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PERFORMANCE EVALUATION OF HYBRID SOLAR AIR-WATER HEATER WITH VARIOUS INLET AIR TEMPERATURE DURING HEATING PROCESS

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Abstract

Research about hybrid solar air-water heater that can heating both air and liquid has been conducted for enhancing the usage of solar thermal energy. In the previous study, thermal efficiency of this collector was investigated with many operating and external conditions, but all of previous experiment conducted using outdoor air as inlet air of collector. Thus, in this study,

the performance change of hybrid solar air-water heater was investigated with change of inlet air temperature during air and liquid were heated simultaneously. As a result, thermal efficiency for liquid heating was increased with increment of the inlet air temperature. On the contrary to this, thermal efficiency for air heating of collector was decreased with increment of inlet air temperature. In case of total thermal efficiency of collector considered air and liquid heat gain, it was also decreased with increment of inlet air temperature. From these results, it was confirmed that using outdoor air directly as inlet air of collector is better for the use of solar energy. However it is hard to conclude that which is better between using outdoor air and heated air on the perspective of energy saving of building because heat storage performance was increased if the return air or any heated air is used as inlet air of hybrid solar air-water heater when air and liquid was heated simultaneously even air and total thermal efficiency is decreased. Thus, the necessity of more profound study and consideration about this as a further study was also confirmed.

Keywords

Solar thermal energy, Flat plate solar collector, Heat pump, Energy conservation

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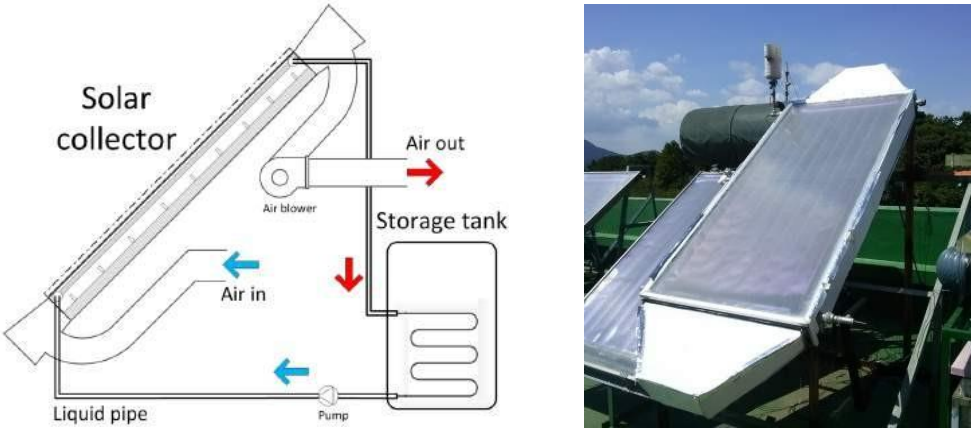
1. Introduction

With concerns about exhaustion of energy and environmental pollution caused by increment of fossil fuel usage, many researches for improving the efficiency of renewable energy have been conducted. As a part of these trends, research about hybrid solar air-water heater has been conducted for enhancing the use of solar thermal energy. The hybrid solar air-water heater is flat plate solar collector that can heating air and liquid respectively or simultaneously, while traditional flat plate solar collector can heating only one of air and liquid. Thus, this collector can be applied to hot water supply system as well as air-conditioning system in winter. And also it can be used for making heat source that regenerating liquid desiccant of liquid desiccant cooling system in summer. So, many previous studies was conducted for developing this collector with many operating and external conditions (K.H. Choi et al, 2014), (H.W. Choi et al, 2014, 2015), but all of previous experiment conducted using outdoor air as inlet air of collector. Thus, in this study, performance change of hybrid solar air-water heater was investigated with change of inlet air temperature during air and liquid were heated simultaneously and confirming the effect of inlet air temperature of collector on thermal efficiency.

2. Experimental apparatus and method

Hybrid solar air-water heater is flat plate solar collector that can heating both air and liquid by installing air channel beneath absorbing plate. It is composed of nine air channels with nine liquid pipes and fins are installed in an air channel for improving heat transfer from absorbing plate to flow air. Absorbing area is approximately $2m^2$ and it is located in Busan, Republic of Korea. Schematic and actual view of hybrid solar air-water heater are shown in Figure 1.



(a) (b)

Figure 1: *Schematic and actual view of hybrid solar air-water heater; (a) schematic of hybrid solar air-water heater (b) actual view*

Experiment was conducted on constant liquid and mass flow rate at clear day. Inlet air of collector was heated by electric heater and the temperature difference between inlet air and ambient was set as 0ºC, 13 ºC and 23 ºC. as a measuring devices, T-type thermocouple, PT100 were used for air and liquid temperature and testo435, turbine flowmeter were used for air and liquid mass flow rate. In case of solar irradiance, pyranometer was used.

Thermal efficiency of collector can be defined as the ratio of the useful gain over some specified time period to the incident solar energy over the same time period (Duffie J.A. & Beckman W.A., 1991), (M.A. Karim & M.N.A. Hawlader, 2004). Thus, thermal efficiency for air and liquid heating and total thermal efficiency of collector can be written as equation (1), (2) and (3).

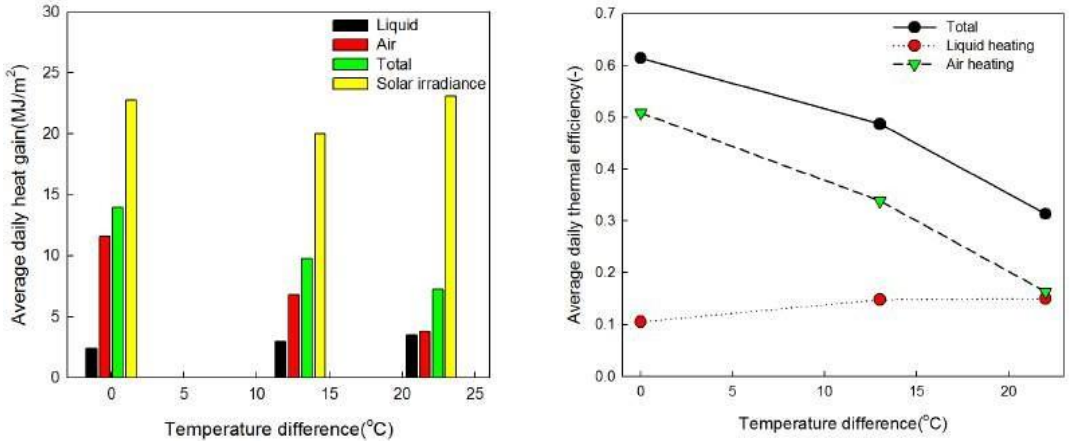
$$\eta_L = \frac{\int Q_L dt}{\int G A_c dt} = \frac{\dot{m}_L C_{p,L} \int (T_{L,out} - T_{L,in}) dt}{A_c \int G dt} \quad (1)$$

$$\eta_{air} = \frac{\int Q_{air}\,dt}{\int GA_c\,dt} = \frac{\dot{m}_{air}\,C_{p,air}\int (T_{air,out} - T_{air,in})dt}{A_c\int G dt} \quad (2)$$

$$\eta_t = \frac{\int Q_t\,dt}{\int GA_c\,dt} = \frac{\int Q_{air}\,dt + \int Q_L\,dt}{A_c\int G dt} \quad (3)$$

3. Result and discussion

Average daily heat gain and thermal efficiency in collector are shown in Figure 2 with respect to temperature difference between inlet air and ambient. Heat gain of liquid was increased slightly with increment of temperature difference on the similar solar irradiance. But, heat gain of air and total heat gain were shown significant decline with increment of temperature difference. In case of thermal efficiency, thermal efficiency for liquid heating was shown from 10% to 15% and it was increased with increment of inlet air temperature similar with heat gain because heat transfer from liquid to air was decreased. On the contrary to this, thermal efficiency of air was decreased with increment of inlet air temperature and it was shown from 15% to 50%. In case of total thermal efficiency, it was shown from 30% to 60% and it was also decreased with increment of inlet air temperature similar with thermal efficiency for air heating.



(a) (b)

Figure 2: *Heat gain and thermal efficiency with respect to temperature difference between inlet air and ambient; (a) heat gain (b) thermal efficiency*

4. Conclusions

In this study, performance of hybrid solar air-water heater was investigated with change of inlet air temperature when the air and liquid were heated simultaneously. As a result, thermal efficiency for liquid heating was increased with increment of inlet air temperature. But thermal efficiency for air heating and total thermal efficiency of collector were decreased with increment

of inlet air temperature because the decrement of thermal efficiency for air heating was more than increment of thermal efficiency for liquid heating. Thus, using outdoor air directly as inlet air of collector is considered as a better way for the use of solar energy. But it is hard to conclude that which is better between using outdoor air and heated air on the perspective of energy saving of building because heat storage performance was increased if the return air or any heated air is used as inlet air of hybrid solar air-water heater. So, the necessity of more profound study and consideration about this as a further study was also confirmed.

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