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Design and Verification of a Constant Temperature and Humidity Air Conditioner for Wheat Green Feeding Incubator

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ABSTRACT
This paper designs a process air conditioner used in the wheat green feed cultivation container to keep the internal air state of the cultivation container stable near the temperature and humidity point suitable for the growth of wheat green feed. Computer modeling was carried out to study the airflow organization in the box. The simulation obtained the data of 15 measuring points in the box , and calculated the fluctuation of the data: the standard deviation between the summer temperature and the target set temperature of 28°C is 0.45, and the standard deviation between the relative humidity and the target set relative humidity of 75% is 0.70 ; the standard deviation between the winter temperature and the target set temperature of 28°C is 0.64, and the standard deviation between the relative humidity and the target set relative humidity of 75% is 1.14. From the results, it can be inferred that the air in the box of this system is evenly mixed, and the performance of controlling the temperature and humidity environment in the box to a state conducive to the growth of wheat is good, and the air state in the box fluctuates less with time.
Keywords: *Constant temperature and humidity; CFD simulation; Wheat green feed incubator*

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I. Overview

In order to ensure the stable and high-quality production of wheat green feed, advanced facility planting technology can be used to ensure its annual and regional production, save its planting costs, and maximize its output. Facility planting, also known as factory planting, is a cutting-edge planting technology currently used in various countries. It aims to give plants appropriate light, water and room temperature through technical means in small closed spaces such as containers or multi-storey buildings, and cultivate crops in large quantities.

In the greenhouse cultivation environment, scholars have studied the constant temperature and humidity control of the indoor environment by using the HVAC system: Bao Lingling et al. used the ground source heat pump air-conditioning system to control the indoor environment of the greenhouse at 20.0 ~ 25.0 ℃ to meet the high - grade Flower growth temperature requirements; Xu Guofeng et al. In order to improve the disadvantages of single greenhouse air-conditioning system , low equipment operation stability and low economy in severe cold areas, through the analysis of the annual temperature data in Harbin, they proposed a parallel system and a complementary system . kind of solution . It can be seen that the existing research is basically the design or improvement of the greenhouse air-conditioning system, and the temperature and humidity control accuracy is limited. Compared with greenhouse planting, facility planting has greatly increased planting density, and the dehumidification effect of crops leads to greater heat and humidity load; the dense placement of culture plates makes it more difficult to mix the air from the air conditioner with the air in the box, and it is easy to cause uneven airflow in the box , the phenomenon of heat accumulation and dampness. It can be seen that it is not appropriate to directly apply the greenhouse air conditioner to facility planting.

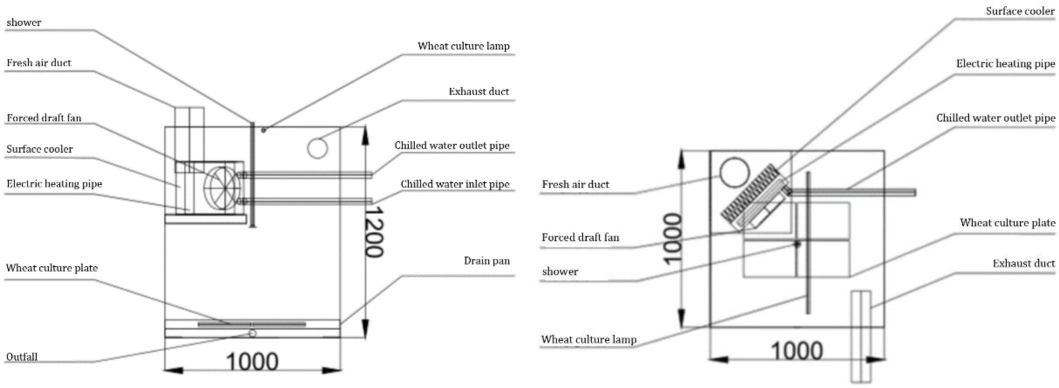
This paper designs a constant temperature and humidity air conditioning system specifically for a wheat green feeding cultivation container located in Shanghai . Aiming at the characteristics of plant concentration in the crop incubator, the size and characteristics of the heat and humidity load of wheat green feed were studied , which provided a follow-up research basis for the calculation of the load of the cultivation container; with the computer model verified by the test, the actual cultivation of crops in the chamber was simulated. The temperature, humidity and air velocity distribution of the air under certain conditions are used to verify the actual performance of the system.

II. Study on Heat and Humidity Load of Wheat Green Forage in Incubator

In this paper, a self-made small-scale wheat green forage incubator was used to conduct a scale test to study the heat and humidity load characteristics of wheat green forage during the actual incubator cultivation process, so as to obtain the heat and humidity load caused by crops in a unit space.

2.1 Design of small scale incubator

The incubator is located in Shanghai , the size of the box is 1.0m×1.0m×1.2m, the enclosure structure is 18mm double-sided aluminum foil sandwich foam insulation board (windproof aluminum foil paper + 18mm polystyrene foam board), and 40mm is left on the front of the box ×30mm observation port and a movable small door. Wherein, 4 wheat culture plates are placed in the center of the bottom of the incubator, and the size of each culture plate is 34cm×25cm. The systems that need to be set in the incubator include: sprinkler drainage system, supplementary light system, ventilation system, temperature control system, humidity control system and temperature and humidity measurement system. The schematic diagram of the incubator structure is shown in Figure 2.1.



(a) Front view (b) Top view

Figure 2.1 Schematic diagram of the structure of the wheat incubator

The working principle of each system in the incubator and the equipment used are as follows:

1. sprinkler drainage system

12V DC miniature water pump with a rated power of 30W is selected for water supply. The maximum flow rate of the pump is 0.1L/min and the maximum head is 15 m; the nozzle with an aperture of 0.8 mm is selected to achieve atomized spraying effect, and the spray diameter is 0.7-0.9 m; The time relay is used to control the start and stop of the water pump to realize the effect of automatically controlling the water spray time and water spray volume. At the bottom of the incubator, there is a water receiving tray with an inclination angle of 3° and a size of 1m×1m, which is used to discharge excess water during the spraying process and prevent wheat seeds from rotting after soaking in water for too long.

2. Fill light system

Choose a full-spectrum LED plant fill light with 15w power. The supplementary light has continuous spectrum, saturated color gamut, and high light efficiency, so it can ensure sufficient photosynthesis and normal growth process during crop cultivation, and is energy-saving and has a long service life.

3. ventilation system

The photosynthesis of crops can convert carbon dioxide in the air into their own organic matter, and in a hydroponic environment, carbon dioxide is the only carbon source for crops. Measured by the carbon dioxide concentration tester , when the incubator is closed and the crops are cultivated, the carbon dioxide concentration in the incubator is close to zero in about 400 seconds. The number of air changes per hour in the ejection box is 9 times, that is, the required fresh air volume per hour is 1 0.8 m ^{3}/h .

4. Temperature and Humidity Control System

In order to realize the constant control of the air temperature in the box, an electric heating tube is installed in the incubator to heat the air sent into the box after being processed by the air conditioning unit. The electric heating tube is connected to the PID controller , the PID controller is connected to the temperature sensor as the input, and the solid state relay controls the electric heating tube circuit on and off as the output to realize the automatic control of the temperature in the box.

The spraying system that supplies water to the crops leads to high relative humidity of the air in the box.

Therefore, the air in the box is cooled and dehumidified through the surface cooler, and the treated air is reheated through the electric heating tube to realize decoupling control of temperature and humidity. The air treatment adopts the primary return air method, part of the return air is directly discharged from the system, and the remaining return air is mixed with fresh air in front of the surface cooler for cooling and dehumidification treatment. The operating logic and air processing flow chart of the air source heat pump unit are shown in Figure 2.2 and Figure 2.3 :

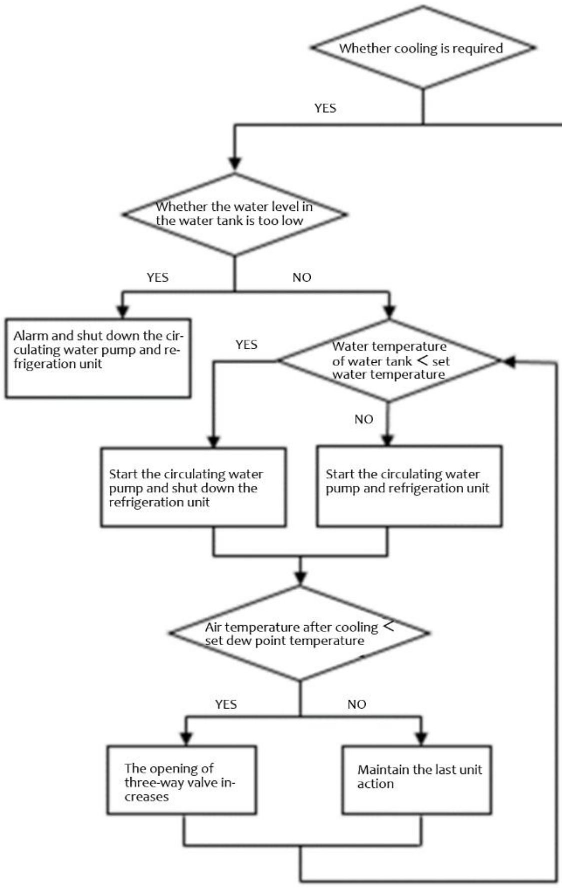


Figure 2.2 Logic diagram of cooling operation of air source heat pump unit

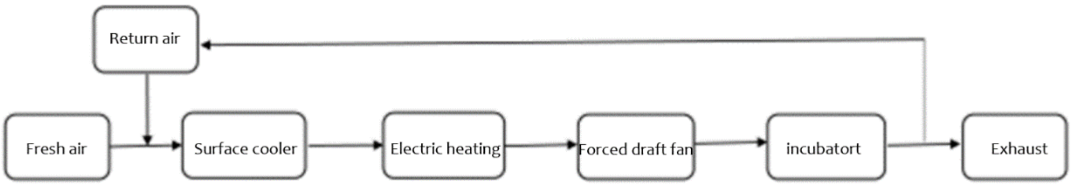


Figure 2.3 Flow chart of air treatment

2.2 Operating parameters and status of the incubator

The air temperature setting in the box is selected as the dry bulb temperature of 27 ℃ and relative humidity of 70 % , which are more suitable for crop growth. The sowing density of wheat cultivation was 0.88 kg /m ^{2} . The air temperature outside the box is taken as dry bulb temperature 3 0.4 ℃ and wet bulb temperature 2 8.2 ℃.

After the experimental system runs stably, the air state in the box is measured at intervals of 5 minutes, and a total of 10 sets of data are taken . The fluctuations obtained are shown in Figure 2.4 :

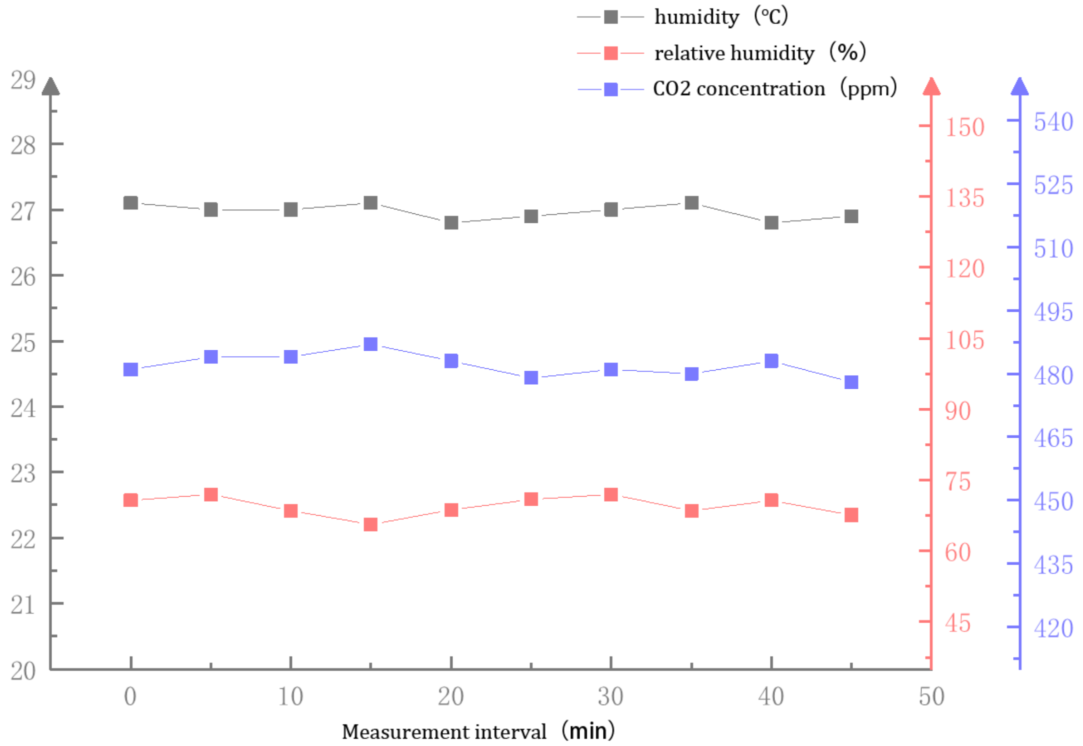


Figure 2.4 Curve of the air state in the box changing with time

It can be seen that the carbon dioxide concentration in the box fluctuates between 478ppm~487ppm , the fluctuation range is not large and is close to the outdoor air carbon dioxide content; the ambient temperature range is 26.8°C~27.1°C, the fluctuation range is only 0.3°C, and the relative humidity is 65.6 % ~ 72.0% fluctuations, the fluctuation difference is 6.4% . The temperature and humidity can be stabilized around the preset value with small fluctuations, and the system can meet the required temperature and humidity control requirements.

2.3 Calculation of heat and humidity load generated by wheat

The heat and humidity load generated during the wheat cultivation process is obtained by subtracting other types of cold loads and the reheating heat of the electric heating tube from the cooling capacity generated by the system. It is determined by calculation that when the sowing rate of wheat cultivation in this experiment is 0.88 kg/m^2, the heat dissipation of wheat is 12.4W/m^2, and the moisture dissipation is 5.6g/(h ·m^2).

III. Design and Verification of Air Conditioning System for Cultivation Container

Design the training container and its supporting system, including calculating the annual air-conditioning load in the container, proposing an air treatment plan, and optimizing the logic strategy of the air-conditioning system control. Finally, the computer model is used to verify the airflow organization in the box during the cultivation process to verify the effectiveness of the system.

3.1 Basic structure and equipment of training container

The green feeding container is smaller than a 40 - inch standard container, with a length, width, and height of 11.35m , 2.22m , and 2.30m , and is movable. See Figure 3.1 and Figure 3.2 for its basic structure :

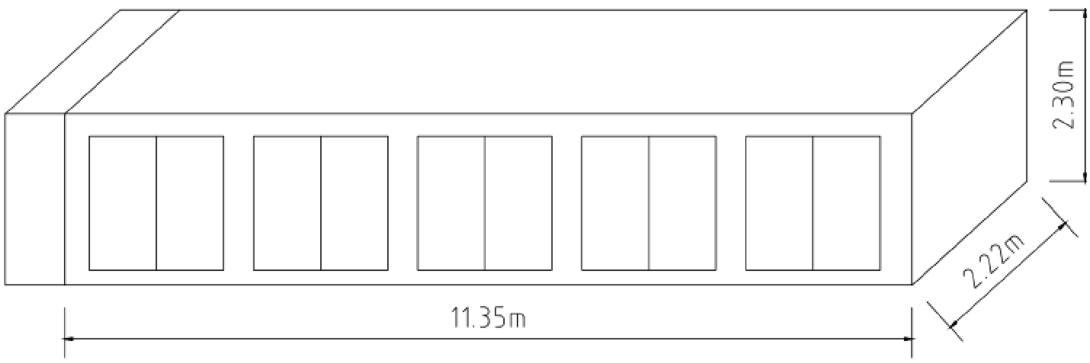
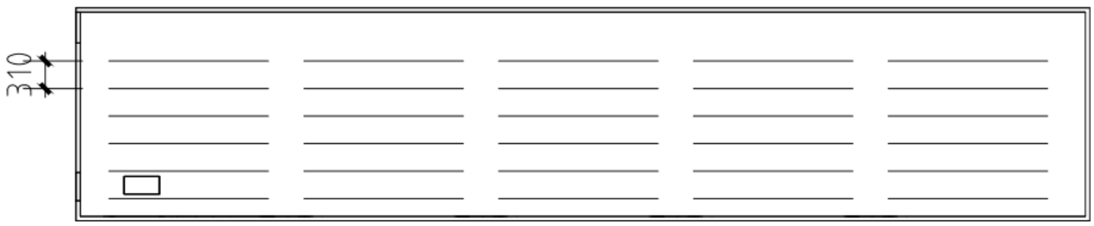
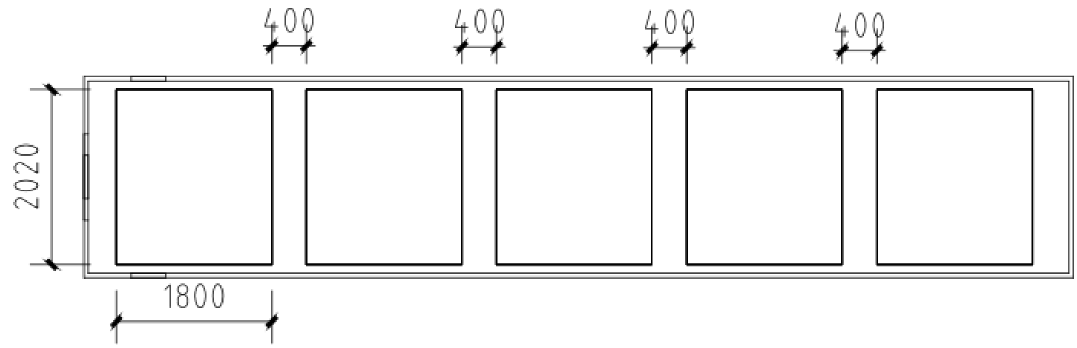


Figure 3.1 Schematic diagram of the size of the green feeding incubator



(a) Front view



(b) top view

Figure 3.2 Schematic diagram of the internal structure of the green feeding incubator

There are five movable doors on the wall of the box, and there are six layers of movable culture plates behind each door. There are 30 culture plates of 1.8m×2.02m in total , and the direct distance between the culture plates of the same layer is 0.4m . The spacing is 0.31 m. The outer protection structure is ordinary steel plate plus 50mm polystyrene foam board, and an additional layer of 50mm air insulation layer is added on the same top surface. It is set that 100kg of wheat seeds are cultivated on each batch and each culture plate in the cultivation container. In order to meet the needs of crop photosynthesis , there are 60 groups of LED lights in the box, and the lighting power of each group is 15W. In addition, the incubator is equipped with a nozzle to spray and irrigate the wheat. The spray flow rate is 10.8L/min, spraying for 2 seconds every 10s, and the spraying amount is 2600kg/day.

3.2 Air conditioning system design inside the box

3.2.1 System form and air treatment process

The air source heat pump is selected as the host of the cold and heat source, and the air in the box is processed by a return air method. Part of the return air is directly discharged out of the box, part of the return air is mixed with the fresh air before the surface cooler , and then the surface cooler is cooled and dehumidified to the dew point of the machine, and then reheated by the electric heating tube, and the supply air is treated to a suitable temperature. into the box, thereby realizing the decoupling control of temperature and humidity. Similarly, the treatment process of winter air is that the outdoor fresh air is directly mixed with the indoor return air, and then heated by a surface heat exchanger to reach the air supply state point, and finally the air sent into the incubator is blown into the incubator along the heat-humidity ratio line. The air is treated to the target set temperature and humidity.

3.2.2 Load calculation

According to the thermal parameters of the container envelope, the setting state of the indoor air and the calculation parameters of the local outdoor air, the specific values of the sensible heat and latent heat cooling loads in the container in summer are calculated as shown in Table 3.1 :

Table 3.1 Summary of Cooling Load of Green Feed Cultivation Containers

design object	Indoor sensible heat and cooling load/kW	Indoor latent heat cooling load/kW	Total indoor cooling load /kW	Fresh air cooling load/kW	Total cooling load in summer/kW
Green feeding container	3.05	6.81	9.86	6.24	16.1

The specific values of the heat load of the air conditioner in winter are shown in Table 3.2 :

Table 3.2 Summary of heat load of green feed cultivation container

design object	Heat consumption of exterior wall/kW	Roof heat consumption/kW	Ground heat consumption/kW	Heat consumption of outer door (with cold air intrusion)/kW	Fresh air heat consumption/kW	Total heat load/kW
Green feeding container	1.03	0.45	0.45	0.40	13.8	16.13

The specific values of various wet loads in the box are shown in Table 3.3 :

Table 3.3 Summary of wet load of green feeding container

design object	Water surface dehumidification wet load kg/h	Spray mist wet load kg/h	wheat moisture load kg/h	new rheumatic load kg/h	total moisture load kg/h
Green feeding container	8.677	0.710	0.610	2.503	12.5

Taking the above-mentioned compliances as the calculation basis, combined with relevant standards and documents, the relevant parameters such as air supply, cooling, and heating capacity of the corresponding functional segment are calculated, as shown in Table 3.4 :

Table 3.4 Basic parameter list

Condition	parameter name	value
summer	Air volume G_s	2465.7kg/h
	Fresh air volume G_o	260.8kg/h
	Return air volume G_r	2204.9kg/h
	Cooling capacity Q	16.1kw
	Reheat Q_o	3.5kw
winter	Air volume G_s	2465.7kg/h
	Fresh air volume G_o	984.3kg/h
	Return air volume G_r	1481.4kg/h
	Heating capacity Q	16.2kw

3.2.3 Airflow organization and unit selection

According to the characteristics of the internal load of the training container, as well as the technical characteristics of the constant temperature and cleanliness requirements of the system, the air supply form initially adopts the combination of top air supply and side air supply, and the way of return air from the lower side, as shown in Figure 3.3 As shown, the air outlet in the red box is the air supply from the top, and the blue box is the air supply from the side of the downpipe arranged against the side wall. This method can well ensure the uniform air distribution between the culture plates in the box. sex.

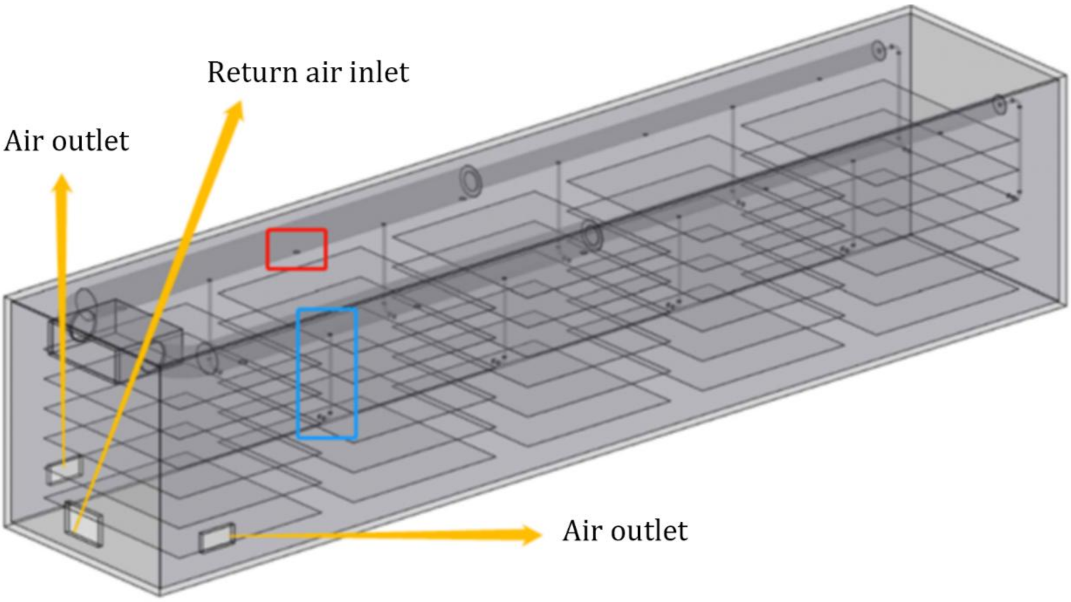
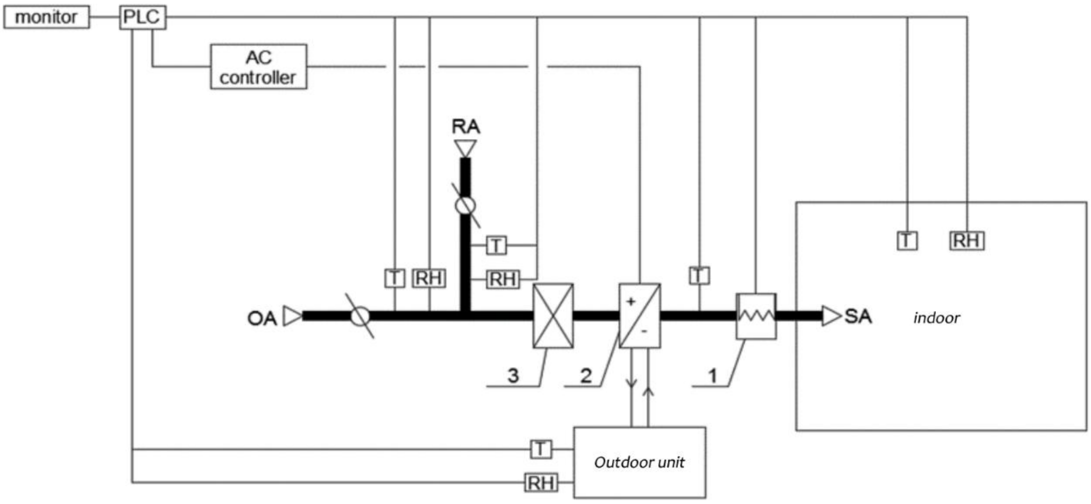


Figure 3.3 Three-dimensional model diagram of the incubator tuyere layout

3.3 Air conditioning system operation control logic

The system sets the air state parameters in the system input box through the human-computer interaction interface of the electronic display screen, and then adjusts the electronic components in the system through the logic control written in the PLC controller, so that the air temperature of the air-conditioning system reaches the set value. Target. In the system, the air-processing surface cooler is directly connected to the air-cooled heat pump host, and directly contacts the refrigerant for heat transfer. Therefore, the control requirements of the system are mainly for the operation control of the air source heat pump host and the air circulation system fan in the system. The control schematic diagram of the system is shown in Figure 3.4 .



1 Electric heating 2 Surface heat exchanger 3 Mixing unit
Figure 3.4 Schematic diagram of air conditioning system control

IV. Simulation research on flow field and temperature field in the box

In the case of no crop cultivation in the box, an actual experiment was carried out to obtain the temperature field distribution data in the box after the system ran stably. Then, the structural model of the cultivation container was established, and the environmental parameters and system setting parameters of the experiment were input to simulate the airflow organization in the box. The obtained temperature field data are compared with the measured results to verify the accuracy of the model. Finally, this validated model was used to simulate the airflow organization during crop cultivation in the research chamber.

4.1 The actual measurement of the airflow in the box after the system runs stably

The observation plane is selected as the vertical plane of 1/2 width of the cultivation container, and 15 measuring points are selected on the observation plane. The selected observation plane and the positions of the measuring points are shown in Figure 4.1. It can be seen from the figure that the 15 measurement points can be divided into 3 groups. The 1-5 measurement points of the first group are vertically distributed in the midpoint of every two culture plates in the first row of culture plates, and the 6-10 measurement points of the second group The points are vertically distributed at the midpoint of every two culture plates in the third column, and the 11-15 measuring points of the third group are vertically distributed at the midpoint of every two culture plates in the fifth column .

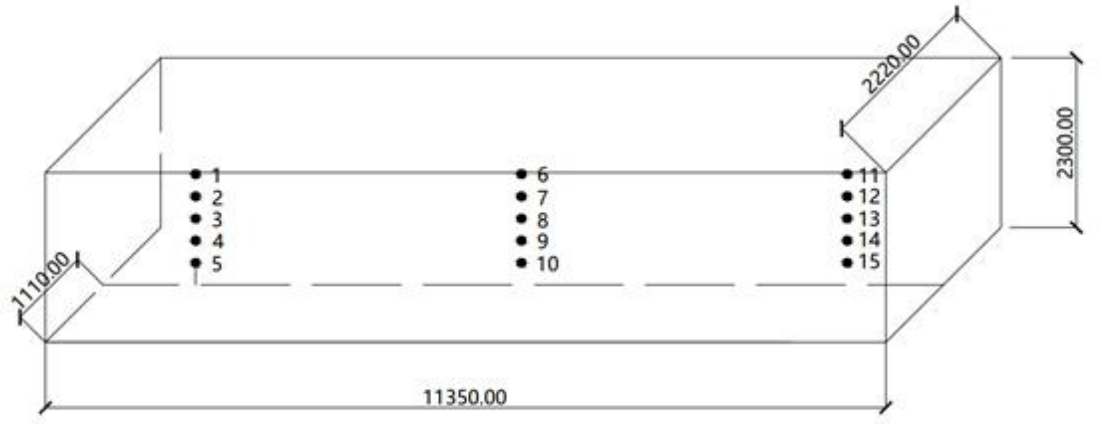


Figure 4.1 The observation surface and measuring point layout of the green feed cultivation container

The air tissue in the incubator was actually measured in the winter working condition, and only the temperature field was measured to verify the model. Thermocouples were arranged at the above-mentioned measuring points for temperature collection, and the collected data was recorded and read using a TP700 data logger . The outdoor computing environment parameters and indoor setting parameters are shown in Table 4.1 :

Table 4.1 Outdoor and indoor setting parameters

	outdoor fresh air	indoor setting
Dry bulb temperature/℃	-1.2	twenty two
Relative humidity	74%	-

the system runs for 30 minutes, the temperature is basically stable, and the specific data of the temperature of the measuring point is shown in Table 4.2 :

Table 4.2 Thermocouple measuring point temperature

Measurement point number	1	2	3	4	5
temperature/℃	2 6.1	2 3.0	2 3.0	2 3.3	2 2.3
Measurement point number	6	7	8	9	10
temperature/℃	2 5.8	2 2.5	2 2.5	2 2.8	2 2.6
Measurement point number	11	12	13	14	15
temperature/℃	2 4.9	2 3.4	2 2.2	2 2.0	2 2.2

4.2 Model establishment, simulation operation and verification

4.2.1 Determine simulation parameters

The physical structure and thermal parameters of the enclosure structure of the cultivation container are as mentioned above, and the environmental parameters outside the box and the set environmental parameters inside the box are consistent with the measured experiments to verify the model. The total parameters are shown in Table 4.3:

Table 4.3 Summary of basic parameters used in simulation without cultivation

parameter name	parameter size	unit	Remark
Incubator size	11.35×2.22×2.30	m × m × m	L×W×H
Culture dish size	2020×1800	mm×mm	—
Target control box temperature	twenty two	℃	
New air dry bulb temperature in winter	-1.2	℃	—
Relative humidity of fresh air in winter	74%	—	—
Supply air temperature in winter	29.8	℃	—
Wind speed in winter	3.5	m/s	—

4.2.2 Model building

The air-conditioning air supply system model of the green feed container needs to be established in Gambit software. It is necessary to determine the relevant size parameters of the built target model and the specific structure and position of the internal structure, and then complete the establishment of the overall geometric model of the green feed container through Boolean operations. Finally, use the grid tool to select a relatively suitable grid type to divide the built model into a grid.

The plan view of the air supply system in the box is shown in Figure 4.2 : it can be seen that the size of the air supply main pipe is Φ 320mm and Φ200mm in turn, the size of the air supply outlet is marked in the figure, and the horizontal distance between each air supply outlet is 1100mm . Ten each. Among them, the air supply outlets between each row of cultivation trays are installed on the down-extending air ducts connected to the main pipes, located at the height of the third layer of cultivation trays, the direction of the air supply outlets is towards the center of the box, and there are 5 down-extending air ducts on each side, totaling ten . Establish its geometric model , as shown in Figure 4.3.

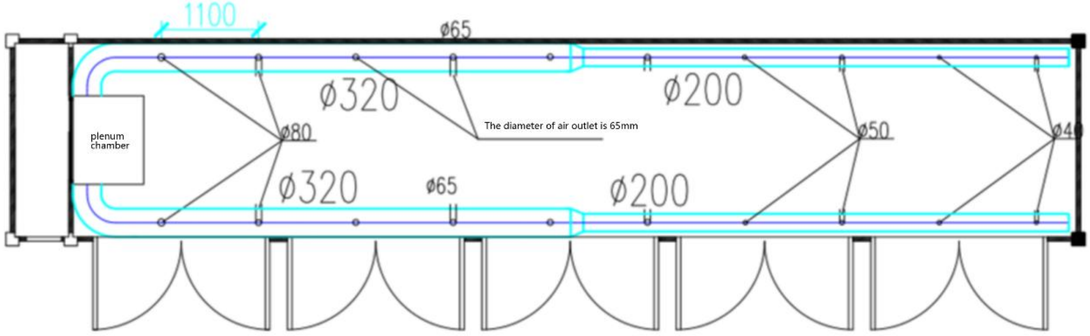


Figure 4.2 Floor plan of the air supply system in the box

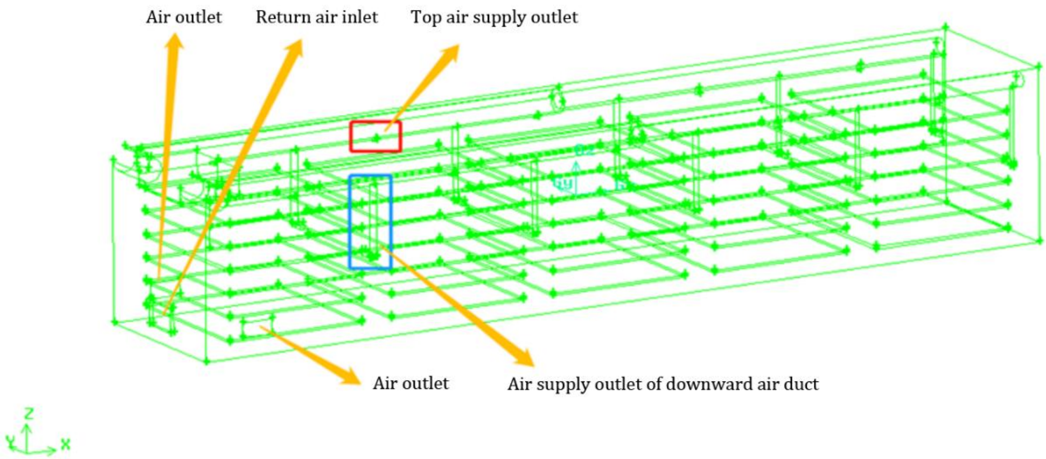


Figure 4.3 3D model diagram

The grid diagram of the cultivation container model is shown in Figure 4.4. The length direction of the cultivation container is the x-axis direction (11350mm), the width direction is the y-axis direction (2220mm), and the height direction is the z-axis direction (2300mm) . The press box is installed in the center of the y-axis direction in the culture container, so this part of the space is not included when building the grid.

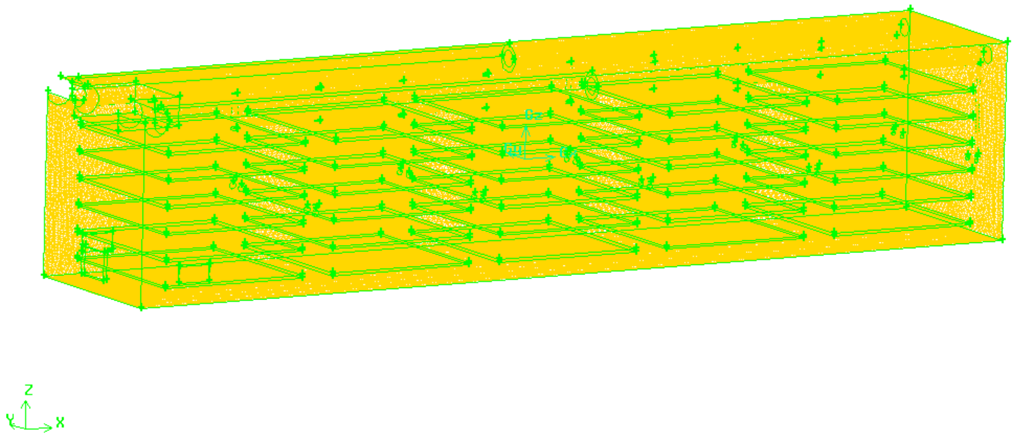


Figure 4.4 Grid diagram of training container model

4.2.3 Simulation results of air distribution test and comparison with experiment

The simulated temperature values of each measuring point in the cultivation container under winter working conditions were compared with the actual measured values, and the results are shown in Figure 4.5 .

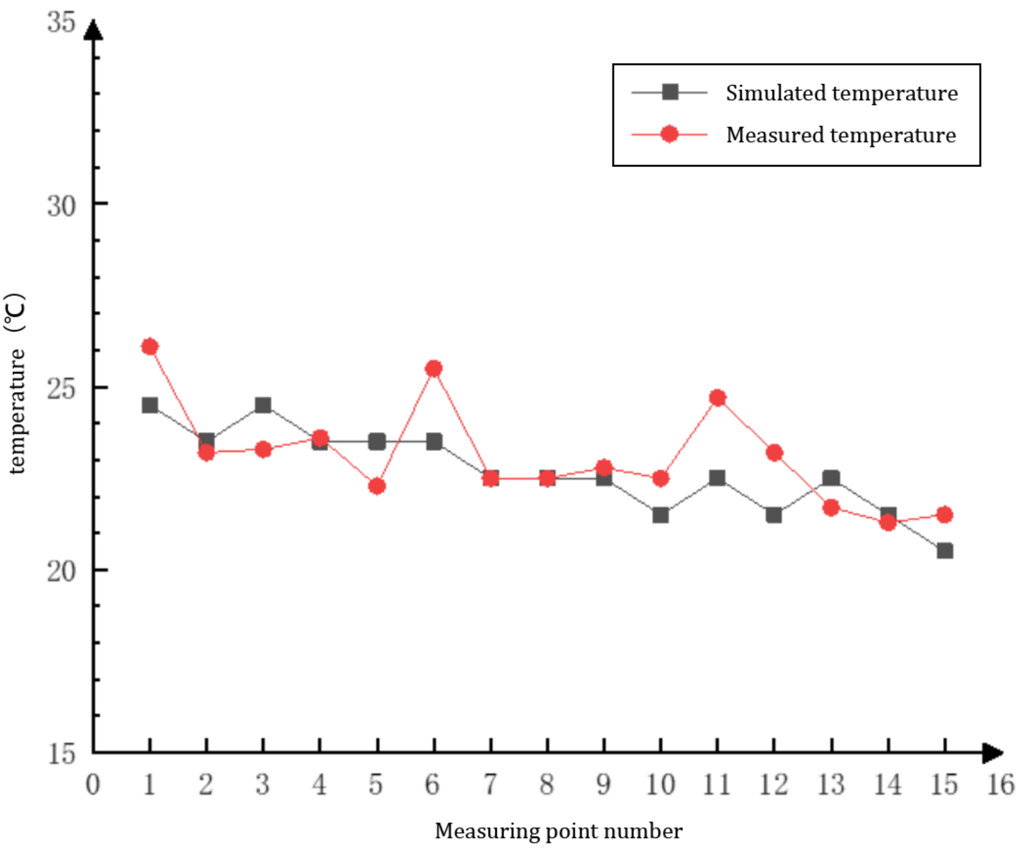


Figure 4.5 Comparison of simulated and measured values of winter temperature

By comparing and analyzing the relationship between the simulated temperature value and the actual measured temperature value under winter conditions, use the correction method provided in the ASHRAE guidelines to judge whether the model is accurate and reliable, and calculate the temperature standard in the process of simulation and actual measurement under winter conditions The average deviation (NMBE) and root mean square error variation coefficient (CVRMSE), its calculation formula is:

$$NMBE = \frac{\sum_{i=1}^{n}(x_i - y_i)}{(n-1)\bar{y}} \times 100$$ Formula (4.1)

$$CVRMSE = 100 \times \sqrt{\frac{\sum_{i=1}^{n}(x_i - y_i)^2}{n-1}} \times \frac{1}{\bar{y}}$$ Formula (4.2)

In the formula: n—the total number of samples during the calculation period;
x_i— simulation calculation value;
y_i-The actual measured value;
$\bar{y}$- the arithmetic mean of the actual measured values.

The ASHRAE guidelines stipulate that the judgment condition of the built model is accurate and reliable when the standard mean deviation (NMBE) is not greater than 5%, and the coefficient of variation of the root mean square error (CVRMSE) is not greater than 15%, the model can be considered accurate and reliable. According to the data mentioned above , the standard average deviation of the simulated temperature under the winter conditions of the model is 1.90%, and the root mean square error variation coefficient is 7.12%, so it can be considered that the model built by the simulation is accurate and reliable.

4.3 Simulation of airflow organization under actual wheat cultivation conditions

Using the model built in section 4.2, a heat dissipation and moisture dissipation module with a height of 5 cm is set at each of the wheat cultivation trays. Through the calculation and analysis of the wheat heat dissipation and moisture dissipation in the previous section , the heat dissipation of wheat is set as 247.8 W/m^3, and the moisture loss is 119 $g/(h \cdot m^3)$. In the Fluent software, select the H 2 O-air component transport material to build a component transport material model for humidity simulation. The settings of other simulation parameters are consistent with Section 4.2 , and the specific parameters are shown in Table 4.4 :

Table 4.4 Summary of basic parameters used in simulation of cultivation conditions

parameter name	parameter size	unit	Remark
Incubator size	11.35×2.20×2.30	m × m × m	L×W×H
Culture dish size	2020×1800	mm×mm	—
summer fresh air dry bulb temperature	34.6	℃	—
summer new rheumatic bulb temperature	28.2	℃	—
Average daily temperature in summer	31.3	℃	
New air dry bulb temperature in winter	-1.2	℃	—
Relative humidity of fresh air in winter	74%	—	—
Summer supply air temperature	18.7	℃	—
relative humidity in summer	70.6%	—	—
Supply air temperature in winter	32.8	℃	—

relative humidity in winter	33.9%	—	—

The observation plane and measuring point positions are consistent with those described in section 4.2 . The simulation results of temperature and humidity distribution during the actual cultivation process in winter and summer are shown in Figure 4.6 to Figure 4.13 and Table 4.5 to Table 4.8 .

4.3.1 Simulation results of temperature field in summer wheat cultivation conditions

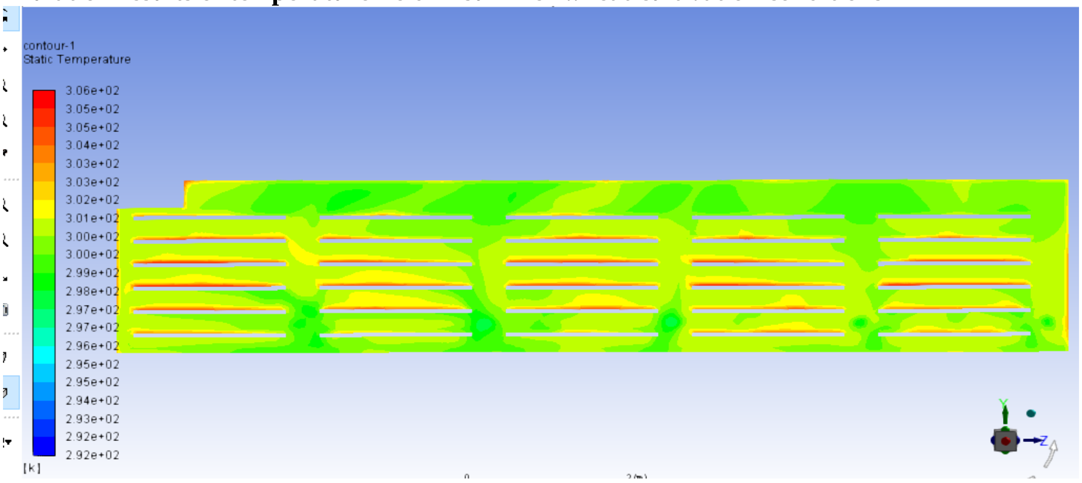


Figure 4.6 Cloud diagram of temperature distribution on the vertical plane of 1/2 width

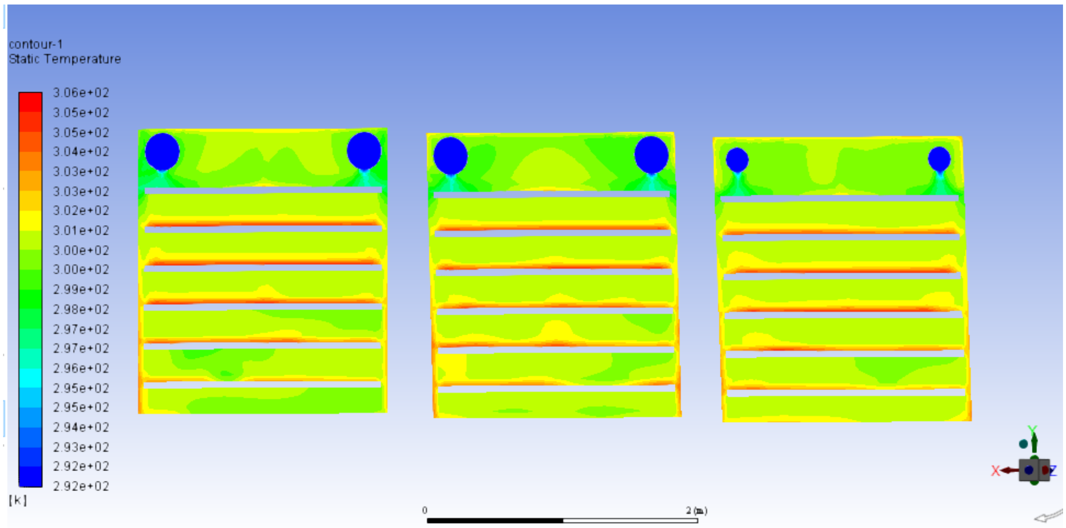


Figure 4.7 The temperature cloud diagram of the yz plane where the three groups of measuring points are located

Table 4.5 Simulated temperature values of each measuring point in the incubator

Measurement point number	Simulation point temperature / ℃	Measurement point number	Simulation point temperature / ℃	Measurement point number	Simulation point temperature / ℃	Measuring point average temperature ℃
1	27.80	6	27.90	11	28.75	
2	27.95	7	27.80	12	27.85	
3	27.97	8	27.80	13	28.05	27.79
4	27.47	9	28.02	14	27.60	
5	27.16	10	27.60	15	27.10	

4.3.2 Simulation results of humidity field in summer wheat cultivation conditions

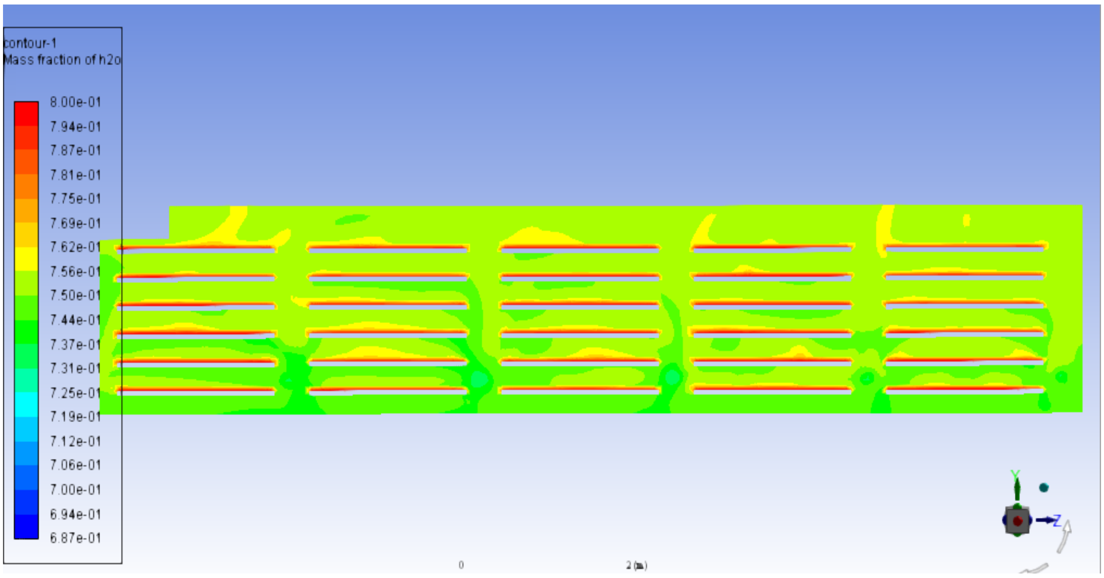
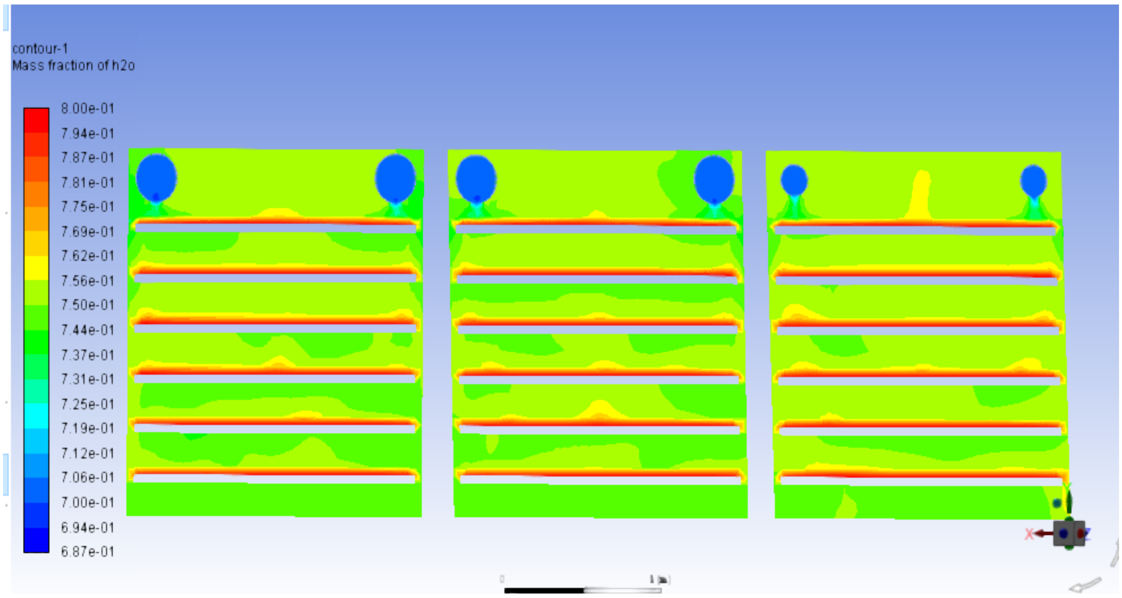


Figure 4.8 Relative humidity distribution cloud diagram on the vertical plane where the width is 1/2



The relative humidity cloud diagram of the yz plane where the three groups of measuring points are located

Table 4.6 Simulated relative humidity values at each measuring point in the incubator

Measurement point number	Simulation point relative humidity/%	Measurement point number	Simulation point relative humidity/%	Measurement point number	Simulation point relative humidity/%	Average relative humidity/%
1	75.25	6	75.70	11	75.35	
2	73.40	7	74.63	12	75.90	
3	75.77	8	75.40	13	75.60	75.21
4	74.90	9	75.50	14	76.10	
5	74.80	10	74.75	15	75.17	

4.3.3 Simulation results of temperature field in winter wheat cultivation conditions

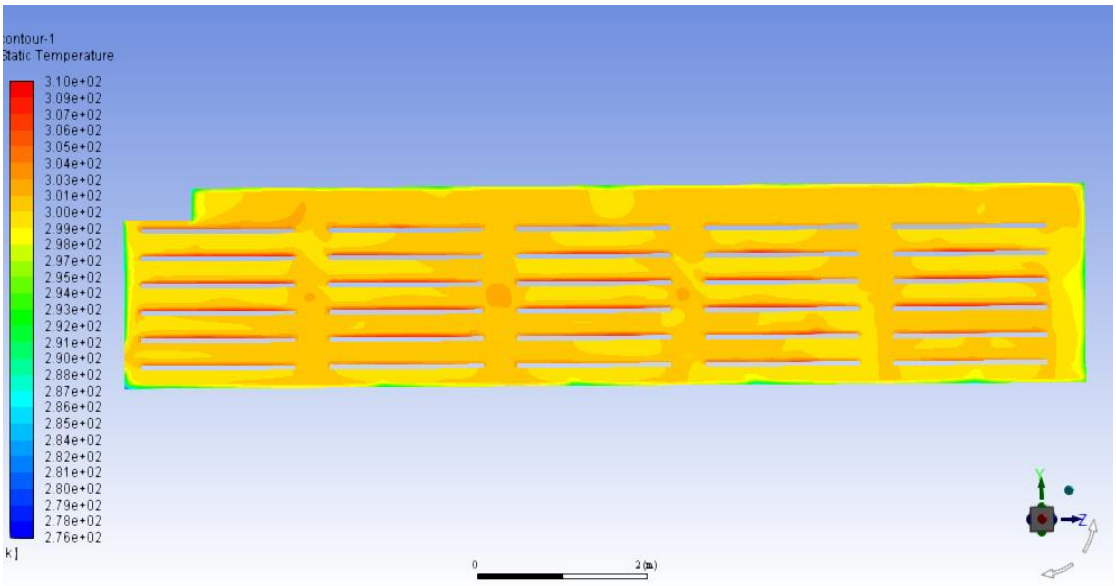
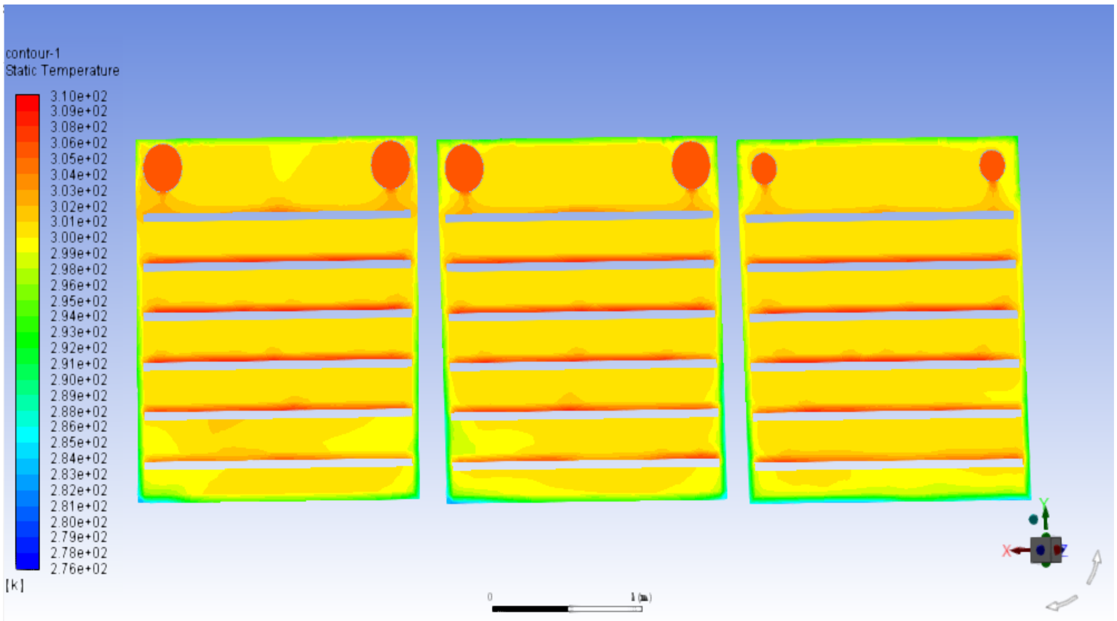


Figure 4.10 Cloud diagram of temperature distribution on the vertical plane of 1/2 width



The temperature cloud diagram of the yz plane where the three groups of measuring points are located

Table 4.7 Simulated temperature values of each measuring point in the incubator

Measurement point number	Simulation point temperature / ℃	Measurement point number	Simulation point temperature / ℃	Measurement point number	Simulation point temperature / ℃	Measuring point average temperature ℃
1	27.10	6	27.42	11	27.54	
2	27.80	7	27.35	12	27.00	
3	28.60	8	27.90	13	28.35	27.56
4	27.40	9	27.35	14	27.30	
5	27.10	10	27.60	15	27.55	

4.3.4 Humidity field simulation results of winter wheat cultivation conditions

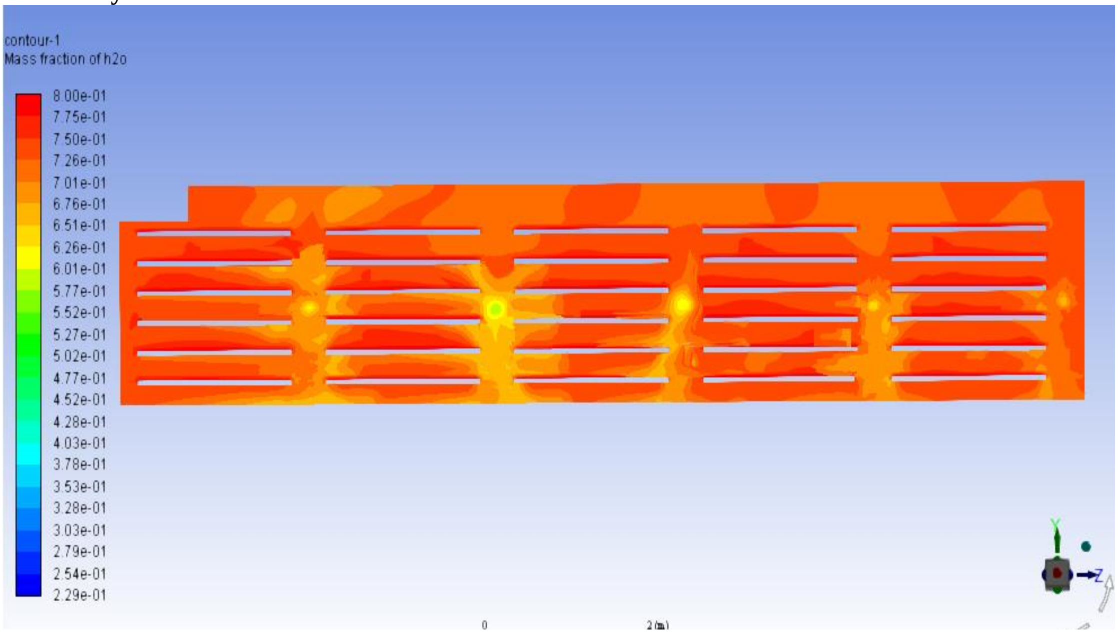
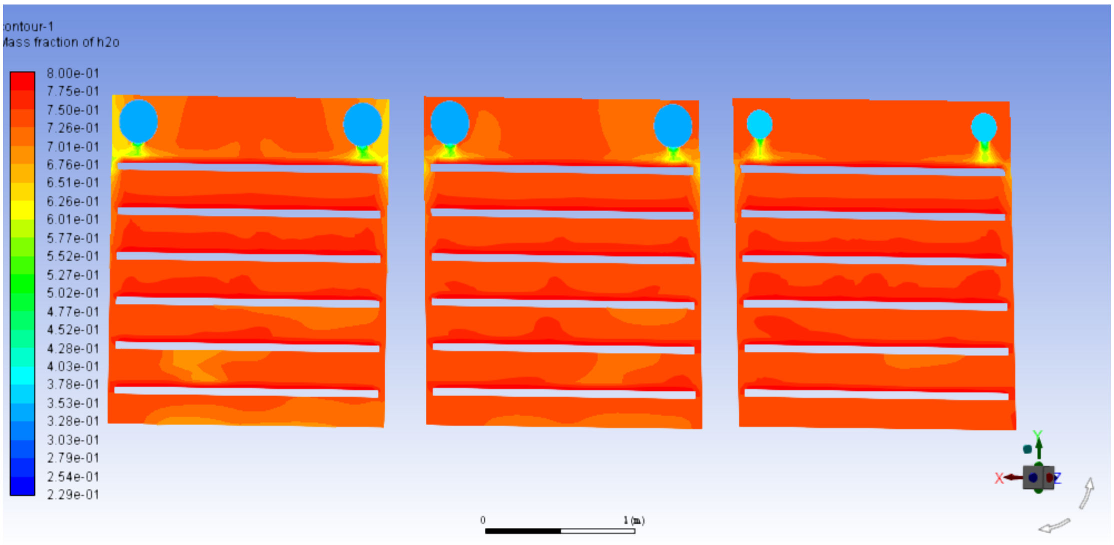


Figure 4.12 Relative humidity distribution cloud diagram on the vertical plane where the width is 1/2



The relative humidity cloud diagram of the yz plane where the three groups of measuring points are located

Table 4.8 Simulated relative humidity values of each measuring point in the incubator

Measurement point number	Simulation point relative humidity/%	Measurement point number	Simulation point relative humidity/%	Measurement point number	Simulation point relative humidity/%	Average relative humidity/%
1	76.95	6	76.38	11	76.27	
2	75.90	7	75.20	12	75.30	
3	75.30	8	75.75	13	74.25	75.02
4	74.70	9	74.87	14	74.05	
5	73.30	10	73.10	15	73.95	

V. Conclusion

This paper firstly introduces that by designing and building a small-scale greenhouse incubator experimental platform, planting wheat green feed and monitoring the environment in the box, the calculated seeding rate of wheat cultivation is 0.88kg/ m^2, the heat dissipation of wheat is 12.4W/m^2, moisture loss is 5.6g/(h ·m^2) . Secondly, this paper designs a constant temperature and humidity air conditioner specially for the black silk cultivation container, and through the model verified by experiments, the temperature and humidity field in the simulation box changes with time, and the simulation results are analyzed. It can be concluded that: in summer working conditions, The standard deviation between the temperature of the 15 measuring points and the target set temperature of 28°C is 0.45, and the standard deviation between the relative humidity and the target set relative humidity of 75% is 0.70; in winter conditions, the temperature of the 15 measuring points and the target The standard deviation between the set temperature of 28°C was 0.64, and the standard deviation between the relative humidity and the target set relative humidity of 75% was 1.14 . The results prove that the air conditioning system designed in this paper can achieve a good uniform mixing effect in the air distribution in the wheat green feed cultivation container, and can stably control the air parameters in the box to maintain a value that is beneficial to the growth of wheat green feed.

Refernces

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