PERFORMANCE STUDY OF A SOLAR STILL WITH SALT HYDRATE AS ENERGY STORAGE MEDIUM

Beer Bahadur Singh
Mechanical Engineering Department, SIET, SHUATS, Allahabad, (U.P.) India

Richa Dubey
Mechanical Engineering Department, SIET, SHUATS, Allahabad, (U.P.) India

Ajeet Kumar Rai
Mechanical Engineering Department, SIET, SHUATS, Allahabad, (U.P.) India

ABSTRACT

A Solar still is a low cost device used for purifying water. Its low productivity is of great concern. Its low productivity is due to poor performance of solar still during off sunshine hours. Many passive solar still have been designed and developed to improve the daily distillate output from the solar still. Energy storage medium is used to enhance the productivity during off sunshine hours. In the present work salt hydrate Mg(NO₃)₂·6H₂O is used as energy storage material in a single basin single slope solar still. Experimental studies are performed in the premises of SHUATS Allahabad, U.P. India and it is observed that the use of Mg(NO₃)₂·6H₂O as energy storage medium in the solar still increases the daily productivity by 22%.

Key words: Solar still, Salt hydrate, Phase Change Material


1. INTRODUCTION

Drinking water is essential for life. Water covers three fourths of the earth surface, but 97% of that is salty. Access to pure drinking water is becoming difficult day by day in the developing countries. Due to rapid growth of population, heavy industrialization, and increasing pollution has worsen the situation. Desalination may be a proper solution but it requires a lot of energy. Solar energy is renewable and sustainable in nature. Solar thermal desalination system gives the better solution to solve drinking water shortage problem. Solar still is a very simple and easy to construct and low cost device. It has many features but the daily productivity from the solar still is insufficient to make it commercial. Different solar still designs (Rai et al. (2013), Khare et al. (2015), Pandey et al. (2016)) have been tested to improve productivity. Limited sunshine hours and poor performance during off
sunshine hours are the two basic reasons behind low daily productivity of solar stills. Energy storage mediums can be used to improve nocturnal output. Abhat (1983), Rai et al (2012), have reviewed work on PCMs and their wide range of applications. Shukla et al (2011), Rai et al (2013), Rai et al. (2015), Hasan et al.(2014), Kumar et al. (2014) and Kumar et al. (2016) used PCM as a energy storage medium in the solar still to improve the daily productivity of solar still. It was reported that the productivity of a solar still can be greatly enhanced by the use of a PCM integrated to the still. In the present study, an attempt has been made to test the performance of a single slope solar still with salt hydrate Mg(NO$_3$)$_2$·6H$_2$O as energy storage material in the basin of the still. The most attractive properties of salt hydrates are: (i) high latent heat of fusion per unit volume (ii) relatively high thermal conductivity (almost double of the paraffin’s) and (iii) Small volume changes on melting. They are not very corrosive, compatible with plastics and only slightly toxic. Many salt hydrates are sufficiently inexpensive for the use in storage.

2. EXPERIMENTAL SET-UP AND PROCEDURE

Figure 1 shows the photograph of two similar single slope solar stills. They are kept on the same platform during experimentation. PCM is loaded in the basin of one of the still while the other still is kept conventional. Passive solar distillation unit consist of water basin of area 1m$^2$. The basin of the still is made up of Galvanized iron. Mass of 4.9 kg of PCM is filled in the thin Aluminum pipes, which are spread in the basin. Basin is now filled with water. Glazing glass cover of thickness 3mm is used as condensing cover. Inclination of the glass covers are at 30°. A distillate channel was provided at each end of the basin for the collection of distilled water. The distillate was collected in thin necked containers and then measured by graduated beaker. Stills were insulated properly by using glass wool.

The experiments were conducted in the premises of SHUATS Allahabad U.P. India in the month of October and November. Experiments started at 8:30 AM at local time. Measuring instruments were calibrated properly. The distillate output was recorded with the help of a measuring cylinder of least count 1 ml. The solar intensity was measured with the help of calibrated solarimeter of least count 2 mW/m$^2$. Anemometer is used to measure the wind velocity.
3. PRODUCTIVITY AND EFFICIENCY OF THE SOLAR STILL

The daily yield $M_w$ can be obtained by adding hourly yield. Energy analysis of a solar still is based on the principle of conservation of energy. Expression for the solar still daily efficiency can be obtained as follows.

$$\eta_{energy} = \frac{(M_w \times L)}{(A_s \times \Sigma I_{(s)} \times 3600)} \quad (1)$$

$L$ is the latent heat of vaporization and is obtained by the expression

$$L = 2.4935 \times 10^6 \times \{1-9.4779 \times 10^{-4}T_w + 1.3132 \times 10^{-7}T_w^2 - 4.7974 \times 10^{-9}T_w^3\} \quad (2)$$

$T_w$ is basin water temperature in $^0C$. $\Sigma I_{(s)}$ is the daily solar intensity. $A_s$ is the basin area of the still in $m^2$.

4. RESULTS AND DISCUSSION

![Figure 1](image1.png)  
**Figure 1** Variation of solar intensity with time of the day

![Figure 2](image2.png)  
**Figure 2** Variation of Temperature of different components of the solar still with PCM
5. CONCLUSIONS

In the present study an attempt has been made to test the performance of solar still assisted with salt hydrate Mg(NO$_3$)$_2$.6H$_2$O as thermal energy storage material in the solar still, which absorbs heat energy during sunshine hours and releases the same during off sunshine hours with little or negligible variation in its temperature. An experimental work was carried out on two similar, single basin single slope passive solar stills. The PCM is used in the basin of one of the still to find its suitability in terms of the performance of the still. It is observed that the use of PCM in the basin of the still increases the daily productivity by 22.9%. Day time distillate output decreases by 11.8% but night time distillate output increases by 185%.
REFERENCES

Performance Study of A Solar Still with Salt Hydrate as Energy Storage Medium


