Comparative Analysis of Double Slope Solar Still Using Al_2O_3 Nanofluid with Conventional Double Slope Solar still

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ABSTRACT

Clean water is a basic need for human and life is impossible without water. As the available fresh water is remains same on earth surface and its demand is increasing day by day due to increasing population on surface of earth and also the rapidly increasing of industries, hence there is an essential and earnest need to get potable water from the saline/brackish water present on or inside the earth. One of the method uses for getting fresh water from saline water is solar distillation this method is simple and economical then other methods. But the distilled of the single basin solar still have very low yield of water. Utilizing nanofluid as an absorber fluid mixing with water is an effective approach to enhance heat transfer in solar still device. In this Research, Attempts are made to make a double slope solar still. The overall size of the basin used Is 300mmx600mmx100mm. The experiments have been conducted to determine the performance of a solar still in climate conditions of Valsad (20.63ºN,72.93ºE, elevation 17 m), Gujarat. This experiment compares the single basin double slope solar still with Aluminum Oxide (Al_2O_3) nanofluid and without nanofluid. Two experimental stills of the same basin size are fabricated and tested the performance of single basin double slope solar still with and without nanofluid simultaneously.

Keyword : - *Solar, Distillation, Double slope, Nanofluid etc.*

1. INTRODUCTION

Water is available in abundant and important substance in nature. It is absolutely essential for life and vegetation. Water is the basic necessity for human being. Clean water is a basic need for human and without water life will be impossible. The origin and continuation of mankind is based on water. Water is an abundant natural resource that covers 71% of the earth's surface. About 96.5% water is in the ocean as brackish water. So, only about 3% of all water sources are available as fresh. Less than 1% fresh water is within human reach and the rest is permanent ice, snow cover and permafrost [1]. Even this small amount (ground water, lakes and rivers) is believed to be adequate to support life and vegetation on the earth. About 25% of the world does not have access to satisfy quantity and quality of fresh water and more than 80 countries face severe water problems. The physical evidence of water scarcity can be found in increasing magnitude around the world. Today, nearly 40% of the world's population live in water scarce conditions, and this situation could worsen if current growth trends continue. In some area, the salinity of water is too high but considered as fresh drinking water. In many cases, fresh water was transported for long distances or very expensive distribution network is requiring for very small community it is too costly. The increasing industrial as well as agricultural activity in all over the world contributes to the depletion and pollution resources of fresh water. To supply of fresh water is becoming an increasingly important issue in many areas of the world. The provision of drinking water is biggest problem for the developing countries.

By using solar energy for the desalination process we can get fresh water from saline brackish water very easily and economically. Solar water Distillation is also known as "Solar Still". Also it requires low maintenance, so we can install anywhere where the solar radiation and saline water is available. Solar desalination exhibits considerable economic advantages over other salt water desalination processes because of cost-free solar energy, reduced operating and maintenance costs and its simple structure and design. The use of solar energy is more economical and advantageous than the use of fossil fuel and electricity in remote areas having low population densities, low rain fall and abundant availability of solar energy. The purification of water involves the removal of un-dissolved and dissolved substances as well as harmful microbes. The un-dissolved substances are removed by filtration and the microbes are killed through chlorination and by boiling. Solar desalination does all these three function. M.R. Rajamanickam et.al. Use GI sheet for basin compare DS and SS solar still and conclude that double slope solar still have higher output [2]. Hitesh N. Panchal use different Cu, GI and MS sheet as absorber plate and conclude that Cu sheet as basin has higher output [3] he was also Vary glass cover thickness and conclude that for 4mm thickness has higher output. [4].

Nanofluids are a new class of fluids which promise to significantly enhance thermal, rheological and tribological properties of technological fluids. They are obtained by dispersing solid nanoparticles (diameter <100 nm) made by metallic oxides, metals, carbon nanotubes etc. in common fluids such as water, glycol, oils and refrigerants. The use of nanoparticles promise to get much more stable fluids, no obstruction, low wearing and huge enhancements of thermal conductivity and eventually of heat transfer coefficients with respect to the base fluid (Choi, 1999).[5]

2. WORKING PRINCIPLE OF DOUBLE SLOPE SOLAR STILL

In Desalination brackish or saline water is evaporated using thermal energy and resulting steam is collected and condensed as final product. This is the simple device to convert brackish or saline water into the fresh distilled water, it use solar energy as energy source in the form of solar radiation to increase temperature of water. Due to the simplicity of this device it has various applications in the industrial as well as domestic sectors shown in Fig.1. The simple concept of this system is to use solar energy for getting drinkable fresh water from saline water. The Water left in basin evaporate by the solar radiation and water vapour is transmit on the glazing cover which condense by the wind then the water is collected by providing small angle to the glazing cover.

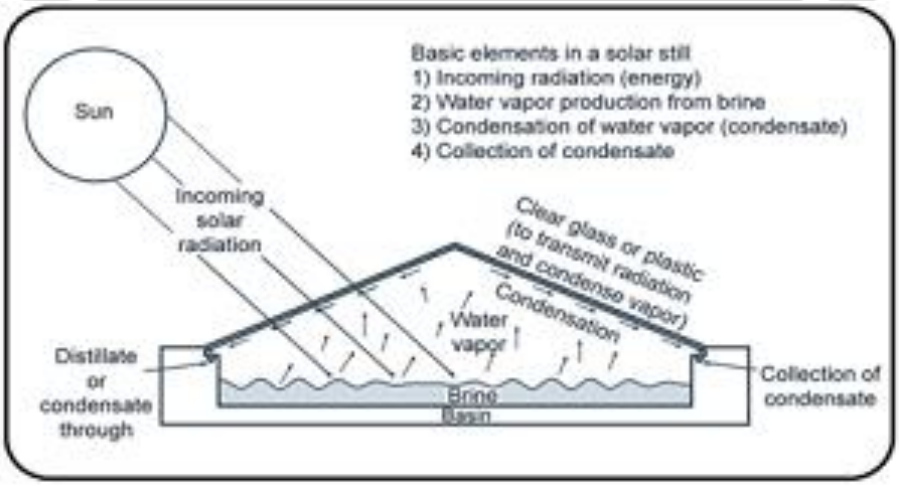

Fig-1 Working principle of solar still

The ideal basin use for the distillation has shallow and wide structure with the black painted at the inner surface wide to increase the surface area and black paint is use for to trap maximum amount of solar radiation. The painted surface is baked in the sun to free from the toxicity of color otherwise the toxic volatiles are also evaporate with the

distilled water. The basin is painted black to increase water temperature so that rate of evaporation can be accelerated. For the collection and condensation of water the transparent cover is used. If the temperature difference between glass cover and basin plate temperature are increase than distilled output is increase.

3. DESIGNING AND ACTUAL EXEPERIMENTAL SETUP

3.1 Material and Designing

Absorber plate is use for to absorb the maximum amount solar radiation. In this reserch work the galvanized iron sheet is use. It is price effective and not more different in thermal conductivity than other material. The galvanized sheet use for the solar still has 2 mm thickness and 300mmx600mmx100mm dimensions. The basin is black painted by the matt type color to increase absorption capacity. The wood is choose for the basin insulating material. It's availability and cheapest cost is main advantage. The thickness of insulating wood is 10 mm. Plywood has the density 545 kg/m^3 and thermal conductivity of wood is 0.120 W/mk so it act as a better insulating material. The PVC pipe with 1 inch diameter cut from the centre is used for the collection of distilled water output. The window glass cover is generally use for the glazing. The thickness of glass cover is optimum to get maximum radiation. As per the review suggested by the Hitesh N Panchal, Dr. P. K. Shah (2011) 4mm [4] thickness of glass cover is chooses for the glazing cover. The glass cover is fixed at the angle of 20º which is latitude of the location of valsad (20.63º N, 72.93ºE). For the experimental study the model are as shown in the fig-2. The dimensions of the basin are as follow.

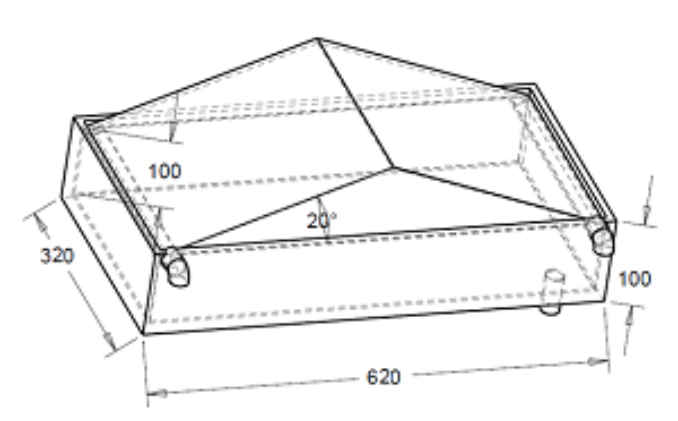

Fig-2 Dimensions of double slope solar still

3.2 Actual Setup and methodology

Two identical basins from galvanized iron sheet which has 14 gauge (2mm) thicknesses are manufactured with the dimension 300mmx600mmx100mm . The basin is painted with the matt type black color to increase the maximum solar radiation absorption capacity. The basin is insulated by the wood with thickness of 10mm. Glass cover are fixed at the angle of 20º (lattitude of the location) on both side at upper edge of the basin for the collection of distilled water output for double slope solar still. Silicon is used for the joining of the glasses. M-Seal is used for the leak proofing of the system. The collecting channels are fixed just below the glass cover for the collection of water. Two 10mm holes are drilled on the basin for the circulating of water and other for the fixing the thermo couple inside the basin. The 20mm hole is drilled at the bottom for the drainage purpose.

Fig-3 Actual experimental setup

4. PREPARATION OF NANOFLUID

For the nanoparticles at the nanometric scale the physical behavior is different than at the higher scale material and also mechanical, thermal, electrical, optical and magnetic properties are good than solids. The main reasons to produce nanoparticles are its high surface area to volume ratio. In different liquid like ethylene glycol, water and oils nanoparticles are dispersed and nanofluid is to be obtain. Homogeneous and stable solution is the first requirement of nanofluids for the better performance in experiment. There are different techniques which are used for making nanofluids but two step methods is mostly preferable method which are as follow:

4.1 Two Step Method

In this method the nanoparticles are mixed with the base fluids and then by the ball milling, low or high energy ultrasounds, high pressure homogenization, mechanical stirring by any of above methods the dispersion can be done to get nanofluid. By this method we can get different particles and base fluid combinations. This method is effective for the oxide nanofluids, but it is less effective for the metal nanofluid because their effects on physical properties are negative; Nanoparticles alumina powder (Al2O3) is insoluble in water. So 2-way method is used to dissolve the Nanoparticles in the base fluid i.e. water. First we take 4 liters of water as base fluid and we add Nanoparticles Al2O3 and Sodium Dodecyl Benzene Sulphonate (SDBS) as the dispersant. Alumina and SDBS are mixed in the ratio of 10:2. After that magnetic stirring and vibrator are used to suspend the Nanoparticles for 1 hour. Finally we will get the nanofluid.

5. INSTUMENTATION

5.1 Calibrated PV cell for solar radiation

Pyranometer are expensive and not easily available. Therefore, in order to measure the solar radiation a solar cell can be used. It is known fact that the current outputs of solar cell is linear function of solar radiation and not depend on the temperature. Therefore current produce by solar cell can be used as a measure of solar radiation at given time.

Fig-4 PV cell for Radiation Measurement

Solar radiation (W/m^2) = K * cell current (Amp) Where, K =2175 W/m^2 Amp is proportionally constant for calibrated solar cell. For this instrument the accuracy is 10% for more than 200 W/m2 and 25% for less than 200 W/m^2.

5.2 Thermo couple RTD PT-100

PT-100 is most use temperature sensor. PT-100 is named as such because platinum is used as sensing material and at with perfect calibration it has 100 ohm resistant at 0ºC. For the increment or decrement of temperature, the resistant value of platinum change linearly. Thus it can be used to identify the temperature by comparing the resistant value. The temperature range for this sensor is -20 to 400 ºC. It has ±1ºC error. In PLC programming for a certain PT-100, the temperature log chart with resistant is programmed, thus it can be used in automation system.

Fig-5 Thermo couple with temperature indicator

5.3 Anemometer

An anemometer is a device which measures the speed of wind. In digital anemometer spinning cups turn a paddle wheel inside a metal canister that breaks a light beam and generate a pulse of current. An electronic circuit times the pulse and uses them to calculate the wind speed.

Specification

Velocity range:0-45 m/s , Resolution:0.1

Threshold:0.3, Accuracy:±3% ±0:2

Temperature Range: 0-60ºC, Operating humidity: less than 80% RH

Pressure range: 500mB-2Bar

Fig-6 Anemometer

5.4 TDS Meter

TDS meter is used to test the water purity by measuring total dissolved solids of the water. The concentration of salt and minerals increase the conductivity of the water. TDS meter measures the conductivity of water and estimates the TDS from that. A TDS meter display the TDS in parts per million (ppm). 1 ppm would indicate the 1 milligram of dissolved solid in each kilogram of water.

Fig-7 TDS Meter

6. RESULT OF EXPERIMENT

The experiment was carried out at the GEC,Valsad (20.63ºN,72.93ºE,) in Gujarat. The water maintain in the solar still at the level of 3cm. The Al_2O_3 nanofluid concentration ratio was take constant 0.1% in water. The PH value was 6.59 and TDS value was 3380 ppm of sea water before distillation and after distillation, it were 7 pH and ppm was vary between 109 to 114 ppm. The experiment is carried out on the day 27th march 2016. The variation of ambient temperature,solar radiation, wind velocity, distilled water output were measured for whole day from 8:00am to 6:00pm. Orientation for the experiment was taken east-west direction. Here in the fig-9 the variation of hourly distilled water output for the double slope solar still with and without nanofluid is shown.

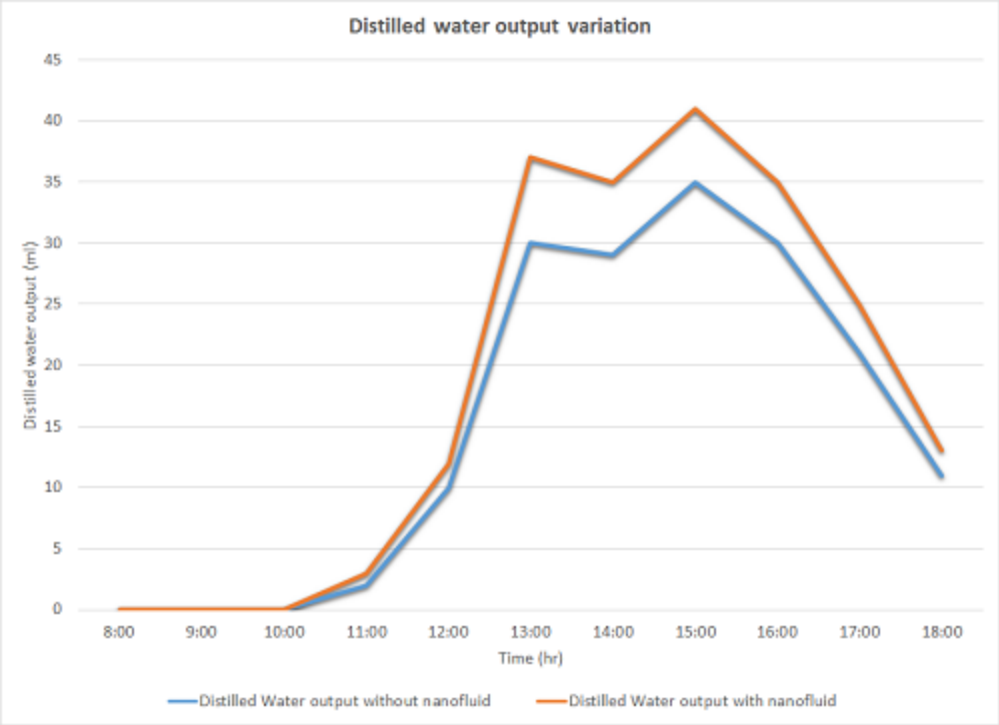

Fig-8 Variation of Distilled water output with Time

7. CONCLUSIONS

This experiment is mainly performed to see the effect of the nanofluid on double slope single basin solar still. As nanofluid increases the thermal conductivity of basin water, the temperature of basin increases rapidly so the temperature difference between water and glass cover is increases which is the main cause of increasing evaporation rate of solar still. So the condensation rate also increases and daily production of distilled water increases for the still with nanofluid. This increase in daily output is 19.64% more than still without nanofluid.

8. ACKNOWLEDGEMENT

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