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AN EXPERIMENTAL STUDY ON SINGLE BASIN DOUBLE SLOPE PASSIVE SOLAR STILL WITH DIFFERENT WATER DEPTHS

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Abstract - ***The renewable energy sources such as solar, wind, bio-mass, and geo-thermal are environment friendly and perennial in nature. The harnessing of energy through these resources, using efficient technologies, is expected to play an important role in serving a clean source for the human being. Water is very important for human survival. Water is a basic necessity. It is used for drinking, cooking, bathing, cleaning and irrigation. Supply of drinking water is a major problem in developed as well as in developed economies owing to high pollution. Therefore for the purpose of human use purified water is required. In the coastal areas saline water is available. In this work a double slope single basin passive type glass solar still with total outer basin size of 1m x 0.5m x10cm is fabricated with inclination of 15^o. Productivity of water is measured for 1 cm, 2 cm and 3 cm depth of water for three sunny days. Similarly, productivity of water is measured by addition of layer of coal for 1 cm, 2 cm and 3 cm depth of water for three more sunny days. Some days we have repeated the experiment because of unpredictable weather conditions. It was observed from the results that productivity of water is inversely proportional to depth of water. The results also show that the still with layer of coal found to be more productive than only water.***

Index Terms - ***Minimum depth, Transmittance variation, Incidence angle variation, Distillation; Purification of water; Heat and mass transfer***

I. INTRODUCTION

Recently, there has been thorough research on the Non-Conservation Source of Energy. Renewal Energy resources are getting priorities in the whole world in order to provide sustainable power generation and safe world to the future generation. The fossil fuel will not remain as the leading source of energy as it is exhaustible. It is unfortunate that the development and progress by human till recently has been obsessed by voracity for ease, power and control of the resources. As a result natural resources have been oppressed unmindfully leading to almost a crisis stage. It is only about last two three decades that social scientists have been able to draw the attention of the administration and the world political leadership to pay attention to the problemThe contribution of sun to meet human energy demand is significant. For long term sustainable energy resources like solar power offers a gorgeous choice to meet growing energy demand without affecting surroundings. With the growth of population and industry and agriculture development, shortage of water has become a major problem in most countries. Distillation is one of the most suitable methods for supplying safe water. There is a shortage of fresh water in rural and urban areas. Clean potable water is a basic necessity for man along with food and air. Fresh water is also required for agricultural and industrial purposes. Direct uses of water from sources like rivers, lakes, sea and underground water reservoirs are not always worthwhile, because of the presence of higher amount salt and detrimental organ. There is severe deficiency of fresh drinking water in remote and rural areas of many countries. At most of the places, enough saline water is available. But, it is not suitable for drinking and other domestic, agricultural and industrial applications. On the other hand, people are unable to use existing popular desalination devices for example Aquaguard or RO purifier in rural area to get fresh water because of limited or even no supply of grid-connected electricity. As most of the desalination technologies require electricity to run these devices, there is dire need to find some desalination systems working with locally available renewable energy sources. Fresh water is a renewable resource, hitherto the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia and North America, although it is still uncertain how much natural renewal balances this convention, and whether ecosystems are endangered.

II. MODES AND BASIC LAWS OF HEAT TRANSFER

The heat transfer process in a solar still can be broadly classified into internal and external heat transfer processes

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based on energy flow in and out of the enclosed space. the internal heat transfer is responsible for the transportation of pure water in the vapor form leaving behind impurities in the basin itself whereas the external heat transfer through the condensing cover is responsible for the condensation of pure vapor as distillate. Both these processes are briefly explained in the following sections.

A. *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.[9]

- Conduction is the transfer of heat within a medium or between different mediums which are in direct physical contact. Heat conduction occurs without appreciable displacement of the molecules constituting the medium.
- Convection is the process of energy transport affected by circulation or mixing of one portion of the fluid with another. Convection is possible only in a fluid medium like gas, liquid or a powdery substance and is directly linked with the transport of medium itself.
- Radiation is the transmission of heat in the form of radiant energy or wave motion without affecting the material medium between the heat source and the receiver. Radiation exchange requires no intervening space or medium and in fact occurs most effectively in vacuum.

B. *External Heat transfer*

The external heat transfer consists of conduction, convection, and radiation processes which are independent of each other. It is considered as the loss of heat energy from the solar still to the atmosphere. The heat lose in the solar still from glass cover outer surface to the atmosphere is called as top loss heat transfer process and from water mass to the atmosphere through insulation is called as bottom and side loss heat transfer process. The higher the former the higher will be the yield from the solar still and lower the latter better will be the yield.[11]

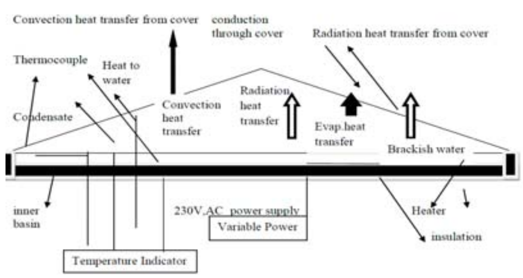

Fig 1 - Heat transfer in Single basin double slope simulation still [6]

III. SINGLE BASIN DOUBLE SLOPE DESCRIPTION AND FABRICATION

Solar still is a simple device which can convert available devastate or brackish water into potable water using solar energy [6]. Research has been made to build up double slope for constraint dimension to boost efficiency in purifying water. Double slope Single basin solar still is accessible with two sides of glass tilted with an inclination at an angle of 15^0.The condenser cover of a double slope solar still may be well thought-out as a system having two thermally free flat plates. The high inclination and contradictory site of each one consequence in a different direction with respect to the sun and therefore the characteristics of absorbed and transmitted energy are diverse [4]. The basin of distiller still was triangular-shaped condensing cover under two still orientations, east–west and north–south. This makes a difference from single slope Solar still.

A. *Experimental Set up*

A schematic diagram of the double-slope single-basin solar still is shown in Figure, and a photograph of the experimental setup of double-slope single-basin solar still with an inclination angle of the condensing glass cover (15°) is shown in Figure 2. The experiments were conducted for many days with different salt water depths in the basin. Among the observations of experimental days, distinctive days have been chosen for the proposed correlation based on the output and standard solar radiation. The overall size of the inner basin is 0.992m x 0.492m x 0.092m and that of the outer basin is 1m x 0.5m x 0.01 m. The gap between the inner and outer basin is air strongly full to capacity with glass wool. The outer basin is made up of glass cover. The top is covered with two glasses of thickness 4 mm inclined at 15 on both sides. The outer surfaces are covered with glass wool and thermocole layers as insulation. In the present research, 6 days of constant experiment was conducted using corresponding passive solar stills. In order to replicate the constant operation of stills, all of them operated for 24 hrs as a pre-test operation. As a consequence, the primary temperatures of brines were above the ambient temperature at the commencement of the first day of experiment. The strength of brine in the basins was accustomed to a particular value at the commencement of each day.

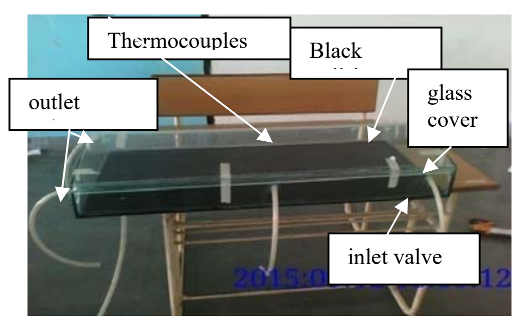

Fig 2 - Photographic Cross section view of Single Basin Double slope basin without insulation

B. *Construction of Double slope Solar Still*

A Single basin double slope solar still is enclosed with glass of thickness 3mm with overall size of outer basin of length 1m x 0.5 m x 10cm and that of the inner basin size 8mm minus from outer basin means 1-0.008m x 0.5-0.008 m x.0.1-0.008 m which is equal to 0.992m x 0.492m x 0.092m with 15^0 inclination of glass cover. Thermocouples inserted in different holes dipped at various locations like on upper surface, lower surface to measure temperature of air velocity, air pressure, temperature of steam vapor and condensed water. A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. Thermocouple is a combination of two dissimilar metals and has a property of generating emf by grasping temperature gradient and vice versa. When two metals having different work functions are placed together, a voltage is generated at the junction which is nearly proportional to the temperature. This junction is called Thermocouple. This principle is used to convert heat energy to electrical energy at the junction of two conductors. The principle is based on seeback effect. The experiment performed in the presence and absence of coal to get pure water and the result compared that with the presence of coal more purification can be achieved. In this way with the use of different materials like glasses, thermocouple, black paint , insulating material and coal a simple arrangement can be made to get the purified water and can calculate different parameters of air temperature. surface viscosity and efficiency through Double slope Single basin still.

C. *Working Principle:*

The experiment is based on the principle of Heat transfer. The principle of Radiation, Evaporation, Condensation processes are applied in this experiment. The radiated light is achieved through sunrays, this is radiation process, the water evaporates through heat, and this is evaporation and then condenses on upper surface of basin. Thermodynamics helps to determine the quantity of work and heat interactions when a system changes from one equilibrium state to another [21]. It operates on the principle of natural hydrological cycle of evaporation and condensation of water. The impurities leave through evaporation process in the basin of the still and the condensation process produces pure water. The steam accumulated on the upper surface of the basin and slides down through outlet valve. The single basin single slope solar still is the simplest design which can be fabricated at much lower cost with easily available materialsFor given depth, all the observations are taken for 24 h duration starting from 6 am. The temperature of the atmosphere, basin water and the condensate are noted for every 15 min.[4]

D. *Factors affecting performance of solar still*

Rational amounts of clean water can be formed via low-priced and sturdy solar stills in places that are open to the elements to solar radiation and have brackish water. The outcome of a solar still is subjective by three factors; namely ambient, operating, and design conditions. Ambient conditions include ambient temperature, isolation, and wind velocity, while operating conditions include water depth, various dyes, still orientation, and inlet temperature of water among others.[10]

1) Climatic parameters

(a) Solar radiation:- Solar radiation represents the most indispensable factor that is still productivity. Many researchers have investigated the effect of solar radiation on still productivity, and their outcome indicate that solar still effectiveness increases with rising incident solar radiation*.*

(b)Wind speed The cause of wind speeds is trivial succumb. Efficiency increases with dilapidated cover temperatures. The temperature difference between glass and water widens with diminishing cover temperature, which as a result enhanced the natural flow of air collection within the still.

(c) Ambient temperature –Several researches investigated and the results proved that a minuscule increase in the order of 3% in the performance of solar stills was made possible by an ambient temperature of 5C.

2) Design parameters*:*

(a) *Water Depth* The depth of the water in the basin is thought to actively control the performance of a still. Quite a few studies were conducted to confirm this fact, mostly involving design optimization of solar stills via the analysis of water depth in basins. The domino effect positively showed output decrease as the depth of water in the basin increases. At lower water depths, the distillation process improved significantly, but it was almost halted when the sun was absent.

(b) *Inclination of cover*: The capitulate from a solar still closely relies on the tilt angle of the solar glass. This angle in turn depends on inclination and the direction the cover is facing, and also its latitude.

(c) *Selection of material:* The research and enlargement done so far has yielded supplementary positive information on the resources of solar stills. The still cover, being one of the most important components, should have its constituent material carefully vetted. Among the possible choices are glass and plastic

IV. RESULT AND DISCUSSION

The experiments were conducted with single basin double slope passive solar still on different days constantly. The annotations were measured for assessment for the days; the atmospheric conditions are almost same. In first day in the case of normal glass cover the water is collected in measuring jar through outlet valve with 1 cm water level collecting 440 ml purified water from overall surface, then from 2cm water level in second day collecting total of purifying water 363 ml, then 3cm on third day collecting 268 ml purifying water. Similarly, in the presence of coal with 1cm water level 552 ml water is collected on first day, 419 ml collected with 2cm water level on second day then 378ml on third day with 3cm water. Graphs are plotted between Temperatures and time to compare the variations of productivity rates of water with the presence of coal and

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without coal. At each stage of variation in temperature, the condensed water collection is recorded at every one hour. The graph is non-linear which shows the temperature after evaporation of water changes at every instant of time. In this way purification of water will be achieved without electricity after condensation.

1) The effect of depth of water without coal.

At 1 cm water level the output obtained of purified water collection of 440 ml at different time and at different temperature like at 10 ‘O’ clock on upper surface temperature is 35^{0}C, Water level temperature is 43^{0}C, on black coating temperature is 36^{0}C, on inner surface temperature 39^0 C and air level temperature is 30^{0}C the purified water collected is nil. Again, at 11 ‘O’ clock 47^{0}C, 58^{0}C, 52^{0}C, 53^{0}C, 34^{0}C respectively then we obtain 35ml of water. Similarly at 12 ‘O’ clock the respective temperatures are 52^{0}C, 65^{0}C, 58^{0}C, 58^{0}C, 35^{0}C respectively then we obtain 85ml of water.

Now at 1 ‘O’ clock the respective temperature 53^{0}C, 66^{0}C, 63^{0}C, 56^{0}C, 36^{0}C respectively then we obtain 95mi of water. At 2 ‘O’ clock the respective temperatures are 52^{0}C, 45^{0}C, 60^{0}C, 53^{0}C, 33^{0}C the water collected is 75ml. At 3 ‘O’ clock the measured temperature are 47^{0}C, 44^{0}C, 55^{0}C, 48^{0}C and 31^{0}C the obtained water is 65ml. Now at 4 ‘O’ clock the measured respective temperature is 38^{0}C, 37^{0}C, 46^{0}C, 38^{0}C, 30^{0}C the collected temperature are 55ml. At the end at 5 ‘O’ clock the respective measured temperature are 35^{0}C, 34^{0}C, 44^{0}C, 30^{0}C, 28^{0}C the obtained water is 30 ml. Thus overall 440 ml of water collection can be calculated. From the given observation table the graph can be drawn between condensed water verses time and it is observed that the graph obtained is non-linear.

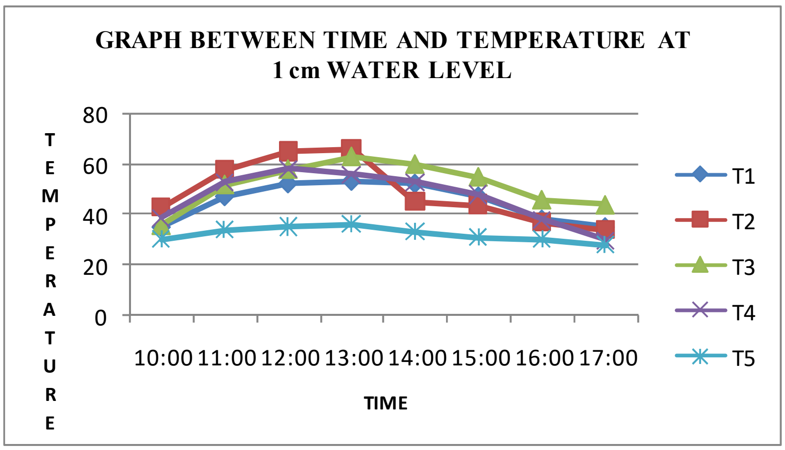

Fig 3 - Graph between Time and Temperature at 1 cm water level

2) The effect of depth of water with the presence of coal

Fig 4 - Graph between Time and Temperature at 1 cm water level with coal

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Now in the presence of coal at 1 cm water level the output obtained of purified water collection of 552 ml at different time and at different temperature. A graph is drawn between condensed water and time and found that graph is non linear but water achieved in more purified form as compared with normal evaporation process.

3) Comparison of Cumulative collections for various depths
Cumulative production is the total amount of added hourly production for a period of 8 hours Calculated from the Fig.6.13 (without adding coal) and Fig.6.14 (with adding coal)

Cumulative production is the total amount of added hourly production for a period of 8 hours Calculated from the Fig.5 (without adding coal) and Fig.6.14 (with adding coal). It is clear from the graph that hourly production was higher for lower water depth. Hourly production should be compared with the day temperature and it can be deduced that the condensate production is proportional to the temperature available. At the starting hours, the hourly production is increases up to 1 pm. and after that decreases. At higher depth the productivity is lower. But it is found that the productivity is higher with addition of coal as comparison to without adding coal

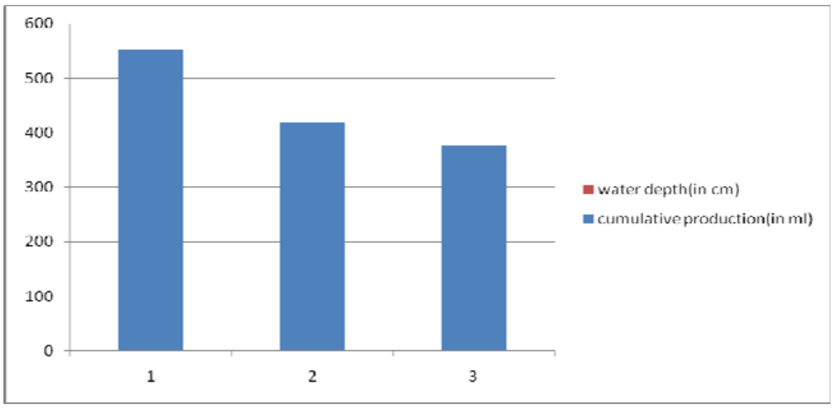

Fig.5 - Cumulative productivity for various water depths with addition of coal.

V. FUTURE SCOPE AND RECOMMENDATION

The detailed survey of the above review shows that multi-effect active solar stills are highly efficient compared to the single effect active and passive stills and multi-effect passive stills. The recommendations can be much of the research has to be focused especially on multistage evacuated system of desalination in order to cater the fresh water needs of rural population by producing 20 to 30 per day economically. So care has to be taken to use effective insulating materials and heat storage medium for enhancing the temperature of water and high rates of condensation.

VI. 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. In this work a double slope single basin passive type still is experienced under laboratory conditions for 1 cm, 2 cm and 3 cm depth of water for three sunny days. To enhance the productivity water, coal is added as water absorbing material and again experiments were conducted with 1cm, 2cm and 3 cm depth of water for three more sunny days. 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. Addition of coal really enhanced the productivity by 20% in comparison with without addition of coal.

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