IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 12, December 2015.
www.ijiset.com
ISSN 2348 – 7968

Review on Effect Of Absorbing Materials Used In Solar Still To Reduce The Reflective Radiation Losses

I. Nawaz[1], Mohd Zaheen khan[2]

[1]Department of Mechanical Engineering, Faculty of Engineering & Technology
Jamia Millia Islamia, New Delhi, 110025, INDIA

[2]Research Scholar, Department of Mechanical Engineering, Faculty of Engineering & Technology
Jamia Millia Islamia, New Delhi, 110025, INDIA

Abstract

Over 97.5 percent of all the Earth's hydrosphere comprises of saline water from the oceans, while the remaining 2.5 percent is fresh water. Approximately 1 percent of the world's fresh water is available for human use. This water is found in lakes, rivers, ponds and some underground sources. This water is not enough to be used as distilled water. But still people are compelled to use it due to lack of availability of purification sources. Solar Still is an equipment that is used to distil water. But due to lower efficiency it cannot be profitable in the market putting forward a pressing need for improvement of the efficiency of solar still. The most important parameter that affects the efficiency is the intensity of solar energy falling on the still. In this paper a study is carried out to show the effect of various absorbing material on distillate production to achieve maximum efficiency by reducing the reflective radiation losses. Absorbing materials like charcoal, black granite stone, black rock salt, dye are studied here. With the help of past research work we can conclude that the reflective radiation losses are decreased and efficiency of still will increase with different absorbing materials as compared to efficiency with out any absorbing material.

Key words: *Solar still, Desalination, Absorbing material, Reflection losses, Productivity.*

1. INTRODUCTION

The process of solar distillation is used to distill saline water by using solar energy. Supply of drinking water is a major problem in under developed as well as in some developing countries. Along with food and air, water is a necessity for man. Man has been dependent on rivers, lakes and underground water reservoirs for fresh water. Most of the human diseases are due to saline water problem. Around 2 million children die every year and 40 million people are affected by water borne diseases. However the increasing industrial activities may lead to a situation whereby countries need to reconsider their option with respect to the management of its water resources. Surveys show that the about 97.5% of water available on earth is saline. Only 1% is fresh and the rest is brackish. Around 1% of the world water is potable and this amount is not evenly distributed on Earth. So, developed and developing countries are suffering the problem of potable water. Many developed countries have given utmost priority to rural water supply in their development plans. Distillation is the oldest technique to distillate brackish or salty water into potable water. Various technologies have been invented for desalination from time to time and people have accepted distillation without knowing future environmental consequences.

Distillation of brackish or saline water, wherever it is available, is a good method to obtain fresh water. However, the conventional distillation processes such as Multi-effect evaporation, Multi stage evaporation, thin film distillation, reverse osmosis and electrolysis are energy intensive techniques, and are only feasible for large stage water demands. The alternative solution of this problem is solar distillation system and a device, which works on solar energy to distillate water, called solar still. Solar still is very simple to construct, but due to its low productivity and efficiency it is not popularly used in the market. Solar still is works on solar light, which is free of cost, but it requires more space. Its material is easily available in the market and it doesn't require highly skilled labor for maintenance. A lot of work is being done to increase the efficiency of solar still. It has been observed that compared to passive solar still active solar still's productivity is higher.

2. SOLAR DISTILLATION

Fig.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 concrete, galvanized iron sheet (GI) or fibre reinforced plastic (FRP) with a top cover of transparent material like glass, plastic etc. The inner surface of rectangular base is blackened to efficiently absorb the solar radiation, incident at the surface. There is a provision to collect the distillate at lower end of the glass cover. The brackish or saline water is fed into the basin for purification. The solar radiation, after reflection and absorption by the glass cover is transmitted inside an enclosure of the distiller unit. This transmitted radiation [τ_g I (t)] is further partially reflected [R'_w I (t)] and absorbed [α'_w I (t)] by the water mass. The attenuation of solar flux in water mass depends on it's absorptivity and depth. The solar radiation finally reaches the blackened surface where it is mostly absorbed. After absorption of the solar radiation at the blackened surface, generally known as basin liner, most of thermal energy is convected to water mass and a small quantity is lost to the atmosphere, by conduction. Consequently, the water gets heated, leading to an increased difference of water and glass cover temperatures. There are basically three modes of heat transfer radiation ($\dot{q}_{rw}$), convection ($\dot{q}_{cw}$) and evaporation ($\dot{q}_{ew}$) from the 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 into the channels provided at the lower ends of glass cover, under gravity. The collected water in the channel is taken out by the system for further use. The thermal energy received by the glass cover, through radiation, convection and latent heat, is lost to the ambient by radiation and convection.

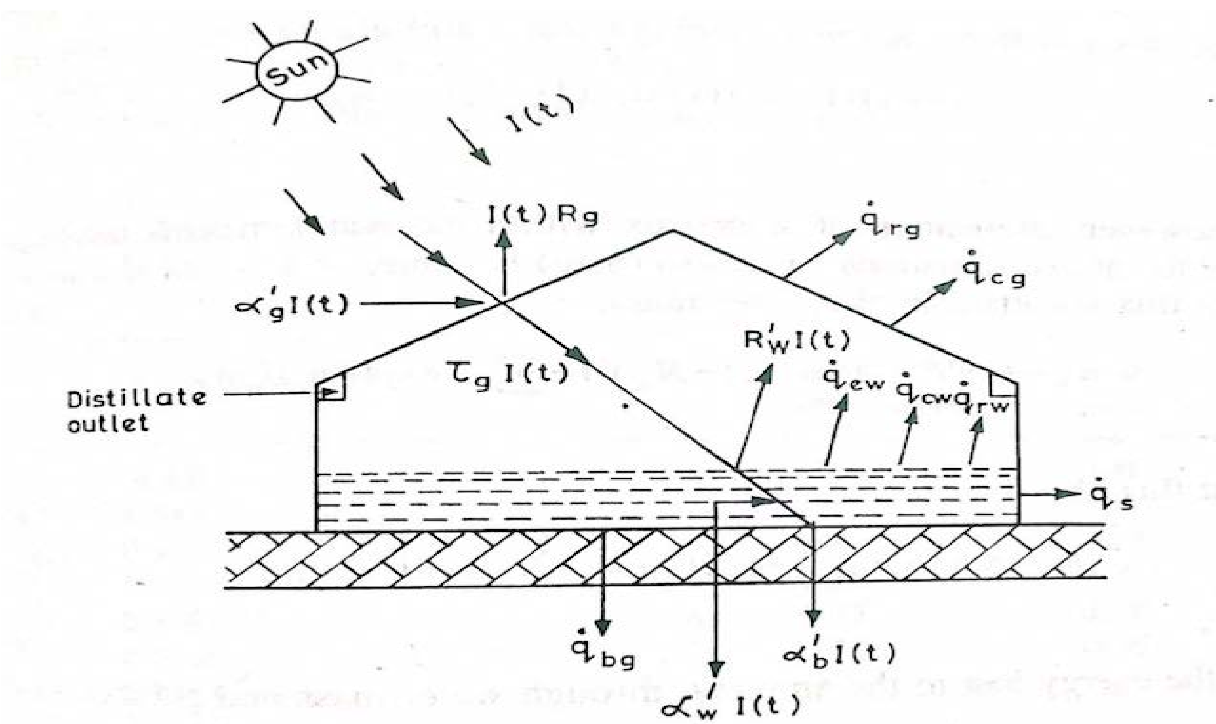

Figure 1 Energy flow diagram in a conventional solar still

The fraction of solar flux, at different components of the distiller unit has been shown in figure. 1 and can be mathematically expressed as,

Solar flux absorbed by the glass cover: $\alpha_g' = (1-R_g)\alpha_g$
(1)

Solar flux reflected by the water mass: $R'_w = (1-R_g)(1-\alpha_g)R_w$

(2)

Solar flux absorbed by the water mass: $\alpha'_w = (1-R_g)(1-\alpha_g)(1-R_w)\alpha_w$
(3)

Solar flux absorbed by the basin liner: $\alpha'_b = (1-R_g)(1-\alpha_g)(1-R_w)(1-\alpha_w)\alpha_b$
(4)

Solar flux lost to the ambient, through water and glass cover,

$$= (1-R_g)(1-\alpha_b)(1-R_w)(1-\alpha_g)(1-\alpha_w)$$

3. EXTERNAL HEAT TRANSFER

3.1 TOP LOSS COEFFICIENT

Due to small thickness of glass cover, the temperature in the glass may be assumed to be uniform. The external heat transfer radiation & convection losses from the glass cover to the outside temperature, $\dot{q}_g$, can be expressed as;

$$\dot{q}_g = \dot{q}_{rg} + \dot{q}_{cg} \quad (5)$$

3.2 BOTTOM AND SIDE LOSS COEFFICIENT

Heat is also lost from the water in the basin to the ambient through the insulation and subsequently by convection and radiation from the bottom or side surface of the basin. The bottom loss coefficient (U_b) is;

$$\frac{1}{U} = \frac{1}{h} + \frac{L}{K} + \frac{1}{h+h} \quad (6)$$

4. INTERNAL HEAT TRANSFER

The heat exchange from the water surface to the glass cover inside the distillation unit is governed by radiation, convection and evaporation and hence these heat transfer modes discussed separately.

4.1 RADIATIVE LOSS COEFFICIENT (h_{rw})

The water surface and the glass cover are considered as infinite parallel planes. The rate of radiative heat transfer ($\dot{q}_{rw}$) from the water surface to the glass cover for these parallel planes is;

$$\dot{q}_{rw} = h_{rw}(T_w - T_g) \quad (7)$$

here, h_{rw} is the radiative heat transfer coefficient from water surface to glass cover

4.2 CONVECTIVE LOSS COEFFICIENT (h_{cw})

Heat transfer occurs across humid in distillation unit by free convection, which is caused by the effect of buoyancy, due to density variation in humid fluid occurs due to temp gradient in fluid. Now the rate of heat transfer from water surface to glass cover ($\dot{q}_{cw}$) by convection in the upward direction is;

$$\dot{q}_{rw} = h_{rw} (T_w - T_g) \tag{8}$$

4.3 EVAPORATIVE LOSS COEFFICIENT (h_{ew})

The mass transfer coefficient h_e in terms of convective heat transfer coefficient h_{cw} is;

$$\frac{h}{h} = \frac{L}{C} \text{ x } \frac{M}{M} \text{ x } \frac{1}{P} \tag{9}$$

5. OVERALL HEAT TRANSFER

5.1 TOP LOSS COEFFICIENT

The top loss coefficient (U_t) from the water surface to the ambient air is;

$$\dot{q}_t = U_t (T_w - T_a) \tag{10}$$

5.2 BOTTOM LOSS COEFFICIENT

Rate of heat loss through the bottom of the insulation from water to ambient air is;

$$\dot{q}_{bg} = U_b (T_w - T_a) \tag{11}$$

6. EFFECT OF STILL PARAMETERS

6.1 EFFECT OF WIND VELOCITY

As concluded by cooper (1969 a), the output increases by 11.5% for average wind velocities from 0 to 2.15 m/s, while the increase is only 1.5% for average wind velocities from 2.15 m/s to 8.81 m/s. thus, wind at higher velocities has a lesser influence on the distillation rate.

The wind blowing over the glass cover causes faster evaporation from it resulting in a fall in the temperature; thus the yield from the solar still increases for larger water depth in the still. However, for smaller water depth the wind has no effect on the output. Even for larger water depth, wind velocity above a particular value (around 5m/s) has not much effect on the yield.

However, as the wind velocity increases, the convective heat loss from the glass cover to ambient increases hence the glass cover temperature decreases which increase the water glass cover temperature difference and hence the overall yield.

6.2 EFFECT OF AMBIENT TEMPERATURE

With the decrease in ambient temperature, the glass temperature decreases and the difference (T_w - T_g) increases, but there is a general fall in the overall temperature of the system, hence the output decreases.

6.3 EFFECT OF THERMAL CAPACITY ON OUTPUT

Cooper (1969 a) has studied the effect of water depth on the distillate output, as shown in figure 2. As we see from the figure, without insulation, the gains from decreasing the water depth are only marginal, but with insulation, the difference is more marked, specially at low depths.

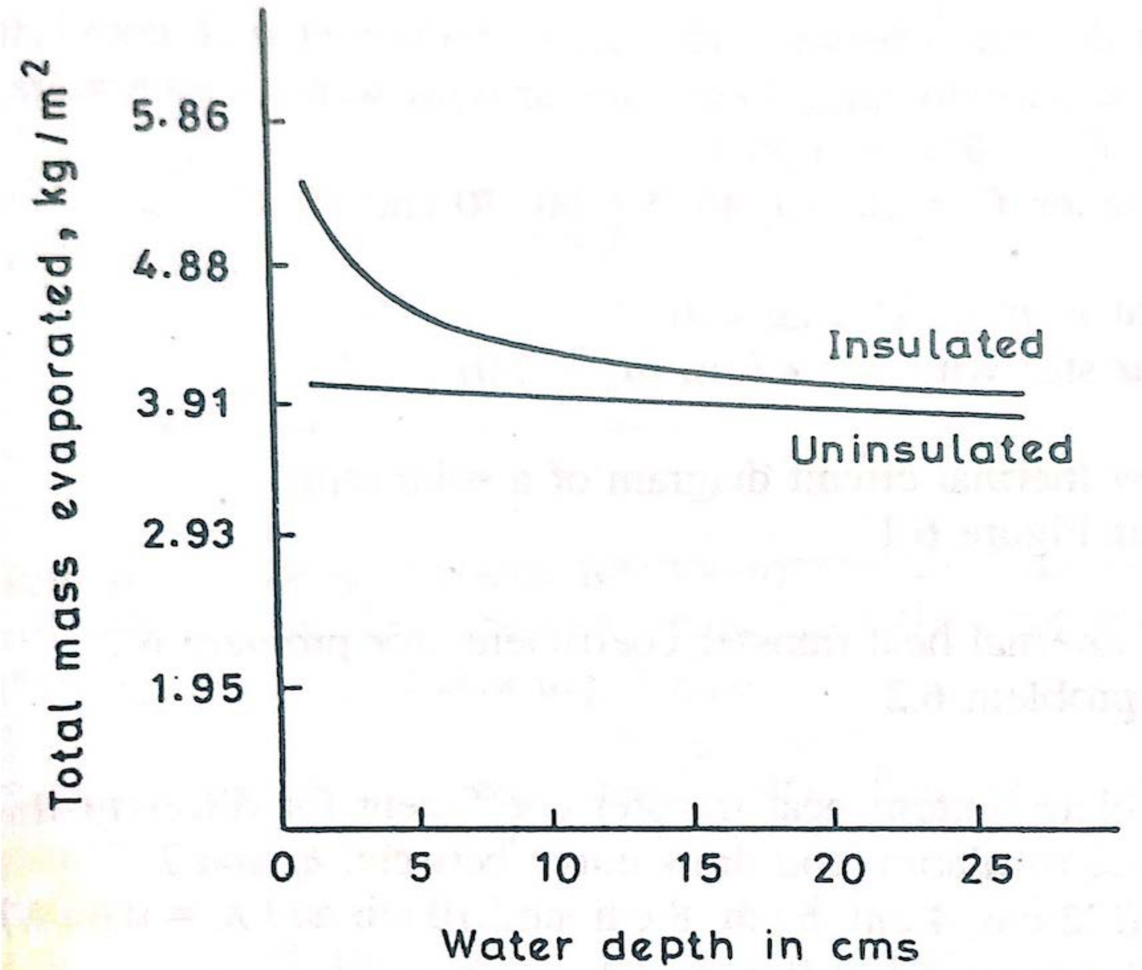

Figure 2 Output from a still, for varying water depths with and without insulation

6.4 EFFECT OF CHARCOAL PIECES ON THE PERFORMANCE OF A STILL

It affects the performance of a still because of its wettability, large absorption coefficient for solar radiation and its property to scatter, instead of reflect, the solar radiation. I conclude from the study done by **Akinsete and Duru (1979),** the effect of charcoal is most pronounced in the mornings and on cloudy days when the value of direct radiation is low. The presence of charcoal pieces utilizes the diffused radiation much better than the conventional unlined still. It was also seen that the charcoal lined still is relatively insensitive to basin water depth as long as a good amount of the charcoal remains uncovered.

CONCLUSIONS

The current study shows the importance of the solar distillation at lower water depth. Inner glass temperature plays a key role to determine the yield. The daily yield is more for active distillation as compared to passive mode using inner glass temperature. Yield is also directly related to thermal conductivity of condensing cover materials, charcoal gives a better yield compared to glass and plastic due to higher thermal conductivity.

ACKNOWLEDGMENTS

Mohd Zaheen Khan is particularly indebted to the Jamia Millia Islamia, Central University for its generous support. He is also grateful to Prof. G.N.Tiwari, Centre for Energy Studies IIT Delhi, for his kind help and suggestions during this work.

REFERENCES

[1] Cooper, P.I., Digital Simulation of Transient solar still Processes, Solar Energy, 12, 313, (1969a)

[2] Akinsete, V.A and Duru, C.U, A cheap method of improving the performance of roof type solar still, Solar Energy, 23 (3), 271, (1979)

[3] Khalifa, A.J.N., A.M. Hamood Performance Correlations for Basin-type Solar Stills. Desalination 249 (2009) 24-28

[4] McCluney, W.R. Solar Distillation of Water. Available at http://www.fsec.ucf.edu/en/publications/.../FSEC- EN-3-80.pdf - United States. Accessed date: May 29, 2010

[5] Improving Basin Solar Stills. Available from: www.appropedia.org/Improving_Basin_Solar_Still s Accessed: July 5, 2010

[6] G.N. Tiwari, S.K. Shukla and I.P Singh, Computer Modeling of Passive/Active Solar Stills by Using Inner Glass Temperature, Desalination, 154, (2003), 171-185.

[7] Anil K Rajvanshi, Effect of Various Dyes on Solar Distillation, Solar Ener., 27, (1981), 51–65.

[8] Anil Kr. Tiwari, G.N. Tiwari, Effect of water depths on heat and mass transfer in a passive solar still: in summer climatic condition Centre for Energy Studies, Indian Institute of Technology, Delhi, Hauz Khas, New Delhi 110016, India, Fax +91 (11) 26862037; email: gntiwari@ces.iitd.ernet.in, Received 15 March 2005; accepted 10 November

2005.

[9] A.K. Tiwari, G.N. Tiwari, 2007, Annual performance analysis and thermal modeling of passive solar still for different inclination of condensing cover, IJER 31 (14), pp. 1358–1382.

[10] Badran OO, 2007, Experimental study of the enhancement parameters on a single slope solar still productivity, pp. 36–43.

[11] Dunkle, R. V, 1961, Solar water distillation, The roof type still and a multiple effect diffusion still, International developments in Heat Transfer, A. S. M. E., In proceedings of International Heat Transfer, University of Colorado, Part V, p. 895.

[12] G.N. Tiwari, 1992, Recent advances in solar distillation, Contemporary Physics-Solar Energy and Energy Conservation, Wiley Eastern Ltd, New Delhi, India, (Chapter II).

[13] G.N. Tiwari, A.K. Tiwari, 2007, Solar Distillation Practice in Water Desalination Systems, Anamaya Publication Ltd, New Delhi, India.

[14] G.N. Tiwari, Vimal Dimri, Usha Singh, Arvind Chel, Bikash Sarkar, 2007, Comparative thermal performance evaluation of an active solar distillation system, IJER 31, pp. 1465–1482.

[15] H.S. Aybar, 2006, Mathematical modeling of an inclined solar water distillation system, Desalination 190, pp. 63–70.

[16] Salah Abdallaha, Omar Badranb, Mazen M. Abu-Khaderc, Performance evaluation of a modified design of a single slope solar still, Desalination 219 (2008) 222–230

[17] G.N. Tiwari and S. Suneja, Solar Thermal Engineering System, Narosa, New Delhi, 1997.

[18] S. Suneja and GN. Tiwari, Optimization of number of effects for higher yield from an inverted absorber solar still using the Runge-Kutta method, Desalination, 120 (1999) 197-209.

[19] A.K. Tiwari, G.N. Tiwari, Thermal modelling based on solar fraction and experimen- tal study of the annual and seasonal performance of a single slope passive solar still: the effect of water depths, Desalination 207 (2007) 184–204.

[20] S. Kumar, G.N. Tiwari, Optimization of collector and basin areas for a higher yield for active solar stills, Desalination 116 (1998) 1–9.