Design Of Medical Waste to Energy Incinerator for Zimbabwe: Case for Warren Park Polyclinic

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Abstract

This research focuses on the design of waste-to-energy incineration at Warren Park Polyclinic. The current problem at Warren Park Polyclinic involves mismanagement of medical waste due to lack of onsite incinerator and also poor health services due to load shading. At the polyclinic there are nearby creatures which take waste which is awaiting transportation as they don't own an incinerator leading to health and safety risks of surrounding people and mostly patients loss of trust in clinic`s sensitive waste disposal such as placentas. There is also poor sterilisation of medical equipment due to load shading. This waste to energy incineration enables the clinic to properly sterilise medical equipment at no cost as they will use boiled water from incineration waste energy and it will also enable the clinic to provide better waste management by having an incinerator on site. The research includes literature review involves different ways in which energy is recovered from incineration and how resultant flue gas is filtered before it's released to environment. Further to the report there is information on data collection which involves the use of questionnaires and interviews so as to fully understand the type and properties that the people at Warren Park clinic will require. The amount of fuel, oxygen and draft fans required for complete combustion were noted via the stoichiometry and heat balance equations. Results from the study proved that the Warren Park Clinic can burn waste at 80kg/hr. while producing 55 litres of boiled water per burn used for sterilisation.

Keywords
Design, Incineration, Medical Waste, Heat Generation, Warren Park Polyclinic

1.Introduction

Medical waste involves waste produced from all healthcare facilities such as blood banks, drug stores and research centres as according to the World Health Organization (Fadaei 2022). This waste increases as pandemics strike such as Covid 19 or when the population increases (Maalouf 2021). With the increase in global population medical waste management is becoming one of the many complex challenges facing humanity (Windfeld and Brooks 2015). Medical waste management is crucial as it`s improper management possess great threat to people especially the healthcare and waste carriers despite the fact that healthcare system is there to provide treatment and safeguard of people (Rao and Babanyara 2013).This is supported by Ernst as he claimed that, the way in which solid waste is handled is crucial to one`s community`s health and welfare (Ernst 2008) Medical waste can be divided into risk waste which is about (10 – 25%) of the total produced medical waste and non-risk waste which is about (75-90%) of the total produced medical waste. The percentage of the risk waste may be smaller but its danger it's catastrophic as it has been established that worldwide about 5.2 million people die each year from waste related diseases. The dangers of exposure to medical waste varies from skin and respiratory diseases to contamination of HIV/AIDS and hepatitis with its microorganism on waste spreading and causing diseases (Abubakar and Bogoro 2013).

The proper collection and disposal of this waste is of great importance as it can directly and indirectly impact the health risks to both public and the environments as shown on fig 1 below. Improper waste management involves all unsafe ways of waste disposal and it imposes great danger. Improper waste management can lead to sharps inflicted injuries which are very deadly .WHO (World Health Organization) opined that syringe infections cause 21 million Hepatis B infections, 2 million Hepatis C infections and around 260 000 HIV infections and this could all be avoided by proper disposal of the medical waste (Abubakar and Bogoro 2013).The following image shows a worker stepping on a syringe due to improper waste management.

Figure 1. Risk at a Dump Site in KwaraState Nigeria (Mokuolu, 2009).

However, in most developing countries more risks happen from searching at waste disposal due to lack of incinerators and is shown on image below

Figure 2. Child playing with infectious waste (Mokuolu,2009).

This waste can be properly managed via incineration, autoclaving, hydroclaving and shredding with incineration being a cheap method of waste disposal. Incineration involves the controlled burning of the waste and its harmful microorganisms present are completely destroyed under high temperature (Abubakar and Bogoro 2013). This incineration process can be maximized by harnessing it`s waste energy while also serving its purpose of the waste reduction (Makarichi 2018). Health care facilities operate 24/7 and consume loads of energy. In hospitals energy can be used for various uses as heating for sterilisation, electricity for lighting, compressed air for therapy and cooling for ventilation (Kolokotsa 2012) . Globally Only 8 per cent of the hospitals (mainly the health centres) consume annually <200kWh/m^2, 56 per cent between 200 and 400kWh/m^2 and 36 per cent consume >400kWh/m^2 (Delpech 2018).

This waste to energy incineration can provide lots of merits such as:

a) Solid waste gets reduced up to 90%

b) Demand of landfilling is reduced

c) Cost of transportation to other incinerators or landfills is reduced

d) Reduction in environmental pollution. Thus it`s very reasonable that with every effort to reduce generation of waste materials, the option of energy recovery from waste be seriously considered.

e) Reduced to zero costs of energy.

Background

The incinerator which the Warren Park Polyclinic owned and used to burn its medical waste as well as Suburban Medical waste (nearby clinic) is now out of use and they are now resorting to sending their medical waste for later incineration to Harare Hospital which owns an incinerator. The incinerator which they owned produced lots of pollution harming the environment when it was burning the waste endangering surrounding people. The incinerator was an old model with a slow burn rate of less than 15 kgs/hr and required approximately 9 maintenances per year. As they would wait for the waste to be transported for incineration, animals such as monkeys are becoming a nuisance taking the waste leading to mismanagement of waste and concerns of patients as even their placentas are taken by the animals. Fig 2 shows the old model incinerator once used by people at Warren Park Polyclinic.

Figure 3. Showing the medical Incinerator which Warren Park Polyclinic used.

Problem Statement

At Warren Park Polyclinic there is mismanagement of waste as they wait for waste transportation which leads to health and safety risks of the surrounding people. It is also facing poor sterilisation of medical instruments due to load shading.

1.1 Objectives

1. To design an incinerator that burns medical waste (pathological, sharps, infectious and chemical) waste at 80kg/hr. using diesel.
2. To design an incinerator which is suitable for clinic with < 100 beds.
3. To design an incinerator which heats water to 100 degrees for sterilization

2. Literature Review

2.1 Medical Waste

According to RD Kulkarni (2007), medical waste is a subset of hospital waste that relates to material produced as a result of patient evaluation, care, or immunization, as well as linked biomedical research. Everything from used needles to soiled bandages, body parts, diagnostic tests, blood, chemicals, pharmaceuticals, medical equipment, and radioactive substances is considered medical waste. The term "healthcare waste" refers to any unwanted material that contains infectious material. This includes waste produced by healthcare facilities like doctor's offices, hospitals, dental offices, labs, and research facilities as well as unused vaccines and human tissues (Brenner B, 2020). Types of medical waste includes sharps, pathological waste, infectious waste, hazardous waste and radioactive waste. Medical waste is defined as any waste that is released from diagnosis, immunization and treatment of human and animals in which if not properly handled poses huge threat to the people especially the healthcare workers (Windfeld and Brooks 2015). The medical waste has been divided by WHO (World Health Organizations) into

a) pharmaceuticals which involves chemicals or drugs that are expired or contaminated.
b) infectious waste which involves waste from surgeries or used dressings which contains lots of pathogens capable of disease causing on exposure.
c) sharps which involve disposable syringes or broken glasses.
d) pathological which involves waste from the body or body parts.
e) chemical which involves waste from diagnosis.
f) radioactive which is waste contaminated with radioactive substances.
g) pressurized containers.

Medical waste regulations were started in 1988, the Medical Waste Tracking Act (MWTA,1988) after a life teffifying act occurred due to poor waste management. This incident involved 12 children in India who played with vials they discovered in dumpster and were infected with AIDS as the vials had blood contaminations(Shareefdeen 2012).

Incineration:

Incineration includes the burning of elements of waste at high temperatures ranging from 1800 to 2000 degrees Fahrenheit in order to completely burn the waste to fumes and ashes. This incineration can also be used to destroy dioxins while recovering energy from carbon components (Liu,2018).During the 1930`s incinerators have been in vogue and an act was put forth by US people so as to add pollution control devices such as precipitators and their costs increased leading to its shut down in the next 5 years(Tammemagi 1999). Waste disposal through incineration has been widely agreed to due to its advantages which involves waste reduction of infectious waste and emission of toxic gasses at low costs. A well designed incinerator alos involves devices for gas cleaning to ensure safety to its surrounding people (Fasinmirin and Olanrewaju 2019).

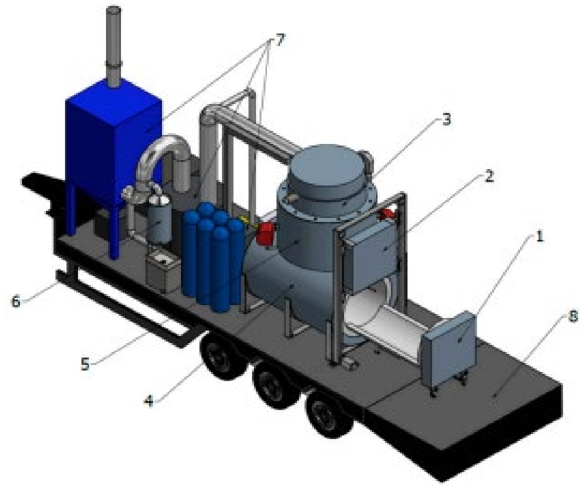


Figure 4. Basic components of an incinerator (Ferdowsi 2012)

1 – Loading stage where the medical waste is fed carefully ensuring all safety precautions by use of human power or hydraulics automatic loading so that heavy and dangerous waste is easily loaded and secured.
2 –Control Panel where it controls the automatic feeding system so as to ensure tight fitting and also monitor the inside temperatures so as to ensure the incinerator is performing at optimum conditions.
3, 4 5 - chambers: This is where the waste is burnt to ashes via the use of petrol and oxygen from air.
7 – Filtration where the toxic gases are filtered so as to release them in air as safe and clean gasses and not harmful to people.

Types of Incinerators

Rotary incinerators

The rotary kiln is a horizontal refractory-lined cylinder rotating about its axis and charging waste directly. The inserted waste is agitated by the kiln`s motion with its flow rate depending on the kiln`s speed around 1 - 3rpm. The rotary kiln involves a secondary chamber, and the air is provided to help burn out the waste. As the waste is subjected to the turbulence, it is contacted by air and combustion is initiated. The kiln system however, requires more extensive air control than modular units ((Huffman and Lee 1995). A contend and detailed rotary kiln incinerator must define the process that occur at different spatial balances and different phases (Marias, 2003).

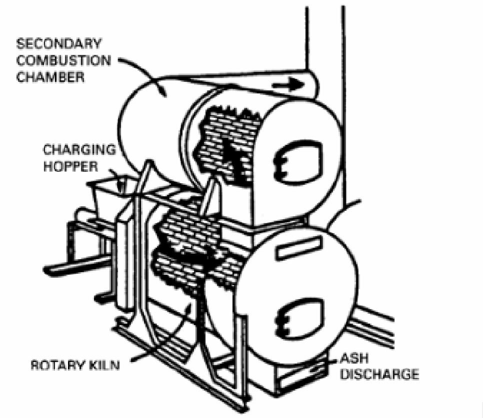


Figure 5. Rotary Incinerator (Huffman and Lee, 1995).

Excess incinerators

In this type of incinerator the waste is fired into the first combustion chamber where in the second chamber it provides supplementary fuel for the unburnt organic from the first chamber. The second chamber alos provides temperature and residence time.The incinerator involves multiple of internal baffles which escorts the combustion gasses through 90 degrees in both vertical and lateral positions (Huffman and Lee 1995).

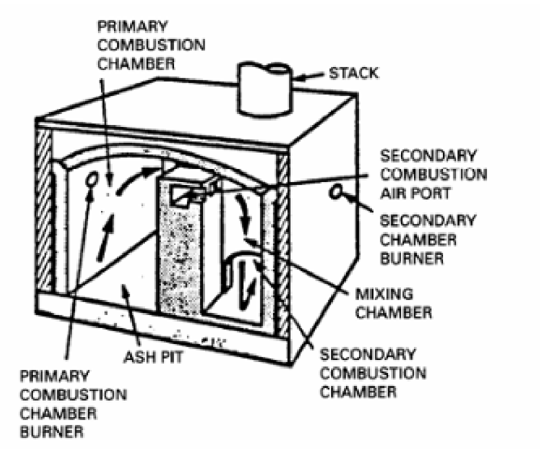


Figure 6. Excess Incinerator (Huffman and Lee, 1995).

Starved air incinerators

This is when it makes use of less than required amount of oxygen for combustion of waste so as to bur the waste If the gas is hot, the air will self combust and burn all waste . This type of incinerator involves 2 chambers in which the first chamber the waste is fired with oxygen which is less than the required stoichiometrically. The off gas is then sent to chamber number 2 where 100 % -140% of air required is inserted (Huffman and Lee, 1995).

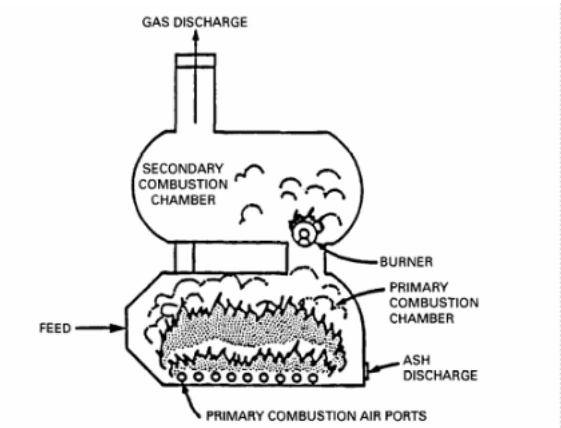


Figure 7A. starved air incinerator (Huffman and Lee, 1995)

Heat Recovery:

Heat recovery involves recovering waste energy via different technologies. Waste energy is the heat that is discarded and not put to use (Jouhara,2018). Higher temperatures typically yield better waste heat quality and easier optimization of waste heat recovery processes, making it crucial to maximize recoverable heat potential and efficiency in waste heat recovery systems (Choate and Davidson 2008).

Dean dscribed hoe the energy recovery system from the waste incineration would reduce the geyser bills at a hospital. He also discussed the possibility of producing the heat from incineration (Dean 1996). Bujak also experimented and reported the useful thermal efficiency coefficient of the system of thermal conversion of waste, including heat recovery and useful energy reflux (Bujak 2009). Tests have demonstrated the efficiency of designing and building medical waste incineration systems with heat recovery, which not only perform their primary waste management function but also offer energy savings (Bujak 2015).

2.3 Calorific values

Calorific values refers the heat produced during combustion, typically expressed in joules per kilogram of the energy in fuel or food. Calorific values enables us to see how much energy is available in certain foods and fuels (Zhao 2022) Different medical waste have different calorific values shown in Table 1,

Table 1. Calorific values of some medical waste

Medical waste	Caloric value J
Plastics	32 540 – 46 480
Sterilized cotton	25 560 -32 530
Infectious waste	20 920 -37 180
Hazardous waste	11560 – 12 000

Heating values

The heating value of a waste is the energy released during incineration, measured in Btu/lb (1 Btu/lb = 2.324 J/g). It can be reported on two value that is the higher heating value and lower heating value. Higher heating value (HHV) refers to heat released from fuel combustion with condensed water, while lower heating value (LHV) is based on gaseous water as the product (Azevedo and Sheng , 2005).

Properties of medical waste components

	HHV (Btu/lb)	Density (lb/ft^3)	Moisture (Wt%)	Heat value, as fired (Btu/lb)
Human anatomical	8000–12,000	50–75	70–90	800–3600
Plastics	14,000–20,000	5–144	0–1	13,900–20,000
Swabs, absorbents	8000–12,000	5–62	0–30	5600–12,000
Alcohol, disinfectants	11,000–14,000	48–62	0–0.2	11,000–14,000
Animal infected anatomical	9000–16,000	30–80	60–90	900–6400
Glass	0	175–225	0	0
Beddings, shavings, paper and fecal matter	8000–9000	20–45	10–50	4000–8100
Gauze, pads, swabs, garments, paper, cellulose	8000–12,000	5–62	0–30	5600–12,000
Plastics, syringes	9700–20,000	5–144	0–1	9600–20,000
Sharps, needles	60	450–500	1	60
Fluids, residuals	0–10,000	62–63	80–100	0–2000

Figure 7 B. Heating Values of medical waste.

2.4 Waste to Energy

Incineration is the oldest technologies regarding waste to energy and is very effective. It involves a heat recovery system and also flue gas cleaning so as to keep the environment clean and people safe. It can be used with various heat recovery technologies so as to increase incineration efficiency with energy source coming from waste energy from incineration The waste burning is done at temperatures above 850 degrees Celsius (wood et al. 2013). Below shows a typical waste to energy incineration flow diagram.

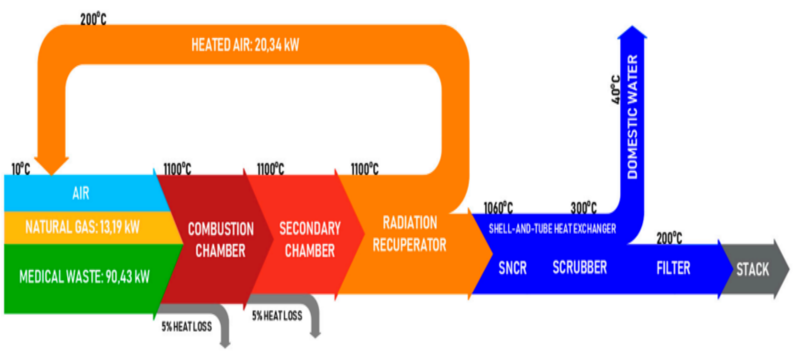


Figure 8. Waste to energy incineration flow diagram Ferdowsi,2012)

2.5 Case Study

1. **Metro Vancouver waste to energy facility**

   The Metro Vancouver waste to energy facility opened in 1988 where it processes almost 300 kilo tonnes per year of municipal waste to 180 kilo Mega Watts of energy. 20 % of about a million waste burnt is sold to neighbouring facilities(Elkamen and Shareefdeen , 2015). Below shows Metro Vancouver waste to energy process,

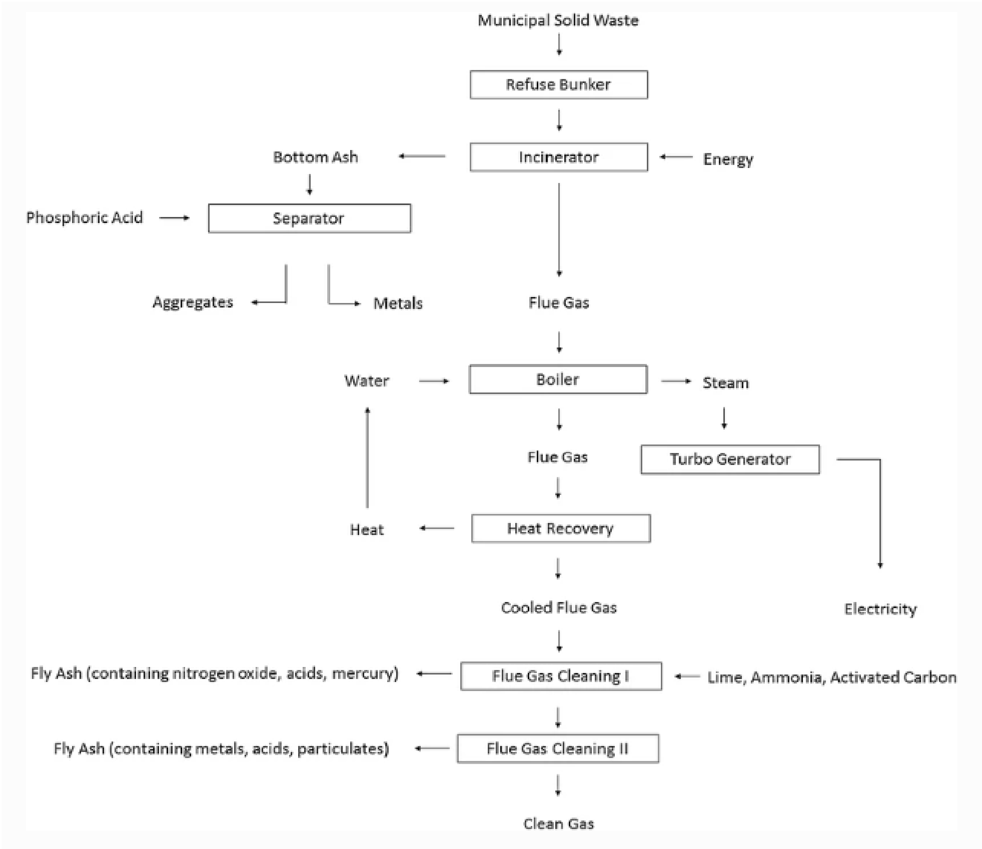


Figure 9. Metro Vancouver waste to energy (Elkamen and Shareefdeen , 2015)

2. Waste Based power unit at Kathoda ,Jabalphur,India.

11. 5 MW of waste is produced from daily waste of 600 tonnes produced.This provides electricity to 18000 homes in Jabalphur. This project has been running since 2020 and is successful under PPP. The waste is however not segregated producing minimal pollution. (Sharma and Tripathi 2013).

Figure 10. Non segregated waste at Jabalphur (Sharma and Tripathi, 2013).

3. Data Collection

Data was collected from the Warren Park Polyclinic via secondary data collection means from the books of the Warren Park Polyclinic. Data survey was also collected from medical centres with incinerators such as Suburban Clinic, Malbereign clinic and Parirenyatwa clinic by asking questionnaires which consisted of 5 multiple choice questions and 8 questions with a 10-point Likert scale response. The survey was designed for any 15 random workers who include the team working at the incinerators and also medical aid workers who collect the medical waste that is from 20 February 2023 to 03 March 2023. The participants were given 5 minutes to fill the form anonymously and 47 were recorded which however 42 were recorded as the rest were not fully completed. Data was collected via more quantitate data collection methods than qualitative as it is less biased, less time consuming and focused.

4. Methods

For the research, the researchers used various methods such as

1. Autodesk Invertor for the 2D and 3D designs together with its simulations of the suggested design prototype.
2. Mat lab for calculating complex design equations
3. Autodesk inventor was used for CFD heat analysis of the chamber.
4. Arduino Uno for the temperature design of the control panel.
5. Use of labs in determining the relative abrasion resistance of refractory bricks.

5. Results and Discussion

5.1 Numerical Results

From the research there were the following results:

The sum of garbage produced from the Warren Park Polyclinic and Suburban Clinic as it also sends its waste to warren park polyclinic which is next door on a once-a-month and day-to-day basis was measured so as to get a illustration extent of garbage to be castoff for the design purposes.

Table 2. Amount of waste produced by the 2 clinics.

Amount of waste produced from clinics	Per day	Per week	Per month
Warren park clinic	30 kg – 55kg	200kg – 300kg	800 kg – 1500 kg
Suburban Clinic	10 – 25 kg	70 – 100 kg	280 – 400 kg

Where 55 + 25 = 80kg.

Total oxygen from waste for stoichiometric burning per hour,

Tissue (9.78) + polyethene (72.72) + cellulose (29.5) + Polyvinylchloride (32.3) = 114.3kg/h

Assume Fan efficiency of 75% and motor efficiency of 90%

Power required for FD Fan, BHP = Flow * Head/ (Efficiency *75.8)

Motor Power required = 0.57*0.90 =0.51 say 0.5HP

Calculating water that is to be boiled from waste energy

Q = V * $\rho * C_p$ * ΔT

Where,

Q = heat content in joules

V = flow rate (m^3/s)

ρ = density of flue gas (kg/m^3)

C_p = specific heat of substance (J/Kg.K)

ΔT = temperature difference of in and out of system.

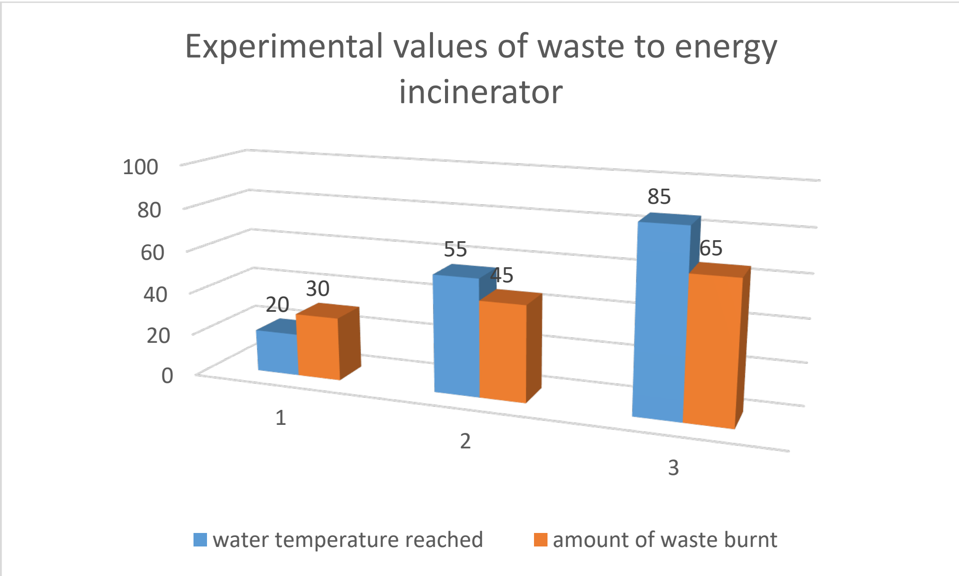
$$967.512975 = V * 0.33 * 2460.3 * (100 - 22)$$

$$V = 0.0153 * 3600$$

= 55 litres of boiled water for sterilization per burn.

5.3 Graphical Results

Table 3 . Experimental results of waste to energy.



5.4 Data Analysis

The estimates were made using the incinerator at Warren Park Clinic, which can burn 85 kg of medical waste every hour. Chikmagalur City, which has 11 hospitals and 27 private clinics and generates around 85 kg of trash per day, generated a mass balance analysis at a rate of 1607.6 kg per hour (Rajiv, 2017), which is more than the researchers' intended mass flow rate of 1338.8 KJ per hour. There is also one Baghdad Medical city Hospital of 100 kg/hr with the mass balance of 3564.86kg/h (Salam,2013). Kuwadzana has a mass rate of 1200kg/h.

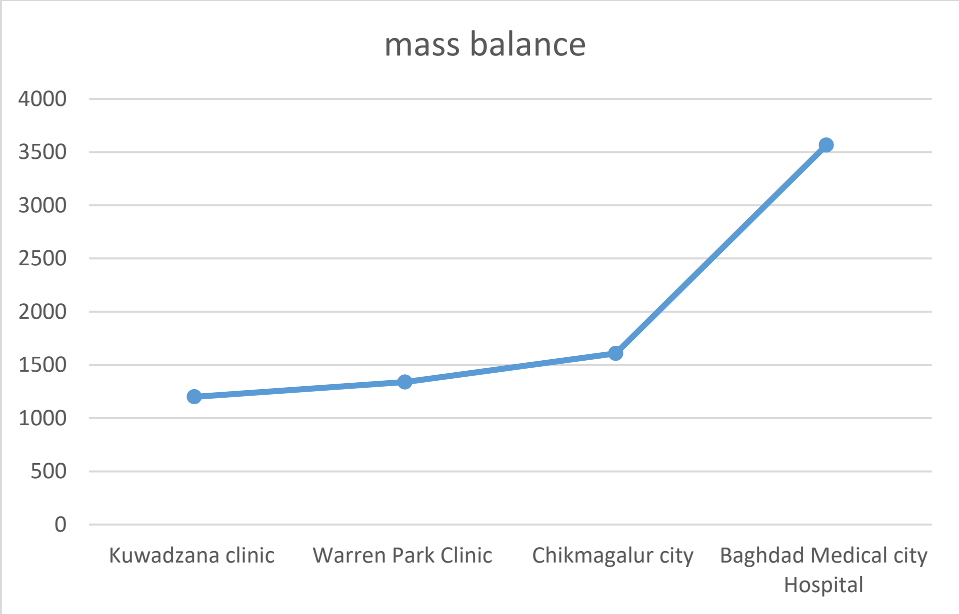


Figure 11. Graph comparing different medical institutions on mass balance

<u>Simulations on Incinerator</u>

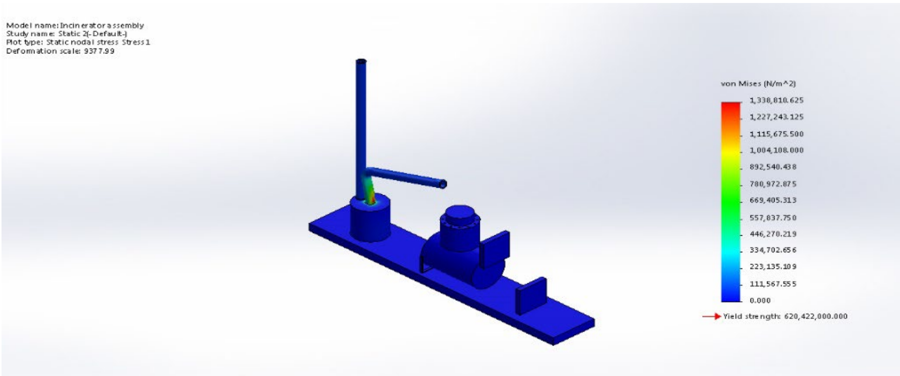


Figure 12. Von Mises Stress analysis of the connecting pipe.

5.5 Proposed Improvements

1. On the incinerator feed door, there is need for automatic tight fitting closing door so as to avoid un-purified and harmful smoke from escaping through the feed door which can impose danger to the surrounding people.
2. Need for pollution detecting sensors and display so as to measure and show the amount of pollution gases being released in the atmosphere so as to ensure there is thorough pollution control and filtering happening at the incinerator after every burn.
3. The energy recovery system can be added by encamping the heat harnessing mechanism that collects the heat that is not used for water heating to be used to provide heating in the clinic wards at zero to costs especially during the winter season as it will be very cold.
4. For safety the feed door should be automatic so as to enable minimum contact with the infectious waste.

5.6 Validation

During the prototype testing, smoke and heat was flowing back to the door and this was accounted for by inserting a second fan on the chamber.

To test the hypothesis of the draft fan problem leading to decrease in rate of combustion using the following hypothesis,

$H_{0=}\mu$ = 80kg/hr. (the draft fan will have no effect on rate of combustion)

$H_{1=}\mu < 80$ kg/ hr. (the draft fan will have effect on rate of combustion.)

And it concluded that the draft fan inefficiency leads to decrease in rate of combustion.

6. Conclusion

The largest value of the estimated quantity of waste was about 80kg per day which also included the waste from Suburban which is approximately 292 tonnes per year. This waste involves 70% yellow bags and 30% red bags. 3.07 m3 is discovered to be the design volume for the secondary chamber in order to maintain a retention time of one second. The heat energy balanced showed that the energy release from incineration can be used to boil 55 litres of water per burn which is sufficient for sterilisation at the Warren Park Polyclinic and satisfied the 3rd objective of designing an incinerator which heats water up to 99 degrees for sterilisation. The first objective was not 100 percent met as the draught fan was not performing to full capacity and the second objective was met as the incinerator was suitable for the clinic. Therefore the project was a success.

References

Bujak, J., Thermal treatment of medical waste in a rotary kiln. *Journal of Environmental Management*, *162*, pp.139-147, 2015.

Chandler, A.J., Eighmy, T.T., Hjelmar, O., Kosson, D.S., Sawell, S.E., Vehlow, J., Van der Sloot, H.A. and Hartlén, J., 1997. *Municipal solid waste incinerator residues*. Elsevier

Future, C.E., 2021. What is Waste Incineration? [WWW Document]. Conserve Energy Future. URL https://www.conserve-energy-future.com/advantages-and-disadvantages-incineration.php

Johnson, I., Choate, W.T. and Davidson, A.,*Waste heat recovery. Technology and opportunities in US industry*. BCS, Inc., Laurel, MD (United States), 2008.

Kolokotsa, D., Tsoutsos, T. and Papantoniou, S., Energy conservation techniques for hospital buildings. *Advances in Building Energy Research*, *6*(1), pp.159-172, 2012.

Lee, C.C. and Huffman, G.L., 1996. Medical waste management/incineration. *Journal of Hazardous Materials*, *48*(1), pp.1-30, 1996.

O. A. Mokuolu, "Health-care waste management, Microsoft power point presentation for HCWM-SQHN" Kwara state 2009, Nigeria.

Selvan Christyraj, J.R.S., Selvan Christyraj, J.D., Adhimoorthy, P., Rajagopalan, K. and Nimita Jebaranjitham, J., Impact of biomedical waste management system on infection control in the midst of COVID-19 pandemic. *The Impact of the COVID-19 Pandemic on Green Societies: Environmental Sustainability*, pp.235-262,2021.

Shareefdeen, Z.M., Medical waste management and control. *Journal of Environmental Protection*, *3*(12), p.1625, 2012.

Shareefdeen, Z., Elkamel, A. and Tse, S., Review of current technologies used in municipal solid waste-to-energy facilities in Canada. *Clean Technologies and Environmental Policy*, *17*, pp.1837-1846, 2015.

Sharma, S. and Tripathi, A., Energy from Urban Waste: A Mysterious Opportunity for Energy Generation Potential. *Urban Energy Systems: Modeling and Simulation for Smart Cities*, p.141, 2023.

Sheng, C. and Azevedo, J.L.T., Estimating the higher heating value of biomass fuels from basic analysis data. *Biomass and bioenergy*, *28*(5), pp.499-507, 2005.

Windfeld, E.S. and Brooks, M.S.L. , 'Medical waste management – A review', *Journal of Environmental Management*, 163, pp. 98–108, 2015. Available at: https://doi.org/10.1016/J.JENVMAN.2015.08.013.

13Xie, R., Li, W.J., Li, J., Wu, B.L. and Yi, J.Q., Emissions investigation for a novel medical waste incinerator. *Journal of hazardous materials*, *166*(1), pp.365-371, 2009.

Zhao, H., Liu, H., Wei, G., Zhang, N., Qiao, H., Gong, Y., Yu, X., Zhou, J. and Wu, Y., 2022. A review on emergency disposal and management of medical waste during the COVID-19 pandemic in China. *Science of the Total Environment*, *810*, p.152302.

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Tawanda Mushiri is a Senior Research Fellow at the University of Johannesburg in the Faculty of Medicine and Health Sciences. His education is as follows: PhD (Doctor of Engineering), fuzzy logic system design for reducing machinery failure in industries and was obtained at the University of Johannesburg in 2017; Master's degree in Manufacturing Systems and Operations Management (MSc. MSOM) from UZ, which he completed in 2012. He did an MSc in Medical Physics at National University of Science and Technology in Zimbabwe (2019 – Sept 2022). For this masters he mastered Radiotherapy for Cancer Treatment, Nuclear Medicine, Radiation Protection and Safety, Medical Electronics and Instrumentation and Diagnostic Radiology. His main research is on Breast Cancer Treatment using Machine Learning and a BSc in Mechanical Engineering in 2008 from the University of Zimbabwe. His main research focus is on the Robotic First Aid (RFA) systems to reduce Road Traffic Accidents (RTA). He is the point person for Artificial Intelligence at UZ.