International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Increasing the Productivity of V-Type Solar Still Augmented with Biomass Heat Source

A. Senthil Rajan[a]*, S. Tharunkarthikeyan[b], A. Alaudeen[c]

[1]Department of Mechanical Engineering, Mohamed Sathak Polytechnic Kilakarai, Ramanathapuram, Tamilnadu 623806, India
Tel. +91 9443862822;
Email: *senthilrajan.73[at]gmail.com*

[2]Department of Electrical and Electronics Engineering Engineering, St. Josephs Institute of Engineering Technology, Chennai, India

[3]Principal, Mohamed Sathak Polytechnic Kilakarai, Ramanathapuram, Tamilnadu 623806, India

Abstract: ***A solar still with a 0.9 × 0.8 × 0.75-meter v-type stepped design was fabricated using galvanized iron sheet and tested with varying water depths from 2 to 4 centimeters, in combination with a biomass heat source. The one end of the basin becomes attached with a heat exchanger having zero.1/2 m diameter and 4.5 m duration, and having five numbers of bends. The feature of the warmth exchanger is to transfer high temperature electricity from biomass warmness supply to the saline water in the nevertheless at a consistent present day charge using circulate pump. Numerous strong, sensible, latent warmth garage materials and evaporative surface materials are used within the nevertheless alongside one of a kind colour dyes delivered inside the nevertheless to boom the saline water temperature. To convey down the glass cowl temperature, the outer glass become cooled using sprinkler manually at normal c program language period. Experiments have been conducted with biomass heat supply for non-stop circulates mode and sun warmth radiation mode. An inward slope of the glass cover was maintained towards the center of the nevertheless and the cover was cemented by using chemical adhesive to decrease air leakage An outlet is also supplied to empty out distilled water and a 2˚ slope is maintained for the water collection channel for easy outward float of distilled water. The performances of changed nonetheless have been compared with conventional nonetheless of the same size strolling underneath the equal meteorological situations. The tremendous, sensible heat garage materials produce 58% more productivity than traditional nonetheless. Also, evaporative substances produce 20% greater productiveness than traditional nonetheless. The performance of the v-still with continuous flow mode produces greater efficiency than solar mode. The performance of traditional still changed into depressed while as compared with all other sorts of operation. Black coloration dye performs well while compared with different colour dyes. Sprinkler, solar still 14% more than conventional still. The main objective of this work is to investigate the performance of the inclined flat plate solar still integrated with and without biomass boiler along with sensible heat storage materials and evaporation material. A biomass boiler supply heat in to the still through heat exchanger. Various water depths of 2cm, 3cm were analyzed. Various combinations of sensible, evaporative materials were used in the still to increase productivity. Glass cover cooling is provided with the help of wicks and manual cooling at regular interval of time to increase condensation rate. To increase evaporative area sponges, wicks were used along with sensible materials. Materials such as sand, metal pieces, stones, were used as the sensible heat materials. The performances of still with biomass boiler are compared with performances of still without biomass boiler***

Keywords: v-type still, biomass, colordye, sensible materials, latent heat materials, evaporative materials

1. Introduction

Water is the main source for all the industrial and social activities. Many countries facing serious water problems. The economy of these countries depends on water. Many methods are available for solving water demand but the easy and economical solution to solve this problem is by desalination methods. Many desalination technologies were available of them our research is focused on solar stills. Fath and Hosny, (2000), analyzed the thermal performance of a single sloped basin still with an inherent built in condenser to improve condensation rate. Badran, (2009), studied the performance of a single slope solar still using different operational parameters experimentally. The results showed that daily productivity of the still can be increased by reducing the depth of the water in the basin. Vertical diffusion solar still coupled with flat plate reflector was designed by Tanaka and Nakatake, (2007), the distillate production rates were increased. Atikol et al, (2005), study inclined solar water distillation system and tested with three variants, base plate, black cloth, wick and black fleece wick. Nakatake, (2009) made a study, on increase in distillate productivity by inclining the flat plate external reflector of a tilted wick solar still in winter. The increase in fabricated a still which contains double slope, single basin. A thin layer of water is maintained in the still and many type of wick materials are used. They found that the production rate is a complex function of water, glass and its difference. Nassar et al, (2007), have successfully shown the effect of vacuum on the performance of the roof type solar still and conducted that the reduction in power required to produce 1 kg of fresh water will be 90.1% and water production rate is 20.11 kg/m2. Minasian and Karghouli, (1995), designed a wick type basin solar still and proved meet production of water increases by 85% than conventional basin. T. V. Arjunan and H. S. Aybar, (2005), analyse different heat storage medium and found meet blue metal store as a storage medium increases 5% productivity. Voropolulos et. al, (2004), experimentally investigated the hybrid still coupled with solar collectors the results showed that the productivity is doubled by coupling Muafag suleiman. K. and Tarawneh (2007) conducted the experiment on effect of water depth on still he also uses sprinkler for glass cooling to reduce glass cover temperature and improves productivity of still. 14% more than conventional still. The main objective of this work is to investigate the performance of the inclined flat plate solar still integrated with and without biomass boiler along with sensible heat storage materials and evaporation

material. A biomass boiler supply heat in to the still through heat exchanger. Various water depths of 2cm, 3cm were analyzed. Various combinations of sensible, evaporative materials were used in the still to increase productivity. Glass cover cooling is provided with the help of wicks and manual cooling at regular interval of time to increase condensation rate. To increase evaporative area sponges, wicks were used along with sensible materials. Materials such as sand, metal pieces, stones, were used as the sensible heat materials. The performances of still with biomass boiler are compared with performances of still without biomass boiler.

2. Experimental set up

A v-kind solar still turned into fabricated with 1.5mm thick moderate metallic. The dimensions of the basin become 0.9 × 0.8 × 0.75 m. The decrease basin turned into fitted with 10mm diameter G. I warmness exchanger having five numbers of turns the basin is painted black to soak up most solar radiation. The location and bottom positions of the stills were insulated with 3mm thick thermocouple insulation layer to lessen heat losses. The condensing surface is made from undeniable glass with 3mm thickness is ready at 300 inclination to the horizontal axis. A rubber sealant is applied to keep the glass intact with the metallic to prevent the vapor leakage from the nonetheless. An inward slope of the glass cowl changed into maintained closer to the middle of the still and the cover was cemented with the aid of chemical adhesive to minimize air leakage An outlet is also provided to drain out distilled water and a 2˚ slope is maintained for the water collection channel for easy outward go with the flow of distilled water. Provisions were made to supply uncooked water, run out the basin water and insert thermocouples. The biomass boiler having 150mm outer diameter and shell thickness 15 mm and peak 750 mm fabricated from solid iron became used as a high temperature source. The boiler is internally fired with locally to be had biomass substances. The feed water to the boiler drum via gravity from the enter feed water deliver tank that's positioned above the elevation of the boiler. Protection valves and stress gauges are present inside the boiler.

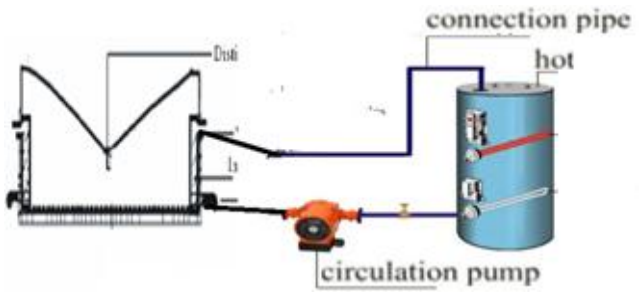

Figure 1: Experimental set for v-type solar still with biomass boiler

3. Working

Sun nevertheless is provided with 2-4cm depth of water through the inlet pipe in the nevertheless. Biomass boiler become full of feed water supplied from the inlet supply tank. Biomass having 1kg of mass are fed within the furnace through the gasoline deliver door and ignited manually. Water in the drum gets heated the burnt fuel passes thru the internal aspect of the hearth tube and exhausted to the environment through the chimney. The boiled water is sent in the sun nevertheless via the heat exchangers and the circulation pump. The water within the sun nevertheless absorbs warmness from the heat exchangers and evaporated into vapors reaches the lowest floor of the cover. The pinnacle floor of the basin became Cooled externally the vapor condenses and accrued in the condensate collection channel as distilled water. a collection flask collects the distilled water. Water move and the burning system inside the boiler continuous via circulation pump at regular speed. within the solar mode the nonetheless is uncovered to solar radiation most effective. Figure 1 suggests the experimental set

Accuracies and error for various measuring instruments

S. No.	Instrument	Accuracy Range	% error
1	Pyranometer	±30 W/m^2 0-1800 W/m^2	3
2	Digital thermometer	±1˚C 0˚C-100˚C	2
3	Thermocouple	±1˚C 0˚C-100˚C	0.4
4	Anemometer	±0.2 m/s 0.4-30.0 m/s	1
5	Measure jar	±10 ml 0-1000 ml	2

4. Results and Discussions

a) Effect of water depths on productivity

The impact of water intensity in the nonetheless basin in the productivity is proven in Figure 2 it's miles glaring that as the water intensity extended, The productiveness will be reduced. this is due to be growth of the warmth potential of the water inside the basin, effects, in decrease water temperature in the basin main to lower evaporation price the nevertheless with 2cm produces extra output than different depths.

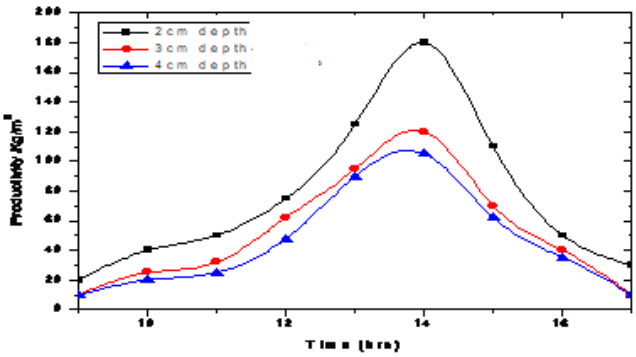

Figure 2: Effect of water depths on productivity

b) Effect of metrological data on water, basin temperature

The Figure 3 suggests the variant of solar radiation and water, basin temperature. The solar radiation regularly increases from starting and reaches most at midday after wards it falls. The water temperature is maximum at 64 ^{0}c and minimal of 32^{o}c. The wind velocity is low at high radiation and maximum at low radiation.

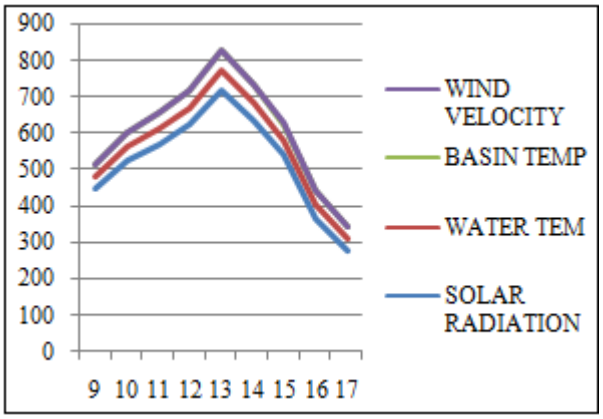

Figure 3: Effect of metrological data on water, basin temperature

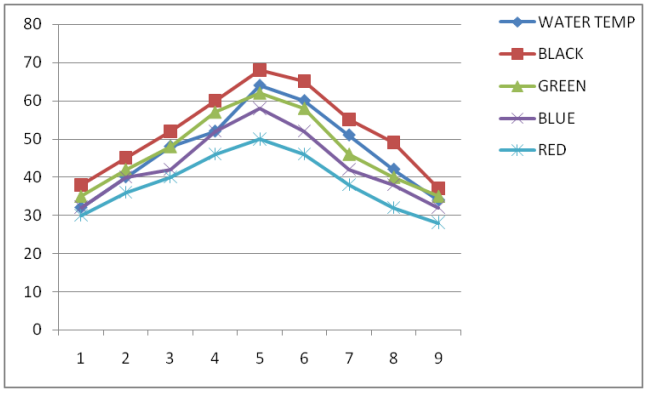

Figure 4: Effect of adding colour dye to the vapour and output in the still

c) Effect of adding color dye to the still

Figure 4 compares the day by day fluctuations of the water temperature with 10 mm of water via including coloration dye. As can be seen, the temperature of many factors rises progressively till they reach their better price at noon and after wars it falls and reaches the lower at nighttime. The dye delivered also increases the water temperature inside the basin. Special black coloration dye absorbs more strength than others. Dyes in water reduces its transparency, thereby declining mild penetration in the water, subsequently influencing photosynthesis which therefore reduces dissolved oxygen including food coloring to water causes a change in shade. The pigment molecules from the food coloring dissolve into the water and reason the shade exchange. This is a bodily alternate. Given that no new substances are produced, no chemical response has taken region. The presence of black dye in the water will soak up more energy than the colorless water; this may reason the water temperature to be higher than the basin liner

d) Effect of vapour temperature with dye on productivity

Figure 5 compares the everyday fluctuations of the vapour temperature with 10 mm of water through including colour dye. As may be seen, the temperature of vapour rises step by step till they attain their better price at noon and after wars it falls and reaches the decrease at night. The black dye brought additionally increases the vapour temperature inside the basin. Vapour temperature of green dye turned into 700c at noon in solar mode. Figure 5 suggests the output from the still with numerous dyes used inside the nonetheless. The most output was recorded for black dye due to the absorption of greater power from solar than others colorations. Dyes in water reduces its transparency, thereby declining light penetration in the water, consequently influencing photosynthesis which therefore reduces dissolved oxygen adding meals coloring to water reasons a trade in coloration. The pigment molecules from the meals coloring dissolve into the water and purpose the colour exchange. That is a bodily alternate. On the grounds that no new substances are produced, no chemical reaction has taken area. The presence of black dye within the water will take in more electricity than the colourless water; this will motive the water.

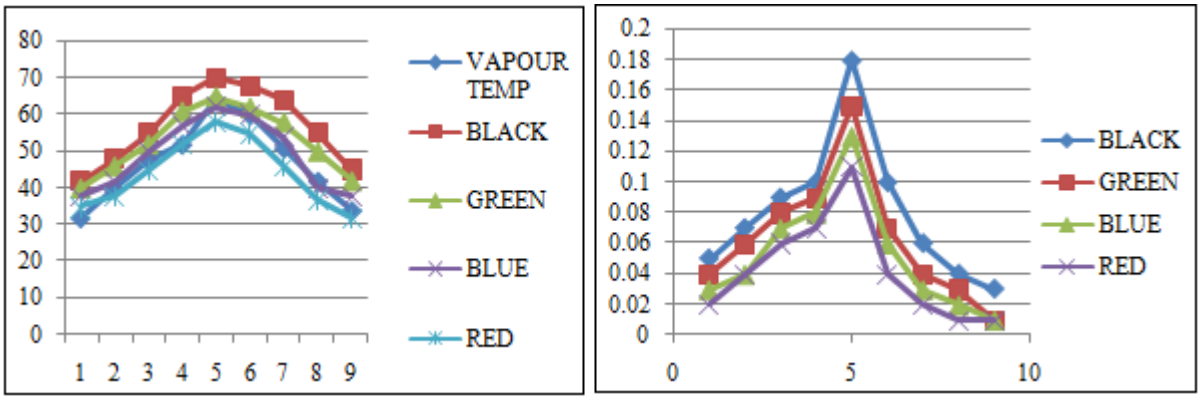

Figure 5: Effect of vapour temperature with dye on productivity

e) Effect of output with biomass boiler and solar mode

The addition of biomass boiler to the single basin still improves the water manufacturing from the still. Since the water is heated within the biomass heater and exceeded through a warmth exchanger outfitted with the bottom of the nevertheless. The biomass heat deliver relies upon on the amount of gasoline burnt within the biomass heater so if we burnt extra fuel the quantity of heat furnished will increases and also increases the temperature within the nonetheless as a end result greater water production from the nonetheless than solar concentrator primarily based stills. The water depth is thin layer (10cm) all the quantity of warmth furnished is applied to evaporate water the productiveness become 1400ml/m2 /hr for 2cm. The still without boiler produces 200ml/m^2/hr.

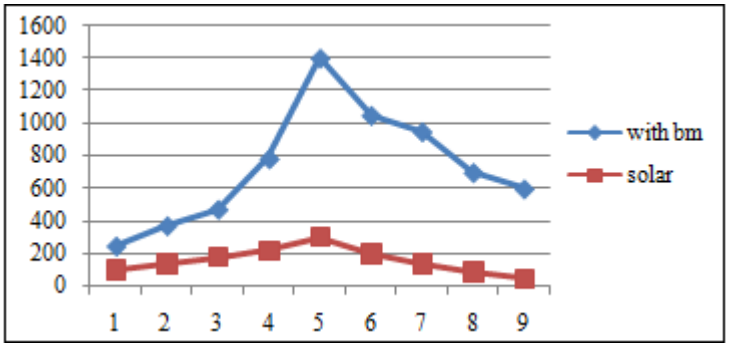

Figure 6: Effect of output with biomass boiler and solar mode

f) Effect of sensible, latent heat, evaporative materials in the still with biomass boiler

Impact of realistic warmness storage substances on productiveness in solar mode a few substances can save extra amount of heat strength and increases the heat potential of the basin further to growing the basin absorption. These materials absorb energy during heating durations and released energy slowly all through cooling. The Figure 7 indicates the productivity of diverse solid sensible warmness storing substances with time numerous substances which include Aluminum, Granite portions are positioned in the still with 10 cm water depth and examined. The productivity of aluminum pieces are 48percentgreater than traditional nonetheless the alternative substances consisting of granite, cast-iron produces 34%, forty five% greater productiveness than conventional still whilst operated underneath solar mode. The productiveness is taken for common sun radiation of 500-800 W/m2 at some point of numerous days of take a look at trails The Figure 7 shows the productivity of the diverse latent warmness storage substances in sun mode. Various liquid substances such wax and ethylene glycol are packed in the billet and added into the still. The latent warmth substances having belongings of changing their section from liquid to within the still. The reading plotted on the Figure 7 is taken for the common wind pace of one. 8-2.5 m/s on numerous days of check trails. Due to capillary action sponges, bricks and coconut coir absorbs more water. Hence, exposure vicinity is improved. Addition of these materials inside the nevertheless increases the water by capillary motion which ends up in boom the evaporation charge within the nonetheless. As proven in Figure eight productiveness is multiplied by using about 38 % for coconut coir, 49% for sponges and 26 % for bricks than conventional nonetheless operated in sun mode. The reading plotted on the Figure 7 is taken for the average wind speed of one. Eight-2.5m/s on diverse days of test trails.

The Figure 7 shows the productivity of the numerous latent warmness storage substances in solar mode. Numerous liquid materials such iodine and ethylene glycol are packed within the billet and introduced into the still. The latent warmth materials having a property of changing their segment from liquid to vapors at some stage in charging durations and from vapors to liquid phase again at some stage in discharging periods. In the course of the charging intervals it absorbs electricity and releases throughout discharging. The productiveness of glycol is 30% higher than traditional nonetheless. Further, the productivity of iodine became 18% higher than the conventional nevertheless.

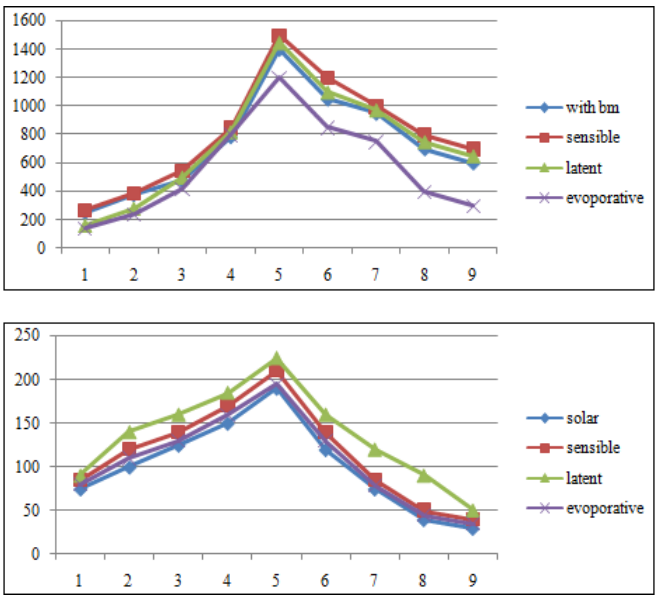

Figure 7: Effect of sensible, latent heat, evaporative materials in the still with biomass boiler

g) Economic Analysis

The general fabrication fee operating value of each traditional and changed nevertheless is Rs.8000 ($a hundred and sixty). The cost of feed water is negligible. No protection cost. The value in step with liter of distilled water is Rs.20. ($0.2) and the average productivity of the still is 3542 kg/m2. The still produced a median of 1085 kg/m2. For this reason the fee of water produced in line with day is Rs.70 ($0.20) for changed still and Rs.20 for traditional nonetheless. net profits for still with biomass boiler =cost of water produced-maintenance cost =Rs. (25-zero) = Rs.25 ($ zero.25) For nonetheless most effective it's miles Rs.20 and payback length = investment / next profits in keeping with day = 8000 / 70 = 114 days Pay lower back duration for conventional nonetheless =8000 /20 = 400 days Taking biomass boiler into account, For biomass boiler mode payback period = 10000/90 = 114 days.

5. Conclusion

The following findings end result from an intensive experimental investigation into how special dyes affected the neighborhood and international heat switch coefficients in primary sun nonetheless.

1) The black dye in water absorbs more sunlight than different dyes and enables in increasing productivity inside the nevertheless.
2) Use of realistic, latent warmth, Evoporative surfaces storage substances within the nonetheless improves productivity with the aid of seventy three% than traditional nonetheless
3) Biomass boiler materials additional power to the solar still
4) Biomass used are eco pleasant
5) productivity recorded is more with nonetheless attached with boiler
6) sun still produces less output than biomass boiler attached stills
7) decrease water depth produces excessive yield
8) Biomass boiler produces 35% greater yield than normal sun nevertheless
9) advent of biomass boiler will increase water and vapour temperature
10) Payback duration of v-kind biomass nonetheless is 114 days

References

[1] Ashok Kumar, Tiwari GN. Use of waste water in double slope solar still through heat exchanger. Energy conversion and management 1990; 30 (2); 81-90.
[2] Voropoulos K Mathioulakis E Belessiotis V. A hybrid solar desalination and water heating system. Desalaination 163 (2000): 189-95.
[3] O. O. Badran, H. A. Al-Tahaneih. 'The effect of coupling a flat plate collector on a solar still productivity', Desalination 183 (2005): 137-142.
[4] V. Velmurugan, K. Srithar, 'Performance analysis of solar stills based on various factors affecting the productivity—A review'. Renewable and Sustainable Energy Reviews 15 (2011) 1294– 1304.
[5] A. Senthilrajan, K. Raja, P. Marimuthu. Multibasin desalination using biomass heat source and analytical validation using RSM. Energy conversion and management 2014; 87, 359-366.
[6] A. Senthilrajan, K. Raja, P. Marimuthu. Augumentation of single basin and a pyramid still desalination using common biomass heat source and Analytical validation using RSM. Australian journal of basic and applied sciences, 2014; 8, 212-218.
[7] Badran, O. O., Experimental study of the enhancement parameters on a single slope solar still productivity. Desalination, 2000; 209, 136–143.
[8] Aybar S. Hikmet, Egelioglu Fuat and Atikol U. An experimental study on an inclined solar water distillation system. Desalination, 2008; 180, 285-289.
[9] Kalidasa Murugavel, K., Chockalingam, Kn. K. S. K., Sivakumar, S., Ahamed Riaz, J., Srithar, K, 2010. Single basin double slope solar still with minimum basin depth and energy storing materials. Applied Energy, 2010; 87, 514– 523.
[10] Hassan E. S. Fath and H. M. Hosny. Thermal Performance of a single sloped basin still with an internet built in additional condenser. Desalination, 2000; 142, 19 – 27.
[11] Atikol U. An experimental study on inclined solar water distillation system. Desalination, 2005; 180, 285 – 89.
[12] Hiroshi Tanaka and Yasuhiro Nakatake. Increase in distillate productivity by inclining the flat plate external reflector of a tilted – wick solar still in winter. solar energy, 2009; 152, 90 – 91.
[13] Zeinab S. Abdel-Rehim, Ashraf Lasheen. Experimental and theoretical study of a solar desalination system located in Cairo, Egypt. Desalination 2007; 217, 52 – 64.
[14] Hiroshi Tanaka and Yasuhito Nakatake. A vertical multiple-effect diffusion-type solar still coupled with a heat-pipe solar collector. Desalination, 2004; 160, 195-205.
[15] Muafag Suleiman K. Tarawneh, Effect of Water Depth on the Performance Evaluation of Solar Still, 2007; 1, 17-25.
[16] M. Boubekri and A. Chaker. Performance of an Active Solar Still. Desalination, 2002; 249, 019–022.
[17] Kandpal TC, Garg HP. Financial Evaluation of Renewable Energy Technologies. Macmillan India Ltd., 2003.
[18] Shiva Gorjian, Bharath Ghobadian, Teymour Tavakkoli Hashjin, Ahamed banker. Experimental performance evolution of a stand-alone point focus parabolic still. Desalination, (2014) 352; 1-17.
[19] S. A. El-Agouz. Experimental investigation of stepped solar still with continuous water circulation. Energy conversion and management, (2014) 86; 186-193. I