An Experimental Study and Performance Analysis of Double Slope Solar Still Filled with Aluminum and Granite at Different Depth of Water

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Abstract— Two major challenges for human society today are shortage of fresh water and limited resources of conventional energy. Solar still is one of the methods to convert saline, brackish water into fresh water using the unconventional source of energy i.e. solar energy which is freely and abundantly available in planet earth. [11] The commonly method using in the solar still are active and passive solar still According to the basis of design solar still are classified into single slope solar still and multi slope solar still[9]. In the active type solar still the external sources are used while in case of passive solar still there is no need to use external sources. Most important design parameters influencing the productivity are optimization of glass inclination, intensity of solar radiation, absorber plate area, thickness of glass cover, basin filled with different materials, Nano particles mixed with water in the basin, free surface area of water and depth of water. The main difficulty in conventional still is maintaining minimum depth and large surface area of water. Researchers have put efforts to develop various designs of solar stills to maintain in the minimum depth of water using different types of materials in the stills to increase the productivity.[3] In this review, we are attempting to study of different depth of water using double slope single basin passive solar still filled with aluminum and granite. In the following case it is observed that granite gained maximum productivity and thermal efficiency than compare to others.

Key words: Renewable, Conventional, Productivity, Solar Radiation, Sunshine, Energy, Aluminum, Granite, Passive Solar Still, Purification

I. INTRODUCTION

Water and energy are two inseparable commodities which continue to influence the growth of the human civilization. In global, 71% of the earth's surface is water. Of this, nearly 97% of water resources found on the earth's surface are stored in the oceans and seas and it is salty. Only 3% of the total water resources are fresh water. The major amount of fresh water is found frozen in the form of ice sheets and glaciers. The rivers and lakes have only 0.3% of the world's fresh water. The expansion of population and development of industries also leads to damaging the available source of fresh water. [6]

II. OVERVIEW OF ENERGY

The population and standard of living of the people of any country is important factor for energy consumption of that country. Energy is the capacity to do work. The standard of living of any country can be directly related to its per capita energy consumption. Energy is required for development of country. The world energy demands are mainly fulfill by the fossil fuels today. The fossil fuels are very limited on earth and fossil fuels are not available same quantity of every country.[10]

III. RENEWABLE ENERGY

Renewable energy sources are known as non-conventional energy sources they are continuously renew by natural processes. A renewable energy system is an "alternative" one, it is able to provide some or whole part of the energy needs which is met by the fossil ones. Such a system is also sustainable because the energy supply will sustain continuously, as the sun continues to shine, gravity to apply on the objects and the earth to rotate. Fossil fuels, on the other hand, like petroleum, coal and gas are the conventional ones having no sustainability. Nuclear energy is another alternative to the sustainable to the sustainable usage but it is out of scope, for its being a controversial issue for more than a generation.[15]

IV. SOLAR ENERGY

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar.

V. APPLICATION OF SOLAR ENERGY

Solar energy used today in number of ways:

- As heat for making hot water, heating buildings, and cooking.
- To take the salt away from sea water.
- To generate electricity with solar cells or heat engines.
- To use sun rays for drying clothes and agriculture product (like brinjal, potato etc.)

VI. PRESENT STATUS OF PURE WATER

Water is very important to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the living in water ecosystem (i.e., the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human consumption. It is now generally accepted that aquatic environments cannot be understand simply as holding tanks that supply water for human activities.

VII. SOLAR DISTILLATION

Solar distillation seems to be a promising method and alternative way for supplying fresh water. Several solar still designs have been proposed and many of them have found significant applications throughout the world. Solar desalination systems have low operating and maintenance costs and require large installation areas and high initial investments. [9]

VIII. PRINCIPLE OF SOLAR DESALINATION

A basin of solar still has a thin layer of water, a transparent glass cover that covers the basin and channel for collecting the distillate water from solar still. The glass transmits the sun rays through it and saline water in the basin or solar still is heated by solar radiation which passes through the glass cover and absorbed by the bottom of the solar still. In a solar still, the temperature difference between the water and glass cover is the driving force of the pure water yield. It influences the rate of evaporation from the surface of the water within the basin flowing towards condensing cover. Vapour flows upwards from the hot water and condense. This condensate water is collected through a channel. [14]

IX. EFFECT OF SLOPE ON SOLAR STILL

One of the factors that contribute to the productivity of solar still is the number of slopes that can be used in the glass cover. The conventional numbers of slopes used are moreover single slope in the basin type stills.

Hence this project introduce a concept of multi slope (2 slope) solar still are analyze the outcome with comparison to the conventional double slope solar still. The two models are made with the use of same materials and same dimensions to keep in a same location to undergo the experimental process with similar climatic conditions. The comparison mostly done between the productivity of the still for similar factors and conditions that the experiment is being carried out.[11]

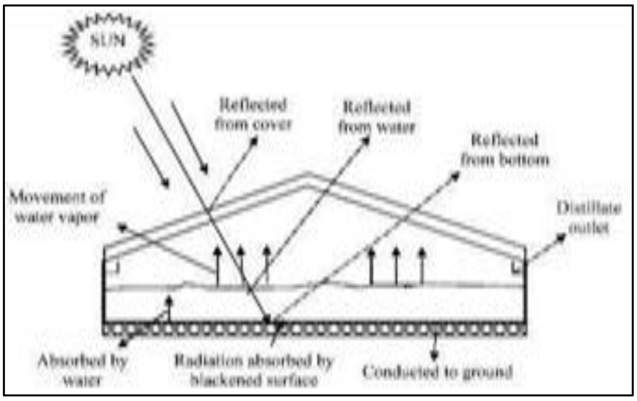

Fig. 1: Double slope solar still

X. EXPERIMENTAL WORK

A. Experimental Setup of Double Slope Solar still

The experimental setup of double slope solar still is shown in fig 2 and fig 3.

Fig. 2: Length wise double slop solar still conventional solar still

Fig. 3: Width wise double slope solar still Non-conventional solar still (modified)

B. Experimental setup of modified solar still field with material granite and aluminum

The experimental setup of solar still show in fig 4 and fig 5

Fig. 4: width wise double slope modified solar still material using granite

Fig. 5: width wise double slope modified solar still material using aluminum

C. Modes and Basic Laws of Heat Transfer

The heat transfer process in a solar still can be mainly classified into internal and external heat transfer processes based on energy flow in and out of the enclosed space.[14]

1) Internal Heat Transfer

The heat exchange between water surface and glass cover inner surface of the solar still is known as internal heat transfer. There are three modes, namely convection, radiation and evaporation processes, by which the internal heat transfer process within the solar still is governed.

2) Convection

Thermal convection is a process of energy transport by the circulation or mixing of a fluid medium. Convection is possible only in fluid medium and is directly linked with the transport of medium itself. With respect to origin; two types of convection are distinguished: forced and natural or free convection.

In natural or free convection, the circulation of the fluid medium is caused by buoyancy effects that are by the difference in the densities of the cold and heated particles.

Chilling effect of cold wind on a warm body, heat flow from a hot pavement to surrounding atmosphere and heating of air in a room by a stove and heat exchange on the outside of cold and warm pipes are the examples of free convection.

3) Radiation

Thermal radiation is the transmission of heat in the form of radiant energy or wave motion from one body to another across an intervening space. Radiation exchange in fact occurs most effectively in vacuum.

The basic rate equations for radiation heat transfer are based on Stefan-Boltzman law;

$$E_b = \sigma_b A T^4 \quad (1)$$

Where E_b is the energy radiated per unit time, T is the absolute temperature of the surface, and σ_b is the Stefan-Boltzman constant.

$$\sigma_b = 5.67 \times 10^{-8}\ W/m^2 K^4 = 4.86 \times 10^{-8}\ kcal/m^2hr\ K^4 \quad (2)$$

Equation is essentially valid for an ideal radiator or a black body –suffix b designates a black surface. The radiant energy emitted by a real surface is less than that for an ideal emitter and is given by

XI. RESULT AND DISCUSSIONS

The various results obtained in the experimental process which are carried out on basin area of 0.5 m^2 with a water depth of 1cm, 2cm, and 3cm in north-south orientation is as follows

T_1 = Bottom surface temperature with black body
T_2 = Air temperature inside the solar still
T_3 = Inside glass surface temperature
T_4 = Outside glass surface temperature
T_5 = Atmospheric temperature

A. *Calculation of Efficiency*

– Efficiency = (yielding × latent heat)/ (area × solar intensity)
– Yield = kg/second
– Latent heat = latent heat of vaporization, (J/kg)
– Area = m²
– Solar intensity = W/m²

B. *Calculation of latent heat*

$$\text{Latent heat} = 2.4935\times10^{3}[1-(9.4779\times10^{-4}\times(T_2)+1.3132\times10^{-7}\times(T_2^{2})-4.7974\times10^{-9}\times(T_2^{3}))]$$
; for<70°C [8]

C. *Overall Productivity with Respect To Time*

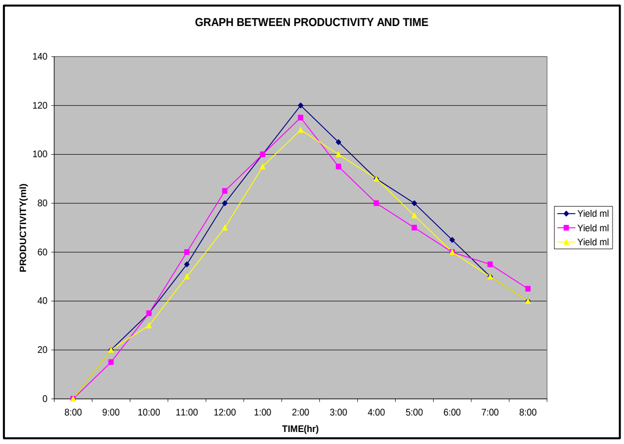

Fig. 6: Conventional solar still

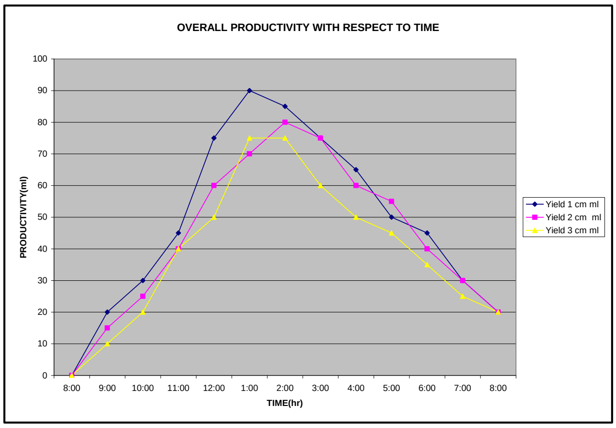

Fig. 7: Modified solar still

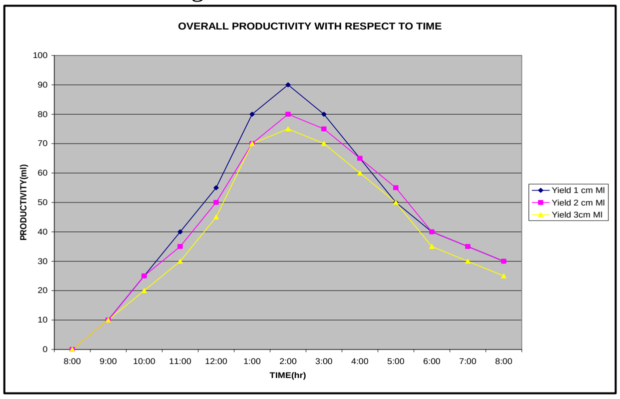

Fig. 8: Modified solar still using aluminum

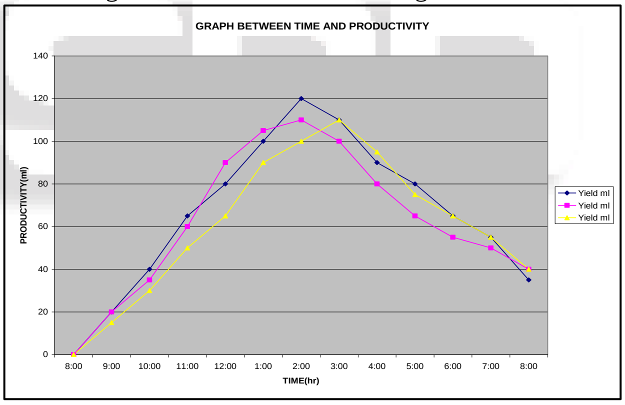

Fig. 9: Modified solar still using granite

D. *Variation of productivity and solar radiation with respect to time*

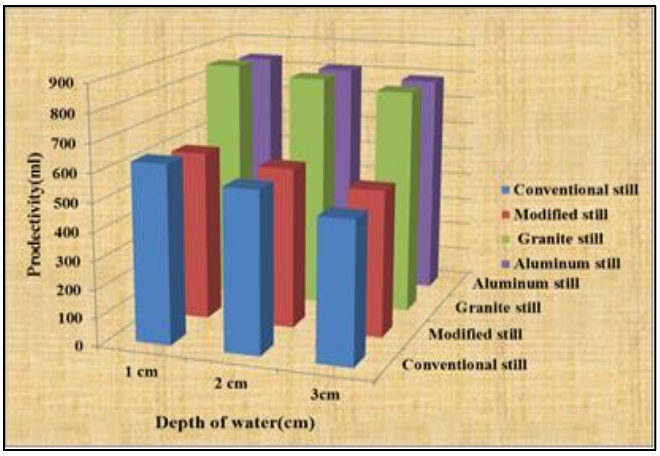

Fig. 10: Variation of productivity and solar radiation with respect to time

E. Productivity Comparison

From the fig 7, it noted that the fresh water productivity of single basin double slop solar still is higher at 1 cm depth of water in modified solar still filled with jute. The total productivity obtained in conventional solar still is 630 ml, 600 ml is find out in case of modified still,840 ml and 880 ml obtained in still filled with Aluminum and Jute respectively.

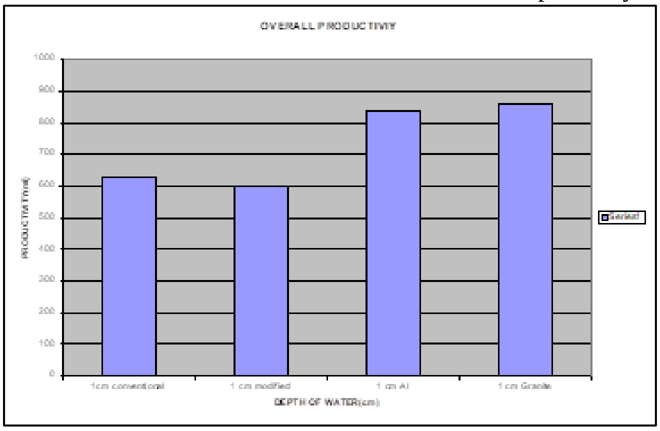

Fig. 11: Overall productivity with respect to depth of water

XII. CONCLUSION

1) A single basin double slope solar still with an inner glass basin size 1 m x 0.5 m x 0.1 m and that of the outer basin size 0.992 m x 0.492m x 0.092 m has been fabricated with transparent glass of 8 mm thickness. Top cover of the basin is closed with transparent glass of 4 mm thickness at 150 inclinations from both sides. The inner layer is black painted for more absorption.
2) It was observed from the experiments that productivity of water increases with decrease in depth of water and maximum productivity is observed for 1 cm depth of water.
3) In the present thesis the passive double slope solar still for two different material and base fluid has been analyzed for climate condition of Bhopal for the month of June.
4) As discussed above measured yielding in consecutive three sunny days in which the measured yielding in conventional solar still is maximum in 1 cm depth of water which is 630 ml, in modified solar still the maximum yielding is 600 ml at 1 cm water level while in case of aluminum the maximum yielding is 840 ml at 1 cm depth of water and 860 ml in case granite which is also at 1 cm depth of water.
5) It was observed that the maximum productivity obtained in case of still filled with Granite which is 860 ml that is greater than 36.50% from conventional still,43.33% from modified still and 2.38% from still filled with Aluminum.
6) It was observed that in case of modified still the efficiency of still was maximum at 02.00 pm which is 10.37% at 1 cm depth of water while compare with conventional still the efficiency of still was maximum at 01.00 pm at 1 cm depth of water which is 10.17%.
7) It was observed that in case of still filled with Granite, the efficiency of still was maximum at 06.00 pm which is 15.58% at 3 cm depth of water while compare still filled with Aluminum the efficiency of still was at 06.00 pm at 2 cm depth of water which was 14.75%.
8) It was observed that the maximum efficiency obtained in case of still filled with Granite which is 15.58% that is greater than 53.19% from conventional still,50.24% from modified still and 5.62% from still filled with Aluminum.
9) Therefore, It was observed that the maximum yielding and efficiency were to be measured in case of Granite material.

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