ICCPGE 2016, 1, 25 - 30

Experimental study of solar still performance coupled to a solar collector for potable water production

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Abstract

The problem of drinking water shortage is a worldwide issue that made millions of people suffers this shortage. Different classical energy processes were used to partly solve the problem, but they were suitable only for large population areas due to their high capital, operation and maintenance cost. For these reasons, alternative methods must be sought for rural arid areas. This method uses solar energy to drive basin-type and tilted-wick-type solar stills to produce distilled water. The basic idea of the work is to check the production of basin still and tilted wick still using solar energy for solar desalination, using brackish water and solar energy. The still is basically a rectangular basin lined with black or blackened porous material that acts as the solar energy collector. The still was constructed from galvanized iron steel with dimensions 52×75×6 cm. the base area of 52×75 cm. The still inclined at 13^o. Distilled water volume collected was recorded continuously for each hour. The productivity of tilted type still with preheated water was 5.307 L/m^2 day at an average solar radiation of 676.537 w/m^2. The productivity of basin type solar still without preheated water was 3.025 L/m^2day at an average solar radiation 721.49w/m^2.

Keywords: Desalination; tilted wick still; solar collector.

1. Introduction

Water is of the same importance to man as air and food it can be obtained from rivers, lakes and underground water reservoirs for domestic life, agriculture and industry.Today fresh water demand is increasing continuously, because of the industrial development, intensified agriculture, improvement of standard of life and increase of the world population. Only about 3% of the world water is potable and this amount is not evenly distributed on the earth.on deserts and islands where underground water is not readily obtainable and the cost of shipping to the places where it needed is high.A it is worthwhile to take into consideration of producing potable water from saline water, using solar energy that is abundance in deserts [1]. Desalination has become increasing important in providing an economically viable solution to the problem of decrease of fresh water resources. There are many factors to take into consideration to make a new technology. Researches must look towards cleaner sources of energy .fossil fuel resources will soon be expired due to high rate of it is consumption. Different types of water desalination processes have been developed;such as that include technologies phase change or thermal processes described here include multi-stage flash, multi-effect boiling, vapor compression, and freezing processes[2]. All these process neede high power and expensive technology.The use of solar desalination technology to meet the growing needs of drinking water or for agricultural purposes become necessary these days . The solar energy technology is becomes apart of the solution to the problem of future water shortages because of their

economic and their uses on small scales in small cities and rural area where fresh under ground water reservoires are not available but brackish water and salty water are available to produce fresh water [3]. Save money through the use of renewable solar energy is the fact that can not be over looked or underestimated. The cost of energy we use on the increase and so is our need of energy. Protection of the environment is another reason push us to go to the use of solar energy in our daily life. Reduction of pollution caused by burning fuel oil should be an urgent need of attention for the protection of the environment for a better tomorrow to enjoy the clean air we breathe and life for future generation to come. The pollution and global warming experienced by our cities today is the result of gas emissions resulting from the use of fuel oilgr greenhouse effect .The saves sun provides us with clean energy, renewable energy and free energy will help us to provide money ,reduce our costs and at the same time help us to protect the environment for brighter morning and have it blessed by future generations.

2. Material and Methods

A block diagram of the experimental setup is shown in figure (2.1). The system is made of saline water storage tank which is painted black. The raw water in storage tank goes through The solar clocter to heat it of them to the solar desalination. The saline water then flows to the solar distillation unit. The water vaporated by the unit is condensed on the glass cover. The rest of saline water flows out from the still into the concentrated saline water receiving tank.The experimental solar still is of low construction cost, and low running cost as it doesn't use any external classical or active source of energy.

2.1. Material used

1- Galvanized iron
2- Glass sheet
3- Silicon sealant
4- Wood sheet
5- Holding tank for saline water
6- Saline water
7- Copper tube
8- Plastic pipe
9- Black textile
10-thermocouples
11-valves

2.2. Experimental setup

The setup consists of:-

The solar distillation unit Glazing:
A flat glass sheet 6mm thick and 75*52 cm has been used as a cover. The light transmittancy of 6mm glass is approximately 90% with a reflectance of 6%. Thicker glass will have slightly lower transmittance, and it fixed in a parallel position to the collector surface at a height of 6cm to minimize the distance between the flowing water surface and the cover. The glass cover is sealed to the wooden frame with silicon rubber to minimize leakage.

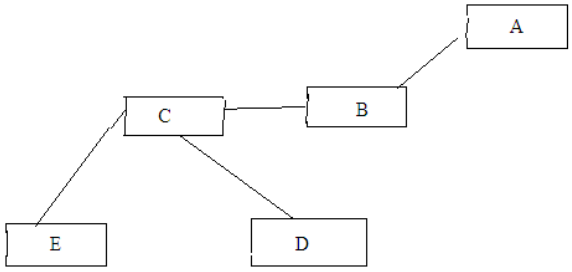

Figure 2.1: Block diagram of experimental setup

A: saline water storage tank
B: solar collector
C: solar distillation unit
D: concentrated saline water receiving tank
E: condensate

Metallic tray:
It is 52*75*6 cm with a thickness 2 mm galvanized iron with a one –half cylinder put in parallel with its width. Inside it for saline water outlet, and provided with a galvanized iron tube sealed to the other side with slots in both the cylinder and the tray for water inlet. Galvanized iron used to decrease corrosion.
Wooden frame:
The width of the wooden frame is 56 cm with height of 8 cm and the length of the wooden frame is 78 cm with a height of 8 cm.
The roof of the basin type solar still basin solar still is inclined by 13^o with horizontal surface . This angle is the optimum of solar energy reception[3].
The solar collector unit:
Solar collector consists of a metal tray painted black, and installed by the pipe of copper twisted, and thickness of 3/8 in, and painted also black .Chinese glass cover ,and tend to the south at an angle of 45^oThe solar collector is connected with the so-

lar still to increase the inlet temperature to the still and increce the productivity of of fresh water . The area of the solar collector is 2 m^2 two designs were used in this study

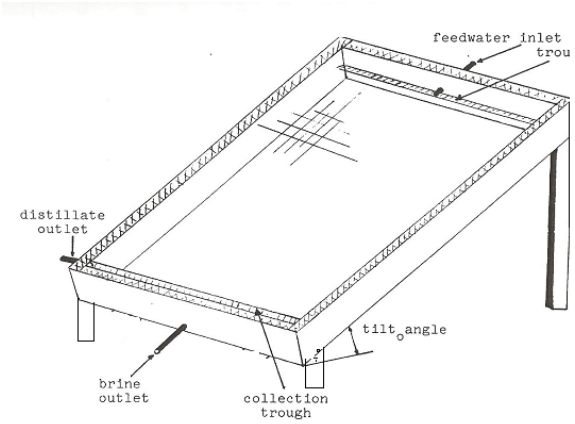

Figure 2.2: Experimental tilted wick type solar still

1. Basin type solar still in which the water is in batch form ,where the water surface is horizontal only roof of the basin of tillted.
2. Tilted wick type in which the surface on which the water is continuously flowing of the tilted surface to the horizantal by 450 were the water is just saturating aporous black wick to reach efficent evopoation (thin film evaporation) [3].

Figures (2.4,5) shows the details of the still used in the experiments .

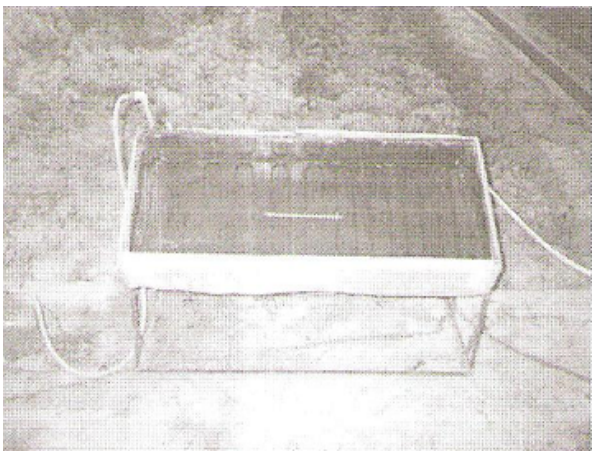

Figure 2.3: Copper pipe flat plate collector.

Figure 2.4: Solar still with solar collector

Figure 2.5: Tilted wick and basin type solar still with solar collector.

3. Results and Discussion

The following product fresh water values, air temperature, glass temperature ,and bottom temperature. Table (2.1) shows the experimental result (basin type and tilled type) with collector. When the temperature difference between the water temperature and glass cover temperature increase, the amount of distilled water from the still increase and the maximum distilled water occurred between the hours 14.00 to 15.00 pm It can be see distilled water values are increase at coupled collector.

4. Conclusion

Solar radiation was the most important factor that affects productivity of the solar still. Higher solar radiation result in higher productivity of the solar

Table 2.1: Experimental result (basin type and tilled type) with collector

Time (hr)	water Temperature with out Collector (^{0}C)	water Temperature with collector (^{0}C)	Tg (glass) ^{0}C	Ta (air)^{0}C	Tb (bottom surface) ^{0}C	Tilted wick Distillate ml/m^2	Basin Distillate ml/m^2
9	26	34	30	26	35	0	0
10	31	52	37	31	48	205.12	64.10
11	33	70	42	35	61	435.8	166.66
12	35	79	43	38	64	642.01	410.25
13	39	86	44	38	68	897.4	474.35
14	41	87	43	40	69	948.4	500
15	40	88	47	41	68	1038.46	717.9
16	40	85	47	41	68	974.3	564.0
17	39	78	42	37	59	769.2	461.53
18	35	60	37	35	48	512.8	307.6

Table 2.2: Experimental result for distillate and brine obtained from feed water(4) .

Parameter	Unit	Brackish feed water concentration	Distillate water concentration	Brine water concentration
PH at (23.4 ^{o}C)	-----	7.95	7.3	8.2
T.D.S	mg/l	3080	36.8	4180
Cl	mg/l	475	2.2	425
Na	mg/l	475	21	525
K	mg/l	30	8.4	40
Ca	mg/l	170	4	140

still. Efficiency of the solar stills studied had a little alteration with increasing of ambient air temperature.

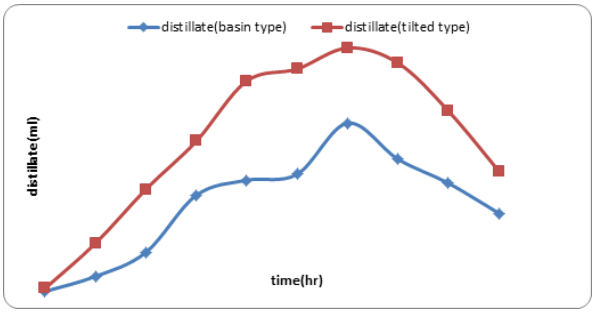

Figure 4.1: Hourly variation of tilted type and basin type of distillate water

When the Solar still is coupled with a Solar collector to preheat the inlet saline water temperature the water productivity is increased. The use of black porous material as the solar radiation absorber leads to an increase in the productivity of solar stills. This because this thin film evaporation involved.

Acknowledgment

The authors gratefully acknowledgment financial support given for this work by the Al-Mergib University.

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