Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

The Effect of Water Surface Level in sensible heat material on Yield of Single Basin Solar Still: Experimental Study

To cite this article: Dan Mugisidi *et al* 2019 *J. Phys.: Conf. Ser.* **1373** 012014

The Effect of Water Surface Level in sensible heat material on Yield of Single Basin Solar Still: Experimental Study

Dan Mugisidi[1,*], Berkah Fajar [2], Tony Utomo [2], Syaiful [2]

[1]Doctoral Programe, Department of Mechanical Engineering, Faculty of Engineering, Universitas Diponegoro, Indonesia
[2]Department of Mechanical Engineering, Faculty of Engineering, Universitas Diponegoro, Indonesia

[*]Email: dan.mugisidi@uhamka.ac.id

Abstract. The purpose of this experiment is to study the yield of the single basin solar still as an effect of water surface level in sensible heat material in a single basin solar still. The study is conducted on an open floor roof top at the Faculty of Engineering, Muhammadiyah University Prof. DR HAMKA in Jakarta, Indonesia. The study is conducted within two month and use 3 solar stills made of 3 mm Stainless Steel with dimensions 420 mm x 305 mm. The cover is made of 3 mm glass with a slope of 30 degrees. Iron sand that used as sensible heat material is taken from Glagah beach, Kulonprogo in Yogyakarta, Indonesia. 3 solar stills containing 20 mm height of iron sand. The height of the water in the three solar stills is 15mm (V1), 20mm (V2) and 25mm (V3) so that sequentially the surface of the water will be below the surface of the iron sand, the same as the surface of iron sand and above the surface of iron sand. The results obtained show that the daily yield accumulation of V2 is on average 49% higher than V1 while V3 is 57% higher above V1.

1. Introduction

Solar still is a simple device and only has 1 chamber to evaporate and condense basin water. The solar still is heated by the sun and the heat absorbed by the heat sink, then the heat is transferred to basin water. The hot water evaporates and then condense on the cover glass, expected to flow in the collecting gutter. The water that enters the collecting gutter will be channelled to the reservoir and already turned into fresh water.

Various methods and materials are used to improve the performance of solar still including Efforts to increase productivity are carried out using heat storage from sensible heat material. An experimental study use carbon powder performed charcoal particles is used as absorber medium and increase productivity as much as 15% [1]. El-Sebaii use sand as sensible storage material under basin liner [2]. Sand compare with servotherm medium oil is used as sensible heat storage material and placed beneath basin liner [3]. Carbon powder as a porous solar absorber inside solar still improve yield average 35% [4]. Sensible heat storage materials like quartzite rock, red brick pieces, cement concrete pieces, washed stones and iron scraps placed inside solar still [5]. The black jute clothes act as porous absorbers in basin water inside the solar still [6]. Extended porous fins made up of blackened old cotton rags are dipped partially inside the basin of the still [7]. The use of Portland cement black-blackened, as heat storage, increases freshwater production by 39% [8]. still. A modified solar using silica sand and layered with black coal powder at its surface compared with conventional solar still to study its heat and mass transfer

[9]. To our knowledge, no experimental research has been conducted using iron sand to enhance productivity of solar.

The present work is using iron sand as a porous absorber inside solar still. Since some study already prove that water level inside basin have significant influence [10] then it is motivate to vary water surface to become below, same level and above of iron sand surface to see its effect.

2. Experimental set up

Three single basins solar still are fabricated with stainless steel plate 2mm SUS304 and the cover use 3mm glass. Effective dimensions of the solar still 403mm x 305mm. At figure 1, all solar stills are filled with iron sand up to 20mm and basin water varied in height 15mm, 20mm, and 25mm, which are called V1, V2 and V3 respectively. Data was taken on August 19, 2018, August 29, 2018 and September 1 2018 starting at 08.00 to 17.00 without put solar radiation condition into account. Temperature was measured using the calibrated thermocouple type K, which has an accuracy of 0.1%, in 15 minutes interval. Digital anemometer 0 – 30 with interval 0,1 m/s was used to measure wind speed. The water level inside all solar still maintain at fix level using buffer tank outside the still. The iron content in iron sand varies depending on the area of mining, it can be 59.8% [11] to 76.35% [12]. In this experiment, the iron sand used content 70.3% of iron and was taken from Glagah beach, Kulonprogo in Yogyakarta, Indonesia. Pororsity of the iron sand is calculated using equation:

$$\phi = \frac{V_v}{V_t} \tag{1}$$

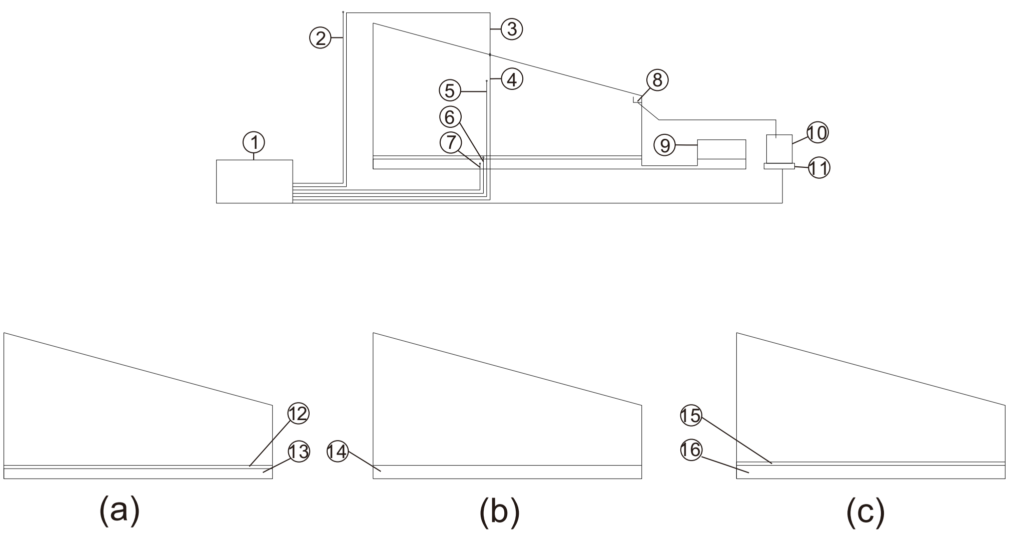
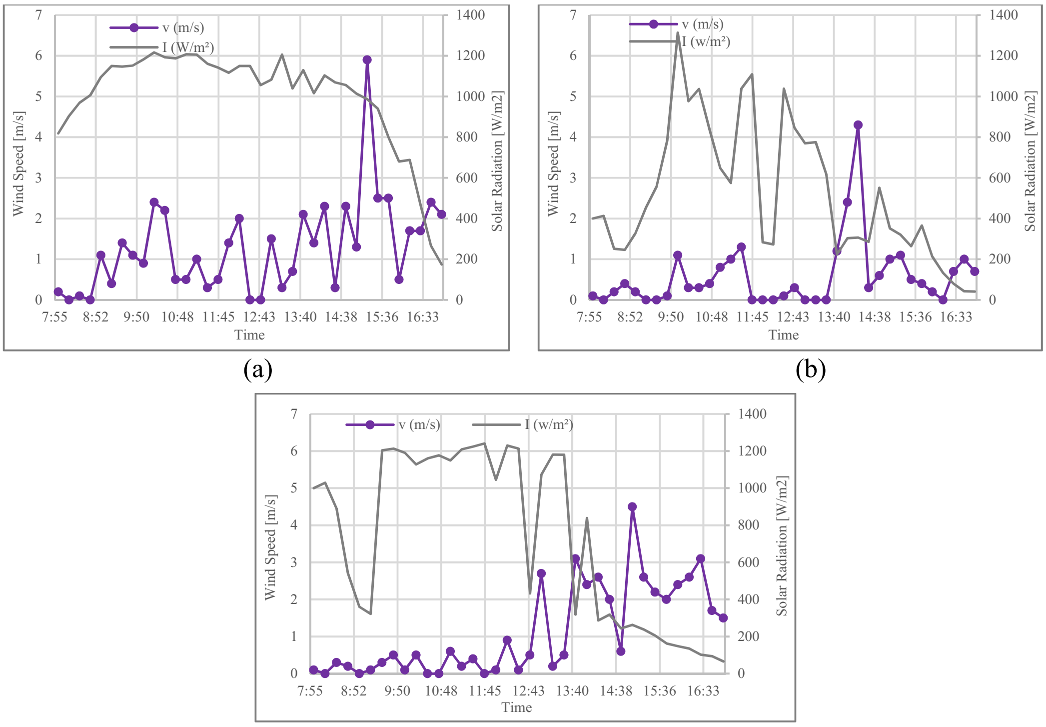


Figure 1. Single slope solar still *contains ;* (a) Iron sand 20mm height and basin water 15mm height namely V1, (b) Iron sand and basin water 20mm height namely V2, (c) Iron sand 20mm height and basin water 25mm height namely V3. 1 = Data Collector, 2 = Solar radiation sensor, 3 = Tgo Sensor, 4 = Tgi sensor, 5 = Tv sensor, 6 = Tw sensor, 7 = Ts sensor, 8 = Gutter, 9 = Water basin buffer, 10 = Fresh water collector, 11 = Weighing, 12 = Iron sand in V1, 13 = Mixed of water and iron sand in V1, 14 = Mixed of water and iron sand in V2, 15 = Basin water in V3, 16 = Mixed of water and iron sand in V3.

3. Result and discussion

Solar radiation and wind speed affect temperature and productivity of solar still [13]. As shown in figure 2, solar radiation and wind speed fluctuate all the time and it affect temperature in solar still. As can be seen in figure 3 to figure 4, temperature inside the solar still is fluctuation and respond to solar radiation, eventhough the response is different for each type of solar still. Temperature profiles are shown on solar still V1, V2 and V3 has a profile like a bell shape even though solar radiation fluctuates this because the heat of solar radiation is absorbed by sensible heat material material and released when solar radiation drop [2][14].



(a) (b)

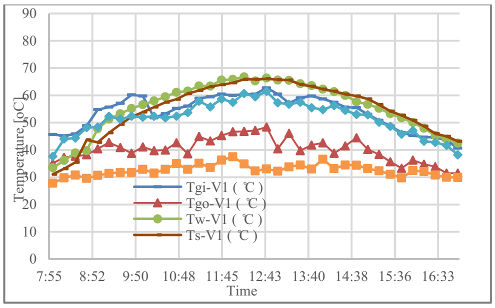
(c)

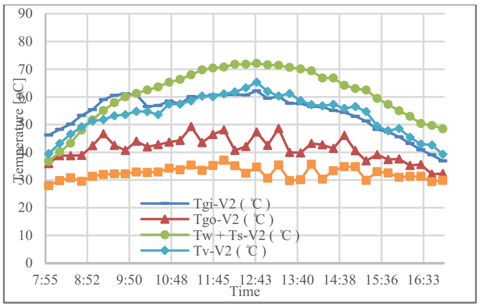
Figure 2. Solar radiation and wind speed at August 19, 2018 (a), August 29, 2018 (b) and September 1, 2018 (c).

In this study, water and sand were mixed. Thus, water temperature (Ta) and sand temperature (Ts) have a very similar temperature profile. At V1, the water surface is below the sand surface and the water temperature is lower than the sand temperature. In V3, the water surface is 5 mm above the sand surface and the water temperature is higher than the sand temperature. These results indicate that there is a gradient temperature due to the propagation of heat in the sand takes some time.

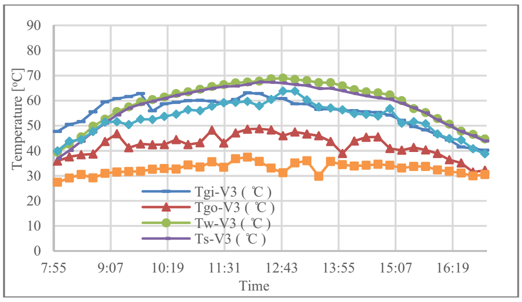
Daily accumulation yield can be seen at Fig 6. Although daily accumulation yield obtained is in accordance with solar radiation, the results follow a certain sequence, from the smallest V1, then V2 and the largest V3.

The level of water in V1 is lower than surface level of sensible heat material. The porosity of sensible heat material is 43.7% and the water rises to the surface with capillarity through the porosity of the material at the speed 0.34 mm/s. Since the surface area of the sensible heat material 1.57 times bigger than the area of solar still and the flow rate 0.0025 ml/s, the heat that accumulated on the surface of sensible heat material is not use to heat and evaporate the water but released. For comparison, the average evaporation rate of V3 is 0.0096 ml/s. That is the reason why the daily yield of V1 is lower than two others. Furthermore, since surface level of water as high as iron sand, part of iron sand particle is higher than water, so that heat accumulated on iron surface transfer to the basin water and air above it. As a result, daily yield of V2 is lower than V3, as shown in **Table 1**.



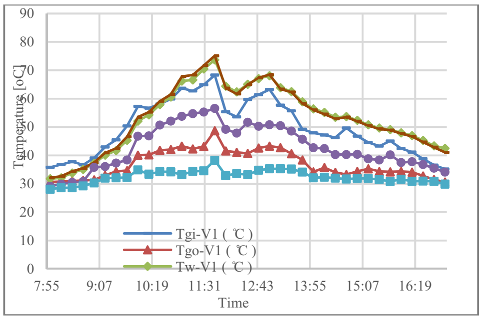


(a) (b)



(c)

Figure 3. Experiment at August 19, 2018. Tgi=inside glass temperature, Tw=water temperature, Ta=ambient temperature, Tgo=outside glass temperature, Tv=vapour temperature, I=solar radiation



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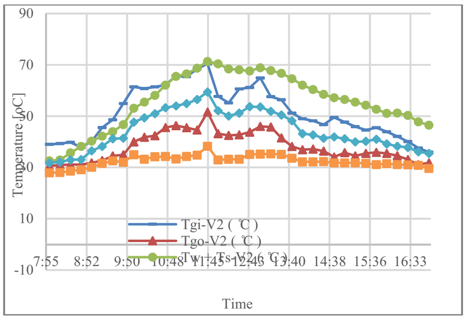

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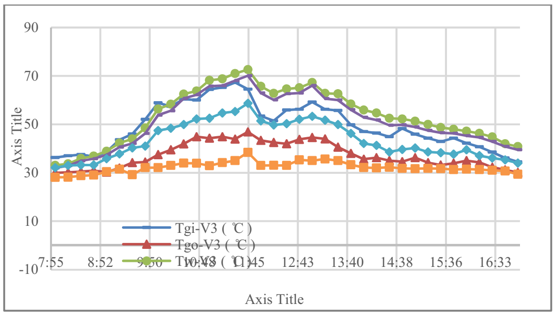
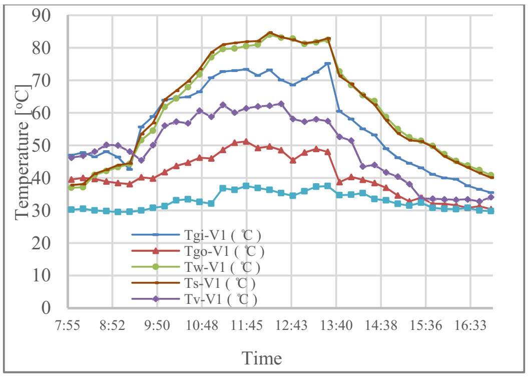
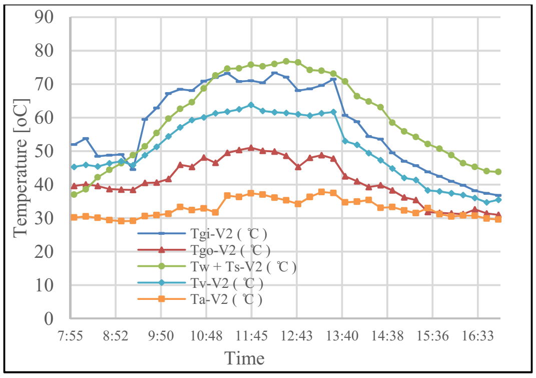


(c)

Figure 4. Experiment at August 29, 2018



(a)



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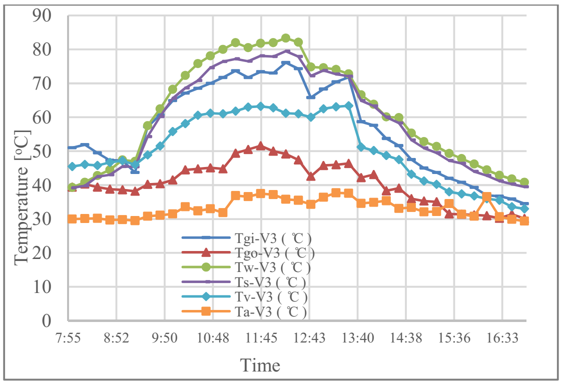

(c)

Figure 5. Experiment at September 1, 2018

TABLE 1. Daily yield of V1, V2 and V3

Date	V1 [gr/m^2]	V2 [gr/m^2]	V3 [gr/m^2]	ΣI [W/m^2]
19-Aug-18	925	2,175	2,450	36.933
29-Aug-18	392	667	708	19.056
1-Sep-18	500	958	1,125	26.811

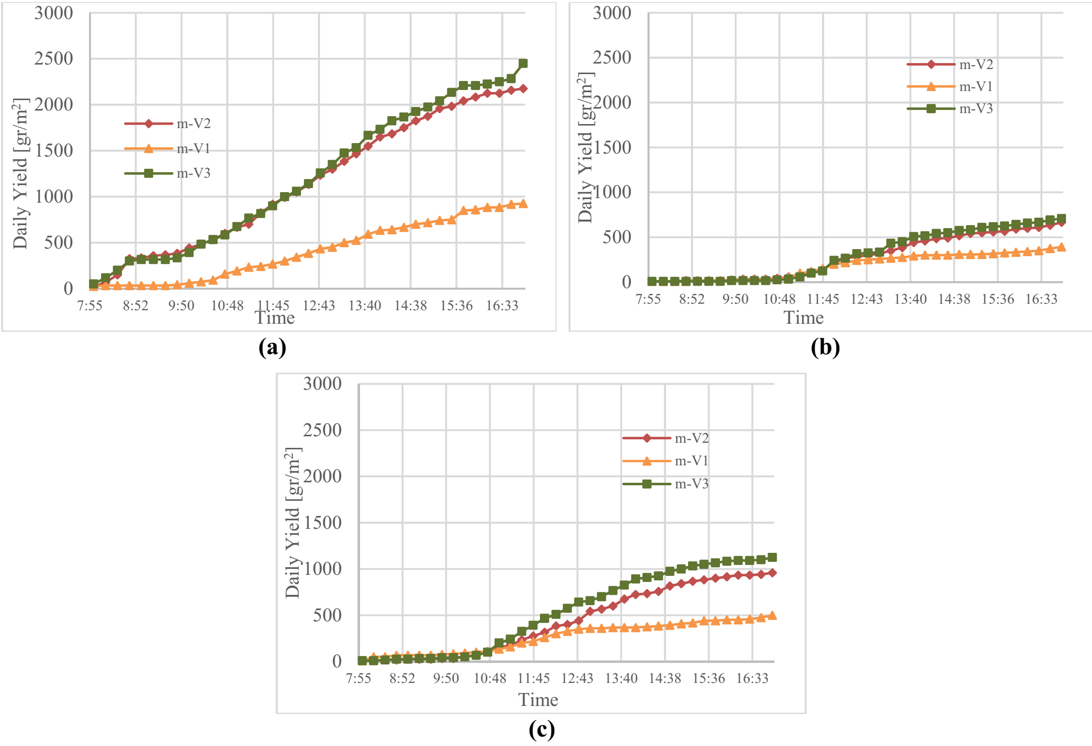

FIGURE 6. Daily yield of P, V1, V2 and V3 at August 19 (a), August 29 (b) and September 1, 2018 (c)

4. Conclusion

The experiment using iron sand as a sensible heat material material and functioned as an absorber was carried out using a single slope solar still. Experiment result shows that daily yield of solar still that using iron sand as absorber affected by basin water surface level. Accumulation of daily yield V2 is on average 49% higher than V1 while V3 is 57% higher above V1 therefore it is recommended to set the water level above the surface of iron sand.

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