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EXPERIMENTAL STUDY OF HEAT TRANSFER CHARACTERISTICS OF SOLAR WATER HEATER COLLECTOR WITH ADDITION WAVYFINS ON PIPE

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ABSTRACT

Utilize the potential of solar energy there are two kinds technology already applied, there are solar thermal technology and solar photovoltaic. Solar water heater collector is one of the utilized solar energy. One way to improve the efficiency of collector solar water heating is to add external fins on pipes. This experimental was carried in environment Mechanical Engineering ITS, located in -7.27˚LS and -112.79˚BT. It is used to cover clear glass with angle of solar collector 10˚ and flow rate variation 75 l/h, 150 l/h and 225 l/h. Date is collected every one hour from 09.00 am - 15.00 pm for each variation. The measured parameters are upside glass temperature, underside glass temperature, water input, water output, pipe, absorber plate, surrounding, solar radiation and wind speed. The results obtained from this study are the highest efficiency of collector at the flow rate of 225 l/h is 63.87%, and the highest outlet temperature of water at the flow rate of 75 l/h is 46°C. The addition of wavy fins on pipes can improve the efficiency of the collector.

Keywords: solar water heater, collector, wavy fins, flow rate, collector efficiency.

INTRODUCTION

Solar energy was one alternative energy that can be useful in life every day. For the usefulness of the potential solar energy, there are two kind technologies that have been applied, the solar thermal energy and the solar photovoltaic energy [1, 2]. Solar water heater collector was a technology that using solar energy. Solar collector widely used today in general design type flat-plate collector. However, this type of water heater has a small efficiency [3, 4]. Efficiency can be improved by expanding the field of heat absorption. Performance solar collector with addition of fins is better than without addition of fin [5, 6]. Figure-1 shows the wavy fins used in this study. The specification of wavy fins shown in Table-1.

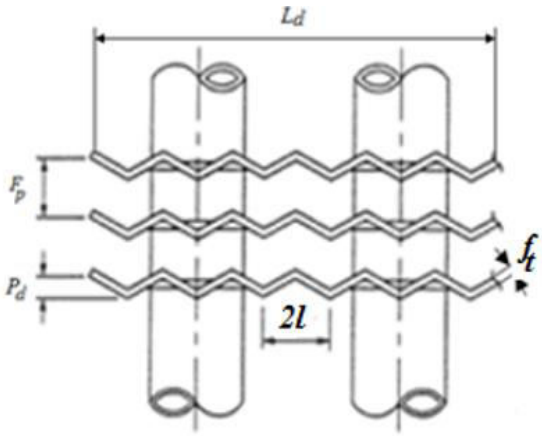


Figure-1. Wavy fin on pipe [7].

Table-1. Specification of wavy fins.

Fin pitch, F_p (mm)	Wavy amplitude, P_d (mm)	Fin length, L_d (mm)	Wavy length, $2l$ (mm)	Fin thickness, f_t (mm)
35	15	1.616	80,8	0,55

EXPERIMENTAL METHOD

This study is conducted with varying water flow rate: 75 l/h, 150 l/h, and l/h at collector angle 10°. Figure. 2 shows the copper pipes be composed serpentine which to flow water, diameter of copper pipe 1.59 cm, and are installer fin-shaped pipe with a thickness 0.5 mm. Plate absorber of solar collector is made of zinc plate 1.5 m x 0.5 m were painted black. Measure of cover glass is 1.5 m x 0.5 m with a thickness of 5 mm. The reduction heat losses towards the side and under-side of collector used glass wool insulation with a thickness of 5 cm.

Dimension of solar water heater collector with addition wavy fins can be seen Figure-2 and the installation in Figure-3.

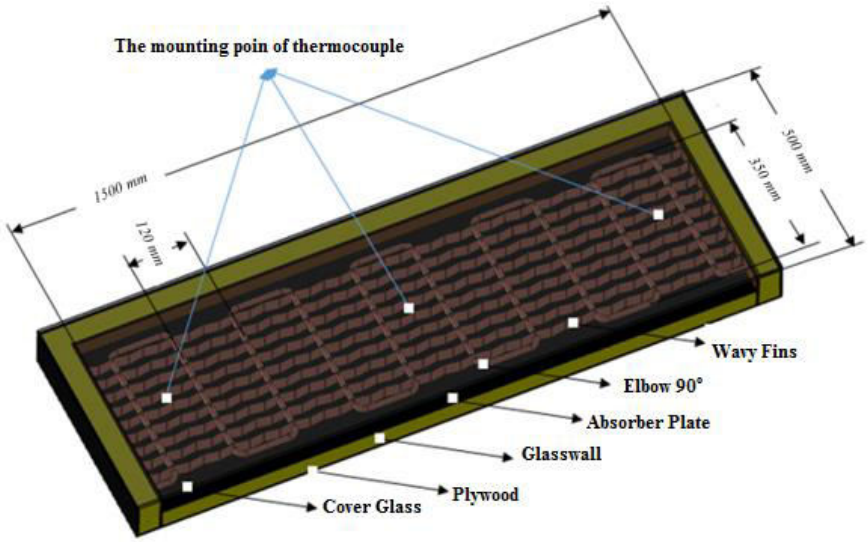
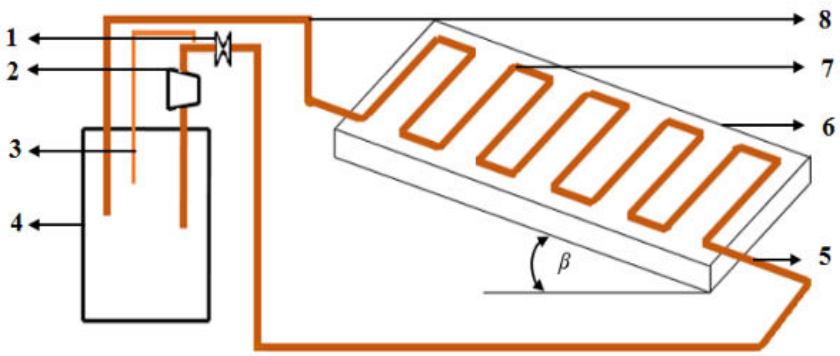


Figure-2. Dimension of solar water heater collector.



1. Valve
2. Pump
3. *By* Pass
4. Storage
5. Inlet channel
6. Solar collector
7. Pipe serpentine
8. Outlet channel

Figure-3. Installation solar water heater collector.

The efficiency and the actual amount of solar energy water heater collectors are absorbed can be determined by calculating the solar radiation on a tilted surface of solar collector. Solar radiation on a tilted surface can be calculated by the equation [7]:

$$I_T = I_b R_b + I_d \left(\frac{1+\cos\beta}{2}\right) + I\rho_g \left(\frac{1+\cos\beta}{2}\right) \quad (1)$$

Heat transfer of solar water heater collector with addition external wavy fin on pipe are convection, conduction and radiation. Solar radiation absorbed by the absorber (*S*) will be the thermal energy the received solar collector (*Q*) and other into a heat loss coefficient (*UL*).

The amount of thermal energy received by the solar collector and the amount thermal that is utilized water heater will be calculated based on the following equation [7]:

$$Q_{Solar\ collector} = Ac.F_R\left[S - UL\left(T_{fi} - T_u\right)\right] \quad (2)$$

$$Q_{Water\ Heater} = \dot{m}c_p(T_{fo} - T_{fi}) \quad (3)$$

The energy losses of the solar collector can be calculated using on the following equation:

$$Q_{loss} = Q_{\ Solar\ Collector} - Q_{\ Water\ Heater} \quad (4)$$

Efficiency of solar collector water heater can be calculated by the following equation:

$$\eta_{Solar\ collector} = \frac{Q_{Solar\ collector}}{A_c I_T} \quad (5)$$

where,

$Q_{solar\ Collector}$ = heat received by solar collector (MJ)

$Q_{Water\ Heater}$= heat utilized to water heater (MJ)

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Ac = surface area (m^2)
F_R = heat removal factor
S = solar radiation absorbed (MJ/m^2)
I_T = solar radiation on a tilted surface (MJ/m^2)
UL = overall heat loss coefficient (W/m^2K)
T_{fi} = inlet temperature of water (°C)
T_{fo} = outlet temperature of water (°C)
T_u = ambient temperature (°C)
W = flow rate (l/h)

RESULT AND DISCUSSIONS

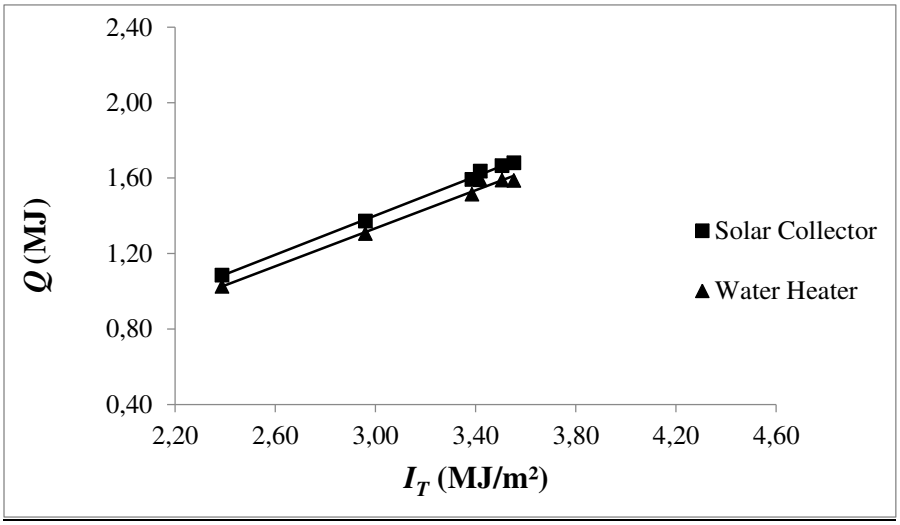

Figure-4. The $Q_{Solar\ Collector}$ and $Q_{Water\ Heater}$ funcition the intensity solar radiation at flow rate 225l/h with β=10˚.

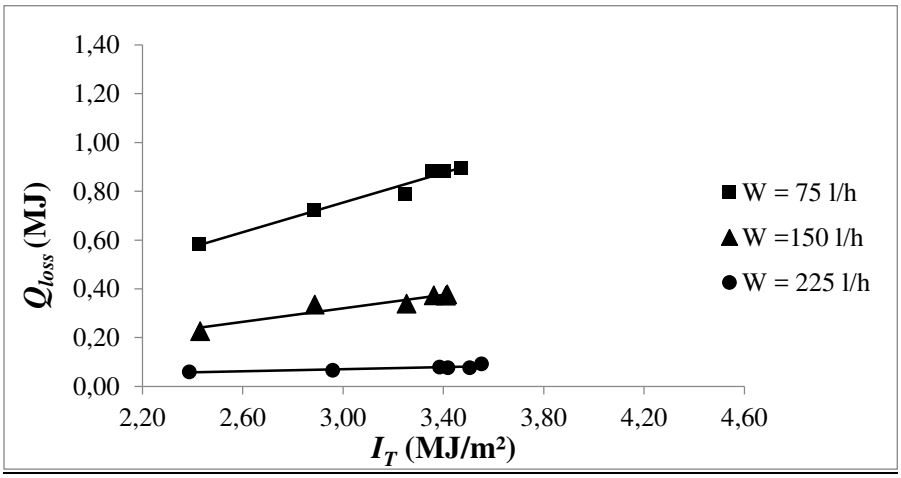

Figure-5. The Energy losses function the intensity solar radiation.

Figure-4 shows the thermal energy of solar water heater collector with addition wavy fins, from the figure we can see that increased heat in the collector is proportional to the solar radiation (I_T). Where are the greater (I_T) on the solar collector, the greater (Q) received by solar collector. This is due the amount (I_T) absorbed by absorber plate is greates than the heat loss coeffisien that occurs at the solar collector. The amount of heat received by solar collector and the amount of heat utilized water heater also influenced by the flow rate. The amount of $Q_{Solar\ Collector}$ and $Q_{Water\ Heater}$ on the flow rate 225 l/h at tilt angle 10˚ respectively are 1681 MJ and 1,591 MJ.

Figure-5 illustrations the energy losses of solar collector. Energy losses is the difference between $Q_{Solar\ Collector}$ and $Q_{Water\ Heater}$. The greater $Q_{Solar\ Collector}$ and $Q_{Water\ Heater}$, the smaller Q_{loss}. The highest Q_{loss} occur at flow rate 75 l/h is 0,896 MJ. The amount Q_{loss} at flow rate 150 l/h and 225 l/h respectively are 0,377 MJ and 0,092 MJ. The flow rate has a role in reducing energy losses. Where the greater flow rate then greater heat utilized and smaller losses. This is due addition of flow rate will increase mass flow rate. So when the large mass flow rate become larger than the heat utilized also increasingly large.

Figure-6 shows the efficiency of solar collector with addition wavy fins. The highest efficiency occurs at flow rate 225 l/h is 63.87%, higher 1.01% of the efficiency at flow rate 150 l/h and higher 1.4% of the efficiency at flow rate 75 l/h. The amount of efficiency at flow rate 150 l/h and 75 l/h respectively are 63.23% and 62.93%. On the figure can be seen that the greater flow rate, the efficiency of solar water heater collector become larger. This is due $Q_{Solar\ Collector}$ at flow rate 225 greater then $Q_{Solar\ Collector}$ at 150 l/h and 75 l/h.

Figure-7 indications the impact of the addition wavy fins against outlet temperature of water. Outlet temperature of water on solar water heater collector that uses fins (wavy fins and helical fins) and without fins, have the same relative increase. However, on the solar water heater collector with addition wavy fins have the outlet temperature of water is higher than the solar water heater collector without fins. So that heat received by heating pipes also the greater than without fins, and the distributed to working fluid also getting greater. Whereas if it is compared to solar water heater collector of helical fins, outlet temperature of water is smaller. The highest outlet temperature of water on solar water heater collector with addition wavy fins occurs at flow rate 75 l/h is 46˚C or 3% higher than the outlet temperature of water on solar water heater collector without fins 43˚C, or 3.10% lower at the outlet temperature of water on solar water heater collector with addition helical fins 49.1˚C which is occurs at flow rate 75 l/h. This is due on the solar water heater collector of wavy fins, the heat loss greater than that of the solar water heater collector of helical fins.

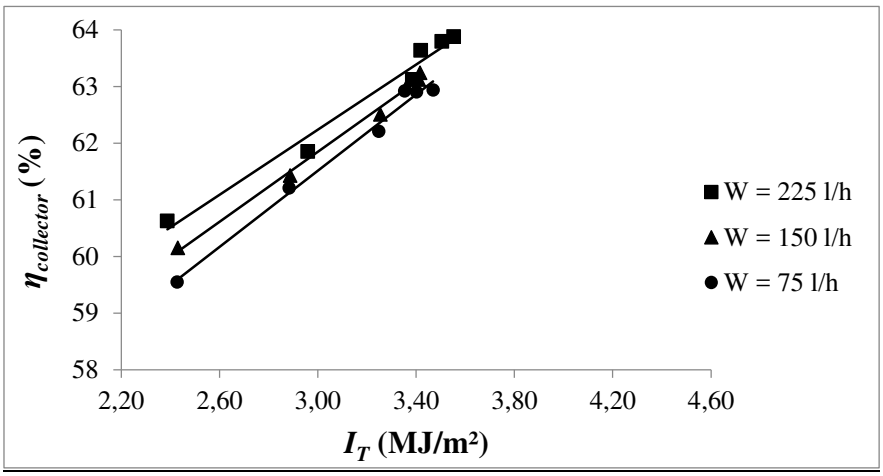

Figure-6. The efficiency of solar collector function the intensity solar radiation at β=10˚.

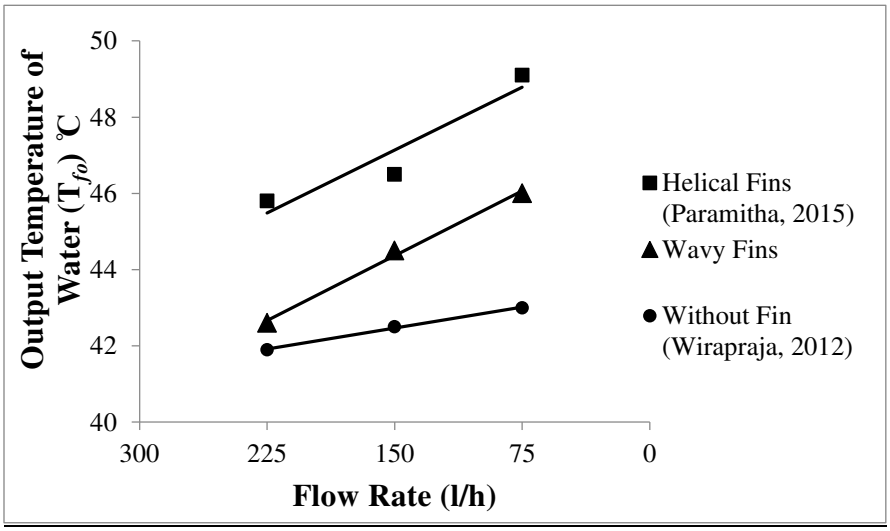

Figure-7. The output temperature of water function the flow rate after 6 hours heating.

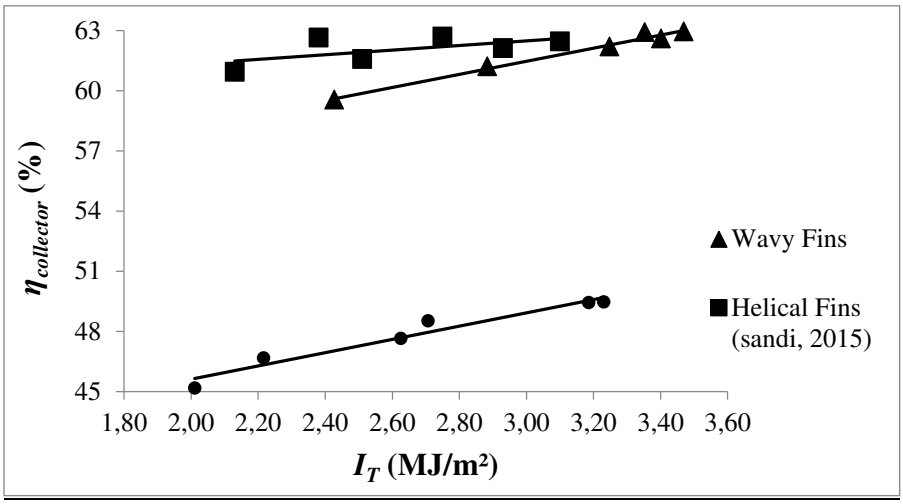

Figure-8. The efficiency of collector function the intensity solar radiation with addition fins and without fins.

Figure-8 illustrations the efficiency of solar water heater collector that uses fins (wavy fins and helical fins) and without fins function the intensity solar radiation. On the figure, it can be seen that the solar water heater with fins have better efficiency than the solar collector without fins. The better efficiency of solar water heater collector are that uses wavy fins is 63.39%, be used helical fins is 62.69% and without fins 49.46%. The efficiency of solar water heater collector with addition wavy fins higher 1.1% than the helical fins and higher 21.97% than without fins. This is due to the difference in the absorbed heat area on the pipe. The larger absorbed field, the greater efficiency of solar water heater collector.

CONCLUSIONS

The addition wavy fins at solar water heater collector can increase efficiency of solar water heater collector. Where the efficiency of solar collector greater 1.1% than the solar water heater collector uses helical fins and greater 21.97% than the solar water heater collector without fins. Moreover, the addition wavy fins can be increase the outlet temperature of water by 3% then the solar collector without fins. The increase flow rate at solar water heater collector with addition wavy fins can be increase efficiency from 0.99% to 1.4% for each the improve flow rate. The highest efficiency of solar water heater collector with addition wavy fins occurs at flow rate 75 l/h is 63.39%.

REFERENCES

[1] F. Struckmann. 2008. Analysis of a Flat-plate Solar Collector. Project Report.

[2] B. A. Dwiyantoro and S. W. Chau. 2013. The dependence of microdroplet size on the parameters governing the dewetting process on circular micropillar arrays. Journal of Mechanical Science and Technology. 27(7): 2005-2013

[3] B. A. Dwiyantoro. 2013. A numerical study of an injection-compression molding process by using a moving grid. Applied Mechanics and Materials. 249-250: 472-476

[4] B. A. Dwiyantoro. 2014. Numerical study on the influence of the corner curvature of circular micropillar on microdroplet size via a dewetting process. Applied Mechanics and Materials. 493: 111-116

[5] E. Wirapraja. 2012. Analisa kinerja pemanas air menggunakan kolektor surya pelat datar dengan satu kaca penutup. Tugas Akhir. Jurusan Teknik Mesin Institut Teknologi Sepuluh Nopember.

[6] S. Pramirtha and B. A. Dwiyantoro. 2015. Studi eksperimental pengaruh laju aliran air terhadap efisiensi thermal pada kolektor surya pemanas air dengan penambahan external helical fins pada pipa. Jurnal Teknik Pomits. (4) :B-62-67.

[7] J. A. Duffie and W. A. Beckman. 2013. Solar Engineering of Thermal Processes. John Wiley & Sons. Canad