Effect of Nanofluid in Single Slope Double Basin Solar Still

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ABSTRACT

Clean water is a basic human necessity and without water life will be impossible. As the available fresh water is fixed on earth and its demand is increasing day by day due to increasing population and rapidly increasing of industry, hence there is an essential and earnest need to get fresh 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 desalination. This method is simple and economical than other methods. But the distilled of the single basin solar still have very low yield of water. Utilizing nanofluid as an absorber fluid is an effective approach to enhance heat transfer in solar still device. Also double effect with double basin will increase productivity of still by utilizing latent heat of condensation. This experiment compares the double basin-double effect single slope solar still with and without water nanofluid. Two experimental stills of the same basin area will be fabricated and will be tested the performance of double basin-double effect single slope solar still with and without nanofluid simultaneously.

Keyword : - *Distillation, Nanofluid, Solar still and Inclination angle etc….*

1. INTRODUCTION

It is a well-known fact that fresh water is basic need for the continuity of all life. It is also the key to the industrial and agricultural development of rural areas. Only about 3% [1] of the world water is potable and this amount is not evenly distributed on the earth. Large quantities of fresh water are required in many parts of the world for agricultural, industrial and domestic uses. In some region of India underground water is brackish and also India have around 7516 km long coastline [2].

However, there is limited access to drinking water that meets acceptable standard levels of biological, chemical and physical constituents. Over 97% of water available on the earth's surface is salty (Tiwari et al., 2003), and environmental pollution caused predominantly by anthropogenic activities is also contributing to the degradation of fresh water resources. The World Health Organization (WHO) in 2008 reported that 78 % and 96 % of the rural and urban populations used clean drinking water in 2006 on a global scale respectively. So, 4 billion cases of diarrhea are reported annually, with 88 % of them being ascribed to the use of unclean water, and insufficient sanitation and hygiene (WHO, 2007). This indicates the need for interventions that aim at providing clean water [3].

The report, "Progress on Drinking Water and Sanitation 2012", by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, says at the end of 2010, 89% of the world's population, or 6.1 billion people, used improved drinking water sources. The report estimates that by 2015, 92% of the global population will have access to improved drinking water. But 8% of the world's population are still without access to safe drinking water [4].

According to the WHO, the permissible limit of salinity in water is 500 parts per million (ppm) and for special cases up to 1000 ppm. Most of the water available on earth has salinity up to 10,000 ppm, and seawater normally has salinity in the range of 35,000–45,000 ppm in the form of total dissolved salts. Excess brackishness causes the problem of bad taste, stomach problems, and laxative effects. The purpose of a desalination system is to clean or purify brackish water or seawater and supply water with total dissolved solids within the permissible limit of 500 ppm or less. This is accomplished by several desalination methods.

2. WORKING PRINCIPLE OF SOLAR STILL

Solar desalination is used by nature to produce rain, which is the main source of the fresh water supply. Solar radiation falling on the surface of the sea is absorbed as heat and causes evaporation of the water. The vapor rises above the surface and is moved by winds. When this vapor cools down to its dew point, condensation occurs and freshwater precipitates as rain. All available manmade distillation systems are small-scale duplications of this natural process.

Solar still uses the greenhouse effect to evaporate salty water. It consists of a basin in which a constant amount of seawater is enclosed in an inverted V-shaped glass envelope as shown in Fig-1, the sun's rays pass through the glass roof and are absorbed by the blackened bottom of the basin. As the water is heated, its vapor pressure is increased. The resultant water vapor is condensed on the underside of the roof and runs down into the troughs, which conduct the distilled water to the reservoir. The still acts as a heat trap because the roof is transparent to the incoming sunlight but opaque -to the infrared radiation emitted by the hot water (greenhouse effect). The roof encloses the vapor, prevents losses, and keeps the wind from reaching and cooling the salty water [5].

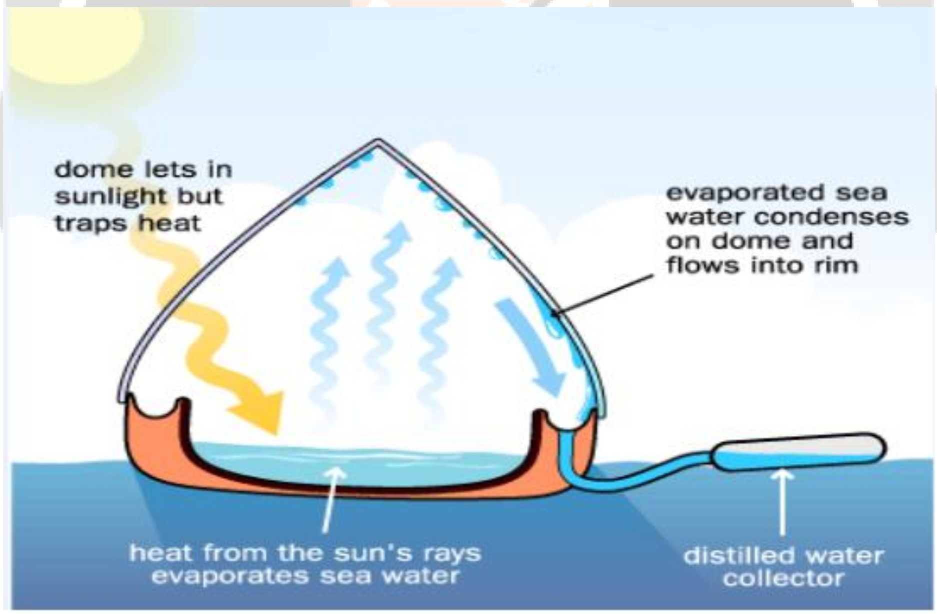

Fig -1: Working of simple basin type solar still[5].

3. CLASSIFICATION OF SOLAR STILL

Solar desalination systems (solar stills) are classified broadly into two categories: passive and active solar stills as shown in Fig- 2. Passive systems are those in which solar energy is collected by the structure elements (basin liner) for evaporation of saline water. Various types of passive solar stills are described in the literature like conventional solar still, vertical solar stills, plastic solar stills, cascade type solar stills, multi wick solar still, multi effect or multi stage solar still, multi basin solar still, greenhouse type solar still, spherical solar still etc. In the case of active solar still, an additional thermal energy by external mode is required for faster evaporation. The extra energy may be obtained from a flat plate solar collector, additional condenser, inverted absorber [5].

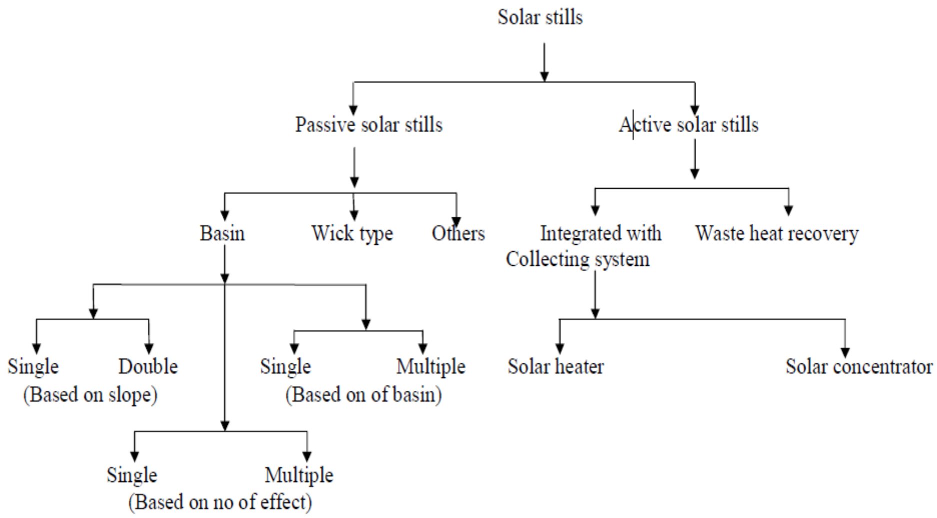

Fig -2: Classification of solar still[5].

4. APPLICATION OF SOLAR STILL

There are many coastal areas where seawater is abundant but potable water is not available in sufficient quantity. Apart from drinking purpose, pure water is also useful for health and industrial purposes such as hospitals, schools and batteries etc. Many parts of India, particularly, rural areas, coastal areas and many urban areas too, have a major drinking water problem. Sufficient drinking water, at accepted purity level, is just not available. Solar desalination has been introduced and applied as an option for household drinking water for several colonies communities. Low cost solar stills offer an immediate and effective solution in reliably providing safe drinking water year after. Also the solar still are used in the coastal area for the agriculture water needs.

Advantages:

Basin type solar still has a many advantages as follow:

- It not utilizes costly conventional fuels.
- Its design is also simple passive type solar still not need any moving part for the process.
- Solar energy is also available abundant in the nature.
- It is also pollution free.
- It uses the available material.
- It does not require skilled labor for operation and maintenance.
- It has no operating cost.
- It is the economical method to produce water than the other methods.

Disadvantages:

Basin type solar still has some disadvantages as follow:

- It has low productivity of water because it uses solar energy for evaporation.
- For the higher production of water it requires larger area of still.
- For the larger plants it requires higher installation cost.
- It works on solar energy so it depends on the sunshine hours so we only get water in the sunshine hours.

5. OPTIMUM INCLINATION ANGLE

To find the optimum angle of slope for double basin solar still, first of all total solar radiation should be calculated falling on to the inclined surface for the location of Valsad (20.63° N, 72.93° E).

To find out average yearly total solar radiation fall on to the inclined surface, general equations of solar radiation fall on horizontal surface is used and then it should be converted into inclined surface by using the tilt factor for beam, diffuse and reflected solar radiation.

Then by varying inclination angle, the average yearly solar radiation is calculated for each inclination angle of the glass cover of solar still where the slope is facing due south. Results are shown below in graphical presentation in Fig- 3 and 4.

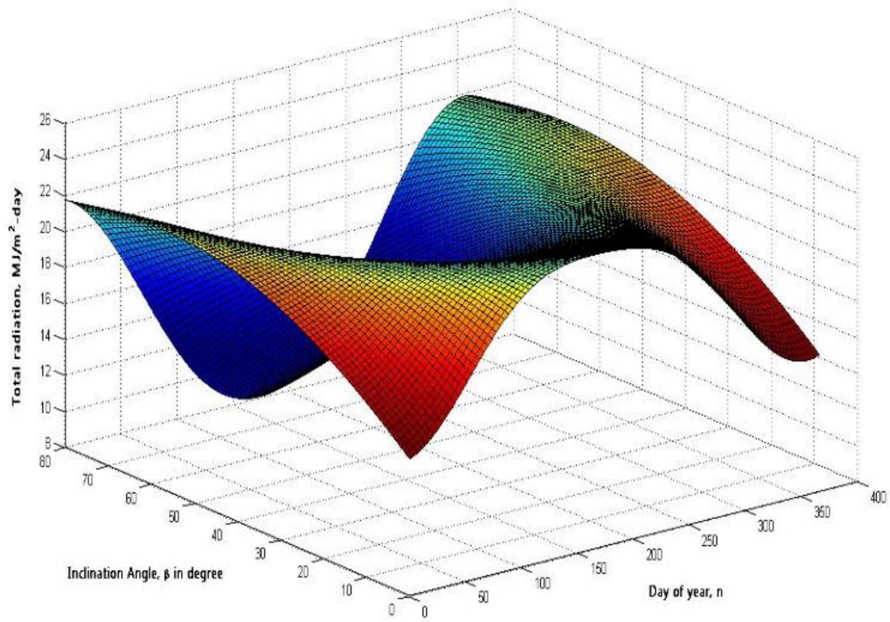

Fig -3: Variation of radiation on tilt surface against inclination angle and day of year.

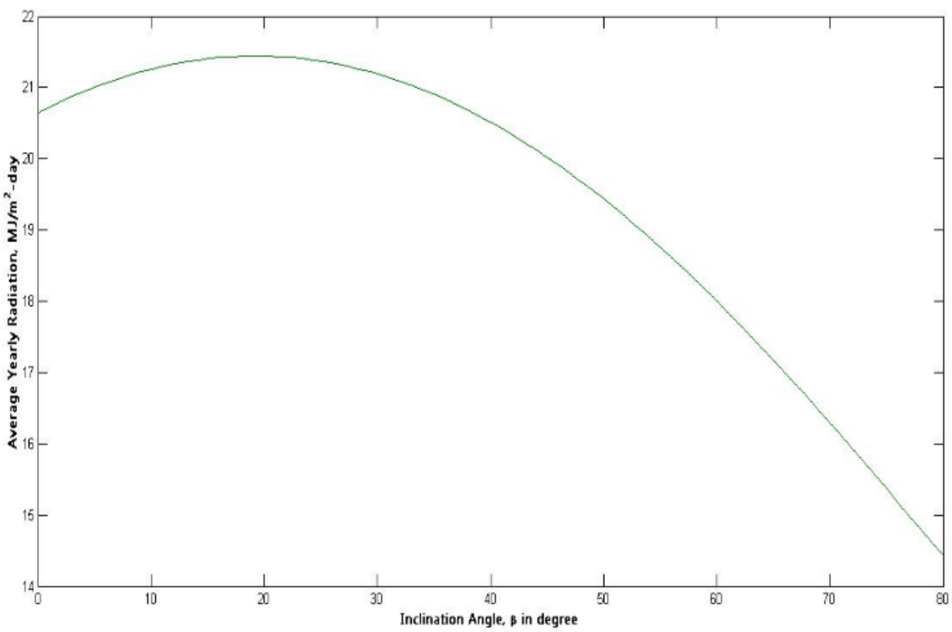

Fig -4: Variation of average yearly radiation against inclination angle.

It is found that the inclination angle of glass cover of solar still is 20° when slope is facing due south on the basis of total yearly solar radiation fall onto the specified inclination angle. This inclination angle is same as the latitude angle of location of Valsad, Gujarat, India which is 20.63° N.

Fig- 3 only shows the solar radiation falling per day for particular inclination angle while Fig- 4. Shows the average solar radiation over the year for particular inclination angle of glass cover.

6. BASIC DIMENSION OF SOLAR STILL

Many researchers have done the experimental work to find optimum depth of water in basin of solar still. From the conclusion of the research work, it is found that 4 cm of water depth in lower basin is best for double basin solar still.

The lower basin dimensions are taken as 500 mm X 500 mm. And by taking small height of basin as 100mm and glass cover angle of 20°, the large height of lower basin is calculated by Pythagoras rule as 300 mm.

While considering inclination angle of glass cover, the distance between two glass cover in double basin solar still is taken such that raw water in upper basin will not touch the condensing side of upper glass cover. So the distance between two glass cover is taken as 100 mm.

In upper basin, two section glass partition are also used of 60 mm X 500 mm dimension. All dimensions are shown in below Fig- 5.

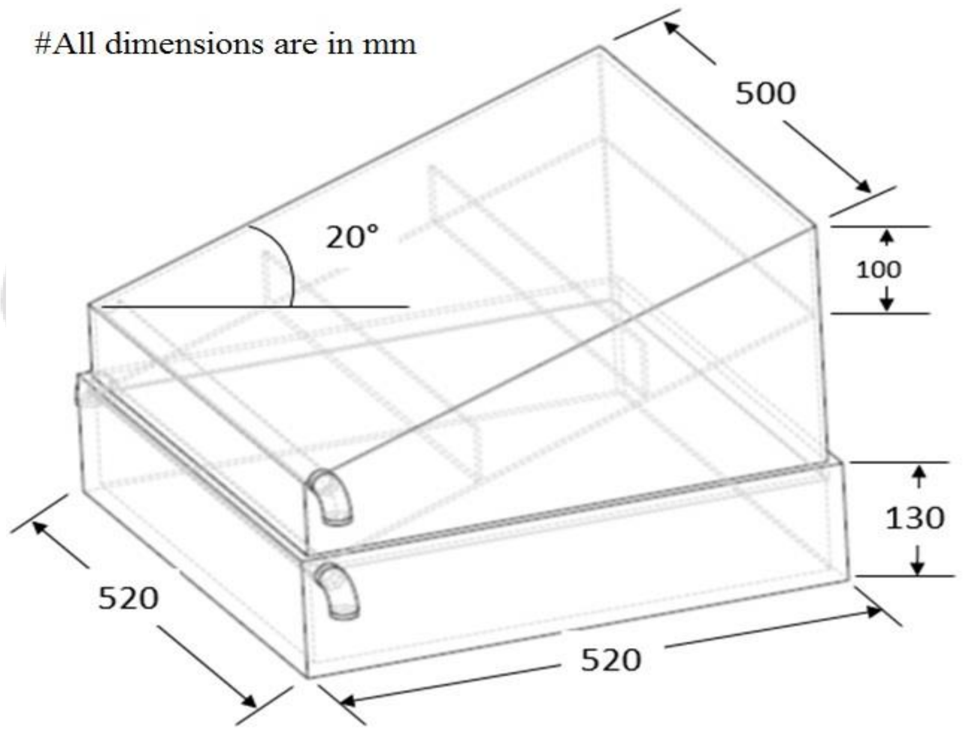

Fig -5: Wireframe model of actual setup of double basin solar still with basic dimension.

7. RESULT OF EXPERIMENT

Here the two identical experimental setup are manufactured and experiment is performed simultaneously for both setup. In one setup nanofluid is added in lower basin which is the aluminum oxide nanofluid. Aluminum oxide nanofluid is suspended particles in water as base fluid.

Generally, the nanofluid is the fluid which contains the suspended nano sized particles not more than 100 nm size in base fluid like water or ethylene glycol. This suspension is created by various techniques like magnetic agitation, ultrasonic agitation etc. So nano particle remain suspended in base fluid for long time. As the particle has small size the thermal conductivity of fluid is increased to desired level for the application as heat transfer fluid.

In this experiment, one setup is sea water with nanofluid of aluminum oxide and another with only sea water. The main observation of this experiment is that daily production of solar still with nanofluid increases which is shown in Fig- 6.The increase of daily production is around 49% compare to the solar still without nanofluid.

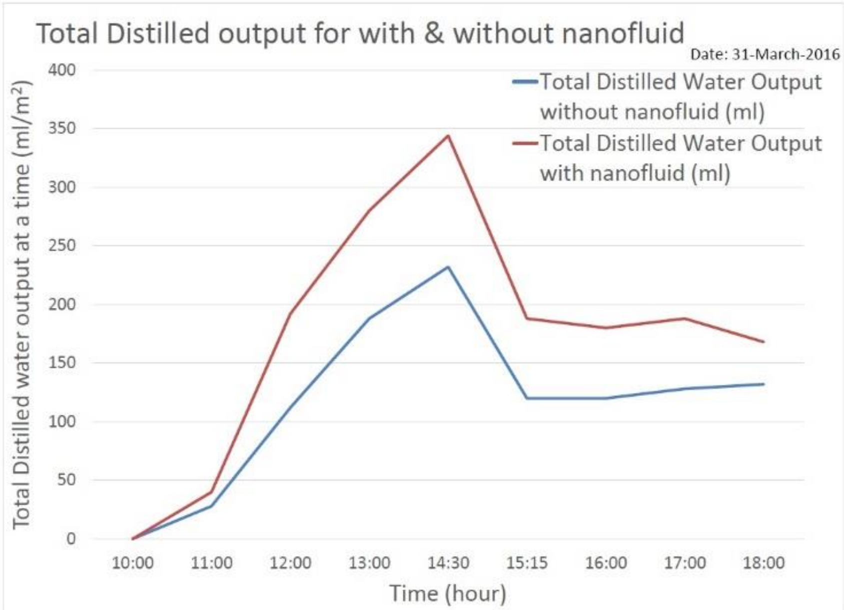

Fig -6: Comparison of Distilled water output for with and without nanofluid against time.

As this is the experiment done on double basin solar still, the difference between upper and lower basin distilled output is also shown in Fig- 7 for hourly time basis.

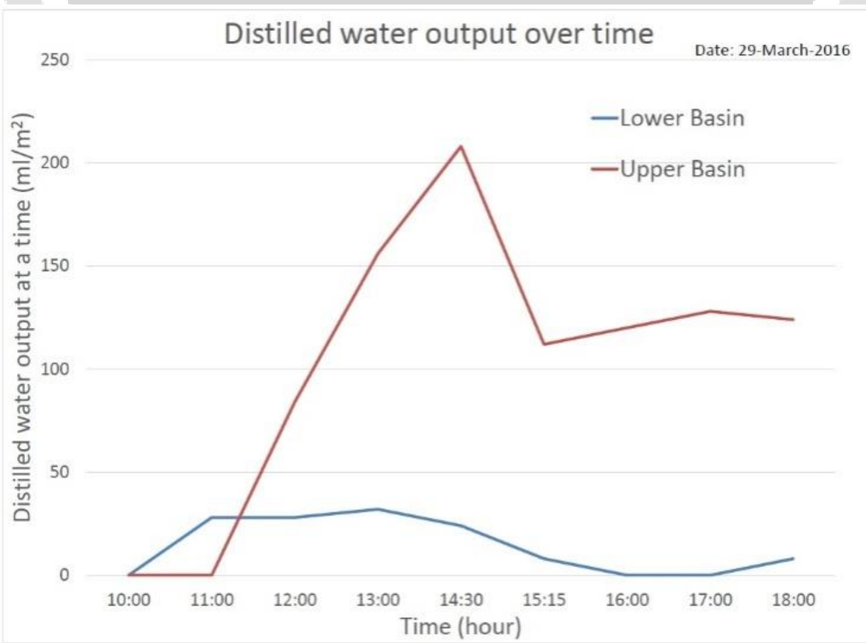

Fig -7: Output in upper and lower basin against time.

8. CONCLUSIONS

This experiment is mainly performed to see the effect of the nanofluid on double basin solar still. As nanofluid increases the thermal conductivity of basin water, the temperature of lower 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 49% more than still without nanofluid.

Also it is observed that hourly output of upper basin is higher compare to the lower basin because of more temperature difference between water and glass cover.

9. ACKNOWLEDGEMENT

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