Active Solar Still

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Abstract: *This paper is about active solar still. The objective is to develop a solar based water purification system or a solar water purifier. We are intended to develop this system for use in rural areas where the availability of clean drinking water is a problem and even a greater problem of power shortage is there. Solar water purifier presently yields a total of 2.88lit of water per 24 hours. If we consider losses then it will yield approx. 10 liters of water in 24 hours by surface area of 0.288*m^2*. This production capacity is way beyond what we can achieve with a passive solar still and it is sufficient for the need of a single person. And this water is fed into a solar still. This does the job of collecting water vapors that rise from the surface of water being feed into it.*

I. INTRODUCTION

It is being assumed that by 2025, two third of human population on earth will face shortage of fresh water [1]. The demand for fresh water is rapidly increasing, while supply has been decreasing over the decades.

Many types of renewable energy resources are available for the desalination of water and have been reviewed in detail by Kalogirou [2] and reported that solar distillation has become more popular in recent years, particularly in rural areas. It is a simple technology and more economical than the other available methods. A solar system simply works on hydrological cycle having evaporations and condensations.The solar radiation enters the basin through transparent cover. The water is heated and then evaporates and condenses on the inner surface of the transparent cover. The evaporated water leaves all contaminates and microbes in the basin and is collected in a separate container. Several types of solar stills have been developed; the simplest type is the single-basin type, which is simple in construction and operation. Normally, this is termed a passive solar still ; the main disadvantage of this type is low yield of purified water, the yield of a passive solar still is 2 kg/d m^2 (winter) to 5.5 kg/d m^2 (summer) [3]. Various new designs of passive solar stills like concave wick, tube type, and weir type were also reported for productivity enhancement [4–6]. So much work for increasing the yield has resulted into active mode of solar still. In an active solar still, additional thermal energy is supplied to the basin to in-crease the water temperature using solar collectors. A detailed analysis of design and performance of active solar stills has been reported by Sampathkumar et al. [7].

The single basin solar still was coupled with a flat plate collector in natural circulation mode, which resulted in a increased productivity of 30 to 52% compared to the simple solar still [8–11]. Over 50% of the productivity increment was achieved by coupling the solar still with a flat plate solar collector in forced circulation mode [12–15]. The solar still coupled with a parabolic concentrator increased the productivity by 35 to 45%, and this increase was larger in the double effect still [16–18]. The stepped solar still with a solar pond that used a fin and sponges in the basin increased the productivity by 80% [19–21]. Single basin solar stills coupled with hybrid photovoltaic systems gave three times the yield of that from a simple solar still [22,23]. Dwivedi and Tiwari [24] conducted an experimental study on a double slope solar still coupled with a flat plate collector in natural circulation mode and found that the thermal efficiency of a double slope active solar still was lower than the thermal efficiency of a double slope passive solar still. This work combines the two distinct water treatment systems i.e. pre filtration or slow sand filtration with active solar still technology. The first one separates out the turbidity from water and keep unwanted materials like silt, fine particles etc. away from water heater by flirting them out before entering the water heater so that heater can be saved from damage.

II. SOLAR WATER HEATER SPECIFICATIONS

The system uses a 100 lpd capacity solar water heater for the active heating of water the water tank of heater is thermally insulated and can hold the temperature for 48 hours which is very useful for the areas with uneven sunlight distribution.

Fig. 1: Evacuated solar water heater

Place – MRIU campus , c-block 2^{nd} floor side roof .

Manufacturer – Sun bliss .

Capacity – 100 Lpd.

Surface area of tube – 0.311m^2

No. of tube = 10

Total surface area of tube = 3.11

Diameter off tube = 555mm

Volume of tube = 2.86lit.

Volume of 10 tube = 28.6lit.

Capacity of water tank = 100-28.6
= 71.4lit.

Other relevant database.

Solar intensity = 4 to 7 kwh/ (per day)

Taking average = 5.5 kwh

Solar intensity = 5.5x1000 kWh 24h
= 0.220kw/

Solar intensity = 200 mw/
= 0.2kw/

Total solar energy in one tube = surface area of tube * solar intensity
= 0.311*200mw/
= 61w

Heating capacity of tube

Time	9am-10am	12pm-1pm	2pm-3pm
Temperature	25°c	25°c	25°c
	25°-37°c	25°-45°c	25°-47°c
Δ°c 13°c	20°c	22°c	

Average temperature change Δ°c = 13+20+22/3
= 18.33°c

Now,

Q = mcΔt
= 2.86kg*4.2kj/kg c *(18.33)°c/36000sec
= 61 watt.

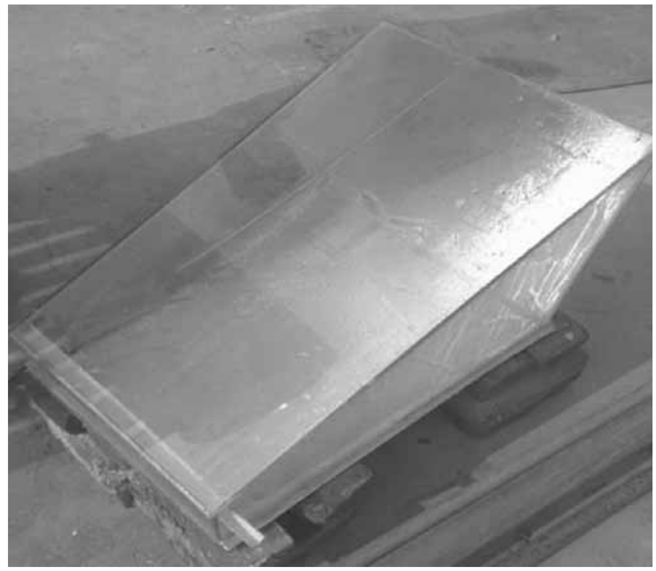

Fig. 2: Condensing Unit (solar still)

Solar still has base surface area of 0.24 m^2
Top surface having surface area of 0.28 m^2
Surface area of side and back surface 0.828 m^2

Top surface is used as primary collection surface for collecting distillate.

III. TESTING AND DEPLOYMENT

Table 1: Reading 1 (amount of water collected at 85°c)

Surface	Total time	Water collected	Water tempera-ture	Surface area
Top surface	20 min	40 ml	85°c	0.28 m^2
Side wall 1	20 min	27.42 ml	85°c	0.192 m^2
Side wall 2	20 min	27.42 ml	85°c	0.192 m^2
Back wall	20 min	28.57 ml	85°c	0.20 m^2

Table 2: Reading 2 (amount of water collected at 80°c)

Surface	Total time	Water collected	Water tempera-ture	Surface area
Top surface	20 min	38 ml	80°c	0.28 m^2
Side wall 1	20 min	26.05 ml	80°c	0.192 m^2
Side wall 2	20 min	26.05 ml	80°c	0.192 m^2
Back wall	20 min	27.14 ml	80°c	0.20 m^2

Table 3: Reading 2 (amount of water collected at 80°c)

Day 1 Oct 15	Temperature °c	Time (24 hrs)	Mass flow rate
Inside temp °c	Outside temp °c		
30	25	9:00	4.8 kg/hr
70	35	12:00	4.8 kg/hr
80	35	16:00	4.8 kg/hr
80	30	18:00	4.8 kg/hr

Table 4: Reading 2 (amount of water collected at 80°c)

Day 2 Oct 15	Temperature °c	Time (24 hrs)	Mass flow rate
Inside temp °c	Outside temp °c		
30	25	9:00	4.8 kg/hr
70	35	12:00	4.8 kg/hr
82	36	16:00	4.8 kg/hr
73	31	17:45	4.8 kg/hr

Table 5: Reading 2 (amount of water collected at 80°c)

Day 2 Oct 15	Temperature °c	Time (24 hrs)	Mass flow rate
Inside temp °c	Outside temp °c		
30	25	9:00	4.8 kg/hr
70	35	12:00	4.8 kg/hr
85	39	16:00	4.8 kg/hr
87	35	17:30	4.8 kg/hr

Table 6: Reading 2 (amount of water collected at 80°c)

Day 2 Oct 15	Temperature °c	Time (24 hrs)	Mass flow rate
Inside temp °c	Outside temp °c		
30	25	9:00	4.8 kg/hr
70	35	12:00	4.8 kg/hr
82	36	16:00	4.8 kg/hr
85	38	17:45	4.8 kg/hr

Total water collected in 20 mins = 40ml (by the mean of top surface)

Water to be collected in 1h = 40*3 = 120 ml (by the mean of top surface)

Water to be collected in 24h = 40*3*24 = 2880ml = 2.88 litters/24h

Water to be collected by 1m^2 = 2.88/0.288 = 10.285 lit/day/m^2 effective surface area

This is the amount of water that can be collected in 24 hours only by the means of top surface.

There is a considerable amount of water that is lost from the back and side walls. That amount can also be collected by using collectors on these surfaces.

Surface area of waste surfaces = 0.584m^2

If we take that water in consideration then amount of water collected on these surfaces is

Water collected by top surface = 10 lit / day

Surface area of top surface = 0.288 m^2

Area of other 3 surfaces = 0.584 m^2

water distilled by other 3 surfaces = 0.584/0.288*2.88 =5.84 lit

Table 7: Total water being distilled by purifier

Water collected	Water lost	Total water being distilled in 24 h
Effective surface area	Non Effective surface area	Total
2880 ml	5840 ml	8720 ml
2.88 litters	5.84 litters	8.720 litters

IV. CONCLUSIONS

Solar water purifier presently yields a total of 2.88lit of water per 24 hours. If we consider losses then it will yield approx. 10 liters of water in 24 hours by surface area of 0.288. This production capacity is way beyond what we can achieve with a passive solar still and it is sufficient for the need of a single person. All this production of water is done only by the means of solar energy and no other power sources is required. In remote areas where there is shortage of electric power this can be an appropriate solution for drinking water requirements. The main component used in this system is solar water heater that uses sunlight for heating water. And this water is fed into a solar still. This does the job of collecting water vapors that rise from the surface of water being feed into it.

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