ANALYSIS ON THE OPERATING CHARACTERISTICS OF SOLAR WATER HEATER IN COMBINATION WITH AIR SOURCE HEAT PUMP WATER HEATER

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ABSTRACT

Solar water heater cannot supply hot water in cloudy and raining days alone. It in combination with air source heat pump water heater (ASHPWH) is a good choice. The performance of the two kinds of water heater is affected by the water temperature. It is important that the ASHPWH operate at a right temperature of the water. A solar water heater with 4m^2 flat-plate collector assisted by a 1.5kW ASHPWH is studied in this paper. The results show that both the collector efficiency of the solar water heater and the COP of the ASHPWH system decreases as the water temperature increases. The highest and lowest collector efficiency of the solar water heater are 54.4% and 45.6% respectively. The COP of the ASHPWH system ranges from 6.48 to 2.61 as the water temperature increases. Operating sequences of these two kinds of water heater affect solar energy utilization ratio and the power input of the ASHPWH system.

Keywords: solar; water heater; air source; heat pump

1. INTRODUCTION

Solar water heater is wildly used today. But solar water heater cannot supply hot water in raining days. A auxiliary hot water heater is necessary for it to insure that hot water can be supplied all aroud the year. Air source heat pump water heater (ASHPWH) acquires hot water by absorbing heat energy from the ambient air and has been used since the 1950s. Solar water heater in combination with ASHPWH is a good choice(B. J. Huang et al. 2004,2001; J. P. Chyng et al. 2003). Because of the high COP of ASHPWH (Jie Ji et al. 2005), it can save more energy than electric water heater. As the COP of ASHPWH changes with water temperature obviously, rational water temperatures can let it operate at high COP which can save more energy. Water temperature also affect the efficiency of a solar water heater. So right water temperatures are very important to solar water heater in combination with ASHPWH. This paper reports on simulation studies on the operating performance of a solar water heater with 4m^2 flat-plate collector and a 1.5kW ASHPWH. The simulation results and their analysis are also presented.

2. SIMULATION OF SOLAR WATER HEATER

2.1. PARAMETERS AND CONDITIONS

A solar water heater with 4m^2 flat-plate collector is studied. The 4m^2 flat-plate collector is composed of two pieces collectors. The parameters of each piece of collector is listed in Tab.1. Tab.2 shows the conditions of the simulation.

Tab. 1: Parameters of the collectors

length	width	stuff	tube number	tube external diameter	tube internal diameter	tube pith	fin thickness
2m	1m	copper	8	10cm	9cm	125cm	0.3mm

Tab. 2: Conditions

radiation intensity	wind velocity	absorptivity of fin	reflectivity of cover plate	transmissivity of cover plate	ambient temperature
800W/m^2	5m/s	0.95	0.12	0.88	20℃

2.2. RESULTS

In the simulation of the solar water heater, the ambient temperature is 20℃ and the temperatures of the tested water are 20℃, 25℃, 30℃, 35℃, 40℃, 45℃ and 55℃. The collector efficiency of the solar water heater is simulated at each of the temperature and the results are shown in Fig.1.

The results show that the collector efficiency of the solar water heater gradually decreases from 54.4% to 45.6% as the water temperature increases. This is caused by the increasing of the thermal loss with the water temperature. The results also show that the collector efficiency is acceptable when the water temperature increases to 55℃.

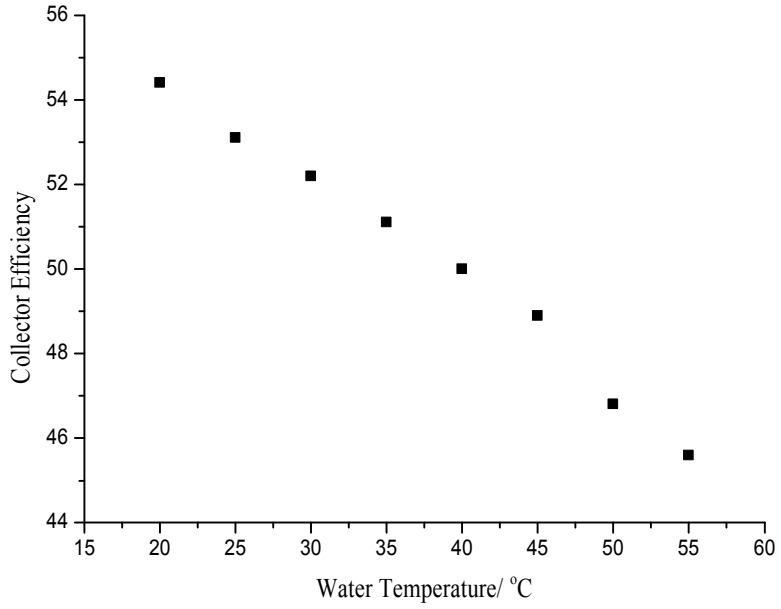

Fig. 1: collector efficiency of the solar water heater

3. SIMULATION OF ASHPWH

3.1. CONDITIONS

A 1.5kW (rated power) ASHPWH is studied to find out the effects of the water temperature to the COP of the ASHPWH system. In this simulation the dry-bulb temperature is 20℃ and the wet-bulb temperature is 15℃. The initial and final temperature of the water are 20℃ and 55℃ respectively.

3.2. RESULTS

The COP variation with the water temperature is showed in Fig.2. The results show that COP decreases rapidly with time as the water temperature increases. During the water temperature changing period, the COP of the ASHPWH system ranges from 6.48 to 2.61. This is caused by the increasing of the power input of the ASHPWH system.

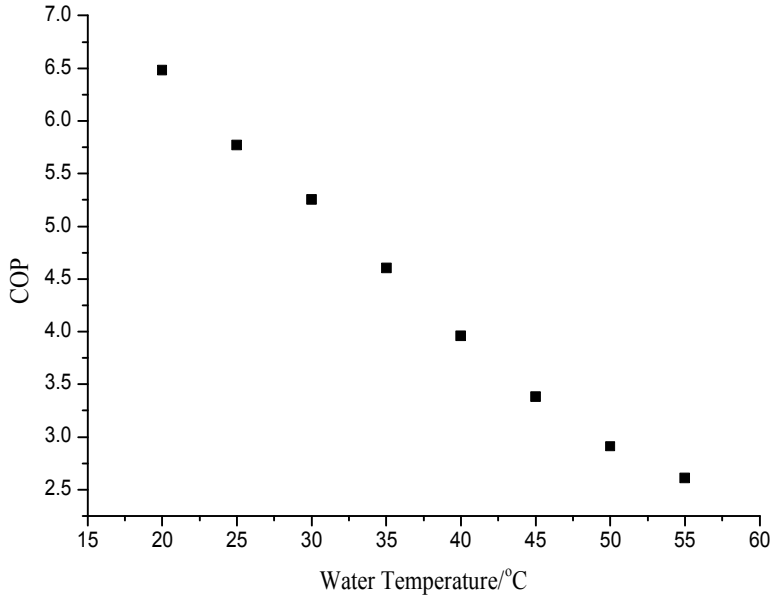

Fig. 2: COP of the ASHPWH system

4. DISCUSSION AND CONCLUSIONS

According to the simulation results, both the collector efficiency of the solar water heater and the COP of the ASHPWH system decreases with time as the water temperature increases. The highest and lowest collector efficiency of the solar water heater are 54.4% and 45.6% respectively. So letting solar water heater operates at lower water temperatures can utilize more solar energy. The COP of the ASHPWH system ranges from 6.48 to 2.61 as the water temperature increases from 20℃ to 55℃. Operating at lower water temperatures is also benefit for the ASHPWH system and more energy can be saved.

When solar energy is not enough, such as cloudy days, the solar water heater should combine with the ASHPWH, either the solar water heater operate at lower water temperature or the later system do. Operating sequences of these two kinds of water heater affect solar energy utilization ratio and the power input of the ASHPWH system. Because the COP of the ASHPWH decreases more rapidly than the collector efficiency of the solar water heater do, letting the ASHPWH operate fistly and the solar water heater operate afrerwards in cloudy days is a good choice. The optimum operating strategy of the solar water heater in combination with ASHPWH is too complicated to discussing in this report. More discussions will be given in the future studies.

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