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The Exploration on the Energy Saving Potential of an Innovative Dual-temperature Air Conditioner and the Mechanism of the Theoretical Mixed Refrigeration Cycle

1 Introduction

The paper focuses on refrigeration systems of room air–conditioners.

What's the shortcoming of the conventional air conditioner?

- Obvious draft sensation;
- The non-uniform temperature distribution, large gradient distribution of vertical temperature;
- low thermal comfort.

1 Introduction

How to solve the problems encountered ?

- The above problems could be solved by the radiation cooling air condition system.
- The cooling load of the room is divided into sensible and latent cooling loads.

dry fan coil units

1 Introduction

But the independent temperature and humidity control air conditioning system still has some problems for small refrigeration system.

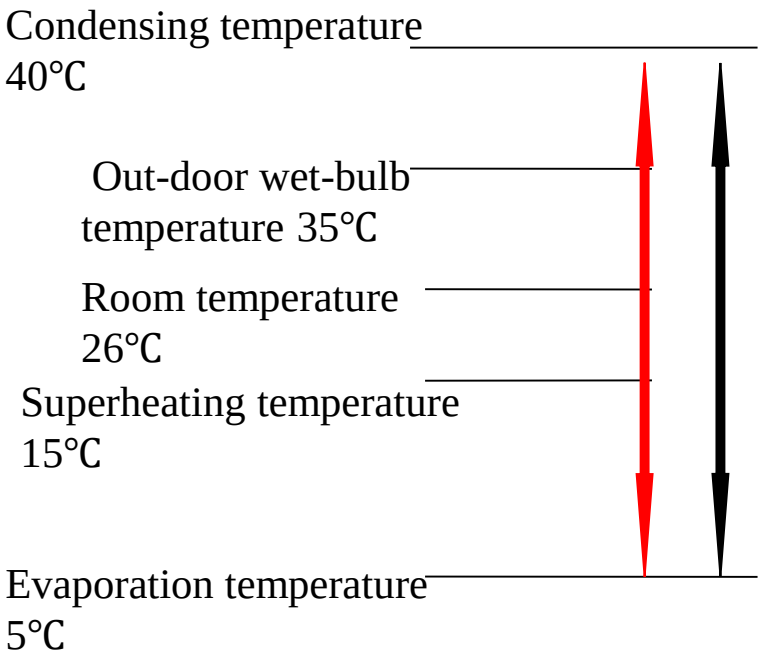
- The energy efficiency of small radiation cooling air conditioner system is not obvious.
- The indoor air temperature distribution in rooms with radiant cooling is more comfortable and less energy consumption.If the radiant cooling can be supplemented by a fresh air supplying system, it may even improve the indoor air quality.
- Water is usually used as the medium in conventional air conditioning systems. The heat exchange between refrigerant and the chilled water may cause secondary loss.

1 Introduction

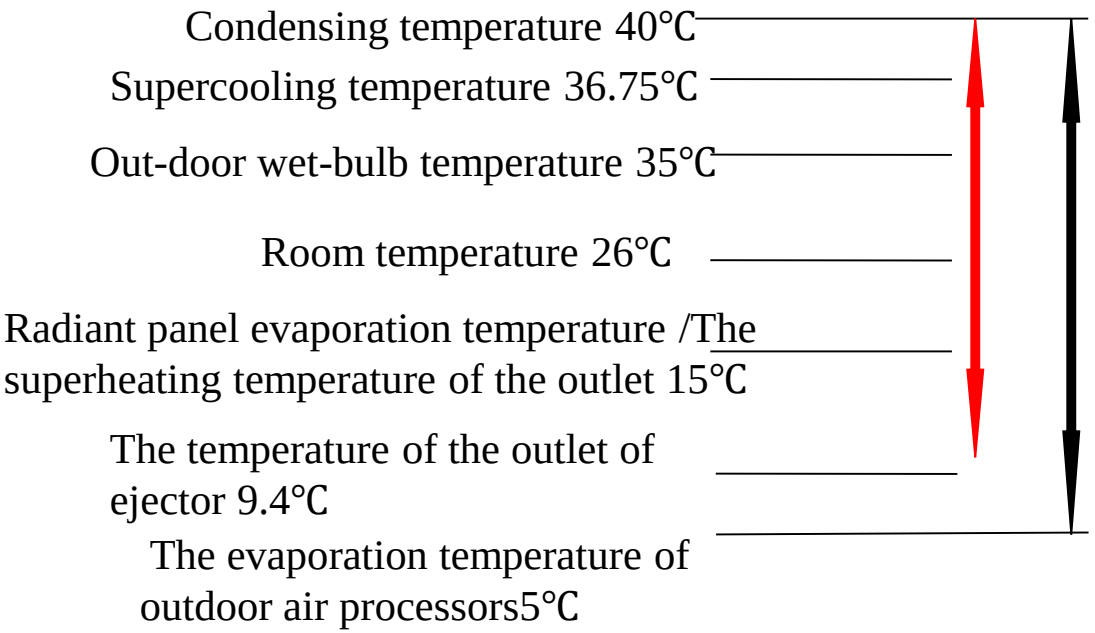
➢The secondary heat loss is an obvious shortcoming of the radiation air conditioner. However, energy losses caused by secondary heat transfer leave more room for the whole system performance to be improved if they can be avoided.

➢An innovative dual-temperature air-conditioner and the corresponding theoretical refrigeration cycle were proposed.

1 Introduction



The temperature schematic diagram of cooling dehumidification for summer of conventional air conditioning (cryogen type)

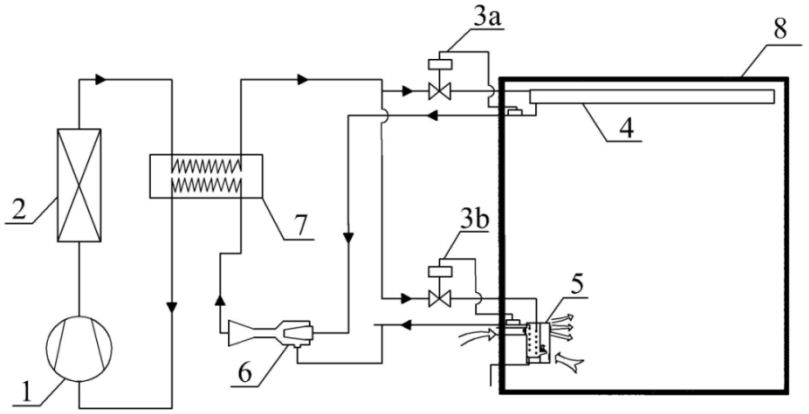


The temperature schematic diagram of cooling dehumidification for summer of dual-temperature air conditioner

➢That is ,using evaporator or condenser as the radiation panel to avoid the secondary heat loss.

2 The comparison and analysis between systems

2.1 Mechanism and system pattern of the innovative dual-temperature room air conditioner



1.Compressor 2.Condenser 3a/3b.thermal expansion valve 4.Metal radiant panel 5.Air Processor 6.Ejector 7.Regenerator 8.Room

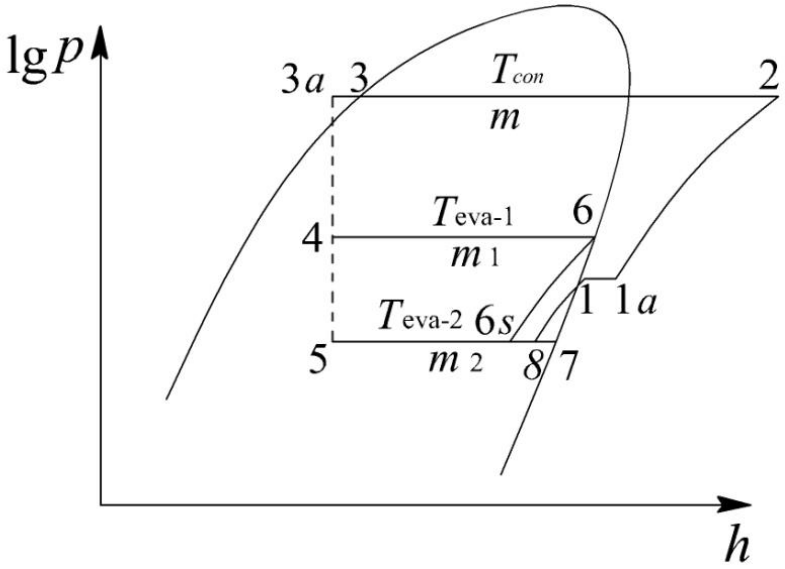


Fig2.1 Schematic of the dual-temperature air conditioner and the corresponding theoretical refrigeration cycle

2 The comparison and analysis between systems

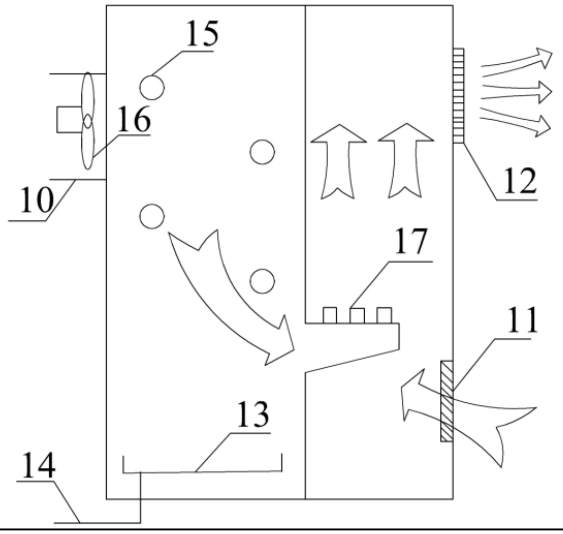
2.2 Operational States and Performance Analysis on the Dual-temperature Air Conditioner

2.2.1 Determination on the Ratio of the Load Shared by Two Evaporators and the Supply Air Parameters

An office of 40 m^2 in Xi'an was selected as an example.

- Cooling load shared by the radiant panel and the AHU(the air-handling unit) in the dual-temperature air conditioner is mainly decided by the sensible and latent cooling loads.

2 The comparison and analysis between systems



9.The outside air outlet 10.Return air 11.supply air outlet 12.Condensate drain pan 13.Condensate drain pipe 14.Evaporator coil 15.fan 16.Induction nozzle

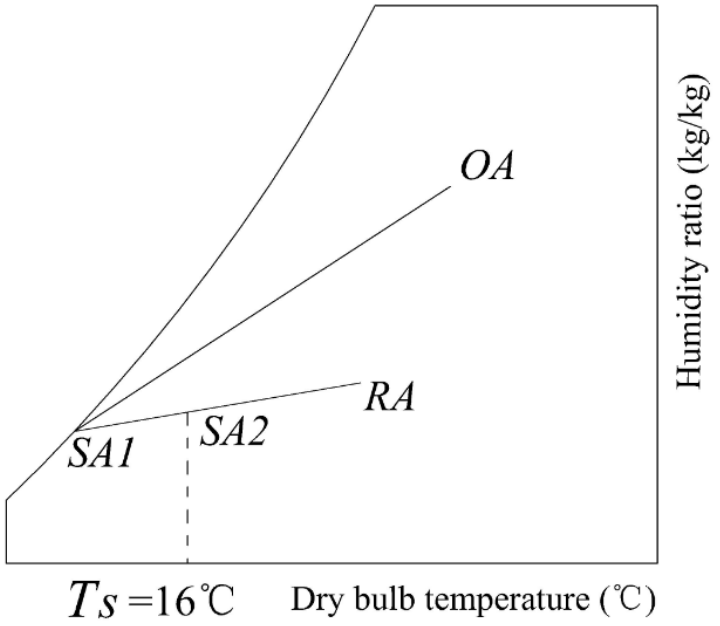


Fig2.2 Structure of the induction type fan coil and the *h-d* diagram of the air handling process

- The fresh air induces the indoor air and the temperature of the mixed air meets the requirement.
- The cooling capacity ratio of the chilled panel and the AHU should be 3:2 at the rated condition.

2 The comparison and analysis between systems

2.2.2 Analysis on the Theoretical Refrigeration Cycle of the Dual-Temperature Air-Conditioner

The model assumes that:

- The pressure loss along flow pipes, in the condenser and evaporators, etc. are neglected.
- The refrigerant leaving the condenser and the evaporator are deemed as saturated liquid and saturated vapor, respectively.
- The refrigerant is in quasi-equilibrium state and the processes occurring in the ejector are idealized neglecting various losses. The acceleration and the diffusion process in the ejector are deemed as isentropic, which can make use of the energy to its advantages.

2 The comparison and analysis between systems

- The pressure of the refrigerant leaving the nozzle in the ejector drops to the low evaporation pressure and mixes with the refrigerant induced from the evaporator of low evaporation pressure at constant pressure.

- The kinetic energies of the refrigerant entering the nozzle, leaving the evaporators and the ejector are neglected.

❖By using the software REFROP8.0,

❖The characteristic states of dual-temperature air conditioner could be obtained.

2 The comparison and analysis between systems

Table 1 Refrigerant properties of the characteristic states in the theoretical dual temperature refrigeration cycle

State Point	Pressure /MPa	Temp./℃	Enthalpy/kJ/kg	Entropy/ kJ/（kg·K）
1	0.64833	9.4	408.81	1.7418
1a	0.64833	15	413.12	1.7569
2	1.5336	60.32	435.12	1.7569
3	1.5336	40	249.65	1.1665
3a	1.5336	36.75	245.33	1.1526
4	0.78931	15	245.33	1.1582
5	0.58411	5	245.33	1.1629
6	0.78931	15	410.16	1.7302
6s	0.58411	5	403.12	1.7302
7	0.58411	5	406.85	1.7436
8	0.58411	5	406.34	1.7418

2 The comparison and analysis between systems

For the dual-temperature refrigeration cycle,

$$COP = \frac{\dot{Q}_1 + \dot{Q}_2}{W}$$

It may reach 7.43 ideally.

2 The comparison and analysis between systems

2.3 Operational states and performance analysis on conventional air-conditioner

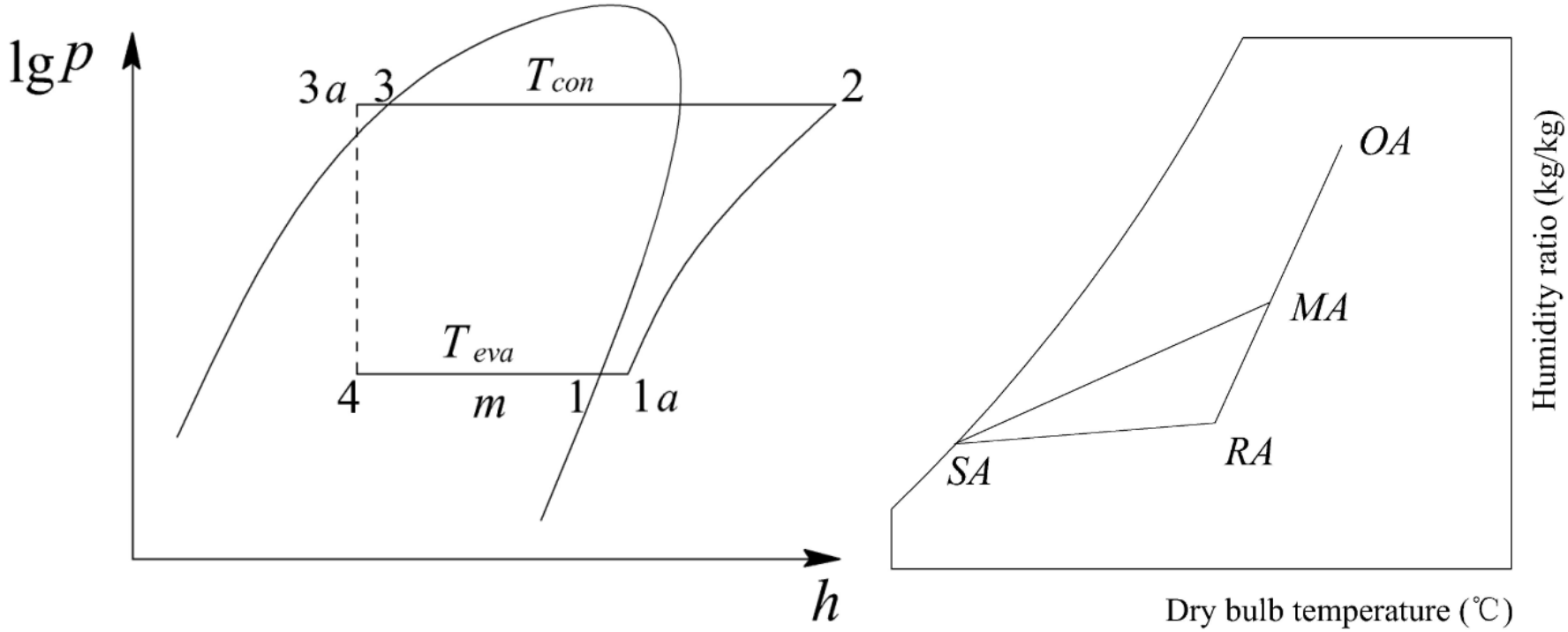


Fig.3 Theoretical refrigeration cycle of the conventional air conditioner with fresh air and the *h-d* diagram of the air handling process

2 The comparison and analysis between systems

Table 4 Refrigerant states properties in the theoretical refrigeration cycle of a conventional air conditioner

State Point	Pressure/MPa	Temp./℃	Enthalpy/kJ/kg	Entropy /kJ/(kg.K)
1	0.58411	5	406.85	1.7436
1a	0.58411	15	414.38	1.7702
2	1.5336	65.42	439.59	1.7702
3	1.5336	40	249.65	1.1665
3a	1.5336	34.29	242.12	1.1422
4	0.58411	5	243.04	1.1547

the COP of the theoretical refrigeration cycle is:

$$COP = \frac{h_1 - h_4}{h_2 - h_1} \approx 6.53$$

2 The comparison and analysis between systems

2.4 Comparison of the performance of the two types of the air-conditioners

(1) The draft sensation and the noise can be weakened. And the indoor thermal comfort can be improved by radiant cooling, compared with that produced by the conventional room air conditioner.

(2) The suction pressure of the theoretical refrigeration cycle of the dual-temperature air conditioner improves to be 0.6483MPa from 0.5481MPa.

(3)The pressure ratio of the compression process reduces by 9.94%. And the power consumption decreases from 0.770kW to 0.677kW as the result, neglecting the fan power. The COP of the theoretical refrigeration cycle improves by 13.73% to be 7.43.

3.The next step :

- For radiation panel : ascertain parameters of radiation panel such as :sizes, material, tube spacing , etc.
- For air handling unit : the parameter of the AHU changes with the load.
- The ejector design on the variable condition.
- Design and develop the appropriate products.


Thank You