A Comparative Experimental Study & Performance Analysis of Double Slope Passive Solar Still Filled with Aluminum & Jute

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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. 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. 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 jute. In the following case it is observed that jute gained maximum productivity and thermal efficiency.

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

I. INTRODUCTION

Energy is an absolutely necessary component for the economical development of any country. Energy is the capacity to do work. [12]It is the most important and primary input for development. All living organism needs energy for their operations. The standard of living of any country can be directly related to its per capita energy consumption. The annual per capita consumption of India is very low as compare to any other countries. The growth of economy is supposed to grow minimum. Advance economies with high living of standards have relatively high levels of energy use per capita, but their per capita energy use is stable or the change is very slow.

II. RENEWABLE ENERGY

Renewable energy sources are also known as non-conventional energy sources which are continuously replenished by natural processes. For example-solar energy, hydro energy, geothermal energy, wind energy, bio energy, tidal energy etc. are the examples of renewable energy sources. The potential of renewable energy sources is enormous as they can in principle meet many times the world’s energy demand. It is becoming clear that future growth in the energy sector will be primarily in the new regime of renewable energy, and to some extent natural gas-based systems, not in conventional oil and coal sources. In recent years, India has emerged as one of the leading destinations for investors from developed countries. This attraction is partially due to the lower cost of manpower and good quality production. The expansion of investments has brought benefits of employment, development, and growth in the quality of life, but only to the major cities. This sector only represents a small portion of the total population. The remaining population still lives in very Poor conditions. India is now the eleventh largest economy in the world, fourth in terms of purchasing power. It is poised to make tremendous economic strides over the next ten years, with significant development already in the planning stages. This report gives an overview of the renewable energies market in India. We look at the current status of renewable markets in India, the energy needs of the country, forecasts of consumption and production, and we assess whether India can power its growth and its society with renewable resources. India has encountered a negative balance in overall Energy consumption and production. This has resulted in the need to purchase energy from outside the country to supply and fulfill the needs of the entire country.

III. SOLAR ENERGY

Solar energy is the energy that is in sunlight. It has been used for thousands of years in many different ways by people all over the world. As well as its traditional human uses in heating, cooking, and drying, it is used today to make electricity where other power supplies are absent, such as in remote places and in space. It is becoming cheaper to make electricity from solar energy and in many situations it is now competitive with energy from coal or oil. A solar cooker can be used for cooking food.

A. Application of Solar Energy

1) Solar energy used today in number of ways:
2) As heat for making hot water, heating buildings, and cooking
3) To generate electricity with solar cells or heat engines
4) To take the salt away from sea water.
5) To use sun rays for drying clothes and agricultural product (like potato, brinjal etc.)

IV. PRESENT STATUS OF PURE WATER

Very small quantity of Earth's water is in a fresh, liquid state, and nearly all of this is dirty by both illnesses and harmless elements. For this reason, refining of water is very essential. Keeping these things in mind, a novel active solar still has been invented which will change the dirty/salty water into pure/potable water by the solar energy. The results are obtained by evaporation of the dirty/salty water and fetching it out as pure/drinkable water.

Clean water is a basic human necessity and without water life will be impossible. The running of renewed water is suitable a progressively important issue in many areas of the world. The increasing world populace growth together with growing manufacturing and agricultural undertakings all over the world contributes to the exhaustion and pollution of renewed water resources. The position of supplying potable water can hardly be overstressed.

V. 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]

A. *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 as shown in figure 1.4 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]

B. *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[9].

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.

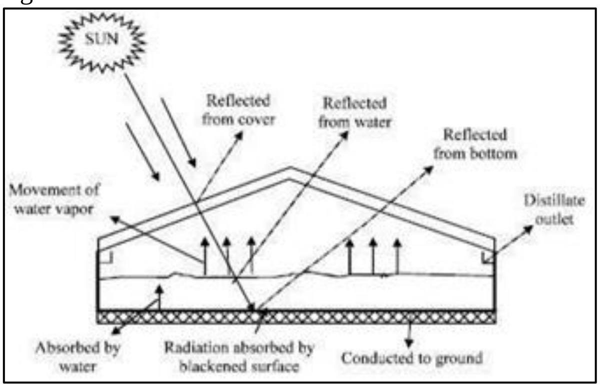


Fig. 1: Double slope solar still[9]

VI. 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 jute 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 Jute

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.[8]

D. 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.

E. 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.

F. 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.

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

VII. Result & 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

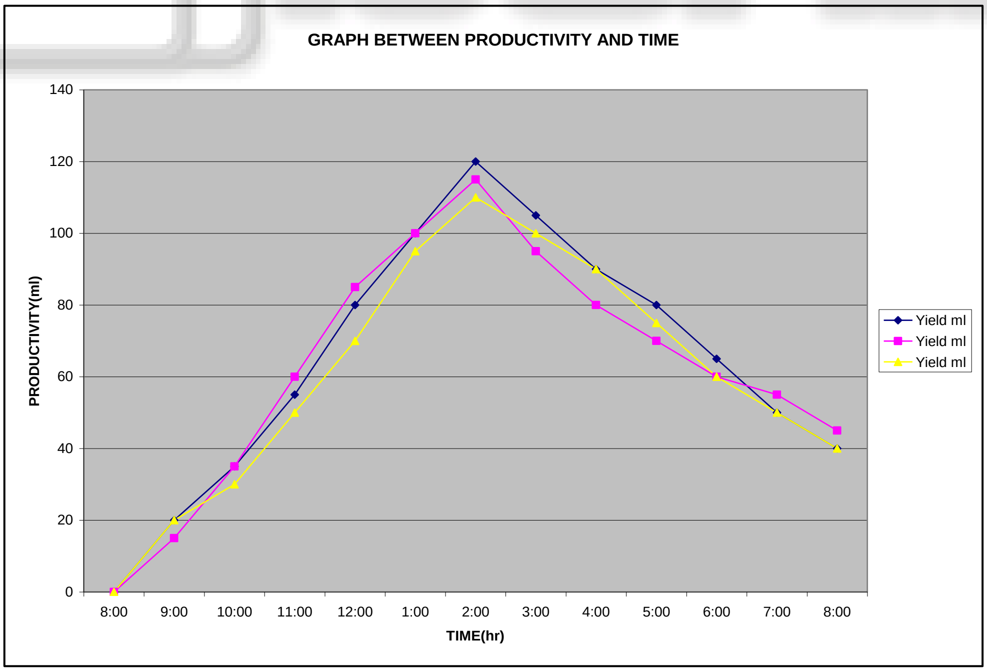
A. Calculation of Efficiency

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

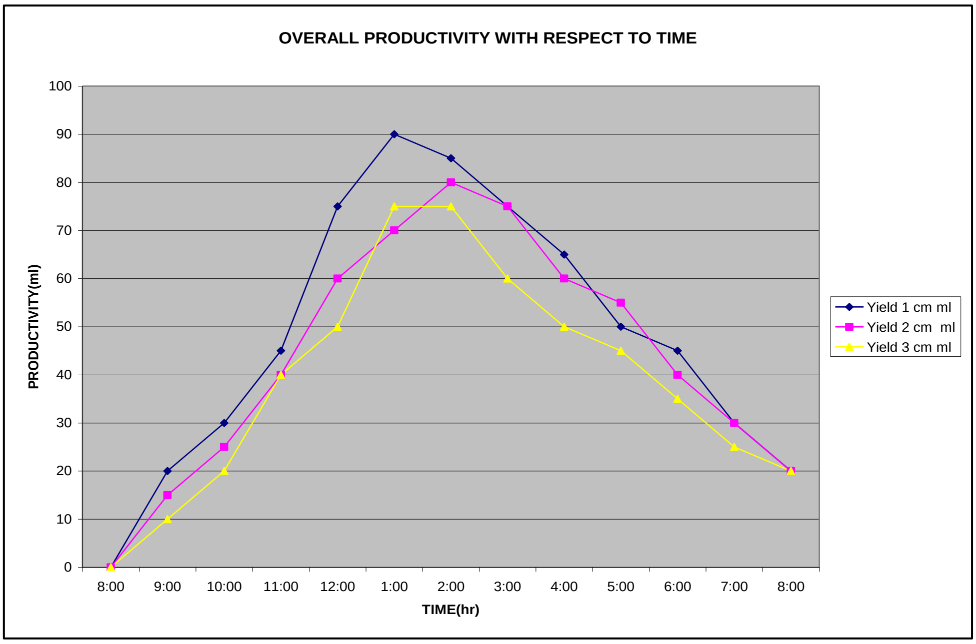
B. Calculation of latent heat

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

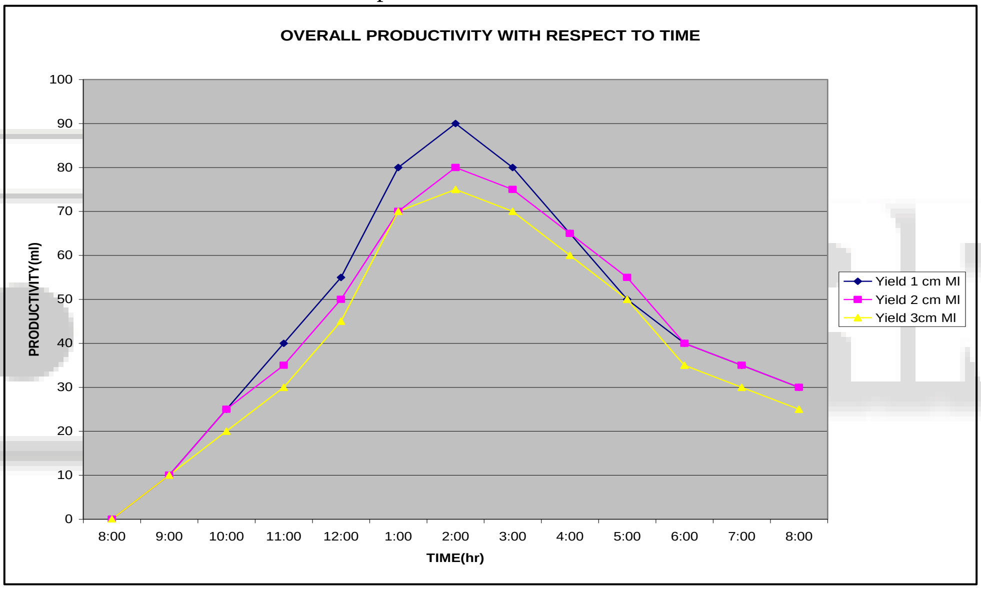
VIII. Overall Productivity With Respect To Time



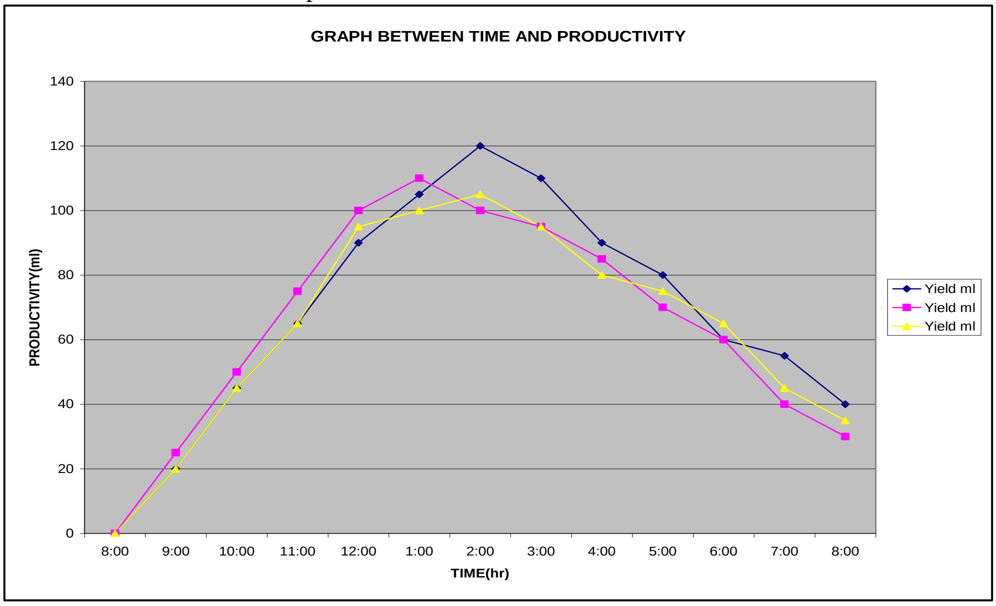
Graph 5: Conventional solar still



Graph 6: Modified solar still



Graph 7: Modified solar still use aluminum



Graph 8: Modified solar still use jute

IX. VARIATION OF PRODUCTIVITY WITH RESPECT TO DEPTH OF WATER

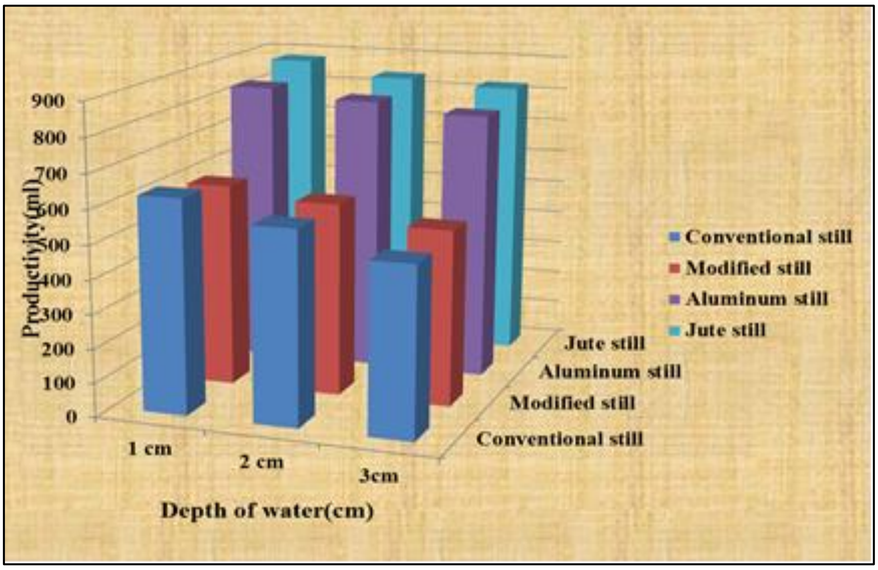


Fig. 6: productivity with respect to depth of water

X. 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.

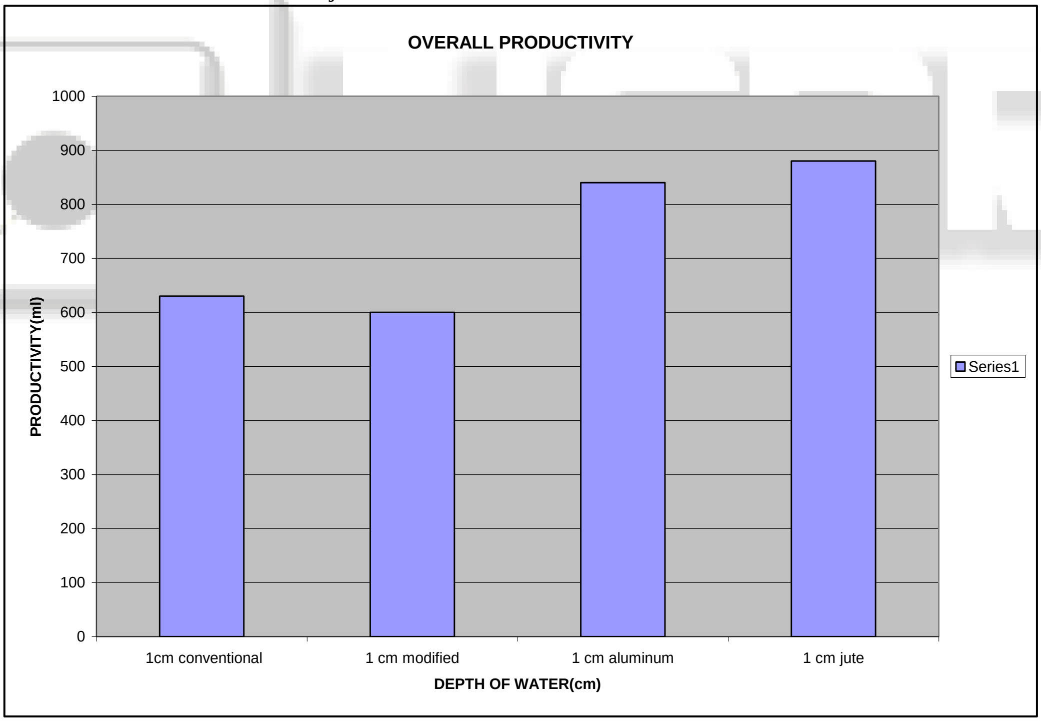


Fig. 7: Overall productivity with respect to depth of water

XI. CONCLUSION

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 15^0 inclinations from both sides. The inner layer is black painted for more absorption.

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.

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.

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 880 ml in case jute which is also at 1 cm depth of water.

It was observed that the maximum productivity obtained in case of still filled with Jute which is 880 ml that is greater than 39.68% from conventional still,46.66% from modified still and 4.76% from still filled with Aluminum.

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%.

It was observed that in case of still filled with Jute, the efficiency of still was maximum at 06.00 pm which is 15.69% at 3 cm depth of water while compare still filled with Aluminum the efficiency of still was at 06.00 pm at 3 cm depth of water which was 14.52%.

It was observed that the maximum efficiency obtained in case of still filled with Jute which is 15.69% that is greater than 54.27% from conventional still,51.13% from modified still and 8.05% from still filled with Aluminum.

Therefore, It was observed that the maximum yielding and efficiency were to be measured in case of jute material.

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