Solar Distillator- A Review

Ashwin B. Ganorkar [1], Rupali R.Dorwe [2]
[1, 2] Dept. Of Mechanical Engineering
[1, 2] Priyadarshini Bhagwati College of Engineering, Nagpur

Abstract- *Fresh water is the essence of life and it is the most important constituent of the environment. Water is a basic human requirement for domestic, industrial and agriculture purposes. Supplying fresh and healthy water is still one of the major problems in different parts of the world especially in arid remote areas. Again there are many coastal locations where seawater is abundant but potable water is not available. Our goal is to efficiently produce clean drinkable water from solar energy conversion. Distillation is one of many processes that can be used for water purification. This requires an energy input as heat, electricity and solar radiation can be the source of energy. When Solar energy is used for this purpose, it is known as Solar water Distillation.*

Keywords- Solar distillation, active solar distillation, passive solar distillation.

I. INTRODUCTION

Distillation has long been considered a way of making salt water drinkable and purifying water in remote locations. As early as fourth century B.C., Aristotle described a method to evaporate impure water and then condense it for potable use. P.I.Cooper, in his efforts to document the development and use of solar stills, reports that Arabian alchemists were the earliest known people to use solar distillation to produce potable water in the sixteenth century. But the first documented reference for a device was made in 1742 by Nicolo Ghezzi of Italy, although it is not known whether he went beyond the conceptual stage and actually built it.

Some of the water distillation ways are described as:

Desalination: In this method, the brackish or saline water is evaporated using thermal energy, and resulting steam is collected and condensed as final product.

Vapour compression: In this process of desalination water vapour from boiling water is compressed adiabatically and vopour gets superheated. The superheated vapour is first cooled to saturation temperature and then condensed at constant pressure.

Reverse osmosis: In this process saline water is pushed at high pressure through special membranes allowing water molecules selectively to pass and not the dissolved salts.

Electrodialysis: In this method water is passed through a pair of special membranes, perpendicular to which, there is an electric field. Water does not passed through the membranes while dissolved salts, pass selectively.

Among non conventional methods, distillation is the most prominent; the conventional distillation plants, round the globe, are energy intensive and utilizes non-renewable energy. Solar distillation has the inherent advantages of low energy consumption. Moreover, it is simpler and more economical than other methods. It requires simple technology and easy maintenance hence it can be used at any place without much problem [1]

II. WORKING PRINCIPLE OF SOLAR DISTILLATION

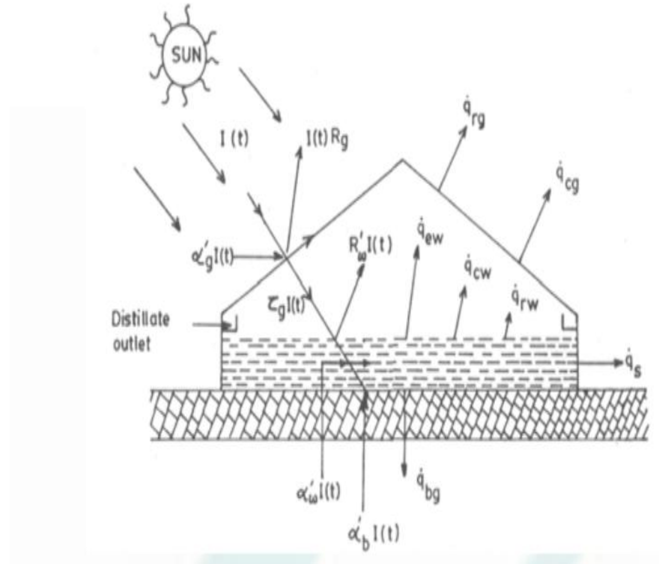

Figure 1: Conventional Solar Still

Figure 1 shows the various components of energy balance and thermal energy loss, in a conventional solar distiller unit. It is an airtight basin, usually constructed out of concreted cement, galvanized iron sheet (GI) or Fiber Reinforced Plastic (FRP) with a top cover of transparent material like glass, plastic etc. The inner surface of the rectangular base is blackened to efficiently absorb the solar radiation, incident at the surface. There is a provision to collect distillated output at lower ends of glass covers. The brackish or saline water is fed inside the basin for purification using solar energy. The solar radiation after reflection and absorption by the glass cover is transmitted inside on enclosure of the distiller unit. This transmitted radiation [g I(t)] is further partially reflected [Rw 1(t) and absorbed [w I(t)] by the water mass. The attenuation of solar flux in water mass depends on its absorptivity and depth respectively. The solar radiation finally reaches the blackened surface where it is mostly absorbed. After absorption of solar radiation, most of the thermal energy is converted to water mass and the rest which is very small is lost to the atmosphere. The water thus gets heated leading to an increased of difference of water and glass cover temperature. There are three modes of heat transfer namely radiation (qrw), convection (qcw) and evaporation (qew), from water surface to the glass cover. The evaporated water gets condensed on the inner surface of the glass cover after releasing the latent heat. The condensed water trickles in to the channels provided at the lower ends of glass cover under gravity. The collected water in the channel is taken out of the system for appropriate use [2].

III. CLASSIFICATION OF SOLAR DISTILLATOR

Solar distillation systems (solar stills) are classified broadly into two categories: passive and active solar stills. Passive systems are those in which solar energy is collected by the structure elements (basin liner) for evaporation of saline water. Various types of passive solar stills are described in the literature like conventional solar still, vertical solar stills, plastic solar stills, cascade type solar stills, multi wick solar still, multi effect or multi stage solar still, multi basin solar still, greenhouse type solar still, spherical solar still etc.In the case of active solar still, an additional thermal energy by external mode is required for faster evaporation. The extra energy may be obtained from a flat plate solar collector, additional condenser, inverted absorber.

IV. RESEARCH ON SOLAR DISTILLATION

Mehta et.al. worked on design of solar distillation system[3]. They prepared a model which converted the saline water to pure/potable water using the renewable source of energy (i.e. solar energy).The model produced 1.5 litres of pure water from 14 litres of dirty water during six hours. The maximum temperature achieved was530oC. It was possible to convert the saline water into potable water by using this model. Umamaheswaran studied solar based distillation system for domestic application [4].These studies gave in detail the information about the construction, testing and analysis of parabolic trough collector/reflector configuration for small scale domestic purpose water distillation application. It was observed that peak optical efficiency of a parabolic trough was in the range of 70-80%.The worrying factor was the area occupied by the collector. There was need to improve collection efficiency to reduce the area requirement. Younis et.al. studied the factors affecting water distillation by solar energy[5]. The performance was studied with respect to the parameters like the water salinity (28, 35 and 58 mmoh/cm,(ds/m), the water depth (6,9 and 12cm), the glass cover thickness (2,4 and 6mm), the percentage of daylight (43.7 , 47.4 and 52.1%), the solar radiation, the ambient air temperature, the wind speed and the relative humidity. They observed that the distillation output increased with high value of ambient air temperature and solar radiation. Ozuomba et.al. investigated the performance of a solar water distillation kit fabricated from local materials[6].They fabricated aroof-type solar water distillation (RSWD) kit. This model was tested under various environmental conditions. According to them, it was possible to increase the efficiency of the system by using large absorber surfaces.In their research work, Gowtham et.al. carried out desalination by concentrating solar thermal energy through a parabolic trough concentrator[7]. They increased the energy storage capacity through paraffin wax as latent heat storage material, maintaining low depths and utilization of various scrap materials for heat storage. This solar heater was analyzed to have 54% higher productivity compared to conventional solar distiller. Bhattacharyya studied solar stills for desalination of water in rural households[8].Though solar stills were having advantages like easy construction, use of low cost material, simple operation and low maintenance requirements, the problem with this system is high initial cost, land requirement and dependence on atmospheric conditions. According to him capillary tubes were gaining importance because of their high output. El-Nashar studied the multiple effect evaporator using solar energy [9].According to his study, this system was technically and economically feasible. Verma et.al carried out optimization of parameters affecting the performance of passive solar distillation system by using Taguchi method[10].Four parameters studied by them were ,glass cover angle, Water temperature ,glass cover temperature, Average spacing between water and glass cover. Machale et.al. studied parabolic trough system[11]. The system produced water of high quality with negligible maintenance. Sengar and Kurchania designed solar geysercum distiller for domestic use[12].Baskaran studied solar powered membrane distillation(MD) and reverse osmosis process(RO)[13]. According to his discussion, MD has significant advantages over other processes including low sensitivity to feed concentration and ability to operate at low temperature.MD or RO with solar application was very attractive alternative. Eze.et.al. worked on solar distillation for refining the beach water [14]. They analyzed various chemical and biological parameters of the seawater. They observed that the solar still with an average efficiency of 36.8% performed within the acceptable range for passive solar systems. An investigation on design and development of wick type solar distillation system was carried out by Sengar et.al.[15].They carried out chemical analysis of pure and impure water. Single Basin Wick Type Solar Desalination Plant (SBWSD) had efficiency of47.14% in winter and 56.29% in summer. Jorapur and Rajvanshi carried out alcohol distillation by using solar still[16].They used a flat plate solar collector system. The collection efficiency was 28%.According to them, solar distillation of alcohol using flat plate collectors was economically not viable. Sharma and Bhatele carried out solar distillation with different feeds[17].The modes of feed were fresh water from the main supply and hot-water from the natural convection-solar water heater under withdrawal and non -withdrawal conditions. According to them, the temperatures of the humid air/ vapour in the solar still, drastically increased from the water level. It dropped at glass surface With fresh water feed, the efficiency after first three hours was 13 -14percent. It increased to 65.57 % and 64.87 % when there was extra withdrawal and the feed was hot water from solar water heater. Al-Hamadani et.al used phase change materials, used storage medium of solar energy[18].They found that the energy efficiencies for solar still integrated with Lauric acid and Myristic acid were 39.6% and 34.4%. They also observed that productivity of solar still integrated with Lauric acid was 22% more than the solar still integrated with Myristic acid.Srivastava and Agrawal studied economics of a high performance solar distilled water plant[19].According to the studies, the production cost of the distilled water produced per litre by the high performance plantwasRs.5.07. The cost for the conventional still is Rs.7.90 and the market cost was Rs.20.00. They concluded that this was very economical, cost effective, minimum maintenance and the zero energy cost option. Badran carried out theoretical analysis of solar distillation using active solar still[20].According to them,active solar stills can be one of the options for enhancing the productivity of stills. Also wind speed and insulation thickness can contribute to the enhancement of the overall yield.Tenthani et.al carried out investigation on improved solar still for water purification[21].They observed that conventional solar still (CSS) suffers from low production of distilled water. They designed two conventional stills with an identical geometry but painted the internal surfaces of their walls with white colour. They concluded that painting the internal urfaces of the walls of the still white improved the distillate output of the still.Suneesh and Jayaprakash carried out work on experimental validation of double slope solar distillation[22]. They analyzed the parameters like productivity, efficiency, internal heat transfer. The overall efficiency was observed to be 28 percent. According to their studies, still design was good enough to reduce convective and radiative heat loss and thus ensured maximum evaporation.Patel et. all investigated the effect of dye on distillation of a single slope active solar still coupled with evacuated glass tube solar collector[23].They used heat storage materials like black, blue and red dye. When exposed to sunrays, temperature inside the evacuated glass tube was more than 80oC.They concluded that output with black dye was higher compared to other dyes .Multistage evaporation system was designed by Chandak et.al. for production of distilled water [24].The yield in this case was 2.3 times than of single effect. According to them the system had great application in food processing industry for juice thickening, sauces, jams, salt concentrating systems and distilled water applications, desalination etc. According to Shukla, there are many coastal areas where seawater is abundant but potable water is not available[25].Their study showed that the use of integrated condensers will reduce the glass temperature. They observed that the daily productivity of (Newly designed Solar Still) NDSS was slightly higher than the (Conventional Solar Still) CSS in all days. There view carried out by Gupta et.al. reveals that various investigators have used thermal modeling technique to analyses performance of Solar water distillation device [26].Solar distillation efficiency can be enhanced by increasing evaporation rate that is a combined effect of solar radiation, cover glass temperature, water contamination density, base plate absorptivity. Also providing additional heat by solar water preheating system will help in enhancing the efficiency of the system.

V. CONCLUSION

Solar distillation is cheap, simple and effective method to purify water. In this paper review has done on techniques used to improve the efficiency of solar distillator. It is observed that efficiency of solar distillator can be increased by increasing temperature difference between surfaces. The problem of land requirement and high initial cost needs to be tackled in order to make this technique more adoptable and acceptable

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