



## AN EVALUATION OF HEAT LOSS ON TOP OF SOLAR COLLECTOR WITH MULTILAYERED ABSORBER IN SOLAR WATER HEATING SYSTEM

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### ABSTRACT

Solar water heating system is one of the applications of solar energy. One of the components of solar water heating system is solar collector that consists of an absorber. The heat loss to the surroundings is an important factor in the determination of performance of the solar collector. The smaller value of heat losses to the surrounding will result the higher performance of the solar collector. Thus, this study is conducted to evaluate the heat loss of top of solar collector with multilayered absorber in solar water heating system. Methods used in this paper include solar collector with multilayered absorber is tested and evaluated by examining the heat loss at top of solar collector in solar water heating system. The results show the impact to the solar water heating system is indeed predictable where multilayered absorber in solar collector is proven to play its main role when it able to keep the hot water temperature longer at minimum amount of 176.4 W/unit area as for heat loss.

**Keywords:** solar water heating system, solar collector, multilayered absorber.

### INTRODUCTION

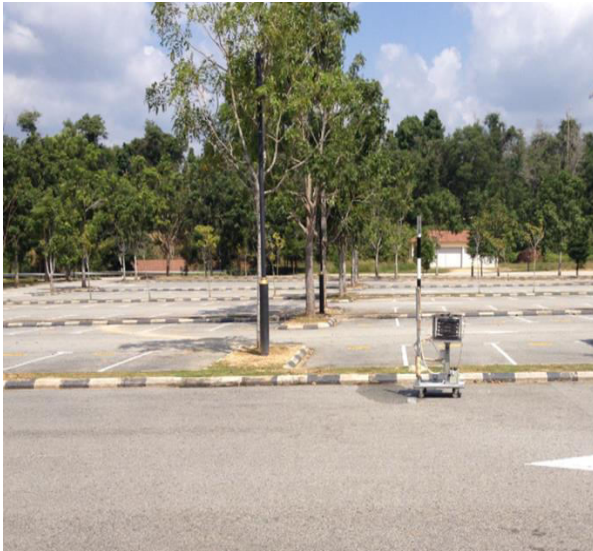
Energy is one of important daily resources in all walks of life [1, 2]. There are many types of energy resources in this world and the most common one is electrical energy [3]. Its importance to people is inevitable as if slightly changes occurred can directly affect all human activities [4]. This can be seen when there is only a change in the price of energy resources [5], it affects almost all human activities causing political and economic crisis [3, 4]. It happens due to the world's energy supply based on fossil fuels diminishing. This resource will begin to decrease starting in 2015 [7]. The impact of burning fossil fuels has also caused airspace is becoming increasingly polluted and global warming occur [8].

Instead of using fossil fuel as energy sources, there has been another alternative energy that can be used in decreasing the undesirable effects to the environment which is solar energy [9]. Solar energy is one of renewable energy that cannot be exhausted and is constantly renewed [10]. It also considers economic, environmental friendly and safety aspects which is worthwhile to be broadly applied and adapted by people plus, it can be harnessed either by directly or indirectly deriving energy from sunlight [11]. As there has been increased in demand as well as the cost of fossil fuels energy especially for domestic use, this solar energy on the other hands, can overcome that problem especially in terms of water heating system application [12]. The system can be a good system if there is less heat loss from the system. The heat loss to the surroundings is an important factor in the determination of performance of the solar collector. The

smaller value of heat losses to the surrounding will result the higher performance of the solar collector. Heat loss will be occurred on the system such as at top, bottom and edge of the system. In this paper, it focuses only on top of solar collector with multilayered absorber in solar water heating system.

### EXPERIMENTAL SET UP

The experiment conducted is called short term day as (STD) because of it is conducted within short period which is 10 minutes. The first step, solar water heating system being exposed to the intensity of the global radiation around 1.25 pm about 10 minutes as shown in Figure-1. The time is choosing because of the vertical position towards the solar water heating system. This experiment is conducted to determine the heat loss at the top of solar collector with multilayered absorber as shown in Figure-2 in solar water heating system.



**Figure-1.** Multilayered absorber solar collector of solar water heating system expose to the intensity of the global radiation around 1.25 pm about 10 minutes.



**Figure-2.** Multilayered absorber in solar collector.

### Experimental materials

Table-1 below show the items or materials that use in long term experiment which are solar water heating system, pyranometer, digital temperature sensor, container, container of mineral water, small bench and weighing scale.

**Table-1.** The experimental materials, their specifications and functions for STD experiment.

Item	Specification	Function	Total item use
Solar water heating system	Multilayer absorber (6 layers) of solar collector	To produce hot water	1
Pyranometer	Apogee Logan UT SP-110	To measure the intensity of the global radiation	1
Digital temperature sensor	K-type	To record the temperature for each point	7
Container	75g of container	To collect hot water	1
Container of mineral water	1.5litre of container of mineral water	container of mineral water as a water supply	1
Weighing scale	-	To weigh the mass of empty container or with water	1
Small bench	-	To support water channel in horizontal condition	1

### Experimental procedure

Experiment started within 10 minutes, started with water (from the pipe water supply) is filled into the temporary water storage continuously until end of the heat transfer experiment. Then, water will be flow through the multilayer absorber and directly out through outlet without container. Initial reading is recorded as per below:

- ambient temperature ( $T_{at}$ )
- input temperature ( $T_1$ )
- absorber temperature ( $T_2$ )
- output temperature ( $T_3$ )
- outer cover temperature ( $T_{co}$ )



- f. inner cover temperature ( $T_{ci}$ )
- g. air temperature at collector ( $T_{at}$ )
- h. intensity of the global radiation ( $G_t$ )

After initial reading being recorded, the next reading to be recorded is in every 30s. When reaching certain time that is in 30s as a time interval (differ according to every experiment), the reading from 'a' until 'h' is recorded.

Then, water (from the pipe water supply) is filled into the temporary water storage continuously until end of the heat transfer experiment and water will be flow through the multilayer absorber and directly out through outlet without container. This procedure repeated continuously until end of the heat transfer experiment. The reading from 'a' until 'h' is recorded until the last reading is at the 1.35 pm.

### MATHEMATICAL MODELLING

This equation is applied in the experiment of short term day (STD) analysis in which the total heat loss from top at the solar collector has been presented in this section.

Heat transfer coefficient from collector absorber to cover can be expressed as the sum of  $h_{1c}$  and  $h_{1r}$ :

$$h_1 = h_{1c} + h_{1r} = \frac{1}{r_3} + \frac{1}{r_4} \quad (1)$$

and that from the cover to ambient as:

$$h_2 = h_{2c} + h_{2r} = \frac{1}{r_1} + \frac{1}{r_2} \quad (2)$$

The effective emissivity,  $\varepsilon_{eff}$  of collector and cover given by:

$$\varepsilon_{eff} = \left[ \frac{1}{\varepsilon_{abs}} + \frac{1}{\varepsilon_{poly}} - 1 \right]^{-1} \quad (3)$$

$$Ra = Gr Pr = \frac{g \beta' \Delta T L^3}{\nu^2} Pr \quad (4)$$

The value of Nusselt number,  $Nu$  can be obtained, using expression given by Holland *et al.* (1976) for air as medium between collector absorber and the cover:

$$Nu = 1 + 1.44 \left[ 1 - \frac{1708}{Ra \cos \beta} \right]^+ \left( 1 - \frac{\sin(1.8\beta)^{1.6} 1708}{Ra \cos \beta} \right) + \left[ \frac{Ra \cos \beta}{5830} \right]^{1/3} - 1 \quad (5)$$

$$h = Nu \frac{k}{L} \quad (6)$$

The effective top heat transfer coefficient from solar collector to ambient is given by

$$U_t = [(1/h_1) + (1/h_2)]^{-1} = \left[ \left( \frac{1}{r_3} + \frac{1}{r_4} \right)^{-1} + \left( \frac{1}{r_1} + \frac{1}{r_2} \right)^{-1} \right]^{-1} \quad (7)$$

and the rate of heat loss from the top per unit area can be given as

$$\dot{q}_{loss,top} = U_t (T_2 - T_a) \quad (8)$$

### RESULTS AND DISCUSSIONS

In this experiment, heat transfer process has very much highlighted as its nature and laws has been technically discussed and calculated through the research procedures. In this context, the process of heat loss in the solar collector of solar water heating system is inevitably happened therefore it shall be measured by identifying how much value of the heat loss occurred. It begins with the solar radiation in short term range has penetrated into the solar collector through its cover and absorber. The radiation that enters through the cover has smashed the outer surface (cover) of chosen absorber changing it into heat. The cover of the chosen absorber has transferred the heat to the inner part of absorber through conduction which causing the heat to be transferred into the solar collector through convection. Due to its surface's nature, the heat transfer process by this radiological condition is low; leading to the outer cover temperature,  $T_{co}$  is lower than the absorber temperature,  $T_2$  as shown in Figure-3.

Based on Figure-3, it shows the temperature input of water  $T_1$  has a regular value as the water supply always flows through the inlet in order to fill in the absorber space and water channel. However, the temperature output of water  $T_3$  is raised along with the rise of absorber temperature  $T_2$ .

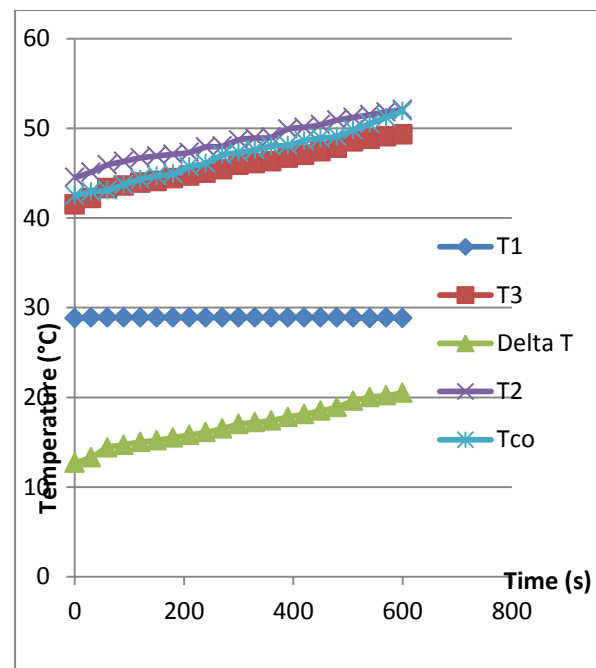
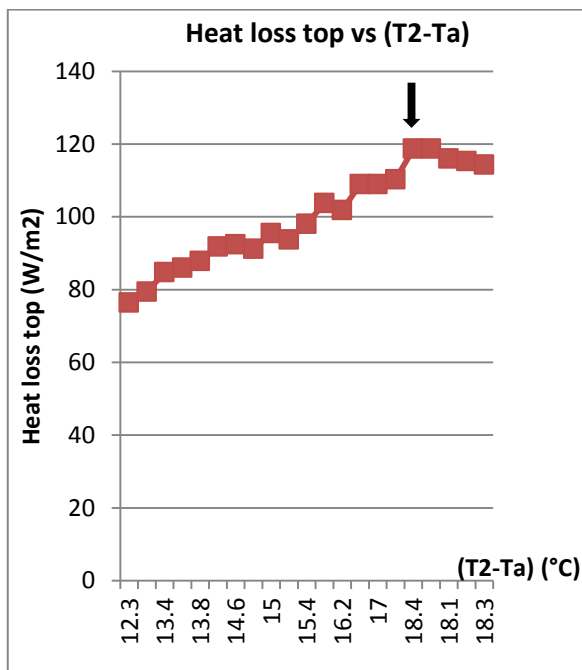


Figure-3. Temperature (°C) versus Time (s).



The heat losses at the cover surface also happen, but with the low conduction thermal nature. In this experiment, heat loss of system (top),  $\dot{q}_{loss}$  of solar collector with multilayered absorber in solar water heating system was analyzed to examine how far that system could absorb the heat. Figure-4 shows the heat loss that happened at the top of the solar collector for solar water heating system. This heat loss value has risen from the first point till the 17<sup>th</sup> point (marked with arrow) and stabilized with the little decreasing. The maximum heat loss gives the value of 118.71 W/unit areas. The heat loss to the surroundings is in important factor in the determination of performance of the solar collector. The smaller value of heat losses to the surrounding will result the higher performance of the solar collector.



**Figure-4.** Heat loss from top solar collector versus (T<sub>2</sub>-T<sub>a</sub>).

## CONCLUSIONS

The heat loss to the surroundings is in important factor in the determination of performance of the solar collector. The smaller value of heat losses to the surrounding will result the higher performance of the solar collector. At glance, multilayered absorber inside the solar collector can be considered as a good one for a solar water heating system where it is proven to play its main role when it able to keep the hot water temperature longer at minimum amount of 176.4 W/unit area as for heat loss.

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