Control System and Algorithm of Sewage Treatment Plant Based on Artificial Intelligence

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Abstract. With the improvement of people's awareness of environmental protection in recent years, the related problems of water pollution treatment have gradually come into people's view. As the source of life, water accounts for a huge proportion in our lives, but at the same time, water pollution is quietly spreading in places we don't know. The continuous discharge of heavy industrial wastewater, agricultural wastewater and domestic sewage leads to increasingly serious water pollution. Sewage treatment (ST) is imperative, and its social benefits are huge, but the corresponding cost is high, and the return on investment is low. Traditional ST methods can not load large-scale ST. How to carry out ST based on artificial intelligence (AI), build ST plant control system, and make ST enter the era of automation is the problem to be solved. The purpose of this paper is to put forward the reform of control system for ST plant based on AI, apply AI into ST, and realize the automation and precision of ST plant. This paper mainly uses the fuzzy self-tuning PID control system algorithm, through the analysis of ST control object, analysis of fuzzy self-tuning PID controller design to complete the ST control system settings. In this paper, the literature review method and data analysis method are used. By collecting relevant data, the control system of ST plant is constructed to simulate ST, and the real-time data of ST is analyzed. The traditional PID control and fuzzy self-tuning PID control are compared. The experimental results show that the wastewater treatment plant system based on AI input, in the aspect of wastewater treatment, the concentration of COD and BOD in the treated wastewater are reduced by a certain proportion, the dissolved oxygen content in the wastewater reaches about 2.0mg/l, which meets the national discharge standard, and its rising time is reduced to 25 seconds, and the adjustment time is saved by 50 seconds.

Keywords: Sewage Disposal, Control System, Control Algorithm, Artificial Intelligence

1. Introduction
With the rapid development of China's economy, water pollution has become a major problem we have to face, especially how to treat domestic sewage has become the top priority of our daily life [1-2]. The traditional ST system is still running in today's era, but the effect is not as good as expected.
Therefore, the main content of this paper is how to improve the ST control system and strengthen the ST level based on artificial intelligence technology and traditional ST technology [5-6]. The study of ST control system can effectively reduce the cost of ST, improve the efficiency of ST, and has an important impact on improving water quality, which is of great significance to China's economic power [7-8].

In the study of wastewater treatment, many scholars at home and abroad have studied it and achieved good results. Kress N and others pointed out that foreign ST plants were the first to use modern technologies such as automatic control, video communication and monitoring to treat sewage. Europe, America and other western developed countries have invested a lot of money in how to ensure the reliable performance of ST projects. In the late 20th century, the ST industry in the United States began to apply the automatic control principle in the ST process. So far, most enterprises in the ST industry have used high-tech technologies such as parameter adaptive control and detection [9]. Huang y pointed out that with the rapid development of China's economy, China has also introduced the automatic control technology of western developed countries in the process of ST, but most of China's ST industry directly introduces a set of automatic control equipment from western developed countries, and there is no innovation in technology, and the scale is far from meeting the technical requirements [10].

Based on artificial intelligence, this paper puts forward the research of ST plant control system. By studying the control algorithm of the control system, artificial intelligence is applied to ST to realize the automation of ST plant. This paper mainly studies the fuzzy self-tuning PID control system algorithm, through the analysis of ST process, select dissolved oxygen content as the control object, design ST control system. At the same time, by using the literature review method, through a large number of collection and access to relevant information, through understanding the status quo of ST at home and abroad, it is found that new technologies and new methods are used for ST, and then simulate the real-time operation of ST plant, collect data, analyze the gap between the traditional PID and fuzzy self-tuning PID control algorithm system, and prove the fuzzy self-tuning PID control The feasibility of the system in the application of ST.

2. Control system algorithm of ST plant

2.1. ST process

The main purpose of ST is to get the sewage source that meets the national discharge standard. ST is a complicated process. After entering the treatment plant and removing the large floating objects through the coarse grid, it is necessary to raise the height of sewage by lifting the pump house. The sewage flows into the remaining process through its own gravity, and then the sewage does not have to complete the remaining process through the role of the pump, which can achieve the purpose of "saving and environmental protection". The wastewater then enters the fine grid again, and then enters the grit chamber to remove inorganic particles, and then enters the main stage of wastewater treatment for biochemical treatment. Through a series of biochemical reactions, some specific treatment methods are used to remove the bacteria in the sewage, and finally reach the national discharge standard.

2.2. Design of control object for ST

(1)Analysis of control objects.

In this paper, the traditional PID control and fuzzy control are combined, and the self-tuning fuzzy PID control method is used to complete the control of dissolved oxygen concentration in the ST system. In this paper, the dissolved oxygen concentration is used as the index parameter to judge whether the sewage is up to the standard after being treated by the system. Dissolved oxygen concentration control is an important part of the actual ST process. The system takes the dissolved oxygen concentration as the controlled object, and changes the value of dissolved oxygen concentration in real time to meet the water quality requirements of different stages of ST.

(2)Design of fuzzy adaptive PID controller.
In fact, three two-dimensional fuzzy controllers are used to adjust the coefficients KP, Ki and KD of PID controller. Its control principle is summarized as follows: firstly, according to the actual deviation change rate, the two-dimensional fuzzy controllers FC1, FC2 and FC3 complete a series of processes such as fuzzification, fuzzy reasoning and defuzzification respectively, and finally get the real-time on-line regulation. After the inverter receives the control signal, it changes the speed of roots blower in time. In particular, the deviation e is the difference between the detected value of do and the expected set value, and the deviation change rate EC is the difference between the current deviation value of do and the last deviation value.

2.3. Design of ST control system
As for the design of ST control system, the PLC system of the control station mainly adopts s72400 series and adopts wireless communication mode. Among them, 4220 mADC active signal a I quantity is 35 channels, 4220 madcao quantity is 16 channels controlled, 206 channels of Di input of monitoring contact are monitored, and 96 do output channels are controlled. PLC system is set up on the site of sand settling tank to monitor the whole set of equipment to ensure the normal operation of ST control system. PLC system is also set in sludge dewatering and concentration room to protect the safety of sludge dehydrator and monitor the relevant parameters. At the same time, PLC system is set up in chlorine adding disinfection system to control chlorine dosage, water barrier valve and sampling pump.

The design of automatic control system of ST plant shall consider three principles: centralization of management, dispersibility of control and data sharing. The stability of system operation shall be considered for equipment selection, and the system operation is convenient and easy to maintain, and the system shall be easy to expand, reasonable in operation and good in performance. The automatic control system of ST plant should consider the requirements of its operation management and safe operation, that is, the intelligent process control, real-time alarm, real-time protection, real-time operation and real-time adjustment are emphasized, such as shortening working time, reducing operation cost and reducing working difficulty. Configuration software is used by the upper computer The real-time monitoring of important state in each process of ST plant is realized to ensure that the effluent quality of the ST plant meets the national sewage discharge standard.

2.4. Fuzzy self-tuning PID control algorithm
The design of ST system needs to control the amount of ST while taking into account its economic benefits, which makes the accuracy of the control system very high. Because the ST is not quantitative, and its influencing factors are constantly changing, the design of ST system needs to use fuzzy self-tuning PID control model, using fuzzy level to calculate. According to the operation mode of the ST system, the control algorithm runs in the system, which can achieve the maximum precision treatment on the basis of ST. The parameter expression algorithm is as follows:

\[
u(k) = K_p(k)e(k) + K_i(k)\sum_{i=0}^{k} e(i) + K_d(k)[e(k) - e(k-1)]\]

(1)

PID controller is a linear controller. When the given value and the actual output value are known, the controlled deviation E (t) can be obtained by subtracting them. Then the deviation E (t) can be linearly combined by proportion, integral and differential to obtain the control variable U (t), which acts on the controlled object. The control law of PID is as follows:

\[
u(t) = K_p[\frac{1}{T_i}\int_0^t e(t)dt + T_o \frac{de(t)}{dt}]\]

(2)
3. Experimental study on control system of ST plant

3.1. Subjects
In order to prove the feasibility of the fuzzy self-tuning PID control system in ST, this paper selects the traditional PID controller as the contrast object, according to the actual sewage operation and production process of ST plant, through the data analysis of simulated ST, expounds the limitations of the traditional PID controller in today's ST, and shows that the fuzzy control algorithm is effective. The algorithm is combined with the traditional PID controller to form a hybrid intelligent controller, that is, the fuzzy adaptive PID control strategy is used to control the DO concentration.

3.2. Experimental method and steps
This paper mainly uses the fuzzy self-tuning PID control system algorithm, through the analysis of ST control object, analysis of fuzzy self-tuning PID controller design to complete the ST control system settings. In this paper, the literature review method and data analysis method are used. By collecting relevant data, the control system of ST plant is constructed to simulate ST, and the real-time data of ST is analyzed. The results of traditional PID control and fuzzy self-tuning PID are compared.

4. Experimental research and analysis on control system of ST plant

4.1. Real time data analysis of ST plant
Dissolved oxygen concentration in ST system can not only reflect the content of organic pollutants in water, but also be used as controlled parameter. The results show that there is a certain relationship between dissolved oxygen concentration and biological oxygen demand, chemical oxygen demand, sludge concentration and aeration rate. Select the ST plant for five times in a certain period of time, as shown in Table 1.

| Influent COD concentration | Influent BOD concentration | Effluent COD concentration | Effluent BOD concentration |
|---------------------------|----------------------------|----------------------------|---------------------------|
| 123.03                    | 25.39                      | 0.41                       | 0.05                      |
| 108.3                     | 72.86                      | 0.76                       | 0.03                      |
| 288.65                    | 27.3                       | 1.12                       | 0.25                      |
| 203.85                    | 130.2                      | 10.76                      | 3.43                      |
| 53.35                     | 110.6                      | 9.45                       | 2.87                      |

Figure 1. Real time data sheet of ST plant
It can be seen from Figure 1 that the COD and BOD concentrations of the inlet and outlet water under the actual conditions of the ST plant, the COD and BOD concentrations of the sewage entering the treatment plant are all seriously over the standard, and the concentrations are reduced to a certain extent after being treated by the ST plant. It is found that as long as the content of dissolved oxygen in water reaches about 2.0mg/l, it has reached the national emission standard.

4.2. Comparative analysis of traditional PID and fuzzy self-tuning PID

The traditional PID control has started to operate under load in the ST plant. Its ST system can not meet the current large amount of muddy and complex sewage, and its operation speed and efficiency need to be improved. Nowadays, the ST system based on artificial intelligence creates fuzzy self-tuning PID control, which is an innovation to some extent. The traditional PID and fuzzy self-tuning PID are put into the ST site simulated. The data comparison results are shown in Table 2.

|                     | Rise time | Adjustment time | Maximum overshoot | Dissolved oxygen solubility |
|---------------------|-----------|-----------------|-------------------|----------------------------|
| Traditional PID     | 35s       | 110s            | 45%               | 1.91mg/L                   |
| Fuzzy self-tuning PID | 25s       | 55s             | 25%               | 1.6mg/L                    |

**Figure 2.** Comparative analysis table

It can be seen from Figure 2 that the introduction of self-tuning fuzzy PID controller into the ST system has greatly improved the rise time, regulation time, overshoot and dissolved oxygen content compared with the traditional PID controller, which makes the control system have good dynamic and static characteristics.

5. Conclusion

Based on the traditional PID control system, the fuzzy self-tuning PID control system is added to control the ST plant system, and artificial intelligence is applied to ST to realize the automation of ST plant. In this paper, dissolved oxygen content is chosen as the controlled object, and the fuzzy self-tuning PID controller is designed, and its application in ST is simulated by the actual model. In the experiment, the data samples are collected, the data will be selected in real time for analysis, and
compared with the traditional PID, and the advantages of fuzzy self-tuning PID control algorithm are analyzed intuitively. It is proved that the control system mode is convenient to operate and maximize the economic benefits, which will significantly improve the automation level of ST plant.

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