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Design and Experimental Analysis of Double Slope Single Basin Solar Still Using Phase Changing Materials, Sensible Heat Storing Elements and Reflectors

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Abstract : *Double slope single basin solar still using phase changing materials like (Paraffin wax) and Sensible heat storing elements like (black pebbles) with reflector plate which can increase the productivity of clean drinkable water. When Solar energy is used for this purpose, it is known as Solar water Distillation. Solar Distillation is an attractive process to produce portable water using free of cost solar energy. This energy is used directly for evaporating water inside a device usually termed a "Solar Still". The limited availability of clean water resources and the abundance of impure water available for potential conversion into potable water, In addition, there are many coastal locations where seawater is abundant but potable water is not available. Our main goal is to efficiently produce clean drinkable water from solar energy conversion.*
Keywords - *K-Type Thermocouple, Phase Changing Materials (Paraffin Wax), Reflector, Sensible Heat Storing Elements (Black Pebble), Solar Still.*

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I. INTRODUCTION

Due to environmental issues and limited fossil fuel resources, more and more attention is being given to renewable energy sources. In the recent years solar energy has been strongly promoted as a viable energy source. One of the simplest and most direct applications of this energy is the convergence of solar radiation into heat. Solar radiation can be widely used for water heating in hot water systems, swimming pools as well as a supporting energy sources for central heating installations. The energy of the solar radiation is in this case converted to heat with the use of solar panel.

Water is a basic necessity of man along with food and air. Fresh water resources usually available are rivers, lakes and underground water reservoirs. About 71% of the planet is covered in water, yet of all of that 96.5% of the planet's water is found in oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps and 0.001% in the air as vapor and clouds, Only 2.5% of the Earth's water is freshwater and 98.8% of that water is in ice and groundwater. Less than 1% of all freshwater is in rivers, lakes and the atmosphere.

Undoubtedly, water is one of the essential resources on entire earth. No creature including human beings, animals, plants or insects can live without water. Water is one of the precious gift by the nature of mankind and we must save it for future generation. The increasing developments in technologies and population have resulted in a large demand of fresh water. Now a days, clean and fresh water are not easily available. Clean and fresh water is using for domestic purpose. Without clean and fresh water we can't survive. Particularly, clean water is not available easily in arid, semiarid region and also in remote areas. The transportation of clean water in remote areas is expensive. So, necessity of this region to purify water easily with low cost. We know, various processes of purification water such as reverse osmosis, multi-effect distillation, nano filtration, membrane distillation. But these methods are economically very expensive.

When we use solar energy for purifying water then it will be less expensive. Because of on earth solar energy is available abundantly. In remote areas abundantly solar energy as well as water is available. But sea water is not useful for drinking purpose because of sorts of contaminants. Desalination In which sea or brackish water is convert into pure form of water by removing all sorts of contaminants. Solar still is the system of converting sea or brackish water into pure form of water by removing all sorts of contaminants. This water distillation system that can purify water from nearly any source, a system that is relatively cheap portable, and depends only on renewable solar energy.

II. DESIGN AND DIMENSIONS OF SOLAR STILL

OUTER BASIN DIMENSION :-

1. Length = 900mm
2. Width = 600mm
3. Height = 280mm

Inner Basin Dimension :-

1. Length = 870mm
2. Width = 570mm
3. Height = 105mm

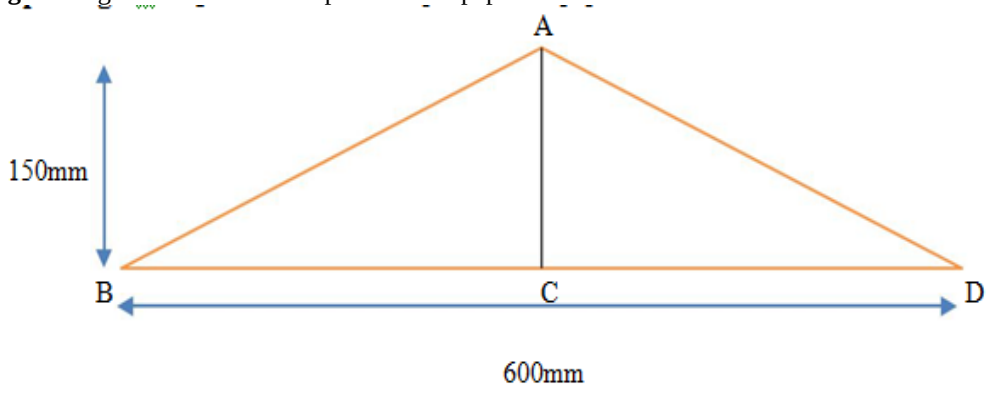
Area of Inner Basin= L*b = 870*570 = 4,95,900 mm^2

Volume of Inner Basin= L*b*h = 870*570*105 = 5,20,69,500mm^3

1 $mm^3 = 10^{-6}$ Lit

Therefore, 52.0695 Lit water in inner Basin

Slope Angle:- Angle ABC = 26.50° as per research paper.



So, tan(26.50°) = AC / BC BC=600/2=300mm

Therefore, AC = 150mm.

Insulation :- Glass wool is between inner and outer basin.

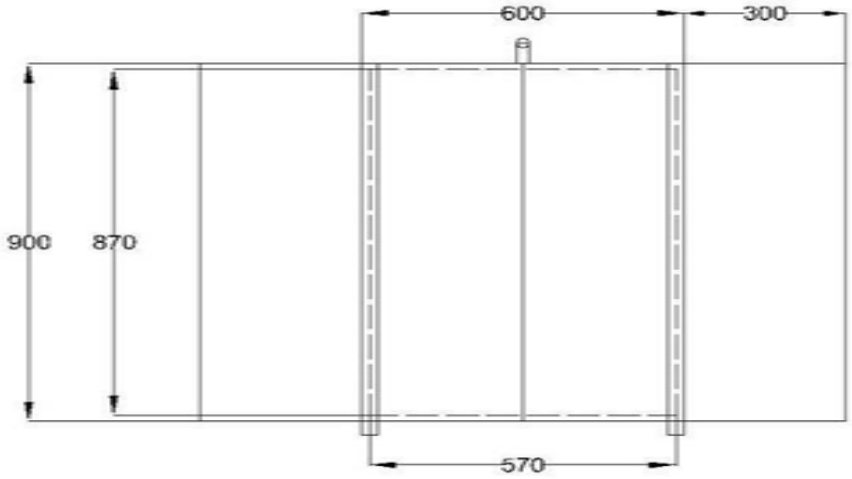
Difference between all side and bottom of inner and outer basin = 15mm.

Thickness of insulation is 15 mm.

Reflector (mirror) Dimension:-

1. Length = 600mm
2. Width = 300mm
3. Thickness = 5mm

III. Cad Model Of Double Slope Type Solar Still



IV. Cost Analysis For Solar Still

1.Total cost of G.I. box = Rs 3000
2.Cost of carbon black paint = Rs 100
3.Cost of glass = Rs 300
4.Cost of Reflector = Rs. 550
5.Cost of insulation and sealing (Silicon Glue) = Rs. 480
6.Cost of the hoisting mechanism and other auxiliaries = Rs 500
7.Cost of labour and machining = Rs 1500
8.Cost of Temperature Sensor = Rs 1555
9.Cost of other parts (Piping's) = Rs 100
10.Cost of Report Writing= Rs. 1500 (Typing, Editing, Color Printing, Binding)
11.Cost of Black Pebble = Rs 210
12.Cost of Paraffin Wax = Rs 130
13.Cost of Al pipe =Rs 250
14.Cost of water testing = Rs 1200
Net cost of the Project = Rs. 11,375/-

V. Assemblying And Manufacturing

Fabrication of the whole unit is pretty straight forward and involves metal cutting, welding, glass cutting, sealing, painting and drilling. All these processes can be done at any local workshop using simple machines – lathe, drill, welding, milling etc.

THE STEPS IN THE PROCESS OF ASSEMBLING ARE OUTLINED AS FOLLOWS:

1. The outer box made of GI will be fabricated first. It will be made of double wall and will be filled with Glass wool to provide insulation.
2. Top Cover (Double slope Type) will be fabricated then. It will be supported by GI Fittings.
3. Condensate Channels will be made on the Top of Basin for the passage of condensed pure water.
4. Water Inlet and Outlets have been made in Basin and Top Glass cover.
5. ONE water inlet and TWO water outlet.
6. Reflectors in order to increase efficiency are then fixed on two sides of glass cover.
7. Thermocouples which will indicate temperature inside still at various levels are then attached.
8. The whole system is sealed using sealant to prevent the air from leaking in from the atmosphere.

Photographs Of Double Slope Solar Still

VI. Observation

DAY 1

DATE: - 30/03/2018, TIME :- 8.00 AM TO 8.00 PM.

Time	Quantity of Output water(ml)	Time	Water Temp(T1)°C	Vapour Temp(T2)°C	Atmospheric Temp(T3)°C
8am-10am	100	8am	35	32.5	31.5
10am-12pm	200	10am	37.5	43.5	34.1
12pm-2pm	550	12pm	47	50	35.4
2pm-4pm	400	2pm	52.3	54.2	35
4pm-6pm	150	4pm	53.2	53.5	36.8
6pm-8pm	50	6pm	49	44.6	32.6
	Total = 1.45 Lit.	8pm	43	40.2	32.1

Table 1 Testing On Bore well Water Without Using PCM, SHSE And Reflector Plate

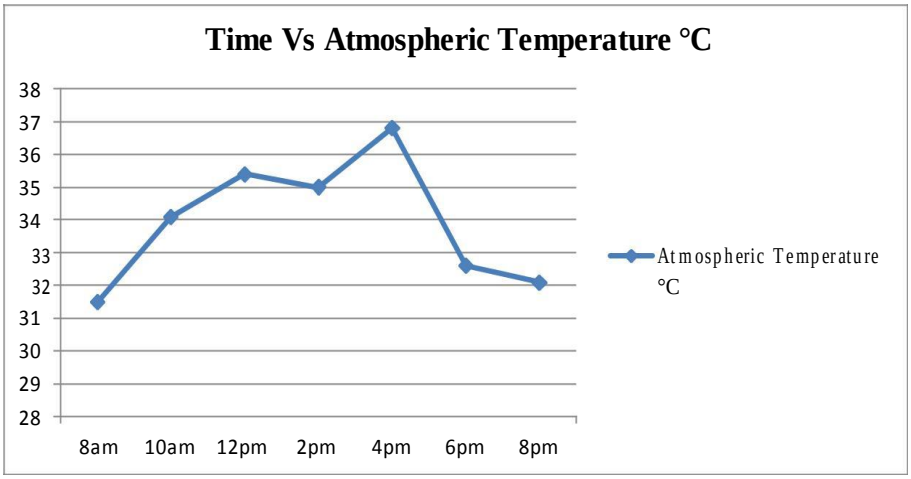


Fig.1 Time Vs Atmospheric Temperature

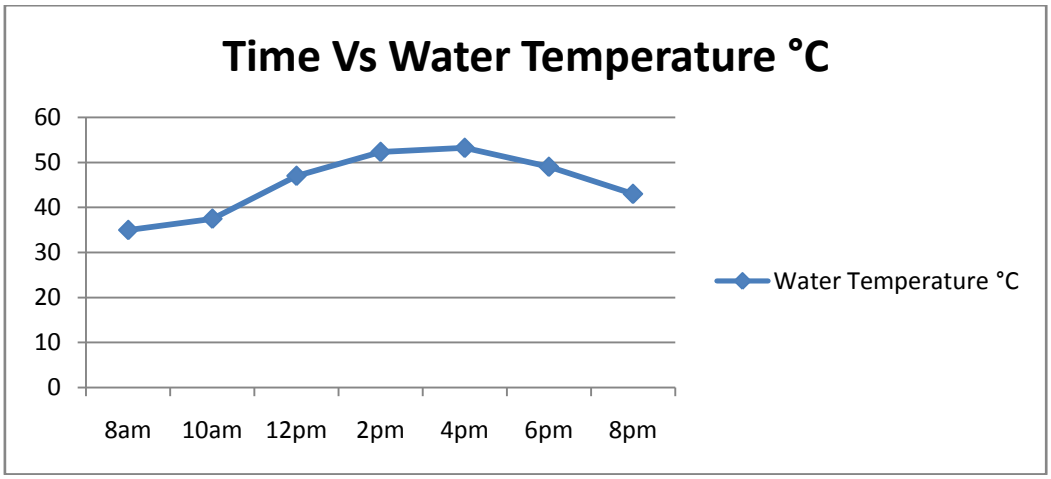


Fig.2 Time Vs Water Temperature

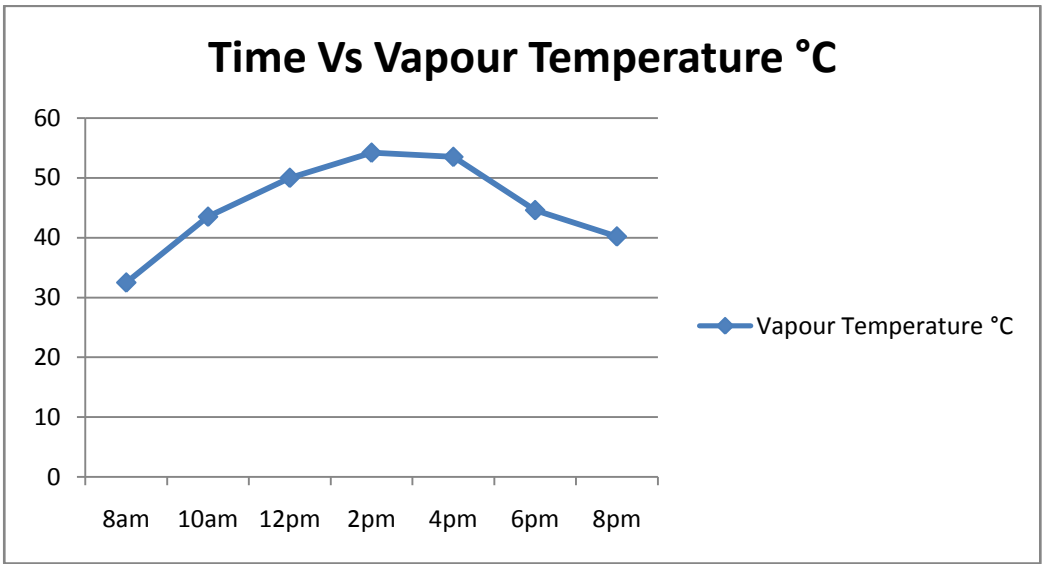


Fig.3 Time Vs Vapour Temperature

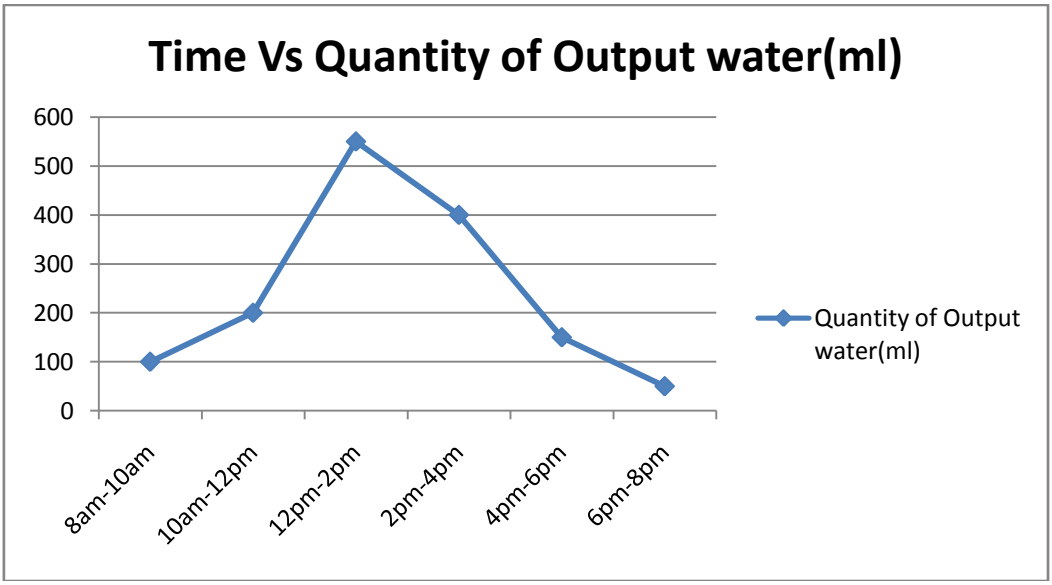


Fig.4 Time Vs Quantity of Output water (ml)

DAY 2
DATE :- 31/03/2018, TIME:- 8.00 AM TO 10.00 PM.

Time	Quantity of Output Water(ml)	Time	Water Temperature(°C)	Vapour Temperature(°C)	Atmospheric Temperature(°C)
8am-10am	200	8am	36	33.5	30
10am-12pm	350	10am	38.9	43.5	34.2
12pm-2pm	700	12pm	46.2	50.2	35.2
2pm-4pm	400	2pm	53.8	53.5	34.9
4pm-6pm	200	4pm	53.2	53.5	36.3
6pm-8pm	150	6pm	50.2	44.7	33.5
8pm-10pm	100	8pm	43.8	40.2	32.5
	Total = 2.1 Lit.	10pm	40	34.2	31.3

Table 2 Testing on Bore Well Water With Using PCM, SHSE and Reflector Plate

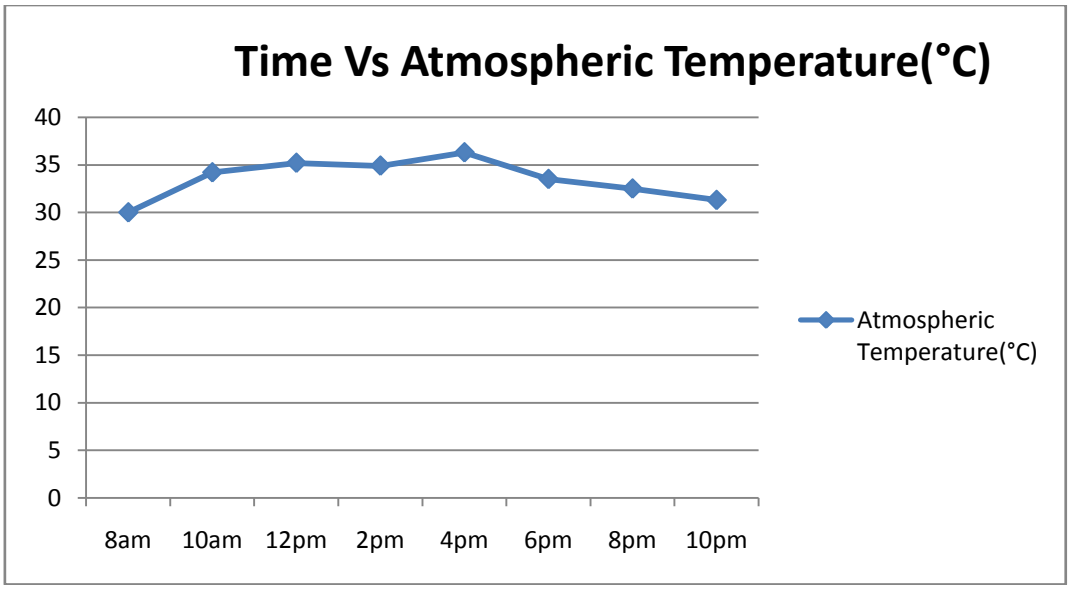


Fig.5 Time Vs Atmospheric Temperature

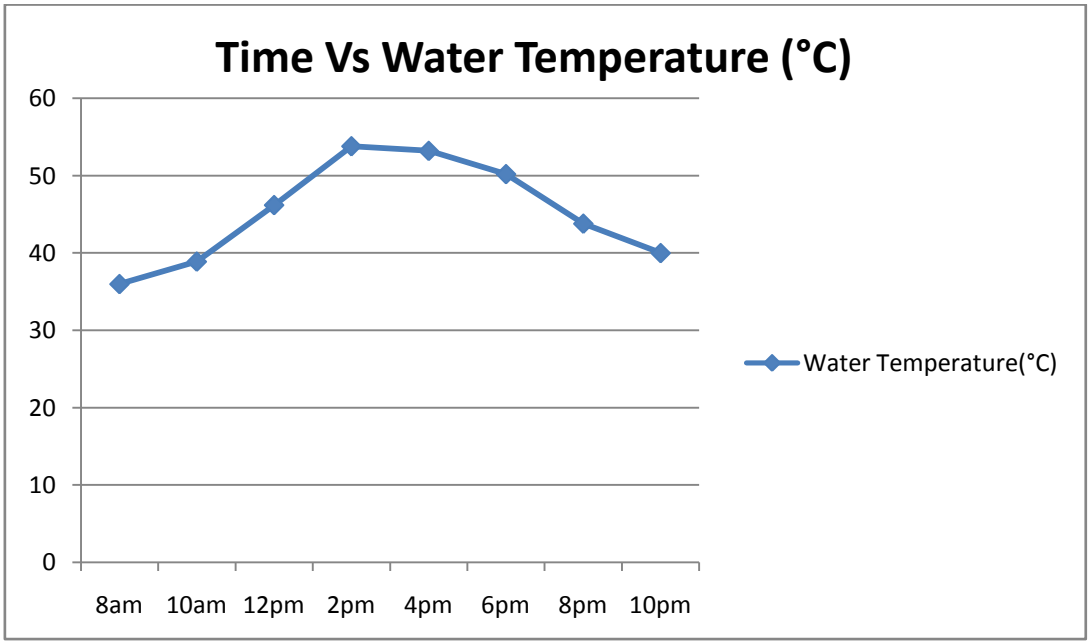


Fig.6 Time Vs Water Temperature

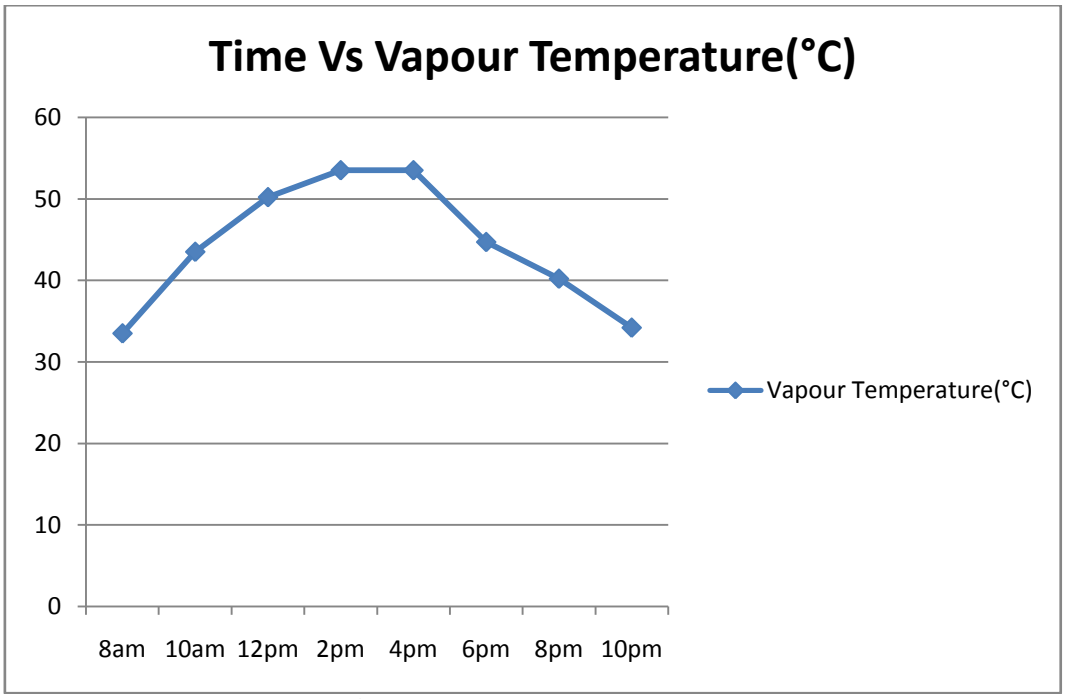


Fig.7 Time Vs Vapour Temperature

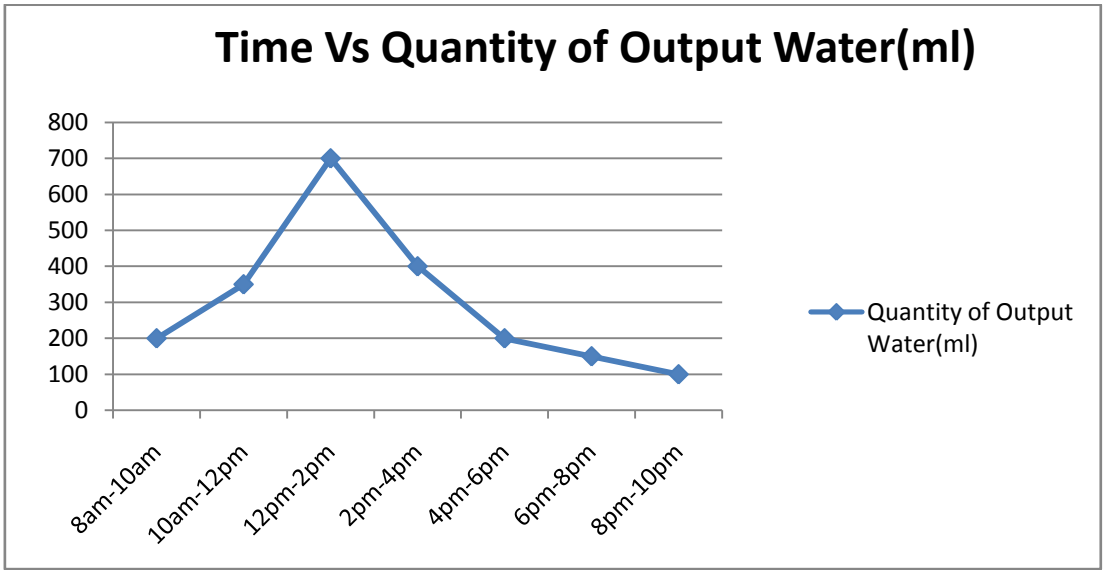


Fig.8 Time Vs Quantity of Output Water (ml)

DAY 3
DATE :- 02/04/2018, TIME:- 8.00 AM TO 10.00 PM.

Time	Quantity of Output Water(ml)	Time	Water Temperature(°C)	Vapour Temperature(°C)	Atmospheric Temperature(°C)
8am-10am	150	8am	35.9	33.8	30
10am-12pm	400	10am	38.4	43.5	34.4
12pm-2pm	600	12pm	46.6	50.4	35.2
2pm-4pm	450	2pm	54	53.3	34.9
4pm-6pm	200	4pm	53.5	53.8	36.2
6pm-8pm	150	6pm	52	44.9	33.6
8pm-10pm	100	8pm	43.2	40.3	32
	Total = 2.050 Lit.	10pm	41	34.9	31

Table 3 Testing on Salt Water With Using PCM, SHSE and Reflector Plate

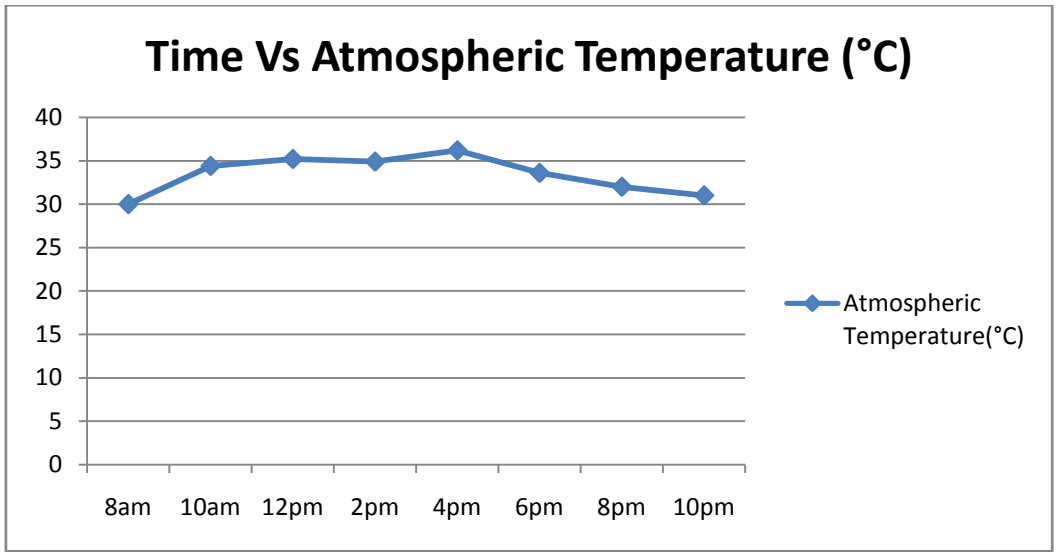


Fig.9 Time Vs Atmospheric Temperature

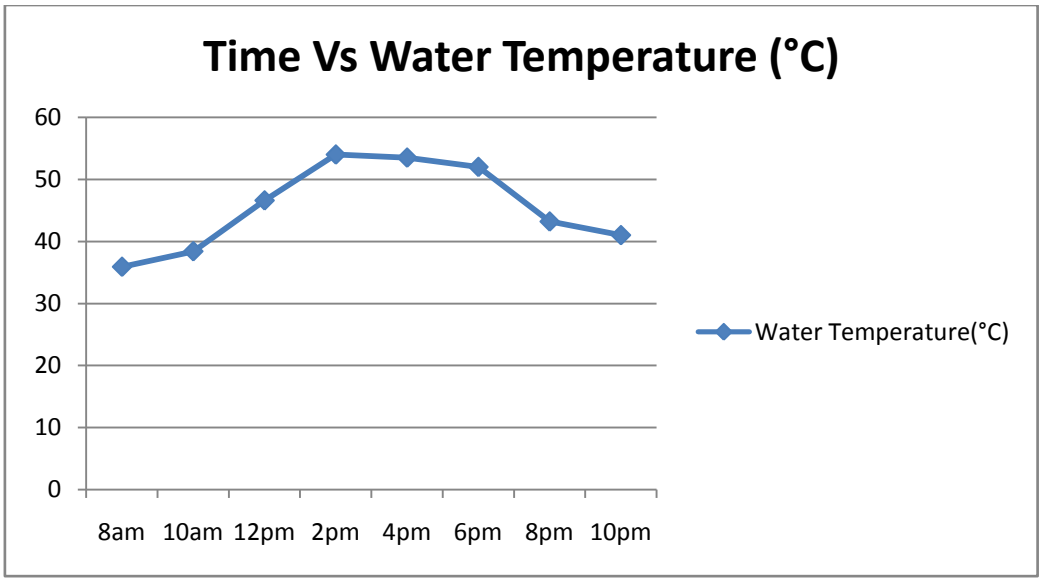


Fig.10 Time Vs Water Temperature

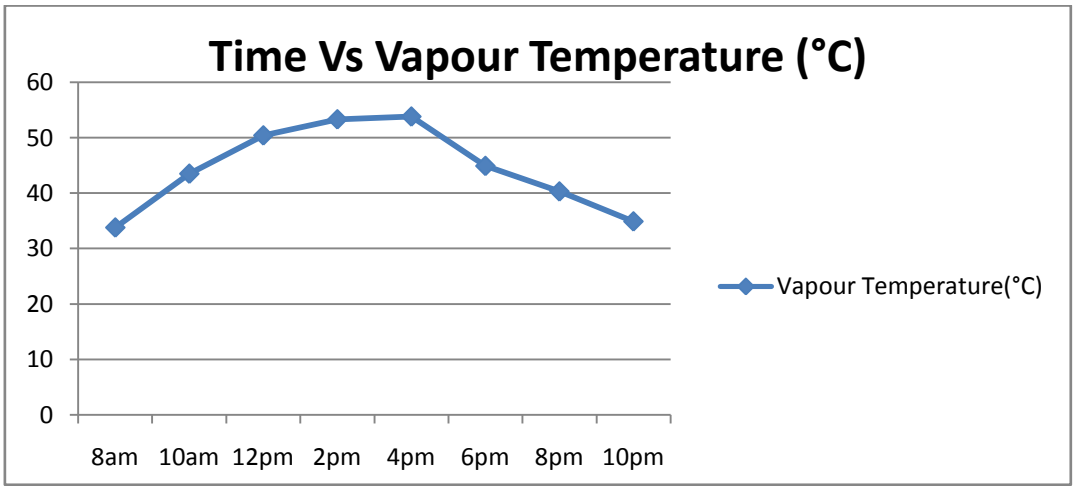


Fig.11 Time Vs Vapour Temperature

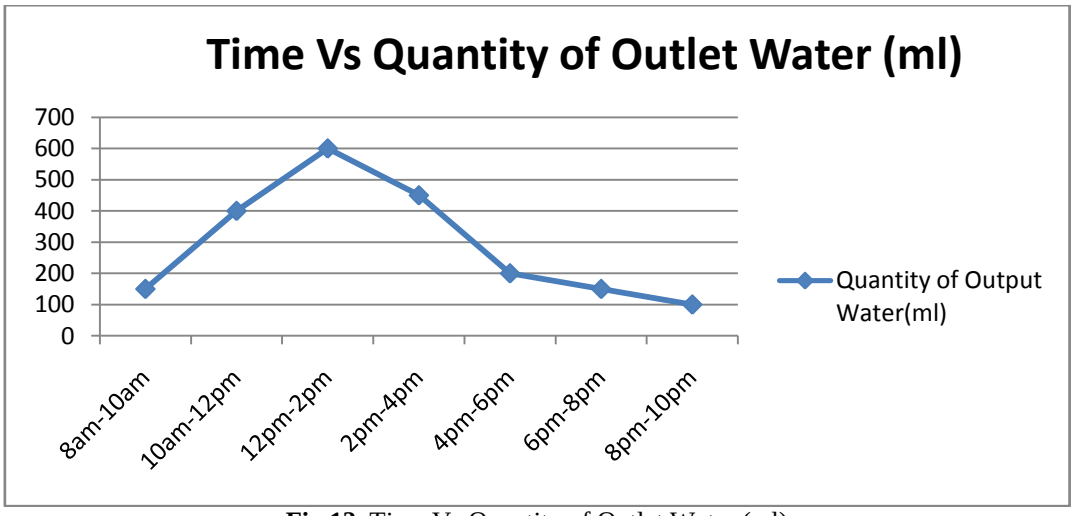
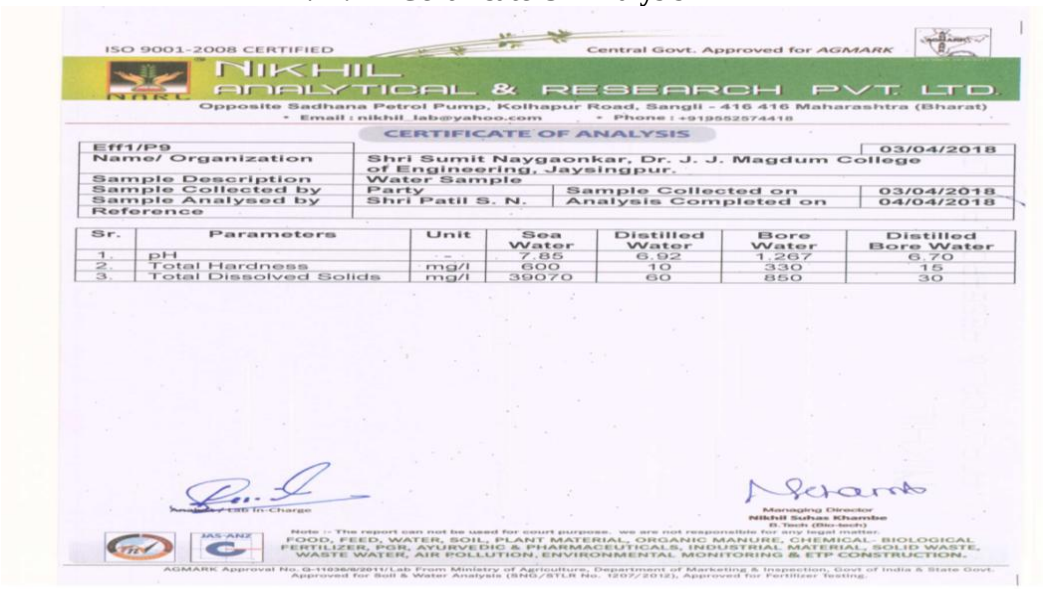


Fig.12 Time Vs Quantity of Outlet Water (ml)

VII. Certificate Of Analysis



ISO 9001-2008 CERTIFIED — Central Govt. Approved for AGMARK

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CERTIFICATE OF ANALYSIS

Eff1/P9			03/04/2018
Name/ Organization	Shri Sumit Naygaonkar, Dr. J. J. Magdum College of Engineering, Jaysingpur.		
Sample Description	Water Sample		
Sample Collected by	Party	Sample Collected on	03/04/2018
Sample Analysed by	Shri Patil S. N.	Analysis Completed on	04/04/2018
Reference			

Sr.	Parameters	Unit	Sea Water	Distilled Water	Bore Water	Distilled Bore Water
1.	pH	- -	7.85	6.92	1.267	6.70
2.	Total Hardness	mg/l	600	10	330	15
3.	Total Dissolved Solids	mg/l	39070	60	850	30

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VIII. Result

Sr. no	Set up type	Water type	Quantity of Water (Ltr)	PH	Total hardness	Total Dissolved Solids
1	Without PCM, SHSE, Reflector	Bore water	20	1.27	330	850
2		Distilled bore bore	1.45	6.7	15	30
3	With PCM, SHSE, Reflector	Bore water	20	1.27	330	850
4		Distilled bore bore	2.1	6.7	15	30
5		Sea water	20	7.5	600	39070
6		Distilled sea water	2.05	6.92	10	60

IX. Conclusion

1. Output water PH is neutral and good for drinking.
2. Output water total hardness and total dissolved solids reduced to such extent that we can drink water. Also we can avoid more diseases.
3. It was found from the experimental analysis that increasing the ambient temperature from 36˚C to 53.8˚C.

4. The Solar distillation involves very low maintenance cost and no energy costs as it involves only solar energy which is free of cost.
5. Solar still productivity also increases by use of reflectors, Black Pebbles & PCM.
6. From the graph, we can conclude that the increase in temperature and hence evaporation is maximum in period 12am to 3pm and we also get more water in evening.

Advantages:-

1. Free of charge sun energy (during sunlight it eliminates 500 Watt electric consumption per one hour of sunlight).
2. There are no moving parts; it is therefore reliable and almost maintenance free (cleaning is required though).
3. Water taste is claimed to be better since the device act as a Solar Water Vaporizerand it doesn't boil the water (resembling rain water).
4. Neutral pH is claimed (like rainwater), not like the not neutral pH of steamed distilled water.

Limitations:-

1. Low distillate output per unit area.
2. Leakage of vapour through joints.
3. Maintance required in consistently sea water used as in contains more salt.
4. Productivity decreases with time for a variety of reasons.
5. Cost per unit output is very high.

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