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Tubular solar still performance equipped with mica sheet and fins

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Abstract
Water being the utmost important for life (including the humans) represents the bulk biomass of living organisms. Due to highly limited availability of fresh usable water and its contamination generated the need for its purification. Although solar stills are well known apparatus for production of distilled water from saline water, yet its limited productivity make it of less utility. In the present experiment, a flat mica plate and fins has been embedded in the tubular solar still to augment evaporation of the water from the input saline water. Compared to conventional solar stills, the currently modified tubular solar still increased the output by 25%.
Keywords: *Tubular solar still, Mica sheet and fins*

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I. Introduction

Water being the utmost important for life (including the humans) represents the bulk biomass of living organisms. Water is the fundamental basis of life because it is essential for every living creature on earth. Out of total water available on the earth, 97.4% is marine or oceanic water and rest is fresh water. The marine fraction of water is saline and cannot be used for drinking purpose. Out of fresh water, 1.8% occurs in form of snow and only 0.8 % as readily available fresh water. This minute but highly important fraction of fresh water is continuously getting contaminated at an alarming rate due to anthropogenic and developmental activities involving the unwarranted minerals, needless salts, organic and inorganic ingredients, effluents, excreta, lifeless animals, debris etc. Such unwanted and undesired alteration in the quality of fresh water has detrimental effect on humans and other living organisms. Thus, there is urgent need at global scale to generate the devises which can purify/distil water from various types of contaminations. In this regard, the Solar Distillation have shown potential for producing potable water from brackish and low-quality underground at reasonable and low cost.

The Solar Distillation technology can ameliorate the water scarcity problems in association with other water purifying technologies. Solar distillation involves processes and functionality similarity to natural hydrological cycle. It uses the apparatus (named as solar still) to evaporate the water by the use of solar energy which in turn being collected as distillate after the vapour condensation. The major advantages of this include the both use of renewable solar energy (in place of electrical energy generated from conventional fuels) and protection of environment from the degradation. Numerous investigators from all over the biosphere have conducted investigations for improving the productivity and efficiency of conventional solar still by amendments in functioning and design parameters [1-8]. The control or reduction of heat losses from base of solar still play a crucial role in the efficiency of solar still, especially of tubular solar till. The adequate insulation of solar base may insure the storage of the absorbed thermal energy. Therefore, in the present investigation the effect of insulation on the productivity of a basin type solar still have been examined which have shown the potential to improve productivity of the still, significantly.

II. Experimental Setup

The experiments have been designed and conducted on the tubular solar still at Amroha, India (28.9052^0N, 78.46° E) having typical tropical climatic conditions. A solar still having the horizontal plate as absorber of 0.62 m^2 was designed and fabricated. The plate has been made of galvanized iron sheet (thickness 0.5mm) and coated in black paint. The try is surrounded by tube-shaped structure made up of polycarbonate sheet. The entire area of the polycarbonate cover is 2.6 m^2. Experiments was performed by placing the tubular solar still in operation in sunlight for a 24-h period.

This innovative work led significant advancement in the field of tubular solar still by adjusting the positioning and direction to capture highest insolation. As a result of which the productivity of the system increased substantially, compared to other type of solar still.

The modified design of TSS used in the current investigation including its condensing chamber have been shown in Figure 1.

Figure 1. Photographic view of Tubular solar still equipped with mica sheet and aluminium fins.

III. Performance Evaluation Of Tubular Solar Still

The performance of a solar still is expressed as the amount of water evaporated by unit area in the basin in daily

Performance of solar still = $\sum_{24hour} mew$

3.1. Thermal efficiency

The ratio of the quantity of thermal energy utilized to get certain amount of distilled water to the incident solar energy within a given period is known as thermal efficiency.

A. Instantaneous efficiency

The evaporation process inside the distiller system can be considered as an iso-baric atmosphere procedure at thermal steadiness, then all absorbed solar radiation is exploited for evaporation and thermal losses

The expression for instantaneous efficiency (η_i)

$$\eta_i = \frac{mew * L}{I(t) * Aw}$$

B. Overall thermal efficiency

The expression for thermal efficiency ($\eta_{passive}$)

$$\eta_{passive} = \frac{\sum m * L}{Aw \int I(t) dt}$$

3.2. Exergy efficiency

The exergy efficiency of the solar still may be expressed as [9]

$$\eta_{Ex} = \frac{\text{Exergy output of solar still}}{\text{Exergy input of solar still}} \frac{(Exevap)}{(Exin)}$$

Exergy in-put equation of solar still have been described by the Petela [10] as given below,

$$Ex_{input} = I(t)\, A_w [1 + \frac{1}{3}\left(\frac{T_a}{T_s}\right)^4 - \frac{4}{3}\left(\frac{T_a}{T_s}\right)]$$

Further, the exergy available for solar still can be obtained as [11]

$$Ex_{out} = Ex_{evap} = m\, L\, (1 - \frac{T_a}{T_w})$$

IV. Experimental Outcomes

4.1Combined effect of Aluminium fins and mica sheet on tubular solar still

The half hourly variation of solar intensity with time during the experimental observation is given in the Figure 2. Maximum solar intensity 1230 Wm^{-2} recorded at 11:30 AM and minimum solar intensity 900 Wm^{-2} recorded at 04:00 PM.

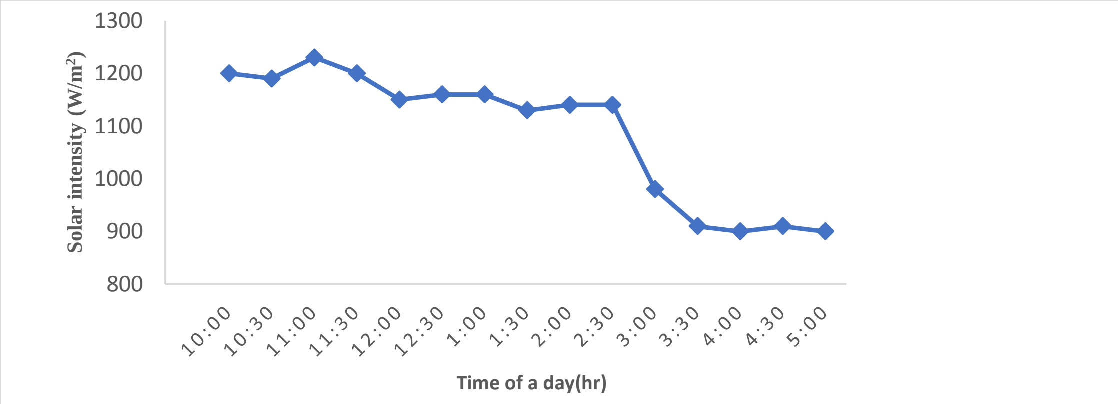

Figure 2. Diurnal variation of solar intensity with time.

Figure 3 shows the half hourly variation of water and condensing cover temperature with time of a day. Average water temperature was higher compared to average condensing cover temperature.

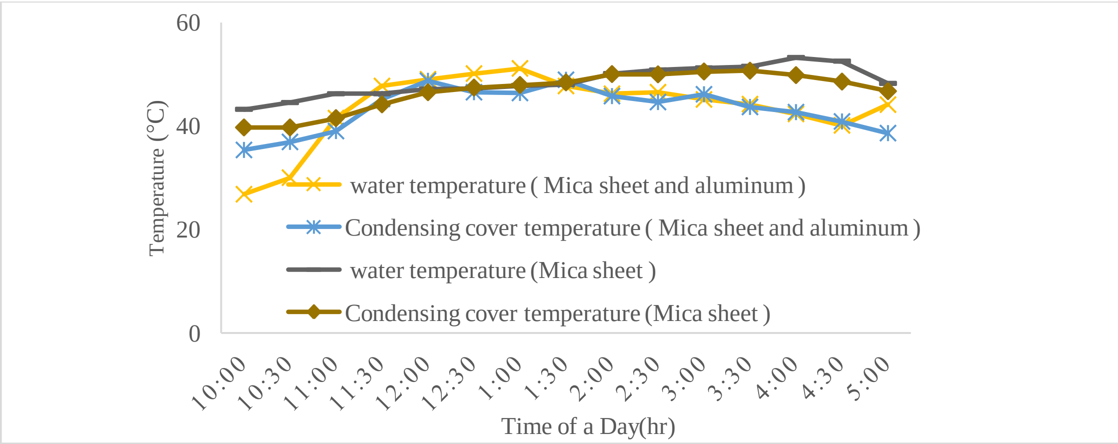

Figure 3 Variation of water and condensing cover temperature with time of a day

Figure 4 demonstrate the variation of tubular still productivity equipped with Mica sheet and Aluminium. Total productivity of tubular solar still equipped mica sheet and aluminium higher than tubular solar still equipped with Mica sheet. Aluminium fins increased the productivity by 42%.

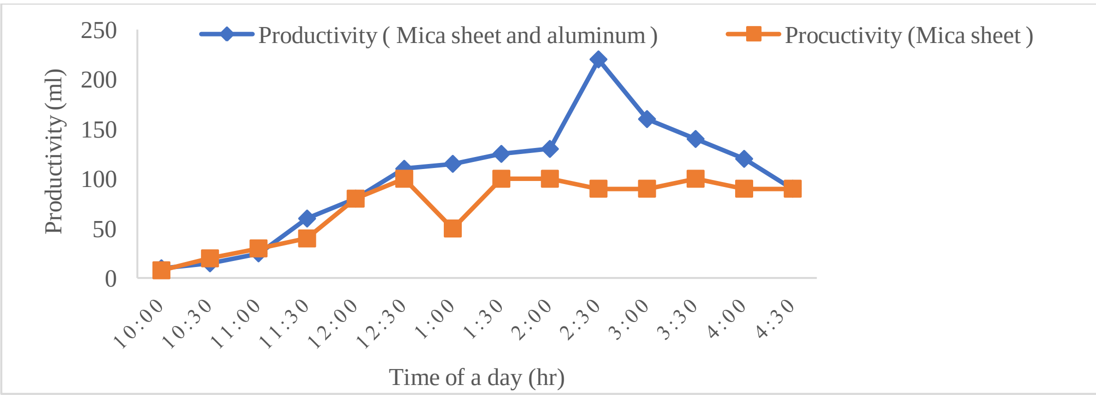

Figure 4 Variation of productivity with time of a day

4.2 Effect of modification in basin on productivity of solar still

The modification in the basin affects significantly the daily productivity of tubular solar still as given in the Figure 5.

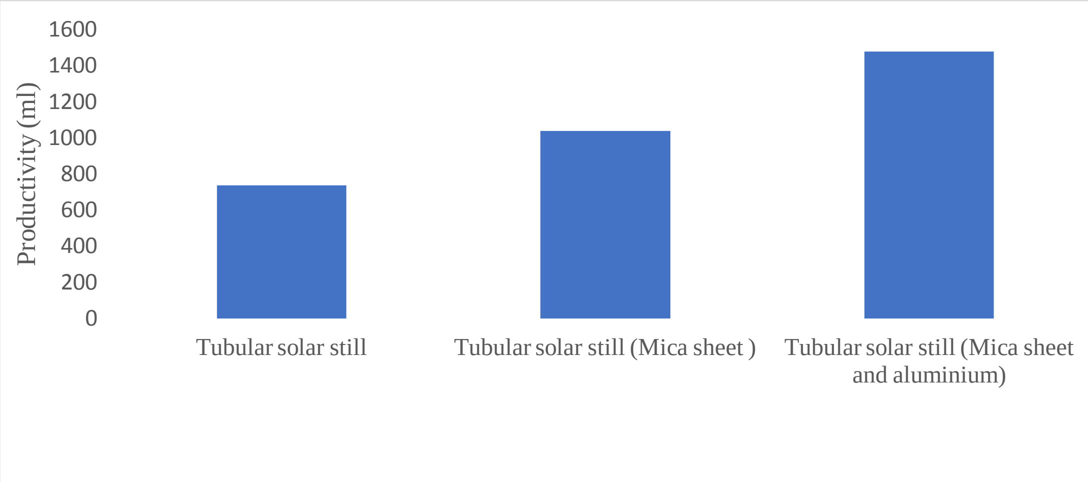

Figure 5. Compression of daily productivity tubular solar still with other types of solar still

V. Conclusions

Mica sheet act as insulating materials and prevents heat loss from the basin. Further, aluminium fins accelerated the convection phenomena. The energy efficiency of tubular solar still, tubular solar still (mica sheet) and tubular solar still (mica sheet and aluminium) were 8%, 11% and 16%, respectively. The exergy efficiency of tubular solar still (mica sheet) and tubular solar still (mica sheet and aluminium) is 1.29 % and 1.84, % respectively. Attaching the fin in the basin resulted in considerable enhancement of both the energy efficiency (by 45%) and exergy efficiency (by 42.6 %). Thus, the present experimental demonstration involving the insulation in base (in form of mica) of tubular solar still showed the potential to serve as an important devise for the fulfilment of demand of purified water.

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