

An Experimental Approach to Increase Efficiency of Modified Solar Still and Comparison between Conventional, Modified and Modified Solar Still using Iron as Heat Storage Medium

Prof. Abhishek Kumar¹ Shubham Dwivedi²

¹Assistant Professor ²Scholar of Master in Technology

^{1,2}Department of Mechanical Engineering

^{1,2}Kailash Narayan Patidar College of Science and Technology, Bhopal (M.P.), India

Abstract— The existing desalination system works on the electricity, high grade on non-conventional energy like gases, fossil fuel & coal. While the extraction of thermal energy from these fuels, carbon footprint residues occurs, this may cause increase in greenhouse gases in environment, ozone layer depletion and many health hazards on mankind. It may also cause global warming which is a major threat & burning topic to the sustainability of life. The harming of solar energy is most efficient & less sophisticated opportunity towards the green technology. The desalination using solar energy is one time investment for lifetime production of pure water up to 15 to 25 years. In this dissertation, multiple method of desalination has been discussed. The productivity of passive solar stills can be improved or enhanced by using various storage materials or by some simple modification in the design of still. These solar still can be used to convert brackish water into fresh water. Conventional solar stills has low productivity and productivity of solar still many research iterate and puts their effort consistently. Many researches have used metal particles of Nano sized to improve the thermal efficiency of the still. In this project, conventional and modified solar stills are used for the performance analysis, results were carried out with depth of water and graphs were plotted. In terms of yield, maximum conversion of water is obtained from double slope single basin passive solar still with iron as storage material with 839ml of pure water at 1 cm depth of saline water, which is in comparison 39.68% more than the non-conventional & 46.67% more than the conventional solar still with only saline water. The efficiency goes maximum by 15.52% using iron pieces at 6 PM and 3 cm of saline water, on using conventional still with saline water at 1cm it gives 10.17% at 1 PM & it gets 10.37% when non-conventional solar still is used with only saline water at 2 PM. In terms of efficiency, it is observed that the overall maximum efficiency is obtained by using iron is 15.52% which is 54.27% higher than the yield of conventional still using water and 33.9% more than the non-conventional still with saline water.

Keywords: Solar Still, Passive Solar Still, Conventional Still, Modified Still, Storage Medium, Iron, Sun Meter, Anemometer, Condensation, Yield, Productivity

I. INTRODUCTION

Energy is defined as “the ability to do work”. It plays a vital role in the development of any country. As we know, living organism needs energy for their work. The degree of development of the country is measured by the scale of utilizing of energy for human survival. Humans are continually doing research to find the alternatives of energy. So, they can increase their comfort level. As a country grows and develops the gross domestic product (GDP) increases and

almost proportional to the energy consumption. Human development index (HDI) of India is very low, as compared to other countries. But, it is assumed that it will increase in upcoming years. Energy intensity is defined by the ratio of energy consumption to GDP. This factor is higher for developing countries in comparison to developed countries. “India’s energy intensity is 3.7 times of Japan and 1.55 times of USA”.

To full fill the demand of energy, people use various sources which can provide the energy effectively and efficiently. But, with increase in population, energy requirement also increases. If we are exploiting the energy resources very soon they gets fully exhausted from the nature, so we need to find the alternatives of non-renewable energy which are also called Renewable source of energy.

Various high and medium technologies have been developed for water purification such as reverse osmosis (RO), multi-stage flash distillation (MSF), multi-effect distillation (MED), vacuum distillation, and vapor compression. But solar distillation is a simple technology which utilizes solar energy (an ample source of non-conventional or renewable energy). It is an economical, effective and environment friendly technology. The most simple and least expensive solar stills are passive solar stills. Kamel Rabhi, Rached Nciri et al. [1] In this work a modified single-basin single-slope solar still is developed. A pin fins absorber and a condenser are integrated in the modified solar still. A detailed still design and still functioning description is carried out. An experimental comparative performance study is conducted between the conventional still, the still with condenser, the still with pin fins absorber and the still with both condenser and pin fins absorber. A gain of water production in the order of 32.18% is recorded for the still with condenser (using air flow and external condenser) compared to the conventional still. For the case of the still with simple pin fins absorber, the water production gain is only 14.53% compared to the conventional still. Zakaria Haddad, Abla Chaker, Ahmed Rahmani [2] proposed A schematic description of the solar still. It consists mainly of a basin type, single slope solar still in which the VRW is integrated against the rear side of the still. The basin area of the still is 0.36 m² (0.9 m × 0.4 m) fabricated using 1.0 mm thickness galvanized iron and painted with black spray paint to increase solar ray's absorption. The basin is placed inside a rectangular wooden box of 4 cm thickness and the bottom space between them is filled by 8 cm of glass wool to reduce bottom thermal losses. Which results in increase in distillate output. V. Velumurugan et al. observed that when the wick was used in a single basin solar still, the productivity increased up to 29.6% as compared to the use of sponges which increased the productivity by 15.3%. In the same still, when fins were used,

the increment observed was 45.5%. Basharat Jamil, Naiem Akhtar [4] The present work was carried out at Heat Transfer and Solar Energy Laboratory, Mechanical Engineering Department, Aligarh Muslim University, Aligarh, India (27.89°N, 78.08°E). The actual view of experimental setup, i.e. conventional single slope basin type solar still. Galvanized Iron sheet of gauge 22 was used for the construction of solar still. Basin area was kept 1m² with an aspect ratio of 2:1. This is in accordance to the fact that an absorber aspect ratio of 2:1 gives optimal collection of solar energy in the solar still. Ravishankar Sathyamurthy, P.K.Nagarajan, B.Madhu [5] It is clearly seen that the effect of integrating solar still improves the yield of fresh water from both solar still. The heat extracted from the solar still (Tubular) was utilized for evaporating water from the single basin pyramidal solar still. Experimental results also showed that the flow rate of water for cooling the external cover of the tubular solar still is limited from 10 to 100 ml/min as the extraction of heat from the cover was minimum at increased mass flow rate. Nisrin Abdelal, Yazan Taamneh [6] In this research, four pyramid-shaped solar still basins were designed and fabricated with the same shape, dimensions and materials but with different absorber plate base materials. The first basin's absorber plate was made of galvanized steel painted in black, the second basin's plate was made of CF/2.5 wt% CNT modified epoxy composite, the third plate was made of CF/5 wt% CNT modified epoxy composite, and the fourth plate was made of CF/2.5 wt% GNP modified epoxy composite. The experiments were carried out in 4 days in September under the outdoors climatic conditions of Irbid city, in Jordan. Brackish water was used in all experiments. Each solar still unit consisted of several parts: a galvanized steel container painted in black and filled with 5 cm thick foam for insulation purposes. A 70 × 70 cm² galvanized steel plate painted in black was used as the base for the first solar still, whereas the base was composite plate attached to the galvanized steel plate for the remaining three distillers. M.H. Sellami, T.Belkins, M.L.Aliouar [7] Four identical solar still prototypes were constructed and assembled, one of which was used as a witness unit (i.e. a reference unit without a sponge) while the parameters under investigation were applied to the other three units. The four units operate under recorded meteorological conditions, namely ambient temperature, solar irradiance and wind velocity shows a cross section schematic of the single-slope basin solar still used in these experiments. The solar still support was made of 40 mm thick wood. Its basin (absorber) is a tray (480 × 370 × 30 mm) made of 3 mm thick galvanized metal. The absorbers of both stills were blackened on the surface to ensure maximum absorption of solar irradiance for effective heating of the brackish water. The base of each assembly was further glued with a 30 mm thick polystyrene insulation. The 3 mm thick removable glass cover of the stills was placed such that it makes an angle of 30° with the horizontal which is recommended for the Ouargla region. The glass cover was sealed tightly with silicone sealant to prevent any vapor leakage. Lovedeep Sahota, G.N.Tiwari [8] Body of the still is fabricated with fiber reinforce plastic (FRP) with a top cover of 4 mm thick transparent glass at angle of 30°. The still is kept in east-west direction to retrieve maximum solar

radiation. Area of the inner surface of rectangular base of the still is 2×1 m² and it is blackened to absorb maximum solar radiation.

Fraction of solar radiation has been reflected from outer surface of transparent condensing cover and water surface, maximum solar radiation penetrates into the still and absorbed in fluid and blackened inner surface. P. Vishwanath Kumar, Anil Kumar, OmPrakash, Ajay Kumar Kaviti [9] In the there study, a detailed evaluation of all the solar stills both single and multi-effect type with passive and active configuration is obtainable. The present reading aims at telling the design stipulation and stress the qualities and demerits of a variety of solar stills upon which study has been done till recent past. Also a discussion on prospect scope is given with some recommendations in the field of solar stills enhancement to economically produce sustainable drinkable water. Ali. F.Muftah, M.A. Alghoul n, Ahmad Fudholi, M.M. Abdul- Majeed, K. Sopian [10] This exertion intends to study the many studies on factors that influence the presentation of solar stills. The consequences showed that the sanitization yield of solar stills are appreciably prejudiced by ambient conditions (e.g. ambient temperature, insolation, wind speed, dust and cloud cover), operating conditions (e.g., depth of water, various dyes, salt deliberation and inlet temperature of water), and design conditions (e.g. diverse passive/active designs of solar stills, incline of the cover, equipment selection, storing supplies, reflectors, insulation, gap distance and sun tracking system). The above study has proved that the decontamination productivity of solar still is prejudiced by climatic, operational, and design parameters.

II. METHODOLOGY AND EXPERIMENTAL SET UP

The experiment is done in environment condition of BHOPAL city having 77° 36" E 23° 16" N in the month of June. This double slope single basin solar still includes the basin area of 1×0.5 m² with the two inclined faces having inclination 15° each. The experimental setup consists of five components:

The placement of solar still is key here, the side with transparent glass section is placed facing South direction while the opaque triangular section must face north. The actual picture of experimental setup is shown in fig below:

III. RESULTS AND DISCUSSION

The experiments were carried out at 1 cm, 2 cm and 3 cm depth of water in 13th, 14th and 15th June respectively at three different solar stills. One is conventional solar still which slope is arranged along length wise and other two stills are modified stills which slope were arranged along width wise. First day in the case of normal glass cover, the water was collected in majoring jar through outlet valve with 1 cm water level: collecting 630 ml in conventional still, 600 ml in modified still with only saline water & 840 ml in case of iron. In the second day, the condensate collected at 2 cm depth of water is 570 ml in case of conventional still, 570 ml in modified still and 815 ml in iron still. Last day, the experiments were carried out at 3 cm depth of water and the amount of condensate by using different material as: 505 ml

through conventional still, 520 ml through modified still and 790 ml by using iron pieces.

In all three days, the solar intensity was also measured at time interval of an hour between 8:00 am to 8:00 pm. First day, the maximum solar intensity was 1150 W/m² at 1:00 pm. Second day, the maximum solar intensity was 1157 W/m² at 1:00 pm and the last day maximum solar intensity was measured 1248 W/m² at 1:00.

For measuring the temperature, the k type thermocouple wire with digital display unit was used and these were placed at 5 different point for measuring temperature and another one thermocouple point was arranged to measure the ambient temperature.

Where,

T₁ = Bottom surface temperature with black body

T₂ = Air temperature inside the solar still

T₃ = Inside glass surface temperature

T₄ = Outside glass surface temperature

T₅ = Atmospheric temperature

Latent heat of vaporization of fluid (L)

$$= 2.4935 \times 10^6 [1 - (9.4779 \times 10^{-4} \times (T_2) + 1.3132 \times 10^{-7} \times (T_2^2) - 4.7974 \times 10^{-9} \times (T_2^3))] ; \text{for } T_2 < 70^\circ\text{C}$$

$$\text{Efficiency } (\eta) = (M \times L) / (A \times I)$$

Where, M = yield in Kg/s

L = Latent heat of vaporization in J/Kg

A = Area of base of still in m²

I = Intensity of radiation in W/m²

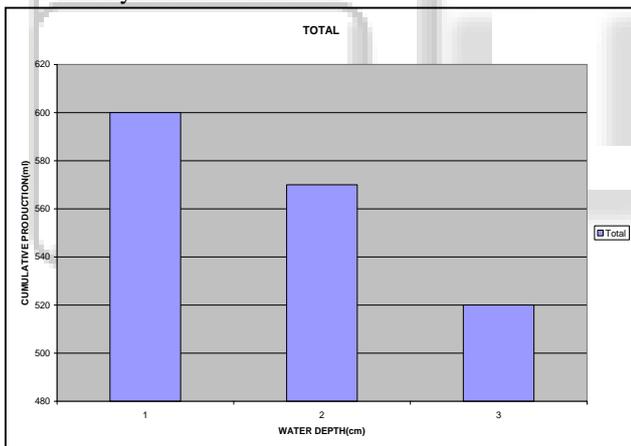


Fig. 4: Cumulative production with respect to depth of water for modified still

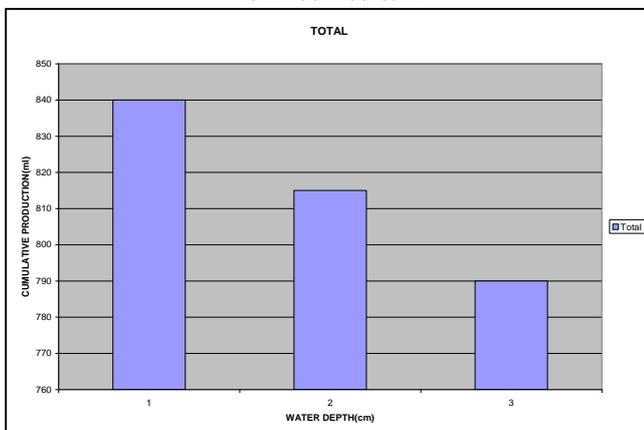


Fig. 5: Cumulative production with respect to depth of water for iron

IV. CONCLUSION

This project consists of three double slope single basin passive solar stills which are used with different storage material in one of the still and water is used in two stills i.e. a conventional still and non-conventional. Observations have been noted during the experiments and from the analysis of results which came and graphs were plotted with respect to respective parameters are as follows.

- In terms of yield, maximum conversion of water is obtained from double slope single basin passive solar still with iron as storage material with 839ml of pure water at 1 cm depth of saline water, which is in comparison 39.68% more than the non-conventional & 46.67% more than the conventional solar still with only saline water.
- The efficiencies get maximum by 15.52% using iron pieces at 6 PM and 3 cm of saline water, on using conventional still with saline water at 1cm it gives 10.17% at 1 PM & it gets 10.37% when non-conventional solar still is used with only saline water at 2 PM.
- In terms of efficiency, it is observed that the overall maximum efficiency is obtained by using iron is 15.52% which is 54.27% higher than the yield of conventional still using water and 33.9% more than the non-conventional still with saline water.
- So, it can be concluded that the iron is optimized storage material for the production of pure water by using single basin double slope passive solar still.

V. FUTURE SCOPE

There is always an opportunity to more explore a one technique from one level to other level. The more exploration is required to optimize the existing technique and to make it more efficient. In this project, future opportunities to make it more authentic and optimized are as follows,

- For this project, to get the exact results of the experiment and to validate the experimental results, thermal analysis with help of computational fluid dynamics can be done.
- By taking reference of these readings obtained by using different material, the new materials can also be used and investigated the performance of still.
- In this project, only conventional design of still is used with some storage material. In future, the more comparison can be obtained by using different designs with same materials
- At present, the storage materials are used individually in each still but, for more exploration mix of two or more material can be used to investigate the efficiency and productivity and comparison could be done.

REFERENCES

- [1] Kamel Rabhi, Rached Nciri, Faozi Nasri, Chaouki Ali and Habib Ben Bacha "Experimental performance analysis of a single basin single slope solarstill with pin absorber and condenser" Desalination 416 (2017) 86-93.

- [2] Zakaria haddad, Abla and Ahmed Rahmani “Improving the basin type solar still performance using a vertical rotating wick” *Desalination* 418 (2017) 71-78.
- [3] Hitesh Panchal and Indra Mohan “Various methods applied to solar still for enhancement of distillate output” *Desalination* 415 (2017) 76-89/
- [4] Barsharat Jamil and Naiem Akhtar “Effect of specific height on the performance of a single slope solar still: An experimental study” *Desalination* 414 (2017) 73-88.
- [5] Ravi Shankar Sathyamurty, P.K. Nagarajan and B. Madhu ”A Review of integrating solar collectors to solar still” *Renewable and Sustainable Energy Reviews* 77 (2017) 1069-1097.
- [6] Nisrin Abdelal and Yazan Taamneh “Enhancement of pyramid solar still productivity using absorber plates made of carbon fiber/CNT – modified epoxy composites” *Desalination* 419 (2017) 117-124.
- [7] M.H. Sellami, T. Belkiss and M.L. Aliouar “Improvement of solar still performance by covering absorber with blackened layers of sponge” *Groundwater for Sustainable Development* 5 (2017) 111-117.
- [8] Lovedeep Sahota and G.N. Tiwari “Effect of nanofluids on the performance of passive double slope solar still: A comparative study using characteristic curve” *Desalination* 388 920160 9-21.
- [9] P. Vishwanath Kumar, Anil Kumar, Om Prakash and Ajay Kumar Kaviti “Solar still system design: A review”, *Renewable and sustainable energy resources*.
- [10] Ali F. Muftah, M.A. Alghoul n, Ahmad Fudholi , M.M. Abdul Majeed and K. Sopian “Factors affecting basin type solar still productivity: A detailed review” *Renewable and Sustainable Energy Reviews* .
- [11] K.R. Ranjan¹, S.C. Kaushik¹ and N.L. Panwar¹ “Energy and exergy analysis of passive solar distillation systems”, *International Journal of Low-Carbon Technologies* 2016, 11, 211–221.
- [12] A.K. Sethi & V.K. Dwivedi (2012) ‘Evaluation of internal heat transfer coefficient of Double Slope Active Solar Still under forced circulation mode, *International Journal of Engineering Research & Technology (IJERT)*, Vol. 1 Issue 8, 1-5.
- [13] M.R. Rajamanickam, A. Ragupathy “Influence of Water Depth on Internal Heat and Mass Transfer in a Double Slope Solar Still”, *Energy Procedia* 14 (2012) 1701 – 1708.
- [14] Rahul Dev, H.N. Singh, G.N. Tiwari. —Characteristic equation of double slope passive solar still. *Desalination* 267:261–266, 2011.
- [15] Kalidasa Murugavel, K., Sivakumar, S. Riaz Ahamed, J., Chockalingam, Kn. K. S. K., and Srithar, K., “Single basin double slope solar still with minimum basin depth and energy storing materials”, *Applied energy*, Vol.87, pp.514-523, 2010.