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Optimization of denitrification treatment of freshwater aquaculture tailwater based on distributed control technology

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ABSTRACT

Because the traditional freshwater aquaculture tailwater denitrification treatment method has the problems of poor tailwater denitrification effect and slow denitrification treatment efficiency, an optimization method for freshwater aquaculture tailwater denitrification treatment based on distributed control technology is proposed. Using distributed control technology to design the freshwater aquaculture tailwater denitrification treatment distributed control system (DCS) composed of the chlorination room circuit module, the reaction tank valve circuit module, the filter instrument control module and the flushing pump control circuit module; Through the DCS control system, the blower is used for dissolved oxygen control, two $Al_2(SO4)_3$ solution pools are designed for dosing control. Combining the advantages of proportion integral differential (PID) control and fuzzy control, the fuzzy control self-tuning PID intelligent control is used to construct a fuzzy control model to complete freshwater aquaculture tailwater removal nitrogen treatment optimization. The experimental results show that the freshwater aquaculture tailwater of this method has a higher denitrification rate and a faster denitrification treatment efficiency.

Keywords: Distributed control technology; Freshwater aquaculture; Tailwater denitrification; Fuzzy control

1. Introduction

In recent years, with the rapid development of China's social economy, people's living standards are constantly improving, and the market demand for aquatic products is constantly increasing, which brings new opportunities for the development of China's freshwater aquaculture industry. In order to meet the demand of the market, freshwater aquaculture gradually developed to the direction of large-scale, intensive, high-density breeding pond method has been widely used, compared with the traditional breeding method, the high-density cultivation method is adopted, a lot of residual and waste into water bodies, bait led to the breeding in the study, such as not timely and effective treatment, not only deteriorate, water for aquaculture environment lead to fish, shrimp, crab breeding animal diseases, such as aquaculture product quality and production; However, high-density farming will produce a large number of feces and residual bait, which will be discharged into the water, resulting in the continuous intensification of tailwater pollution [1]. In order to minimize the harm caused to the human body by this kind of residual pollutants, it is necessary to enhance the tailwater treatment technology of freshwater aquaculture wastewater on the basis of economic optimization [2,3].

At present, the treatment of aquaculture tailwater has become an important factor affecting the development of China's aquaculture industry. In China, the concept of

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"Environmental Protection and Resource Conservation" is strongly advocated, so denitrification treatment of freshwater aquaculture tailwater is particularly necessary [4]. Therefore, it is of great practical significance for healthy aquaculture and sustainable development to promote environmentally friendly freshwater aquaculture mode and tailwater treatment [5]. Under the support and supervision of governments at all levels, nitrogen removal facilities for freshwater aquiculture tailwater have been set up in some farms, and certain effects have been achieved.

The development of tailwater treatment and control systems for urban freshwater aquaculture in China was relatively late [6]. After the 1990s, automatic control technology was introduced into the process of tailwater treatment for freshwater aquaculture. As early as the 1970s, automatic control technology began to be applied in China's water treatment industry. Until the 1990s, automatic control technology developed rapidly in the water treatment industry [7]. In the past two decades, the application of automation technology and information technology in China's water treatment industry has been rapidly developed, creating good social and economic benefits [8]. However, compared with foreign developed countries, the automation and information technology of China's water treatment industry is still very backward, which is mainly reflected in the treatment process and automation level. There is a lack of integration between information technology and automation technology, a large number of process data are not timely collected and play a role, and the development of intelligent decision-making information technology is slow. Energy conservation and emission reduction, as the main goal of the development of the water treatment industry, have attracted much attention. However, automation and information technology, as important technical means of energy conservation and emission reduction in the water treatment industry, still need to be improved [9]. From the solution of domestic water, tailwater treatment of intelligent control and optimal management, to the maximum extent to save resources, to achieve the optimal scheduling of resources, to minimize the operation cost of the water treatment industry. Freshwater fish tailwater denitrification process as an important part of the water treatment industry is also a large number of integrated automatic control system adopts PLC control equipment, can meet the requirements of the production process, to a great extent improve the integration degree of the distributed control station, improve the stability of the system is running, freshwater fish tailwater denitrification treatment to reduce costs, improve the economic benefit.

In China, the research on tailwater treatment is far behind that of foreign developed countries, especially in the aspect of automatic control of tailwater treatment, which is consistent with the economic development in China. At first, the tailwater treatment control was basically on-site control cabinet operation or manual operation. Due to the wide geographical distribution of the tailwater treatment equipment, it brought great inconvenience to the overall control, thus hindering the development of the tailwater treatment level. Literature [4] based on the electric flocculation technology of freshwater fish tailwater denitrification process, electric flocculation as a kind of green environmental protection water treatment technology, due to its simple operation, high pollutant removal efficiency, equipment cover an area of an area small, much attention has been paid to the advantages of this paper the research progress of electrical flocculation technology, water purification mechanism, influence factors and its application in mariculture, this paper introduces the electric flocculation technology to remove the algae, the removal of turbidity and chemical oxygen demand (COD), denitrification and phosphorus removal, sterilization and coupling application with other water treatment technologies, also introduces the energy consumption of the electric flocculation technology calculation, hydrogen recycling and challenges [10]. However, the denitrification rate of tailwater in freshwater aquaculture is low. Literature [5] based on plus plant carbon source of freshwater fish tailwater denitrification process, through the static release experiment, compared with the maize straw, corn cob and miscanthus feature of static release in the water of the sea, explores the law of acid treatment and alkali treatment on COD release, and USES the vertical, the undercurrent of artificial wetland system research, leaching liquid of wetlands, and add COD seawater circulating water aquaculture tailwater denitrification effect, the results showed that the three kinds of plant carbon source have considerable COD release quantity, corn cob n p release quantity is smaller, more suitable for as additional carbon source [11]. Acid treatment and alkali treatment can improve plant carbon dissolution rate of carbon source, but the release of alkali treatment rate is more stable, more suitable as a pretreatment method, add corn cobs, extract wetland of nitrate nitrogen and cod removal rate up to 90.63% and 88.56% respectively, showed that adding plant carbon source can significantly improve the effect of artificial wetland sea denitrification, and prove to leach liquid carbon source to replace plants the feasibility and effectiveness of the carbon source. However, the denitrification efficiency of the freshwater cultured tailwater is low.

To raise the level of computer control for the improvement of the industrial production process of product quality, reduce the secondary pollution and cost control has a lot to improve, so far, can simulate the artificial operation of the computer control system of process control engineering and production equipment management has become an indispensable part of, more and more attention by people and applied to practical engineering. Based on this, this paper optimized the denitrification treatment of freshwater aquaculture tailwater by using the distributed control technology on the basis of the traditional denitrification treatment method. The distributed control technology is a multi-level computer monitoring technology based on a communication network, which comprehensively applies computer, communication, display and control technology to realize centralized management and decentralized control of the production process. By using distributed control technology, denitrification treatment of freshwater aquaculture tailwater can be carried out effectively, so as to improve the utilization rate of water resources, alleviate the increasingly tense water resources in China, and promote the rapid development of the economy.

2. Distributed control technology

The distributed control system is an advanced instrument control system based on microprocessor, which adopts the design principles of decentralized control function, centralized display operation, autonomy and comprehensive coordination. Distributed control systems are commonly referred to as DCS, which can also be literally translated as "distributed control systems" or "distributed computer control systems". Its basic design idea is to adopt decentralized control, centralized operation and management, and adopt multi-level hierarchical and cooperative autonomous structure. Its main characteristics include centralized management and decentralized control [12]. DCS has been widely used in power, metallurgy, petrochemical, environmental protection and other industries. Distributed control is a high-tech system integrating 4C technology (Computer, Control, Communication, CRT). It is a new kind of control technology that adopts computer technology to monitor, operate and manage the production process centrally and realize the control of the field device decentralized. The characteristics of the distributed control system is in the central monitoring system through the working condition of hardware and software for the whole management and scheduling command, each production equipment after receiving orders according to the independent control system to run the system configuration and operation, the system also has a decentralized control, centralized management and monitoring, and operation, etc. By using this control system can run instead of an instrument process data on-line detection, real-time diagnosis field failure and make alarm indication, the change trend of various parameters were analyzed, and timely response and predict the production performance, the record, to view and manage the whole process of production, the attendants really done it the purpose of diversification [13].

3. DCS control system of tailwater denitrification treatment

This design adopts centralized management and decentralized control system, which is mainly composed of the central control room and each control sub-station. The whole DCS control system structure of freshwater aquaculture tailwater denitrification treatment is composed of the circuit module of the chlorine room, the valve circuit module of the reaction tank, the instrument control module of the filter and the control circuit module of the flushing pump. According to the function and equipment characteristics of each module, the optimal hardware configuration that meets the control requirements is obtained.

3.1. Chlorine room circuit module

The chlorination circuit mainly consists of the following three parts:

3.1.1. DCS1-01 Module interface

This interface includes DI (digital input) and DO (digital output). DI interface includes selection of absorption device, operation of absorption device, failure of absorption device, alarm of chlorine leakage, selection of axial flow ventilator/automatic, operation of axial flow fan, failure of axial flow fan, etc. DO interface includes axial flow fan on/off, absorption device on/off, etc. [14]. The specific distribution is shown in Fig. 1:

3.1.2. Chlorination module

The whole process and equipment distribution of chlorine addition are shown in Fig. 2. There are two chlorine addition points. The first point goes all the way through the generator to the sodium hypochlorite storage tank and then to the chemical feeder. Among them, signals in the generator CC1-A and sodium hypochlorite tank signal = CV-A are all transmitted to DCS1-01 through cables. The other chlorination point directly reaches the hydrochloric acid storage tank through the generator and then enters the hydrochloric acid tanker through the acid unloading pump. The signal in the process is also transmitted to DCS1-01.

3.1.3. Alarm and low-voltage module

The alarm and low-pressure module is shown in Fig. 3. The chlorine leakage alarm (CC101) generates a start signal and sends it to the absorption control box and DCS. Once chlorine leakage occurs, the chlorine leakage alarm is activated and then prompts the absorption control box to start working. The signal in the absorption control box (=CC-MA) is also transmitted to the DCS. Three fans (C-F1, C-F2, C-F3) respectively send signals to DCS through three fan control boxes (=CF1-A, =CF2-A, =CF3-A) [15,16]. The

PLC1-01	I/O																		
	DI											DO							
	Selection of absorption device	Operation of absorption unit	Absorber failure	Dew chlorine alarm	Automatic selection	Axial flow fan operation	Axial flow fan failure				Total	Axial fan on / off	Absorption unit on / off					Total	
	1	1	1	1	3	3	3				13	3	1					4	

Fig. 1. Indirect chlorination port of DCS.

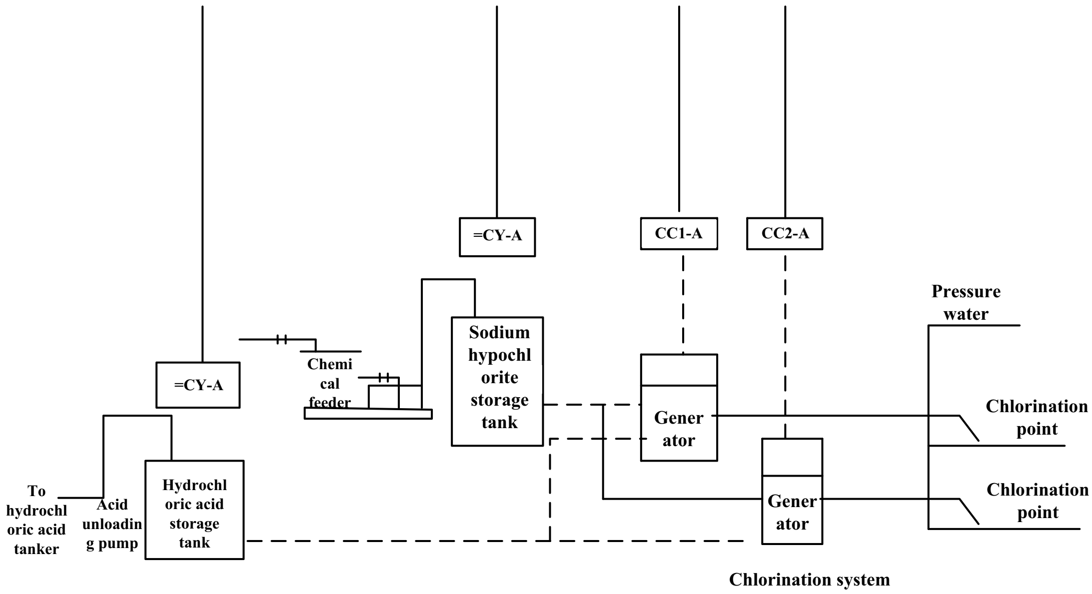

Fig. 2. Schematic diagram of chlorination module.

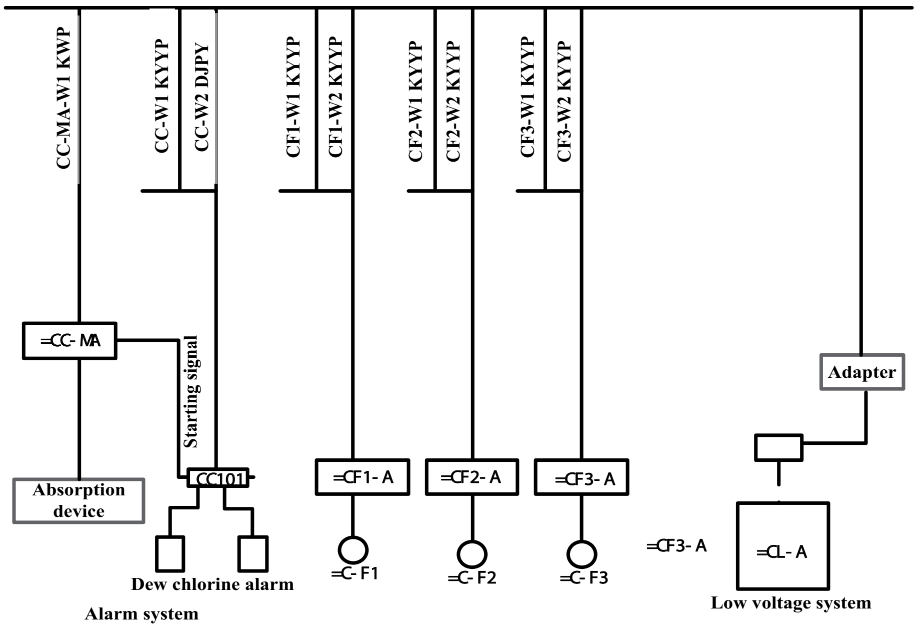

Fig. 3. Diagram of alarm module and low voltage module.

low-pressure chlorination module (=CL-A) supplies power to the fan, chlorine leakage alarm, and absorption control box through an adapter.

3.2. Reaction tank valve circuit module

The valve wiring of the reaction cell is shown in Fig. 4, the solenoid valve (V1~V20) is connected to the local control box (D-V1~D-V20), FU is a fuse, and the circuit is protected when the current is too large, DCS1-02 is connected to the circuit. SA is a manual automatic transfer switch. When SA is set to automatic, DCS will automatically operate the solenoid valve. When SA is set to manual, the toggle switch (SL1~SL20) will control the solenoid valve [17].

3.3. Filter instrument control module

The filter instrument control circuit module is divided into two parts, here is the example of the first filter:

3.3.1. DCS2-01 module interface:

This interface includes AI (analog input), AO (analog output), DI (digital input) and DO (digital output). The signals included in the AI interface are: liquid level signal, differential pressure signal and outlet valve position signal. The signals included in the AO interface are: the outlet valve position adjustment control signal. The DI interface includes signals: inlet valve switch, inlet valve position, inlet valve failure, outlet valve switch, outlet valve position, outlet valve failure, air flush valve position, air flush valve failure, water flush valve position, water Flush valve switch, water flush valve failure, drain valve, drain valve switch, drain valve failure, primary filter drain valve switch, primary filter drain valve position, primary filter drain valve failure, instrument failure, etc. [18]. The DO interface includes water inlet valve control, water outlet valve control, air flush valve control, water flush valve control, drain valve control, exhaust valve control, and preliminary filter water drain valve position. DCS is connected to the local console of the filter module (=F1L-A).

3.3.2. Filter instrument structure

Fig. 5 shows the filter instrument structure. Sewage enters the filter tank from the water inlet through the control of the water inlet valve. After filtering, it is flushed with air (the air enters the exhaust valve through the air flushing pipe to control the discharge), and the water is flushed (the clean water is discharged by the exhaust valve). The backwash valve controls the entry and discharges from the outlet pipe) to the primary filter tank, and discharges through the primary filter water outlet. The signals in the whole process are: inlet valve signal (F1V1), drain valve signal (F1V6), filter water level (LET301), filter differential pressure (LDT301), exhaust valve signal (F1V5), air flush valve signal (F1V4), clean water valve signal (F1V2), backwash water valve signal (F1V3), primary filter water drain valve (F1V7), etc.

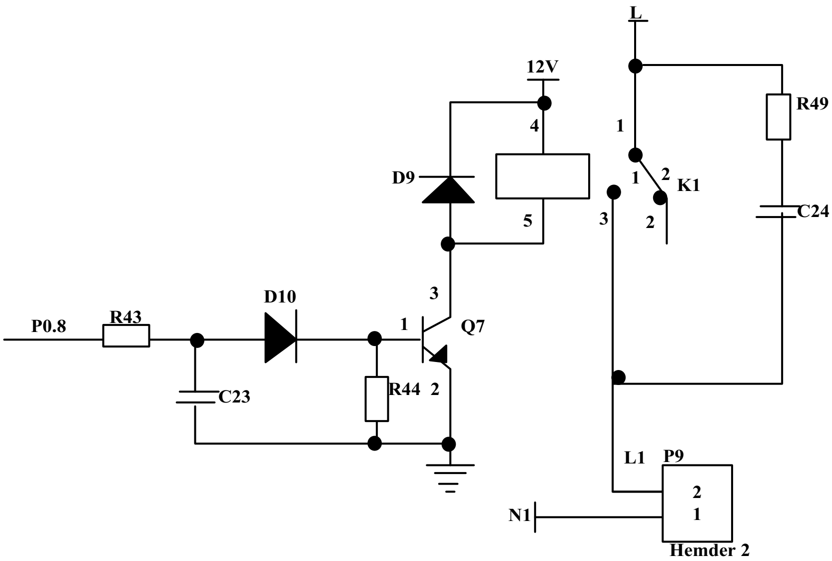

Fig. 4. Principle diagram of solenoid valve control.

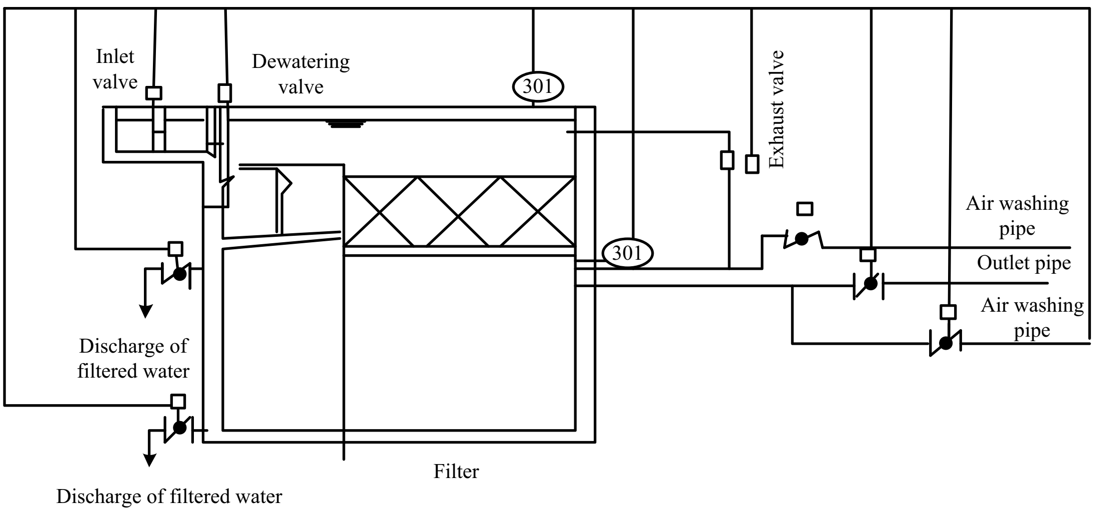

Fig. 5. Filter instrument structure diagram.

3.4. Flushing pump control circuit module

The backwash pump room control circuit is shown in Fig. 6. Press the start button ST, the circuit is connected, the relay KM is energized, the relay switch KM is closed, the KP1 switch is disconnected, the HG light is off, and the HW light is on. When the SA transfer switch is turned to the automatic gear, the automatic control contact is closed and the circuit starts to work. At the same time, the KM switch in the motor circuit is closed and the motor moves. QF is an air switch that protects the circuit from overcurrent [19,20]. When the transfer switch SA is in manual mode, press the ST button to start the circuit, and press the SP button to stop the circuit. SL is an emergency stop switch. Whether the circuit is running in automatic or manual mode, press the SL button to stop the circuit. The solenoid valve (=FP1-V) is controlled by the toggle switch SA1 and is enclosed in the local control box (=FP1-A).

In the motor drive circuit, KM is a relay switch (normally open state). When the relay KM is energized in the control circuit, the switch KM is closed, the circuit is turned on, and the motor starts to run. FU is a fuse that protects the circuit in order to prevent excessive current. PW is a digital display transmission smart meter. FP1-M is the No. 1 backwash pump. The motor drive circuit is packaged in the low-voltage power distribution cabinet (=L-A05).

Using the designed DCS control system for tailwater denitrification treatment, lay the foundation for the next step of optimization of freshwater aquaculture tailwater denitrification treatment.

4. Optimization of denitrification treatment of freshwater aquaculture tailwater based on fuzzy algorithm

4.1. Blower control

The denitrification treatment of freshwater aquaculture tailwater must add more denitrification agents, increase the air volume of the aeration tank blower, and control the dissolved oxygen to facilitate the removal of total nitrogen in the

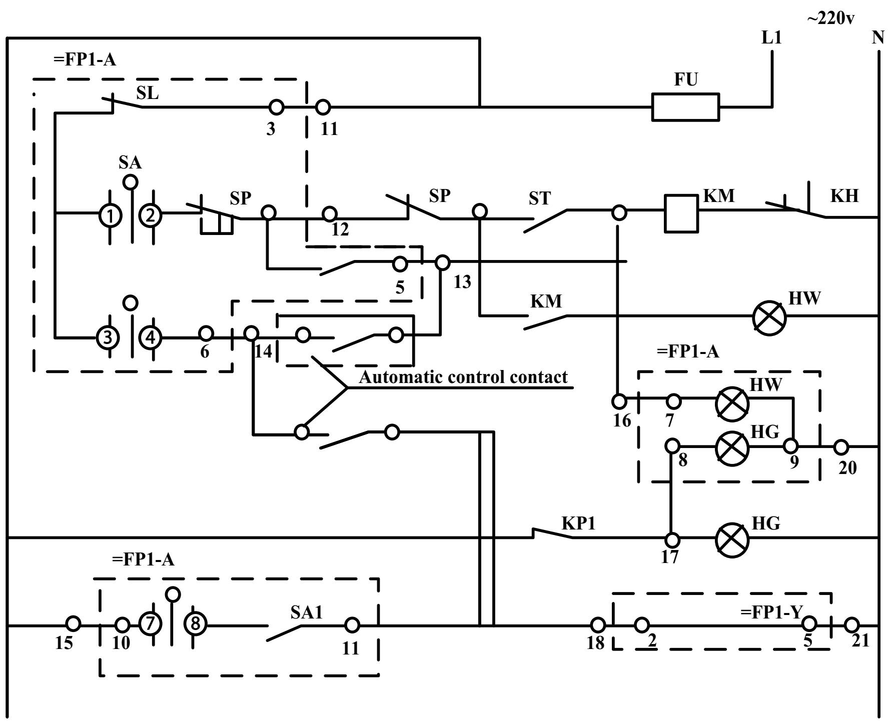

Fig. 6. Backwash pump control circuit diagram.

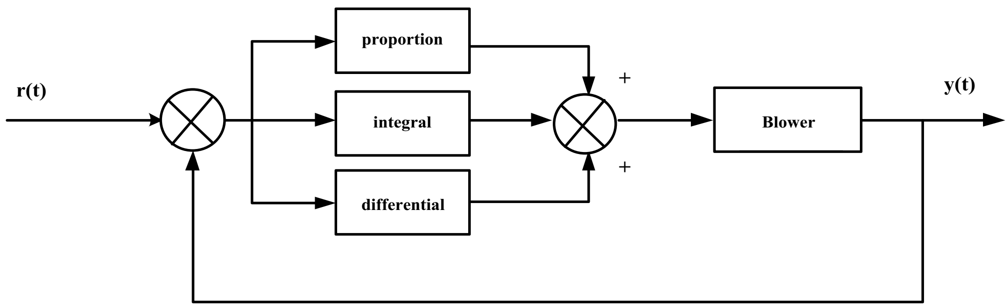

Fig. 7. Dissolved oxygen PID control principle diagram.

sewage. When the dissolved oxygen concentration reaches the set value of 2.5 mg/L, the total nitrogen removal rate can reach the highest. This article takes freshwater aquaculture tailwater denitrification treatment as the main control object, and adopts the dissolved oxygen control method. The main equipment for dissolved oxygen control includes electric valves, blowers, online dissolved oxygen analyzers, and proportion integral differential (PID) controllers. First, set the aerobic demand of the PID controller. At the same time, the actual amount of dissolved oxygen in the biochemical pool is detected by the online dissolved oxygen meter, the two are compared, and the PID calculation is given to give the output, which is used to adjust the blower power, and the air intake is adjusted by the blower power size. Electric valves and pressure transmitters are installed on the air manifold connected to the blower, and the number of blowers can be selected according to the pressure change of the air manifold [21].

As the core component of dissolved oxygen control, PID controller plays an especially important role. The principle diagram of dissolved oxygen PID control is shown in Fig. 7.

- $r(t)$: The oxygen demand set by the PID controller;
- $y(t)$: The actual amount of dissolved oxygen in the biochemical pool.

It can be seen from the schematic diagram that traditional PID control is used in dissolved oxygen control, and parameter adjustment is very important, but PID parameter tuning is relatively troublesome. To obtain PID parameters suitable for engineering needs, it takes a period of exploration by engineers and technicians.

4.2. Dosing room control

It includes two parts of control, which are two control designs for preparing $Al_2(SO4)_3$ solution and adding $Al_2(SO4)_3$ solution. This system has two $Al_2(SO4)_3$ solution pools [22].

4.2.1. Preparation of $Al_2(SO4)_3$ solution control

This part of the control adopts liquid level control. The two $Al_2(SO4)_3$ baths in the initial state are both empty. At this time, the outlet valve of the No. 1 $Al_2(SO4)_3$ solution bath is opened, and all other electric valves are closed. status. When the liquid level of the No. 1 $Al_2(SO4)_3$ solution pool reaches the lowest set level, the outlet valve of the No. 2 $Al_2(SO4)_3$ solution pool opens. After a delay of 20s, the No. 1 $Al_2(SO4)_3$ solution pool is closed. At the same time, the No. 1 $Al_2(SO4)_3$ solution pool alarms, and the No. 1 $Al_2(SO4)_3$ solution pool starts to dispense medicine. Open the water supply valve. When the level gauge reaches the set level, close the water supply valve GF3 and turn on the mixer, Use a forklift to add bags of $Al_2(SO4)_3$. After adding the medicine, the mixer can run continuously [23]. After a delay of 30 min, the No. 1 $Al_2(SO4)_3$ solution pool starts to do the liquid, open the $Al_2(SO4)_3$ liquid delivery valve, and open the corresponding outlet valve, and close the mixer at the same time. When the level gauge L2 reaches the set level, close the feed valve, close the outlet valve, and open the feed valve at the same time. When the level gauge L2 reaches the set maximum level, close the feed valve, and the $Al_2(SO4)_3$ solution in the No. 1 $Al_2(SO4)_3$ solution pool is finished.

4.2.2. Add $Al_2(SO4)_3$ solution control

The liquid medicine is delivered by the metering pump. The metering pump 1 is used and 1 is prepared. The flow rate of the metering pump is related to the nitrogen content in the water ($Q_{pump} = 101.51P \times (P_1–P_2) \times Q_{water}$). Manually measure the nitrogen content P_1 at the dosing point every 8 d. The nitrogen content P_2 in the factory water is measured by an online total nitrogen analyzer. The treated water Q_{water} is measured by an electromagnetic flowmeter. The P_1 value is manually input and the computer can get the metering pump. For the output flow Q_{pump}, the actual output flow Q_{pump1} of the metering pump is measured by the electromagnetic flowmeter behind the exit of the metering pump, and the metering pump is adjusted to make $Q_{pump} = Q_{pump1}$.

4.3. Fuzzy control model

The DCS control system for the denitrification treatment of freshwater aquaculture tailwater is a system with large inertia, long lag time and certain uncertainty. The ideal control effect cannot be obtained by using traditional PID control, and because the system is a time-varying, non- It is difficult to establish a precise mathematical model for a linear controlled system. Using a fuzzy algorithm-based control system for control can not only make the control system more reliable, but also get a good control effect. Fuzzy control does not need to establish a precise mathematical model of the system, it can simulate human logic thinking methods for control, can transform the control strategy expressed by human language into fuzzy control rules, and can summarize and summarize the control experience of the operating technicians. Multiple control rules, these rules can be realized by a fuzzy controller. After this design, the system has better robustness, stability and control effect than using PID control alone. Therefore, this chapter will focus on fuzzy control in freshwater aquaculture. Research on the application of tailwater denitrification treatment in DCS control.

Combining the advantages of PID control and fuzzy control, using fuzzy control self-tuning PID intelligent control to achieve the purpose of optimizing the denitrification treatment of freshwater aquaculture tailwater. The schematic diagram of fuzzy control is shown in Fig. 8:

According to the idealization of the CASS biochemical treatment environment, it is assumed that there are only three substances in the environment: microorganisms, nitrogen-containing organic pollutants, and dissolved oxygen. Through the establishment of dynamic models of biochemical reactions among the three, Morton's equation, a classic equation in sewage treatment, is used to illustrate the relationship between the above three.

$$u = \frac{u'S}{K_S + S} \quad (1)$$

where u is the specific increase rate of microorganisms; u' is the maximum specific increase rate; K_S is the

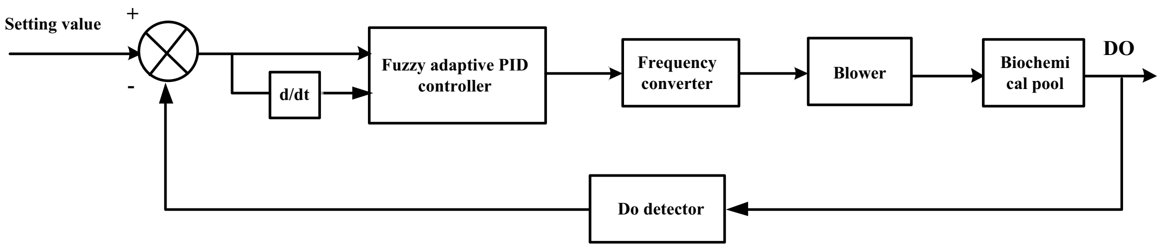

Fig. 8. Fuzzy control principle diagram.

saturation constant, that is, the concentration of organic matter at $u = u'$; S is the concentration of organic matter (mg/L).

Establish a balance equation for the three substances.

- Microbial reaction rate

The net growth rate of microorganisms = total growth rate-decay rate;

$$\frac{dX}{dt}=\frac{u'S}{K_S+S}\frac{D_0}{K_0+D_0}X-K_DX \tag{2}$$

where K_0 is the saturation constant of dissolved oxygen concentration; K_D is the attenuation coefficient of microorganisms; D_0 is the dissolved oxygen concentration.

- Organic pollutant reaction rate

Organic pollutants + oxygen = microorganisms

$$\frac{dS}{dt}=-\frac{1}{Y}\frac{u'S}{K_S+S}\frac{D_0}{K_0+D_0}X \tag{3}$$

where Y is the microbial yield. In order to facilitate the solution, take the value of the microbial observable yield Y_0, that is, the ratio of the COD insoluble change rate to the soluble change rate.

- Dissolved oxygen reaction rate

$$\frac{d\text{DO}}{dt}=-u'\frac{1-ff_xY}{fY}\frac{SX}{K_S+S}\frac{D_0}{K_0+D_0}-f_xK_dX+u \tag{4}$$

where f is the coefficient of organic pollutants and oxygen demand; f_x is the coefficient of oxygen consumed by microorganisms; According to the material balance physics, that is, the net change rate of mass = mass input rate-mass output rate-mass consumption rate, performing Laplace change get Eq. (5).

$$G(s)=\frac{Q(s)}{C(s)}=\frac{C_1-C_2}{V_s+V_k}=\frac{R}{S+K} \tag{5}$$

The above formula turns the first process into an inertial link. According to the relationship between the dissolved oxygen concentration and the growth environment of microorganisms, the selected gas–liquid transfer dual model establishes its transfer function.

$$\frac{d\text{DO}}{dt}=\frac{Q(t)}{V}\left(y_{\text{in}}(t)-y(t)\right)+K_La\left(u(t)\right)\left(y_{\text{sat}}(t)-y(t)\right)-R(t) \tag{6}$$

where $y(t)$ is the dissolved oxygen concentration in the liquid phase; $y_{\text{in}}(t)$ is the dissolved oxygen concentration in the water; $y_{\text{sat}}(t)$ is the saturated dissolved oxygen concentration; $Q(t)$ is the water flow; $u(t)$ is the air flow in the pool; $K_La(u(t))$ represents the aerator entering the pool. The flow rate of oxygen in the gas is generally expressed as the following formula.

$$K_La=k_1\left(1-e^{k_2-q_{\text{air}}(t)}\right) \tag{7}$$

where k_1, k_2 is a constant and $q_{\text{air}}(t)$ is the air flow. According to the chemical principle of dissolved oxygen concentration detection and the non-linear characteristics of dissolved oxygen concentration, the approximate model is obtained based on the field parameters and combined with the above formula.

$$G(S)=\frac{R}{S+K}e^{-\tau s} \tag{8}$$

The above model is a first-order inertial link with pure lag. The initial value of the steady-state gain of the system is set to $K_C = 7.625$, $T_C = 3{,}240$. According to the technical knowledge and experience of the engineers and technicians, the lag time of the DO biochemical reaction is 16s. In this way, Eq. (8) can be transformed into Eq. (9):

$$G(S)=\frac{K_C}{T_0S+1}e^{-\tau s} \tag{9}$$

where T_0 is the control time constant. According to time experience, T_0 is 1/30~1/40 of T_C, so T_0 should be 80~108 s. In this design, T_0 = 90 s, τ = 16 s = 16 s, K_C = 7.625, which can get fuzzy the control model is:

$$G(S)=\frac{7.625}{90S+1}e^{-16s} \tag{10}$$

5. Simulation experiment analysis

In order to verify the performance of the optimized method for denitrification treatment of freshwater aquaculture tailwater based on distributed control technology in practical applications, simulation experiments were performed. Taking a freshwater aquaculture farm as the research object, adopting the optimization method of freshwater aquaculture tailwater denitrification treatment based on distributed control technology proposed in this article, the literature [4] proposed freshwater aquaculture tailwater denitrification treatment method based on electric flocculation technology and literature [5] The proposed freshwater aquaculture tailwater denitrification treatment method based on additional plant carbon sources is to treat the tailwater denitrification of the farm. The freshwater farm is shown in Fig. 9:

Distributed control of tailwater denitrification treatment is performed on this freshwater farm. The control room is shown in Fig. 10.

The simulation software is used to simulate the freshwater farm tailwater treatment process scene, as shown in Fig. 11.

Through the simulation of the tailwater treatment process scene, type Simulink in the MATLAB command window for modeling. From the previous analysis of the DCS control model for the denitrification treatment of freshwater aquaculture tailwater, it can be seen that the input is the deviation of the DO measurement value and the change of the deviation, and the output is the change of the PID parameter proportional, integral, and differential. The fuzzy PID controller can be determined according to the input and output. The input and output relationship. In order to facilitate system settings, you need to use the Edit > Creatc Subsystem command to encapsulate the above module, and then use the Edit > Mask Subsystem command to design the parameters. In Simulink Simulation > start to simulate the above model, click the oscilloscope Scope to get the simulation result, as shown in Fig. 12:

According to the simulation curve, it is not difficult to see that when the system is around $T = 90$ s, the dissolved oxygen concentration is set to 3.5 mg/L, and the system enters a stable state to maximize the total nitrogen removal rate. Since then, the system has been operating stably without the overshoot phenomenon appears. It meets the requirements

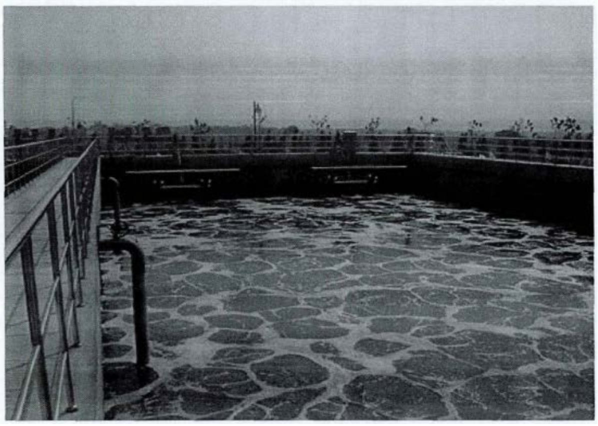

Fig. 9. Freshwater farm.

Fig. 10. System central control room.

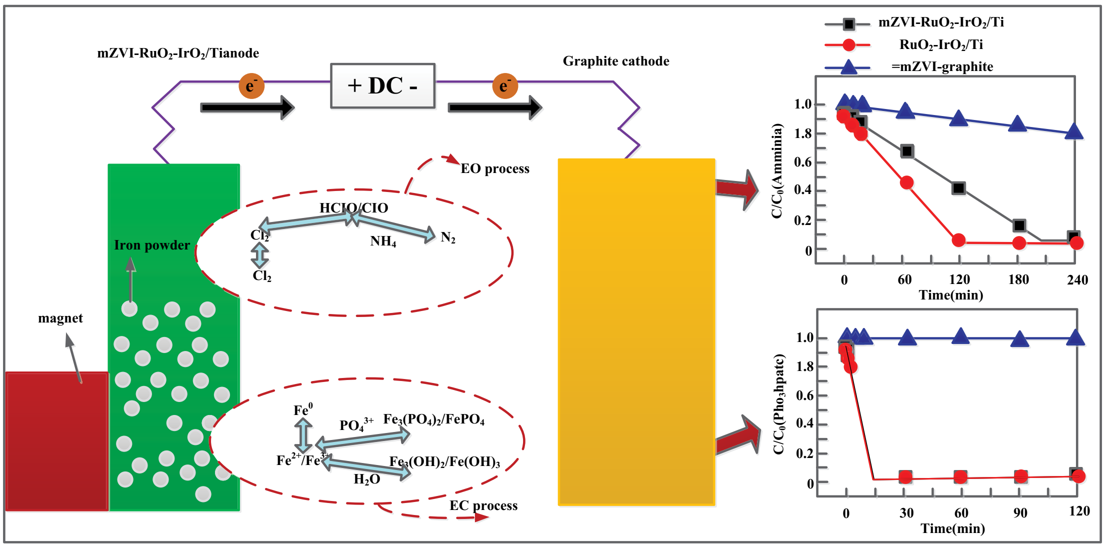

Fig. 11. Scenario simulation of the tailwater treatment process.

of this article for denitrification treatment of freshwater aquaculture tailwater.

In order to verify the effectiveness of the method in this paper, the optimization method for the denitrification treatment of freshwater aquaculture tailwater based on distributed control technology, the denitrification treatment method of freshwater aquaculture tailwater based on electro-flocculation technology, and the denitrification of freshwater aquaculture tailwater based on additional plant carbon sources The nitrogen removal rate of freshwater aquaculture tailwater of the treatment method was compared and analyzed, and the comparison result is shown in Fig. 13.

According to Fig. 13, it can be seen that the denitrification rate of freshwater aquaculture tailwater is between 60% and 100% based on the optimized method for denitrification treatment of freshwater aquaculture tailwater based on distributed control technology. The nitrogen treatment method and the freshwater aquaculture tailwater denitrification treatment method based on additional plant carbon sources have a nitrogen removal rate between 40% and 64% and less than 20%, respectively. The denitrification rate ratio of freshwater aquaculture tailwater denitrification treatment method based on distributed control technology for optimization method of freshwater aquaculture

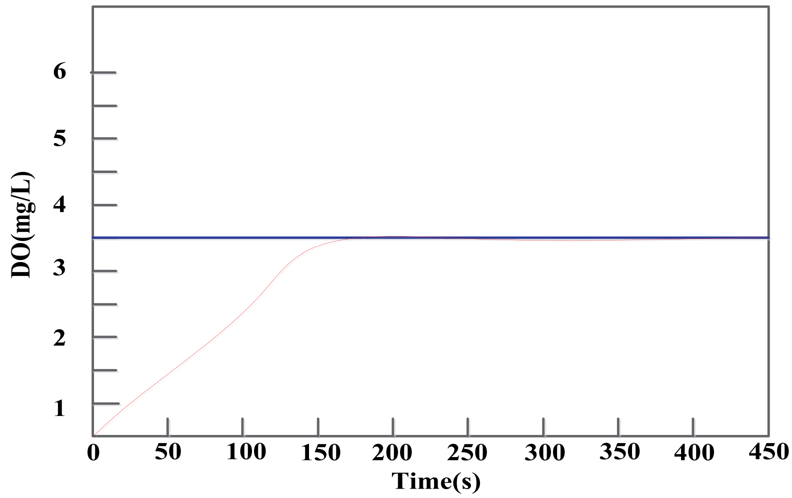

Fig. 12. Fuzzy adaptive PID simulation results.

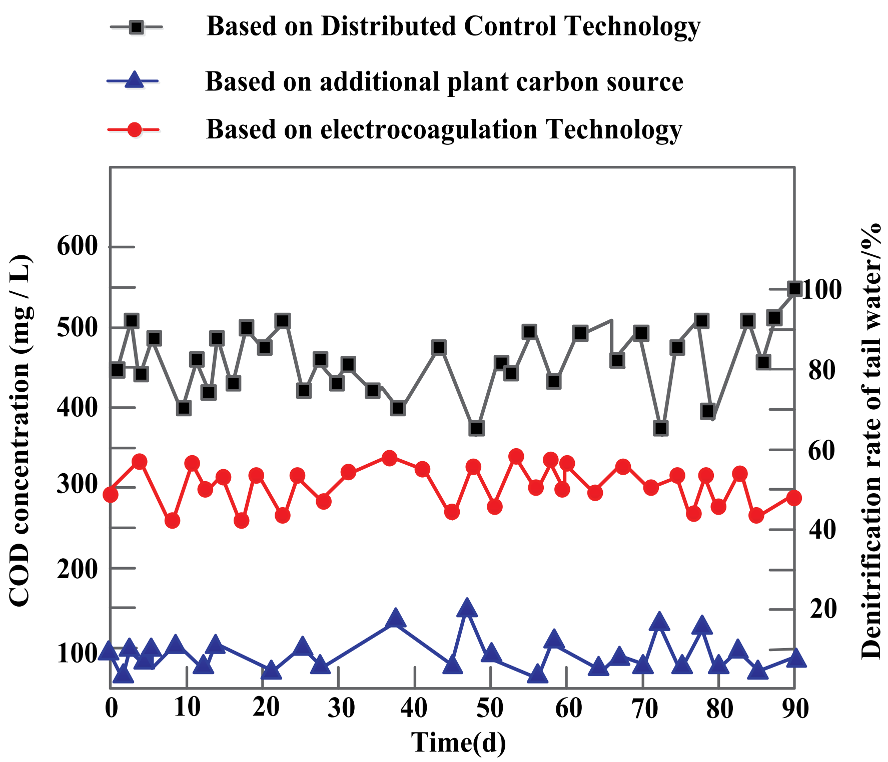

Fig. 13. Comparison results of tailwater denitrification rate of three methods.

tailwater denitrification treatment method based on electro-flocculation technology and freshwater aquaculture tailwater denitrification treatment based on additional plant carbon source The method has a high denitrification rate in freshwater aquaculture tailwater, which shows that the freshwater aquaculture tailwater denitrification effect of the freshwater aquaculture tailwater optimization method based on distributed control technology proposed in this paper is better.

In order to further verify the effectiveness of the method in this paper, the optimization method for the denitrification treatment of freshwater aquaculture tailwater based on distributed control technology, the denitrification treatment method of freshwater aquaculture tailwater based on electro-flocculation technology and the denitrification treatment method of freshwater aquaculture tailwater based on additional plant carbon sources The nitrogen treatment method of freshwater aquaculture tailwater denitrification treatment time was compared and analyzed, and the comparison result is shown in Fig. 14.

According to Fig. 14, it can be seen that the freshwater aquaculture tailwater denitrification treatment optimization method based on the distributed control technology proposed in this paper is relatively stable, basically controlled within 5~10min, while the freshwater based on the addition of plant carbon sources The freshwater aquaculture tailwater denitrification treatment time of the aquaculture tailwater denitrification treatment method fluctuates greatly, between 3 min and 50 min. The freshwater aquaculture tailwater denitrification treatment time based on the electro-flocculation technology is relatively The freshwater aquaculture tailwater denitrification treatment time based on the freshwater aquaculture tailwater denitrification treatment method based on additional plant carbon sources is more stable, but it is still better than the freshwater aquaculture tailwater denitrification treatment optimization method based on the distributed control technology proposed in this article The tailwater denitrification treatment time is long. It shows that the method in this paper can effectively control the denitrification treatment time of freshwater aquaculture tailwater and improve the efficiency of tailwater denitrification treatment.

6. Conclusions

In order to improve the freshwater fish tailwater denitrification effect, in this paper, based on distributed control technology of freshwater fish tailwater denitrification process optimization method, used to complete the freshwater aquaculture tailwater denitrification treatment process of real-time monitoring and automatic control, in freshwater fish tailwater denitrification with premise, improve the degree of intelligent sewage treatment, the freshwater fish tailwater denitrification rate of the best, and shorten the tailwater denitrification processing time.

Industrial automation control system in China started late, control equipment and the field control technology also there is a big gap compared with developed countries, the development of control system has significant limitations, the mainstream of control devices and configuration software on the market is still mainly rely on imports, although with the development of the automation industry in China in recent years, there have been some domestic PLC devices and configuration software, but in terms of system reliability and stability, and has a great gap with imported equipment or. The distributed control system for denitrification treatment of freshwater aquaculture tailwater has the following shortcomings:

- Although the remote automatic control of system equipment has been realized, there is still a long way to go to realize the interlocking control of all equipment in the factory and the unattended production site.

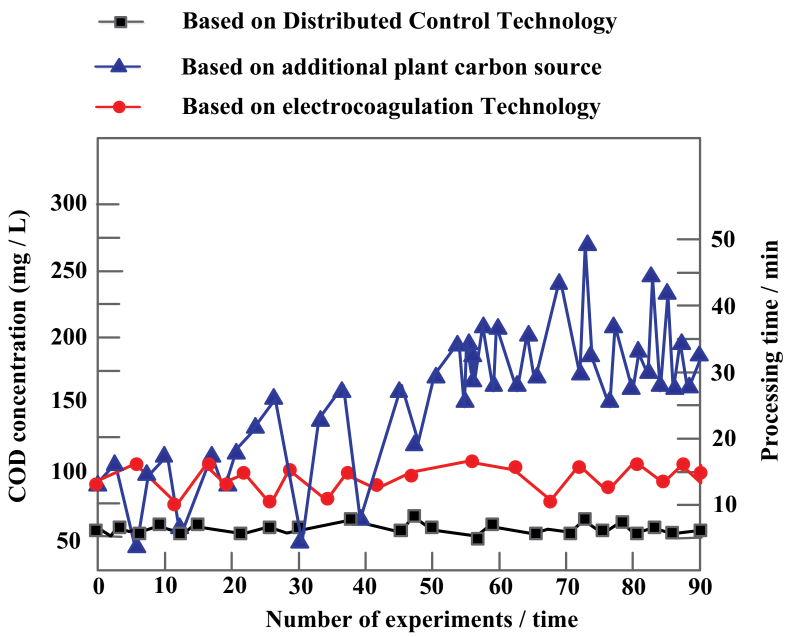

Fig. 14. Tailwater denitrification treatment time.

- In terms of energy dispatch, with the operation of the distributed control system, the cost of sewage treatment is reduced to a certain extent, and there is still a certain gap between it and the optimal allocation of resources.
- In the water treatment industry, no advanced treatment technology has been found to make the treated wastewater directly available for human use.

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