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STUDY OF WATER DESALINATION USING A SOLAR ENERGY SYSTEM WITH HUMIDIFICATION AND DEHUMIDIFICATION

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Thesis submitted in partial fulfillment of the requirements for the Degree of M.Sc. in Mechanical Power Engineering

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STATEMENT

This thesis is submitted as a partial fulfilment of M.Sc. in Mechanical Power Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ABSTRACT

The present work is an experimental investigation of a water desalination system using solar energy that applies the humidification and Dehumidification principles. A prototype/test rig was designed, fabricated and assembled in order to study the effect of water flow rate and the humidifier inlet water temperature against desalinated water productivity. The system consists of a spray type with no packing bed humidifier, a copper coiled Dehumidifier, a flat plate solar water heater, an air blower, a water pump, a water flow meter, a water tank, three thermocouples and four gate water valves. The system is based on an open water- closed air cycle.

A new approach is used such that the humidifier, dehumidifier and the connecting duct between them are made of Poly Vinyl Chloride (PVC) pipes; which makes the system lighter in weight, doesn't need insulation unlike metal sheets and anti-rust.

This prototype is expected to be a platform to drive the commercialization of a new solar desalination system based on humidification and dehumidification principle. This will be especially beneficial to face the shortage of fresh water supply in future, specifically in remote areas, with a simple design.

The effect of operating parameters on the system characteristics has been controlled, measured and investigated. It was found that the hot inlet water to the humidifier has a significant impact on the water productivity; they are relatively proportional, thus, the more the hot inlet water temperature increases, the more the water productivity increases. It was also found that Saline water flow rate has an impact on the water productivity but inversely proportional.

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LIST OF APPREVIATIONS

CAOW	: Closed Air Open Water
COP	: Coefficient of Performance
CWOA	: Closed Water Open Air
ED	: Electro Dialysis
FFWP	: Four Fold Web Plate
GOR	: Gain over Recovery
HDH	: Humidification and Dehumidification
IDA	: International Desalination Association
MED	: Multi Effect Desalination
MEH	: Multi Effect Humidification
MSF	: Multi Stage Flash
MVC	: Mechanical Vapor Compression
OAOW	: Open Air Open Water
PVC	: Poly Vinyl Chloride
RO	: Reverse Osmosis
TDS	: Total Dissolved Salts
TVC	: Thermal Vapor Compression
VC	: Vapor Compression
WHO	: World Health Organization

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CHAPTER 1: INTRODUCTION

1.1. GENERAL

Water is one of the most abundant resources on earth which is essential to life, covering three-fourths of the earth's surfaces. About 97% of the earth's water is salt water in the oceans with salinity up to 30,000 parts per million of total dissolved solids (ppm TDS) and 3% is fresh water contained in the poles (in the form of ice), ground water, lakes and rivers, which supply most of human and animal needs. A Freshwater body contains low concentrations of dissolved salts and other total dissolved solids. Freshwater according to the World Health Organization (WHO) can be defined as water with less than 500ppm TDS.

Man has been dependent on rivers, lakes and underground water reservoirs for fresh water requirements in domestic life, agriculture and industry. The ultimate source of fresh water is the precipitation of atmosphere in the form of rain and snow [1].

There have been various estimates of the global water resource base on different calculation methods [2]. The total volume of water in the world was calculated to be approximately 1.4 x 1018 m3. Surface freshwater is 1.05 x 1014 m3 or 0.3% of the world's freshwater [3]. It was estimated that more than 50% of the surface freshwater as non-renewable water [4]. The amount of renewable water is therefore around 4.2 x 1013 m3 per year which replenishes groundwater source or returns to the oceans by rivers. Most of it (around 3 x 1013 m3 per year) is in flush flows that are not captured by man. It is assumed that the available renewable freshwater resource is between 9 x 1012 and 14 x 1012 m3 per year. However around 70% of is required for the ecosystem and thus only 30% or 4.2 x 1012 m3 per year is available for human consumption [5]. The balance between availability of fresh water and demand has reached critical level. If the world is to depend only on freshwater source, soon any form of life will face extinction.