THE PERFORMANCE EVALUATION OF FOUR TYPES WATER SOFTENER USED FOR BOILER

By

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Dissertation submitted in partial fulfilment of
The requirements for the
Bachelor of Engineering (Hons)
(Mechanical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
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Approved:

AP Dr Setyamartana Parman
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UNIVERSITI TEKNOLOGI PETRONAS
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July 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Anas bin Mohamed Nyan

ABSTRACT

This project is to the performance evaluation of four types water softener used for boiler, based on the existing commercial water softener. Many designs have been utilized today, so here is a project to determine the best design of a water softener tank.

Last semester, researches and studies are based on the existing commercial water softener. Design specifications and parameters are determined for a specified capacity of water usage. The first semester will be temporary halted by the initial drawing of the new design.

This semester, by using CATIA software, the designs of the tank are drawn. Design considerations will be judged for the designs. The project will continue with performance calculations and the final design drawing.

Then, the fabrication is conducted in the workshop to construct the tanks with different designs. After the experiments have been carried out, the results are taken and the performance is calculated. The data will be analyzed and the best design is chosen based on the comparison.

The comparison of performance is indicated by the hardness reduced, pH value and the conductivity of the water after the softening process. The highest value among four selected designs will be chosen as the best design with the best performance.

The discussion part will explain more about the result including the error occurred during the experiment. The recommendation for improvement also provided at the end of this report. As a conclusion, this experiment is successful to meet its objective in finding the best design of water softener for the softening process.

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First and foremost the author's utmost gratitude goes to the author's supervisor, AP Dr Setyamartana Parman. Without his guidance and patience, the author would not be succeeded to complete the project.

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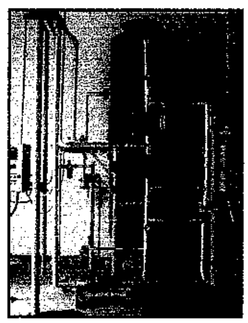

Figure 1.1: Water softener in industrial application

In the industry, water softener is used to remove the hardness in the water. The water softener is the equipment which contains resin inside the tank. Treated water from this equipment is called soft water. Hard water is water containing a quantity of dissolved minerals. When hard water is heated the carbonates precipitate out of solution, forming scale on the heat surfaces. Soap is less effective in hard water because it reacts to form calcium or magnesium salt from the organic acids of the soap. Soft water is treated water where the only cation is sodium. Hard water can be softened by passing it over an ion exchange resin to become soft water.

1.2 Problem Statement

Calcium and magnesium are hard scale forming minerals that build up on piping, heat exchangers, water heaters, boilers and any steam related equipment. This buildup results in costly repairs, increased energy consumption, plugged heat exchangers and boiler tubes. The service life of pipes, appliances and fixtures is greatly reduced due to these "hard" minerals.

This project is done to find the best design of a water softener tank which can service better for the boiler. For this purpose, a specified capacity will be used for this project.

1.3 Objectives of Study

Two main objectives are as stated below:

i) To characteristics and to study the softening performance of four types of water softener tanks.

ii) To study the specifications and the design considerations of the existing commercial water softeners.

iii) To design and develop a design of water softener for a specified capacity of water usage which has highest performance, based on the existing commercial water softeners.

1.4 Scope of Study

This project will cover on the specifications and the design considerations of the water softener, application of CATIA software and prototyping of the water softener.

The main points as the scope of study consist of the following:

i) Processes undergo between the resin and the water – Some processes that undergoes inside of the tank such as ion exchange and fluid flow.

ii) Design of the tank – The best design of water softener which considers all factors.

iii) Software usage for analysis – CATIA is used to draw the designs.

iv) Development of the new design – Prototype is made in smaller size through some manufacturing processes.

CHAPTER 2

LITERATURE REVIEW

Review for the study was taken abundantly from books, journals and the internet.

2.1 How Water Softener Works

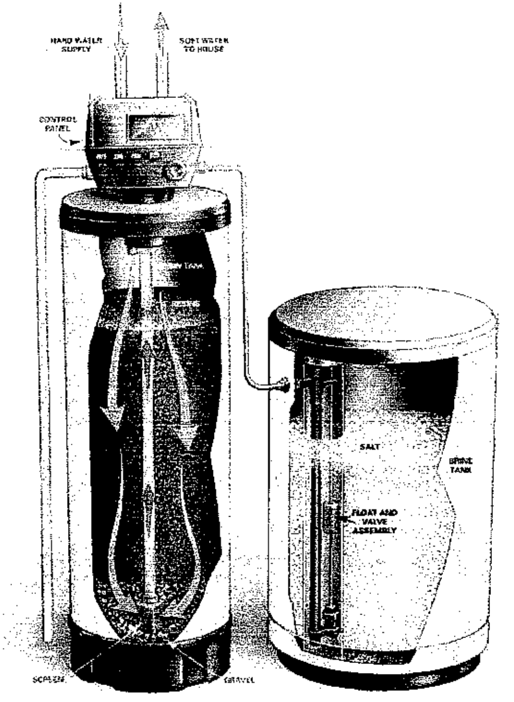

Figure 2.1: Water Softener and Brine Tank

Water softeners remove hardness (dissolved calcium and magnesium) through an ion exchange process. Incoming hard water passes through a tank containing ion exchange resin beads which are super saturated with sodium. As the water passes by the beads, the calcium and magnesium ions replace the sodium ions on the resin and sodium is released into the water. When the resin becomes saturated with calcium and magnesium, a backwash regeneration cycle is instigated. A concentrated salt brine solution (NaCl) is backwashed through the resin, replacing the calcium and magnesium ions on the resin with sodium ions. The regenerate water, containing calcium, magnesium, sodium and chloride flows into the septic tank and eventually into the leaching bed. The amount of sodium added to the water and salts added to the septic system will depend upon the hardness of the water, household water use and the type and operation of the water softener. Potassium chloride (KCl) can be used instead of sodium chloride to regenerate the ion exchange resin. Potassium chloride, which is roughly twice the cost of sodium chloride, is typically used when a resident is on a sodium reduced diet or when the treated wastewater is reused for irrigation. [22]

2.2 Hard and soft water

Water is called "hard" if it contains a lot of calcium or magnesium dissolved in it. Hard water causes two problems:

- It can cause "scale" to form on the inside of pipes, water heaters, tea kettles and so on. The calcium and magnesium precipitate out of the water and stick to things. The scale doesn't conduct heat well and it also reduces the flow through pipes. Eventually, pipes can become completely clogged.

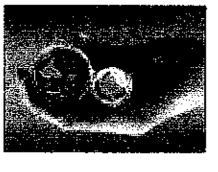

Figure 2.2: Clogged pipes

- It reacts with soap to form a sticky scum, and also reduces the soap's ability to lather. Since most of us like to wash with soap, hard water makes a bath or shower less productive. [12]

2.3 Resin inside the tank

The **water softener resin** is an integral, non-expendable part of a water softener. In fact, it is the central factor that is crucial to the softening of what was once hard water so that it can be used by the household.
To summarize, the resin is responsible for removing the calcium and magnesium ions from the hard water. It also does the job of swapping sodium ions into the water that is now saturated of its calcium and magnesium ions.
The resin acts like a pseudo-filter that prevents the magnesium and calcium ions from remaining in the hard water that flows into the mineral tank. [26]

2.4 Design of the tank

For industry, there are so many design of the water softener which is available today. Most of this equipment is used for their boiler to make sure the boiler and the piping have more lifetimes and could give the better service to the plant.
Some manufacturers give the customer privileges to custom the design by themselves.
Here are the specifications for water softener tanks which has no significant difference for the same capacity of water softeners.[5]

2.4.1 Softener Tanks – Steel:

Butt-welded industrial grade steel. Test hydrostatically at 1.5 times the design pressure and provide certification. (Conform to ASME Boiler and Pressure Vessel Code, Section VIII. Provide stamp on tank and written certification). Sidewall height shall be adequate to allow 50 percent of the mineral bed depth for expansion. Tanks shall have openings for mineral filling and removal. Provide steel supports to hold tanks in operating position above floor (and designed to resist seismic loading requirements for Zone 4, UBC Importance Factor 1.0). Exterior shall be degreased, cleaned, and coated with manufacturer's standard prime and finish coatings. Interior shall have near-white sandblast and lined with phenolic epoxy, 0.20 – 0.25 mm, heat bonded. Interior coating shall be chemically inert, non-toxic, odorless and meet the requirements of CFR 21, Chapter 1, 175.300. Interior linings shall be tested for integrity with a 2500 volt spark test certified with the shipping papers. [5]

2.4.2 Softener Tanks – Fiberglass Reinforced Plastic (FRP):

Polyester reinforced by a continuous roving glass filament overwrap. Hydrostatically test at design pressure and provide certification. Support on a molded structural base. Tanks shall have openings for mineral filling and removal. Provide vacuum breaker. [2]

2.5 System Control

Flow shall be regulated to prevent resin loss, operate between 200 and 690 kPa (30 and 100 psi) supply pressure, and prevent noise and hydraulic shock. Control shall permit only one unit to regenerate at a time.

2.6 External Softener Piping

A. Pipe: ASTM A53, galvanized, Schedule 40.

B. Fittings: Malleable iron, ASME B16.3, or coated cast iron, ASME B16.1, class 125.

A. Flanges: ASME B16.1, Class 125.

D. Threaded Joints: Shall be made with ends reamed out. Apply bituminous base lubricant or fluorocarbon resin tape to male threads only.

2.7 Factors Should Be Considered When Selecting A Water Softener

To choose the right water softener for an application, the steps below are followed to determine the minimum water softener capacity needed.

Step1 - Determining Water Hardness in grains per gallons: First, test the water for hardness. The hardness is usually measured in ppm (parts per million). The figure is took and divided by 17.1 to determine the corresponded hardness in grains per gallons.

$$Hardness\ (grains/gallons) = Hardness\ (ppm) / 17.1$$

Noted that, in special conditions, water softeners are capable of removing iron and manganese. If iron or manganese has been detected presence in the water, the hardness is adjusted as follows:

1 grain of hardness per 0.5 ppm of iron detected

1 gain of hardness per 1.0 ppm of manganese detected.

Step 2 - Daily average gallons use per boiler: Under normal conditions a boiler uses approximately 1 meter^3 a day. However, it can go up to 1.5 meter^3 in hot climates.

Step 3 - Total average gallons used. Multiply number of boiler in the factory per the average gallons use per boiler.

Step4 - Water hardness to be removed daily is determined by multiplying the water hardness in grain per gallons calculated in step one by the total average gallons use in factory calculated in step 4.

Step5 - The water hardness to be removed daily is multiplied for the number of days the water softener functioning without regeneration. Typically the water softener does not regenerate more than once within 2 or 3 days.

The result in step 5 is the minimum softener capacity needed to handle the boiler water demand. [14]

2.8 The Mechanical Design Process

The main process of mechanical design is different throughout industry. Different literature references and different companies may use distinct terminology or classify activities into slightly different groups. Nonetheless, there is agreement on the steps to follow to properly develop products.

Here is the design process:

Market Need Identification

↓

Product Specification

↓

Concept Development

↓

Detail Design

↓

Production

↓

Distribution

Design is an iterative process. There are feedback loops from all of these steps back to all of others. For this project, the author has followed these steps more or less and the detail processes used is explained in this report. [1]

2.9 pH of Water

pH is a measure of the amount of acidity in the stream. A low pH indicates more acidity. Water Quality Standard is the values outside the standard (pH 6.5 - 8.5) indicate poor water quality. The main causes of pipe corrosion are low pH (acid water) typically found on private well water, but is also present in some small municipal water systems. [8]

2.10 Water Conductivity

Water conductivity is the amount of ionic material dissolved in the water. Ionic materials are things like salts. Seawater has a high and freshwater a low conductivity. No single water quality standard determined. In general, a higher conductivity indicates that more material is dissolved material, which may contain more contaminants.

Conductivity in water is influenced by the conductivity of rainwater, by road salt application, fertilizer application, and evaporation. Rainwater has variable conductivity depending on whether the rain clouds formed over the ocean (which tends to have higher conductivity due to ocean salts) or land. Differences in conductivity among different sub watersheds are likely due to interactions with soils as well as human activity. Conductivity can be used as an indicator human activity.

Depending on the type and combination of equipment, DI can produce purity from 100,000 ohms/cm to 18 million ohms/cm (or mega-ohms/cm). [28]

2.10.1 Types of Resins

A deionizer uses two opposing charged resins (cationic and anionic). While the cationic resin removes the cations, the anionic resin removes the anions.

Cationic

The cationic resin is typically made from styrene containing sulfonic acid groups, which are negatively charged. Although the resin is actually negatively charged, it is called a "cationic" resin, referring to the cations that it will exchange. This resin typically comes in the hydrogen ion (H+) form, meaning it is precharged with hydrogen ions on its exchange sites.

Anionic

Anionic resin is typically made from styrene containing quaternary ammonium groups, which are positively charged. Likewise, despite its positive charge, it is called an "anionic" resin, referring to the anions that it will exchange.This resin typically comes in the hydroxide ion (OH^-) form, meaning it is precharged with hydroxide ions on its exchange sites. [23]

CHAPTER 3

METHODOLOGY

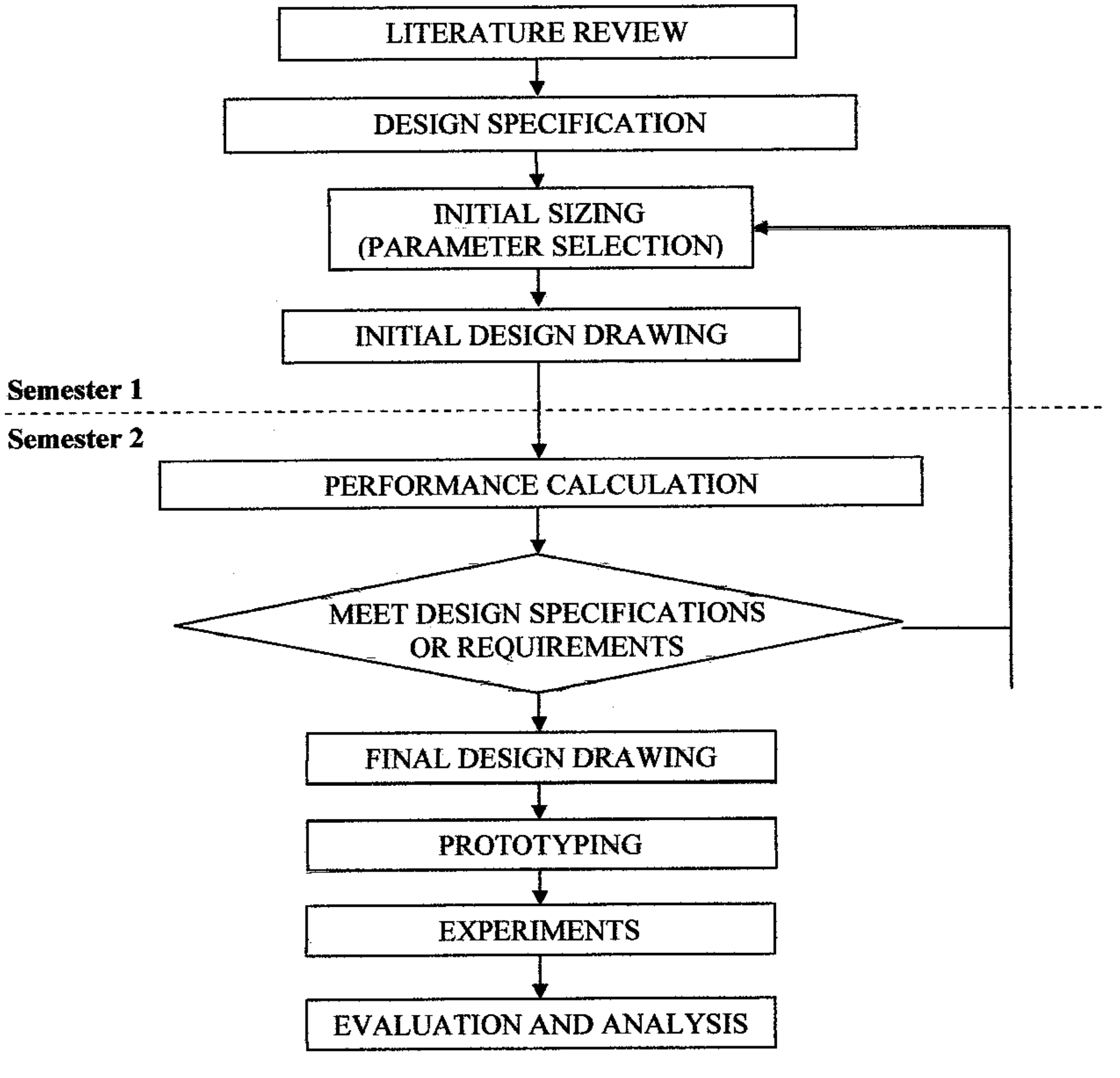

Figure 3.1: Methodology Flow Chart

3.1 Literature Review

For this research, some methods have been used to gather information and studied deeply. They are:

i) Research on internet.
ii) Books and journals in the Information Resource Centre (IRC)
iii) Experience from Industrial Training
iv) Meet with technician or engineer from industry which use the water softener
v) Attempt to meet with the manufacturers if possible

3.2 Design Specification

For the design specifications, first the capacity of the water softener and the hardness of the water are being specified. These values are taken from a company which the author were placed for the internship last semester. This mean is to show the calculations and to get a specified capacity of a water softener so that the author can use it to refer for the tank size. From the tables which are provided by the manufacturers, the standard specifications and sizing can be identified.

3.3 Initial Sizing and Drawings

Selecting the right water softener for home or business begins with an analysis of the water characteristics. In order to properly size a water softener, some factors regarding the water to be softened are required.

From the test of the actual hardness level, or grains per gallon, will be determined and the proper softener size for plant or factory usage can be determined. The drawings will be completed by using the CATIA software for this semester.

3.4 Performance Calculation

Calculations for the water softener will be carried out to evaluate the performance. The computation is referred to the specifications and design parameters which have been recognized earlier. From the calculations, the results will be employed to ensure whether they meet the requirements or not.

3.5 Meet Design Specifications or Requirements

The design must meet the specifications and requirements so that the project can go to the next process which is the final design drawing. If not, then the author need to go back to the initial sizing to make sure all the parameters are in place and follow subsequently processes.

3.6 Final Design Drawing

If the design has fulfil the design specification and requirements, then a final design drawing will be sketched in detail by using the CATIA software with complete dimensions and labels.

3.7 Prototyping

Some manufacturing processes need to be done in this stage. In the planning, the prototype to be constructed is in smaller dimension with 2.5 scale, which is 22 inches height and 4 inches diameter. However, this will depend on the availability of materials and the ability of constructing the prototype.

3.8 Experiments

Experiments will be conducted to test the prototype. Some characteristics may not be exactly like the real tank. However, some important parameters will be identified.

After the constructions part is settled, the equipments and materials needed for this experiment will be prepared. This is to make sure that the experiment can be conducted smoothly.

In the experiment, the tank is located between two water containers. One for the hard water as the source and another is the soft water as the processed water. The water flow is forced by two water pumps to flow the water from the source, through the tank and then flow out of the tank to the processed water container.

Then, 100ml of the processed water is took as a sample and put into a small bottle for each design of tanks for the hardness test.

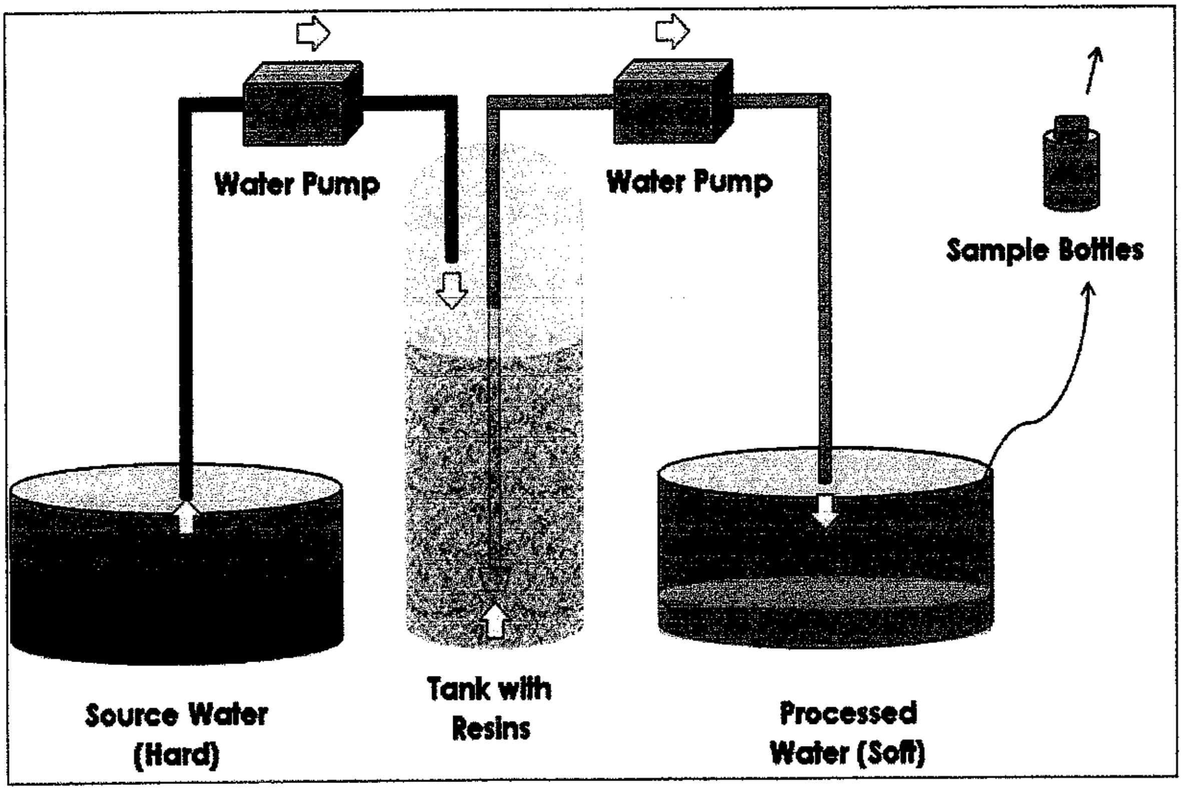

Figure 3.2: Experiment Layout

3.9 Equipments and Materials

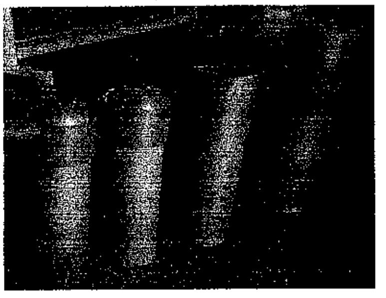

Figure 3.3: Tanks

The tanks are constructed by using 2.5 scales from the standard size of water softener from calculated values. Fabricated in the workshop, these prototypes are made from PVC and modified to get the desired designs. Flat Perspex and end cap are used as the cover of the tanks. Size for all tanks is 4''x22'' (DxH).

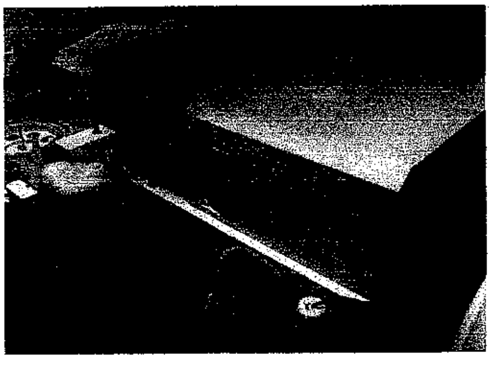

Figure 3.4: AAS Machine

Atomic Absorption Spectrophotometry (AAS) is designed to determine the amount (concentration) of an object element in a sample, utilizing the phenomenon that the atoms in the ground state absorb the light of characteristic wavelength passing through an atomic vapour layer of the element.

Figure 3.5: SubmersiblePump

The submersible Pump is a unique and modern design with a combination of advanced technology and Hi-Tech materials. It is equipped with non- exposable alternative synchronic motor and reliable centrifugal pump with low energy consumption and well insulation. Max flow is 1800L/h. Two pumps with the same type are needed for this project.

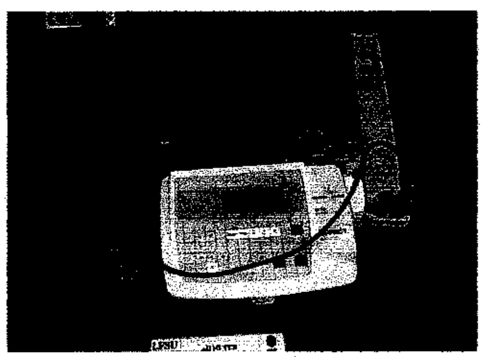

Figure 3.6: PH Meter

A **pH meter** is an electronic instrument used to measure the pH (acidity or alkalinity) of a liquid. A typical pH meter consists of a special measuring probe connected to an electronic meter that measures and displays the pH reading.

Figure 3.7: Resins

Resins of different types will be used to treat the water and put inside the tank and the amounts needed for this experiment is 4kg. (Each design will use 1 kg to make sure the results are not affected by the used resins). In this project, Anionic Resin is selected for the softening.

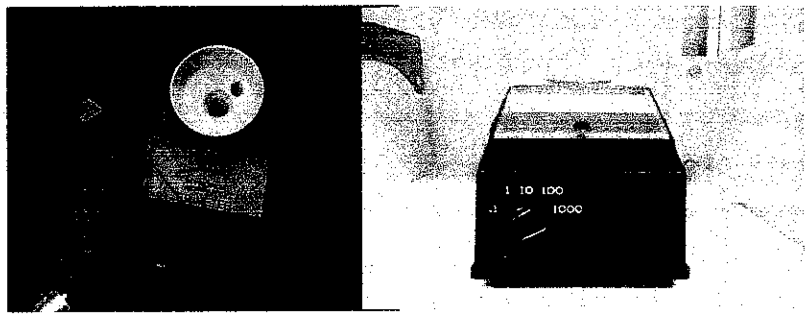

Figure 3.8: EP Meter

EP Meter is used to determine the conductivity of the water after passed the water softener. This EP meter is get from the Civil Lab and need no supervision for the handling because it is easy and safe. It has five conductivity ranges for easy readability. The most sensitive range includes resistivity equivalents, making it ideal for water systems.

3.10 Experiments for Hardness Determination

3.10.1 Method 1: Calmagite Colorimetric (8030)

Figure 3.9: Experiment setup

The colorimetric method for measuring hardness supplements the conventional titrimetric method because this method can measure very low levels of calcium and magnesium. Also,some metals that interfere may be inconsequential when diluting the sample to bring it within the range of this test.

The indicator dye is calmagite, which forms a purplish-blue color in a strongly alkaline solution and changes to red when it reacts with free calcium or magnesium. Determinations are made by chelating calcium and magnesium with EDTA to destroy the red color for both. By measuring the red color in the different states, calcium and magnesium concentrations are determined.

Calculation formula:

$$\text{Total Hardness (mg/l of CaCO3)} = \frac{\text{Total ml titrant used x 0.020N x 50000}}{\text{ml sample volume}}$$

Calculate the hardness of the sample in ppm of calcium carbonate
Compare the hardness of the sample with Calmagite Colometric method.

*For details of the experiment, please refer to APPENDIX.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Calculations

Hardness of the water is usually expressed in engineering terminology as *grains* of hardness per gallon. Sometimes it is expressed as *ppm hardness*. One grain per gallon equals 17.1 parts per million.

4.1.1 Project Conditions

Influent Water Analysis:

Total Hardness: 300 ppm

Daily Water Usage: 1500 liters per day (329.954 gallons per day)

4.1.2 Design Parameters

Normal System Flow and Pressure Drop:5.7 m^3/h @100 kPa (25gpm@15 psi)

Maximum System Flow and Pressure Drop:4.5 m^3/h @100 kPa (20.0gpm@25 psi)

Daily Hours of Water Demand: 24 hours

Operating Temperature Range: 4 – 50 degrees C (40 – 120 degrees F)

Operating Pressure Range (System): 200 – 690 kPa (30 - 100 psig)

Electrical Requirements: Dedicated 120 v, 60 Hz, 1 phase receptacle.

4.1.3 Demand and Sizing

1) Hardness of the water, GPG (grain per gallons) = 300ppm/17.1

=17.544GPG →Excessively Hard.

2) Maximum daily water usage for boiler = 1.5 m^3 = 329.954 Gallons UK

3) Total boiler is 1 unit.

4) Water hardness to be removed daily = 329.954 Gallons x 17.544 GPG

= 5,788.713 grains.

5) For the water softener to function without regeneration for 7 days,

5,788.713 grains x 7 = 40,520.991 grains capacity water softener.

So, the water softener capacity needed for this case is 45,000 grains capacity.

4.2 Software applicable for this project

CATIA is used to redraw the designs found in 3D by using the scale dimensions. These designs are then followed to develop the prototypes.

4.3 Designs Found

Below are some of the designs of water softeners that the author had found. For now, here are the designs for the specified capacity.

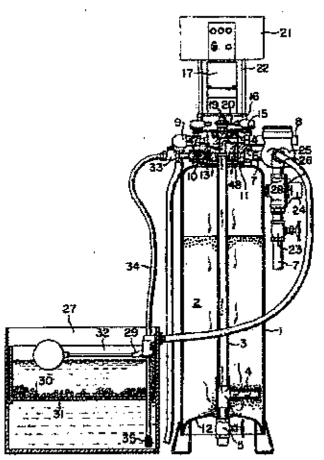

Figure 4.1: Design A

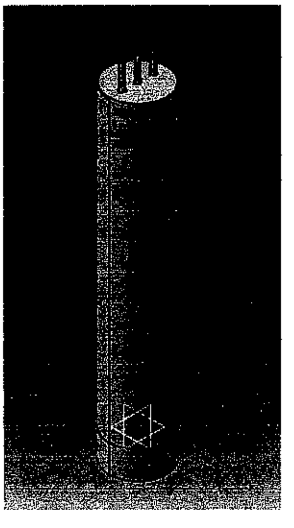

Figure 4.2: CATIA Drawing for Design A

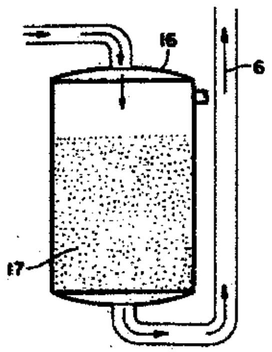

Figure 4.3: Design B

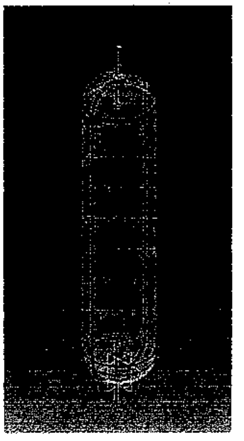

Figure 4.4: CATIA Drawing for Design B

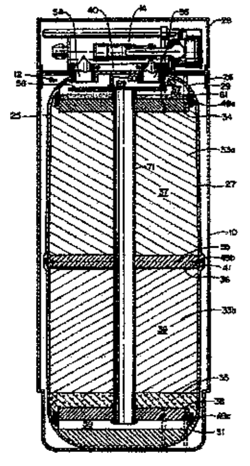

Figure 4.5: Design C

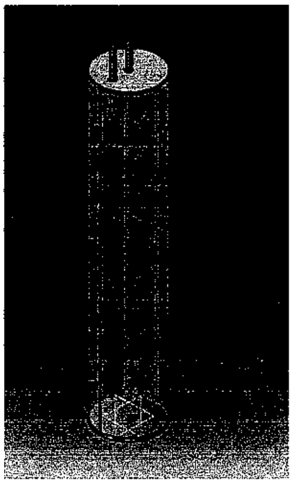

Figure 4.6: CATIA Drawing for Design C

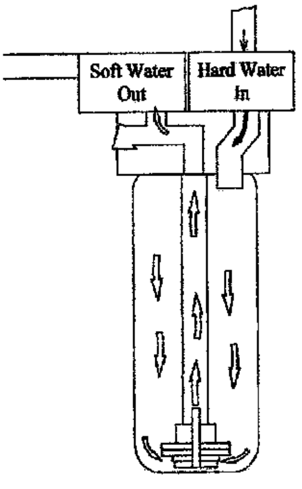

Figure 4.7: Design D

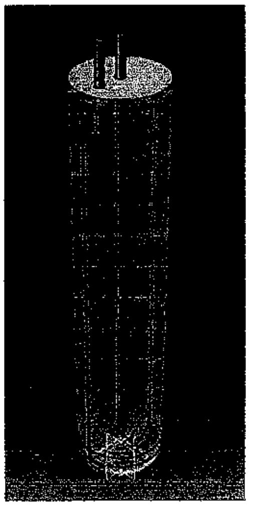

Figure 4.8: CATIA Drawing for Design D

4.4 Material for Tank

Steel with ASME construction is recommended for durability and quality of construction and resistance to shock loads such as water hammer or impacts. ASME construction may be required in certain jurisdictions. FRP is subject to impact failure, cannot withstand a vacuum and is not suitable for seismic areas.

4.5 Construction of Tanks

Initially, the plan was to construct a cylinder shape with holes on both ends. Thread is made there so both ends can be attached with different design of caps which are include the piping and the shape of the bottom and top caps.

So, for the experiments, we will only use the same container and just change the caps for the different design (Figure 4.1). However, due to the difficulties to make thread on the PVC, then the author decided to stick them permanently using glues and thus needed 4 prototypes. (Figure 4.2)

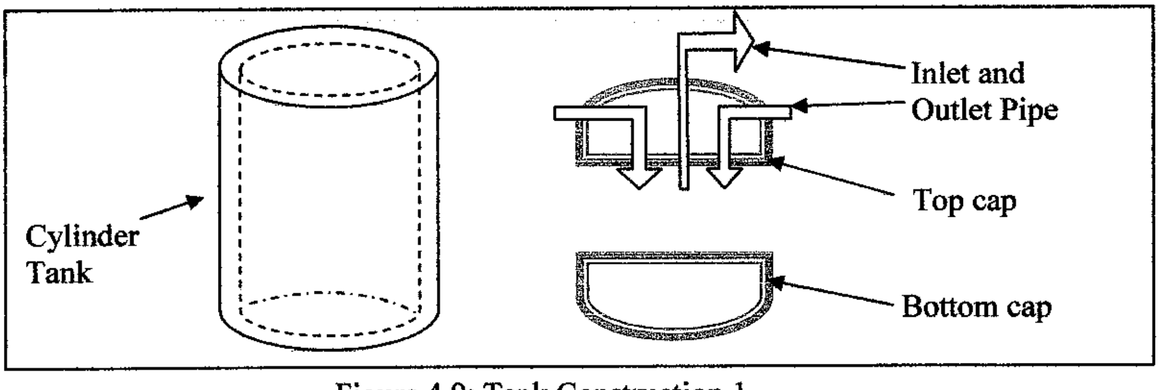

Figure 4.9: Tank Construction 1

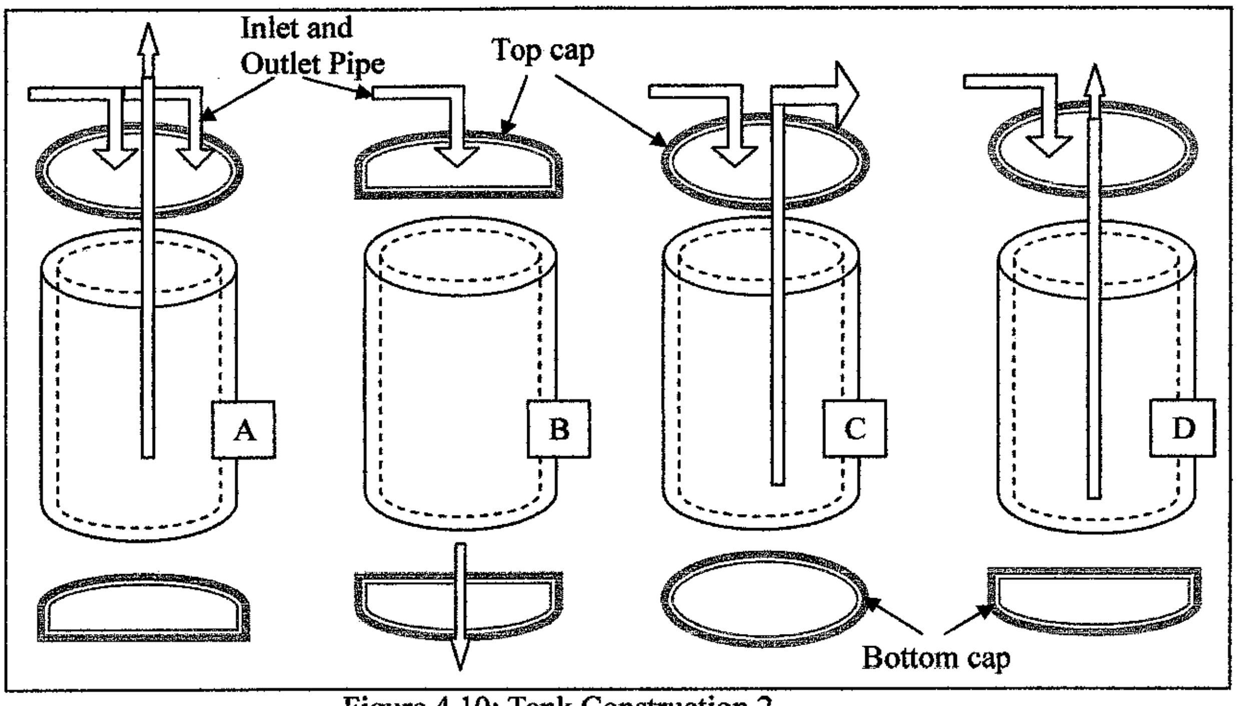

Figure 4.10: Tank Construction 2

4.6 Commissioning of Prototypes

The prototypes have been tested at Village 6, UTP area. This is because the source water is easy to take and enough space with less distraction.

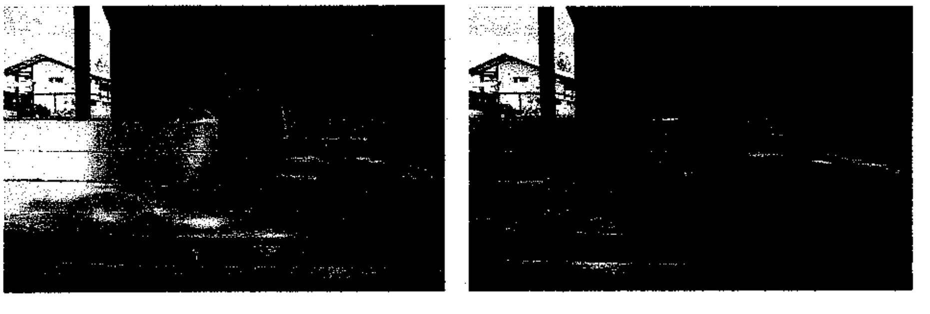

Figure 4.11: Commissioning the prototypes

4.7 Experiments on Treated Water

To test the water after softening process, there are three indicators that are considered which are hardness, pH and conductivity. With the help from Puan Musalmah from Lembaga Air Perak,Ipoh, experiments on the samples have been done successfully.

Figure 4.12: Experiments on Treated Water

Table 4.1: Results of Hardness Experiments

	SOURCE/DESIGN					
TITRATION READINGS (ml)	PIPE	LAKE	A	B	C	D
1st	1.31	1.51	0.08	0.18	0.15	0.12
2nd	1.32	1.52	0.06	0.16	0.15	0.10
Average	1.32	1.52	0.07	0.17	0.15	0.11
TOTAL HARDNESS (ppm)	26.30	30.30	1.40	3.40	3.00	2.20

4.7.1 Summary of results

Table 4.2: Summary results of experiments

	SOURCE/DESIGN					
[illegible]	PIPE	LAKE	A	B	C	D
[illegible]	26.30	30.30	1.40	3.40	3.00	2.20
[illegible]	7.4	5.82	7.33	6.61	6.92	7.12
[illegible]	550	750	900	800	825	850

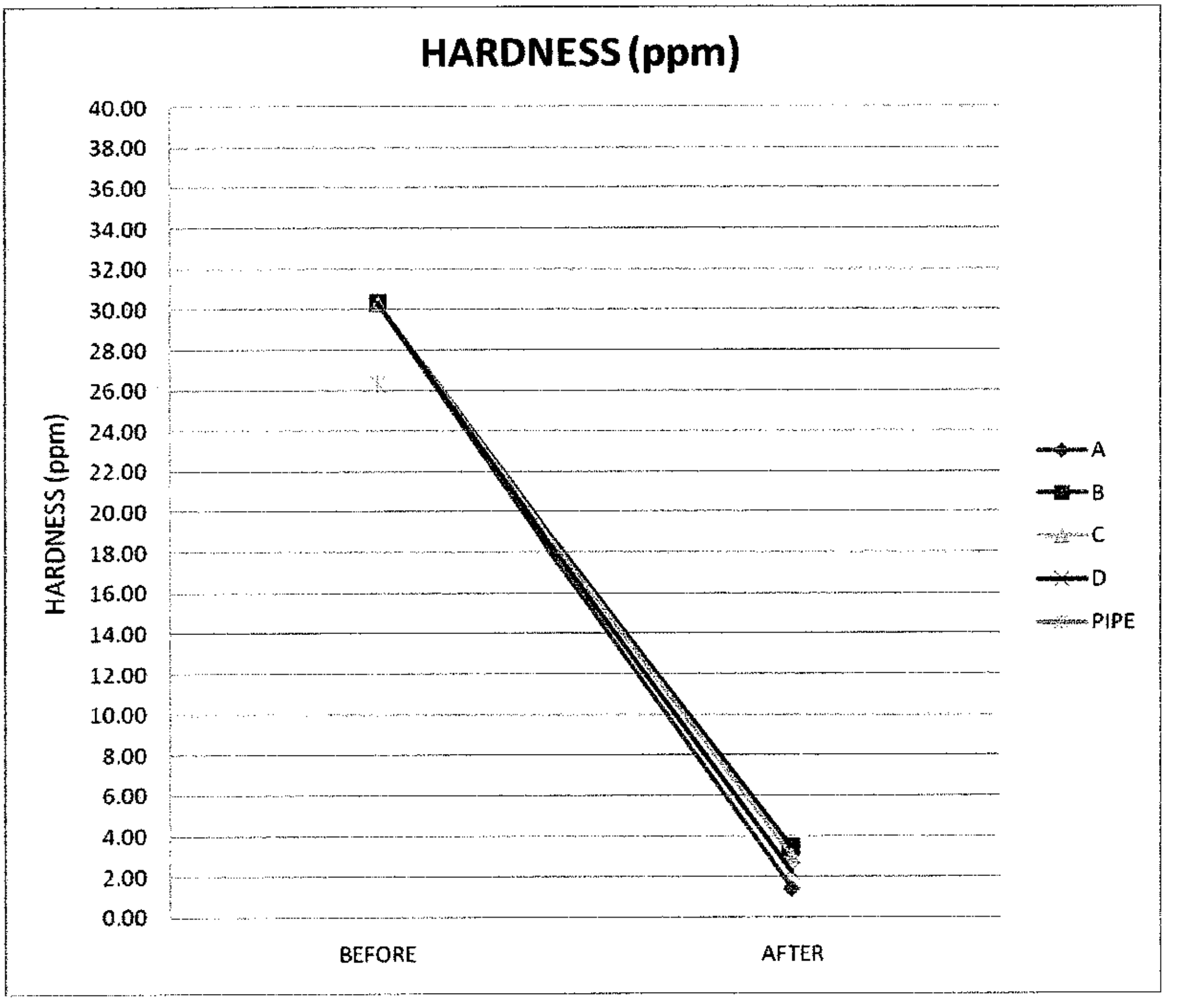

Figure 4.13: Graph of Water Hardness Reduction by Using Four Different Water Softener Tanks Designs

From this graph, it can be seen that all designs produced different results on their reduced hardness values. Before the softening, the hardness is at 30.30ppm. After treated with the resins, design A gives the best reduced hardness value among others which is 1.40ppm.

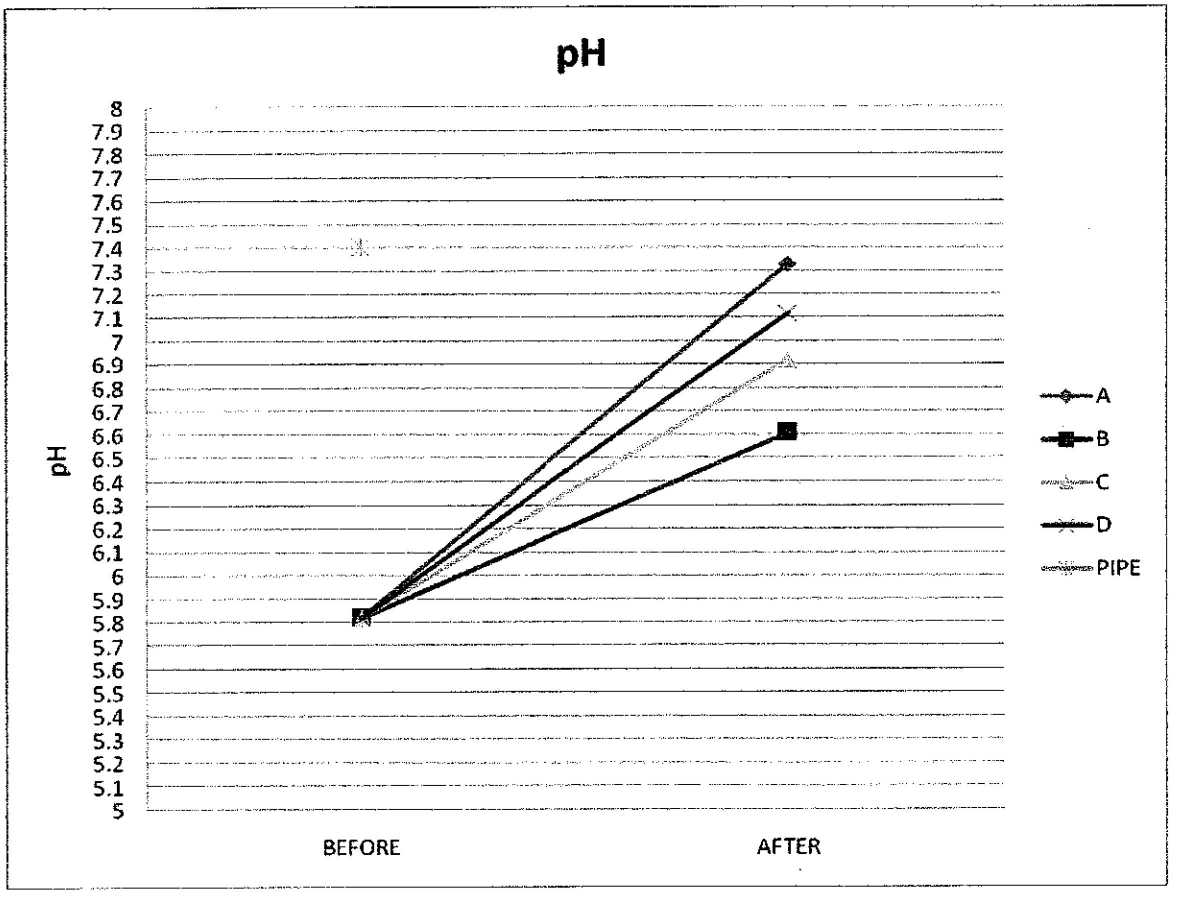

Figure 4.14: Graph of pH Value Changes by Using Four Different Water Softener Tanks Designs

For the lake water sample, the pH increased from 5.82 to more than 7. The highest is the Design A product which became to pH7.33 after treated. In general the pH of the product water for the four water samples was within the recommended standard which is from pH6.5 to pH8.5. (WHO, 1984).

In a related study from internet source, pH did not have a significant effect on the rate of hardness. From these results, it can be said that the more efficiency of resins utilization, the more Hydrogen ion is exchanged thus make the water more base.

The observed pH independence of resins softening would be an asset, especially in tropical developing countries where savings can be made on importation of the chemical used for pH adjustment in conventional chemical treatment.

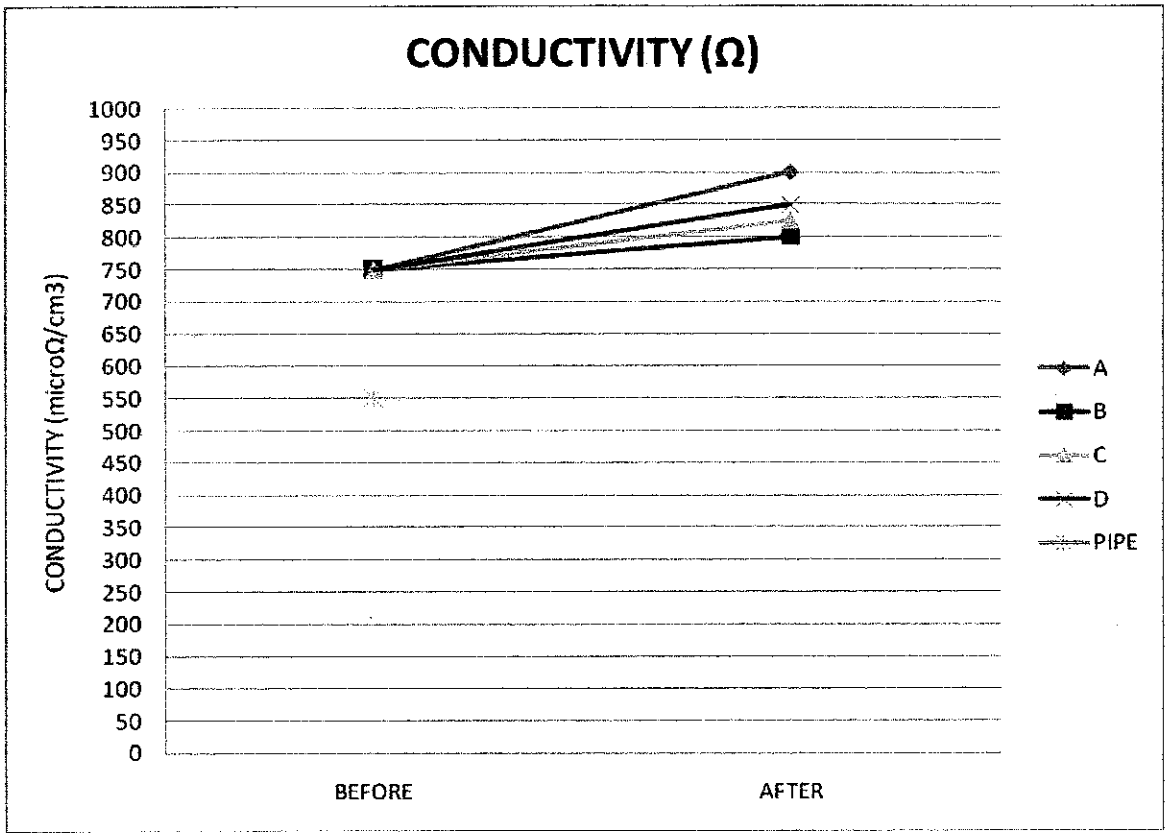

Figure 4.15: Graph of Water Conductivity Changes by Using Four Different Water Softener Tanks Designs

From the experiments, the design A get the highest reading of water conductivity of its treated water sample while the design B is the lowest reading. The conductivities are different because the electrical current is transported by the ions in the water, the conductivity increases as the concentration of ions increases. Thus conductivity increases as water dissolved ionic species.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, this is proved that designs of the water softeners have its own significant on the softening performance.

The hardness of softened water is different for each design. However, the pH and conductivity values are not affected from the softening process. From the experiments conducted, the design A is the best design among tested designs because it has the highest hardness removal (1.40ppm), highest conductivity (900microohm/cm2) and lowest acidic value (pH7.33).

In this project, the different designs have small difference of treated water hardness but in a long run, it would give a big difference in savings and benefit.

From the early, this project has followed its timeline and meets its objectives in design and development of water softener for boiler among existing commercialized designs.

5.2 Recommendation

This project should be continued by any student to do research on the flow distribution of the water inside of the tank and strengthen the evidence that design of the tank has its role on the softening performance.

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[20] http://www.pureandsoftwater.com
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[23] http://www.howstuffwork.com
[24] http://www.nuncbrand.com/us/page.aspx?ID=1233
[25] http://www.adeptpwt.co.uk/products/softeners
[26] http://www.durpro.com/downloads/Softeners-Carbon-
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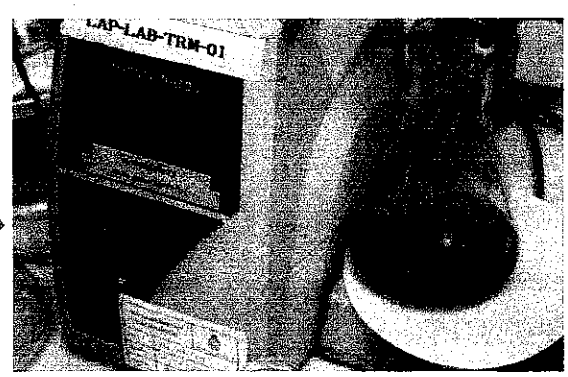
PROCEDURES OF HARDNESS TESTING

1. Select a sample size corresponding to the expected hardness in mg/l CaCO3, according to Table 1.

Range (mg/l of CaCO3)	Sample Volume	Standard Titrant Solution(N)
0-500	50	0.02
400-1000	25	0.02
1000-2500	10	0.02

2. Use a graduated cylinder or pipette to measure the sample volume from Table 1. Transfer the sample into a 250ml Erlenmeyer flask/ Dilute to 50ml with deionized water if necessary.
3. Add 1ml of Hardness 1 Buffer Solution using a pipette. Swirl to mix.
4. Add the contents of 1 ManVer 2 Hardness Powder pillow to the prepared sample. Swirl to mix.
5. Fill the burette and zeroing it with the TitraVer hardness Titrant.
6. Titrate the prepared sample until color changes from red to blue.

Initially the solution was in red color



Titration is enough when solution became blue

The table of hardness and their classifications:

Description	Hardness (mg/l)	Hardness (gr/gal)
Extremely soft	0-45	0-2.6
Soft	46-90	2.6-5.2
Moderately hard	91-130	5.2-7.6
Hard	131-170	7.6-10.0
Very hard	171-250	10.0-15.0
Excessively hard	Over 250	Over 15.0

Hard Water Chart

- 0 to 60 milligrams per liter = Soft Water
- 61 to 120 mg/L = Moderately Hard Water
- 121 to 180 mg/L = Hard Water
- 181 mg/L and up = Very Hard Water

Industry Comparisons

Industry	**Total Hardness** (mg/L $CaCO_3$)
Brewing beer	200 to 300 mg/l
Carbonated beverages	200 to 250
Washing clothes	0 to 50
Steel Manufacturing	About 50

Nominal Wall Thickness Pipe

Nominal wall thickness seamless and welded carbon and alloy steel pipes

Nominal wall thickness for seamless and welded steel pipes according ANSI B36.10 are indicated in the table below:

Nominal Pipe Size *(in)*	Outside Diameter *(in)*	Schedule												
		10	20	30	STD	40	60	XS	80	100	120	140	160	XXS
		Wall Thickness *(in)*												
1/8	0.405				0.068	0.068		0.095	0.095					
1/4	0.540				0.088	0.088		0.119	0.119					
3/8	0.675				0.091	0.091		0.126	0.126					
1/2	0.840				0.109	0.109		0.147	0.147				0.188	0.294
3/4	1.050				0.113	0.113		0.154	0.154				0.219	0.308
1	1.315				0.133	0.133		0.179	0.179				0.250	0.358
1 1/4	1.660				0.140	0.140		0.191	0.191				0.250	0.382
1 1/2	1.900				0.145	0.145		0.200	0.200				0.281	0.400
2	2.375				0.154	0.154		0.218	0.218				0.344	0.436
2 1/2	2.875				0.203	0.203		0.276	0.276				0.375	0.552
3	3.500				0.216	0.216		0.300	0.300				0.438	0.600
3 1/2	4.000				0.226	0.226		0.318	0.318					
4	4.500				0.237	0.237		0.337	0.337		0.438		0.531	0.674
5	5.563				0.258	0.258		0.375	0.375		0.500		0.625	0.750
6	6.625				0.280	0.280		0.432	0.432		0.562		0.719	0.864
8	8.625		0.250	0.277	0.322	0.322	0.406	0.500	0.500	0.594	0.719	0.812	0.906	0.875
10	10.750		0.250	0.307	0.365	0.365	0.500	0.500	0.594	0.719	0.844	1.000	1.125	1.000
12	12.750		0.250	0.330	0.375	0.406	0.562	0.500	0.688	0.844	1.000	1.125	1.312	1.000
14	14.000	0.250	0.312	0.375	0.375	0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	
16	16.000	0.250	0.312	0.375	0.375	0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	
18	18.000	0.250	0.312	0.438	0.375	0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	

- STD - Standard
- XS - Extra Strong
- XXS - Double Extra Strong

SOFTENER SPECIFICATIONS

Resin Tanks (in.)	Brine Tank (in.)	Resin Per Tank/Total (cu.ft.)	Capacity Per Regen/System Min (1)	Max	Flowrate GPM	Salt Qty (lbs.)	Ship Wt. (lbs.)
8X35	18X33	.5	11,000	16,000	4-5	300	201
8X44	18X33	.75	16,000	24,000	5	300	386
10X40	18X33	1	21,000	32,000	6-7	240	279
10X47	18X33	1.25	28,000	42,000	6-8	240	542
10X54	18X33	1.5	32,000	48,000	8	765	371
12X52	18X33	2	40,000	60,000	10-12	765	716
8X35	18X33	.5	11,000	16,000	4-5	240	279
8X44	18X33	.75	16,000	24,000	5	240	542
10X40	18X33	1	21,000	32,000	6-7	765	371
10X47	18X33	1.25	28,000	42,000	6-8	765	716
10X54	18X33	1.5	32,000	48,000	8	650	440
12X52	18X33	2	40,000	60,000	10-12	650	660
10X40	18X33	1	21,000	32,000	6-7	800	920
10X54	18X33	1.5	32,000	48,000	8	800	1785
12X52	18X33	2	40,000	60,000	10-12	1450	1303

PARKER FIBERGLASS AUTOMATIC WATER SOFTENER

MODEL NO	CAPACITY (GRAINS)	FLOW RATE(G.P.M) @15PSIΔP*	@25PSIΔP**	PIPE SIZE (INCHES)	TANK SIZE (DIA/HEIGHT) INCHES SOFTENER	BRINE	MAX HEIGHT (INCHES)	SHIPPING WEIGHT (LBS)
FGA-45-1	45,000	16	22	1	10/54	18/40	62	140
FGA-90-1	90,000	19	26	1	14/65	24/41	73	240
FGA-120-2	120,000	47	64	2	16/65	24/41	80	450
FGA-180-2	180,000	63	81	2	22/54	24/50	73	575
FGA-240-2	240,000	74	97	2	24/60	30/50	80	825
FGA-300-2	300,000	68	91	2	24/71	30/50	91	975
FGA-450-2	450,000	84	105	2	30/72	39/48	95	1,400
FGA-600-2	600,000	85	100	2	36/72	39/60	95	1,850
FGA-750-2	750,000	90	105	2	36/72	42/60	95	2,100

* Recommended maximum continuous flow rate
** Maximum instantaneous flow rate

LEMBAGA AIR PERAK
LAP LABORATORY

SO/IEC 17025
No : 01

TEST RESULT SHEET

me : Anas

te received : 29/10/09

Date Assigned : 29/10/09

Date Completed : 29/10/09

emical Analysis Source : Village 6 Lake, UTP

				①	②	③
tificate Report Number :						
nple Registration Number :						
ather :						
nple Description / Condition :				(V6 Lake)	(B)	(C)
npling Location :						
npling Date :						
npling Time :						
rameters	Lab Inst. Tag No.	MDL	Unit			
sidual Chlorine	LAP-LAB-DRS-01	0.01	mg/l			
	LAP-LAB-PHM-01	SA	SA	5.82		
rbidity	LAP-LAB-NTU-01	0.07	NTU			
lour	LAP-LAB-LCN-01	SA	Hazen			
ioride	LAP-LAB-DRS-01	0.02	mg/l			
uminium	LAP-LAB-DRS-01	0.002	mg/l			
ıe Al Conc.**			mg/l			
nmonia	LAP-LAB-DRS-01	0.018	mg/l			
kalinity (CaCO3) 1 - 0.02n H2SO4)	LAP-LAB-TRM-02	1.0	mg/l	^ml ^ml ^ml mg/l	^ml ^ml ^ml mg/l	^ml ^ml ^ml
ırdness (CaCO3) 1 - 0.02n EDTA)	LAP-LAB-TRM-01	0.8	mg/l	1.51 ^ml 1.52 ^ml 1.515 (avg)	0.18 ^ml 0.16 ^ml 0.170 (avg)	0.15 0.15 ^ml 0.15 (avg)
tal Dissolve Solid	LAP-LAB-CON-02	0.4	mg/l			
nductivity	LAP-LAB-CON-02	1.0	uS/cm	C = 7.5 × 100 micromhos		
ıloride	LAP-LAB-DRS-01	0.24	mg/l	H = 30.3 ppm	H = 3.4 ppm	H = 3.0 ppm
trate	LAP-LAB-DRS-01	0.015	mg/l			
on	LAP-LAB-DRS-01	0.012	mg/l			
anganese	LAP-LAB-DRS-01	0.005	mg/l			
etergents	LAP-LAB-DRS-01	0.005	mg/l			

Bacteriological Analysis

ertificate Report Number :					
ample Registration Number :					
'eather :					
ample Description / Condition :					
ampling Location :					
ampling Date :					
ampling Time :					
arameters	Unit	Dilution			
otal Coliform	Colony / 100ml	(raw water)			
aecal Coliform	Colony / 100ml	(raw water)			

ote :

* Less Than Method Detection Limit (<MDL)
** True Aluminium Concentration due to Fluoride inteferece
*** Value more than National Water Quality Standards

^ ml of titrant used
SA - Depends on Sensitivity of Analysis
**** Test on-site

Non Accredited Method

LEMBAGA AIR PERAK
LAP LABORATORY

TEST RESULT SHEET

ne : Anas

Date Assigned : 29/10/09

e received : 29/10/09

Date Completed : 29/10/09

emical Analysis Source : Village 6 Lake, UTP

tificate Report Number :						
nple Registration Number :				(4)	(5)	(6)
ather :						
nple Description / Condition :				(D)	(A)	(Pipe at Village
npling Location :						
npling Date :						
npling Time :						
ameters	Lab Inst. Tag No.	MDL	Unit			
idual Chlorine	LAP-LAB-DRS-01	0.01	mg/l			
	LAP-LAB-PHM-01	SA	SA			7.40
bidity	LAP-LAB-NTU-01	0.07	NTU			
lour	LAP-LAB-LCN-01	SA	Hazen			
oride	LAP-LAB-DRS-01	0.02	mg/l			
ıminium ie Al Conc.**	LAP-LAB-DRS-01	0.002	mg/l mg/l			
ımonia	LAP-LAB-DRS-01	0.018	mg/l			
calinity (CaCO3) l - 0.02n H2SO4)	LAP-LAB-TRM-02	1.0	mg/l	^ml | ^ml | ^ml | mg/l	^ml | ^ml | ^ml | mg/l	^ml | ^ml | ^ml
rdness (CaCO3) l - 0.02n EDTA)	LAP-LAB-TRM-01	0.8	mg/l	0.12 ^ml | 0.10 ^ml | 0.110 (avg)	0.08 ^ml | 0.06 ^ml | 0.070 (avg)	~~0.08~~ 1.31 ^ml | 1.32 ^ml | 1.315 (avg
tal Dissolve Solid	LAP-LAB-CON-02	0.4	mg/l			
nductivity	LAP-LAB-CON-02	1.0	uS/cm			C = 55×100 mı
loride	LAP-LAB-DRS-01	0.24	mg/l	H: 2.2 ppm	H= 1.4 ppm	H= 26.3 ppm
trate	LAP-LAB-DRS-01	0.015	mg/l			
n	LAP-LAB-DRS-01	0.012	mg/l			
anganese	LAP-LAB-DRS-01	0.005	mg/l			
etergents	LAP-LAB-DRS-01	0.005	mg/l			

Bacteriological Analysis

ertificate Report Number :					
mple Registration Number :					
eather :					
mple Description / Condition :					
mpling Location :					
mpling Date :					
mpling Time :					
rameters	Unit	Dilution			
otal Coliform	Colony / 100ml	[raw water]			
aecal Coliform	Colony / 100ml	[raw water]			

ote :
* Less Than Method Detection Limit (<MDL)
** True Aluminium Concentration due to Fluoride inteferece
*** Value more than National Water Quality Standards

^ ml of titrant used
SA - Depends on Sensitivity of Analysis
**** Test on-site

Non Accredited Method