Research and analysis of air-conditioning system with cooling air and supplying warm-water

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Abstract – This Article prepared the air-conditioning unit with supplying cooling air and warm water. The unit can work in three modes: only cooling air, only supplying warm water and cooling air with supplying warm water. The analysis results showed that the unit is more efficient than traditional systems, the maximum coefficient of performance (COP) is about 5.3 at cooling mode, the COP is 5.7 at mode of heating, and the COP is 4.5 at cooling and water heater mode.

Keywords: warm water; Air conditioning (AC), Coefficient of performance (COP)

1. Introduction

Developing difficulty about the depletion of energy resources has provided the impetus of research and improvement sports for strength saving and consumption reduction. A large fraction of the primary energy price range is consumed by way of homes to run heating, air flow and air conditioning, lighting fixtures, home equipment and gadget [1]. These problems are solved through manner: the primary is the boom in strength usage fee of conventional system; the second is to reduce the strength consumption based on device integration. Heat pump is a high efficiency device; there are many studies and improvement sports for it. In cooling season, the coefficients of performance (COP) were 2.5 and 1. Five for the warmth pump with and without warmth restoration plant [2], Alex et al. [3] performed experimental investigations to a home warmth pump with de superb heater, warmth restoration efficiency and power aspect have been zero. Seventy-four and 0. Seventy-seven. Fanney et al. [4] determined the operation of a floor source warmness pump with de extremely good heater, energy saving efficiency of the gadget was 27%. Valentine et al. [5] discussed the thermal performance of air source warmth pump with de first-rate heater, EER became improved in cooling mode and reduced in heating mode, and the trade variety become among five% ~ 10%. Molszewski et al. [6] analyzed the relation of electricity saving, reasonable performance about warmness pump with warmness healing plan between weather in 28 American towns, the warmth pump with warmness recovery plan electric heater, however, there have no any advantages relative to gasoline heating and fuel heating. Wang et al. [7-8] studied the air conditioner-water heater integration device, the precept of the air-conditioning and heat-water imparting blended heat pump changed into delivered. The authors calculated the quantity of electricity saving and running cost saving, argued the device successfully store strength. Jie.Ji et al. [9-10] ameliorate warmness pump of domestic air-conditioning, making it have the feature of heat-water providing blended heat pump. Through the experimental research on compound gadget, the COP of compound machine become three.5 in cooling-heating mode. This paper consists of the effects of experiments and analyses of an air conditioning with supplying heat water. The performances of the system and components, which includes heat change, water tank, have also been supplied.

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2. Design of the system

The air conditioner with supplying warm water has been designed and constructed, as showed in Fig.1.The system used a condenser with water cooling to reclaim the condensing warmth of the air conditioner. In the cooling process, the condensing warmness of the air conditioner was used to warmness cold water for home heat-water. The condensing warmth reclaim stepped forward COP of the system.

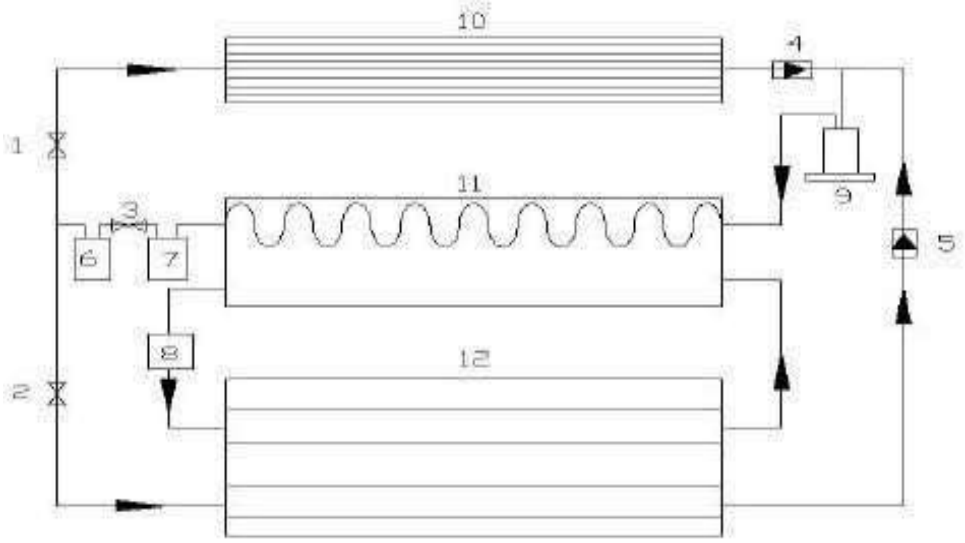

Fig.1.Diagram of the air conditioner and warm-water supplying combined heat pump

The three operation modes of the system were introduced as follows:
The refrigeration mode: check valve (5) and valve (2) had been closed, the refrigerant received warmness from the evaporator indoor (10), thru the compressor (9), then launched warmth to water within the warmness trade tank (11). The warm water released warmth to the air out of doors by air-cooled cycle inside the Condenser (12). The water heater mode: take a look at valve (four) and valve (1) had been closed, and check valve (five) and valve (2) were opened. The refrigerant won warmness from condenser (12) out of doors, via the compress (nine), then released heat to water in the heat trade tank (eleven) for decent- water offering. The refrigeration and water heater mode: test valve (five), valve (2) and water pump (eight) have been closed; take a look at valve (five) and valve (2) had been opened. The refrigerant gained heat from the Evaporator indoor (10), thru the compressor (9), then launched warmness to water within the warmth alternate tank (11) for hot-water offering.

3. Research methods

1 & 2-Valve; 3- Expansion Valve; 4, 5-Check Valve; 6, 7-Accumulator; 8-Water Pump; 9-Compressor; 10-Evaporator; 11- Heat Exchange Tank; 12-Condenser.

Unit Specifications:

Table.1 The main experimental device of the system

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- Hermetic Compressor: Cooling Capacity: 2150/4298Watts, Power Input: 1050/1487Watts, Lock Rotor Amps: 35/35Amps, Rated Load Amps: 4.9/6.8Amps, COP: 2.05/2.89Watts/Watts
- Evaporator: Flow Number: 4, Air Output: ≥800m3/h, Condenser: Flow Number: 6
- Water Pump: Rated Head: 4m, Maximum Head: 5.5m, Rate Flow: 14L/min, Maximum Flow: 30L/min, Power Input: 100Watts
- Thermostatic Expansion Valve, Water Tank Water Capacity: 80L

Research Procedure

A properly-prepared instrumentation machine is deployed to degree various houses of the running process in three modes, along with temperature, stress, mass flux. The different water-inlet fluxes are set for each run of the test. Especially, there are two experimental techniques in Water Heater Mode, as Static Heating (Water heated temperature works up to set temperature in natural convection, by way of direct contact or indirect contact of water and heat exchanger) and Disposable Heating (Water heated temperature works up to set temperature through as soon as warmness alternate of cold water and warmth exchanger). The experiments are carried out below heating and air conditioning widespread condition.

Table.2 Research analysis Parameters

- **System parameters:** Rated Refrigerating: 3500Watts, Rated Warm-water: 250L/h, Refrigerant: R134a, Refrigerant Charge: 2840g.
- **Standard Parameters:** Air-side Dry Bulb Temperature: 27℃, Air-side Wet Bulb Temperature: 19℃, Water-side Dry Bulb Temperature: 35 ℃ ,Water-side Wet Bulb Temperature: 24 ℃, Environmental Pressure: 101kPa, Water-inlet Temperature: 19℃

4. Results and discussion

A sequences of experiments has been completed on the system to evaluate the performance. The experimental results were discussed in different modes.

Cooling Mode

Fig.2 suggests the overall performance coefficients in refrigeration mode. There is an ascending in all performance coefficients, when the recalculating water drift is much less than 4.2kg/min. However, there's a reduction while the recalculating water float is extra than four.2kg/min. The discharge strain decreases with increasing recalculating water flow, because of decrease in water temperature. When the recalculating water float is 4.2kg/min, the ratio of discharge stress to suction strain is the minimal (Table.3). COP varies inversely because the ratio of discharge strain to suction stress, COP is the most while the recalculating water glide is four.2kg/min.

Table.3 The ratio of Discharge Pressure (PD) to Suction Pressure (PS)

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• **Recalculating Water Flow**:	2.03	2.56	3.09	3.62	4.15	4.47	4.79	5.28	5.77
• **PD/PS**:	7.16	7.31	7.5	4.67	3.25	4.33	6.5	6.25	6.0

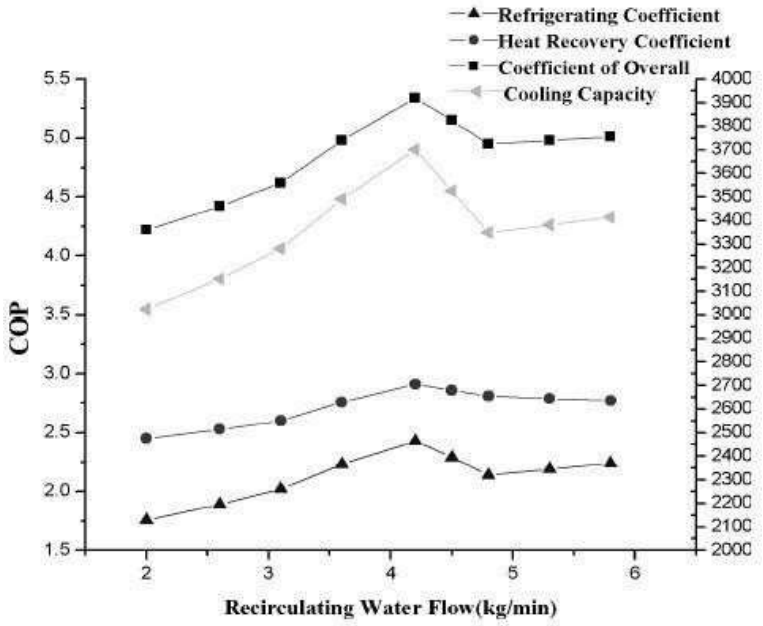

Fig.2 COP in Cooling Mode

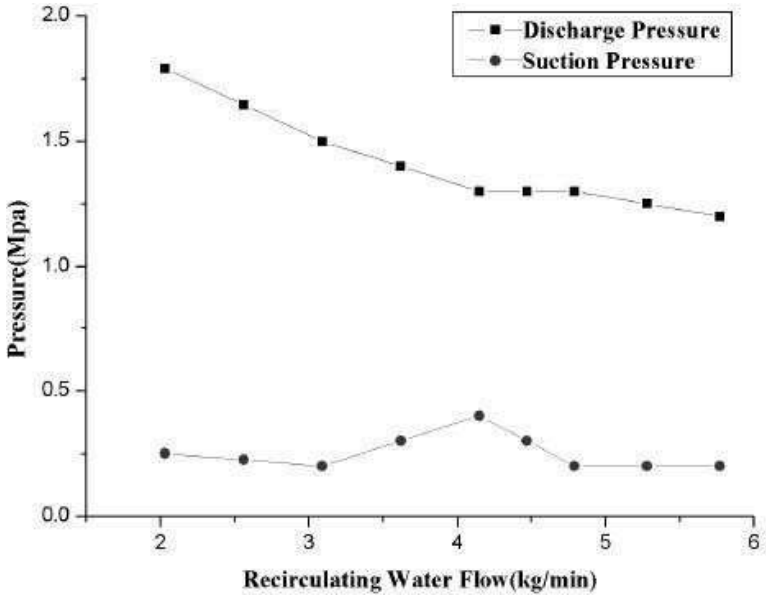

Fig 3 Pressure Variation in Cooling Mode

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Water Heating Mode

Fig.4 and five display water temperature and version in static heating. As showed within discern, water temperature ascends with time. 80L 19℃ water heated achieved set temperature of 55℃, the time is 18 minutes. The most COP, 6.4 is acquired at 8min and COP ascends earlier than 8min, keeps steady after 10min. This fashion may be attributed to the following elements. When the compressor began, there's a huge torque that is larger ate up power. Which result the low COP at beginning time. Then, the COP ascends with discharge pressure and discharge temperature ascending. Finally, heat exchange is steady, average COP keeps at 5. Seventy-eight. Table.4 indicates the performance parameters of the system in disposable heating. As seen within the desk 4, the COP is a long way decrease than the COP of the system by using static heating, as a result of disposable heating cost greater electricity than static heating.

Table.4 Performance Parameters of the system in Water Heater Mode

- Inlet Condenser Temperature = 84.71 ℃
- Middle Condenser Temperature = 39.94 ℃
- Outlet Condenser Temperature = 15.65℃
- Discharge Temperature = 89.65 ℃
- Suction Temperature = 16.74℃
- Outlet Water Temperature= 41.18 ℃
- Outlet Water Flow = 2.65 kg/min
- Discharge Pressure = 1.81MPa
- Suction Pressure = 0.33MPa
- COP = 2.55

Table.5 Performance Parameters of the system in Refrigeration and Water Heater Mode

- Outlet Water Flow Circulation=2.63 kg/min
- Air Volume=836.15m^3/h
- Outlet Water Temperature=42.14 ℃
- Cooling Capacity=3230.24 W
- COP (for Water Heater) =2.5
- COP (for Refrigeration) =1.9

Table.5 shows COP for water heater and COP for refrigeration are 2.5 and 1.9 at Refrigeration and Water Heater Mode. They both are low, due to the machine has to keep enough outlet water temperature and outlet water float. However, the COP of total device is 4.5, its miles greater than conventional single pattern system.

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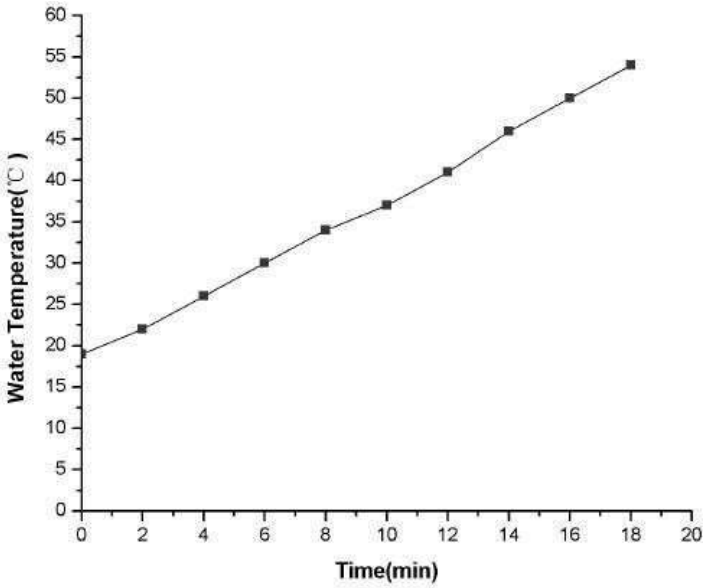

Fig.4 Water Temperature Variation in Water Heater Mode

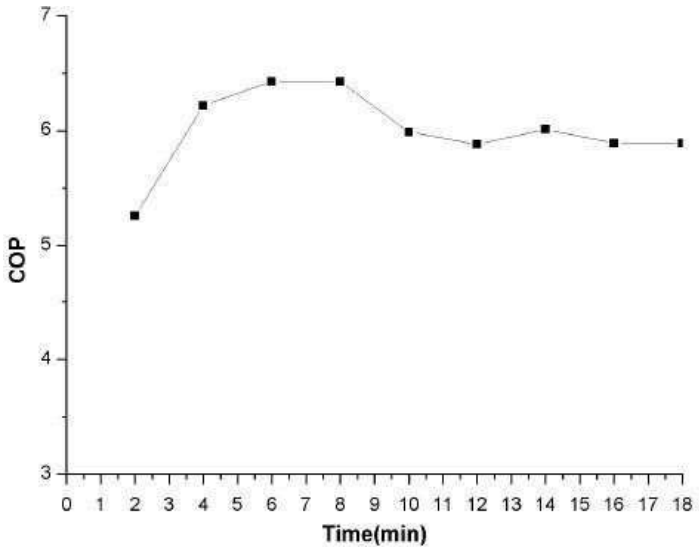

Fig.5 COP Variation in Water Heater Mode

5. Conclusion

A sequences of experiments were achieved to validate excessive effectiveness of the air con and heat- water providing blended warmth pump. Experiment results show that that the device is extra effective than traditional structures, the maximum coefficient of overall performance (COP) is about 5.3 at refrigeration mode, the COP is 5.7 at static heating mode of heating, and the COP is 4.5 at refrigeration and water heater mode.

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