HEATING PERFORMANCE OF AIR SOURCE HEAT PUMP WITH HEAT REGENERATIVE DEVICE USING FIBER BELT

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ABSTRACT

In this research the heat regenerative technology was employed to eliminate frosting on evaporator coil and improve COP of the heat pump system. This heat regenerative device(HRD) has very simple structure consisting a geared motor and a porous fiber belt passing through alternatively between cold and warm air duct.

The laboratory test showed that the heat pump system with HRD yielded an impressive COP higher than 3.5 at the outside air temperature of -7℃ in heating mode.

Key Word:Heat pump, Greenhouse, Heating, Cooling, COP(Coefficient of performance)

INTRODUCTION

The heat pump is one of heating and cooling systems driven by electricity using natural energy as a heat source. The heat pump system was mainly adopted to a cooling system or a refrigeration system. It is used as a heating system or a heating and cooling system of houses, buildings and agricultural facilities in regions with a large amount of electricity.

In cold regions, air-to-air heat pumps do not work well because of some technical problems, such as frosting on evaporator coil at outside air temperature below -5℃.

Therefore, many researchers made an effort to prevent frosting on evaporator coil for the purpose of the COP improvement in heating mode. They reported that the HRD was one of

the most effective methods for defrost of evaporator coil in the heat pump system. In Canada, when the heat pipe heat exchanger was used as the HRD, the COP of air-to-air heat pump showed over 3.0 at the ambient air temperature of -10℃. However the heat pipe heat exchanger is very expensive and cannot guarantee for long term stability.

In this research, new idea for the heat regeneration was adopted, and new HRD was developed with a simple structure consisting of a geared motor and a porous fiber belt passing through alternatively between cold and warm air duct.

MATERIALS AND METHODS

The heat pump system was designed as shown in Figure 1. Main parts of the system consisted of a compressor, an evaporator, a condenser, a four way valve, a heat regenerative device, two filter-dryers, two expansion valves, four check valves, six solenoid valves, and two air ducts.

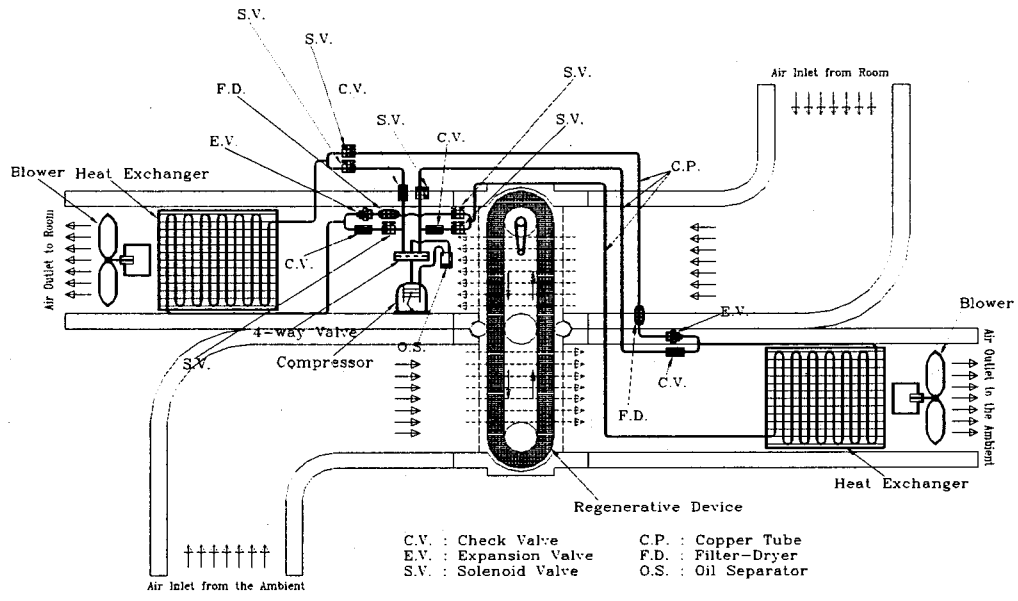

Figure 1. Circuit diagram of heat pump system with HRD.

To estimate the COP of the heat pump system and the thermal efficiency of the HRD,

temperatures of air and refrigerant, air velocity, electric power consumption of heat pump, and volumetric flow rate of refrigerant were measured by sensors and transducers as shown in Table 1.

Table 1 Measuring items, sensors and transducers.

Measuring items			
Temperature(℃)	Air velocity(m/sec)	Electric power(W)	Volumetric flow rate of refrigerant(ℓ /min)
Sensor : T type Probe : Φ 1.0mm Accuracy : ± 0.05%	Model : TSI8465-225 (USA) Range : 0～50m/s Output : 0～5V Accuracy : ± 2.0%	Model : 3181-01 (Hioki, Japan) Range : 0～2000W Output : 0～5V Accuracy:± 1.0%	Model : PT868 (Panametrics, USA) Range : 0～12.2m/s Output : 4～20mA Accuracy : ± 1.0%

The measured values were transferred into a PC based data logger and analyzed. Then, the COP of heat pump system and the thermal efficiency of HRD were estimated with the variation of ambient air temperature.

RESULTS AND DISCUSSION

When the temperature differences between indoor and outdoor air varied from 5℃ to 35 ℃, thermal efficiency of HRD was decreased from 97% to 52% as shown in Figure 2. But when the temperature differences were lower than 25℃, the thermal efficiency maintained over 80%. Therefore the new device was considered to improve the COP of air-to-air heat pump.

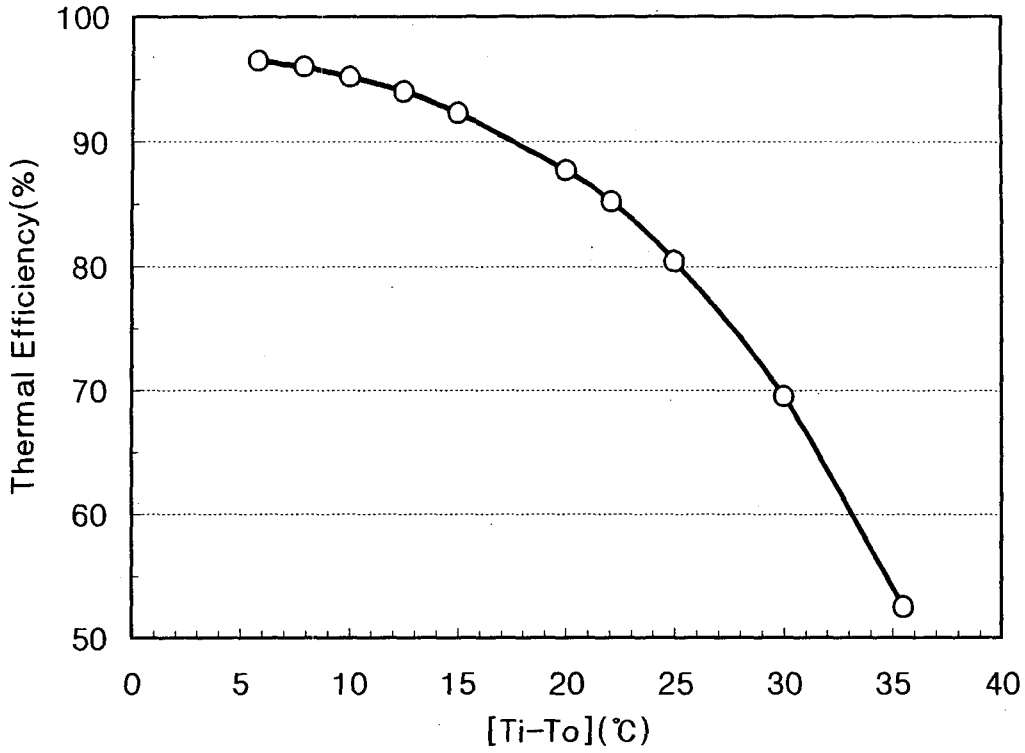

Figure 2. Thermal efficiency of HRD according to the temperature differences between indoor(Ti) and outdoor(To) air.

Then, the new device was equipped to the heat pump system. The COP of heat pump with and without HRD was compared in the ambient air temperature of -7～-1℃ as shown in Figure 3.

When the ambient air temperature was -7℃, the COP of heat pump with and without HRD was estimated at 3.5 and 1.9, respectively, and when the ambient air temperature was -2℃, the COP of heat pump with and without HRD was estimated at 4.0 and 2.2, respectively.

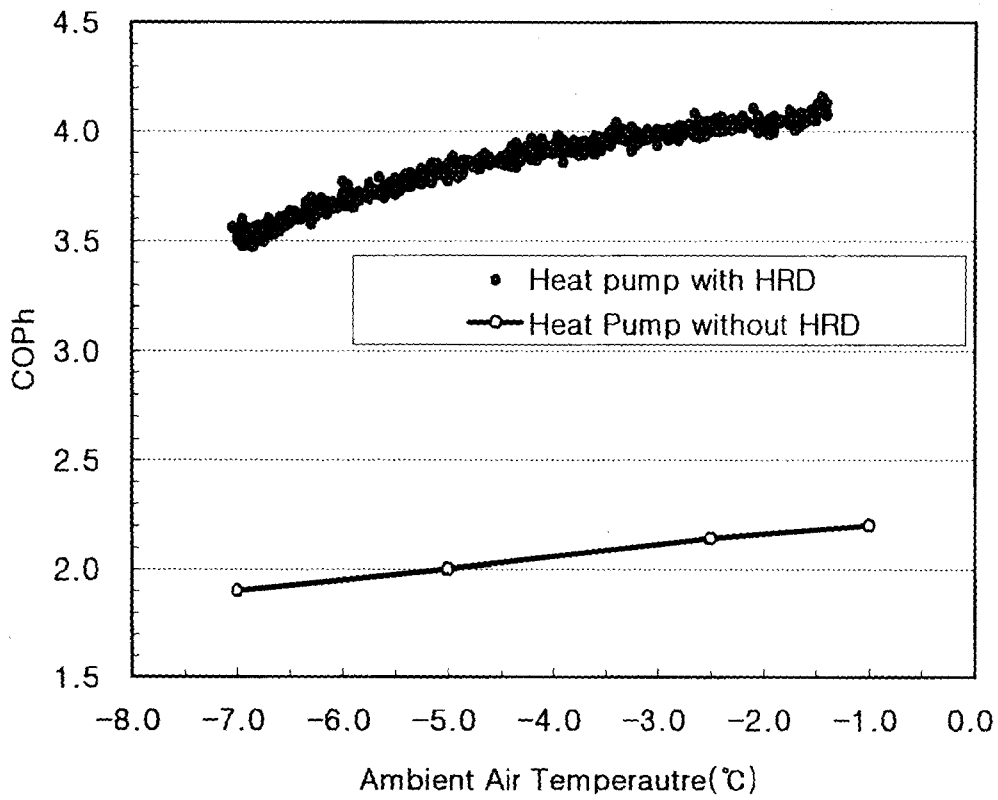

Figure 3. COP of heat pump with and without HRD according to the variation of ambient air temperature in heating mode.

Therefore the COP of heat pump can be improved from 1.6 to 1.8 by the HRD, and by extrapolation of the graph in Figure 3, the COP of heat pump with HRD is predicted at 3.0 when the ambient air temperature was -10℃.

The heat pump system with HRD is expected to work well as a air heater during winter season in South Korea. In 1999, the system was equipped in a greenhouse for the cultivation of orchid *Phalaenopsis*. The floor area of the experimental greenhouse is 330 square meters. There were 10,000 pots of orchids cultivated in this greenhouse. The system worked as an air heater during winter season and as an air cooler during summer season.

CONCLUSIONS

The heat pump is one of heating and cooling systems driven by electricity using natural energy as a heat source. The heat pump system was mainly adopted to a cooling system or a refrigeration system. It is used as a heating system or a heating and cooling system of houses, buildings and agricultural facilities in regions with a large amount of electricity.

In cold weather, air-to-air heat pumps do not work well because of some technical problems such as frosting on evaporator coil at outside air temperature below -5℃.

In this research, the heat regenerative technology was employed to eliminate frosting on evaporator coil and to improve the COP of the heat pump system. This heat regenerative device has very simple structure that consisted of a geared motor and a porous fiber belt passing through alternatively between cold and warm air duct.

The laboratory test showed that the heat pump system with heat regenerative device yielded an impressive COP higher than 3.5 at the outside air temperature of -7℃ in heating mode.

A field test was carried out in a greenhouse for the cultivation of orchid *Phalaenopsis*. The floor area of the experimental greenhouse was 330 square meters with 10,000 orchid pots beung cultivated. The temperature of greenhouse air was set at 25℃ in daytime and 15℃ in nighttime for the flower bud sprouting. The heat pump system worked in heating mode during winter season and in cooling mode during summer season.

This advanced air-to-air heat pump worked very well at the outside air temperature of 37℃ when cooling and -10℃ when heating. High quality flowers in this experimental research were produced and low-cost whole year cultivation of *Phalaenopsis* was realized.

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