Design of Sewage Treatment Process of Shaowu Second Sewage Treatment Plant Based on the Modified Carrousel Oxidation Ditch

Aochuan Duan*

School of Water Conservancy Engineering, Zhengzhou University, Zhengzhou, China, Zip code: 450001

Abstract—This paper is designed for the sewage treatment process of Shaowu City Second Sewage Treatment Plant, focusing on the modified card oxidation ditch process. This sewage treatment plant is mainly purified by living sewage in Shaowu City, and the processing scale is 10,000 m^3d^{-1}. According to the sewage quality and the reality of urban development, this paper selects the hydrolyzate + oxidation ditch + concrete precipitation process. The sewage first hydrolyzedate the acidified tank before entering the secondary treatment to increase the sewage's sewage, then remove the main organic matter in the water and complete the nitrogen removal phosphorus. Finally, further remove the suspension in water. The material and total phosphorus have enabled water quality to meet the "Sewage Treatment Plant Pollutant Emission Standard" (GB18918-2002). The project is expected to invest 3001,500 yuan, and the wastewater operating cost of the equivalent is 0.57 yuan/ton.

1 Introduction

With the acceleration of urbanization, the economy of small towns has developed rapidly. Scale urban expansion and increasing urban population to the ecological environment around the city brought great pressure, especially water environment [1]. According to statistics, in our country, 95% of sewage in small towns is discharged untreated into surrounding rivers, leading to more than 90% of urban water bodies surrounding the destruction [2]. This is mainly due to the foundation of small towns and the lack of sewage treatment facilities, inadequate management, and penetration sewer city reaches only about 50% [3]. In some towns, although there are relatively proper sewage treatment facilities, but most follow the development of big cities more mature sewage treatment process, without taking into account the actual situation and development features of its own small town, resulting in many problems late runs, operating costs are too high, excessive energy consumption, maintenance and management of facilities are not in place and other issues, leading to aging equipment, low processing efficiency, water quality does not meet the corresponding standard [4-6]. Therefore, in the design of small urban sewage process design, the specific situation of the town should be analyzed, and the appropriate treatment equipment should be used, and the quality of the economic benefit is high, and the energy-saving process is minimized while ensuring the quality of the sewage treatment.

In general, conventional sewage treatment includes the following processes: 1 level treatment (Grille), Secondary treatment (Biopsy), Late sludge treatment, Sewage disinfection (Chlorine gas disinfection, Ultraviolet disinfection). The most important link is the biological treatment part. At present, there is a comparative biological treatment process with a circulating active sludge method (Cass), anaerobic-hypoxic-aerobic process (AAO), oxidation ditch treatment process, and the like. At the same time, in order to achieve a better processing effect, many sewage treatment plants will also add three-stage treatment after secondary treatment, such as concrete precipitation, activated carbon, membrane bioreactor method (MBR), and the like.

CASS is relatively complicated in construction and has a function of reactive, precipitation, and drainage [7, 8]. The reaction carried out in the CASS pool exhibits a certain periodic [7]. This process has a wide range of applications in my country's major cities and sewage treatment plants and catering, medical, agriculture and other industries. Guoyang et al. used the CASS process to treat the high concentration of beer wastewater, which efficiently enriched the bacteria with flocculation effect and reduced the residual sludge discharge [9].

The AAO process is a typical anaerobic-aerobic process upgrade and improvement while setting back to the process to achieve synchronous removal of nitrogen phosphorus in the entire process. The AAO process has a good denitrification and phosphorus effect [10], while the microorganism is alternately operated in anaerobic, hypoxia, and aerobic, which can effectively inhibit the expansion of sludge, which is conducive to the subsequent mud water separation. The traditional AAO process requires additional carbon source and supplementary alkalinity, but through the continuous improvement and operation commissioning of professionals and the control of reflux, a reasonable and effective operation plan can be formulated for the sewage treatment plant. Aeration and adding raw sewage to

*Corresponding author. Email: duanaochuan121@163.com

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supplement the carbon source can effectively solve the problem of insufficient carbon source and alkalinity. In this eggplant Face, many domestic sewage plants have achieved more mature experience.

The oxidation ditch is named due to its overall ditch shape, and the sewage and sludge in the structure are circulated and sufficiently in contact with oxygen, and the aeration is carried out in an aerated apparatus such as the transfer. In order to adapt to the sewage treatment of modern towns, there is a development of other types of oxidation ditch such as Carrousel oxidation ditch, Orbal oxidation ditch and Double-ditch oxidation ditch system (DE oxidation ditch), etc. Although the oxidation tank process does not need to set a sedimentation tank, its large area and high energy consumption limit the development of this process.

In order to further improve the quality of the water, the three-level processing is usually set after the secondary processing. Common sewage three-level treatment includes concrete precipitation, activated carbon and MBR. Although MBR has many advantages, the life of MBR membrane and scaling cleaning problems hinder its expanded application in rural areas.

This paper conducts the process design of Shaowu City Second Wastewater Treatment Plant, and its treatment is 10,000 m^3 d^{-1}, a small sewage treatment plant. This design will consider the actual situation of Shaowu City. From the perspective of energy conservation, and economics, the most suitable sewage treatment process is selected by analyzing the water quality characteristics of Shaowu City, focusing on modified card oxidation ditch. The process conducts specific calculations and designs to provide reference for the current small urban sewage treatment process design.

2 Design

2.1. Process selection

Through the water quality analysis, sewage biochemical analysis, sewage biological nitrogen removal feasibility analysis and sewage biological dephosphorus feasibility analysis of sewage in the suburban industrial park mainly served by Shaowu sewage treatment Plant. At the same time, consider the current situation of the economic development of the city, and propose the following process schemes:

Rough grid + fine grill → sanding tank → hydrolyzate → Cass/AAO/oxidation ditch→sedimentation tank →concrete precipitation/activated carbon/MBR →chlorine/UV disinfection.

Through the scheme comparison, the oxidation groove process is simple, convenient for operation and control, and the energy consumption is low during operation, and the improved Carrousel oxidation ditch has good denitrification and phosphorus effect. Therefore, a modified Carrousel oxidation ditch is selected as the secondary treatment process of sewage. Considering the treatment requirements of the factory sewage, the condensation precipitation was finally selected as the three-level treatment of sewage, and the disinfection of tailwater was proposed using ultraviolet disinfection. The remaining sludge produced by this process is mainly used for the land greening of suburban towns, and the remaining long-term sludge can consider sending domestic landfill plants and garbage mixing compost.

Summary above, the final determination process is as follows

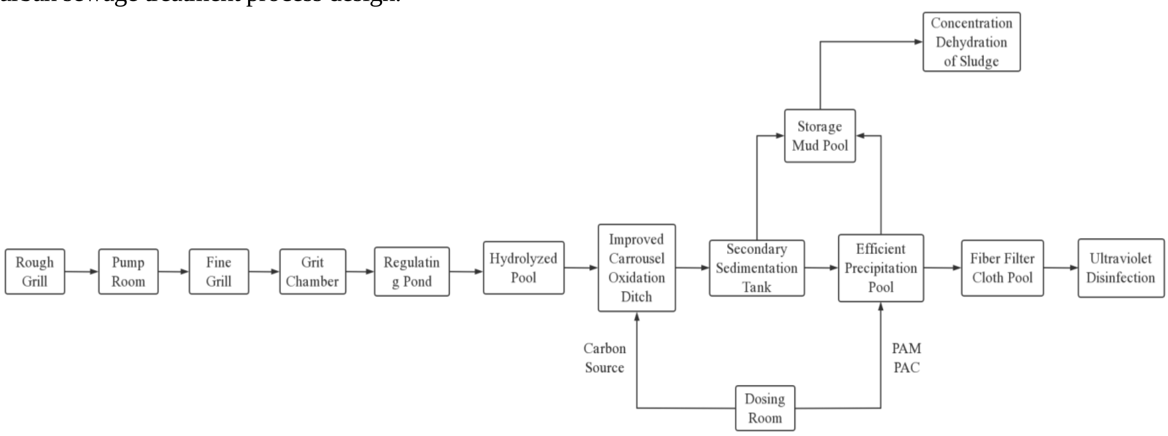

Fig.1 Technological process

The sewage is preliminarily treated by a coarse grid, a pump room and a fine grill, and then enters the sanding tank (primary treatment), in addition to a portion of the suspended matter under the action of gravity and centrifugation; a hydrolyzate tank is provided before the biological treatment Improve the sewage of sewage to ensure the efficiency of the later biological treatment; the modified card oxidation ditch is the main structure of sewage treatment, which removes most of the organic and nitrogen phosphorus in this part; the sewage is subjected to biological treatment. Sludge and wastewater were separated; in order to ensure the exuberant suspension (SS) and total phosphorus (TP) reached the standard, a high-efficiency sedimentation tank was also provided after the Sany sink and added polyacrylamide (PAM) and polyuminum (PAC) Concentrated precipitate, remove impurities in sewage through fiber filter pools; final sewage is discharged after ultraviolet disinfection; sludge in the bink and efficient sedimentation tanks is collected to the mortar pond, and finally enter the sludge removal room Treatment; additional carbon sources of the oxidized ditch in the pharmaceutical interval are added, and PAM and PAC are added to the high-efficiency precipitation pool. Through experimental design and analysis, the expected processing effect of the main link is as shown in the table below:

Table 1 Prospective rate of contaminant removal

Processing unit	Characteristic of water quality	Chemical oxygen demand (COD_{Cr}) (mg L^{-1})	Biochemical oxygen demand (BOD_5) (mg L^{-1})	Total nitrogen (TN) (mg L^{-1})	Ammonia nitrogen (NH_3-N) (mg L^{-1})	Total phosphorus (TP) (mg L^{-1})	Suspended substance (SS) (mg L^{-1})
Suction sump	Inlet water	500	105	40	35	4	400
Hydrolyzed pool	Inlet water	450	100	40	35	4	250
	After processing	184	90	32	28	-	200
	removal rate	20 %	15 %	20 %	20 %	-	20 %
Modified oxidation ditch	Inlet water	184	90	32	28	4	250
	After processing	50	10	15	5	2	150
	removal rate	89 %	90 %	53 %	82 %	50 %	40 %
Coagulatory settler	Inlet water	50	10	15	5	2	20
	After processing	50	10	15	5	0.5	10
	removal rate	-	-		-	75 %	50 %
Effluent standard	After processing	50	10	15	5	0.5	10
Whether to meet the standards		√	√	√	√	√	√

2.1.1. Rough grill

The coarse grille is the first sewage treatment facility in the sewage treatment plant, and a rough grid mainly suspends the sewage.

To ensure subsequent improvement of the normal operation of the pump room.

2.1.2. Sewage boost pump room

After the coarse grill removes large impurities, the sewage is promoted by the pump house. The sewage pump of this engineering is a submersible sewage pump. It has the advantage of effectively cutting suspension impurities that are not filtered in the coarse grid to ensure the normal passage of sewage; this sewage pump installation and maintenance is more convenient. It is very suitable for the treatment of urban sewage.

2.1.3. Fine grill

After the increase, further filtration operation is to remove smaller floats and suspended sewage and improve subsequent processing efficiency.

2.1.4. Vortex-type grit

The sanding tank can be separated by gravity and centrifugation, removing relatively small inorganic particles in the sewage, and preliminary sewage purification to avoid subsequent treatment of these impurities. This design choice is a swirling sanding pool. This type of sandstick has been widely used in sewage treatment in recent years. The swirling sanding tank is a mechanical force to control the flow rate and sewage flow, which has high processing efficiency. The advantages of less investment are relatively small and easy to operate [11].

2.1.5. Hydrolyzate tank

Considering that the nature of the sewage treatment is provided before the secondary treatment (biological treatment), the hydrolyzed acidified tank is provided, and the hydrolyzed acidification process of anaerobic bacteria will be converted into a prolurcative organic substance to improve sewage. The changeability ensures the efficiency of subsequent biological treatment.

2.1.6. Improved Carrousel oxidation ditch

2.1.6.1. design description

The biological treatment portion uses a card oxidation ditch, mainly used to degrade the sewage BOD_5 and COD and N. This design has improved the card oxidation ditch, and anaerobic zone and hypoxia are provided before the oxidized ditch. District, sewage flow to anaerobic → hypoxia → oxygen.

According to the sketch of oxidation ditch (Fig.2), the design parameters are as follows:

(1) Two oxidative grooves.

(2) Single-seat design flow: $Q = 333\ m^3\ h^{-1}$.

(3) Design water temperature: up to 30 ° C, minimum 15 ° C.

(4) Take 20% of the pretreatment efficiency of BOD_5 and NH_3-N prior to entering the oxidation ditch.

2.1.6.2.Design

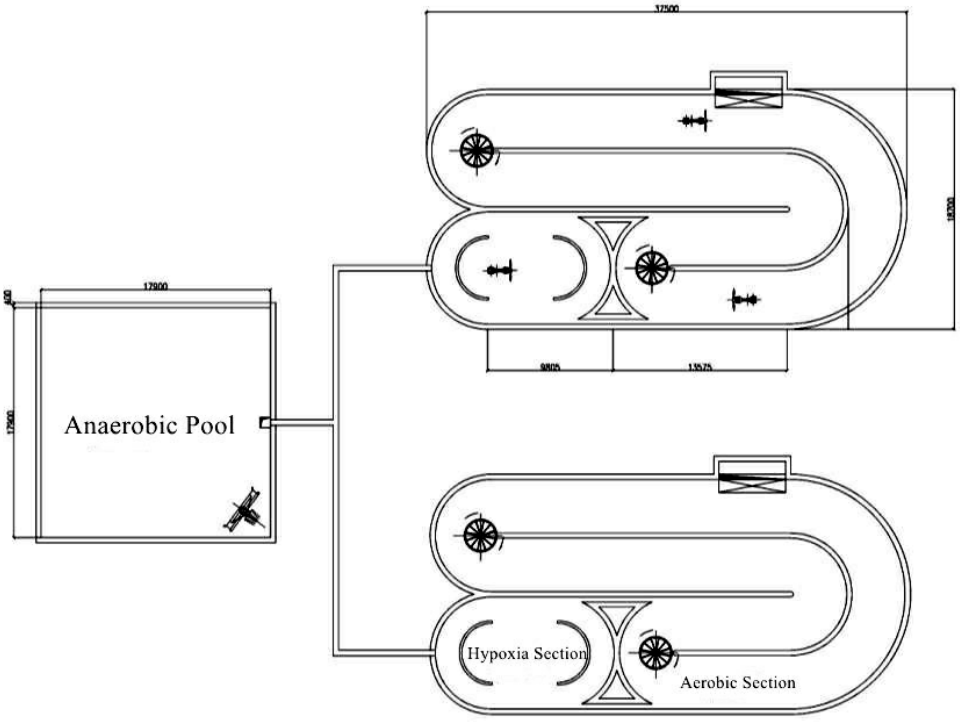

Fig.2 The sketch of oxidation ditch

2.1.6.3.Design Calculation

(1) Determine sludge thread:

Take the nitrite age θ=20 d

$$N_0 = N - 0.05\,(S_0 - S_e) - N_e$$

$$= 28 - 0.05\times(84-10) - 15 = 9.3\,\text{mg L}^{-1}$$

In the above formula:

N_0- Need to make a concentration of nitrate-nitrogen nitrate, mg L^{-1}

N_e-outlet NH_3-N concentration, mg L^{-1}

N-Inlet NH_3-N concentration, mg L^{-1},

$$N = 35\times(1-0.2) = 28\,\text{mg L}^{-1}$$

S_0-Inlet BOD concentration, mg L^{-1},

$$S_0 = 105\times(1-0.2) = 84\,\text{mg L}^{-1}$$

S_e-outlet supply BOD concentration, mg L^{-1}

The denitrification rate is calculated by the following formula:

$$K_{de} = \frac{N_0}{S_0} = \frac{9.3}{84} = 0.11\,\text{kgNO}_3\,(\text{kgBOD}_5)^{-1}$$

The ratio of the total volume of the lack of oxygen pool and the total volume of the oxidation ditch according to the KDE is compared with the denitrification rate:

$$V_D/V = \theta_{cd}/\theta_c = 0.2$$

Where:

V-oxidation ditch, m^3

V_D-hypoxic pool volume, m^3

θ_{cd}-denitrified sludge total mud

The total mud age of sludge is calculated as follows:

$$\theta_c = \frac{\theta_{cd}}{1-\theta_{cd}/\theta_c} = \frac{20}{1-0.2} = 25\,\text{d}$$

Meet the requirements of the oxidized ditch sludge age greater than 20 days.

(2) Calculation of the yield coefficient of sludge:

$$Y = K\left[Y_H + \frac{X_0}{S_0}(1-f_V+f_V f_{NV}) - \frac{(1-f_V)\theta_c b_H Y_H}{1+b_H\theta_c}\right]$$

Where:

K - correction coefficient

Y_H-heterotropic microbial yield coefficient, kgVSS ($kgBOD_5$) $^{-1}$, value range 0.6-0.75

X_0-water suspension concentration, mg L^{-1},

X_0 = 400×(1-0.75) = 100 mg L^{-1}

S_0-in-water BOD concentration, mg L^{-1}

Partial proportion of f_V-in-water SS volatilization, with value range, is generally 0.5-0.65

The ratio of non-aerobic biological degradation in the volatile solids (VSS) in the water in the water is generally 0.2-0.4

Endogenous degradation coefficient of b_H- heterotrophic microorganism

Simplify the above formula to obtain common sludge coefficient calculation formula:

$$Y = K\left(0.6\left(\frac{X_0}{S_0}+1\right) - \frac{0.072\times0.6\times1.072^{T-15}}{\frac{1}{\theta_c}+0.08\times1.072^{T-15}}\right)$$

$$= 1.01\,\text{kgVSS}\,(\text{kgBOD}_5)^{-1}$$

Perform sludge load accounting:

$$L=\frac{S_0}{\theta_c\times Y(S_0-S_e)}=\frac{84}{25\times0.88\times(84-10)}$$

$$=0.051\,\text{kgBOD}_5\,(\text{kgMLSS}\cdot\text{d})^{-1}$$

Meet the sludge load:0.05-0.15 $kgBOD_5$ $(kgMLSS\cdot d)^{-1}$

(3) Calculation of sludge concentration

The sludge concentration is maintained at X=3.5 g L^{-1}, and the sludge index (SVI) is generally selected between 80-150. This design SVI takes 120 mg L^{-1}, the concentration-time of the sludge is $t_E = 2$ h.

The concentration of reflow sludge can be calculated by the following formula:

$$X_R=0.7\times\frac{1000}{SVI}\times t_E^{\frac{1}{3}}=0.7\times\frac{1000}{120}\times2^{\frac{1}{3}}$$

$$=7.35\text{ g L}^{-1}$$

Sludge reflow ratio:

$$R=\frac{X}{X_R-X}=\frac{3.5}{7.35-3.5}\approx91\%$$

(4) The volume of the oxidation ditch:

$$V=\frac{24\times Q\times\theta\times Y(S_0-S_e)}{1000\cdot X}$$

$$=\frac{24\times333\times25\times1.01\times(84-10)}{1000\times3.5}=4267\text{ m}^3$$

According to the basis: $V_D/V=\theta_{cd}/\theta_c=0.2$, you can draw:

Effective volume of oxidized ditch hypoxic region: $V_D=0.2\times V=853.4\text{ m}^3$

The volume of oxidized groove aerobic region: $V_0=(1-0.2)\times V=3413.3\text{ m}^3$

Hydraulic residence time of oxidized ditch:

$$\text{HRT}=\frac{V}{Q}=\frac{4267}{333}=13\text{ h}$$

(5) The volume of the front anaerobic pool

The hydraulic residence time of anaerobic pool takes T_1 = 1 h. The volumetric calculation of the anaerobic pool is as follows:

$$\text{VA}=2\times Q\times(1+R)\times T_1=1272\text{ m}^3$$

(6) Specifications for oxidized ditch

The effective water depth takes H = 4.0 m, and the area of the oxidized ditch: F=V/H=4267/4=1066.75 m^2

The area of the aerobic zone:

$F_o=V_0/H=3413.3/4=853.4\ m^2$

The area of the hypoxic area:

$F_D=V_D/H=853.4/4=213.35\ m^2$

The area of anaerobic zone:

$F_A=V_A/H=1272/4=318\ m^2$

The design size is shown in the figure.

(7) Calculation of oxidized ditch consumption oxygen:

In order to ensure the normal operation of the oxidation ditch in any environment, oxygen demand is calculated in the condition: T=25°C, θ_c=25 d(The amount of oxygen in this condition is the maximum oxygen demand), check the brochure to decompose the unit BOD_5 requires 1.35 kgO_2 $(kgBOD_5)^{-1}$

a. Degradation amount of BOD_5 in unit time is calculated by the following formula:

$$S_t=f_c\times Q\times(S_0-S_e)\times10^{-3}$$

$$=1.1\times333\times74=27.10\text{ kgBOD}_5$$

The f_c in the formula is a load fluctuation coefficient, and 1.1 is taken.

b. Nitride nitrogen in units of time:

$$N_{ht}=Q\cdot[N_0-0.05(S_0-S_e)-2]\times10^{-3}$$

$$=333\times[28-0.05(84-10)-2]\times10^{-3}$$

$$=7.43\text{ kg L}^{-1}$$

c. Denodation amount of denitrification in unit time:

$$N_{0t}=Q\cdot[N_0-0.05(S_0-S_e)-N_e]\times10^{-3}$$

$$=333\times[28-0.05\times(84-10)-15]\times10^{-3}$$

$$=3.10\text{ kg L}^{-1}$$

d. Calculation of oxygen demand:

$$\text{AOR}=1.35\times S_t+4.75\times N_{ht}-2.86\times N_{0t}$$

$$=63\text{ kgO}_2\text{ h}^{-1}$$

e. Revised demand oxygen

Under 25 ° C conditions, the amount of oxygen demultiplexation is taken as K_0=1.59.

$$\text{SOR}=\text{AOR}\times K_0=100.17\text{ kgO}_2\text{ h}^{-1}$$

(8) Calculation of residual sludge

Calculate the remaining sludge according to the sludge age, and the formula is as follows:

$$\Delta X=\frac{VX}{\theta_c}=1194.64\,kgSS\,(\text{kgBOD}_5)^{-1}$$

$$\Delta X_m=\frac{\Delta X}{X_R}=\frac{1194.64}{7.35}=162.54\,m^3d^{-1}$$

Where:

ΔX-Mud production

V-Reaction pool volume

X-Active sludge concentration

θ_c-sludge age

ΔX_m-Average mud production

2.1.6.4. Device selection

(1) Inverse surface aeration equipment

Designed with two inverted surface aeration equipment, the average amount of oxygen supply of aeration equipment is reached 100.17/2=50.10 $kgO_2\,h^{-1}$.

Therefore, the model number of the selected reverse surface aeration equipment is shown in the table below:

Table 2 Performance parameters of umbrella aeration equipment

model	Diameter of impeller (mm)	Rated power of motor (kW)	Oxygen charge ($kgO_2\ h^{-1}$)
HDS 225	2550	30	11-58

(2) Anaerobic area mixer

The volume V_1=1272 m^3 of the anaerobic zone is 5 W/m^3. The desired agitator power is 6360 W, so the model of the selected agitator device is as shown in the following table:

Table 3 Performance parameters of agitator equipment

model	Diameter of impeller (mm)	Wheel speed (rpm)	Rated power of motor (kW)
QJB4/6-400/3-980/S	400	980	4

(3) Oxidative groove thrifter

The oxidized ditch set three soil models as follows:

Table 4 Performance parameters of water impeller

model	Diameter of impeller (mm)	Wheel speed (rpm)	Rated power of motor (kW)
QJB5/4-2500/2-56P	2500	56	5

2.1.7. Secondary sedimentation tank

After the biological treatment, the active sludge will carry the active sludge in the water. Thus the two sinks are provided after the biological treatment, the sewage is subjected to secondary precipitation, the sludge is refluxed, and SS in the sewage is removed while ensuring the subsequent three-level treatment. Normal operation. This design is intended to use the sproff-type two sinking pools of the water around the peripheral water, and the number of construction is 2.

2.1.8. High-density clarification pool

A high-density clarification pool is a three-level treatment process of sewage. Adding PAM and PAC in high-density clarification pools can further remove TP and SS in water, reaching the water. The high-density clarification pool is divided into three parts: mixing area, flocculation area.

The clarification area, where PAC is added to the mixing area, and PAM is added to the flocculation area.

2.1.9. Fiber turntable filter

After high density clarification pool, the filtration equipment has a V-type filter, a surface filtration pond and a turntable filter, and the like. This design selects the filtration device after the turntable filter as a sedimentation tank, which has the advantage of excellent water quality, simple equipment and easy to install, and small area is small. The fiber turntable filter comprises a water tank, filter turntable and outlet, and an automatic cleaning system.

The working state has mainly filtered and late washing.

2.1.10. Disinfectant pool

As the last step of sewage treatment, the ultraviolet lamp can kill bacteria and viruses to ensure water safety.

3 Conclusion

This paper is designed for design discussions on the sewage treatment process of Shaowu City, the characteristics of sewage water quality and actual urban development, and then select the hydrolyzate + oxidation ditch + concrete precipitation process as a sewage treatment process, and the card The oxidation ditch is improved, and the parameters of the card oxidation ditch are determined by specific calculations, and the treatment effect of this sewage treatment process is verified. The result is in line with the expected pollutant removability, so that the water quality reaches "urban sewage treatment Plant Pollutant Emission Standard "1st A standard (GB18918-2002). All calculations and parameters taken in this paper meet the latest national standards, and analyze the specific conditions of sewage and some resident sewage in Suburban Industrial Park, the main services of Shaowu City, and take appropriate treatment equipment due to local conditions. To ensure that the quality of sewage treatment, the economic efficiency is selected, and the energy-saving process has reached a good expected effect (Prospective rate of contaminant removal meets the "Sewage Treatment Plant Pollutant Emission Standard" (GB18918-2002)), in order to provide a reference for the current small urban sewage treatment process design.

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