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Experimental study on split air conditioner with new hybrid equipment of energy storage and water heater all year round

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Abstract

This paper presents a split air conditioner with a new hybrid equipment of energy storage and water heater all year round (ACWES). The authors made a special design on the storage tank to adjust the refrigerant capacity in the storage coils under different functions, instead of adding an accumulator to the system. An ACWES prototype, rebuilt from an original split air conditioner, has been finished, and experimental study of the operation processes of the prototype was done from which some important conclusions and suggestions have been made, which were helpful in the primary design and improvement of an ACWES system for potential users.

Keywords: Energy storage; Split air conditioner; Super cool; Water heater

1. Introduction

With rapid growth of the social economy, the living standard of Chinese people has been improved a lot. As a result, the amount of energy consumed by air conditioners and water heaters

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is increasing rapidly, which leads to the following problems: one is that it is uneconomical if the air conditioner and water heater are individual units exclusively from the viewpoint of cost and installation. The other one is that the power consumed by air conditioners occupies 20% of the total power consumption. Moreover, the increasingly wide use of air conditioners leads to more serious disequilibrium between the supply of and demand for electrical power. The decision of how to shift power load and balance power load is of great importance. One of the important solutions is cool storage (ice storage mainly), which has mainly spread in the commercial buildings in China and is of good social and economical benefit. However, experimental and academic study of domestic storage air conditioners is far from sufficient. The cost share of a storage unit is larger in a domestic storage air conditioner system than in a commercial storage air conditioner. Moreover, the domestic air conditioner is characterized by compact structure and little installation space. The above reasons restrict the development of domestic storage air conditioners if only a storage function is added to a domestic air conditioner. In Japan [1], an ice storage cabinet air conditioner (cooling capacity 28 kW) has been studied. Experimental results show that cool storage use in residential buildings is feasible. In China, Liu [2] simulated the ice storage process for an ice storage cabinet air conditioner (cooling capacity 28 kW too), which showed that when the refrigerant quality was over 0.6, the heat transfer coefficient inside the coils would decrease, accompanied by an increase of refrigerant quality. So, changing the refrigerant direction was advised. Although it was feasible theoretically, it was not practical. It is important to pay much attention to energy conservation in the field of energy storage and heat pump (HP) water heater technology in combination for domestic air conditioners.

In the present study, a split air conditioner with a new hybrid equipment of energy storage and water heater all year round is considered. The idea is simple but effective! The specially designed storage tank can be affixed directly to the split air conditioner. The whole equipment is called ACWES. In summer, the ice storage coils work as the evaporator. Ice storage is done during off peak electrical demand periods and in a relatively cool environment. At the power consumption peak, the storage coils act as a super cool condenser, which not only increases the super cooling degree of the refrigerant flowing from the condenser, but also improves the coefficient of performance (COP) of the split air conditioner. In winter, the energy storage tank is regarded as a heat storage tank, absorbing the condensing heat to store heat during the heating process. The heat storage can supply the heat capacity to defrost and to heat room simultaneously during the defrosting period. Moreover, the ACWES can be transformed to be a HP water heater to provide hot water all year round when the discharging period ends. Although there are many experimental studies on HP water heaters, whether solar HP water heater or normal HP water heater [4–6], there is no study on the integrated system of HP water heater, energy storage and air conditioner technology.

2. System description

Fig. 1 shows the schematic diagram of the ACWES. This system comprises three main units: indoor unit, outdoor unit and storage unit. The ACWES can work in three kinds of operational situations, which are cooling without storage, cooling with coolness storage and hot water supply in summer and heating with and without heat storage, heating with defrost and hot water supply in winter, respectively. The following shows these functions.