EFFECT OF COMBUSTIBLE MATERIAL AND FORCE ON POROSITY OF CERAMIC MEMBRANE.

A PROJECT REPORT

Submitted by

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ABSTRACT

Ceramics are inorganic, nonmetallic solids and crystalline amorphous materials whose molecules are held together by covalent bond and /or ionic bonds. They are usually; hard, brittle, stable to high temperatures, less dense than metals, more elastic and have very high melting points. Ceramics are mostly made from clay soil. Ceramic water filtration involves the use of a porous ceramic (annealed clay) medium to filter microbes and other contaminants from water. The ceramic water filters have undergone improvements to the extent of being able to treat water contaminated by bacteria. Therefore, the project investigated porosity of the ceramic filter with the aim of coming up with a more porous ceramic filter to provide enough water for household level. The filters that were investigated were developed by mixing clay and sawdust in various proportions by volume. The ratios of clay to sawdust that was used were: 60:40, 55:45, 50:50, 45:55, and 40:60 respectively.

The clay and sawdust were measured in volume ratio and mixed thoroughly using a mixer while dry and thereafter made into a workable mass (dough) by adding mrenda *syrup* .This is then mixed until it clamps together completely and soft .Once a workable mass is attained, it was wedged to mix the clay further and remove bubbles from the dough. Different dough were made and molded to disc-shaped using a hydraulic press. The disc-shaped ceramic membrane was then left to dry under room temperature for 14 days before annealing using a programmable furnace. The annealed filters were then subjected to porosity test by using Archimedes immersion technique. It was observed that porosity decreases with increase in ratio of clay to sawdust ,force used during molding also had an effect on porosity in a sense that increase in force reduced porosity.

Contents

DECLARATION

I declare that this project is my original work and has never been presented to any other examining body.

NAME: KIBENI M. PHILEMON.

SIGN: ……………………

DATE: 25th Sep 2017 ……………………...

DECLARATION BY THE SUPERVISOR

This project has been submitted with my approval as the supervisor of Maasai Mara University under the Department of Mathematics and physical science (MPS).

DR. OTIENO FREDRICK

SIGN…………………………………….

DATE…………………………………….

DR. MOTOCHI ISAAC

SIGN……………………………………

DATE…………………………………..

DEDICATION

This study is dedicated to my mother Beatrice Cheptai ,brothers and sister together with my friend Mboa Vincent

ACKNOWLEDGEMENT

I would like to thank the ALMIGHTY GOD for giving me health and strength throughout my studies.

Am grateful for all the people who contributed towards my studies in one way or the other.

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For the undying shadow of the late Stephen Mzee Kipterit Machezo, my father a source of my Happiness .His inspirations and encouragement has enabled me to overcome the challenges of life and maneuver enthusiastically to the point of attaining this level of education -His love was unconditionally beyond his grave …….. May his soul rest in eternal peace.

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ACRONYMS

C-Clay

NGO-Non-Governmental Organization

PFP-Potters for peace

PMMA-Poly methyl methacrylate

PS-Polystyrene

SD-Saw dust

WHO-World Health Organization

YSZ-Yttria –Stabilized Ziconia

CHAPTER ONE: INTRODUCTION

1.0 CERAMIC WATER FILTER

Ceramics are inorganic, nonmetallic solid crystalline amorphous materials usually made of clay soil. Constituent atoms/ molecules are held together by ionic and/or covalent bonds. A filter is a device, instrument, or material which removes something from whatever passes through it. Ceramic water filtration can therefore be defined as, the process that makes use of a porous ceramic (fired clay) medium to filter microbes or other contaminants from water (Brown, Sobsey and Proum,2007).The pore size of the ceramic medium is sometimes smaller enough to trap anything bigger than a water molecule

1.2 BACKGROUND

Outbreak of water-borne diseases is common in Kenya; this is due to supply of unclean water and poor sanitation. This has led to death of many children each year from diarrhea and other related waterborne diseases. Research has shown that National Formal Water Supply can only supply clean water to 42% - 59% of the Kenyan populace- (National Water Quality Management Strategy, 2012). This implies that the rest of the populace relies on rain water and other open water sources like rivers, streams, ponds and lakes. Open water sources are prone to contamination due to domestic waste and industrial activities which discharges organic contaminant into natural waterway. Use of ceramic water filtration is one of the viable solution to the problem at hand. This is because, its capable of removing more than 99% harmful coliform and fecal matter when properly handled (Oyanedes et al 2008, Bielefeld et al ,2009,2010)

Although ceramic filters have proved to be effective in improving water quality users and implementers often express concern over their inability to produce sufficient quantity of water due to their slow flow rate of approximately 1-2 liters per hour (L/H) which arise due to porosity. If porosity could be increased, the rate of filtration will increase hence producing enough water.

1.3 STATEMENT OF THE PROBLEM

Ceramic water filters are effective in removing contaminants in water including microbes that affects water quality. The problem of ceramic filter has been its low flow rate that leads to insufficient amount of water needed in many households. This project intends to improve on the flow rate of ceramic water by increasing the density of pores without compromising the structural integrity of the filter membrane. The study aims at producing a membrane with high porosity by optimizing the ratio of kaolin to combustible materials.

1.4 OBJECTIVES

1.4.1 Main objective

- To improve the porosity of ceramic a membrane.

1.4.2 Specific objectives

- Identify the correct ratio of clay to combustible material that gives high porosity
- To get the loading forces required for moulding highly porous and -effective ceramic membrane

1.5 SIGNIFICANCE

The work will produce ceramic membranes that if used will lower the spread of water-borne diseases. The economy is going to grow because money that would have been used in public health in treating diseases caused by water-borne diseases from contaminated drinking water would be used elsewhere to uplift living standards.

1.5.1 JUSTIFICATION

Ceramic membranes with high porosity will help the growing Kenyan population to get clean water in the required quantity. Achieving this would mean enough water will be available at household level. This reduces death rate especially among children.

CHAPTER TWO: LITERATURE REVIEW

2.1 CERAMIC WATER FILTER

A filter is a device, instrument, or material which removes something from whatever passes through it.Ceramic water filtration can therefore be defined as, the process that makes use of a porous ceramic (fired clay) medium to filter microbes or other contaminants from water (Brown,Sobsey and Proum,2007).The pore size of the ceramic medium is sometimes smaller enough to trap anything bigger than a water molecule

2.2 IMPROVEMENTS IN THE WATER TREATMENT METHODS

The improvements of water treatment methods from ancient times to the present have been necessitated by the desire to remove contaminants that affects appearance of water. This includes, removal of the bad taste of water and further to eliminate pathogens (The water exchanger, 2012).From the boiling of water to kill germs and then filtering through a cloth rag ,to the ceramic membrane for removing bacteria from water and the ceramic pot filter developed by Dr. Fernado Mazeriegos of the Central American Industrial Research Institute (ICAITI) in Guatemala ,to bacterially contaminated water safe for drinking. Ceramic filters were popularly used for centralized water treatment but recently, they are being manufactured for point of use application. (National Academy of science, 2008) and the World Health Organization (WHO)encourages its use as household water treatment system (HWTS) for effective treatment of drinking water. These porous ceramic water filters which vary widely in design, effectiveness, and cost are now treated with a silver solution which acts as a microbicide to inactivate bacteria and this has contributed to the increased performance of ceramic water filter. However, the ceramic filter has been shown to be limited and incapable of treating the viral and chemical contamination in water.

2.3 WATER-BORNE DISEASES

The most common water-borne diseases are; cholera, typhoid and hepatitis A .These are caused by bacteria and are most common diarrheal diseases. Other water-borne diseases are caused by parasites that live-in water e.g. dysentery. The parasite arises from contamination of water sources by the feces of infected individuals. Sources of water-borne diseases includes; lakes, streams, rivers and dams where people get water for drinking and bathing. More than four million diarrhea cases are reported worldwide per year. This constitutes about 2.2million death (WHO, 2008a). It's estimated that 1.9 million of those deaths occur to children below 5 years.(Bosch pinto et al, 2008). Apart from death diarrhea leads to other health problem like dehydration. A frequent occurrence of diarrhea due to malnutrition among children exposes them to other harmful diseases which might temper with cognitive development hence leading to stunted growth.

2.4 ACCESS TO SAFE DRINKING WATER

In Kenya, The national Formal Water Supply can only supply water to between 42% to 59% of Kenyan populace (National Water Quality Management Strategies,2012).This means the remaining populace rely on rain water catchment ,rivers, streams, dams, ponds and lakes for drinking and domestic use(Albert et al.2010).These sources are prone to contamination from poor sanitation and industrial activities which discharge organic contaminants into natural waterway .88% of diarrheal disease is related to unsafe water and poor sanitation facilities (WHO,2007).Need for supply of safe water has raised the eyebrows and made a global health topic hence a solution to it is needed.

2.5 POROSITY AND RATIO OF COMBUSTIBLE MATERIALS IN A CERAMIC MEMBRANE

Performance of ceramic membrane depends on porosity. The study on comparing porosities of samples with different ratios of combustible materials has been done conclusions made from them on how porosity varies with volume of combustible materials. Below are tables showing the ratio by volume of kaolin and combustible materials used in research by different researchers. The table below shows information for the filter studied by Klarman(Molly K, 2009) with three replicates

2.5.1Table 1: Table showing ratio of clay to sawdust used by Molly Klarman

Filter ID	% Combustible volume	% Clay volume	Combustible type	Screen size
53C:47S	47	53	Pine sawdust	0.30
50C:50S	50	50	Pine sawdust	0.30
55C:45S	45	55	Pine sawdust	0.30
60C:40S	40	60	Pine sawdust	0.30
45C:55S	55	45	Pine sawdust	0.30
40C:60S	60	40	Pine sawdust	0.30
0.45µm	47	53	Pine sawdust	0.30
Coffee husk	47	53	Coffee husks	0.30
Rice husk	47	53	Rice husks	0.30

Source (Molly K, 2009)

53%C:47%S was used as a standard used by the filter pure factory. Highest porosity was found at the sample with high percentage by volume of pine saw dust. That is 40C:60S.

2.5.2 Table 2: Table showing ratio of clay to sawdust used by Kelbesa

Clay soil	Grog/ gely	Sawdust	Clay: Sawdust
40	10	50	50C:50SD
43	10	47	53C:47SD
45	10	45	55C:45SD
50	10	40	60C:40SD
55	10	35	65C:35SD

Source: (Kelbesa , 2010)

50C:50SD means fifty percent clay and fifty percent sawdust by volume

2.5.3 Table 3: Table showing ratio of clay to sawdust used by Martin Ochukwu and Nelson Arome

No.	%Clay	%combustible material	Type of combustible materials	Screen size(μm)^2	References
1	80	20	Rice hulls	600	80C:20Rs
2	70	30	Rice hulls	600	70c:30Rs
3	70	30	Rice hulls	425	70C:30Rs
4	60	40	Rice hulls	600	60C:40Rs
5	80	20	Sawdust	600	80C:20Cs
6	70	30	Sawdust	600	70C:30Cs
7	70	30	Sawdust	425	70C:30Cs
8	60	40	Sawdust	600	60C:40Cs

The results for porosity showed that porosity increased with increased percentage by volume for sawdust. Ebele Erhaunga and fellow researchers successfully developed a ceramic filter for household water treatment in Nigeria. It was found that charred animal borne and charcoal volume ratio in the filter increased the porosity of the resulting filter sample (Erhaunga, 2014). Ndungu's study also associated increase in volume of sawdust material to increase porosity (Ndungu, 2015).

Porosity of ceramic membranes varies from one place to another due to properties of the materials used in making the membrane. Membranes made by same volume ratio of kaolin and combustible material but in different places have shown difference in porosity, for instance, membranes made in Cambodia, Ghana and Nicaragua had porosities of 43%, 39% and 34% respectively though they had same ratios of kaolin to sawdust.

Main combustible materials includes hardwood sawdust, coke seed, Naphthalene and occasionally fire ground coke, flour, corn husk,(Crimshow ,1991) and rice husk (Nardo,2005).Petroleum waste products can also be used though they burn out at higher temperature than wooden sawdust(Kamaniska and valuikevicius,2005).Wood consists of volatile oil and small quantities of mineral content. These mineral matter includes; calcium, potassium and magnesium (Kamaniska and Valuikevicius,2005).Hardwood sawdust preferred over softwood sawdust because it does not ‘bloat’ as much as sawdust from softwood, thus leading to membranes having more uniform pores and fewer defects(Kabagambe,2010).Wood sawdust is preferred over other combustible material like coffee husk and rice husk due to their ability to form homogenous mixture with clay(Molly K,2009).Combustion yields ash from mineral matter. This ash constitutes 0.1% to 1% by volume which has little effect on porosity of the ceramic membrane. Mineral ions oxidize and volatilize or form particulate (Regland et al, 1991). Rice husk are not preferred choice because they have low heating value and are characterized by high ash content (18%-20%) by weight (Nardo, 2005).

Removal of contaminants using the ceramic membrane depends on the size of the pores. Membranes showing large pore size will not be effective in removing precipitates and/or bacteria from water as compared with membranes having small pores. This leads to collection of more water per hour (maltelet, 2006).For higher filtration rates, porosity should be high but the pores should be very small in diameter for effective filtration.

Filtration of water by a ceramic membrane depends on the amount of and size of combustible material (sawdust)which have been milled and screened and burnt in the kiln leaving a network of fire pores (Harvey,2008).

Different methods can be used in determining the volume porosity P,of a ceramic membrane. These include;

2.5.4 Ultrasonic pulse velocity (UPV) Measurement.

This is a simple accurate method which can detect and defect (Hall and Hoff, 2010).Porosity and ultrasonic pulse velocity relates as shown below.

$$V_L = V_{LO}\,(1 - MP)$$

Where V_L is the ultrasonic pulse velocity in the porous material V_{LO} is the ultrasonic pulse velocity of the filter at zero porosity, M is a constant which is a function of poison ratio rearranging the above equation we have

$$P = \frac{\Delta V}{MV_{LO}}$$

Where ΔV is the change in the ultrasonic pulse velocity of the specimen

2.5.5Density method

Porosity is defined in terms of bulk density according to the relation (Volkovish and Sakar,2005)

$\rho_B = P\rho_a + (1-P)\rho_S$

Where ρ_B is bulk density of sample ρ_S is density of the pure solid $\rho_a$is the density of air which is much smaller than ρ_B ,Other methods for determining porosity include gas expansion method, optical method, mercury standard porosity and the most recent is the automated standard porosimeter (ASP) which is based on the laws of capillary equilibrium (Volkovish and Sakar, 2005)

2.6 PREPARATION TECHNIQUE FOR HIGHLY PERMEABLE CERAMIC MEMBRANE

Permeability of ceramic membranes primarily depends on its porosity, pore tortuosity and pore morphology .Highly permeable ceramic membrane is achieved by use of pore and fiber building method. Pore method involves adding the number of holes to allow for expansion hence improving the porosity of a ceramic membrane (Cao et al, 2009). Pore method is achieved by use of special kind of pore-forming agents. Template method being a pore forming agent have specific pore size and shape so ordered, increases porosity of a ceramic membrane when used (Peng Wu et al,2015). Here ceramic fiber structures rule film fiber structures to make holes diversification of channel in order to achieve increased porosity (Peng Wu et al, 2015)

The pore forming agent is classified as inorganic and organic type. Most common inorganic pore-forming agents includes; ammonium carbonate, Ammonium bicarbonate and ammonium chloride salts or other inorganic carbons that requires high temperatures to decompose e.g. coal, graphite and ash (Peng Wu et al,2015).Organic pore forming agents includes natural fiber, polymers such as sawdust ,shell flour ,starch, polystyrene (PS),Polymethyl methacrylate (Fu et al,2011,Liu et al,2012,Bhattacharje et al,2007,LI et al,2013)

Research has been done using different pore forming agent and desirable results obtained from them. A ceramic filter with 20vol%BN/SiN_4 and different volume fraction and different fractions of PMMA sphere as pore forming agents gave a porosity of 32.5% to 45.8% (Shao et al,2009).Liu and Wang successfully fabricated porous Ytria-starbilized Zirconia (YSZ) Ceramic by the dry pressing method with different sizes of mono-dispersed poly methacrylate (PMMA) micro-ball (Liu and Wang,2013).

Yang and Tsai used the Alter beg limit test for understanding effect of starch addition to the plasticity of paste (Yang and Tsai, 2008).A study on possibility of enhancing permeability of porous SiN_4ceramic was done by using pore forming additive in form of potato starch (Tolapates et al, 2009).The open porosity of the sample changed between 52% and 66%.

Investigation on porosity using sawdust as a pore forming agent has been done and the results shown that increase in the amount of sawdust do increase the porosity of the ceramic membrane (Molly, 2009; Plappally, 2009; Kelbesa, 2010;Travis,2010;Okechukwu and Isikwue ,2011 and Ndungu,2015).It compliment the a study that was done in Nigeria charred cattle bones and charcoal where the sample with high ratio of charred cattle bones and charcoal gave the highest porosity of 42.26% (Erhaunga et al,2014).

CHAPTER THREE: MATERIALS AND METHODS

3.1. ASSEMBLY OF MATERIALS

Materials used include clay, sawdust and *mrenda syrup*. Clay was collected in Kitale . Sawdust was obtained from eucalyptus tree. Mrenda syrup was extracted from mrenda.

3.2. FABRICATION PROCESS

The ceramic water filters production process follows some common steps regardless of the type of filter being manufactured. The process typically begins with material selection and processing; followed by shaping and pressing the filter element into a mold; drying; Annealing. The primary materials used in the production of ceramic water filters are clay, *mrenda* syrup and combustible material. Usually these materials require processing such as grinding and sieving before they can be mixed together into a uniform mixture that is pressed into a cylindrical shape (Molly, 2009).The following are the basic steps for making a ceramic disc shaped filter (Hagan *et al.* 2009).

1) The raw materials are prepared

- Dry pulverized clay
- A combustible material that has been sifted through a screen so that particles are uniform in size
- Solution of water mixed with *mrenda*

2) The materials are thoroughly mixed using a clay mixer

- First the dry ingredients are added to the mixer and mixed dry
- Water is then uniformly added to get a smooth clay mixture
- The clay is mixed for at least ten more minutes

3) The clay is divided into blocks of approximately 8 kilograms

4) Each clay block is molded into a desired shape using a hydraulic press

- The outer surface of the pressed filter is smoothed over with a plastic scraper to ensure it is even and the rim is sturdy
- Each filter is labeled with a unique stamp/number

5) Filters are dried in the shade for at least three to four hours as they begin to harden.

6) Filters continue to dry on a drying rack for 7-18 days (depending on the climate) to remove excess moisture, which could cause the filter to crack during the annealing process

7) Filters are nicely spaced inside the kiln heat distribution will be uniform

8) Filters are annealed in the kiln where the combustible material burns away forming pores and the clay becomes hard.

- The temperature of the kiln chamber is initially raised to 100 °C for two hours

to remove any remaining moisture

- The temperature is then gradually raised to around 900°C to allow for vitrification (silica and alumina molecules within the clay melt and bond and the chemical structure of the clay is altered)

9) Filters are allowed to gradually cool

- They are first cooled in the kiln for about 24 hours
- They are then moved to drying racks where they continue to cool

10) Silver is applied to the filter as a chemical barrier to bacteria

- The silver solution can be made with silver nitrate or colloidal silver and solution concentrations vary depending on the purity of the silver
- The silver solution is either painted on to both the inside and outside of the filter or it is submerged in the silver solution

3.3. CERAMIC DISC WATER FILTER DEVELOPMENT PROCESS

The filter development process includes grinding clay and sawdust to create a fine powder. The powders was measured and placed in a mixer where the mixing was thoroughly done for 10 minutes to form a uniform mixture and then mixed with *mrenda syrup* to make a workable mass (dough). The wet mixture was molded using a hydraulic press for shaping to obtain the disc shape of the filter measuring 12cm in diameter and 1cm thick. After obtaining the disc shape from the dough it was left to dry in the open at room temperature for a period of two weeks and thereafter taken to the kiln for annealing.

3.3.1. Process Description

Sieving the clay and sawdust was the first step and important to ensure that the pores in the final product were the appropriate size to ensure particle size consistency in the mix. The proportions of the clay and sawdust were measured by volume and placed in a container. The dry mix was mixed in a container by rolling back and forth before putting it in the mixer for thorough mixing.the figure below show the process of sieving sawdust

Figure 1:sieving sawdust

Figure 2 Preparing dry mix by rolling back and forth

The mixture of clay and sawdust was then transferred to the mixer where thorough mixing was done.

Figure 3: Thoroughly mixed Clay and sawdust mixture

720ml of *Mrenda* was measured and then four beakers (250ml beaker) full of the mixture was then added to the syrup. The approximation of 180ml of mrenda syrup per beaker (250ml beaker full) was used so that the mix was not too wet or not too dry for molding. When the wet mix was prepared, it became a moist lump of clay. After this step, the clay was wedged to drive the moisture and get all the air out of the mixture. Wedging consists of folding the clay over upon itself repeatedly and applying pressure. After wedging, the mix became a consistent, air free, and lump of wet clay. The wet mix was then placed in a mold before pressing with a hydraulic press into disc shape filter as shown in figure 8 .Grease was used as a lubricant for the hydraulic press to prevent specimen from sticking to the still mold as well as to reduce friction between the piston and the cylinder during compaction. The following are the steps to press the filter on a hydraulic press;

- Raise the male out of the female mold by turning the bar; lock it into by fitting the male using a nut on the upper part of the press to tighten the threatened shaft.
- Remove the female mold from the hydraulic press.
- Fix metal plate and wetted plastic bag over the female mold.
- Put the dough on the female mold, then by using a fist, create an evenly-distributed depression several inches in the cube of clay this is necessary to allow the male mold to fit into the female
- Put a metal plate on top of the dough ready to be pressed and place the female mold on the press then adjust it by pumping to make the female mold to move up as the male mold is fixed using a bold till the male mold fits into the female mold and press the dough until the excess clay emerges from all sides and the male and female mold are nearly touching on all sides.
- The hydraulic press is released to allow the female mold to move downwards and a room for its removal is created.
- Remove the female mold and turn it upside down on a flat surface raised
- Using a sharp object, press the metal plate that we place into the female mold while holding the female mold till the pressed filter is removed
- Pull the plastic bag to the edge of the raised surface to allow the metal plate below the pressed filter to be removed.

- Finish each filter manually using very wet mixture of clay and sawdust to minimize the surface cracks
- Immediately after finishing the filters label them for future identity
- Leave the filters to dry for two weeks under room temperature and pressure to remove excess moisture which could cause the filter to crack during the Annealing process

Figure 4:Dough placed in the female mold

Figure 5: dough ready to be pressed in the hydraulic press

Figure 6: Pressing the wet mix to the disc shaped filters

Figure 7: Removing the filter from the female mold using a sharp object

Figure8: filter removed from the female mold ready to be air dried

After shaping, the filters dried. The purpose of drying was to remove as much moisture as possible before placing the filters in the furnace. If the filters have excessive moisture, the water evaporates inside the clay when it is annealed and causes the filters to crack. The filters were placed in a dry open space for two weeks

The dried out, prepared filters were placed in the furnace to be vitrified (chemical process which hardens and glassifies the clay).The process involved the use of a programmable electrical furnace. The furnace is first heated slowly to 100^{o}C ,temperature causes the pore water in the clay to boil off and escape .The temperature of 100^{0}C is reached after 10min.The temperature was then raised to 450^{0}C within 30 minutes and the temperature held at this level for 3 hours ,at this temperature water chemically bound to the clay is driven off converting the clay into a hard ceramic .At this point the clay is no longer held together by water, but by sintering ,here small point of contact between clay crystals are held together .The temperature is then increased to 900^{0}C,there are some occurrences that takes place between 700^{0}C to 900^{0}C .At 700^{0} burning process takes place, here Carbon ,Sulphur and Organic molecules begins to combust .This is a crucial process in making filters .This is because pores left over from the burned off sawdust which contributes significantly to the filtering process . The burning reaches the peak at 800^0C, hence complete by 900^0C.The final process that takes place during annealing is Vitrification it starts at 800^0C and involves a glass of metal oxides and silica filling the pores between clay crystals strengthening the ceramic but also reducing porosity. The optimum firing temperature is reached at 890^0C.At this temperature there is a balance between porosity and strength, here almost all the organic matter would have been burned off leaving behind pores and the vitrification process will be in progress through extensively lending some added strength to the final ceramic but also leaving many of the pores. After the ceramic piece was well cooked it was allowed to cool slowly to room temperature.

The process of determining porosity is then done after the sample was cooled to room temperature. This is a crucial step in the development of the filters (Figure 11). After the filter was cooked, the furnace was allowed to cool slowly until the filter can be handled by hand.

Figure 9: component of a furnace

Figure 10: ceramic filters in a furnace

Figure 11: Furnace programmer

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 DEVELOPMENT OF DISC SHAPED FILTERS

Disc shaped ceramic filters were developed by combining clay soil and sawdust from hardwood by volume ratio as shown in table 4.

Table 4:Volume ratio of clay and sawdust used to develop filters

Percentage by ratio		
Clay soil	Sawdust	Clay : sawdust ratio
40	60	40:60
45	55	45:55
50	50	50:50
55	45	55:45
60	40	60:40

60:40 represent the proportion of clay to sawdust respectively i.e. sixty percent clay forty percent sawdust by volume.

Observation

Filters with high percentage of sawdust were observed to be weak and fragile

4.2 DETERMINATION OF SATURATION POINT FOR ABSORPTION OF WATER

To get the time taken by the ceramic filter to absorb water to a saturated point, samples of the filters wire socked in both hot and cold water. There was a slight variation on porosity when for samples soaked in cold and hot water as shown in table 5, 6 and 7

Table5:Sample composition 40C:60SD

Cold water				Hot water			
Weight of dry sample W_d (g)	Weight of saturated sample W_s (g)	Soaking time t (min)	Porosity	Weight of dry sample W_d (g)	Weight of saturated sample W_s (g)	Soaking time t (min)	Porosity
10.02	16.28	2	62.48	11.44	17.68	2	54.54
10.02	16.28	4	62.48	11.44	18.17	4	58.52
10.02	16.44	6	64.07	11.44	18.21	6	59.17
10.02	16.44	8	64.07	11.44	18.21	8	59.17
10.02	16.44	10	64.07	11.44	18.21	10	59.17

Table 6:Sample composition: 55C:45SD

Cold water				Hot water			
Weight of dry sample W_d (g)	Weight of saturated sample W_s (g)	Soaking time t (min)	Porosity	Weight of dry sample W_d (g)	Weight of saturated sample W_s (g)	Soaking time t (min)	porosity
7.32	9.72	2	32.79	12.80	17.87	2	39.61
7.32	10.28	4	40.44	12.80	17.93	4	40.08
7.32	10.43	6	42.48	12.80	18.09	6	41.33
7.32	10.56	8	44.26	12.80	18.09	8	41.33
7.32	10.56	10	44.26	12.80	18.09	10	41.33

Table 7: Sample composition: 50C:50SD

Cold water				HOT WATERT			
Weight of dry sample W_{d} (g)	Weight of saturated sample W_{s} (g)	Soaking time t (min)	Porosity (%)	Weight of dry sample W_{d} (g)	Weight of saturated sample W_{s} (g)	Soaking time t (min)	Porosity (%)
24.22	33.51	10	38.36	26.39	35.24	10	35.24
24.39	34.32	10	40.71	15.24	20.84	10	36.75

Table 8: RESULTS AFTER SUBMERGING THE SAMPLE IN HOT WATER AT 70^0C FOR 5 MINUTES

Sample composition	weight of dry sample W_d (g)	weight of saturated sample W_S (g)	Porosity (%)	Loading force(T)	volume of mrenda syrup per 250 mills beaker mixture
40C:60SD	118.1	184.1	55.93	1.09	180.0
	113.1	173.0	52.96	1.12	180.0
	98.4	151.8	54.49	1.00	180.0
	125.5	184.3	46.85	1.18	180.0
45C:55SD	150.7	221.9	47.25	1.09	180.0
	88.5	132.6	49.83	1.06	180.0
	122.4	177.5	45.02	1.00	180.0
50C:50SD	115.2	152.1	32.03	1.07	180.0
	118.9	154.7	30.12	1.09	180.0
	154.6	196.5	27.10	1.12	180.0
55C:45SD	172.0	217.9	26.69	0.90	180.0
	195.0	248.6	25.95	0.80	180.0
	99.1	135.3	36.53	1.00	180.0
60C:40SD	113.6	145.4	27.99	1.06	180.0
	152.7	187.9	23.05	1.07	180.0
	208.9	253.2	21.21	1.07	180.0

Table 9: RESULTS AFTER SUBMERGING IN COLD WATER FOR 10 MINUTES

Sample composition(Clay: Sawdust)	weight of dry sample Wd (g)	weight of saturated sample ws (g)	Porosity (%)	Loading force (T)
40:60	118.1	198.6	68.16	1.09
	113.1	189.9	67.90	1.12
	98.32	165.6	68.43	1.00
	125.5	211.9	68.79	1.06
45:55	150.7	230.9	53.29	1.09
	88.5	137.4	55.25	1.06
	122.4	190.2	55.39	1.00
50:50	115.2	157.6	36.81	1.07
	118.9	160.4	34.90	1.09
	154.6	204.6	32.34	1.12
55:45	172	225.1	30.87	0.90
	195	253.8	30.15	0.80
60:40	113.6	150.2	32.21	1.06
	152.7	194.4	27.30	1.07
	208.9	262.1	25.47	1.07

Variation of porosity and ratio of clay to sawdust was analyst using the graph of porosity versus ratio of clay to sawdust. The ratio of clay to sawdust was determined using the relation;

$$Ratio\ clay\ to\ sawdust = \frac{Proportion\ of\ clay}{Proportion\ of\ sawdust}$$

Table 10: Variation in porosity in hot water for different proportions of clay to sawdust

Sample composition (Clay: sawdust)	Ratio of clay by volume	Ratio of sawdust by volume	porosity 1 (%)	Porosity2 (%)	Porosity3 (%)	average porosity (%)
40:60	40	60	55.93	52.96	54.49	54.46
45:55	45	55	47.25	49.83	45.02	47.37
50:50	50	50	32.03	30.12	27.1	29.75
5:45	55	45	26.69	25.95		26.32
60:40	60	40	27.99	23.05	21.21	24.08

Table 11:Table of average porosity and ratio of clay to sawdust

average porosity (%)		47.37	29.75	26.32	24.08
Ratio of clay to sawdust	o.67	0.82	1.00	1.22	1.50

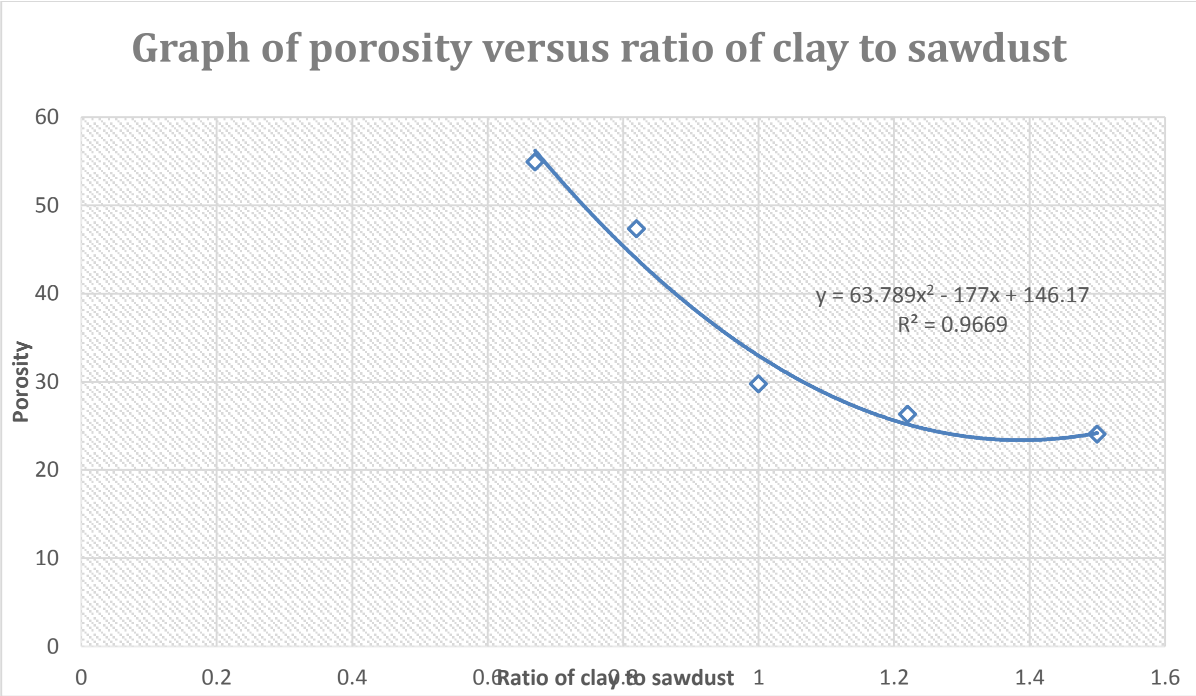


Figure 12: Graph of porosity versus ratio of clay to sawdust

Porosity of ceramic membrane reduces with increase in the ratio of clay to sawdust; this means high porosity is achieved by reducing the ratio of clay to sawdust. Using high percentage of sawdust gives lower ratio of the ratio of clay to sawdust. In this study porosity is predicted to be a linear polynomial with 96.69% accuracy as;

$$Y = 63.789X^2 - 177X + 146.17$$

Where Y is porosity of the filter and X is the ratio of clay to sawdust (Lee et al 2001)

Variation of loading force and porosity was analyzed by plotting a graph of loading force versus porosity using the values in table as shown in figure 13

Table 12: shows loading force and porosity

Loading force(Tones)	1.06	1.09	1.12	1.15	1.16
Porosity %	54.93	47.37	31.12	26.32	24.16

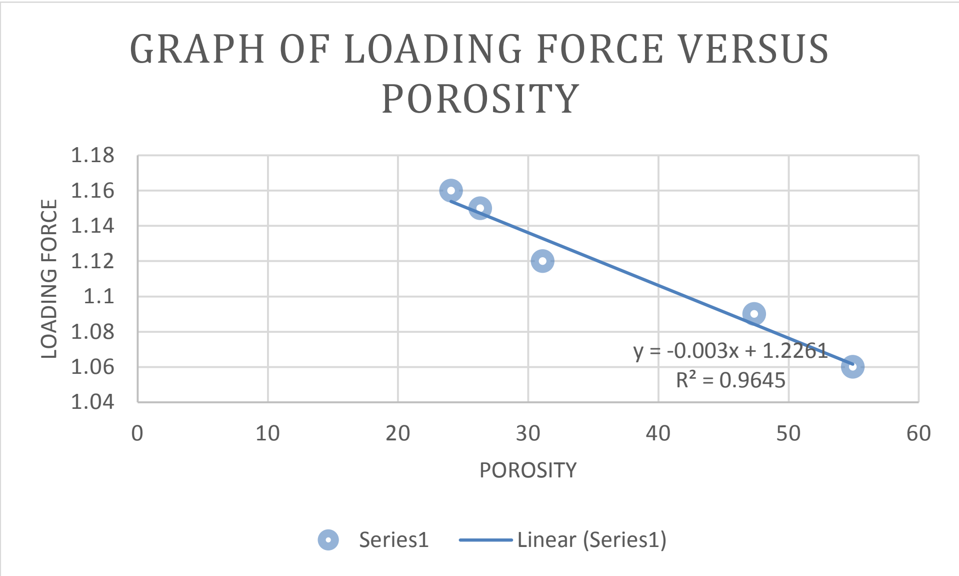


Figure 13: Graph of loading force versus porosity

The porosity of a ceramic membrane and the loading force are inversely proportional with an accuracy of 96.45% as

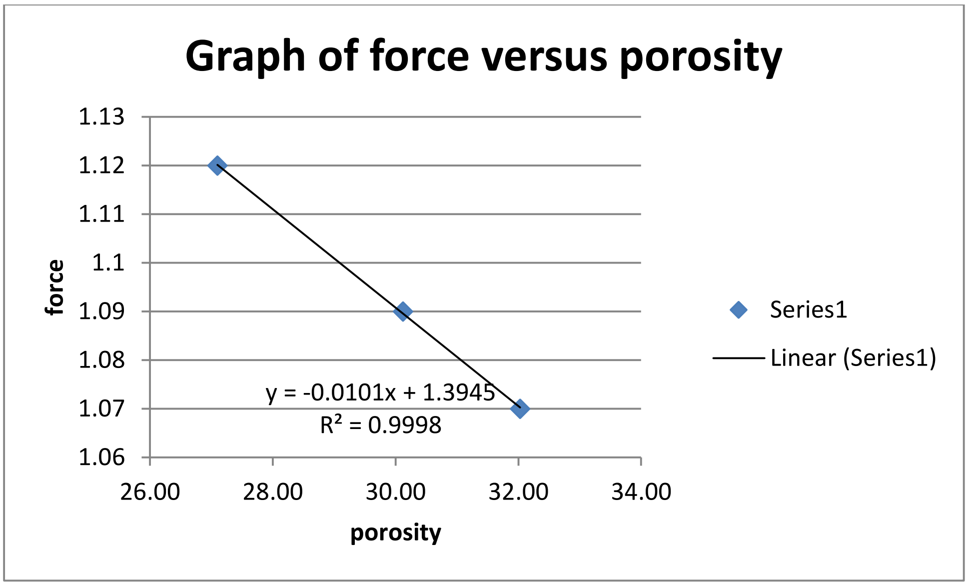
$$Y = -0.003X + 1.2261$$

Where Y is the loading force and X is the porosity of the ceramic membrane. The graph gives a slope of -0.003, when the line of the graph is extrapolated it cuts the loading force axes at a point where the loading force is 1.2261.The value 1.2261 signifies the loading force that would give zero porosity. Increasing the loading force tent to reduce porosity because as the force reduces the interconnection of the pores reduces until the point where there is no more interconnection among pore (zero porosity)

Variation of force with porosity holding then proportion of clay and sawdust constant was also used to investigate the effect of force on porosity.

Table 13:variation of force with porosity

Sample composition (clay: sawdust)	porosity	loading force (T)
50:50	32.03	1.07
50:50	30.12	1.09
5C:50	27.10	1.12



The tables below show how porosity varies in cold and hot water

Table14: variation of porosity in cold water

Sample composition (Clay:sawdust)	Proportion of clay by volume	Proportion of sawdust by volume	Porosity 1 (%)	Porosity 2 (%)	Porosity 3 (%)	Average Porosity (%)
40:60	40	60	68.16	68.43	68.79	68.46
45:55	45	55	53.29	55.25	55.39	54.64
50:50	50	50	36.81	34.9	32.34	34.68
55:45	55	45	30.87	30.15		30.51
60:40	60	40	32.21	27.3	25.47	28.33

Table 15: variation of porosity in hot water

Sample composition (Clay: Sawdust)	Proportion of clay by volume	Proportion of sawdust by volume	porosity 1 (%)	Porosity 2 (%)	Porosity 3 (%)	average porosity (%)
40:60	40	60	55.93	52.96	54.49	54.46
45:55	45	55	47.25	49.83	45.02	47.37
50:50	50	50	32.03	30.12	27.1	29.75
55:45	55	45	26.69	25.95		26.32
60:40	60	40	27.99	23.05	21.21	24.08

Table 16: ratio of clay to sawdust and average porosity of each proportion of clay and sawdust in cold and hot water

Ratio of clay to sawdust	Porosity in cold water	Porosity in hot water
0.67	68.86	54.93
0.82	54.64	47.37
1.00	38.91	31.12
1.22	30.53	26.32
1.50	26.37	24.08

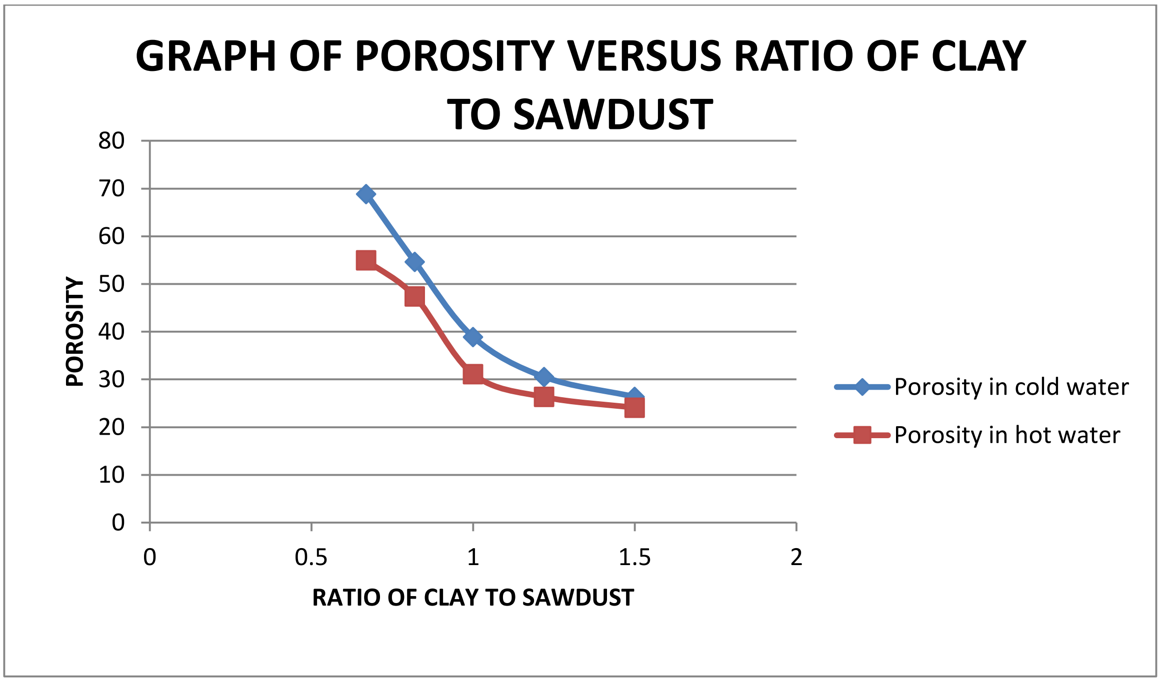


FIGURE 14 Variation of porosity in cold and hot water

4.3 CONCLUSION

Porosity increases with decrease in the ratio of clay to sawdust. The samples with higher proportion of sawdust by volume had higher porosities while those samples with low proportion of sawdust by volume had low porosity. Hence the higher the ratio of clay to sawdust by volume in the mixture the lower the porosity of the ceramic water filter fired at 950^0C.

The increase in loading force decrease porosity.From the graph and the equation zero porosity can be obtained if the porosity is increased to 1.2261.this because as we increase the loading force the interconnection of pores decreases until there is no connection of pores any more

4.4 RECOMMENDATION

Further research is recommended a programmable hydraulic press when investigating on variation of force that is used to make the ceramic filter with porosity is recommended. This is because the small difference in force is not effective to give good variation of force with porosity

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