A NEW HEAT PUMP SYSTEM FOR YEAR-ROUND WATER HEATING AND SEASONAL SPACE COOLING

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Abstract

Using Heat pump to heat water is an energy efficient way for water heating, and especially for the occasions where both water heating and space cooling are needed, heat pump is the most energy efficient way to do so. So far, only a few heat pumps are designed for water heating and space cooling, while most of them are for the occasions for both heating and cooling simultaneously, and even in these systems there is still some space for improving. In addition, for lots of the dwellings, hot water is required year-roundly and air cooling is needed only in summer. A new heat pump system is needed for these innumerable households. This paper presents a new and high energy efficient heat pump system for these applications (year-round water heating and air cooling, and year-round water heating and seasonal air cooling)

1. INTRODUCTION

Hot water supply is a necessity in developed countries and it is becoming more and more popular in the developing countries. Using Heat pump to heat water is an energy efficient way for water heating (You et al 2002). In addition, in the places where there are needs for both heating and cooling, heat pump is the most energy efficient way to do so. However, only a few heat pumps are designed for water heating and air cooling, while most of them are for the occasions for both heating and cooling simultaneously. Even in these systems, there is some space for improving. In addition, for most dwellings, hot water is required year-roundly and air cooling is needed only in summer. Thus, a new heat pump system is needed for these innumerable households. This paper presents a new heat pump system for year-round water heating and air cooling, and year-round water heating and seasonal air cooling.

2. THE DESCRIPTION OF THE SYSTEM

2.1 The General Description of the System

The supposed heat pump system is schematically shown in Fig. 1. It normally comprises a compressor, a hot water tank with a heat exchanger (water heat exchanger, preferably a coil rounding the tank), an outdoor heat exchanger (usually a finned coil with a fan, the outdoor fan), an indoor heat exchanger (usually a finned coil with a fan, the indoor fan), a filter/drier/receiver, an expansion device, a suction accumulator (optional), and a set of control valves. The compressor circulates refrigerant in the heat pump, the water heat exchanger heats water, the indoor heat exchanger and the supply fan conditions and delivers air to the space to be conditioned, wherein the outdoor heat exchanger (and the outdoor fan, if the heat exchanger is a coil) rejects or extracts heat to or from the outdoor environment in water heating and air cooling model, or water heating mode, respectively.

The outdoor heat exchanger is typically located outdoor. However, the so-called outdoor heat exchanger may also be located in some indoor space but it should not exhaust the thermal energy (eg, heat or cold air) to the same space where it is conditioned by the so-called 'indoor heat exchanger', or to the space where the warm or cool air from the heat exchanger is objectionable.

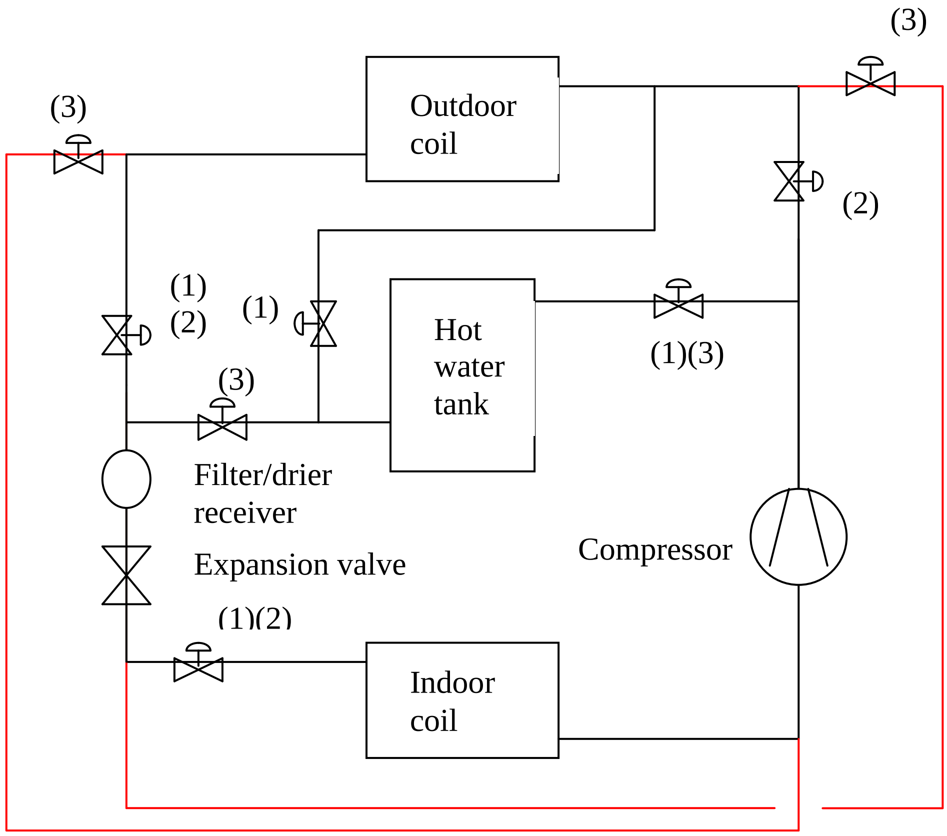

Figure 1. The schematic of the water heating and air cooling or heating system

The working principle of the system is described in the following subsections.

2. 1. Water Heating and Air Cooling Model

In the water heating and air conditioning model, the refrigerant is circulated in this way. When the water needs heat, the high-temperature refrigerant exhausted from the compressor enters the water heat exchanger first to heat the water, and then to the outdoor heat exchanger. After the water is heated to the preset value (usually 60^{o}C), the refrigerant exhausted from the compressor is bypassed/diverted to the outdoor heat exchanger directly. Since the temperature of the outdoor environment (water or air) is much lower than that of the hot water, a low condenser temperature can be achieved when the water is heated to the preset temperature while the air cooling is needed. By this way, the system works in a high energy efficient mode. If the outdoor heat exchanger is a fan coil, the outdoor fan is turned on when the temperature of the refrigerant exiting the coil exceeds that of the ambient air by a certain amount. The speed of the exhaust outdoor fan is preferably variable in proportion to the amplitude of the temperature difference between the refrigerant exiting the coil and the ambient air. By this way, the refrigerant is almost cooled down in the same magnitude (as it is designed) with an economic fan power consumption. Compare to the water being heated, the temperature of the outdoor air changes little, so the temperature of the refrigerant exiting from the condenser (the outdoor coil) changes little, and even though the water heating load changes (with the condenser temperature), there is little impact on the cooling side. The path of the refrigerant could be controlled by the thermal sensor or thermostat of the water or the tank wall.

The cooled refrigerant liquid then goes through the expansion device to expand to low pressure and temperature. The low temperature refrigerant goes through the indoor heat exchanger to cool down the indoor air while the refrigerant is vaporised or even superheated. To make the system respond the air conditioning load efficiently, the indoor fan and the compressor are also preferably to run with variable speeds and its operating speed is related to the cooling load, e.g., the difference between the indoor thermostat set-point and the temperature of the space being conditioned.

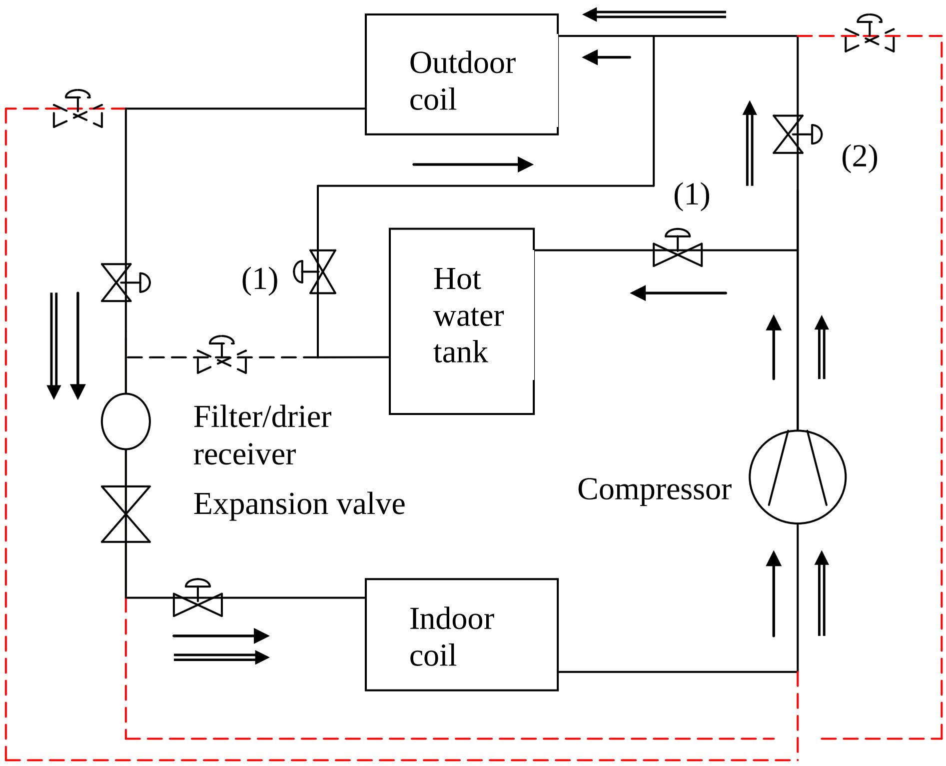

Figure 2. The schematic of the water heating and air cooling or heating system
('⟶' flow circuit of water heating and air cooling model, '⟹' flow circuit of air cooling model)

2. 2. Water Heating Model

In the water heating model, the refrigerant is circulated in this way. The high-temperature refrigerant exhausted from the compressor enters the water heat exchanger first to heat the water, and then the cooled refrigerant liquid goes through the expansion device to expand to low pressure and temperature. The low temperature refrigerant goes through the outdoor heat exchanger to pick up the heat from the heat source, eg, environment. If the outdoor heat exchanger is a fan coil, the speed of the outdoor fan is preferably variable in proportion to the amplitude of the temperature difference between the refrigerant exiting the coil and the ambient air. By this way, the temperature difference of the environment and the evaporator is almost at the same magnitude (as it is designed) with an economic fan power consumption.

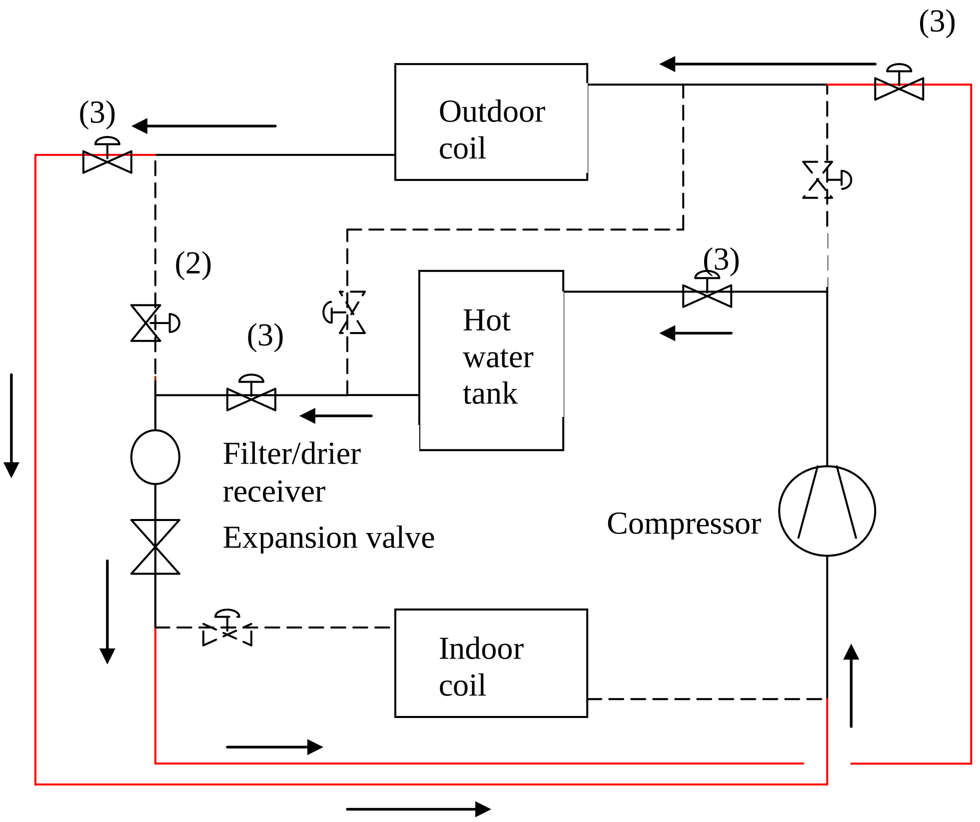

Figure 3. The schematic of the water heating and air cooling or heating system
(‘ → ’ flow circuit of water heating model)

The heat pump system presented may also be modified for other applications such as year-round water heating, and air cooling in summer and heating in winter. In the case of both water heating and space heating needed, a bigger outdoor heat exchanger/fan-coil than usual is needed. Since the performance of heat pump is poor in the very cold areas if there is no other heat source except the ambient air, it is not recommended to use heat pump there. That is also why the systems for both water heating and space heating would not be given in this paper.

3. CONCLUSIONS

This paper presented a new, high energy efficient heat pump system for water heating and air conditioning. It is particularly suitable for the situations where both daily hot water and house cooling year-round, or year-round water heating and seasonal air cooling, are required.

REFERENCES

You. Y., Harmon, S. and Sidney, P, 2002, Quantum 340 Litre Titan Heat Pump Water Heaters And The Applications, 7^{th} International Energy Agency Heat Pump Conference, Beijing, China