

Hemisphere Type Still with Heater for Desalination

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ABSTRACT: Desalination of water has become one of the vital areas of research because of the increasing demand for fresh water. The usage of solar stills is one of the conventional methods for the process of desalination. In this paper, a novel design variation is given to the hemisphere still to increase the productivity of desalination. The plain basin plate of the still is replaced with hemisphere at the top. Experiment has been done to measure the hourly desalinate productivity of both conventional solar still and the hemisphere solar still in the month of May in Tamilnadu, India. Further, a biomass boiler is connected to the stepped-cup solar still to increase the heat inside the still. Productivity of the still with the biomass boiler setup has been measured and compared with the productivity of conventional solar still. Results have shown that the proposed hemisphere solar still design has increased the productivity by 22% compared to the conventional still. Also, the productivity of the hemisphere solar still has shown an enormous 72% increase on the addition of the biomass when compared to the conventional solar still

I. INTRODUCTION

Country development depends on growth of industrial sector. The industry depends upon power and water. Rain is the main source of water in many parts of the country due to insufficient quantity of rain water people suffers from water scarcity and many more water borne diseases are caused due to impure water to solve the current issues water from desalination process may be used. The desalination is low cost and cheap even sea water can be treated and converted to drinking water. Many researches are done to increase the productivity of solar still. Badran (2007) fabricated a single slope solar still and studied the performances using different operational parameters. From the study they found that the depth of water affects the productivity. Aybar et al.,(2005) uses evaporative surfaces such as black cloth wick on the bare plate they compared the production rate of bare plate against wick. The results showed that the productivity of wick is 3 times that of bare plate. Moustafa and Bruswitz (1978) fabricated a stepped still and collector with wick the performances shows that by reducing ration losses the productivity can be improved. Velmurugan and Srithar (2007) uses mini solar pond as a heat source along with stepped still and single basin still connected in series many types of sensible, evaporative surfaces are used in their work. The productivity is increased when compared to conventional still. Hiroshi and Yasuhito ((2003) fabricated a diffusion type solar still using heat pipes in the collector surface. The productivity is increased by 13% than basin type still. Hassan E.S. Fath and H.M. Hosny (2004) uses additional condenser inside the still and reduces the glass temperature. Bassam and Hamzeh (2002) analysis different sizes of sponge cubes inside the still to increase the evaporation in the still by capillary action. The results showed that there is 18% to 27% increase in productivity than conventional still. Velmanirajan et.al,(2012) analyses numerical modeling of aluminum sheets using response surface methodology. Narayanan and padmanaman (2009) uses rsm in their work for predicting bend force during air bending process in intestinal free steel sheet.

II. OBJECTIVE

From the previous research works it was concluded that the increase in the productivity is due to increase in water temperature. In this present work a single basin still and a hemisphere type stills are connected to a biomass heat source. Biomasses such as wood, palm wastes are used in the biomass boiler. The fire tube boiler supplies heat energy to the saline water through the heat exchangers placed inside the bottom of both the basins. The heat exchanger exchanges the heat to the saline water inside the still. The evaporation and condensation occurs inside the still through

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glass covers. The still behaves as a condensing unit. The system does not depend on solar radiation. Experiments are done with different types of water depths, sensible, latent heat and evaporative materials both in solar and biomass modes.

III. EXPERIMENTAL SETUP AND PROCEDURE

The single basin solar still and pyramid type single basin still having same basin area $0.81 \times 0.82 \times 0.75\text{m}$.size are connected to the common biomass heat source. Both the basins are painted black to absorb maximum solar radiation. The side and bottom sides of the stills were insulated with 0.004m thick thermocol insulation layer (015w/m-k thermal conductivity) to reduce heat losses in the still. The condensing surface of the single basin still is made of plain glass with 4mm thickness is fixed at 30° inclination to the horizontal axis. Similarly a hemisphere type still having glass area 1.2m^2 inclined 30° to the horizontal acts as condensing surface. Silicon rubber sealant is used to hold the glass intact with the still to prevent the vapor leakage from the still. Collection troughs were provided below the lower edges of the glass cover to collect the condensate. Distillate outlets were provided to drain the water through hoses and to store in jars. Provisions were made to supply raw water, drain the basin water and insert thermocouples. The biomass boiler having 133mm outer diameter and shell thickness 12mm and height 550mm made of cast iron was used as a heat source. The boiler is fire tube type internally fired with locally available biomass materials. The lower portion of the boiler is called the furnace where biomass is fed in to the furnace through fuel input door. The burnt ashes are collected at the lower end and removed periodically. The lower end of fire tube is connected to the furnace and upper end is connected to chimney. Boiler drum has inlet and outlet to admit the feed water from the boiler. The feed water is supplied to the boiler drum by gravity from the input feed water supply tank which is placed above the height of the boiler. Safety valves and pressure gauges are fitted above the boiler drum for safety aspects. The exhaust gases after passing through the fire tubes are exhausted to the atmosphere through chimney provided at the top of the boiler. The boiler is supplied with biomass and fired manually. The inlet end of both the heat exchangers is connected to the boiler outlet pipe through common connector and outlet end was connected to the circulation pump to circulate water again to the boiler drum. Both the Solar stills are supplied with 2cm depth of water through the inlet pipe in the still. Biomass boiler was filled with feed water supplied from the inlet supply tank. Biomass having 1kg of mass is fed inside the furnace through the fuel supply door and ignited manually. Water in the drum gets heated the burnt gas passes through the inner side of the fire tube and exhausted to the atmosphere through the chimney. While passing, the burnt gas gives out the heat to the water in the outer drum. Thus the water gets boiled. The boiled water is circulated inside both the solar stills through the heat exchangers and the circulation pump. The water inside the solar still absorbs heat from the heat exchangers and evaporated in to vapors reaches the bottom surface of the glass cover. The top surface of the upper basin was Cooled externally the vapors condenses and collected in the condensate collection channel as Distilled water. A collection flask collects the distilled water. Water circulation and the burning process in the boiler were stopped when basin temperature reaches about 75c° .for once flow mode. In the solar mode the still is exposed to solar radiation and the biomass boiler is cutoff from the still. Before starting the experiments the glass cover was cleaned by using cotton cloths.

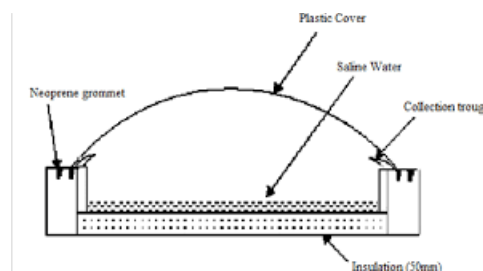


Fig.1 Hemispherical still

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IV. RESULTS AND DISCUSSION

Effect of water depths:

The effect of water depth in the still basin in the productivity is shown in fig.2. It is evident that as the water depth increased, the productivity will be decreased. This is due to be increase of the heat capacity of the water in the basin, results, in lower water temperature in the basin leading to lower evaporation rate. 2cm depth produces 70% more output than conventional still. 3cm, 4cm produces 58% and 36% more than conventional still in solar mode.

Effect of sensible heat storage materials on productivity:

The fig.3 shows the productivity of sea shell as solid sensible heat storing materials placed inside still with 2 cm water depth and tested. The productivity of seashell are 74% more than conventional still when operated under biomass mode. The maximum productivity was 980ml/m² at the starting and the productivity decreases to 620ml/m² towards the end. This was clearly shown in the fig.2 in red and blue colors. The calcium content present in the seashell retains the heat and helps to increase the water temperature in the still.

Effect of evaporative surfaces on productivity:

Due to capillary action sponge absorb more water. Thus exposure area is increased. This leads to increase the evaporation rate in the still. As shown in fig.4 the total productivity is increased by about 62% than conventional still when operated under biomass mode. The maximum productivity is 810ml/m² at the starting and lower production of 450ml/m² at the end.

Effect of latent heat storage:

The fig.5 shows the productivity of latent heat storage material. The wax absorbs heat and melted during melting wax gives out the heat to the water in the basin thus the water temperature gets increased. After gives out heat again it solidifies and absorbs heat thus continuous charging and discharging of wax results in increasing the water temperature and productivity in the still. Waxes are introduced in the still in the form of small billets. An aluminum billet having 10mm diameter and 30mm long are packed with wax at half of the volume is kept inside the still to improve water temperature. The maximum productivity of 800ml/m² is obtained in both the stills together at the starting.

Annova output:

The following table.1 shows the analysis of variance (ANNOVA) for the experimental values. The result indicated that the predictability of the model is 99% confidence and the predicated response fit well with those of experimentally obtained values. The p-value is less than 0.0001 for the entire model which indicates that the model is statistically significant. The tables .1 shows the model values for water depth tested with 2cm water depth in both pyramid and single basin still.

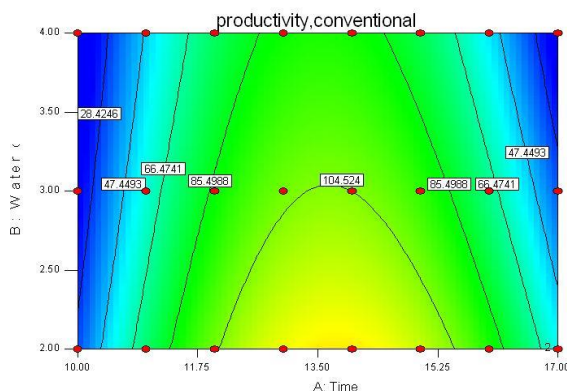


Fig. 2: Effect of water depth in conventional still.

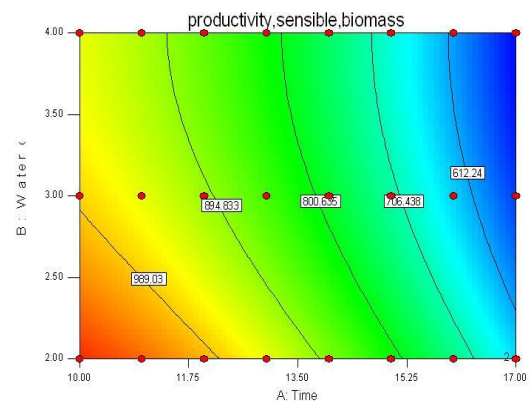


Fig. 3: Effect of sensible heat storage material

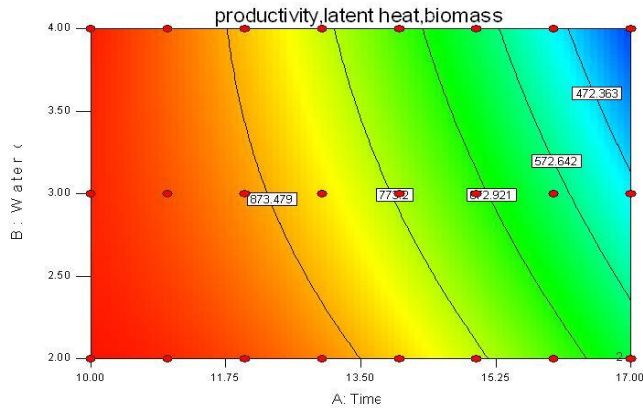


Fig. 4: Effect of Latent heat storage material

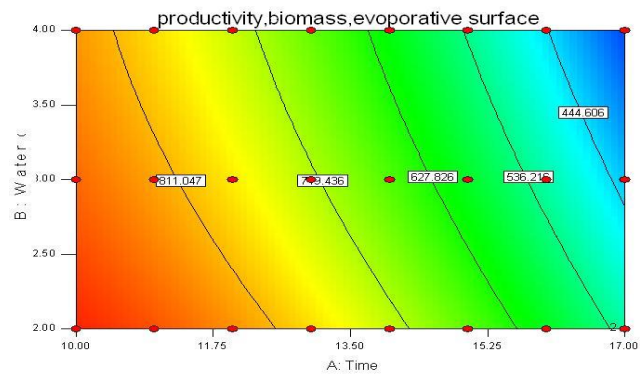


Fig. 5: Effect of Evaporative materials

V. CONCLUSION

An experimental work has been conducted to predict the productivity of a single slope solar still and hemispherical solar still coupled with common biomass boiler using different solid, liquid sensible heat storage mediums and various evaporative materials and water depths. Based on the experimental results the following conclusions are made An increase in the water temperature is due to heat supplied in the biomass heat source. Changes in solar radiation do not affect production. Solar still behaves as condensing unit. Biomass is eco friendly.

Cost of water production is low. Glass cover cooling increases the condensation rate in the still.

Use of seashell as solid sensible heat storage materials in the still improves productivity by 74% than conventional still. The use of sponges as evaporative surfaces increases the area of exposure and still productivity by 62%. The use of wax as latent heat materials increases 60% productivity than conventional still. Lower water depth in the still increases 72% productivity in the still. Single basin and hemispherestill coupled with heat source produces more yield than conventional still. Productivity of hemisphere still is more when compared to single basin type solar still

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