Guideline on Applying Heat Pump from Air Conditioning System

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Abstract

The objective of this research was to study the guideline on applying the heat pump and the performance of the heat pump from air conditioning system with supplying various cooling load in order to find the possibility to build heat pump system. A heat pump is a device that provides heat energy from a source of heat to a destination. The experimental apparatus consisted of a vapor compression refrigeration system with a capacity of 9000 Btu/h and the refrigerant R-22 was used as working fluid, air cooled heat exchanger and the electric heater was installed on the evaporator to adjust the cooling load.

During the test, the air temperature was varied from 30, 35, and 40 $^{\circ}C$ and the air velocity passing through the heater and condenser were kept constant at 1 and 4.5 m/s, respectively. The results showed that when the air temperature was 40 $^{\circ}C$, the coefficient of performance (COP) of the system was 3.90. It was found that the power consumption of compressor was 1.43 kW, the rate of heat transfer in condenser and evaporator were 5.59 and 4.14 kW, respectively. And the outlet temperature of air at the condenser was 39.20 $^{\circ}C$. Therefore, applying heat pump from air conditioning system is a technically feasible to develop the commercial application in order to save energy and reduce environmental pollution.

Keywords: Heat Pump, Air-conditioning System, Heat Transfer, Coefficient of performance

1. Introduction

Energy consumption is a major concern because the trend of using energy especially the power of nature such as petroleum, coal, etc. has been increased, as a result these energy may be poor in the future. *The heaters* that produce hot *water with fuel oil that cause* the smoke pollution or the high cost of electric water heater system. Therefore, heat pump system has been designed with conversed air conditioning principle. The objective of heat pump was producing hot water from compressor with *cold air* as a *by-product*. This can be used for air conditioning in the areas that not require much cold. Hence, the air-conditioning system works better and has less energy consumption [1,2]. The heat pump water heaters are widely used in commercial applications especially in both hotels and resorts that have high electricity cost [3-5]. They can replace the fuel oil *that makes* the smoke pollution. For the industry, they can be used in the curing process or drying. Accordingly, this paper proposes a performance study of heat pump while various cooling load.

Nomenclatures

COP	=	*Coefficient of performance*
$h_{comp,i}$	=	Enthalpy at the compressor inlet (kJ/kg)
$h_{comp,o}$	=	Enthalpy at the compressor outlet (kJ/kg)
$h_{cond,i}$	=	Enthalpy at the condenser inlet (kJ/kg)
$h_{cond,o}$	=	Enthalpy at the condenser outlet (kJ/kg)
$h_{evap,i}$	=	Enthalpy at the evaporator inlet (kJ/kg)
$h_{evap,o}$	=	Enthalpy at the evaporator outlet (kJ/kg)
$\mathring{m}_r$	=	Mass flow rate of refrigerant (kg/s)
P1, P2, P3, P4	=	Pressure Gage
$Q_{condenser}$	=	Heat transfer rate from the refrigerant in the condenser (kW)
$Q_{evaporator}$	=	Heat transfer rate from the refrigerant in the evaporator (kW)
T1-T6	=	Measure points of copper tube surface temperature $(^{\circ}C)$
T7-T11	=	Measure points of air temperature $(^{\circ}C)$
$W_{compressor}$	=	Compressor power consumption (kW)

2. Vapor compression refrigeration system cycle

In order to apply the heat pump from air conditioning system, it can be explain that when the air conditioner was turned on and the gas refrigerant was absorbed by compressor. The compressor compressed the high temperature and pressure refrigerant in order to cooling and condensed the liquid at the condenser before decreased the pressure at the expansion valve and then refrigerant flows to the evaporator. While the liquid refrigerant within the evaporator absorbed the heat from the air in order to decrease the air temperature, then evaporated to low pressure gas and flow to the compressor as the cycle as shown in Fig.1 [6,7].

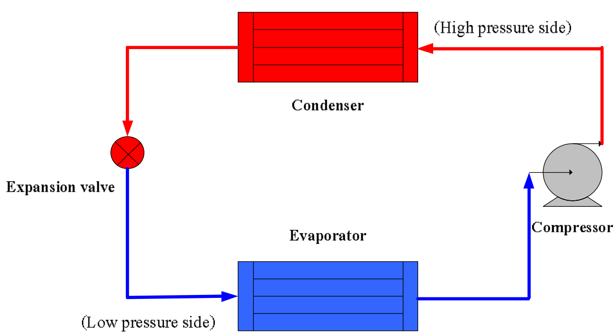

Fig. 1 Air conditioning system

3. System design and experimental set-up

Heat pump system consisted of vapor compression refrigeration system with a capacity of 9,000 Btu/h and the refrigerant R-22 was used as working fluid.

Many preliminary studies were presented the heat pump system employed a solar collector which served as the evaporator for system [8-10]. Accordingly, the heat pump system in this study employed a heater which served as the evaporator for system. This experiment was performed to prepare the set up for getting reliable data as shown in Fig. 2. The air conditioner was turned on and the gas refrigerant was absorbed by compressor. The compressor compressed the high temperature and pressure refrigerant in order to cooling and condensed the liquid at the condenser before decreased the pressure at the expansion valve and the refrigerant flows to the evaporator.

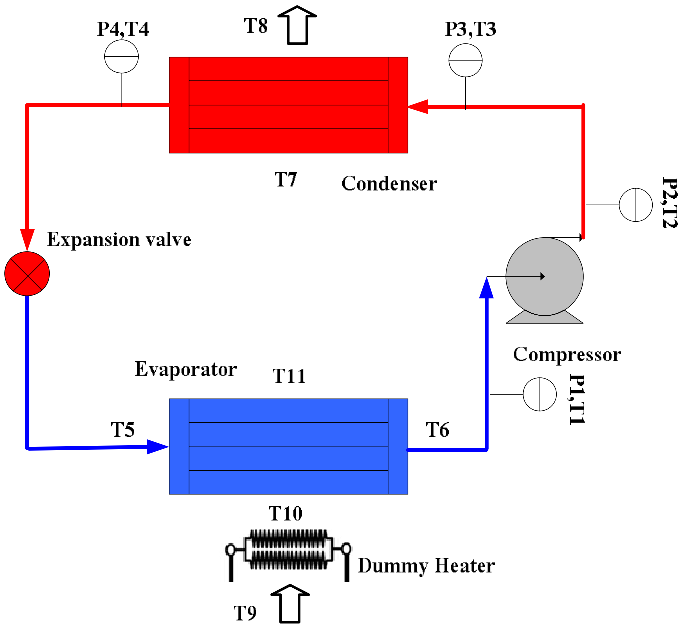

Fig. 2 Schematic diagram of experimental apparatus

While the liquid refrigerant within the evaporator absorbed the heat from the air in order to decrease the air temperature, then evaporated to low pressure gas and flows to the compressor as the cycle. The electric heater was installed on the evaporator to adjust the cooling load of the heat pump system, the air of suction evaporator was absorbed passing through the heater in order to increase the temperature before into the evaporator.

The experimental data were recorded after steady state condition was established. The air flow rate was measured with anemometer and the pressure points of the air-conditioning system were measured by bourdon pressure gages. The temperatures of refrigerant were recorded with Type K thermocouples.

Equations (1)-(4) were used to calculate the desired parameters. The compressor power can be using by Eq. (1). The heat transfer rate from the refrigerant in the condenser and evaporator can be using by Eqs. (2-3) consequently. The system *coefficient of performance* can be using by Eq. (4).

$$W_{compressor} = \overset{\circ}{m}_r \left(h_{comp,o} - h_{comp,i} \right) \qquad (1)$$

$$Q_{condenser} = \overset{\circ}{m}_r \left(h_{cond,i} - h_{cond,o} \right) \quad (2)$$

$$Q_{evaporator} = \overset{\circ}{m}_r \left(h_{evap,o} - h_{evap,i} \right) \quad (3)$$

$$COP = \frac{Q_{condenser}}{W_{compressor}} \quad (4)$$

4. Results and discussion

The experiments were conducted in the period time of 12 hours which the relevant parameters were recorded every 10 minutes. The air temperature was varied from 30, 35 and 40 $^{\circ}C$ and the air velocity into evaporator was kept constant at 1 m/s.

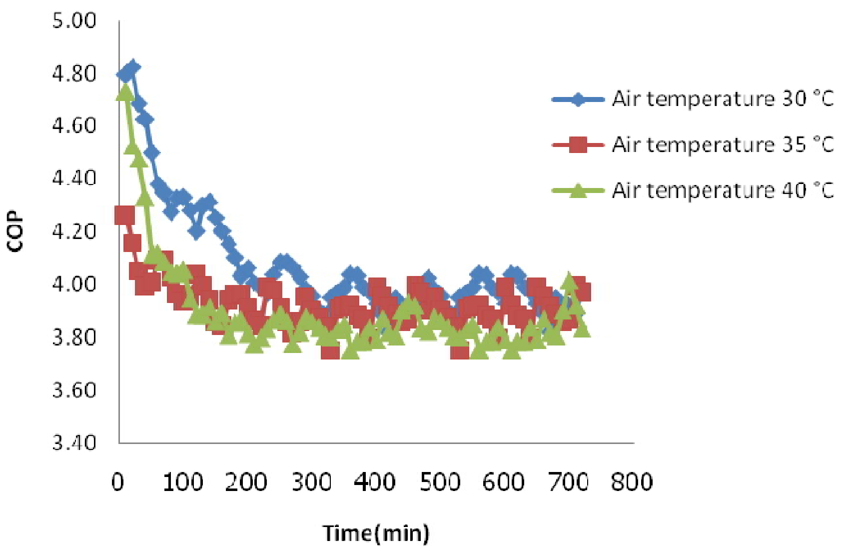

Fig. 3 The comparison of coefficient of heat pump system performance under different temperature patterns

Fig. 3 shows that when the air temperature was varied from 30, 35 and 40 $^{\circ}C$, the COP of the system were 3.97, 3.94, and 3.90, respectively. Hence, the maximum coefficient of performance (COP) of the system occurs at 30 $^{\circ}C$. According to this result, as the higher rate of heat transfer from the refrigerant in the condenser therefore the more quantity of refrigerant fluid entering the evaporator.

The COP decreases with increasing air temperature entering evaporator. Due to the higher adsorbed heat by refrigerant fluid so to increase the evaporator temperature. This means that to increase the load of compressor power.

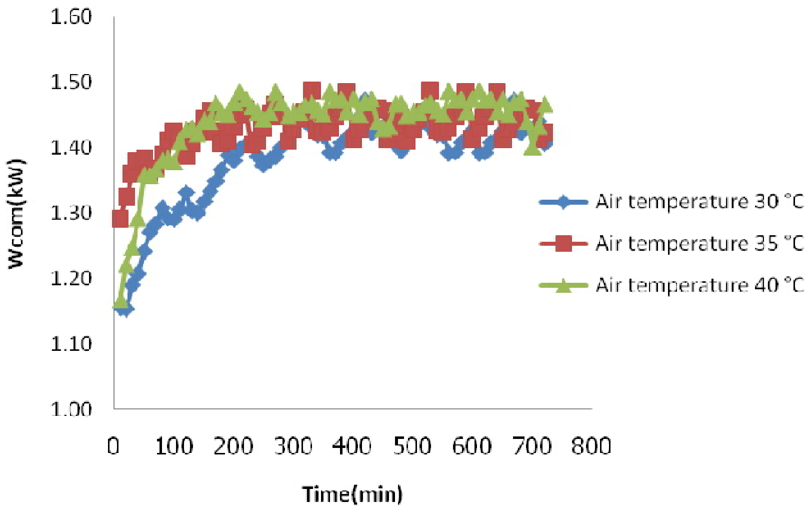

Fig. 4 The comparison of compressor power consumption under different temperature patterns

Fig. 4 shows that the comparison of compressor power consumption under different temperature patterns. It can be seen from the figure that the compressor power consumption were 1.41, 1.42, and 1.43 kW, respectively. The reason for this is the similar to the one as described in Fig. 3. Moreover, the refrigerant flowing through evaporator before entering compressor was superheated. This indicates that if the refrigerant was more superheated thus the load of compressor power also increases.

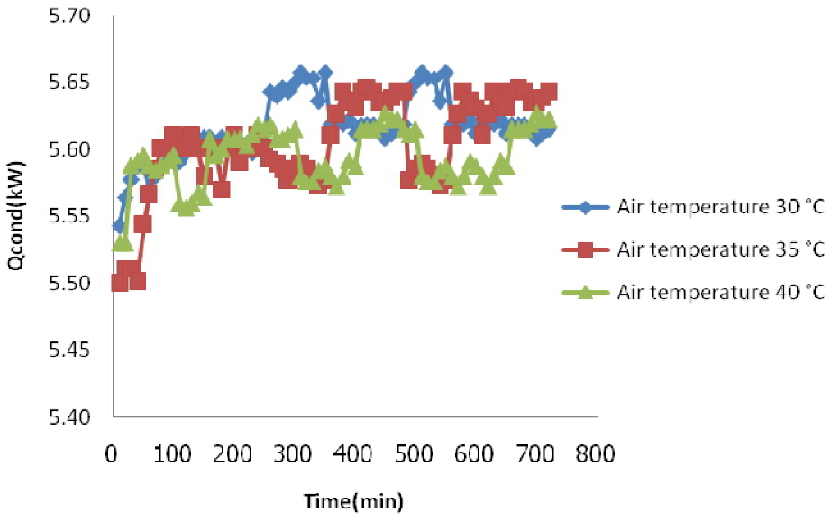

Fig. 5 The comparison of heat transfer rate of condenser in heat pump system at different temperature

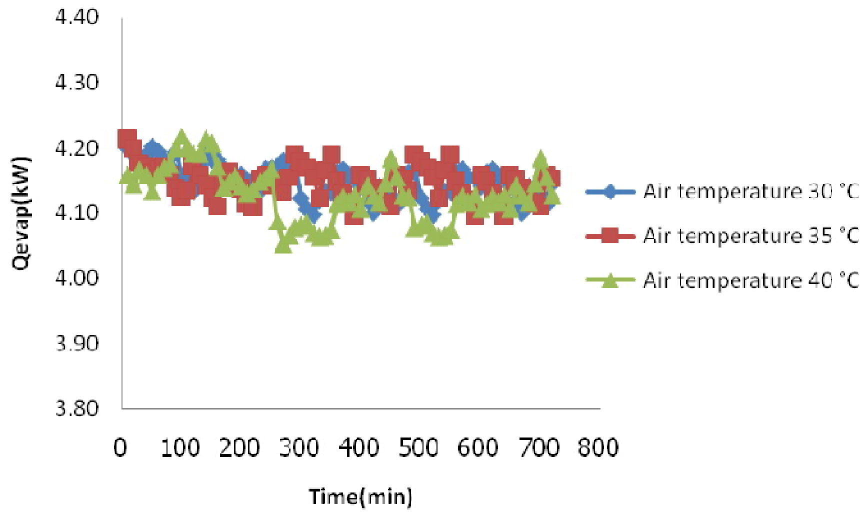

Fig. 6 The comparison of heat transfer rate of evaporator in heat pump system at different temperature

Figs. 5-6 show that the comparison of heat transfer rate of condenser and evaporator in heat pump system at different temperature that was varied from 30, 35 and 40 $^{\circ}C$. It can be seen that the heat transfer rate of condenser were 5.61, 5.60 and 5.59 kW and the heat transfer rate of evaporator were 4.16, 4.15, and 4.14 kW, respectively. This is because the more subcooled refrigerant exit from condenser thus the maximum heat transfer occurs at 30 $^{\circ}C$ and air velocity 1 m/s as shown in these figures.

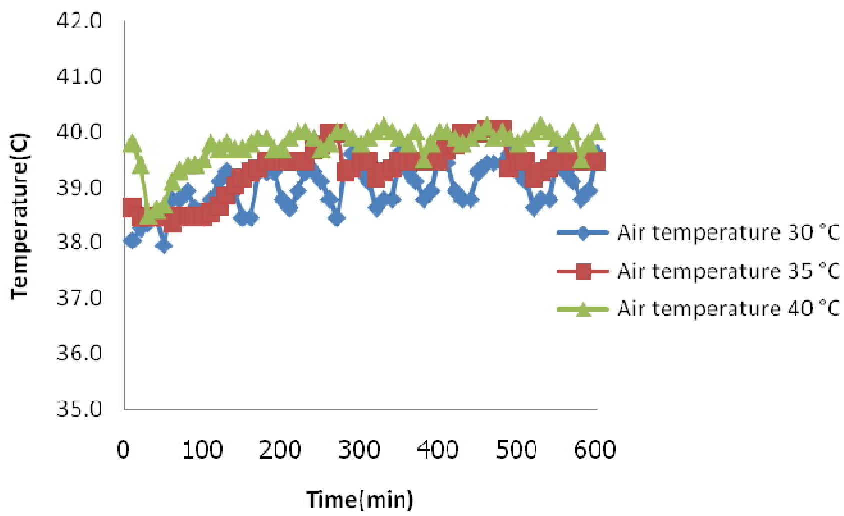

Fig. 7 The comparison of air temperature exit from condenser at difference temperature

Fig. 7 shows that the air temperature exit from condenser at difference temperature. It can be seen that the air temperature exit from condenser of heat pump system were 38.95, 39.10, and 49.20 $^{\circ}C$, respectively. This means if the temperature was adjusted at 40 $^{\circ}C$ and the air velocity was 1 m/s, the refrigerant entering evaporator adsorbed heat that received from the heater. According to this reason, the refrigerant that transfers heat at condenser also increases. Simultaneously, the air temperature exit from condenser also increases.

As a result, this study proposes a technique which can be applied to an air-conditioning system/heat pump system in addition to the previous researches [11,12]. The research result found that applying heat pump from air conditioning system can enhance the performance of heat pump which corresponded with the research about the performance of heat pump for cooling load variation [13].

5. Conclusions

A study to apply the heat pump from air conditioning system while various cooling load, it was found that the outlet air temperature of electric heater influenced to the heat transfer of condenser.

The results showed that when the temperature was 40 $^{\circ}C$ and air velocity was 1 m/s, the coefficient of performance (COP) of the system was 3.90. It was found that the power consumption of compressor was 1.43 kW, the rate of heat transfer in condenser and evaporator were 5.59 and 4.14 kW, respectively. And the outlet temperature of air at the condenser was 39.20 $^{\circ}C$.

6. Acknowledgement

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