International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 12 Issue 3 ǁ March 2024 ǁ PP. 202-207

A Simulation Model for Series Double Evaporation Temperature Air Conditioning Units Using Simulink

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Abstract
This article studies a dual evaporative temperature air conditioning system with air ducts connected in series, in order to promote the process of temperature and humidity decoupling regulation in direct expansion air conditioning systems. The dual evaporator temperature air conditioning system can achieve higher cooling capacity under lower energy consumption conditions, and the dual evaporator can more conveniently and reasonably handle temperature and humidity, obtaining a larger adjustment range. This article explores the adjustment range of temperature and humidity decoupling regulation by adjusting the air supply fan and compressor to change the air supply volume and refrigerant flow rate through the two evaporators, thereby changing the characteristics of the system's refrigeration conditions, such as the refrigeration output TCC of the unit and the sensible heat ratio ESHR of the equipment. This article conducts research through two aspects. On the one hand, it renovates the previous double evaporative temperature air conditioning experimental platform to study the operational characteristics of the system under actual conditions; On the other hand, using Matlab to establish mathematical models for system simulation and deeper research.
Keywords: *Double evaporation temperature; Device sensible heat ratio; Refrigeration capacity; Model*

Date of Submission: 05-03-2024 Date of acceptance: 18-03-2024

I. CONTRODUCTION

In buildings, indoor temperature and humidity are important indicators of indoor air quality. Whether they are too high or too low is crucial for the human body's heat and comfort, as well as indoor storage. Therefore, controlling indoor temperature and humidity within an appropriate range is of great significance[1-4]. Direct expansion air conditioning systems, as the main equipment for air cooling and dehumidification, are widely used in the air conditioning industry due to their simple structure and convenient application. The requirements for sensible and latent heat treatment of direct expansion air conditioners vary under different environmental conditions. Therefore, it is necessary to adjust and handle different sensible and latent heat requirements for direct expansion air conditioners. Establishing a steady-state simulation model for direct expansion air conditioning can help researchers explore the effects of changing the supply air volume and compression frequency of the evaporator on the operational performance (sensible heat, latent heat) of the air conditioning system in a series double evaporative temperature air conditioning system, as well as the impact of changing the heat transfer area on system performance.

II RESEARCH MODEL BUILDING

This simulation is to model a series double evaporator air conditioning system on the MATLAB platform. Calculation models for refrigerant and air properties, as well as models for the four major components of refrigeration systems [5], According to the algorithm flowchart 3.7 of the series double evaporation temperature air conditioning system, build the system.

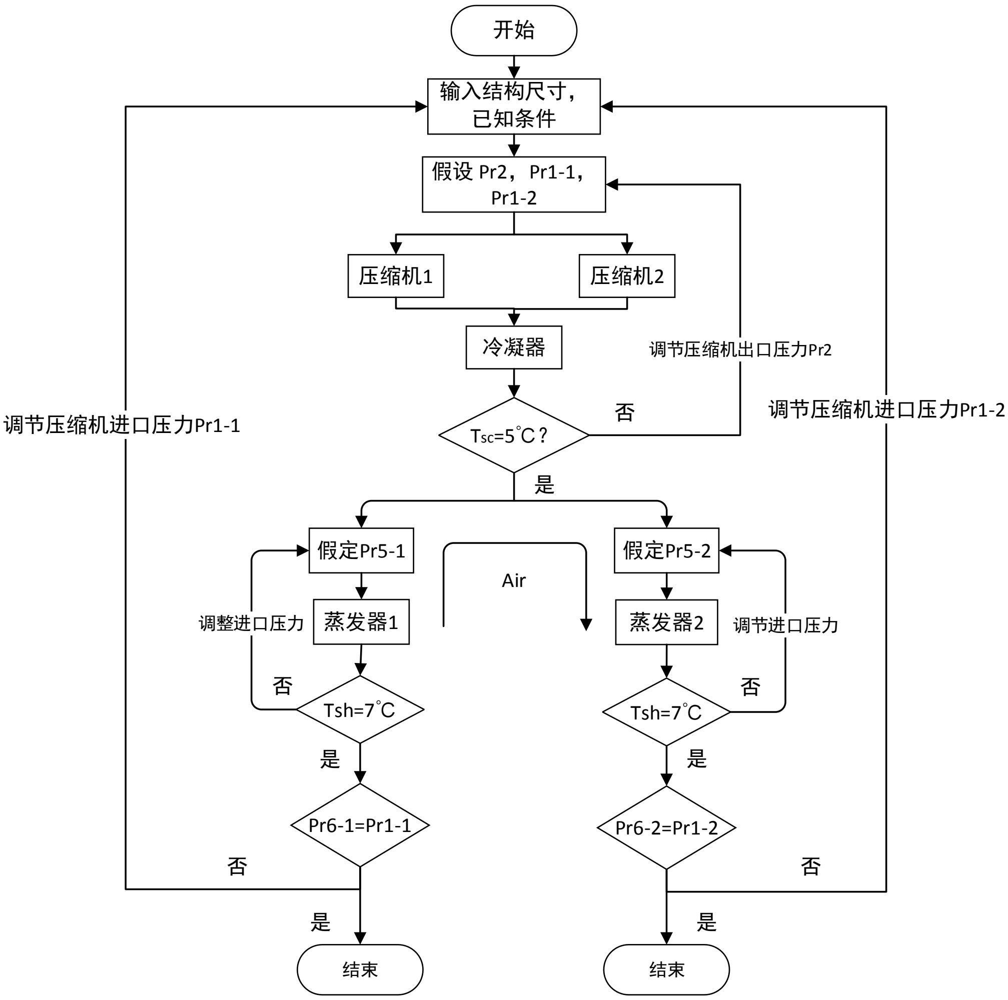

Figure 2.1 Algorithm flow of series double evaporation temperature air conditioning system

The specific process of the algorithm is as follows：

1) Input the structural parameters of condenser, evaporator 1, evaporator 2, and compressor, as well as the inlet air parameters of condenser and evaporator 1. As the air ducts are connected in series, the inlet air parameters of evaporator 2 are the outlet air parameters of evaporator 1;

2) Assuming the inlet pressures Pr1-1 and Pr1-2 of the compressor and the inlet enthalpy value hr1, determine the refrigerant parameters at the compressor inlet, and assume the outlet pressure Pr2 of the compressor (inlet pressure of the condenser);

3) After calculating the compressor, obtain the refrigerant parameters at the inlet of the condenser, and then perform the condenser calculation to output the refrigerant and air parameters at the outlet of the condenser；

4) Compare the subcooling at the outlet of the condenser with the set subcooling of 5 ℃. If the error is within the allowable range, turn to 5). Otherwise, adjust the assumed condensing pressure Pr2 and turn to 3)；

5) Due to the presence of a dual evaporation temperature compressor, the evaporation pressures of evaporator 1 and evaporator 2 are different; Assuming the refrigerant inlet pressure of evaporator 1 and evaporator 2;

6) Determine the refrigerant parameters at the inlet of evaporator 1 based on the inlet flow rate, pressure, and enthalpy value (enthalpy value at the outlet of the condenser), enter the evaporator 1 module for calculation, and output the refrigerant and air parameters at the outlet of evaporator 1; Compare the outlet pressure of evaporator 1 with Pr1-1, and if the error is within the allowable range, turn to 7); Otherwise, adjust the assumed inlet pressure of evaporator 1 and turn to 6);；

7) Determine the refrigerant parameters at the inlet of evaporator 2 based on the inlet flow rate, pressure, and enthalpy value (enthalpy value at the outlet of the condenser), enter the evaporator 2 module for calculation, and output the refrigerant and air parameters at the outlet of evaporator 2. Compare the outlet pressure of evaporator 2 with Pr1-2, and if the error is within the allowable range, turn to 8); Otherwise, adjust the assumed inlet

pressure of evaporator 2 and turn to 7); ;

8) Output results

III SIMULATION EXPERIMENT PROCESS

In the enthalpy difference laboratory, the air enthalpy difference method is used to test the operational performance of air conditioning units. The enthalpy difference laboratory is often used to measure the refrigeration or heating conditions of air conditioning units, and is commonly used to provide certain environmental conditions such as temperature and relative humidity; The enthalpy difference laboratory is mainly composed of two independent rooms, an indoor operating room and an outdoor operating room, which can simulate the indoor and outdoor environment required by the unit[6]. The enthalpy difference laboratory is mainly composed of room enclosure structure, air conditioning system, air temperature and humidity sampling system, air volume measurement device, measurement control system, etc. The schematic diagram of the enthalpy difference laboratory is shown in Figure 3.1.

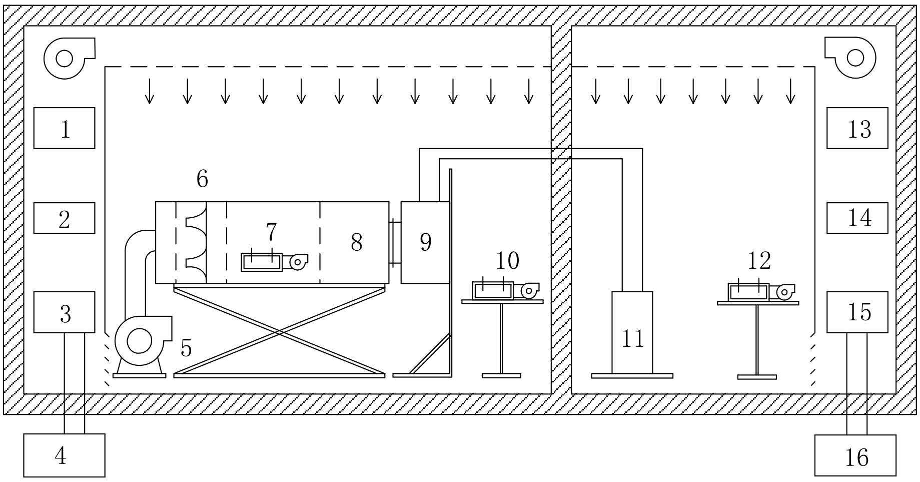

Figure 3.1 Schematic diagram of enthalpy difference laboratory system

1-Indoor side humidifier	2-Indoor side heater	3-Indoor side evaporator
4-Indoor side refrigeration unit	5-Induced draft fan	6-nozzle
7-Measurement of body temperature and humidity	8-static pressure box	9-Indoor unit of the tested machine
10-Indoor side temperature and humidity measurement	11-Tested outdoor unit	12-Outdoor temperature and humidity measurement
13-Outdoor humidifier	14-Outdoor side heater	14-Outdoor side evaporator
16-Outdoor refrigeration unit		

Select an experimental condition for experimental exploration. Based on the design status of outdoor high temperature conditions in the Shanghai area, the inlet dry bulb temperature of the double evaporation temperature test bench is determined to be 34.6 ℃ and the relative humidity is 62%. Therefore, the indoor environment conditions of the enthalpy difference chamber are set to have a dry bulb temperature of 34.6 ℃ and a wet bulb temperature of 28.2 ℃.

Under the experimental conditions, the stable indoor environmental conditions remain unchanged, and the air volume settings of the dual evaporation temperature test bench are 400 meters respectively ^{3}/ h. 600 m ^{3}/ h. 800 m ^{3}/ h. 1000 m ^{3}/ h. The compressor frequencies are 30Hz, 40Hz, 60Hz, 80Hz, 100Hz, and 120Hz, respectively. For 24 different sets of air supply values and compressor frequencies, the fan speed and compressor control cabinet are adjusted to meet the requirements of 24 different data sets; At the same time, by adjusting the opening of the electronic expansion valve, the superheat of both suction ports of the dual evaporation temperature compressor is ensured to be 5 ℃.

When the temperature fluctuation range of the wet and dry bulb inside the enthalpy difference chamber is within 0.1 ℃, it can be considered that the double evaporation temperature test bench operates stably under this experimental condition. At this time, data is collected through LabVIEW software, once every 30 seconds, for a collection time of 15 minutes. The collected data is recorded, and the average value is taken for error reduction processing.

Using the simulation system model of series double evaporation temperature air conditioning established in Chapter 3, explore the impact of compressor frequency and air supply volume changes on the performance of air conditioning units. When the structural size parameters of the simulated air conditioning components and the test bench components are set to be the same, the inlet air state parameters of the high-temperature evaporator are set to a dry bulb temperature of 34.6 ℃ and a relative humidity of 62%. The inlet air state parameters of the low-temperature evaporator are set to the outlet air state parameters of the high-temperature evaporator, and the overheating degree of the high-temperature evaporator and the low-temperature evaporator are both set to 7 ℃. The other system parameters are consistent with the steady-state experimental unit parameters under experimental conditions. In the simulation of experimental conditions, the supply air volume values are divided into four groups (400m) ³/ h. 600m ³/ h. 800m ³/ h. 1000m ³/ h) The compressor frequency values are divided into 6 groups (30Hz, 40Hz, 60Hz, 80Hz, 100Hz, 120Hz), totaling 24 sets of simulated data. Produce a two-dimensional coordinate map of the cooling capacity TCC and sensible heat cooling capacity based on the obtained simulation data.

IV CONCLUSION

From Figure 4.1, it can be seen that changing the air supply volume and compressor frequency on the air side has a similar effect on the operational performance of the double evaporation temperature test bench as the experimental results. The cooling capacity TCC and sensible heat cooling capacity of the test bench vary with the same pattern as the experimental results, and will not be repeated. Among them, at a supply air volume of 1000m ³/ h. When the compressor frequency is 120Hz, at point A 'in the figure, the simulated total cooling capacity TCC reaches its maximum value, which is 12.44KW. At this time, the sensible heat cooling capacity reaches its maximum of 4.69Kw; At a supply air volume of 400m ³/ h. When the compressor frequency is 120Hz, i.e. point B 'in the figure; At a supply air volume of 400m ³/ h. When the compressor frequency is 30Hz, at point C 'in the figure, the simulated sensible heat cooling capacity reaches the minimum of 1.6Kw, and the simulated cooling capacity is the minimum of 3.98Kw; At a supply air volume of 1000m ³/ h. When the compressor frequency is 30Hz, that is, point D 'in the figure. The adjustment range of cooling capacity TCC is 8.46KW, and the adjustment range of sensible heat cooling capacity is 3.09KW; The adjustment range of sensible heat cooling capacity is the largest in the small cooling capacity area, and the range from C 'to D' is 3.09Kw. As the cooling capacity increases, the adjustment range of sensible heat cooling capacity gradually decreases. At the maximum cooling capacity, the adjustment range of sensible heat cooling capacity is the smallest.

As shown in Figure 4.2, the 24 sets of data obtained from the experiment are concentrated in the irregular area formed by points A, B, C, and D on the two-dimensional coordinate map of cooling capacity TCC and sensible heat cooling capacity. This area is the simulated operating area of the air conditioning unit under experimental conditions. The shapes of irregular regions A ', B', C ', and D' obtained through simulation are similar to the operating region ABCD shown in the experimental results, as shown in Figure 4.3.

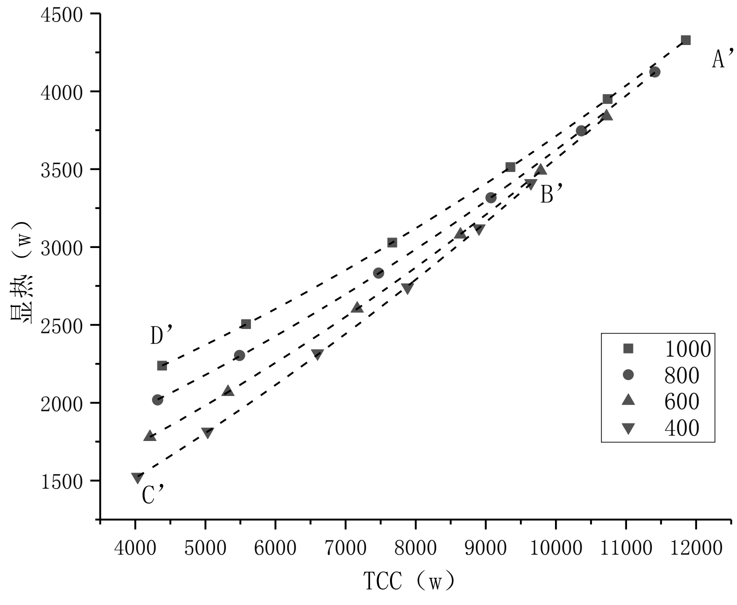

Figure4.1 Simulation results of a series double evaporative temperature air conditioning system under experimental conditions

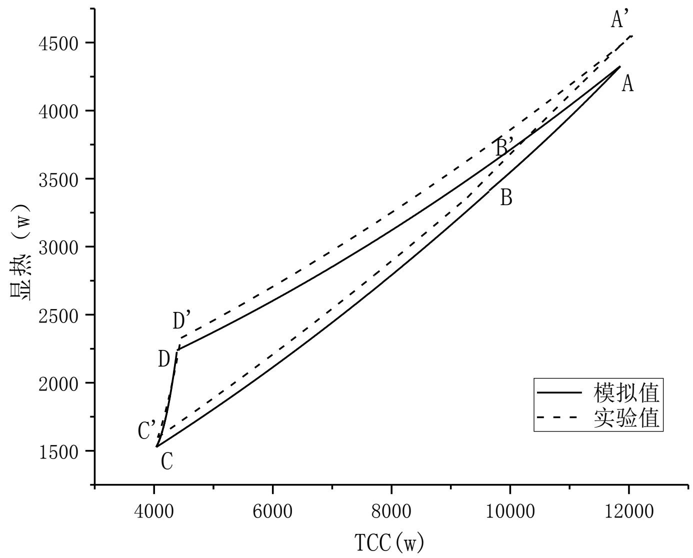

Figure4.2 Comparison between experimental data area and simulated data area under experimental conditions

Perform error analysis between the 24 sets of data obtained from steady-state experiments (cooling capacity TCC and sensible heat) and the simulated results, and check the accuracy of the model. Figure 4.3 shows the error values of 24 sets of experimental ESHR data and simulated ESHR data. The two error lines are plotted as a decrease of 5% and an increase of 1% in experimental ESHR data. Figure 4.4 shows the error values of 24 sets of experimental ESHR data and simulated ESHR data, and the error values of 24 sets of experimental data TCC and simulated data TCC. The two error lines are obtained by increasing the experimental TCC data by 5% and decreasing it by 5%, respectively. As shown in the figure, among the 24 sets of data, the simulated data TCC falls within the 5% error line of the experimental data TCC, and the simulated data ESHR also falls within the 5% error line of the experimental data ESHR. Therefore, the steady-state series double evaporation temperature air conditioning simulation system model established in Chapter 3 has certain accuracy.

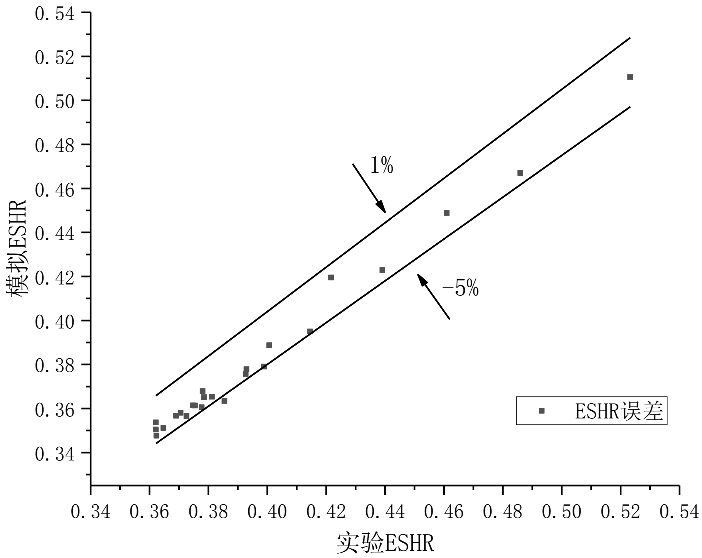

Figure4.3 Error values between experimental data ESHR and simulated data ESHR

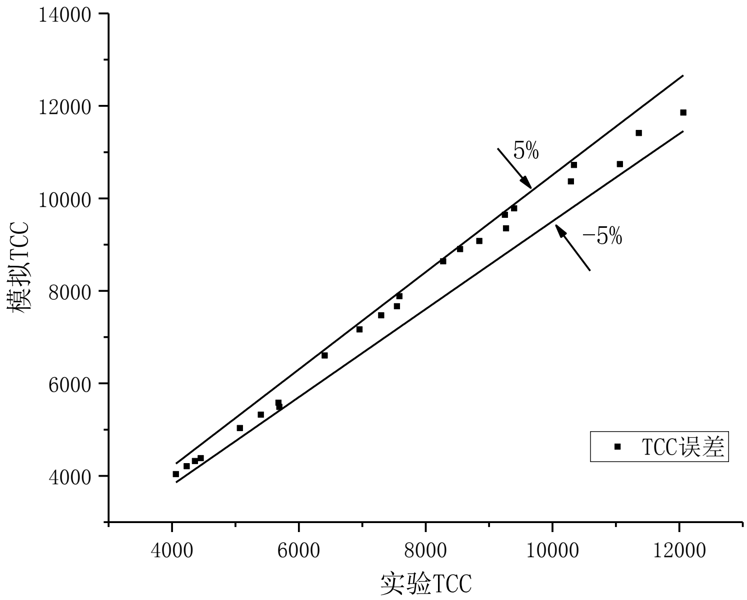

Figure4.4 Error value between experimental data TCC and simulated data TCC

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