UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF A NOVEL WATER DISTILLER USING FRESNEL LENS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

CHRISTER RUBEN ANAK CHRISTOPHER

B071410252

940617135221

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design and Development of a Novel Water Distiller Using Fresnel Lens**

SESI PENGAJIAN: **2017/18 Semester 1**

Saya **CHRISTER RUBEN ANAK CHRISTOPHER**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_____ _____

Cop Rasmi:

Alamat Tetap:

No 2, Lorong Awan 16, Kuala Ampang,

68000, Ampang,

Selangor

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared that this report entitled "Design and development of a novel distilled water using Fresnel lens" is the results of my own research except as cited in references.

Signature	:	……
Author's Name	:	CHRISTER RUBEN ANAK CHRISTOPHER
Date	:	

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor's in Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

……

Muhammad Nur Bin Othman

(Supervisor)

……

Azrin Bin Ahmad

(Co-Supervisor)

ABSTRAK

Penggunaan masa untuk penyahairan air dan ketidaksesuaian reka bentuk adalah kelemahan untuk sistem penyahgaraman solar biasa. Terdapat beberapa kes dimana segelintir pulau kecil di Malaysia hanya bergantung pada air perigi sebagai sumber utama untuk mendapatkan air bersih. Tujuan kajian ini adalah untuk merekabentuk dan membangunkan sistem penyahgaraman menggunakan kanta Fresnel yang kurang memakan masa dan menjimatkan kos. Penyahgaraman berkuasa solar yang disepadukan dengan kepingan kanta Fresnel nipis direka bentuk dan dibangunkan untuk mengatasi masalah yang berlaku dalam sistem penyahgaraman solar biasa. Tiga reka bentuk konseptual telah dibangunkan menggunakan perisian CAD dan sedang dinilai menggunakan rumah kualiti (HOQ). Prototaip diuji menggunakan tiga jenis sampel air iaitu air laut, air paip dan air sungai. Sampel air didedahkan kepada cahaya matahari untuk membolehkan proses penyahairan sepanjang hari dan jumlah air bersih yang dihasilkan diukur setiap jam. Setiap jenis air menghasilkan jumlah air bersih yang berlainan. Oleh itu, penambahan lensa Fresnel diketahui boleh meningkatkan jumlah air bersih yang dihasilkan semasa proses penyahgaraman.

ABSTRACT

Time consumption for water desalination process and the impracticality of design is a drawback for a normal solar still. There are cases where some small island in Malaysia depends only on water well as the main water supply. The purpose of this study is to design and develop a solar powered desalination system which is less time consuming and cost effective. A solar powered desalination integrated with a thin sheet of Fresnel lens was designed and developed to overcome the problem which occurs in a normal solar still. Three conceptual designs has been developed using CAD software and being evaluated using house of quality (HOQ). The prototype is being tested using three types of water samples which are sea water, tap water and river water. The water samples are exposed to sunlight to allow the desalination process throughout the day and the amount of clean water produced are measured every hour. Each types of water produces different amount of clean water. Hence, the addition of Fresnel lens is known to increase the amount of clean water produced during desalination process.

DEDICATION

I would like to dedicate my sincere indebtedness and gratitude towards my beloved parents for their continuous support and sacrifices throughout my life. I would like to thanks everybody which contributes to my final year project directly or indirectly. I would be grateful for their comments and suggestions, which has crucial for the successful completion of this final year project.

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere gratitude to my supervisor, Mr Muhammad Nur Bin Othman and co-supervisor, Mr Azrin bin Ahmad for their invaluable guidance, continuous encouragement and constant support in making this report. Without their advice and assistance it would be difficult for me to complete this final year project. I really appreciate their guidance which enables me to develop and understand this research thoroughly from the very beginning to the completion of this report.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATRUE

CAD	-	Computer-Aided Design
QFD	-	Quality Function Deployment
HOQ	-	House of Quality
RO	-	Reverse Osmosis
MSF	-	Multistage Flash distillation
SFL	-	Spot Fresnel lens
LFL	-	Linear Fresnel lens

CHAPTER 1
INTRODUCTION

1.0 Introduction

In this modern era, the demand of energy is increasing and available energy sources are depleting in a fast rate. Energy is separated into two which is renewable and non-renewable energy. A type of energy which is absolutely natural and environmental friendly is known as renewable energy. Moreover, the main advantage for this form of energy is it can be produce repeatedly. It is one of the well-known sources of energy to be used to power all the necessities in our daily basis. The renewable energy technology is rapidly growing as it is very cheap in term of costing and can be harvested easily which are the most important criteria for every industry.

Another alternative source of renewable energy which is currently being used in most factories is solar energy. It is a form of energy which is generated by sun's ray. Solar energy is also known as an abundant source of energy because it is constantly available and can easily be harvested to generate power. Besides, solar energy contributes a major role for extensive variety of utilization such as solar cooker, solar desalination energy generation, solar pumps and solar water heaters.

A solar desalination system is basically operates by harvesting the sun's ray to separate salts as well as other contaminant from water to produces clean and drinkable water. Water will begin to evaporate once it reaches its boiling point temperature, other contaminants which are heavy and have higher boiling point will be left behind. In addition, the use of this solar desalination system is very safe as it doesn't have any moving mechanical parts and does not release any harmful vapor to the atmosphere which can cause greenhouse effect. Moreover, a solar desalination system with the addition of Fresnel lens will hence increase the heating rate of

contaminated water in which will result of clean water produced in a short period of time.

Fresnel lens is made up of thin plastic sheet containing grooves which are specifically designed to deflect light. Once the sunlight reaches these grooves, it will direct the sunlight towards the center which is called the focus point. The groove feature of the Fresnel lens enables sunlight to be concentrated as well as produce tremendous amount of heat.

1.1 Problem statement

Nowadays, the urge to find for an alternative energy source is mainly caused by the rapidly rise in energy consumption and fossil fuel depletion which is a major crisis that the world is confronting. All of the available equipment today is mostly depend on fossil fuel during its operational period. Moreover, the main problem of using fossil fuel is that the source is non-renewable. In other words, the energy is valid for one time usage only and will become extinct at some point. Besides, the cost needed to obtain this fossil fuel will continue to rise as the number of fossil fuels deplete even further.

The nature is also badly affected where it has already caused many disasters to the earth due to overuse of fossil fuel. Utilizing fossil fuels as the main source of energy have various downsides where harmful fumes will be released to atmosphere which may cause further destruction of the surrounding ecosystem in a long term usage. Water covers most of the earth surface. Almost 97% of water is located in the oceans and the remaining 3% is fresh water. Domestic usage of fresh water is important especially as a drinking water. However, the water available in the ocean is saline in nature and it would require tremendous amount of heat energy in order to produce fresh water out of the seawater.

A solar desalination system is a method of producing clean water by using solar power. The energy released by the sun is clean as well as renewable. However, this process is known to be very time consuming. It could take a few days just to produce a little amount of clean and drinkable water. Furthermore, the heat energy

produced by the sun is insufficient in order to increase the rate of water evaporation for the desalination process.

Besides, most of solar powered desalination system is available in large sizes in which it will be placed around villages or at a certain location where the source of clean water is difficult to be found. The drawback for these types of design is it can only be placed at one spot. It would be much more convenient if it can be used anywhere. In the modern era where technologies are continuously improving over time, portability of a certain product is one of the aspect where people are continuously seeking. Therefore, a new design improvement of a solar powered desalination system is needed to be developed in order to fulfill the demand and be able to solve the current situations.

1.3 Objective

There are several objectives for the design and development a novel Fresnel lens water distiller. Below are the listed scopes of this project:

1. To design and develop a portable water distiller using Fresnel lens.
2. To test the newly designed and developed water distiller with the addition of Fresnel lens.

1.4 Scope

This study will focus on the design and development a novel Fresnel lens water distiller. Below are the listed scopes of this project:

1. The Fresnel lens water distiller will be design and developed using Solidworks.

2. The Fresnel lens water distiller will be tested using seawater, tap water and river water during daytime.

3. A thin sheet of Fresnel lens size of an A4 paper is used.

CHAPTER 2
LITERATURE REVIEW

2.0 Solar Energy

Solar energy is basically an energy released by the sun. The energy emitted by the sun is in radiation form. It is known as a renewable source of energy because the energy that it releases is sustainable and inextinguishable unlike fossil fuels which are limited. Besides, solar energy is absolutely clean and non-polluting type of energy because it does not release any harmful fumes, toxic waste as well as greenhouse gasses. Therefore, it is a cost effective and efficient energy because it be can be found abundantly everywhere throughout the earth. In order to fully utilize the energy from the sun, it must be harvested and converted into another form of energy. A study performed by Arsović et al., (2015) states that the solar energy is efficient and cost effective for cooling a hot cabin based on the output energy and high efficiency obtained. According to J.Reif et al., (2015), the utilization of direct solar desalination system using solar thermal collectors is mostly favorable for high efficient solar desalination system.

2.1 Desalination

According to Joe Patrick Gnanaraj et al., (2017), a desalination process means the process of separating dissolved salt as well as other contaminants that could be found in water. It is done by transforming seawater into fresh water which is clean and suitable for human consumption. Desalination process can be done by using membranes (RO) which act as a filter or by thermal where water vapor is

formed due to the heating of seawater. The desalination system can be separated into two categories which is passive desalination and active desalination. Besides, it is known as an economical way in producing clean water. Desalinations process consist of various types such as solar desalination, reverse osmosis (RO), multistage desalination and many more.

2.1.1 Reverse Osmosis Desalination

A reverse osmosis desalination system works by pushing water through a membrane to separate salts and other particles from water. The basic flow of a reverse osmosis system is depicted in Figure 2.1. A study done by Ali et al., (2017), states that the effectiveness of a reverse osmosis desalination permeate is affected by several factors such as materials, membrane constructions, feed salinity and feed pressure. According to Cay-Durgun et al., (2017), the separation performance increases as the force applied increase. However, tremendous amount of energy is required as high energy is used to enable the operation RO desalination process which will lead to increase of operation cost as well.

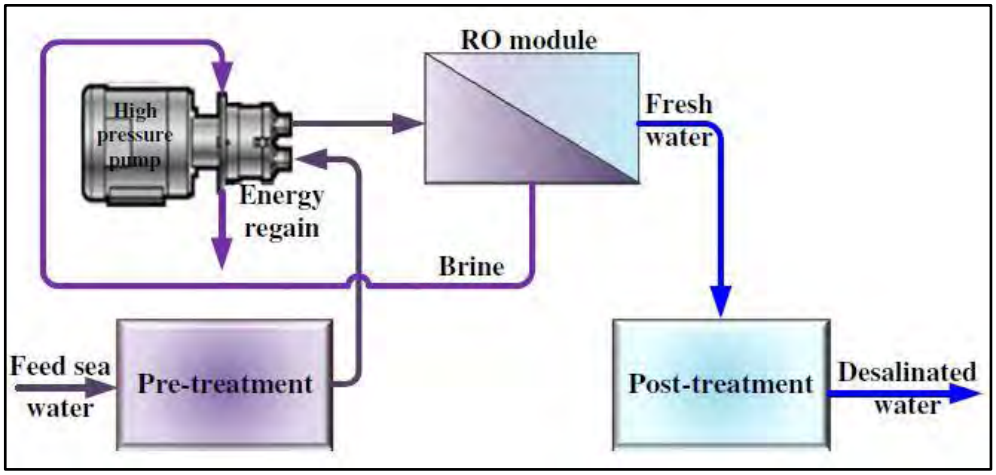

Figure 2.1: Basic flow of RO system (Ali et al., 2017)

2.1.2 Geothermal Desalination

Heat generated from the earth's core is recognized as geothermal energy. It could be found beneath the earth's crust where a layer of extremely hot and molten rock, called magma is present. According to Gutiérrez et al., (2009), the majority of the geothermal sources have huge flow and temperature variations which may affect the production of fresh water desalination rate. The fresh water production rate is linearly depending on the temperature difference between the cold sea water and hot sea water.

Based on Gude, (2016), thermal energy and electrical energy are both needed for thermal desalination process such as hydraulic flow, evaporation process and to transport the feed and product water. Besides, geothermal energy provides stable and reliable heat supply to ensure the stability of thermal desalination and also reverse osmosis. Furthermore, geothermal energy is cost-effective for desalination process and also environmental friendly because it does not release any emission of air pollutants and greenhouse gasses to the environment.

2.1.3 Solar desalination

Solar desalination system is a method to produce clean water which has been discovered long time ago. Based on Bhattacharyya, (2013), a solar desalination system is a method that separates water from salts and other harmful chemical by utilizing the power of the sun. Basically, the operational principle is by utilizing the sun radiation to heat up and evaporates saline water inside a closed container. The saline water is sustained on a black plate in the lower part of the solar distiller. The sun will eventually heat up the contaminated water until it evaporates and clean distilled water droplets will formed once water vapor cools and condenses on the surface of the transparent slanting glass or plastic. The droplets will fall along the slanted surface and collected through special channels located under the slanted surface.

A study done by Tiwari, Singh, & Tripathi, (2003) found that the most economical solar still to supply drinking water for domestic applications at decentralized level is a double slope fiber re-inforced plastic (FRP) conventional solar still. Besides, this type of solar still has a simple design and easy operation which doesn't need skilled manpower. In addition, it is suitable to be used in rural area due to its low maintenance cost. Moreover, Birzer et al., (2014) also states that this type of desalination system can be easily build from simple materials including wood, glass tubes, metals and plastics.

Besides, having no moving parts means that it is easy to operate and maintained. Another study done by Morad et al., (2017) found that the amount of fresh water produced totally depend on surrounding temperature and solar radiation. Furthermore, production of fresh water decreases with increasing in the amount of water salinity. Besides J.Reif et al., (2015) also found that the uses of solar desalination systems need to consider factors including location, climate, and access to seawater or brackish water as well as land use and ecological issues.

2.2 Classification of solar desalination

2.2.1 Passive desalination

A passive type of desalination follows a very basic principle in which solar energy is harvested to produce fresh water using a basin structure. Water will start evaporate at a certain temperature due to the heat released from the sun and then the condensed vapor will be formed on the surface of the glass cover. A container will collect the clean and drinkable water. Moreover, various types of passive solar desalination system that are available such as solar still, spherical solar, multi stage solar still, spherical solar still etc. The structure of a simple passive desalination system is shown in Figure 2.2.

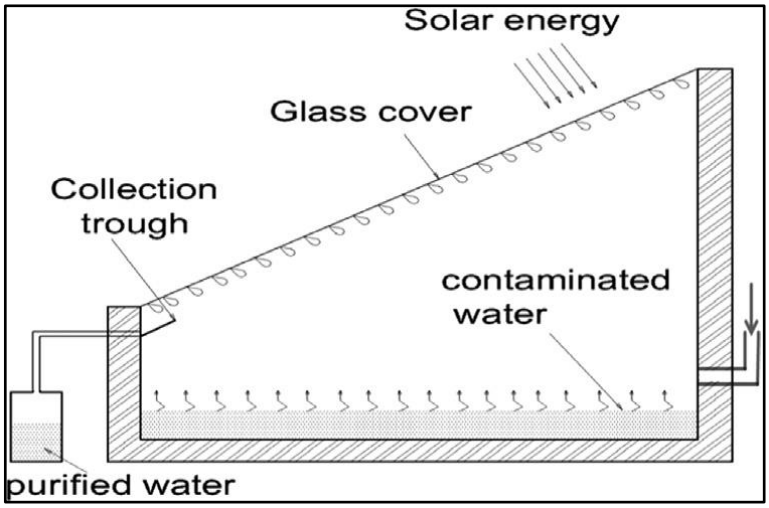

Figure 2.2: Simple structure of a passive desalination system

2.2.1 (a) Multi Basin Solar Stills

A multi basin solar still is used to increase the efficiency for production of fresh water by utilization of the latent heat of condensation. It requires two or more basins to enable the reusable of latent heat. In a double basin solar still, another glass sheet is fixed in between the basin liner and the glass cover. This glass sheet act as the base of an extra basin for the saline water, and the whole assembly operates as two simple basin solar stills stacked above one another. The water in the upper basin utilizes the upward heat loss from the water in the lower basin. The system for double basin desalination is depicted in Figure 2.3.

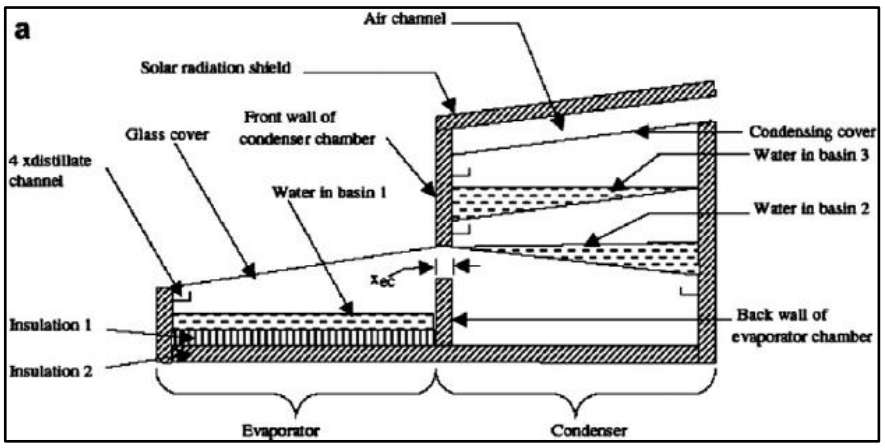

Figure 2.3**:** A schematic of a double basin desalination system

2.2.1(b) Wick Type Solar Stills

Based on Bhattacharyya, (2013), a wick type solar still contains a porous dark fabric or film supported by a tray or a frame, covered by a glass or plastic sheet and in an airtight enclosure. The wick solar still is adjustable to the solar radiation to avoid from dripping back the desalinated water into the wick. A drain is located at the bottom edge of the fabric for the concentrated seawater. A wick type solar still is favourable by people in rural areas as a choice to obtain clean drinking water and for other domestic purposes. The solar wick desalination system is shown in Figure 2.4.

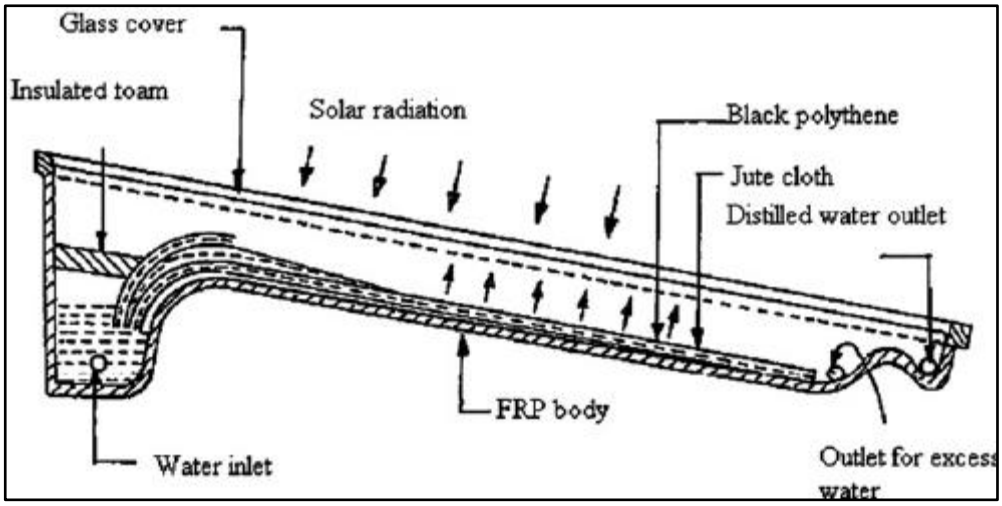

Figure 2.4: Solar wick desalination system

2.2.2 Active desalination

An active desalination system utilizes external energy sources such as solar heater, solar concentrator or other heating devices as a support to the desalination process. It is used to increase the heating rate of water as well as the efficiency of the desalination process. According to Morad et al., (2017) an observation found that the temperature of vapor of the active desalination system is lower than the normal solar desalination system due to the presence of the vacuum pump, which increases the evaporation rate of the sea water under low temperature condition.