Solar Distillation: A Review

Sunil Jayant Kulkarni[1*]
[1*]*Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India.*
**E-mail: suniljayantkulkarni@gmail.com*

Abstract:

The scarcity of water is a major problem in the large part of the world. The problem is so severe that many countries are fighting to solve the problem of potable water and many people are even becoming the victims of the deceases because of intake of impure water. The purification of water is energy intensive process. Solar distillation is attractive alternative as it uses solar energy. It is also easy in construction, simple in operation, has low maintenance and operating cost. High initial investment is though the limiting factor. The present review summarizes the research carried out on solar distillation. Various investigators have investigated the solar distillation with various storage or phase change materials, using different dyes and various number of effects to improve the effectiveness and efficiency.

Keywords:

Efficiency; output; energy; temperature.

Introduction

With growing population, the demand for water is ever increasing. With limited water resources, it is a challenge for human population to meet the need of drinking water. In many parts of world the intake of impure water has been in major health concern with large number people succumbing to water born deceases. The industrial and domestic wastewater treatment and its reuse for various purposes like agriculturei, sanitation and washing is very effective way to conserve water resources[1,2,3,4,5]. The removal of various pollutants from the wastewater was carried out by various investigators successfully[6,7,8,9,10].These measures can save the water used for sanitation, washing and agriculture. The problem of drinking water can be solved by using various purification techniques to treat the saline water to make it potable. Distillation is one of the operation which can purify the water to this extent. The process needs heat for distilling water. Use of solar energy for distillation is attracting the researchers as it solves the energy problem in the distillation. The investigations are carried out in order to increase the economy and effectiveness of solar distillation. This review aims at summarizing the research carried out on solar distillation in order to improve the process and make it more adoptable.

Research on Solar Distillation

Mehta et.al. worked on design of solar distillation system[11]. 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 was 530^{o}C. It was possible to convert the saline water into potable water by using this model. Umamaheswaran studied solar based distillation system for domestic application[12]. 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[13]. 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[14].They fabricated a roof-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[15].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[16].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[17]. 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[18]. 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[19]. The system produced water of high quality with negligible maintenance. Sengar and Kurchania designed solar geyser cum distiller for domestic use[20].They observed that the efficiency of solar distillation unit was 36.70 and 27.48% respectively in winter and summer.Temperatures achieved in winter and summer were 48.68 and 52.28°C respectively. Al-Hamadani and Shukla worked on use of Lauric Acid as storage medium for water distillation using solar energy system[21]. Phase change material (PCM) like Lauric Acid increased the daily productivity and the efficiency

with higher mass of PCM with lower mass of water in solar still basin. They observed that the distillate productivity at night and on day for solar still with PCM increased by 127% and 30-35% respectively than without PCM one.

Baskaran studied solar powered membrane distillation(MD) and reverse osmosis process(RO)[22]. 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[23]. They analysed 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.[24].They carried out chemocal analysis of pure and impure water. Single Basin Wick Type Solar Desalination Plant (SBWSD) had efficiency of 47.14% in winter and 56.29% in summer. Jorapur and. Rajvanshi carried out alcohol distillation by using solar still[25].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[26].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 droped at glass surface. With fresh water feed, the efficiency after first three hours was 13 -14 percent. 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[27].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[28].According to the studies, the production cost of the distilled water produced per litre by the high performance plant was Rs.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[29]. 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[30].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

surfaces 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[31]. They analyzed the parameters like productivity, efficiency, internal heat transfer. The oveall 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[32].They used heat storage materials like black, blue and red dye. When exposed to sunrays, temperature inside the evacuated glass tube was more than 80^{o} C.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 [33]. 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[34].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. The review carried out by Gupta et.al. reveals that various investigators have used thermal modeling technique to analyses performance of Solar water distillation device [35]. 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.

Conclusion

Solar distillation is easy and effective method for purification of water. It involves basic modes of heat transfer namely radiation, convection and conduction. The solar distillation can be made more economical by using different dyes as absorbing medium, phase change materials and modifying the design. 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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About Author

Mr. Sunil Jayant Kulkarni has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. He has published 35 international review and research papers and presented 15 research papers in international conferences. His area of research includes adsorption, distillation, environmental engineering. He is on the reviewer/editorial board of 16 international journals and reviewed many international papers.