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Effect of Differences in Cover Materials to Improve the Performance of Water Heaters

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Abstract

Solar energy application is widely used for heat energy, such as for cooking, seawater distillation, water heaters, and food product dryers. One way to use solar energy is to use a solar collector, in principle, sunlight is focused on an absorber which will then be used to heat the water inside the absorber. Water heating collectors are designed or made is a type of solar flat plate collector that has a dimension 150×80 cm, and the pipe used to heat the flowing water is a 1 inch copper pipe with length 140 cm. Using rubber insulation to keep the heat out of the collector can be minimized and any kind of cover plate that is different variations of glass (a), aluminum (b), aluminum plus glass (c), and black paint aluminum plus glass (d). The purpose of this study is to compare the effect of cover plate variations on the performance of a water heater. Based on the results of the study at 1:00 p.m the highest temperature of the water out of the cover glass (a) reaches 72 ^{o}C on solar intensity 1200 W/m^2, aluminum cover (b) reaches 56 ^{o}C on solar intensity 1198 W/m^2, aluminum cover plus glass (c) reaches 58 ^{o}C on solar intensity 1130 W/m^2, and aluminum black paint cover plus glass (d) reaching 62 ^{o}C on solar intensity 1200 W/m^2. From these results, it can be concluded that the cover glass (a) greater efficiency in comparison cover A, C, and D.

Keywords:*solar water heater, cover plate collector, different material, cover plate.*

I. Introduction

Energy is a basic need for daily activities, for example in the industrial and household sectors. Currently, the main energy source for humans in the world comes from fossils such as petroleum, coal, and natural gas. However, the amount of energy is limited. So we need another source of energy, one of which is solar energy. This is based on the fact that solar energy is renewable energy, safe, free and pollution-free (without CO_2 emissions) [1]. The temperature of the hot water requirement for preheating is around 40 - 45 ^{o}C, so the solar water heater (SWH) must reach the temperature for these needs. Flat plate collectors can be designed for applications that require a moderate temperature rise, up to maybe 100 ^{o}C above ambient temperature. Applications for flat plate collectors are water heating in buildings, preheating in the industrial plant industry [2].

The satellite dish collector can produce a higher temperature than the flat plate collector, the temperature can reach> 100 ^{o}C. the concentrator from the collector must be moved in the direction of the sun's motion so that the shadow's falling point remains in the pipe [3]. The advantage of this vacuum collector is that it can insulate the heat of the inner tube with a heat loss rate of head losses <4%. [4]. Various materials can be used for solar collectors including AISI304 [5], aluminum-copper [6], aluminum-silicon [7,8] recycled aluminum alloys [9] with various improvement materials such as shot peening and heat treatment.

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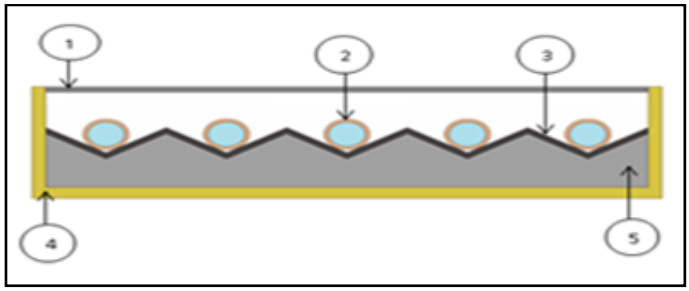
Comparative experimental study of double plate collector and conventional collector on the performance of the solar water heater. Research results; the heat absorption efficiency of double plate solar heaters is higher than the conventional solar heater heat absorption efficiency and the relationship between heat absorption efficiency and (Ti-Ta)/Gt on double plate solar heaters is sharper than conventional solar heaters [10-12]. The double absorber plate of the wave model which produces an average value of heat absorption efficiency on the solar heater double plate wave model an average of 19.81%, while the value of the average heat absorption efficiency of the solar heater is a flat absorber plate of 12.43% [13-16]. The solar water heater test using a paraffin wax heat storage material with a maximum efficiency of 36.6% and an outlet temperature at 20:00 a.m. that is around 40 - 45 ^{o}C [17,18]. The objective of this experiment is to investigate the water-outlet temperature improved and efficiencies of three variations of cover plate materials at the solar collector system.

II. MATERIAL AND METHOD

Materials used for the collector systems were wood with 121 cm display and 81 widths as a casing, aluminum plate sheets with dimensions of 10 x 10 x 0.1 cm, copper pipes Ø 2.54 cm (1 inch) in length 110, styrofoam sheets 0.9 cm thick and powder 10 kg wood as a heat insulator. Measuring instruments used in this study were measuring cups, stopwatches, type K thermocouples, thermometers, and Solar Power meters. While other tools are the main water tank, valves, PVC pipes, and plastic hoses, sun-tracking equipment, water storage tanks.
The schematic of the flat plate collector used in this experiment is shown in Figure 1. The variation made in this experiment is the difference between the cover plate and the water heater performance as shown in Table 1. The position of temperature measurement in the system can be seen in Table 2 and Figure 2.



Caption:

No.	Collector A	Collector B	Collector C	Collector D
1	glass	aluminum	aluminum plus glass	black paint aluminum plus glass
2	copper tube	copper tube	copper tube	copper tube
3	flat plate collector	flat plate collector	flat plate collector	flat plate collector
4	frame collector	frame collector	frame collector	frame collector
5	isolation	isolation	isolation	isolation

Fig 1: Flat plate collector image.

Table 1 Description of the placement of measuring instruments.

Measurement location	Code
Tube temperature 1 $_{bottom}$ and 1 $_{top}$	$(TP_{1,1}),(TP_{1,2})$
Tube temperature 2$_{bottom}$ and 2$_{top}$	$(TP_{2,1}),(TP_{2,2})$
Tube temperature 3$_{bottom}$ and 3$_{top}$	$(TP_{3,1}),(TP_{3,2})$
Tube temperature 4$_{bottom}$ and 4$_{top}$	$(TP_{4,1}),(TP_{4,2})$
Tube temperature 5$_{bottom}$ and 5$_{top}$	$(TP_{5,1}),(TP_{5,2})$
Cover temperature	$(TC_A)(TC_B)$
Room temperature	$(TR_A),(TR_B)$
Plate collector temperature	(T_{Plat})
Room collector temperature	$(T_{RA}),(T_{RB})$
Water-inlet temperature	(T_{f1})
Water-outlet temperature	$(T_{f2A}),(T_{f2B})$

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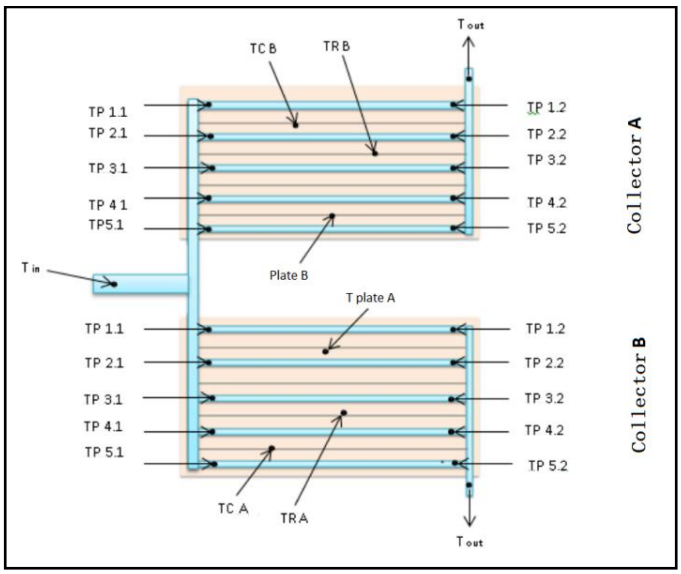
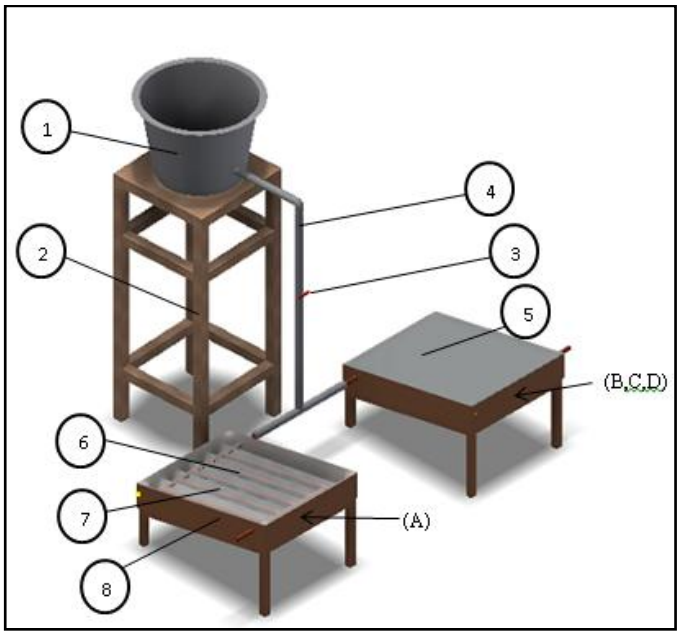


(a)



(b)

Captions: (1) water tanks, (2) water support frameworks, (3) valves, (4) PVC pipes, (5) covers, (6) copper pipes, (7) collector plates, (8) wooden boards.

Fig. 2: (a) placement of measuring instruments on solar collectors (b) flat plate collector schemes.

III. RESULTS AND DISCUSSION

The casing of collector systems in this experiment made from wood with dimension is 1.5 × 0.8 m (in length and width), then the aluminum-flat plate buckled inform an isosceles triangle. Water from the tank inlet and outlet from the solar collector system through copper pipes with dimension is 1 inch diameter and 1.4 m long. The outlet pipe insulated with rubber to minimize the heat losses, while the inlet pipe is not insulated. Data collected from two collectors that formed an isosceles triangular flat plate. The left side of the collector (A) fixed and the right side of the collector (B, C, D) changed position for data comparison. Three variations made in this work are: variations I: collector A with collector B; variation II: collector A with collector C; variation III: collector A with collector D.

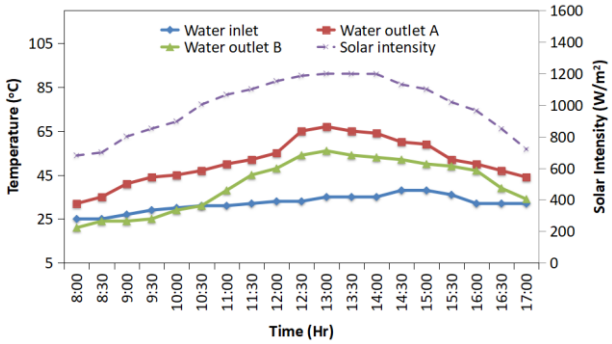


Fig 3: Temperature collected from collector A and collector B.

Figure 3 shows temperature differences between collector A and Collector B, data temperature collected at the water outlet. Collector A (glass cover) has a higher water temperature compared with the collector B (aluminum cover). The maximum of water-outlet temperature obtained at the glass cover is 67 ^{o}C and solar intensity about 1198 W/m^2, data recorded at 13.00 WIB (Indonesia Western Region). The maximum water-outlet temperature obtained at collector A, it is 67 ^{o}C, while the water-outlet temperature in collector B is 56 ^{o}C and solar intensity at 13.00 WIB (Indonesia Western Region) is 1198 W/m^2. The temperature difference between collectors A and collector B is 11 ^{o}C. It indicates that collector with glass cover is more effective to increase water temperature rather than collector with aluminum cover. The water-inlet temperature was 21 ^{o}C, then water-outlet temperature increased in the solar collector system until 67 ^{o}C (glass cover solar collector).

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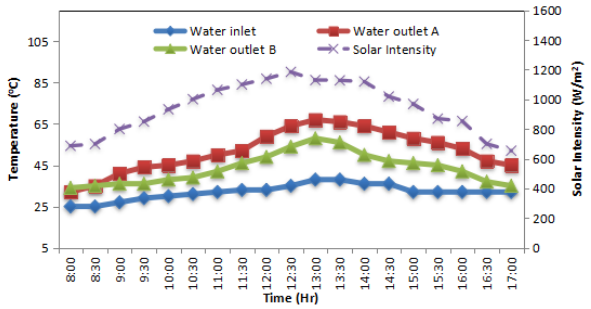

Fig 4: Temperature collected from collector A and collector C.

Figure 4 shows the temperature collected from the comparison between collector A (glass cover) and collector C (aluminum + glass cover). The water-outlet temperature reaches highest in collector A, it is 67 ^{o}C, and water-outlet temperature in collector C appears 59 ^{o}C. Solar intensity obtains 1130 W/m^2 at 13:00 WIB. The temperature difference of water outlet between collector A and collector C is 15 ^{o}C and shown that collector A more effective to increases in water temperature in the collector system if compared with collector C.

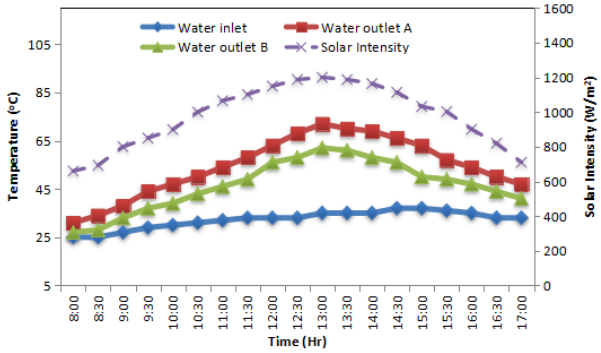

Fig 5: Temperature collected from collector A and collector D.

Figure 5 shows the water-outlet temperature distribution during data recorded from collector A and Collector D (cover with aluminum painted in black color + glass). The highest of water-outlet temperature taken from collector A, it is 72 ^{o}C, and the water-outlet temperature at collector D is 62 ^{o}C. The solar intensity reaches 1200 W/m^2 at 13:00 WIB. Collector A shows more effective to increase on water-outlet temperature if compared with collector D, and the temperature difference is 15 ^{o}C.

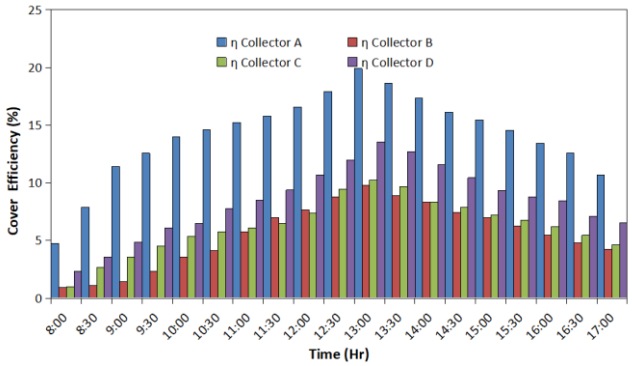

Fig 6: Efficiency of differences collector (A, B, C, and D).

Table 2 The efficiency of different types of collectors.

Experiment	Variation of cover collector	Efficiency (%)		Time
1	Collector A-B	17.54	9.78	13:00
2	Collector A-C	17.54	10.23	13:00
3	Collector A-D	18.65	13.54	13:00

The efficiency of the comparison of all cover variations of the solar collector system can be seen in Figure 6 and Table 3. The data analysis shows that collector A has the highest efficiency is 18.65%, while the lowest efficiency obtained from collector D is 13.54%. Calculation of the efficiency of increasing water temperature using Equation 1. The efficiency of the solar collector system calculated in this experiment based on the data water-outlet temperature of the collector system. In addition, there are several other factors that influence the efficiency of the solar collector system, including humidity, solar intensity, and wind speed. To increase the distribution of the sun's reflection on the copper tube, the flat aluminum plate as a reflector is folded into a triangle-shaped. Further copper tubes are placed between the slopes of the aluminum plate. Triangles are formed at certain angles to receive more sunlight which has an impact on the increase in water temperature that flowing through the copper pipe.

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IV. CONCLUSION

The effect of differences cover plate materials to improve the performance of water heaters have experimented in this experiment. Some conclusions follow, Variation I, Collector A has a higher water temperature compared with the collector B (aluminum cover) and the temperature difference between those collectors is 11 ^{o}C. Variation II, Collector A has maximum water-outlet temperature compared with collector C and the temperature difference of water that two collectors are 15 ^{o}C. Variation III, The maximum of water-outlet temperature found at collector A compared with collector D, and temperature differences are 15 ^{o}C. From the data analysis, collector A has the maximum efficiency is 18.65% and collector D has the lowest efficiency is 13.54%. Some influence factors that impact to increase water-outlet temperature are solar intensity, humidity, and wind speed around the solar collector system.

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