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A Review of Design and Fabrication of Single Slop Solar Water Distillation System Using Phase Change Material

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Abstract – The trouble of eating water is flattering gradually more, due to the two factors; firstly that the population of the world has increased fast and secondly the standard of living of human being has increased. Only 1% of earth's water is in a fresh, liquid form, and nearly all of this is polluted by diseases and toxic compounds. For this cause, purification of water is very important for drinking.

The main objective of the present work is the design and experimental study of a single slope solar still under the Gwalior climatic conditions during months of November and December 2015, used in domestic and industrial applications. In this paper an attempt has been made to experimental investigation of different depth level of water i.e.10litters, 15littersand 20litters in solar water distillation system. Adding Paraffin wax is in solar water distiller, increased distillation time as well as increased distiller productivity. Paraffin wax is a phase change material and good insulator for storing heat. In this paper i have got to two comparative data; without any PCM and with paraffin wax in different depth level of water.

Keywords- Solar Energy, Heat Storing Material (Paraffin Wax), Thermometer Uses, Practical Study, Solar Distiller Productivity

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1. INTRODUCTION

The energy and water are the two most important resources for sustaining of life. Both of them are to be conserved and preserved for the sustainable growth of the world. Around 97% of the water in the world is in the oceanic, approximately 2% of the water in the world is at present accumulate as ice in glacial region, and 1% is fresh water available for the necessity of the animals, plants and human life [1]. That 1% of earth's water is in a fresh, liquid state and nearly all of this is unclean by both diseases and toxic chemicals. For this reason, purification of water is most important .Distilled water is the cleanest form of water everybody wants to discover the solution of above problem with the available sources of energy in order to achieve clean water. Fortunately there is a solution to these problems. It is a technology that is not only capable of removing a very extensive diversity of contaminants in just one step, but is simple, cost-effective, and environmentally friendly. That is use of solar energy [2].

In this study i have used phase change material i.e. Paraffin wax. Paraffin wax is considered the most probable PCM between several materials, because of some of its desirable features. Paraffin wax has elevated latent heat of combination, inadequate super-cooling, low vapor pressure in the melt. Also, it is chemically stable and can be 100% decomposable. However, it has low thermal conductivity that results in lower heat transfer rates during phase changing (freezing/ melting) processes [3].

1.1. About Solar Energy -

Solar energy is the energy produced and radiated by the sun, more specifically, the sun's energy that reaches to the earth. Solar energy is the primary source of all kind of energy on the earth. Solar energy has the chief potential of all the sources of non-conventional energy and if only a lesser amount of this form of energy could be used, it will be one of the best important supplies of energy especially when other sources in the country have short.

Energy comes to the earth from the sun .The solar power reaching at the top of the atmosphere (where sun hits atmosphere) 10^{17} watts and that on earth's surface is 10^{16} watts. The total worldwide power demand of all needs of civilization is 10^{13} watts. Therefore, the sun gives us 1000 times more power than we need .If we can use 5% of this energy ,it will be 50 times what the world will need. The energy radiated by the sun on a bright sunny day is around 4 to 7 kw/m^2 [4]. Solar energy is an effectively inexhaustible form of energy that can be used indirectly and directly. Indirect forms of solar energy include biomass, ocean thermal and wind energies. Direct use of solar energy includes heating of buildings, water and desalination of water.

1.2. Solar Still Working –

The solar radiation is transmitted through the glass or plastic cover and captured by a black surface at the bottom of the still. The inner surface uses a blackened material to increase absorption of the sun rays. In the still working water begins to heat up and the moisture content of the air surrounded between the water surface and the glass cover increases. The heated water vaporizes from the basin and condenses on the inside of the glass cover. In this process, the salts, toxic compounds and microbes that were in original water are left behind. Condensed water drops down the inclined glass cover to an inside collection trough and out to a storage bottle.Fig.1.show the working operation of single slope solar water still [2].

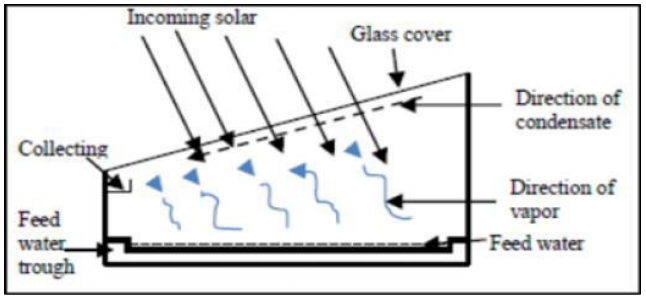

Fig.1. Working operation of single slope solar still [2]

1.3. Types of Solar Still –

The following types solar still are used:

1.3.1. Basin type solar still –

This is the most commonly investigated type of solar still. As shown in Fig.1. It contains a shallow layer of brine. It is sometimes constructed from galvanized steel sheet with a rectangular plan area (supplied either continuously or intermittently with brackish or saline water). Above the brine is a sloping transparent cover of glass or plastic sheet. The generated water vapor can condense on the lower surface of the cover. The cover is sloped to allow the distillate to trickle into troughs from where it is collected in an external reservoir.

1.3.2. Wick-basin type solar still: -

A wick-basin type solar still has great potential due to its higher productivity compared to the other type stills. The construction of the still is quite simple as show in fig.2. The basin and the wick type are integrated to form a wick-basin type solar still. The still consists of metallic basin made of galvanized iron sheets and a glass cover. The bottom and sides are well insulated. The black painted wick used to absorb the solar energy is enclosed by wooden frame.

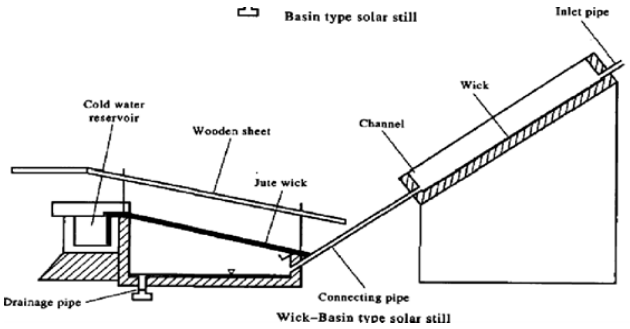

Fig.2.Wick Basin type Solar Still [1]

1.3.3. Tilted Type Solar Still –

Tilted type solar still with flat plate reflector which is simple in construction as show in fig.3. The still consists of a glass cover, tilted-galvanized iron tray, wick material and a flat plate reflector to improve the amount of distillate output for different seasons across year. This type of still has yielded greater distillate output compared to that of a tilted wick type solar still with inclined external flat plate reflector, with one step azimuth tracking of a tilted wick solar still, tilted wick type still with bottom reflector and tilted wick still for the determination of optimum inclination and influence of the reflector[1].

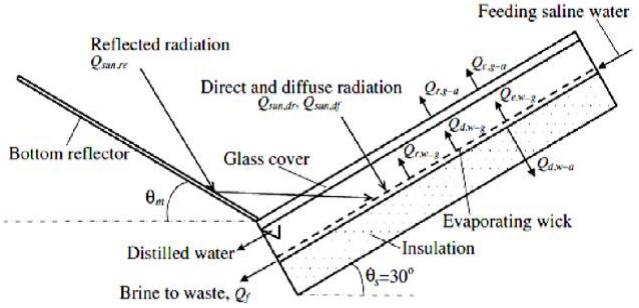

Fig.3. Tilted Type Solar Still [1]

2. LITERATURE REVIEW

A lot of number of research work has been done on solar water distillation system. All the principle and

techniques of purification of water thought solar distiller system have been analyzed in detail.

Mehta et.al [4], have designed a model which will convert the dirty water into pure water using the non-conventional source of energy i.e. solar energy. The basic modes of heat transfer involved are radiation, convection and conduction .The result are obtained by evaporation of the dirty water and becoming it out as pure water. The designed model produces 1.5 liters of fresh water from 14 liters of dirty water during six hours and the efficiency of plant is around 64.37%.Fig.4.Show the working model of solar water distillation system.

Fig.4. Working model of solar distillation system [4]

Chaichan & Kazem [5], conducted a practical study of heat transfer enhancement of paraffin wax existing in single slope solar distiller base and sides. Aluminum powder was added to paraffin wax to enhance its thermal conductivity. The practical tests conducted in Baghdad, Iraqi weathers at Jan and Feb, 2013. Fig. 5 shows the relation between time and temperature divided into intervals of 10 minutes starting from 11 AM to 2 PM). Paraffin wax temperatures increased with time until it reached its melting point at 45°C for the used paraffin. At this stage, the temperature will suspend until all wax melt and becomes liquid. And fig. 6 shows the behavior of discharging paraffin wax for the hours from 2 PM to 5 PM. Paraffin temperatures reduced with time until it reached its solidification point at 45°C for the used paraffin. At this stage, the temperature will suspend until all wax solidified and became solid. The results show that aluminum powder bettered phase modernize resources demonstrates improved thermal conductivity in evaluation to the base substance. Adding aluminum powder to PCM, increased distiller productivity as well as increased distillation time.

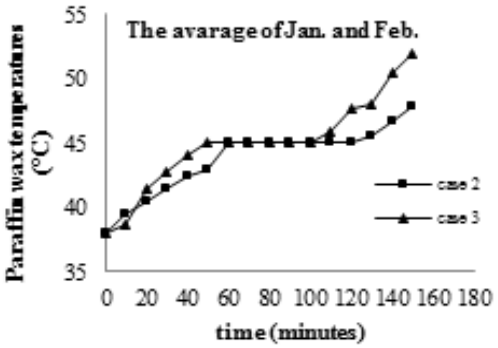

Fig.5. Paraffin wax temperatures versus time during the charging period at February [5]

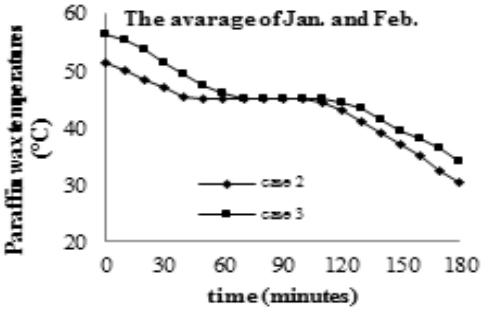

Fig.6. Paraffin wax temperatures versus time during discharging period at January [5]

Srivastava & Agrawal [6], designed high performance plant are compared with that of a conventional basin type solar still of equal material and size. The cost of the distilled water produced is determined by uniform cost analysis method. The analysis revealed that the production cost of the distilled water produced per liter by the high performance plant is Rs.5.07, whereas that for the conformist tranquil is Rs.7.90 when the market cost is Rs.20.00 as show in fig.7. The high performance solar distilled water plant can be a very cheap, cost effective, minimum maintenance and the zero energy cost option. Moreover, there is no pollution involved.

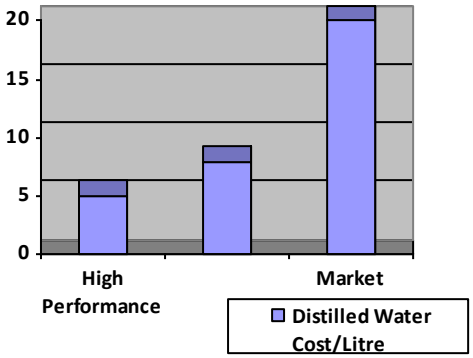

Fig.7.Distilled water cost from different sources [6]

Chaichan & Kazem[7], designed and studies usage of thermal energy storage extracted from concentrating solar furnace to water distillation. Paraffin wax selected as a suitable PCM. It was use for storing thermal energy in two special insulate treasurers. The paraffin wax is getting hot water from concentrating solar dish. This solar energy accumulated in PCM as concealed heat energy. Solar energy stored in a day time with a large amount, and some heat retrieved for further experience. Phase change material was as thermal storage material. The system working time was increased to about 5h with sun tracker by concentrating dish and adding PCM to the system. The system concentrating efficiency, warmth effectiveness, and system efficiency, has augmented by about 64.07%, 112.87%, and 307.54%, respectively. The system working time increased to three hours when PCM added without sun tracker. The system heating efficiency was increased by 41.63% and the system concentrating efficiency increased by around 50.47% and then the system productivity increased by about 180%.

Shabibui & Tahat [8], have investigated experimentally the thermal performance of conventional solar water still with enhanced solar heating system. It was found that 1 cm depth and finned still basin gives the best performance in terms of clean water yield and thermal effectiveness. The adding of the solar water preheater to the system has considerably add to the cove basin saline water heat to almost saturated temperature and saline water in the basin desirable only diminutive heat to be vaporized and hence increases the production of fresh water and improves the solar still thermal efficiency.

Tenthani et.al [9], designed 2 conventional stills were designed with an equal geometry but the inner surfaces of their fabrications were decorated white. These solar stills were tested outdoors under the same atmospheric conditions at the Malawi Polytechnic. Distillate output was measured during experimentation. It was found that the average daily distillate outputs were 2.55 kgm^2 and 2.38 kgm^2 for the experimental still and CSS respectively. In addition, the effectiveness of the investigational solar was 6.8 percent in excess of that of the CSS. It can therefore be concluded that watercolor the inner surface of the ramparts of the still white improves the distillate output of the still.

Medugu and Ndatuwong [10], designed and tested a solar still under real eco-friendly condition of Mubi, Nigeria. They developed theoretical investigation of heat and mass transfer mechanisms inside the still. They did experimental and theoretical investigation on the distillation performance of the solar still. They found that the instantaneous efficiency increases with the increase of the solar radiation and the feed water temperature.

Prasad et al. [11], the still was changed with graphite powder to maximize the absorptivity. In this study, the effect of 4 parameters was studied; the amount of acid, amount of silicate, amount of water depth and graphite powder. The maximum productivity of the still was 1.6 L/m^2. It was found that the productivity of the solar still decreases as the amount of water is increased. When the amount of sodium silicate is increased the productivity increases, but when more than 150g was added the productivity decreased. The same result was obtained when increasing the amount of graphite and acid. The peak performance was obtained by 150g of sodium silicate, 100ml of 2NHCl, and 50g of graphite.

3. CONCLUSION

After study and analyze existing studies, I found that the pure drinking water problem not only a one country problem this is world wise problem .The solution of this problem is use water distillation. Water distillation is a process to produce pure/clean water. A lot of above various research papers find out solutions of these problems they are used solar distillation system. This is low cost, pollution free and renewable source of energy based system. In research paper of Alpesh Mehta, Arhun Vyas, designed modal produces 1.5 liters of fresh water from 14 liters of dirty water during 6 hours. In research paper of Miqdam T Chaivhan, Hussein A Kazem, using aluminum powder with PCM (Paraffin Wax) to enhance single slope solar water distiller productivity. In research paper of Pankaj K Srivastava, Abhay Agrawal, designed and analysis of monthly and the annual productivity of the high performance plant are compared with that of a conventional basin type solar still of equal material and size. In these base papers i have designed and fabricated of single slope solar water distillation system using phase change material i.e. paraffin wax in a form of two packet and comparative experimental study of different depth level water in solar distillation system without and with PCM. The different quantity of water is 10 litters, 15 litters and 20 litters under Gwalior climate condition.

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