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NUMERICAL SIMULATION OF AIR FLOW FIELD AND TEMPERATURE FIELD IN A VERTICAL WALL ATTACHED JET VENTILATED GOSLING HOUSE IN COLD REGION

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KEYWORDS

air diffusion performance index, air supply velocity, CFD, air pool, air supply temperature.

ABSTRACT

The vertical wall attached jet ventilation has the advantages of good air supply quality, low energy consumption and uniform air distribution, which can improve the environmental quality, reduce heating energy consumption and increase the healthy brood rate when applied to the gosling house in cold region. In order to investigate the distribution of the air flow field and the temperature field in the gosling barn by the computational fluid dynamics method, the three-dimensional steady state simulation of the air flow field and the temperature field is carried out in this study. The results show that the maximum air velocity in the living area of goslings exceeds 0.5m/s when the air supply velocity is greater than 1.8m/s, and goslings feel blowing. When the air supply velocity is lower than 0.8m/s, the average air velocity in the gosling living area is lower than 0.2m/s, and the ventilation is insufficient. When the air supply velocity v=1.5m/s and temperature t=305.15k, the average air velocity in the gosling living area was 0.40m/s, the average temperature was 305.20k, the horizontal sticking range of the air supply air was 7.0m, the Air Diffusion Performance Index of the gosling house was 100%. Ventilation is the best.

INTRODUCTION

The Many scholars have conducted in-depth research on vertical wall attached jet ventilation. Li et al. (2019) studied the applicability of attached jet ventilation for buildings with special shape enclosures through experiments and numerical simulations. Jin et al. (2020) introduced upward vertical wall-mounted ventilation in the tea brick fermentation chamber. Ji et al. (2022) used wall-attached jet ventilation to achieve forced convection, and used phase change material wallboard (PCMW) potential storage to improve night ventilation performance. Han & Li (2021) used experimental and numerical methods to study the velocity distribution of wall-attached jet in a slotted ventilation space under isothermal conditions. Li et al. (2022) proposed wall-attached night ventilation (WANV) to enhance the convective refrigeration performance in areas with small daily temperature difference, and studied the air flow morphology and temperature field under different jet supply modes. Hou et al. (2020) studied the flow pattern and characteristics of induced air flow through visual experiments and numerical simulation, taking inclined wall surface as the research object. There are many studies on vertical wall attached jet ventilation, but there is no report on its application to gosling breeding houses in cold regions of China.

Computational fluid dynamic (CFD) is an independent discipline based on classical fluid dynamics and numerical computation methods. There are many researches on the application of CFD in the environmental control of livestock and poultry houses. Cheng et al. (2018) established the calculation model of airflow resistance of a group of chickens in a cage and the simulation model of the ventilation field of the chicken house in summer by CFD method, and studied the influence of different air inlet positions and the air baffle inside the air inlet on the airflow in the chicken house. Tabase et al. (2020) established a steady-state CFD model to predict the airflow and NH3 distribution in pig houses in the UFAD system. Küçüktopcu et al. (2022) used CFD technology to simulate the climatic environment of mechanically

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ventilated chicken houses in summer and winter. Chen et al. (2021) established four 3D CFD models to simulate the air flow field inside and outside the cage-free poultry house. Lee et al. (2022) used computational fluid dynamics (CFD) to analyze the aerodynamic environment under different environmental conditions in the fattening pig house in winter and summer. Bovo et al. (2022) studied and evaluated the effects of geometric parameters and seasons on natural ventilation in existing pig houses located in northern Italy through CFD simulations. Santolini et al. (2021) studied the gas dispersion rule in the area around the naturally ventilated pig house through computational fluid dynamics (CFD) analysis for evaluating gas concentration. CFD simulation is an important means to study the temperature, humidity and air flow field of livestock and poultry.

In this paper, Spaceclaim software was used to establish a three-dimensional model of the gosling house, and CFD method was used to simulate the air flow field and temperature field in the gosling house with vertical wall attached jet ventilation, explore whether the gosling living area can form an "air pool" composed of fresh air, analyze the air quality, and find the best air supply parameters required by the gosling living area, providing a reference for the application of vertical wall attached jet ventilation in the gosling house in cold areas.

MATERIAL AND METHODS

Experimental gosling house

The experimental goose house is a closed gosling breeding house of Anda Shizi Goose Breeding Co., LTD., located in Anda Animal Farm, Suihua City, Heilongjiang Province, with longitude 125.285° E and latitude 46.316°N. The climate zone of this region belongs to the severe cold zone A, with an average annual temperature of 15℃. Brooding period is from March to October every year, during which the average minimum temperature is -18℃, the highest temperature is -5℃. The experimental goose house is located in the north facing south, 29000mm long, 8600mm wide and 2900mm high. The external wall material is 370mm brick wall +100mm polystyrene external insulation board, and the roof enclosure structure uses 75mm thick polystyrene color steel sandwich board. The north wall has 7 windows and a door, and the south wall has 8 windows, all of which use plastic steel doors and windows. The size of the north iron door is 70mm×1870mm, the window size is 1750mm×1750mm, and the window height is 1.0m. The gosling house is equipped with plastic ceiling, adopts the form of flat ground to raise chicks, and adopts drinking area, feeding area and rest area, as shown in Figure 1. 15 to 20 geese per square meter. and 3106 goslings are raised in the goslings breeding house during the test period.

FIGURE 1. Internal structure of goose house.

Field test

From January 11 to 15, 2023, precision instruments were used to conduct field tests on environmental parameters of the experimental gosling barn, including temperature outside and inside the barn, airflow velocity and parameters related to the enclosure structure. Local temperatures were high during the test period, with the temperature outside the goslings' enclosure approaching that of their hatching in March. During the test, the SFG2.5-2R low-noise axial flow fan produced by Zhejiang Fengxing Electromechanical Co., LTD was used in the air supply system. The input power of this fan is 250W, the current is 0.9A, and the air volume is 2100m^3/s,The air supply velocity was controlled by the fan governor and the air supply temperature was controlled by the heating compensator. A slatted fiber air distribution vertical wall attached with jet ventilation system is adopted. The fiber cloth bag air duct is a variable diameter air duct with a gradual change from 300mm to 250mm and a slit width of 30mm. The air supply duct is installed close to the wall along the south window sill, and the air supply outlet is 150mm away from the wall. Two 1750mm×150mm air vents are installed above the north window, with the bottom end 2600mm above the ground. A circular arc deflector with a radius of 300mm is installed at the bottom of the south wall of the gosling house.

The internal air temperature of the gosling house is measured by HOBO MX2303 double external temperature sensor data logger produced by ONSET company of the United States. The temperature range of the instrument is -40℃ to 100℃, and the measurement accuracy is ±0.2℃. The surface temperature of gable wall, ground and ceiling was measured by the American FCR-T62101 infrared thermal imager. The environmental parameter changes in the living area of goslings in the house were mainly considered. The test adopted "田" layout, and a total of 33 measuring points were set up. Among them, 15 measuring points were arranged 40mm above the ground in the house, and 18 measuring points were arranged on three vertical sections. The location of measuring points is shown in Figure 2. The interval between automatic collection and upload of all parameters is set to 1min. The same measuring points were selected for wind velocity measurement and temperature measurement. The anemometer data acquisition method was to record the instantaneous wind velocity every 10 seconds. The average of 6 instantaneous wind velocity within 1 minute was taken as the wind velocity of the measuring point, and the average of 9 measurements was taken as the wind velocity value of the measuring point.

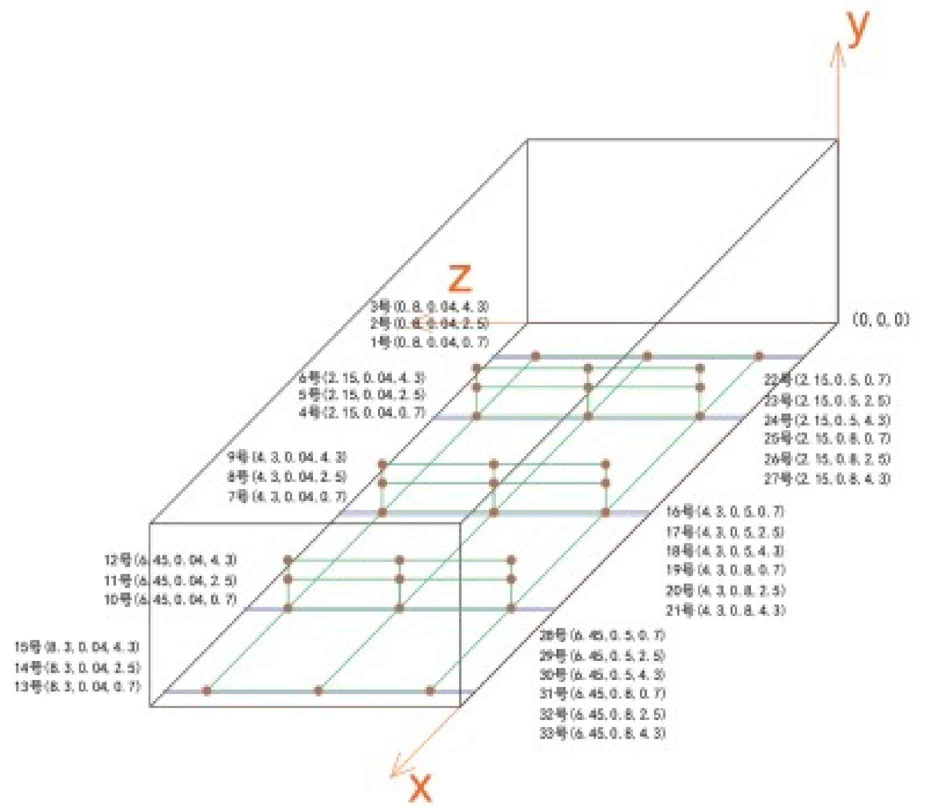


FIGURE 2. Test the location of the measuring points in the gosling house.

CFD NUMERICAL SIMULATION

Geometric model

The 3D model of the gosling house is shown in Figure 3. Taking the crossing point of length and span on the ground of the gosling house as the origin of coordinates, the 3D model is created. The span direction of the gosling house is the x-axis direction, the direction perpendicular to the ground is the y direction, and the length direction of the gosling house is the z direction. The gosling house is completely enclosed and the air flow in the house is mainly affected by the air supply parameters.

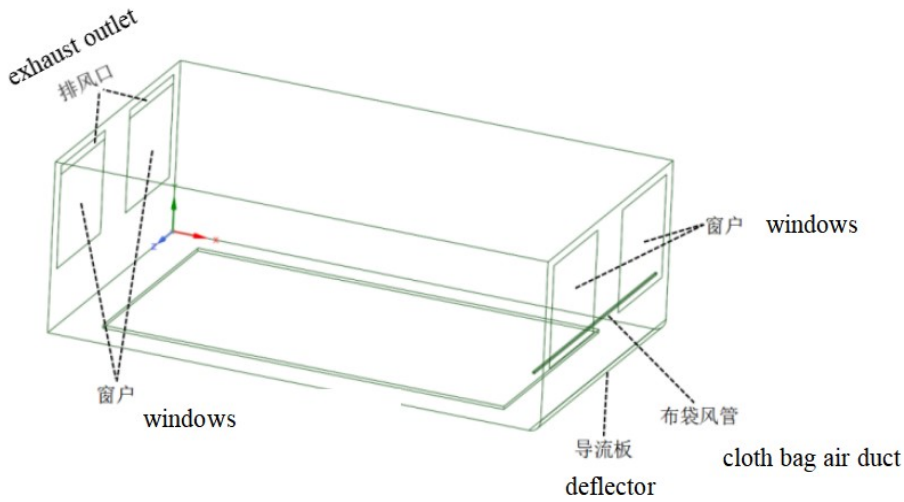
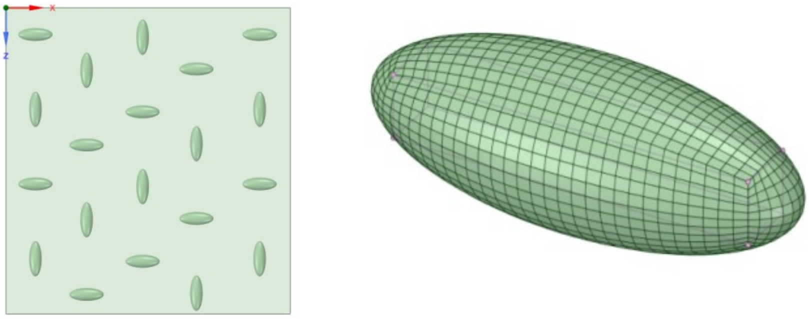


FIGURE 3. Test the 3D model of the gosling house.

Create models and meshes using SPACECLIAM software. In order to save computer resources and enhance the operability of the experiment, the model was simplified. In the width direction, the same size as the solid building was adopted, and the length direction was reduced appropriately. The length of the model was selected as 5m and 665 goslings were raised. Ignoring the influence of wind velocity outside the gosling house on the air flow inside the gosling house, assuming that no people come and go out of the gosling house, assuming that the gas inside the gosling house is incompressible air, ignoring the influence of water tank and trough in the gosling house on the air flow and heat transfer, ignoring the gosling legs, feet and head, simplifying the gosling into a 110mm×40mm ellipsoid model. Gosling distribution (1m^2) and simplified gosling model are shown in Figure 4.



(a) Distribution of goose chicks (b) Simplified ellipsoid model of goose chick

FIGURE 4. Goose chick distribution and simplified model.

The unstructured tetrahedral grid was adopted, and the maximum mesh size was determined to be 64mm after grid independence detection. Local grids such as air supply outlet and exhaust outlet were encrypted, and the maximum size was 8mm, and the number of grid cells was 1044423.

Mathematical Model

The flow of any fluid follows the law of conservation of physics:Law of conservation of mass,Law of conservation of momentum,Law of energy conservation and Law of conservation of components (Niu et al., 2022). the governing equations are mathematical descriptions of these conservation laws. The simulation in this paper is mainly aimed at the air flow and heat transfer in the gosling house. The air in the house can be regarded as an incompressible fluid with constant flow. Therefore, the continuity equation, momentum equation and energy equation of the air flow in the gosling house can be written into the form of the general equation in formula (1).

$$\mathrm{div}\left(\rho\cdot\mathbf{u}\cdot\varphi-I_{\varphi}\cdot\mathrm{grad}(\varphi)\right)=S_{\phi} \tag{1}$$

In the formula, ρ is density (kg/m^3), $\mathbf{u}$ is the velocity vector (m/s), φ represents the universal variable, can represent velocity, temperature, etc., I_{φ} represents the generalized diffusion coefficient, represents a generalized source term. For a particular equation, φ , I_{φ} and S_{ϕ} have a specific form. Table 1 shows the corresponding relationship between the three symbols and each specific equation.

TABLE 1. Values of φ 、 I_{φ} and S_{ϕ} .

Governing equation	φ	I_{φ}	S_{ϕ}
Continuity equation	1	0	0
Momentum equation	u_i	μ	$-\frac{\partial p}{\partial x_i}$
Energy equation	T	$\frac{k}{c_p}$	S_T

Note: u_i is the velocity component along x、y、z axis(m/s), μ is the viscosity coefficient (kg/(m·s)), p is the pressure(Pa), x_i is the length along x、y、z axis(m), T is the temperature(K), k is the thermal conductivity(W/(m·K)), cp is the specific heat capacity (J/(kg·K)); S_T is the viscous dissipation term(W)。

Setting of boundary conditions

The gosling house belongs to the positive pressure mechanical ventilation goose house. The wind velocity and direction in the house were measured by hot wire anemometer and smoke pen. In the simulation, the slit air supply port is set to Velocity-Inlet, the air supply velocity is 1.0m/s, and the air supply temperature is 305.15k. Outflow will be set as outflow on the north wall. Gosling gables, ground, suspended ceiling, doors and Windows, deflectors, etc. will be set as wall boundary wall. The boundary conditions required for simulation will be measured on site. In winter and spring, solar radiation is one of the key factors affecting the distribution of air flow field and temperature field in the gosling house. The discrete coordinate (DO) radiation model was selected according to the radiation heat transfer situation, and the FLUENT solar ray tracing method was adopted to set the main parameters according to the geographical location and the orientation of the gosling house: E 125.285°, N 46.316°, the time zone is +8, the north orientation is [-1, 0,0], and the east orientation is [0, 0, -1]. In order to accurately simulate the relationship between the pressure loss of air flowing through the gosling activity area and the airflow velocity, the gosling activity area in the model was set as a porous medium, and the viscous resistance coefficient 1/α of the porous medium was calculated to be 235 (1/m^2) by regression of the airflow velocity and the static pressure drop after the airflow passed through the gosling living area. The inertial drag coefficient is C_2 and 0.006(1/m).

Numerical solution

The Fluent software was used for numerical solution. By comparing three two-equation turbulence models, the standard *k-ε* turbulent model with the best convergence and minimum error was finally selected. The simulation of near-wall region was performed using standard wall function, the discrete method based on finite volume was adopted for the control equation, and the SIMPLE algorithm was selected for pressure-velocity coupling. The equations of momentum, turbulent kinetic energy and turbulent dissipation rate are discretized in a second-order upwind scheme. The velocity value at a point near the exit and the weighted average value of the airflow velocity surface parallel to the north wall were monitored until the velocity monitoring curve was stable and the simulation was considered to be convergent.

RESULTS AND DISCUSSION

Verification of simulated values

The correctness and reliability of the simulation model are verified by comparing the measured average values of air velocity and temperature at each measuring point with their simulated values.

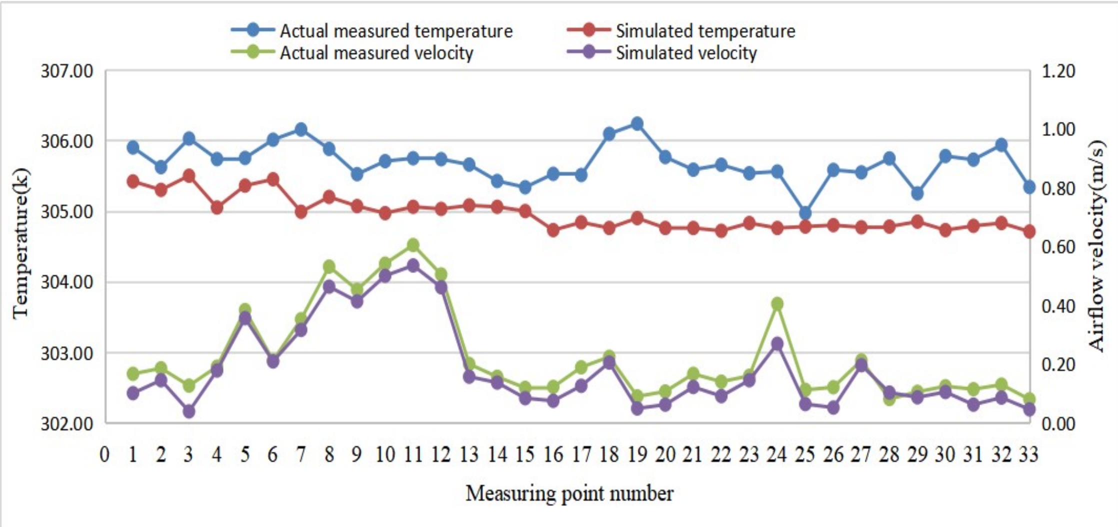
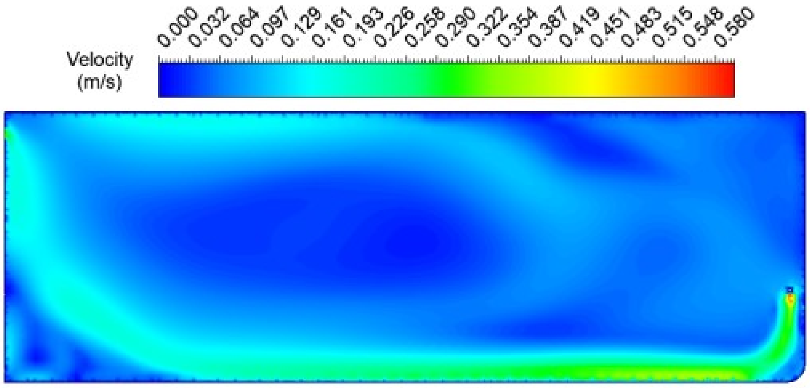


FIGURE 5. Measured and simulated value of temperature and air velocity.

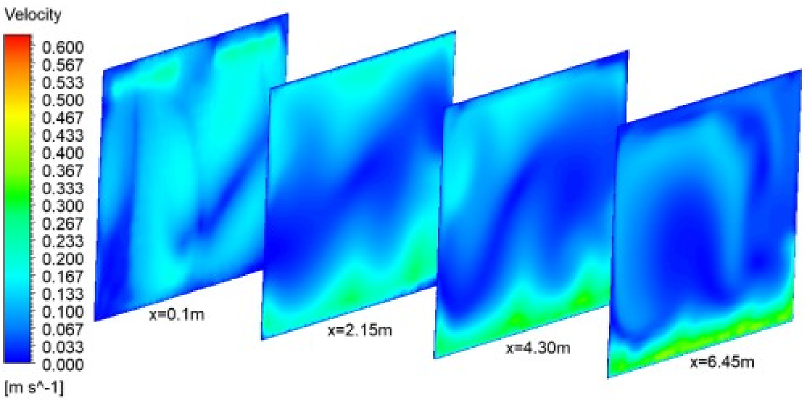
As shown in Figure 2, the measured wind velocity and temperature at each measuring point in the gosling house were compared with the simulated values. Figure 5 shows the comparison results between the measured values and the simulated values. The root mean square error (RMSE) of simulated and measured wind velocity at each measurement point is 0.035m/s, the maximum absolute error is 0.087m /s, and the average relative error is 2.40%. The root mean square error (RMSE) of the simulated and measured temperature at each measuring point is 0.14℃, the maximum absolute error is 1.34℃, and the average relative error is 2.01%. Through verification, it can be considered that the establishment of the model meets the requirements of numerical simulation, the grid division is moderate, the boundary conditions are reasonable, the simulation results are reliable, and the distribution of air flow field and temperature field in the gosling house can be accurately revealed.

Analysis of simulation results of airflow velocity field

As can be seen from Figure 6a, after the supply air flows out of the fiber air distribution duct strip, it quickly deflected and attached to the wall under the action of the Conda effect. In the vertical attachment area, a small amount of air is mixed with the air in the gosling house, and the velocity of the air supply jet decreases slightly. After the air supply jet hits the deflector in the corner, its movement direction changes from vertical to horizontal, and then it is attached to the ground and flows horizontally, forming a layer of "air pool". After the ground is attached to the horizontal direction for a certain distance, the inertial force gradually weakens, and the main body of the air stream floats off the ground under the combined influence of the hot air buoyancy effect and the siphon effect of the exhaust outlet. The distance between the position where the air flow begins to float off the ground and the center of the air supply outlet is the horizontal adhesion range of the air supply. As can be seen more clearly from Figure 6b, under the "hijacked effect" of the attached wall, the main body of the supply air is less mixed with the air outside the attached area, and the air entering the attached area can maintain most of the heat and freshness of the supply air.



(a) z=1.5m longitudinal section velocity distribution cloud map



(b) Cross section velocity distribution cloud map

FIGURE 6. Cloud map of air flow field distribution in gosling house.

The cross-section of y=0.04m captured by the simulation is the middle area of the gosling height, which represents the gosling activity area and is representative for the actual production. The simulation results show that the maximum, minimum and average air flow velocities of 0.38m/s, 0.013m/s, and 0.25m/s in the living area of goslings (y=0.04m plane).

Since the air velocity and temperature at the measuring points have certain fluctuations, in order to more clearly reflect the general change law of the air velocity and temperature at the measuring points at different positions in the gosling house, five monitoring lines (a, b, c, d, e) were selected along the width direction and height direction of the gosling house to compare and analyze the distribution law of the air flow field over the horizontal direction and the vertical direction. The coordinates of monitoring lines are shown in Table 2.

TABLE 2. Coordinate position of monitoring line.

	line a	line b	Line c	line d	line e
x0(m)	0	0	0	0	0
y0(m)	0.04	0.04	0.04	0.5	0.8
z0(m)	2.5	4.3	0.7	2.5	2.5
x1(m)	8.3	8.3	8.3	8.3	8.3
y1(m)	0.04	0.04	0.04	0.5	0.8
z1(m)	2.5	4.3	0.7	2.5	2.5

The velocity distribution of 3 monitoring lines on line a, line b and line c in the width direction y=0.04m of the gosling house was compared, as shown in Figure 7. When the supply air flows out of the guide plate and into the horizontal adhesion zone, the axial velocities of line a, line b and line c increased by 0.17m/s, 0.07m/s and 0.08m/s, respectively, in the range of about 0.5m in the moving direction, and then gradually decreased to 0.05m/s when the flow distance increased to about 1m. The attenuation of axis velocity is mainly due to the continuous expansion of air supply section, which causes a certain momentum loss due to overcoming friction resistance. About 2.5m away from the wall where the exhaust outlet is located, the attenuation rate increases rapidly. The main reason is that after the main body of the supply air reaches the area, the temperature rises, the thermal buoyance effect increases, and the induction effect of the exhaust outlet causes the main body of the supply air to float up. About

1.0m away from the north wall, the air velocity fluctuates, mainly because a small part of the air flow moves in the opposite direction and forms resistance to the forward air flow moving in the horizontal direction. About 0.5m away from the north wall, the air flow is attached to the north wall under the action of the exhaust vent siphon, and finally flows out of the exhaust vent. It can be seen that under the vertical wall attached jet ventilation, the average wind speed in the living area of goslings can meet the growth needs of goslings.

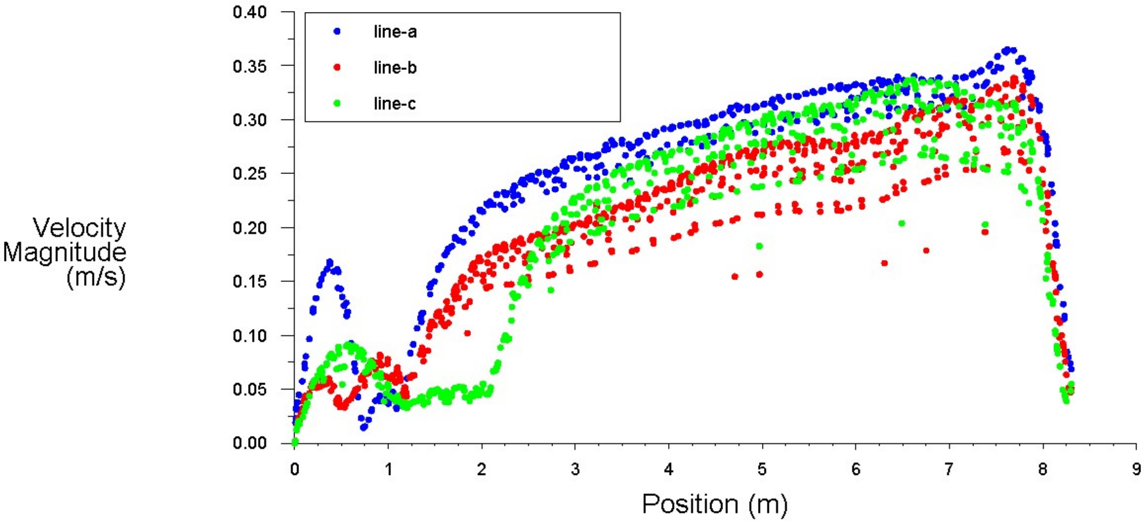


FIGURE 7. Velocity change on the monitoring line at y=0.04m.

The velocity distribution on z=2.5m plane monitoring lines line a, line d and line e in the height direction of the gosling house was compared, as shown in Figure 8. Because line a is in the "air pool", after the supply air strikes the deflector and enters the horizontal direction, the velocity increases and then gradually attenuates, with an average velocity of 0.25m/s. The monitoring lines line d and line e are located above the "air pool". As the axis velocity in the "air pool" area decreases continuously, the enrolling of ambient air increases, resulting in an increase in the airflow velocity around the "air pool". Compared with line e, line d is closer to the main body of air supply, and the average air velocity of line d (0.13m/s) is higher than that of line e (0.07m/s), and the air velocity gradually decreases along the height of the gosling house.

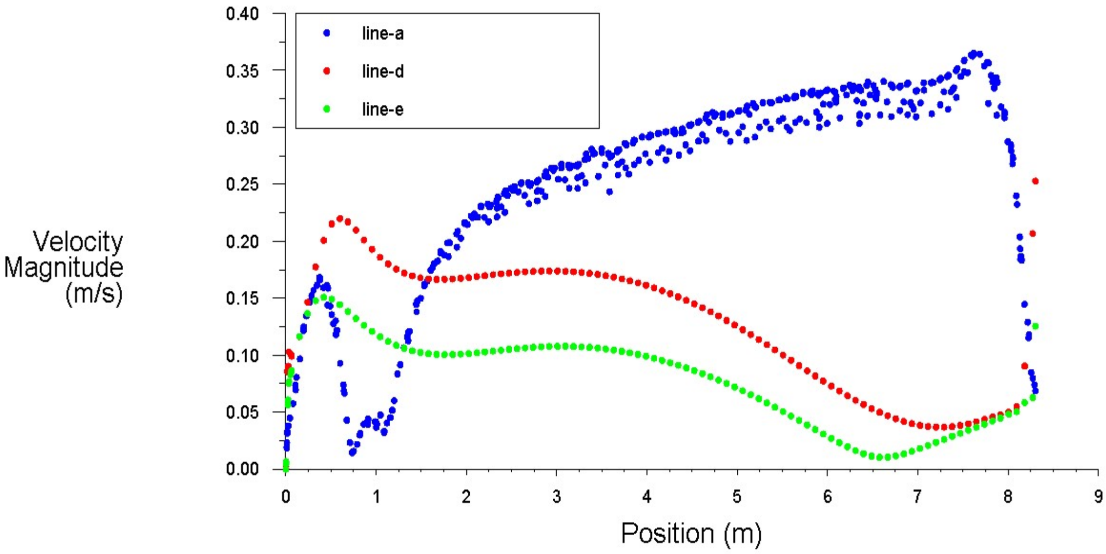
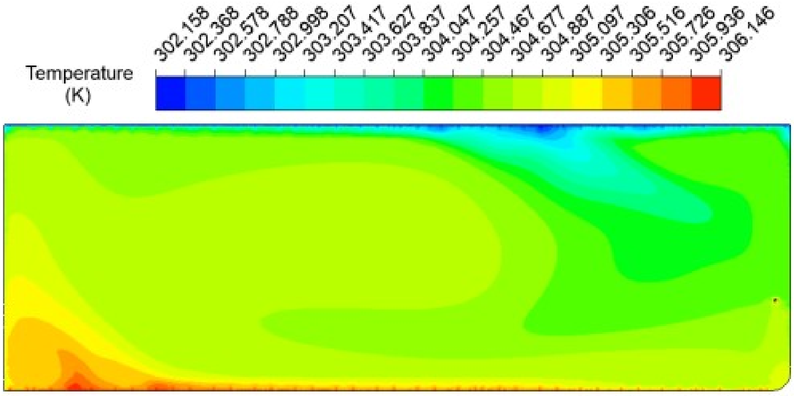
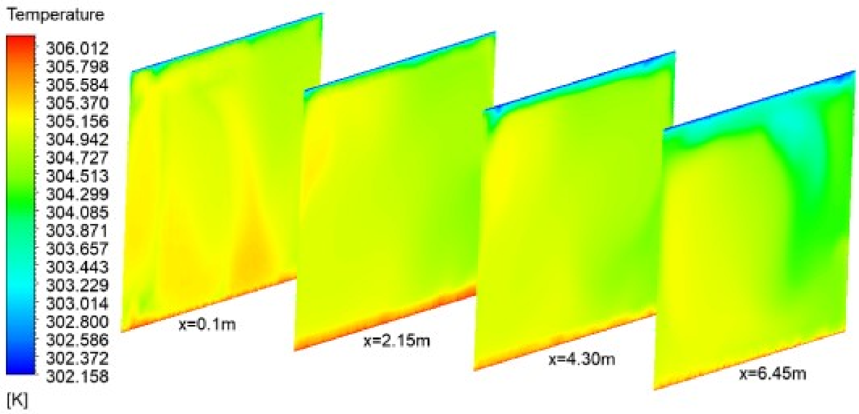


FIGURE 8. Velocity change on the monitoring line at z=2.5m.

Analysis of simulation results of air flow temperature field



(a) z=1.5m longitudinal section temperature distribution cloud map



(b) Temperature distribution indifferent horizontal sections

FIGURE 9. Cloud map of temperature field distribution in gosling house.

As shown in Figure 9a, the temperature field distribution in the gosling house is greatly affected by the air flow field distribution. Since the temperature of the attached wall is lower than that of the supply air flow, the temperature of the supply air flow decreases slightly along the movement direction. After deflecting the deflector, the supply air is attached to the ground and extends horizontally. It can be seen from Figure 9b, during the movement, the heat transfer occurs between the supply air and the ground, and the temperature increases gradually. Due to the low temperature of the north wall, the temperature of the supply air flow drops gradually when it is attached to the wall. The maximum temperature in the gosling living area (y=0.04m plane) was 306.10k, the minimum temperature was 302.19k, and the average temperature was 304.60k. The temperature distribution on line a, line b and line c in the width direction y=0.04m of the gosling house was compared, as shown in Figure 10. The temperature distribution law of the three monitoring lines was basically the same, and the temperature rose slowly and then dropped gradually, with the average temperature being 305.30k, 305.38k and 305.16k, respectively. The temperature distribution in the horizontal direction of the "air pool" area of the gosling house was relatively uniform. The temperature distribution of the living area of the goslings is more uniform, and the temperature is suitable, which can meet the growth needs of the goslings.

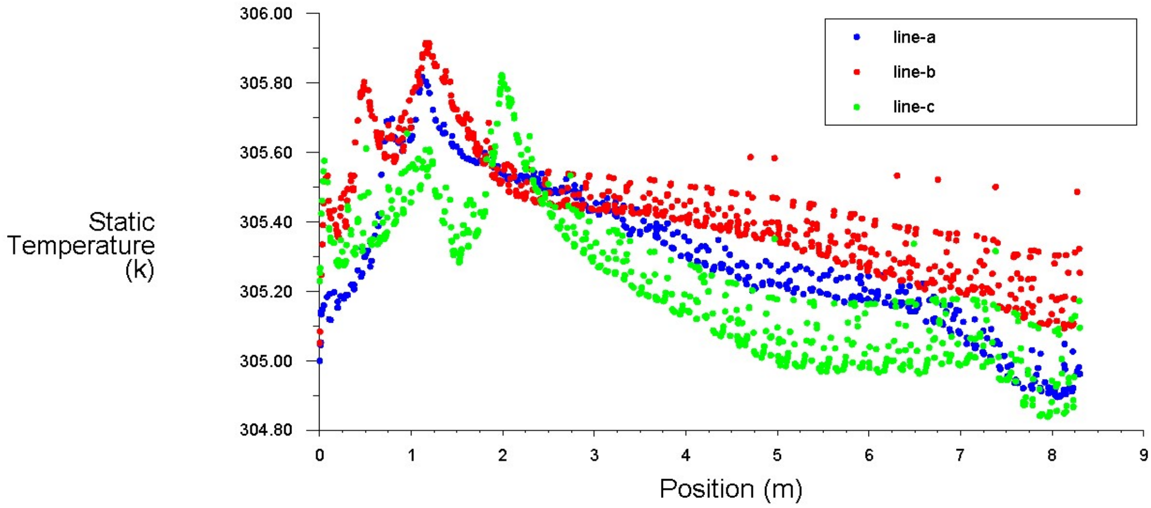


FIGURE 10. Temperature distribution on the horizontal monitoring line y=0.04m.

The temperature distribution of 3 monitoring lines on line a, line d and line e in the height direction z=2.5m of the gosling house was compared, as shown in Figure 11. The temperature fluctuation of line a in the "air pool" is relatively large. After the air supply flow enters the horizontal attachment area, the temperature gradually increases from 304.83k to 305.84k. When the distance from the north wall is about 1.0m, the temperature is attached to the north wall, and the temperature gradually decreases to 305.00k. At the same air supply velocity, there is no obvious thermal stratification in the vertical direction outside the "air pool", and there is no problem of ineffective energy consumption caused by hot air stagnating at the top of the gosling house.

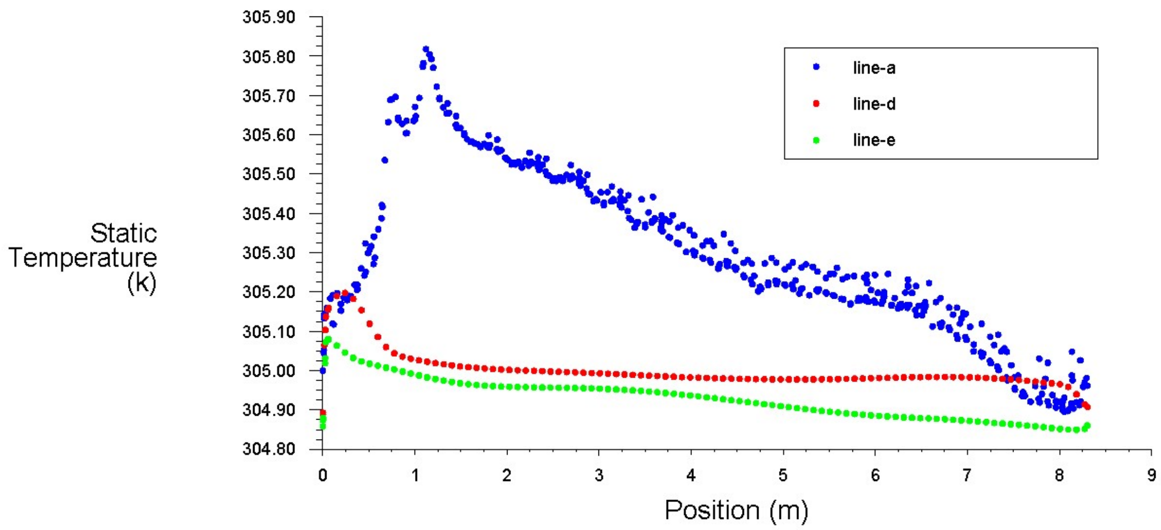


FIGURE 11. Temperature distribution on the horizontal monitoring line z=2.5m.

The influence of air supply velocity on the air flow field and temperature field in Schoolyard

In order to explore the effects of different air supply velocity on the air flow field and temperature field in the vertical wall attached jet ventilation gosling house, on the premise of ensuring the effective air distribution in the gosling living area, In this paper, seven working conditions such as 0.3m/s, 0.5m/s, 0.8m/s, 1.0m/s, 1.5m/s, 1.8m/s and 2.0m/s were selected for simulation. Other boundary conditions remain unchanged.

It can be seen from Figure12 and Figure13 that the supply air velocity has a certain influence on the horizontal adhesion range of the supply air. When the air supply velocity is 0.3m/s, the horizontal adhesion range of the air supply is less than 4.5m. With the gradual increase of air supply velocity, the horizontal adhesion range is increasing. When the air supply velocity v=2.0m/s, the horizontal attaching range of the air supply airflow reaches 7.3m. It can be seen that the air supply velocity is an important factor affecting the air flow field distribution of the vertical wall attached jet ventilation gosling. The ventilation parameters of the barn require that the air velocity of the gosling barn should be between 0.2m/s-0.5m/s (Mackenzie & Kyriazakis I, 2020). When the air supply velocity v=1.8m/s, the maximum wind velocity in the living area of the goslings reaches 0.71m/s, and exceeds 0.5m/s, the goslings will feel the wind. When the air supply velocity v=0.8m/s, the average wind velocity in the gosling living area is 0.11m/s, which is lower than 0.2m/s, and the ventilation in the gosling living area is insufficient.

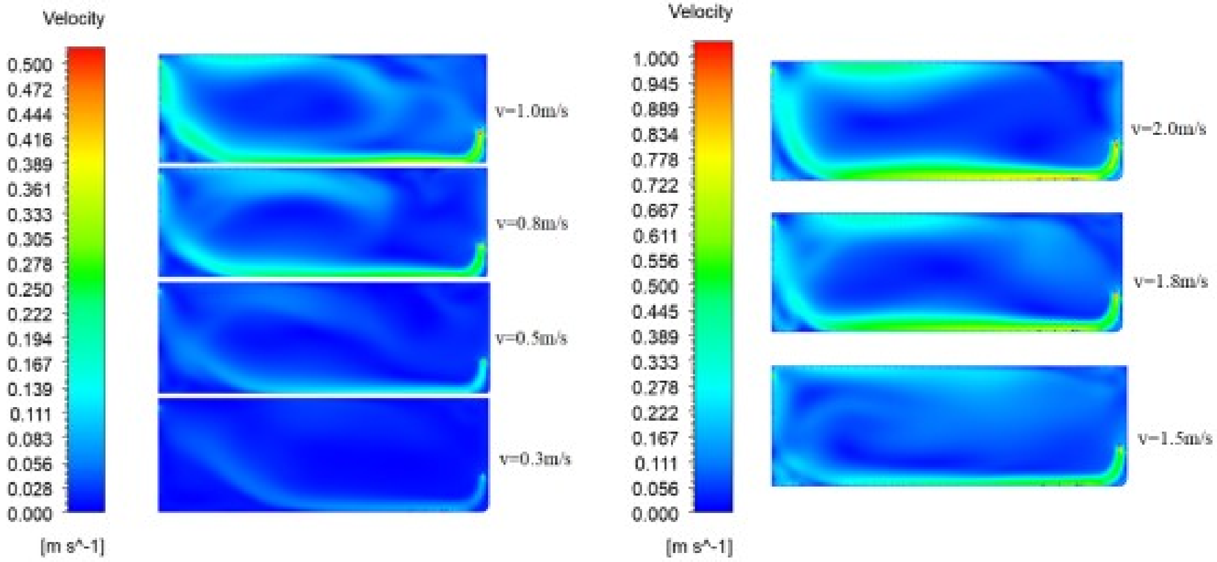


FIGURE 12. Cloud map of air flow field distribution in gosling house at different air velocity.

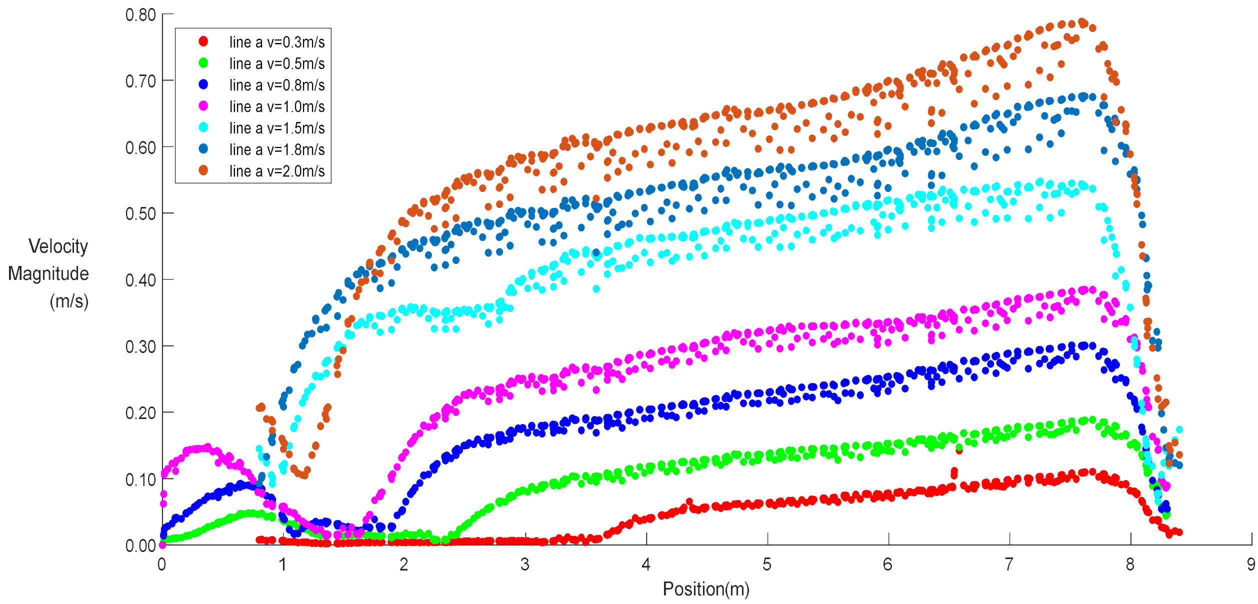


FIGURE 13. Velocity distribution on monitoring line a at different air velocity.

The temperature field distribution on the z=1.5m section under 7 working conditions with different air supply velocity was compared. It can be seen from Figure 14 and Figure 15 that under different supply air velocity conditions, the maximum temperature values on each monitoring line have little difference, and the maximum temperature values appear at the limit point of the horizontal adhesion range. When the air supply velocity v=0.3m/s, the average temperature on the section z=1.5m of the goose house is 304.56k, and the average temperature in the gosling living area (y=0.04m plane) is 305.24k. When the air supply velocity v=2.0m/s, the average temperature on the section of the goose house z=1.5m reaches 304.80k, and the average temperature in the gosling living area (y=0.04m plane) is 305.13k. The different air supply velocity affects the horizontal sticking range and indirectly affects the temperature field distribution in the goslings' living area. With the increase of air supply velocity, the overall temperature in the gosling house increased slightly.

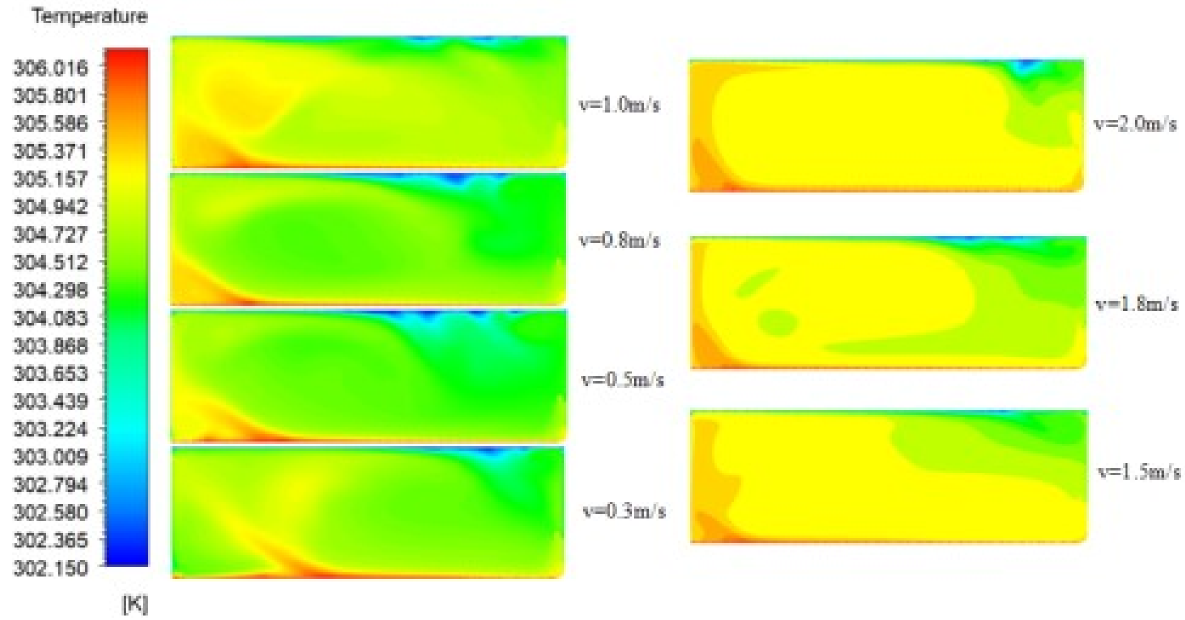


FIGURE 14. Temperature field distribution cloud map of gosling house at different air velocity.

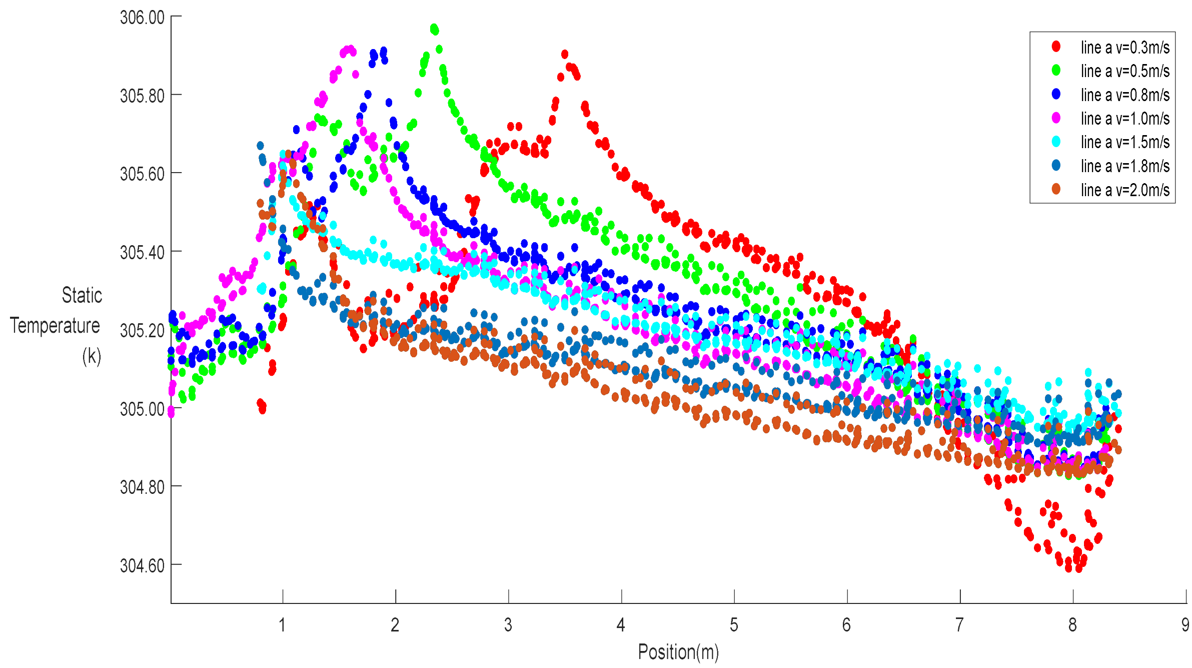


FIGURE 15. Temperature distribution on monitoring line a at different air velocity.

$$Ar = \frac{\beta g b (T_0 - T_f)}{u_0^2} \tag{2}$$

In the formula, $\boldsymbol{\beta}$ is the coefficient of volume expansion ($\boldsymbol{\beta}=1/T_f$), K^{-1}; g is the acceleration of a free-falling body, m/s^2; b is the width of the slit tuyere, which is 0.03m. T_0 is the supply air temperature, K; T_f is the mean temperature in the cell, K. Yu et al. found through research that when $Ar < 0.004$, the air flow is consistent with the isothermal jet, and the development of the flow pattern of the supply air flow is dominated by the inertial force. When $Ar > 0.018$, the supply air flow is more affected by the buoyancy. According to the calculation of the relevant parameters of the vertical wall attached jet ventilation gosling house in this study, the maximum Ar of Archimedes is 0.005, and the flow of the supply air is dominated by the inertial force.

Air quality evaluation of gosling house

When the supply air velocity v=1.5m/s and the supply air temperature t=305.15k, the maximum wind velocity in the living area of goslings was 0.49m/s, the minimum wind velocity was 0.21m/s, the average wind velocity was 0.40m/s, the maximum temperature was 305.89k, the minimum temperature was 304.86k, and the average temperature was 305.20k. It can meet the requirements of temperature and ventilation volume of goslings, and the temperature distribution is uniform and the air flow rate is moderate, which is the best combination of air supply parameters of the vertical wall attached jet ventilation house for goslings.

ADPI refers to the ratio between the measuring point meeting the specified temperature and wind velocity and the total measuring point (Shah et al., 2021). In this paper, Air Diffusion Performance Index (ADPI) was used to evaluate the air environment in the gosling house. The influence of air temperature and wind velocity on the comfort of goslings is mainly considered for the effective ventilation of goslings. According to the relationship between the effective temperature difference and the temperature and wind velocity in the house:

$$\Delta ET = \left(T - T_n\right) - a(V - b) \quad (3)$$

In the formula: ΔET is the effective temperature difference, K; T is the air temperature at the monitoring point in the gosling activity area, K;T_n is the design temperature in a given cell, K; V is the air velocity at the monitoring point in the gosling activity area, m/s; b is the control wind velocity, take 0.2m/s control constant, take 7.66.

When the is between -1.5℃ and 1.5℃, the goslings feel comfortable, therefore, the air distribution characteristic index ADPI is:

$$ADPI = \frac{-1.5\,°C < \Delta ET < 1.5\,°C \ number\ of\ measuring\ points}{total\ number\ of\ measuring\ points} \times 100\% \quad (4)$$

The ADPI value can explain the effect of air flow organization in the horizontal sticking zone on the goslings. Under normal circumstances, the ADPI should be >80%, the greater the value of ADPI, the more comfortable the goslings, the better the air flow organization in the house. The data of 33 measuring points are substituted into the formula for calculation,research gosling house ADPI=100%.indicating that the airflow quality of the vertical wall attached jet ventilation in the gosling barn is very good.

CONCLUSIONS

In this paper, the three-dimensional numerical simulation and field measurement of the air flow field and temperature field distribution in the vertical wall attached jet ventilation gosling house in the cold area were carried out by using CFD method, and the following conclusions were drawn:

(1) The model was used to simulate the air flow field and temperature field of the gosling house. The RMSE of the simulated and measured wind velocity values at each measurement point was 0.035m/s, the maximum absolute error was 0.087m /s, and the average relative error was 2.40%. The root mean square error (RMSE) of the simulated and measured temperature at each measuring point is 0.14℃, the maximum absolute error is 1.34℃, and the average relative error is 2.01%. The CFD model can accurately describe the air flow field and temperature field in the gosling house with vertical wall attached jet ventilation.

(2) The air supply air in the gosling house attached to the vertical wall can form a layer of "air pool" in the gosling activity area, and the air flow field and temperature field in the "air pool" are evenly distributed, maintaining most of the heat and freshness of the air supply air, and ensuring the needs of the gosling for ventilation volume and temperature, it is proved that it is of practical significance to apply the vertical wall attached jet ventilation to the gosling house in cold region.

(3) The greater the air supply velocity, the greater the average velocity of the gosling living area, and the longer the horizontal attaching range. When the air supply velocity is greater than 1.8m/s, the maximum wind velocity in the living area of the goslings is more than 0.5m/s, and the goslings feel wind. When the air supply velocity is lower than 0.8m/s, the average wind velocity in the gosling living area is lower than 0.2m/s, and the ventilation in the gosling living area is insufficient.

(4) When the supply air velocity v=1.5m/s and the supply air temperature t=305.15k, the maximum wind velocity in the living area of goslings was 0.49m/s, the minimum wind velocity was 0.21m/s, the average wind velocity was 0.40m/s, the maximum temperature was 305.89k, the minimum temperature was 304.86k, and the average temperature was 305.20k. The horizontal sticking range of the air supply is about 7.0m, the ADPI of the gosling is 100%, under this condition, the air flow organization quality is very good, the ventilation effect is the best, and it can be regarded as the best condition for brooding.

In this study, CFD numerical simulation was carried out on the air flow field and temperature field of the gosling house with vertical wall attached jet ventilation, it is proved that it is feasible to apply vertical wall attached jet ventilation to gosling house in cold area, and find the best condition for gosling growth. which can provide reference for the design and application of vertical wall attached jet ventilation technology in the gosling house in cold regions.

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