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Wind and solar Complementation + Animal Intelligence New Livestock Farm Air Conditioning System

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Abstract

All With the rapid development of animal husbandry in China, there are many problems, such as extensive waste discharge pollution, product safety can not be guaranteed, and ineffective prevention and control of major diseases. Timely updating the air in the breeding farm and ensuring a good air environment in the breeding farm is the fundamental way to ensure the quality of livestock products and reduce air pollution. However, domestic air exchange and disinfection equipment developed for livestock farms are rare, with generally high energy consumption and poor disinfection effect. Based on the above background, combined with wind-wind complementary power generation, Internet of Things and intelligent sensing technology, this paper designs a new livestock farm air conditioning system that integrates the functions of air exchange, clean air, sterilization and disinfection. It fully uses renewable energy to sterilize the air entering and discharging the livestock farm, bringing more dividends to the livestock industry.

Keywords

Farm fresh air system; Ventilation and purification; Ozone sanitizes; Wind and solar power generation; Internet of Things; Cloud-based monitoring.

1. INTRODUCTION

At this stage, the animal food consumption of urban residents is still in the steady growth of "rising" stage, especially beef and mutton, poultry meat, liquid milk and dairy products, aquatic products, will appear a rapid growth trend. With the rise in rural residents' income, the increase in meat and egg consumption will appear in the stage of rapid growth. Overall, the consumption of livestock products by Chinese residents will enter a period of steady increase in the next 15-20 years. The development of animal husbandry in our country still has a lot of development potential. In the livestock production , manure and urine can produce some toxic or odorous gases from livestock or livestock product processing plants. It is distributed by fans through livestock to houses or workshops or by fecal water directly to residential areas near livestock farms.

Outdoor outlets, cesspools composting sites, etc., not only seriously affect the health and production performance of livestock, but also affect the health of residents and environmental protection of residential areas. Therefore, the problem of controlling the odor and harmful gases produced by livestock farms is an urgent problem to be solved in livestock production. The hazards of odors and harmful gases and the characteristics of controlling odors and harmful gases in livestock farms are summarized as follows: Characteristics of odors and harmful gases in livestock farms Manure and urine, excrement and the resulting odors and harmful gases

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cause severe pollution of the quality of water, soil, air and crops in the surrounding environment and become routes of transmission of infectious diseases livestock, parasitic diseases and zoonotic diseases. Livestock farms emit many odor and harmful gas components, mainly ammonia, hydrogen sulfide, Skardin, mercaptan and so on. In the future, China's animal husbandry will continue to grow steadily, and will continue to optimize and upgrade, develop in the direction of green and high quality development; At the same time, more attention will be paid to technological innovation. Based on this, this paper discusses a new method of disinfection and waste gas treatment in livestock and poultry breeding.Table 1. Your table here and center.

2. DESIGN SCHEME

This system architecture is divided into three layers: equipment layer, control layer, Internet of Things layer. The device layer is composed of all physical devices, which is the physical basis of the system; The control layer plays the role of controlling the physical devices and connecting the lot layer; The Internet of Things layer will store and visualize all kinds of data information of the equipment layer, so that managers can monitor the operation of various facilities in real time.The health state of livestock, and can remotely control the equipment to achieve cloud monitoring and control.

2.1. General design block diagram

This system select STM32F407 as the central controller and use W601 IoT as the development board of the Internet of Things. Temperature protection and voltage and current protection are configured to ensure the safe and stable operation of the main control board. The data of temperature, humidity and air quality in the farm are transmitted to the main control board through the sensor, and the closed-loop control of the main control board to the fresh air device is realized. At the same time, the data is uploaded to the cloud network, and the client can obtain the cloud data in real-time to master the data information of the farm.

2.2. Mechanical Design

Mechanical design is shown in Figure 1 and Figure 2. The device is divided into two layers, one layer plays the role of circulation and exchange of air inside and outside the farm; The two-layer air inlet is connected to the ozone purification device, and the outlet is connected to the first layer to disinfect the gas entering and leaving the farm. Each layer is comprises the air inlet, the air outlet, the centrifugal fan, the air volume control valve, the graphene adsorption plate and the PP fiber needle filter plate[2]. The centrifugal fan inhales or discharges the air into the bellows. The air volume control valve combined with the control system can automatically adjust the air intake and air output. The graphene adsorption plate and PP fiber needle filter plate can absorb and filter the impuritiesin the air, and play a profound cleaning role for the gas.

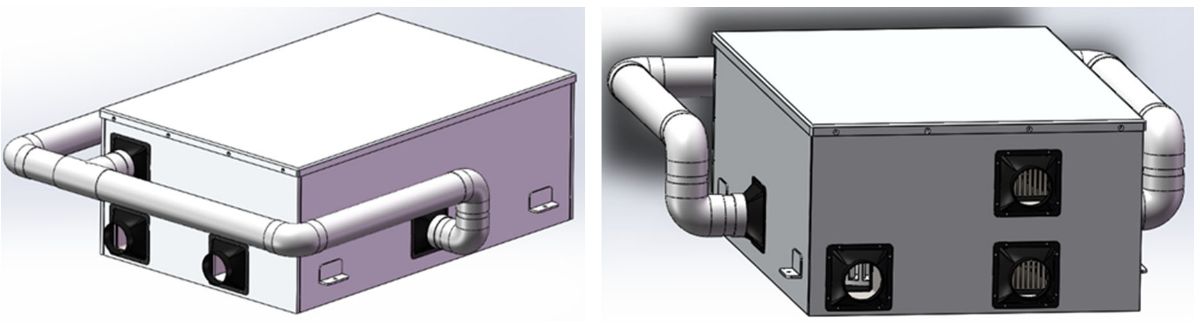

Figure 1. Appearance design of fresh air device

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3. SIMULATION EXPERIMENT

ICEM CFD was used to grid[3]the physical model and Fluent was used to simulate the wind flow in the device. The simulation model was selected as the standard model$k - \omega$[4], and its standard transport equation was as follows:

$$\frac{\partial}{\partial t}(\rho k)+\frac{\partial}{\partial x_i}(\rho k u_i)=\frac{\partial}{\partial x_j}\left[\Gamma_{\mathrm{k}}\frac{\partial k}{\partial x_j}\right]+G_k-Y_{\mathrm{k}}+S_{\mathrm{k}} \tag{1}$$

$$\frac{\partial}{\partial t}(\rho)+\frac{\partial}{\partial x_i}(\rho \omega u_i)=\frac{\partial}{\partial x_j}\left[\Gamma_{\omega}\frac{\partial \omega}{\partial x_j}\right]+G_{\omega}-Y_{\omega}+S_{\omega} \tag{2}$$

where G_k denotes the turbulent energy due to the laminar velocity gradient, $G_\omega$is generated by the equation ω,Γ_k andΓ_ω denotes the diffusivity of k and ω, Y_k and Y_ω denotes the turbulence due to diffusion,S_k and S_ω are user-defined variables.

The calculation of Γ_{k} and Γ_{ω}:

$$\Gamma_k=\mu+\frac{\mu_t}{\sigma_k} \tag{3}$$

$$\Gamma_{\mathrm{k}}=\mu+\frac{\mu_{\mathrm{t}}}{\sigma_{\omega}} \tag{4}$$

Viscosity coefficient:μ_{t}

$$\mu_{\mathrm{t}}=\alpha^*\frac{\rho k}{\omega} \tag{5}$$

$$\alpha^*=\alpha_\infty^*\left(\frac{\alpha_0^*+\mathrm{Re_t}/\mathrm{R_k}}{1+\mathrm{Re_t}/\mathrm{R_k}}\right) \tag{6}$$

The $\mathrm{Re_t}$:

$$\mathrm{Re_t}=\frac{\rho k}{\mu\omega} \tag{7}$$

k and the definition of the turbulent kinetic energy term:

$$G_k=-\overline{\rho u_{\mathrm{i}}'\rho u_{\mathrm{j}}'}\frac{\partial u_{\mathrm{j}}}{\partial x_{\mathrm{i}}} \tag{8}$$

$$G_\omega=\alpha\frac{\omega}{k}G_k \tag{9}$$

The coefficient is defined as α

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$$\alpha = \frac{\alpha_\infty}{\alpha^*}\left(\frac{\alpha_0 + \mathrm{Re_t}/\mathrm{R_\omega}}{1 + \mathrm{Re_t}/\mathrm{R_\omega}}\right) \tag{10}$$

Turbulent dissipation term:

$$Y_\mathrm{k} = \rho \beta^* f_{\beta^*} k \omega \tag{11}$$

Where:

$$f_{\beta^*} = \begin{cases} 1, & \chi_\mathrm{k} \le 0 \\ \frac{1+680\chi_\mathrm{k}^2}{1+400\chi_\mathrm{k}^2}, & \chi_\mathrm{k} \ge 0 \end{cases} \tag{12}$$

$$\chi_\mathrm{k} \equiv \frac{1}{\omega^3}\frac{\partial k}{\partial x_\mathrm{j}}\frac{\partial k}{\partial x_j} \tag{13}$$

$$\beta^* = \beta_\mathrm{i}^*[\zeta^* F(M_\mathrm{t})] \tag{14}$$

$$\beta_\mathrm{i}^* = \beta_\infty^*\left(\frac{4/15 + \left(\mathrm{Re_t}/\mathrm{R_\beta}\right)^4}{1 + \left(\mathrm{Re_t}/\mathrm{R_\beta}\right)^4}\right) \tag{15}$$

Where， ζ^*=1.5, $\mathrm{R_\beta} = 8$, $\beta_\infty^* = 0.09$, $\mathrm{Re_t}$ is given by equation (7)
The dissipation term of ω:

$$Y_\omega = \rho \beta f_{\beta^*} \omega^2 \tag{16}$$

Where:

$$f_{\beta^*} = \frac{1+70\chi_\omega}{1+80\chi_\omega} \tag{17}$$

$$\chi_\omega = \left|\frac{\Omega_\mathrm{ij}\Omega_\mathrm{ik}S_\mathrm{ki}}{(\beta_\infty^*\omega)^3}\right| \tag{18}$$

$$\Omega_\mathrm{ij} = \frac{1}{2}\left(\frac{\partial u_\mathrm{i}}{\partial x_\mathrm{j}} - \frac{\partial u_\mathrm{j}}{\partial x_\mathrm{i}}\right) \tag{19}$$

In formula (18):

$$S_\mathrm{ki} = \frac{1}{2}\left(\frac{\partial u_\mathrm{i}}{\partial x_\mathrm{j}} - \frac{\partial u_\mathrm{j}}{\partial x_\mathrm{i}}\right) \tag{20}$$

β_i^* is given by formula (15):
β is:

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$$\beta = \beta_{\mathrm{i}}\left[1 - \frac{\beta_{\mathrm{i}}^{*}}{\beta_{\mathrm{i}}}\zeta^{*}F(M_{\mathrm{t}})\right] \tag{21}$$

$$F(M_{\mathrm{t}}) = \begin{cases} 0,\ M_{\mathrm{t}} < M_{\mathrm{t0}} \\ {M_{\mathrm{t}}}^{2} - {M_{\mathrm{t0}}}^{2}, M_{\mathrm{t}} \geq M_{\mathrm{t0}} \end{cases} \tag{22}$$

Where:

$${M_{\mathrm{t}}}^{2} = \frac{2k}{a^{2}} \tag{23}$$

$$M_{\mathrm{t0}} = 0.25 \tag{24}$$

$$a = \sqrt{\gamma RT} \tag{25}$$

Constant term in the model: $\alpha_{\infty}^{*} = 1$, $\alpha_{\infty} = 0.52$, $\alpha_{0} = 1/9$, $\beta_{\infty}^{*} = 0.09$, $\beta_{\mathrm{i}} = 0.072$, $\mathrm{R}_{\beta} = 8$, $\mathrm{R}_{\mathrm{k}} = 6$, $\mathrm{R}_{\omega} = 2.95$, $\zeta^{*} = 1.5$, $M_{\mathrm{t0}} = 0.25$, $\sigma_{\mathrm{k}} = 2.0$, $\sigma_{\omega} = 2.0$.

The simulation setup parameters are as follows:

Table 1. Simulation parameter Settings [3,5]

Layer name	Intake air volume	Outgoing air volume	Grapheneple resistance	Filter resistance	Denty	Viscosity
Deflating layer	400 m3/h	300 m3/h	380 Pa	150 Pa	1.225 kg/m	1.7894 x 10-5 kg/(m.s)
Ozone layer	200 m3/h	200 m3/h	380 Pa	150 Pa	2.14 kg/m3	1.7894 x 10-5 kg/(m.s)

The working condition design is as follows:

Table 2. Design of simulation working conditions

Working Condition design	Air volume valve opening
1	1/3
2	2/3
3	3/3

Simulate the inside of the housing to get the grid division diagram as well as the velocity flow diagram as shown in Figures 7 and 8. According to clip processing method, under the premise of knowing the area of each vent, the inlet and outlet air tables under three working conditions are obtained, as shown in Table 3:

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Table 3. Simulation results of inlet and outlet air volume under three working conditions

Working Conditions	Air intake volume of air exchange layer	Ozone layer air intake	Ventilation volume	Ozone layer air output
1	400	200	99.375	65.5
2	400	200	198.75	131.0
3	400	200	298.125	195.6

There are some errors in the simulation and theoretical design results, the error value is between 0.625% and 1.75%, and the error value is minimal and can be ignored. It can be seen that the design of the fresh air system is reasonable.

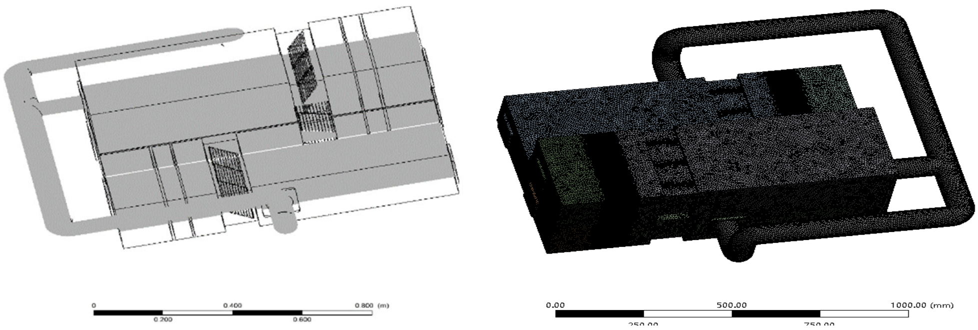

Figure 2. 3 Mesh division and 3Fluent's original structure

Velocity flow diagram:

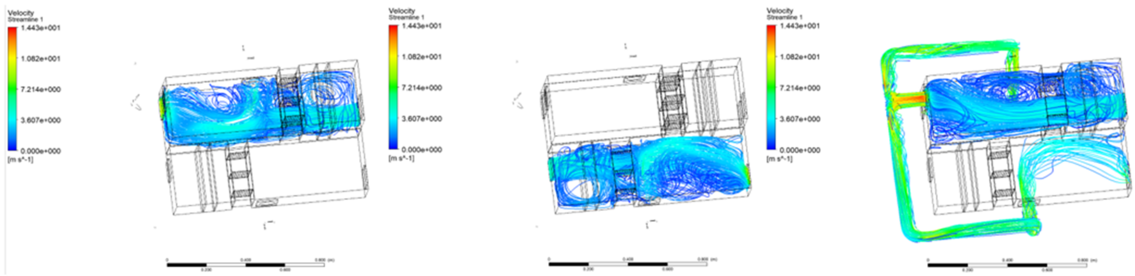

Figure 3. Speed flow diagram

4. OPERATING PRINCIPLE

4.1. Analysis of the working process of the fresh air device

1. Start of fresh air system

When the sensor detects that the content of harmful gases in the farm exceeds the average value, the main control board controls the centrifugal motor of the air exchange layer and the ozone inlet layer to start, and the air volume regulating valve intelligently controls the air volume;

2. Closed loop control of fresh air system

The sensor obtains the content data of all kinds of harmful gases in the farm in real time, and feedbacks to the main control board. The main control board adjusts the amount of ozone in and out of the air to achieve closed-loop control.

3. Realization of air filtration and humidification, dust removal and purification and disinfection functions of fresh air system

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The ozone purification system sends out ozone into the fresh air device, and enters the air exchange layer through the channel to sterilize the air of the air exchange layer; Filtration is divided into two processes: graphene adsorption plate adsorbing dust and gravel; PP fiber needling plate for further filtration; Humidification is carried out through the humidification module.

4.2. The working principle of wind-wind complementary power generation module

1. Wind turbine and photovoltaic panel direct power supply

The electricity emitted by the wind turbine is rectified and filtered, and the electricity emitted by the photovoltaic panel is converted into direct current through the booster circuit by the inverter, and then directly supplies power to the fresh air system.

2. Energy storage module and power grid indirect power supply

If there is still enough power after the wind system is supplied to the fresh air system, the energy will charge the energy storage device; If the energy storage is fully charged, the system will automatically connect the power grid and input the surplus electric energy into the power grid system. When the power generation of the wind-solar complementary system cannot meet the power consumption, the energy storage starts to release energy to compensate for the real-time load difference required by the fresh air system. If the wind-solar storage three can not meet the demand of the fresh air system, the controller will control the grid-connected switch connected to the three-phase power grid, by the power grid to supply the required energy.

5. INNOVATION POINTS

Table 4. Innovation points

Innovation point	Be specific
Ozone sterilization + fresh air system	After the use of ozone can be quickly decomposed, based on retaining the advantages of the traditional fresh air system, such as air change and purification, the function of ozone sterilization, disinfection and deodorization is added.
Wind and solar complementary power generation + fresh air system	Combining the advantages of abundant scenic resources in Northwest China, the wind-solar complementary power generation system is innovatively combined with the fresh wind system, which has the advantages of environmental protection, no pollution, no maintenance and easy installation.
PRS+Internet remote control	Through GPRS+Internet to achieve the whole network interconnection, significantly improve the stability and operation and maintenance efficiency, data transmission low delay characteristics to ensure the reliability of the data. The Internet of Things monitors the temperature, humidity, ozone concentration and air quality of the farm in real time, so that users can know the indicators of the farm anytime and anywhere. Users can also control the equipment through real-time data to meet the user's environmental requirements for the farm.
Innovation of mechanical structure	Different from the traditional mechanical structure of the fresh air system, the fresh air structure is divided into two layers, which can work independently or cooperatively to realize the

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6. BENEFIT ANALYSIS AND APPLICATION PROMOTION

6.1. Economic benefit

Table 5 compares the economic cost of the disinfection method of the fresh air system with the two traditional disinfection methods. The results show that the disinfection operation cost of the fresh air system is lower than that of the traditional disinfection method, and the yield increase benefit is 2.5 times that of the traditional method.

Table 5. Economic benefit estimation table

Types	Price/Yuan	Service life	Running cost (yuan/day)	Yield increase benefit of livestock products (Yuan)
Peracetic acid disinfectant	220/bucket	5 days	44	10000
Formalin	40/ bottle	2 days	20	9000
Fresh air ozone equipment	1100/ set	6 years	18	25000

6.2. Ecological benefits

If the device replaces the traditional ventilation method, each system can save 30kW·h of electric energy per day, save 65700kW·h of electric energy, save 26.28t of standard coal, and 65.5029 tons[6] of greenhouse gases within 6 years of service life cycle. The efficiency of energy saving and emission reduction is very significant.

Table 6. Emission reduction benefits of wind-solar complementary power generation system

Indicators	Introduce fresh air system	Emission reduction benefits (Yuan)
Average electricity supply (kwh/year)	10950.0	6789.000
Saving standard coal (t/ year)	4.38000	3066.000
Greenhouse gas reduction (t/ year)	65.5029	26201.16

The emission reduction of harmful gases in the farm during the 6-year life cycle of this fresh air system is as follows:

Table 7. Estimation table of emission reduction benefits of major polluting gases

Pollutants	Emission reduction (t)	Unit environmental value (yuan /kg)	Emission reduction benefit (ten thousand yuan)
SO_2	6.57000	6.3200	4.1500
NO_X	3.28500	6.3200	2.0760
CO_2	218.343	0.1000	2.1800
H_2S	0.28908	354.25	10.241
NH_3	0.67452	241.44	16.314
DUST	59.5680	0.2000	1.1900
TOTAL	---	---	36.520

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Among them, the emission reduction benefits of HS2 and NH3 are especially significant, and they play a great role in the prevention and control of air pollutants.

7. CONCLUSION

China's livestock farms cover an area of 30000hm^2, with an output of 92.27 million tons of pigs, cattle and sheep, and an output value of 2,577.7 billion yuan. With the increasing development of livestock breeding industry, due to various environmental pollution, the quality of livestock products such as cattle, sheep and pigs is declining, and disease prevention and control is becoming more and more difficult. To solve these issues, the state vigorously control the environmental problems of animal husbandry, to ensure the high quality of livestock products such as cattle, sheep and pigs, and the actual development prospects in the future are good. Promoting the application of this system can realize the construction of low energy consumption and greener farms, while improving the living environment of livestock and increasing the output of livestock products. The device is not only suitable for large farm bases, but also can be extended to individual farmers, helping the household head to reduce costs and improve income.

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