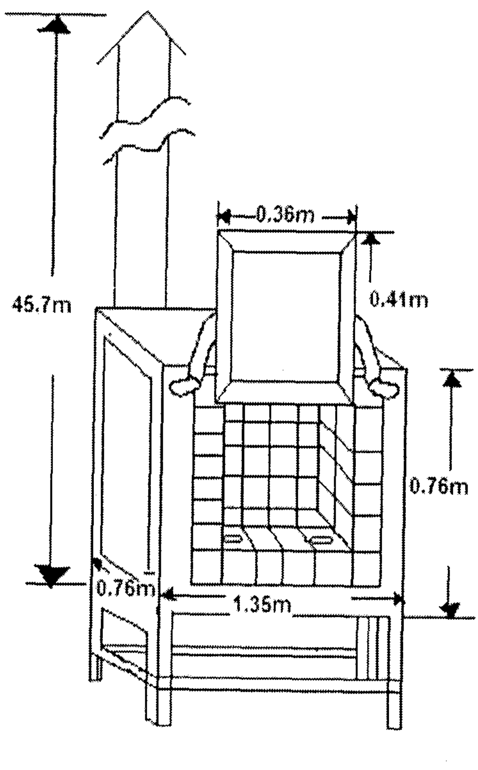


Figure 2: ***Tech Ceram Gas boy incinerator with technical dimensions***

height for total oxidation firing. The value generated from (4) helped to determine the size of the furnace wall leading to the size/ weight of the incinerator and high temperature attainment.

Among other considerations the control of heat loss through the furnace walls by conduction, radiation and convection has the greatest impact on high temperature attainment and capacity of the incinerators.

This development work was based on minimizing heat loss through the walls and calculated values were used in the actual construction of the incinerator. The author has identified heat loss through the walls as the main problem in achieving efficient incineration since radiation and convention heat losses are known to be minimal in incinerators when heat transfer in a stationary state is concerned.

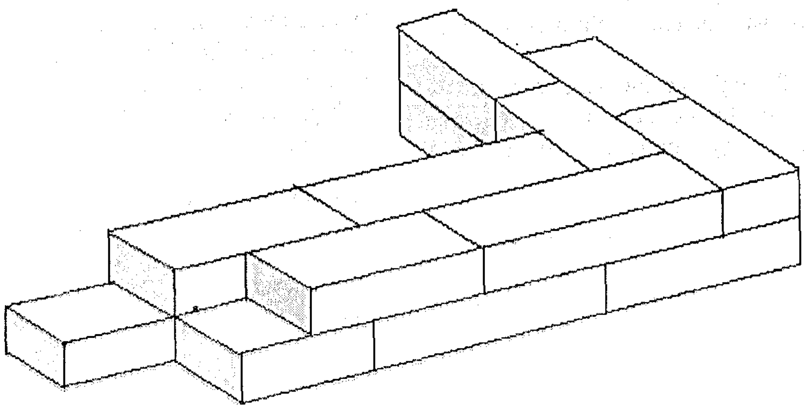
MATERIALS AND METHOD

The gas boy medical incinerator is rectangular in shape (30"x 27"x30") 12 cu ft or (0.4 cu m) basically, it has three main identifiable components, which are:

1. The rectangular metal housing structure made up of 2x2 (0.5mx0.5m) angle iron, 1.25mm metal sheet covering the angle iron framework, metal chimney and easy and simple opening and closing door mechanism even at elevated temperatures.
2. The refractory brick was developed by Kwawukume, 1999 and was laid into the metal frame structure.
3. The large turn down ratio atmospheric gas burners made up of water galvanized pipes and nipple from normal gas cookers, which serve as the gas delivery nozzle and the entire units (the burners) are placed underneath the incinerator structure.

This volume is chosen to accommodate incineration of single to multiple placentas at a single operation without much heat loss in between incinerations. The dimensions of the rectangular shape is also ideal in that it fits easily into any

Figure 3: The laying techniques of the refractory bricks showing independent layer arrangements



available space within a room and it can also accommodate the incineration of limbs should the need arise without any further cutting.

RESULT AND DISCUSSION

Incineration of medical wastes into ashes proved very adequate in this special 0.4 Cu M Incinerator with two locally engineered atmospheric gas burners rated as 158 Kilojoules positioned alternatively in the rectangular refractory framework.

A 52 kg gas bottle was fitted with high-pressure regulator, which delivers controlled gas pressure to the atmospheric gas burners and upon ignition send blue flames swiveling in the rectangular incinerator which dries and incinerates wastes within thirty minutes. The temperature built up is so fast because of the engineering of the entire wall structure. Generally, it is accepted that the greater the number of burners the faster the rise in temperature and large walls are capable of slowing down rise in temperatures since much heat will be lost to the walls. (Kingery, 1976). The results as calculated indicate that heat loss is a function of the thermal conductivity of the refractory bricks, choice and laying geometry of the refractory bricks.

The escape of heat from the incinerator wall by conduction, convection and radiation occur usually at the same time and from all the sides of the incinerator. A properly designed incinerator will keep much of the heat for incineration than through the escape mode. The calculated figures of all the heat energy going through the entire incinerator is not steep which is seen as responsible for the efficiency of this incinerator. Generally it is accepted that a steep temperature gradient causes high heat flow and also heat flows in the direction of temperature gradient. Apart from the selection of the right types of bricks the various temperatures attained at the various temperature boundaries are lower than the heat capacity of the refractory bricks used at such areas in the construction See Fig 4. This is an indication of low heat fatigue on the refractory bricks, which is a function of long life span of the incinerator in service.

Incinerators usually face huge heat loses and every care is taken to fine tune the design and construction of the walls with exact material properties as selected. With the under listed data it became obvious that with time, the hot face

Calculation of Results

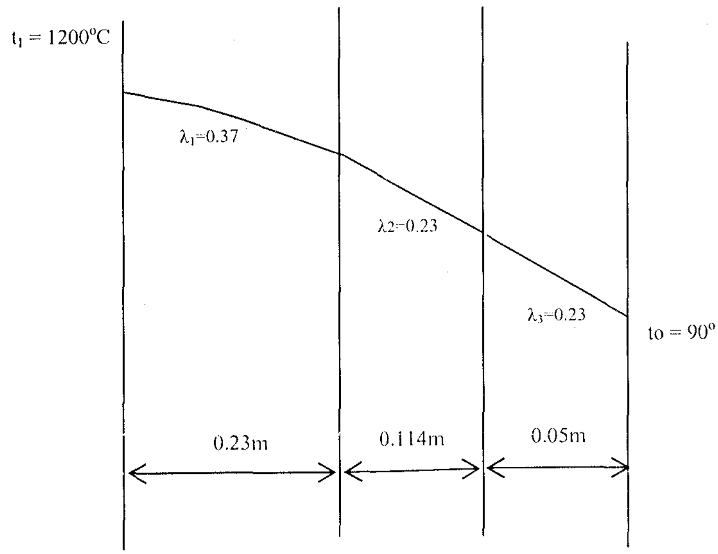


Fig 4 Steady state heat transmission in and around the multi-layer wall of the incinerator

bricks get hotter thereby intensifying the preserved heat in the walls which increases with time and stored heat is available for incineration.

Where Q_1 = Heat capacity transfer through the wall [KCal/m².h]
Q_2 :Heat emission from outside surface.
λ_1, λ_2 and λ_3 = Thermal conductivities at the average temperature of each layer[Kcal/mh°C]
ℓ_1, ℓ_2, ℓ_3 : Thickness of each incinerator wall material [m]
t_i: Inside wall (hot face) temperature [°C]
t_1, t_2,t_3: Each boundary temperature [°C]
t_o: Outside surface temperature [°C]
ta: Ambient temperature [°C]

Excessive heat loss through incinerator walls was prioritized as the major cause that leads to inefficient incineration, difficulty in temperature built up and high-energy costs. Selection of refractory materials and thickness of incinerator walls are fundamental in the design of this gas boy incinerator.

An attempt has been made here to simulate stationary state heat transfer through a multi-layer plane of refractory bricks used and results generated were used to design and construct the incinerator.

The first assumption was that the thermal conductivity in layers 1, 2 and 3 of the wall materials are λ_1, λ_2 and λ_3 and the thickness are ℓ_1, ℓ_2 and ℓ_3 respectively.

The layers of the incinerator wall depend on the thermal conductivity of the refractory bricks as well as the geometry of the bricks in actual construction.

In the case of three layers as with this incinerator, the quantity of heat from the hot face to the utter wall was calculated as follows and the results agree very well with the construction data.

$$Q_1 = (t_i - t_1)(\lambda_1/\ell_1)$$
$$= (t_1 - t_2)(\lambda_2/\ell_2)$$
$$= (t_2 - t_0)(\lambda_3/\ell_3)$$
$$= \frac{t_i - t_0}{\ell_1/\lambda_1 + \ell_2/\lambda_2 + \ell_1/\lambda_3} \quad \text{----} \quad (1)$$

$$Q_n = (t_i - t_1)(\lambda_1/\ell_1)$$
$$= (t_1 - t_2)(\lambda_2/\ell_2)$$
$$= (t_n - t_0)(\lambda n/\ell n)$$
$$= \frac{ti\text{-}to}{\ell_1/\lambda_1 + \ell_1/\lambda_2 + \ldots\ldots + \ell n/\lambda n} \quad \text{---} \quad (2)$$

Substituting into equation. (1)

$$Q_1 = \frac{t_i - t_0}{\ell_1/\lambda_1 + \ell_2/\lambda_2 + \ell_{13}/\lambda_3} \quad (1)$$

$$= \frac{(1200 - 90)}{\frac{0.23}{0.37} + \frac{0.114}{0.23} + \frac{0.05}{0.23}}$$

$$= \frac{1110}{0.622 + 0.496 + 217}$$

$$Q_1 = 831.5 \text{ Kcal}/\text{m}^2.\text{h}$$

$$\text{To find } t_1 = t_i - Q_1(\ell_1/\lambda_1) \quad \ldots\ldots \quad (2)$$

$$= 1200 - 831.5\,(0.622)$$

$$t_1 = 682.8\ ^\circ\text{C}$$
$$t_2 = 270.4\ ^\circ\text{C}$$
$$t_3 = 90\ ^\circ\text{C}$$

From the foregoing, the hot face bricks, which are, exposed to temperatures around 1200 °C, the next layer bricks that are capable of withstanding 1180 °C were only exposed to temperatures below 1000 °C. This temperature distribution makes this incinerator very economical to operate. The temperature at the outer end of the bricks is low which actually indicates that heat input is largely preserved for incineration whilst the heat output is low indicating good working environment of this equipment.

CONCLUSION

Equations 1-3 briefly summaries the total quantity of heat going through the entire incinerator walls which was accommodated in the design and construction of the incinerator layers. The calculated quantities of heat passing through the layers quite easily enabled the choice of the refractory bricks with the view of avoiding accumulation of excessive heat at the boundaries which could be higher than the heat capacities of the refractories in that layer leading to failure of the wall with time.

This incinerator reduces dressings, wet or dry plastics, all organic matter and needles are sterilized and denatured. In addition to the above, small glass sharps including injection bottles are melted and rendered safe. Due to the intensity of the heat, 30-40 kg of placenta /human waste are reduced to ashes within 45 minutes.

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