

## **Solution of Automatic Control System Based on PLC in Decentralized Wastewater Treatment\***

Yang Wang<sup>1</sup>, Yumin Shi<sup>2</sup>, Jianlong Zhu<sup>3</sup>, Yilin Fan<sup>4</sup>

<sup>1</sup>Liaoning Beifang Environmental Protection Co.,Ltd, Shenyang, Liaoning, China

<sup>2</sup>Liaoning Beifang Environmental Protection Co.,Ltd, Shenyang, Liaoning, China

<sup>3</sup>Northeastern University, Shenyang, Liaoning, China

<sup>4</sup>Georgia Institute of Technology, Atlanta, Georgia, United States

**KEYWORD:** Decentralized wastewater treatment; Programmable logic controller (PLC); Automatic control

**ABSTRACT:** Decentralized wastewater increasingly serious, remote control of small scale wastewater treatment station operation has become urgent technology problems. This paper mainly introduces the component and function of automation system used in decentralized wastewater treatment and how to use PLC to achieve automation control. The control automation, resource optimization, management and control integration were archived.

### **background**

Recently, with the urbanization of the rural area and the economic development of township industrial enterprises, more and more industries water was used. The rising living standard in rural area leading the more water resource consumption, more wastewater and more frequently water pollution, which turn point source pollution to non-point source pollution and centralized pollution to decentralized pollution.

In rural area, because of the low level economic development, huge amount of local population and decentralized residence, rural water pollution need to be solved. Therefore, how to keep a good operation of wastewater treatment equipment with the poor management of rural area and poor level of wastewater treatment has direct influence on wastewater treatment effect. In today's wastewater treatment industry, PLC is mostly used in site control. SCADA system monitor mode was used to show and set process parameters by computer to improve the automated level of wastewater treatment<sup>[1]</sup>. This paper aimed to the challenge of maintenance of the decentralized wastewater treatment site and designed automatic control system based on PLC+MCGS software to realize unattended, remote control and automatic alarmed.

### **Technology introduction**

#### **Decentralized wastewater**

Decentralized wastewater means municipal wastewater which cannot be collected by urban wastewater pipe network system or by centralized wastewater treatment system. Decentralized wastewater had the feature of miniaturization, capacity 500m<sup>3</sup>/d, it had a collection of different function in wastewater treatment process and a variety of types and widespread. Water need to be treated decentralized came from decentralized villages, companies far from urban area, schools, living area of highway, sanatorium and holiday resorts. In this paper, decentralized wastewater treatment system consisted of four parts, diving diversion oxidation ditch process, light rotating biological disk process, micro dynamic multilevel filter bed and small-scale integrated device.

#### **Oxidation ditch process**

As the deformation of activated sludge process, oxidation ditch process belonged to extended aeration activated sludge process. It consisted of tank, aerator, inhalant region and exhalant region. Now it had two operation ways, one was continuous way such as Carrousel oxidation ditch, another was

alternately way like VR oxidation ditch. In this paper, secondary sedimentation tank was used for inside track, oxidation ditch was used for outside track, which had the function of aeration, sedimentation, mud-water separation and sludge return.

### Rotating biological disk process

Rotating biological disk process was a technology which can be a biofilm process, it was made of rotary disc, contact reaction tank, and actuating device<sup>[2]</sup>. Rotary disc immersed or partially immersed in contact reaction tank which full of wastewater, driven by the actuating device, spindle drive turntable turn at certain linear velocity, turntable contacted with wastewater and air alternately, after a time period, rotary disc was adhered by the biofilm which adsorbed dissolved oxygen in the water film and resolved organic matter. In this process, microbial was autotrophic. When wastewater was discharged by turntable, air was dissolved in water film continuously, increased the dissolved oxygen. Biofilm contacted with wastewater and air alternately, formed a serial process of oxygen absorption, adsorption and oxygenolysis<sup>[3,4]</sup>.

### Biological filter bed process

Biological filter bed process was a wastewater treatment technology which combined biofilm treatment technology and filtration technology, put wastewater biological treatment and suspended matter removal process together<sup>[5]</sup>. It utilized gravel, marine and some other same size particles to simulate the self-clean mechanism of nature soil aquifer. Filler and microbial were the main parts of biological filter. By using physical-chemical effect(adsorption, sedimentation, filtration, ion exchange) and biodegradation of microbial to remove NH<sub>3</sub>-N, TP and COD. Ceramsite at the size of 20-30 was taken as filter material for experimental micro dynamic multilevel filter bed.

### Integrated wastewater treatment process

Integrated wastewater treatment process was a new wastewater treatment technology which finish multiple reactions or functions in the same reactor by allocating time or space. It consisted of integrated oxidation ditch, SBR treatment technology and integrated biofilm reactor. Multiple A/O-MBBR was adopted in the integrated device, including three A/O chamber, A1, O1, A2, O2 and A3, O3, showed in figure 1. It depended on microbial adhere on carrier to purify water. Less occupation of land, less cost of motivation and no sludge return was needed. MBBR was suitable for treating low concentration wastewater as well as low temperature wastewater.

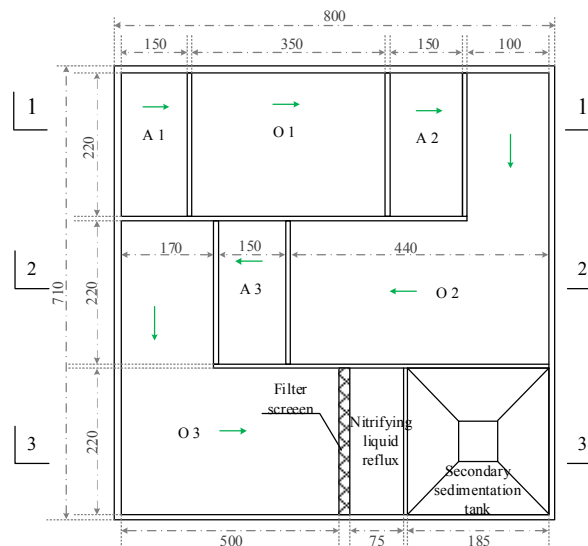


Figure 1. Multiple level MBBR floor plan.

### system composition

Decentralized wastewater treatment system was comprised of four PLC control substation, it used ring optical fiber industrial Ethernet, showed in figure 2. No.1 oxidation ditch technology treatment

station, No. 2 multiple-level filter bed technology treatment station, No.3 light rotating biological disk treatment station, No.4 small-scale integrated device treatment station.

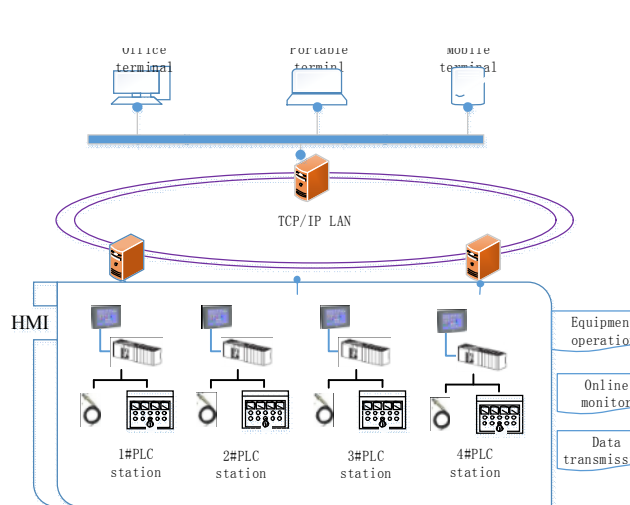


Figure 2. System structural drawing

PLC, selected Omron company's CJ series, was equipped with KUNLUN on-state touch screen at PLC station 1#, 2#, 3#, 4#, which was more convenient to spot operation. One YANHUA ARK-3360L industrial personal computer (IPC) was set to monitor operation condition on wastewater treatment process. One YANHUA IPC was also set in remote control center. All IPC operating systems were windows 7, MCGS monitor software, SQL Server 2008 data base to finish the data storage of process operating state and form report forms as needed.

### monitoring function

Four level control was used in IPC system, centralized control was adopted at monitor center, control station control at wastewater station, touch screen control and hand control on site. In control center and wastewater control station, by using HMI/SCADA system, which was a secondary development of HMI/SCADA system, data collection in every station was realized, and showed in user interface. Following function can be reached

- (1) Dynamic picture display the operation condition and parameters of on site equipment and process.
- (2) Display of historical trend of parameters in each process.
- (3) Real time alarm and history inquiry.
- (4) Generate and print of report forms.
- (5) Set of control parameters.
- (6) Manual operation of Start/Stop of on each equipment, on site touch screen use KUNLUN on state TPC7062K.

### control realization

Four PCL substations constituted wastewater treatment station automatic control system, each control station used a set of Omron CJIM series PLC, equipped with a KUNLUN on state touch screen, to realize the monitor and control of automatic device and other equipments. At the same time, each control substation changed data with main operating station as well as received control order, finally achieved the monitor of the equipment. Mechanism of PLC on site control showed in figure 3.

Each control substation configured a suit of PLC control cabinet. It had the programmable controller, operating interface HMI, 24VDC supply unit, etc. Based on the characteristic of wastewater treatment process, the arrangement of structure and the distribution of on site control, four PLC control substation were set.

(1) PLC 1 substation- diving diversion oxidation ditch process, input water pumped extract wastewater to oxidation ditch and secondary sedimentation tank device, in that device, surfing pump and electromagnetic air pump made plug flow and aeration, discharged after several back-flow, set online COD, NH<sub>3</sub>-N, DO device at imports and exports, monitoring range include above device and online detector, figure 4 shows the mechanism of oxidation ditch.

(2) PLC 2 substation- micro dynamic multilevel filter bed, monitoring range included water input pump, electromagnetic flow meter, electromagnetic air pump, set online COD, NH<sub>3</sub>-N, DO device at imports and exports.

(3) PLC 3 small-scale integrated device treatment process, monitoring range included water input pump, digestive juice reflux pump, return sludge pump, electromagnetic flowmeter, turntable and electromagnetic air pump, set online COD, NH<sub>3</sub>-N, DO device at imports and exports.

(4) PLC 4 substation-light rotating biological disk process, monitoring range included water input pump, electromagnetic flowmeter, turntable and electromagnetic air pump, set online COD, NH<sub>3</sub>-N, DO device at imports and exports.

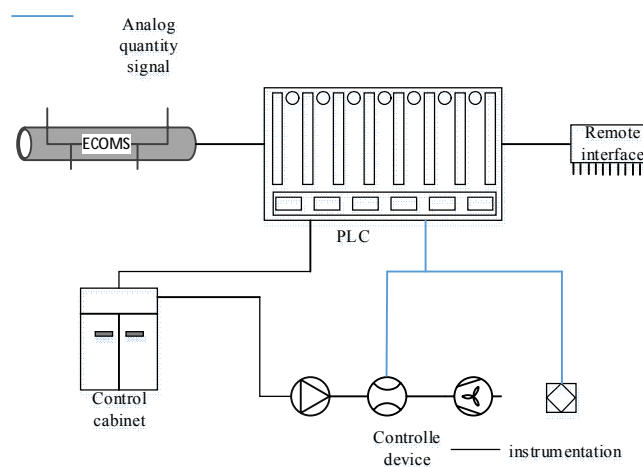


Figure 3. PLC on site control schematic diagram.

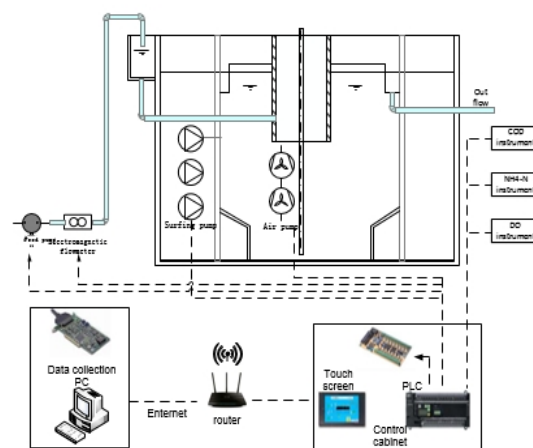


Figure 4. Oxidation ditch technology control schematic diagram.

Using human-computer interface to realize the start and stop of on site equipment, real time display of 4 station's operation condition by upper computer software and remote monitor of equipment, alarm when equipment failure occur, realize unattended function of wastewater treatment. Meanwhile, establish station operation data base, including input water parameter data forms, equipment operating condition data forms and output water parameter data forms.

## conclusion

Based on the PLC decentralized wastewater treatment automatic control system, attained the automatic operation of oxidation ditch process, micro dynamic multilevel filter bed process, rotating biological disk process and small-scale integrated. Also improved the operation efficiency and benefit of wastewater treatment station, realized the function of unattended, remote control and automatic alarm, sufficiently improved the far lag wastewater treatment level and management at rural areas.

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