Faculty of Engineering & Information Technology

Study on Vacuum Desalination of Seawater and Feasibility of Solar as the Energy Source

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Certificate of Original Authorship

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Abstract

This study covers the development of an energy efficient water desalination system that allows a reduction in the use of fossil fuel and meets the scarcity of drinking water. As part of planning to address shortfalls in fresh water supply for the world, several parallel investigations have been underway. Seawater can be a huge source of fresh water. Seawater is desalinated to provide drinking water at many locations throughout the world. Recent advancements in technology have reduced the costs and energy use of desalination. These technical advances and increasing shortages of freshwater have led to increasing numbers of large plants being constructed around the world. This trend is most evident in Australia, with the plant recently commissioned in Perth, a plant under construction on the Gold Coast and proposed new plants in Perth and in Sydney. Desalination is the process of removing salt and other minerals from salt water to produce usable water. A huge amount of energy is needed to do the desalination of seawater. So, a cost-effective and efficient way needs to be introduced to get the fresh water. A solar water heater can warm up the seawater (to a temperature above room temperature) easily during normal day-light condition. Then this warm water can be boiled at low temperature (well below the normal boiling point, 100°C) when surrounding pressure is reduced. The vapour from the boiling will then be condensed back into the liquid water at room temperature.

Experiments were conducted to reduce the surrounding pressure using a vacuum pump to allow water to evaporate at a temperature lower than the normal boiling temperature of 100°C. It also includes the review of literature and construction of the test rig and testing considering various parameters. The preliminary focus is on the evaporation of water at low temperature and pressure. The warm water of the similar temperature that we can achieve from a solar water heater was used to test the system. The ultimate goal of this research would be to establish a simple method to produce fresh water from seawater using a solar water heater, a vacuum pump that runs by solar electricity along with a condenser and pressure vessels.

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Nomenclature

Symbol	Description	Unit
T	Temperature	^{o}C
Q	Flowrate	m^3/s
P	Power	W
Pr	Pressure	kPa
m	Mass	Kg
v	Velocity	m/s
t	Time	s
F	Force	N
E	Energy	J
l	Length	m
ω	Angular velocity	rad/s
V	Volume	m^3
d	Diameter	m
r	Radius	m
Re	Reynolds number	
A	Area	m^2
η	Efficiency	%
%RH	Relative Humidity	%
s	Specific heat of water	kJ/kg-K
ΔT	Temperature difference	K
LH	Latent heat	kJ/kg
g	Gravity	m/s^2
N	Rotational speed	rpm
ρ	Density	kg/m^3

Nomenclature

Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CAOW	Close Air Open Water
CFM	Cubic foot per minute
COP	Coefficient of Performance
CWOA	Close Water Open Air
ED	Electrodialysis
EDI	Electrodeionisation
EDR	Electrodialysis Reversal
EES	Engineering Equation Solver
FAO	Food and Agricultural Organization of United Nations
GDP	Gross Domestic Product
GDP	Gross Domestic Product
HD	Humidification Dehumidification
HFC	Heliostat Field Collector
HTF	Heat Transfer Fluid
HX	Heat Exchanger
IDA	International Desalination Association
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MD	Membrane Distillation
MED	Multi Effect Distillation
MENA	Middle East and North Africa
MSF	Multi Stage Flash
NPV	Net Present Value
PDC	Parabolic Dish Collector
PEPD	Psychometric Energy Process Desalination

Abbreviations

PV	Photovoltaic
RES	Renewable Energy Sources
RO	Reverse Osmosis
SD	Solar Desalination
SEGS	Solar Energy Generating Systems
SNL	Sandia National Laboratory
TDS	Total Dissolved Solids
UNESCO	United Nations Educational, Scientific and Cultural Organization
VC	Vapour Compression
VTC	V-Trough Collector
WRR	Water Recovery Rate
WHO	World Health Organization

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