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ScienceDirect

Procedia Engineering 205 (2017) 2691–2697

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Volume design of the heat storage tank of solar assisted water-source heat pump space heating system

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Abstract

The paper presents a method to design the volume of the heat storage tank of the solar assisted water-source heat pump space heating (SAWHPSH) system. With the area of the solar thermal collector calculated according to the China national design code for solar heating system, the space heating load and the solar radiation are considered simultaneously in this method. The design method of the volume of the solar heat storage tank is elaborated afterwards. In order to show the advantage of this design method, TRNSYS software was used to simulate the same SAWHPSH case project with the volume of the heat storage tank designed by both the method brought out in the paper and the one described in the China national design code. Performances of the system designed by the two different methods are investigated and the results show that the SAWHPSH system with the heat storage tank volume designed by the method presented in the paper has a higher average system COP.

Keywords: Solar assisted water-source heat pump; space heating; heat storage tank; system simulation

1. Introduction

As the energy consumed by the buildings increases year by year, the utilization of clean and renewable energy is increasingly imperative. Because of the characteristics of high efficiency and environmental sustainability, Water-Source Heat Pump is widely used. However, in most northern cities in China, relative low water temperature in heating season leads to heating capacity reduction and performance deterioration. In most part of China, Solar Energy is

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10.1016/j.proeng.2017.10.196

abundant. So one solution to solve the problem above is adding a solar energy system to the heat pump system. So that the hot water heated by solar energy can be used to raise the temperature of water entering the evaporator of the heat pump or directly supply heating to the end users.

Many studies have focused on how the heat storage tank of solar assisted water-source heat pump system influences the performance of the combined system. J.W. Macarthur [1] analyzed the payback period of the tandem solar energy heat pump system and found that the volume of the tank and the area of the collector are the key factors. Y. Kuang [2] had an experimental study on solar assisted water-source heat pump system and found that the heat storage tank is an important component of the combined system. Y. Li [3] used TRNSYS to simulate a solar energy and air/water source heat pump combined heating system with double evaporators heat pump and double water tanks. The results showed that the use of double water tank made the system have a high solar fraction, and even in bad weather the solar fraction could reach 21.26%. L. Cheng [4] studied solar combined heat pump radiant floor heating system and found that for different regions and different buildings the best volume of the tank per collector area is different. With the volume of the heat storage tank increases, the efficiency of the system first rises and then falls. J.G. Cheng [5] studied solar assisted low temperature water source heat pump and concluded that when the collector area is 49% of the heating area and the volume of the tank is 100L per collector area, the system had the best performance and the solar fraction is up to 99.8%.

Heat storage tank is one of the important components in the SAWHPSH system. The volume of the tank directly relates to the heat collecting efficiency of solar collectors and the performance of the system. This paper presents a method to design the volume of the heat storage tank. Four typical days in heating period are chosen to analyze the space heating load and the solar radiation. Then the meteorological data of these days are used to calculate the volume of the heat storage tank with the area of the solar thermal collector calculated according to the China national design code for solar heating system. The same SAWHPSH case project designed by the meteorological data of four typical days are simulated to compare the performance of the SAWHPSH system. Then the same SAWHPSH case project with the heat storage tank volume designed by China national design code [6] is also compared. In this study COP is the decision parameter to analyze the performance of each system.

2. Method

The SAWHPSH system studied in the paper is showed in Figure 1. The time of the charging and discharging cycle of this combined system is one day. The system has four operation modes. In mode1 (M1), the solar hot water in the tank is directly used to heat the users. In mode2 (M2), the water in the tank is used to heat the source side liquid of the heat pump. In mode3 (M3), the water in the tank is used to heat the evaporator of the heat pump by directly flowing into it. In mode4 (M4), only the heat pump operates to heat the users. The operation mode of SAWHPSH system changes according to the average temperature of the tank which is showed in table 1. In the table, T_s is the heat supply temperature, T_h is the highest temperature of the fluid that is allowed to enter the evaporator of the heat pump, and T_w is the temperature of the water source.

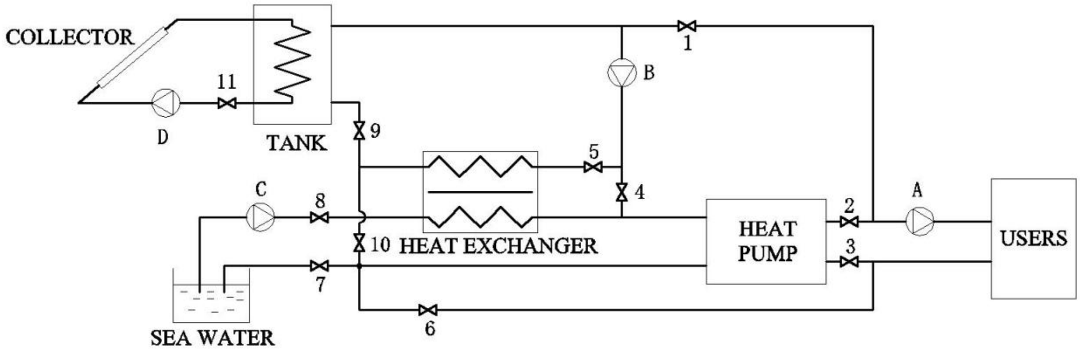

Fig. 1. Schematic diagram of SAWHPSH system