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EFFECT OF CLIMATE & DESIGN PARAMETERS ON THE SINGLE BASIN DOUBLE SLOPE SOLAR STIL using CFD

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***Abstract*: Solar still is possibly the oldest method of desalination of water. Its principle of operation is the greenhouse effect; the radiation from the sun evaporates water inside a closed glass covered chamber at a temperature higher than the ambient. On the basis of different literature survey, a single basin Double slope solar still is selected for further development and performance analysis. The developed solar still basin area of 1 m2 is to be tested with convert in to double basin by using glass tray inside the solar still. So heat loss of the upper portion was reduce it give more output of the pure water. The experimental set up will analyze by single and double basin solar still. The problem will be also announced on Ansys. This setup has been prepared for the climate (BHOPAL) for the performance of the single basin double slope solar stills and to analysis the efficiency of solar still at different design parameter also this experimental setup data's are also verify with Ansys software.**

***Keywords:* Solar Still, Ansys (Fluent 14.5), Solar Energy, etc.**

1. INTRODUCTION

Water is the basic necessity for human along with food and air. There is almost no water left on Earth that is safe to drink without purification. Only 1% of Earth's water is in a fresh, liquid state, and nearly all of this is polluted by both diseases and toxic chemicals. For this reason, purification of water supplies is extremely important. Moreover, typical purification systems are easily damaged or compromised by disasters, natural or otherwise. This results in a very challenging situation for individuals trying to prepare for such situations, and keep themselves and their families safe from the myriad diseases and toxic chemicals present in untreated water. Everyone wants to find out the solution of above problem with the available sources of energy in order to achieve pure water. Fortunately there is a solution to these problems. It is a technology that is not only capable of removing a very wide variety of contaminants in just one step, but is simple, cost-effective, and environmentally friendly.

Most of our earth surface is covered by water; however, less than 1% of total available water is fresh water which is mostly available in lakes, rivers and underground. Again, about one-third of that potential fresh water can only be used for human needs due to mixed factors. Approximately 1.1 billion people in this world have inadequate access to safe drinking water. There are 26 countries do not have enough water to maintain agriculture and economic developments. At least 80% of arid and semiarid countries have serious periodic droughts. A third of Africans and most of Middle-East people live without enough water. The population growth -Coupled with industrialization and urbanization results in an increasing demand for water. In India, the scarcity of desalinated water is severe in coastal areas, especially in the remote coastal areas. Renewable energy based desalination plants can solve this fresh water production problem without causing any fossil energy depletion, hydrocarbon pollution and environmental degradation. In spite of the limitations of being a dilute source and intermittent in nature, solar energy has the potential for meeting and supplementing various energy requirements.

2. LITERATURE

2.1 SOLAR ENERGY

Systems; being modular in nature can be installed in any capacity. Different methods of desalination have been used in several countries to resolve the crisis of drinking water. A variety of desalination technologies has been developed over the years on the basis of thermal distillation, membrane separation, freezing, electro dialysis, etc The two most important technologies are based on the multi22 stage flash distillation (MSF) and reverse osmosis (RO) processes. It is viewed that three processes – MSF, RO, and multiple-effect distillation (MED) will be dominant and competitive in the future For instance, in 1999 approximately 78% of the world's seawater desalination capacity was made up of MSF plants while RO represented 10% Solar distillation is a process where solar energy is used to produce fresh water from saline or brackish water for drinking, domestic and other purposes. There are several distillation methods developed For water desalination technology which differ in simplicity, cost and applications. In the last decades, many researchers have been conducted to minimize the cost of this process, and several.

Methods have been developed. Among these methods, solar distillation appears as one of the best practical and the most economical, especially for mass production of fresh water from high saline water like seawater. High energy cost of the evaporation process contributes most of the running expenditure in various distillation methods. The advantage of solar energy based small desalination plant is the requirement of small quantities of energy which is mostly collected from the sun. This should be the most economical solution to provide potable water to villagers residing at remote areas where proper infrastructure is lacking. Solar distillation looks very attractive as it utilizes the free source of energy – the heat from the sun. Solar water distillation has begun over a century ago. In 1872, a solar plant with capacity around 4000 m2 has been built in Chile and successfully ran for many years. In addition, the small plastic solar stills have been employed to provide potable water for life rafts floating in the ocean during World War II. Thus, the use of solar energy with water distillers has a long history and the technology is well improved and field tested throughout the world. Solar stills can serve the purpose of basic drinking water requirements of man The fresh water crisis is already evident in many parts of India in varied scale and intensity at different times of the year. Also, the demand for fresh water increases with the growth of its population. The conventional desalination technologies are expensive for the production of small amount of fresh water. Also, use of conventional energy sources is costly and not always eco-friendly. Solar distillation is most attractive and simplest technique among other distillation processes especially for small-scale units located at places where sufficient solar energy is available.

2.2 SOLAR STILLS

Solar still is possibly the oldest method of desalination of water. Its principle of operation is the greenhouse effect; the radiation from the sun evaporates water inside a closed glass covered chamber at a temperature higher than the ambient. A schematic diagram of typical basin type solar still is shown in figure 1.

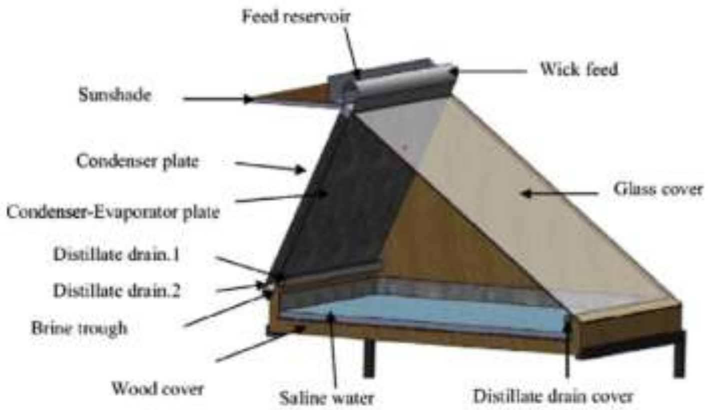

Figure: Design Parameters of Solar Still

The saline water is fed on a black plate in the lower portion of the solar distiller. The heat of the sun causes the water to evaporate and water vapour condenses to form purely distilled droplets of water when it reaches the cool transparent leaning surface made of glass or plastic. The droplets slide down along the leaning surface and are collected through special channels located under the leaning Surface. This is the basic model. Over decades several other designs mostly based on variations in the geometric configurations have been developed to improve the efficiency of passive basin type solar stills.

In active systems, an external source (such as a flat plate or concentrator collector) for additional thermal energy is used to increase the temperature of the saline water in the basin. This class is suitable for commercial production of distilled water. The passive distillation system does not employ an outside source of energy. The advantages of such solar distillers are their design simplicity, low installation cost, independent water production and simple maintenance. But they also have several disadvantages such as low efficiency and deposition of salt, scale and corrosion.

In passive distillation system, the advanced solar stills prove more effective than conventional basin type one especially during winter and rainy seasons. One such example is coupled solar stills. A simple solar still assisted by an external solar collector shows increase in fresh water productivity with the increase in solar collector area of the assisting device. The net efficiency of the coupled system is higher than that of a similar simple still by a value that depends mainly on the system configuration and independent of the meteorological conditions. In solar diffusion driven desalination process, the solar heat input is recycled in a unique dynamic mode which eliminates the need for external cooling to improve water production and reduce the specific energy consumption. The delayed operating mode of such system yields a fresh water production rate of 6.3 L/m2/d for the month of June in Florida with an average specific energy consumption of 3.6kWh/m3 . With the low specific energy consumption, the solar diffusion driven desalination can be competitive with other small scale desalination units for decentralized water production. Low temperature phase-change desalination has several thermodynamic advantages and benefits. The low-temperature phase-change desalination process evaporates saline water at near-ambient temperatures under near-vacuum level pressures. In this system, freshwater production rate of 0.25 kg/h (6 L/d) can be sustained at evaporation temperatures as low as 40ºC. Hence, this process has the prospect to be driven by low-grade heat sources such as waste process heat or solar collectors at temperatures as low as 50ºC. Multi effect solar stills reutilize the latent heat of condensation and further reduce the heat requirement of the process. Unfortunately, most of the approaches can only be taken for centralized plants; the complexity and cost of fabrication are beyond the reach of common villager's enclosure. The still can be inclined or tilted to the solar radiation to avoid dripping back the distillate into the wick. Both insulated and un-insulated models are used. The porous, blackened cloth serves as the surface for absorption and evaporation. Distilled water condenses on the inside surface of transparent cover and collects in a trough at the lower edge of the cover. A drain for the concentrated saline water is set at the lower edge of the fabric. The flow rate of the saline water is most critical as the efficiency of capillary still increases with the decrease in flow rate but too low flow rate leads to localized drying of wick materials or dry spot development.

The advantages of the cloth are many. It increases the surface area of the brine for more evaporation. The thermal capacity of the still reduces which in turn provides faster response to solar radiation. The still can easily be tilted or shifted to intercept the maximum solar radiation as compared to basin type stills. In a diffusion type still, the distance between the cloth surface and the top cover is reduced to a few millimetres which increase the evaporation rate (observed that a tilted wick still has high productivity during the winter months as compared to basin type stills.

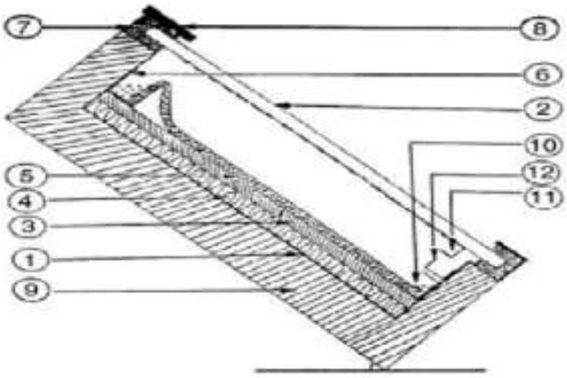

Figure 3: Cross sectional view of a capillary solar still

(1) Galvanised steel tray, (2) Glass cover,
(3) Support board, (4) Polystyrene,
(5) Charcoal cloth, (6) Aluminium channel,
(7) Rubber gasket, (8) Steel strip,
(9) Styrofoam, (10) Brine gutter,
(11) Distillate gutter, and (12) Distillate outlet channel

3. OBJECTIVE

On the basis of different literature survey, a double slope basin solar still is selected for further development and performance analysis. The developed solar still basin area of 1 m2 is proposed to be tested with convert in to double basin by using glass tray inside the solar still. So heat loss of the upper portion was reduce it give more output of the pure water.
The experimental set up will analyze by single and double slope basin active solar still. The problem will be also announced on Ansys software. This setup has been prepared for the climate BHOPAL for the performance of the double slope basin active solar stills and to analysis the efficiency of solar still at different design parameter also this experimental setup data's are also verify with Ansys software.

4. PROPOSED METHODOLOGY

Programming in ansys software is now becoming popular among engineers because it is easy to learn software and it saves time of the programmers. A Ansys is written for calculating the convective, radioactive and evaporative heat transfer rates in the still and also the hourly distillate from the sill. When the program is executed and the average values of the basin water temperature and the glass temperature are entered the Ansys control calculates the various heat transfer rates.

4.1 MATHEMATICAL EXPRESSIONS

Following are the mathematical expression used for the analysis of energy and exergy of considered solar still systems. The thermal efficiency of a passive solar still can be calculated by the following formula.

$$\eta_i = \frac{\dot{m}_{ew} \times L}{A_s \times I(t) \times 3600} \times 100$$

Where,

$$\dot{E}x_{evap} = \sum_{i=1}^{24} \left(1 - \frac{T_a}{T_w}\right) \times \dot{q}_{ew}$$

$$\dot{q}_{ew} = A_s . h_{ew} . \left(T_w - T_{gi}\right)$$

And,

$$\dot{E}x_{in} = \dot{E}x_{sun} = A_s \times I(t) \times \left[1 - \frac{4}{3} \times \left(\frac{T_a}{T_s}\right) + \frac{1}{3} \times \left(\frac{T_a}{T_s}\right)^4\right]$$

Equivalent thickness of materials for same performance as FRP has in case of solar still:

$$l_{material} = \frac{K_{material}}{K_{FRP}} \times l_{FRP}$$

Thickness of Styrofoam of materials for insulation (when solar still is made of any metal and overall thermal conductivity is equivalent to FRP):

Table 1 Nomenclature

A_S	*Area of solar still........m²*
I_t	*Solar intensity..........W/m²*
E_{xout}	*Exergy output..........W/m²*
E_{xin}	*Exergy input...........W/m²*
K_{mat}	*Thermal conductivity of material......W/mK*
K_{met}	*Thermal conductivity of metal..........W/mK*
K_{FRP}	*Thermal conductivity of FRP...........W/mK*
L	*Latent heat of vaporization...........kJ/kg-K*
l_{mat}	*Thickness of material......m*
l_{met}	*Thickness of metal..........m*
$l_{styrofoam}$	*Thickness of Styrofoam...m*
m_{ew}	*Hourly distillate collected.......kg/m²-h*
q_{ew}	*Heat utilized in evaporation of water....W/m²*
T_a	*Ambient temperature...........K*
T_s	*Sun temperature..................K*

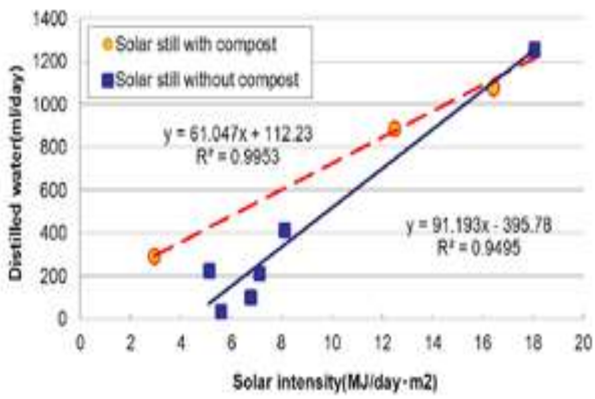

Figure 4 Graphs for Distilled Water

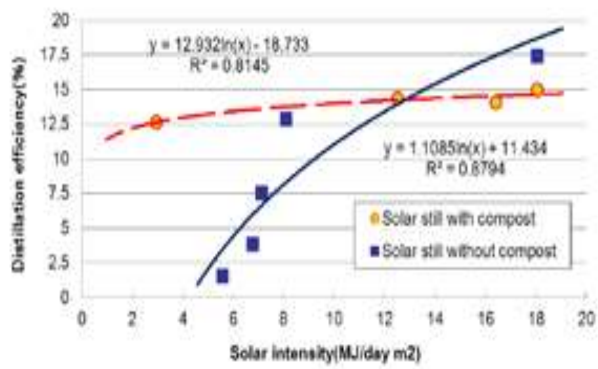

Figure 5 Graphs for Distillation efficiency

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