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Original Paper

Engineering Design of an Industrial Wastewater Treatment Plant in an Eastern Chinese city

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Abstract

Urbanization and industrial growth in an eastern Chinese city have significantly increased wastewater discharge, while the existing domestic treatment plant lacks both capacity and the capability to remove industrial-specific pollutants, necessitating a new industrial facility. Designed for 30,000 m³/d, the plant produces effluent meeting Class one A standard (GB 18918—2002) with core parameters also satisfying Class IV surface water limits. The treatment train comprises three stages: primary pretreatment (screening, grit removal, equalization/emergency tank), modified A²/O biological treatment, and tertiary advanced treatment (Fenton catalytic oxidation, high-density sedimentation, deep-bed filtration) followed by sodium hypochlorite disinfection. Sludge is dewatered by plate-and-frame press, and odorous gases are treated by biofilters. Covering 67.6 mu (4.51 ha) with a functional layout ensuring smooth flow and compact land use, the project represents an investment of about 310 million yuan. Commissioned in 2023, the plant has since operated stably, attaining its design capacity and consistently meeting all effluent standards.

Keywords

Industrial Wastewater Treatment Plant, Fenton Catalytic Oxidation, Modified A²/O

1. Project Background

A coastal city in eastern China covers 1,514 km² with a resident population of 1.203 million, administering 15 towns, 427 villages, 42 communities, and two provincial-level development zones. It possesses 62.5 km of high-quality coastline and 1.08 million mu of shallow sea waters.

In recent years, the municipal government has progressively upgraded urban sewage treatment infrastructure. Currently, two centralized WWTPs (Wastewater Treatment Plant) are in operation: Xincheng WWTP (current capacity: 6.5×10^4 m³/d, expandable to 13×10^4 m³/d) primarily treats municipal domestic sewage; Chengnan WWTP (2×10^4 m^3/d) receives domestic sewage and industrial wastewater from the area south of Qingkou River, with industrial wastewater conveyed via the pipe network. The latter employs a pre-anaerobic oxidation ditch combined with high-efficiency clarification and fiber disc filtration.

As the regional sewerage network continues to expand, the sewage collection rate has steadily risen. Concurrently, sustained investment promotion in the Economic Development Zone has spurred economic growth and population increase, resulting in a corresponding rise in pollutant loads from both domestic and industrial sources. However, the existing Chengnan Wastewater Treatment Plant is no longer adequate to accommodate the projected long-term increase in wastewater volume. Furthermore, some industrial enterprises in the area have left their pretreatment facilities idle, allowing untreated production wastewater to be discharged directly into the municipal network. This not only accelerates the corrosion and deterioration of the drainage infrastructure but also disrupts the biological treatment processes at the plant, significantly compromising pollutant removal efficiency.

Thus, the current urban treatment system faces a dual challenge: insufficient capacity and a lack of specialized treatment units for industrial-specific pollutants. These shortcomings highlight a critical gap in regional pollution control. To address this, a dedicated industrial wastewater treatment plant is planned—both to augment the overall treatment capacity and to introduce advanced treatment units tailored to industrial wastewater, thereby effectively reducing characteristic industrial contaminants.

The construction of this industrial wastewater treatment facility is essential for supporting the region's green and sustainable economic development while improving the quality of the urban and rural aquatic environment. Once completed, it will enable centralized, specialized treatment of industrial wastewater from major enterprises in the Economic Development Zone via a unified pipeline network, reducing the costs associated with decentralized pollution control for individual companies. At the same time, it will prevent the unregulated discharge of high-strength industrial effluents into the watershed, thereby safeguarding the water quality of river basins and ensuring the long-term stability of the biological treatment systems at existing municipal plants.

In summary, this industrial wastewater treatment plant project is a core infrastructure for comprehensive regional water environment management and urban ecological environment improvement, playing an important supporting role in coordinating watershed water pollution prevention and control. The project construction has sufficient practical necessity.

2. Project Scale and Construction Objectives

2.1 Construction Scale

Fully considering the actual water consumption situation of the district, economic development levels of different regions, industrial development layout, population growth and other factors, and in line with the principle of building a water-saving society, based on the current water supply situation with appropriate development margins, water consumption indicators are reasonably selected.

1) Wastewater volume prediction by land use index method

Based on the local land use planning and water consumption indicators for each land use type, the water consumption indicators adopt the lower limit of unit land use water consumption indicators from the "Code for Urban Water Supply Engineering Planning" (GB50282-2016). The long-term wastewater volume prediction for the area south of Qingkou River (excluding the Economic Development Zone) is detailed in the table below.

Table 1. Long-term Industrial Wastewater Volume Prediction Table

Area	Land Use Type	Long-term Land Area (ha)	Water Consumption Index ($m^3/ha \cdot d$)	Water Consumption (m^3/d)	Wastewater Volume (m^3/d)
Area south of Qingkou River (excluding Economic Development Zone)	Industrial land	30.15	60	1809	1356.8
Ganyu Economic Development Zone	Industrial land	584.18	60	35050.8	26288.1
Total					27644.9

2) Calculation of water consumption of existing and planned enterprises

The average daily wastewater discharge of enterprises from the existing Chengnan Wastewater Treatment Plant is 18,000 m^3/d, which will be connected to the newly built industrial wastewater treatment plant after the completion of this project. At the same time, it will receive 5,000 m^3/d of industrial wastewater from a quartz factory and 3,000 m^3/d of wastewater from a seaweed enterprise, totaling 26,000 m^3/d. A certain margin is also reserved for enterprises to be introduced.

Based on the above prediction methods, the long-term total scale of this industrial wastewater treatment plant is determined to be 30,000 m^3/d. The total variation coefficient K=1.7 before the emergency equalization tank (pretreatment section), and 1.25 after the pretreatment section.

2.2 Project Objectives

(1) Current influent water quality

The measured water quality of the existing Chengnan Wastewater Treatment Plant over the past 3 years was investigated and analyzed as follows:

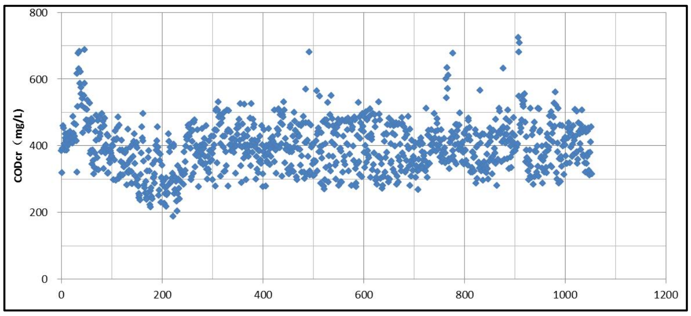

Figure 1. Trend of Influent CODcr

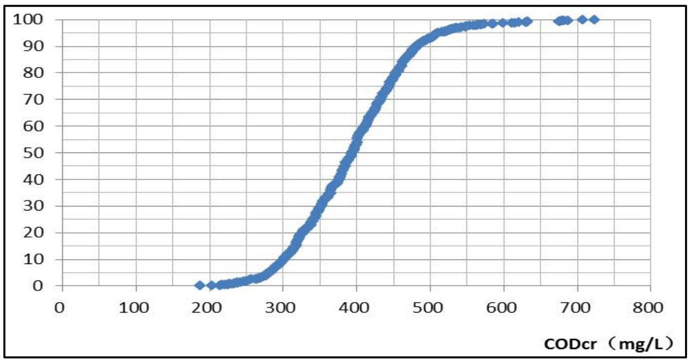

Figure 2. Guarantee Rate Analysis of Influent CODcr

At 85% guarantee rate, the influent CODcr is 465 mg/L; at 90% guarantee rate, the influent CODcr is 475 mg/L; at 95% guarantee rate, the influent CODcr is 510 mg/L. The average influent CODcr is 397 mg/L.

(2) Influent SS (Suspended solids)

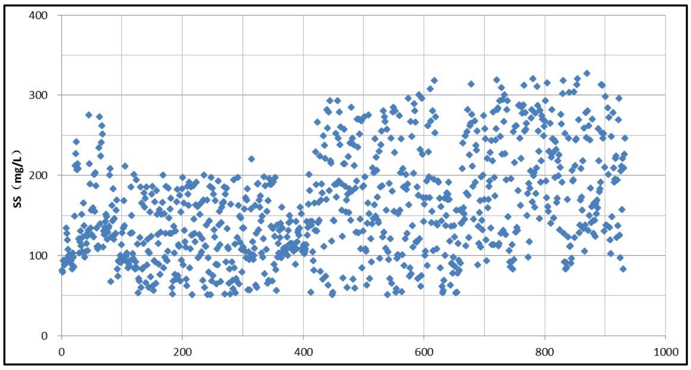

Figure 3. Trend of Influent SS

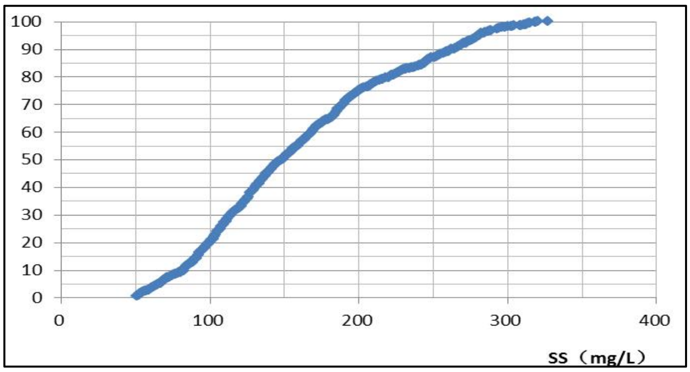

Figure 4. Guarantee Rate Analysis of Influent SS

At 85% guarantee rate, the influent SS is 240 mg/L; at 90% guarantee rate, the influent SS is 260 mg/L; at 95% guarantee rate, the influent SS is 280 mg/L. The average influent SS is 161 mg/L.

(3) Influent NH_3-N(ammonia nitrogen)

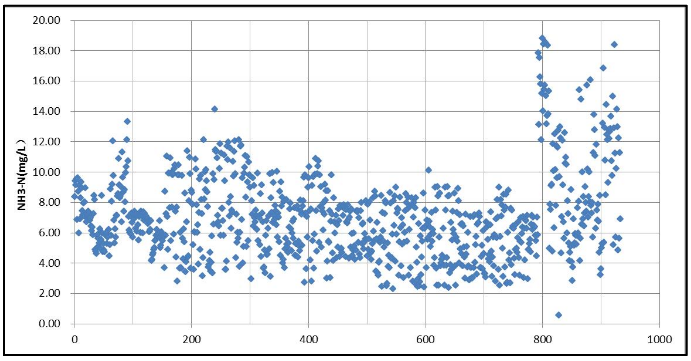

Figure 5. Trend of Influent NH_3-N

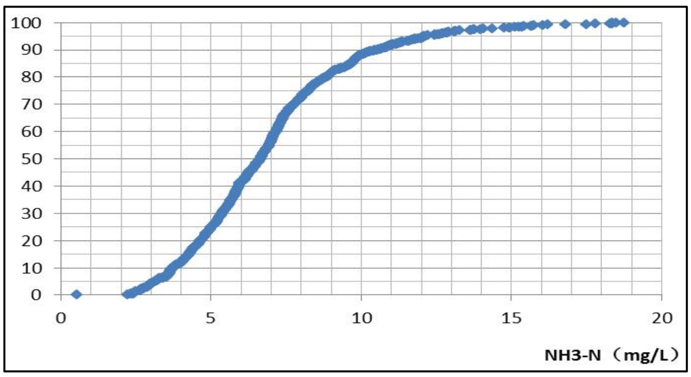

Figure 6. Guarantee Rate Analysis of Influent NH_3-N

At 85% guarantee rate, the influent NH_3-N is 9.5 mg/L; at 90% guarantee rate, the influent NH_3-N is 10.5 mg/L; at 95% guarantee rate, the influent NH_3-N is 12 mg/L. The average influent NH_3-N is 6.98 mg/L.

(4) Influent TP(Total Phosphorus)

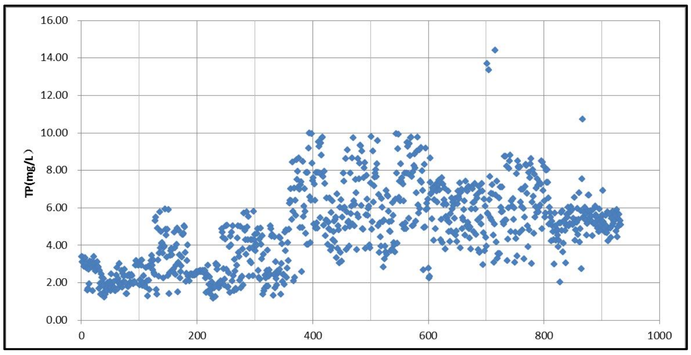

Figure 7. Trend of Influent TP

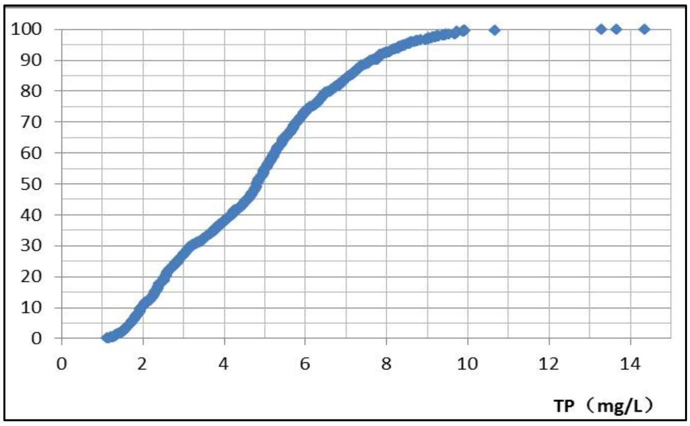

Figure 8. Guarantee Rate Analysis of Influent TP

At 85% guarantee rate, the influent TP is 7 mg/L; at 90% guarantee rate, the influent TP is 7.5 mg/L; at 95% guarantee rate, the influent TP is 8.8 mg/L. The average influent TP is 4.8 mg/L.

According to relevant policy requirements and based on the "Standard for Wastewater Discharge to Urban Sewer Systems" (GB/T31962-2015), the main indicators for enterprise wastewater discharged to secondary treatment wastewater treatment plants are as follows:

Table 2. Pollutant Discharge Concentrations for Enterprise Wastewater Connection

Item	CODcr (mg/L)	BOD_5 (mg/L)	SS (mg/L)	NH_3-N (mg/L)	TN (mg/L)	TP (mg/L)
Water Quality	≤500	≤350	≤400	≤45	≤70	≤8.0

Therefore, referring to measured data from similar urban wastewater treatment plants and combining with the actual situation of the existing Chengnan Wastewater Treatment Plant, after comprehensive analysis, the design influent water quality is determined as follows:

Table 3. Design Influent Water Quality

Item	CODcr (mg/L)	BOD_5 (mg/L)	SS (mg/L)	NH_3-N (mg/L)	TN (mg/L)	TP (mg/L)
Short-term Water Quality	500	70	280	15	25	7
Long-term Water Quality	500	120	320	35	45	7

(2) Design effluent water quality

According to national, provincial and municipal standards and relevant planning requirements, the effluent of this project meets the Class 1A standard of the "Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant" (GB18918-2002), with some indicators meeting Class IV surface water standards, as detailed in the table below.

Table 4. Design Effluent Water Quality Table

Item	BOD_5 (mg/L)	COD (mg/L)	SS (mg/L)	NH_3-N (mg/L)	TN (mg/L)	TP (mg/L)
Limit Value	≤10	≤50	≤10	≤1.5 (3)	≤10	≤0.3

(3) Effluent discharge

The effluent of this project is planned to be discharged to a constructed wetland, transported through pressure pipes from the effluent pump house to a composite constructed wetland treatment process.

3. Wastewater Treatment Process

The selection of the industrial wastewater treatment plant process is particularly important, especially for the treatment of characteristic pollution factors and the response to emergency events. Therefore, this project considers a three-stage treatment process.

3.1 Primary Treatment Process

The primary treatment facilities of this project mainly include coarse screen and influent pump house, fine screen and grit chamber, and equalization (emergency) tank.

(1) Fine screen and grit chamber: used to remove large-sized impurities and sand from the incoming water, ensuring stable operation of subsequent treatment structures.

(2) Equalization tank

An equalization tank is incorporated to mitigate the wide fluctuations in industrial wastewater flow and composition, particularly during plant start- up, shutdown, and maintenance. Enhanced mixing within the tank ensures homogeneous influent quality, thereby safeguarding the performance of downstream treatment units.

(3) Emergency tank

To avoid the impact of emergency wastewater on the wastewater treatment system, an emergency tank is set up to store emergency wastewater. It is generally kept empty to ensure it plays its due role during special periods.

3.2 Secondary Treatment Process

From the analysis of the biodegradability of incoming wastewater, the B/C ratio of incoming wastewater is 0.22, which belongs to relatively difficult-to-biodegrade wastewater. Currently, mature and stable treatment processes in the field of wastewater treatment are basically biological treatment processes centered on simultaneous nitrogen and phosphorus removal. To achieve simultaneous nitrogen and phosphorus removal, it is necessary to pretreat the incoming wastewater to improve its biodegradability.

Therefore, the secondary treatment adopts a biological pretreatment + biological nitrogen and phosphorus removal process.

(1) Biological pretreatment

Anaerobic acidification treatment performs primary decomposition of organic matter and improves the biodegradability of wastewater. The removal rate of organic matter at this stage is not high, but subsequent combination with aerobic treatment can achieve more thorough decomposition and mineralization of organic matter. Anaerobic biological treatment is one of the effective means to improve the biodegradability of industrial wastewater and is widely used as a pretreatment process in the industrial wastewater field.

(2) Biological nitrogen and phosphorus removal process

Currently, wastewater treatment processes with certain nitrogen and phosphorus removal effects for urban wastewater treatment can be divided into two categories: the first is the activated sludge process, and the second is the biofilm process.

According to the composition form, operating performance and operation mode of structures, the activated sludge process is mainly divided into: ① A^2/O series; ② oxidation ditch series; ③ sequencing batch reactor (SBR) series.

The biofilm process purifies wastewater through the adsorption and decomposition of organic pollutants by biofilms. Popular main processes include: biological filters (ordinary biological filters, high-load biological filters, tower biological filters), biological rotating discs, biological contact oxidation equipment, and biological fluidized beds.

Based on the previous water quality data and actual operation and maintenance considerations, the main biological treatment process adopts the modified A^2/O process, which has considerable advantages in terms of shock load resistance, nitrogen removal efficiency, treatment effect, investment and operating costs.

3.3 Tertiary Treatment Process

The tertiary treatment process is the advanced treatment process. Advanced treatment aims to further reduce pollutant indicators such as CODcr, BOD_5, SS, TN, and TP in the effluent. In particular, industrial wastewater contains more refractory organic matter and TDS, which pose greater difficulty for CODcr compliance. Advanced treatment units are necessary to meet effluent requirements.

(1) Advanced oxidation

For refractory organic matter in industrial wastewater treatment, relying solely on biological pretreatment (hydrolysis acidification) is difficult to achieve stable compliance, and it is usually necessary to combine advanced oxidation processes: commonly used are ozone advanced oxidation and Fenton catalytic oxidation.

Ozone oxidation mainly uses fluidized beds and other forms to bring ozone into contact with organic matter in water. The hydroxyl radicals decomposed by ozone can break chains and open rings of organics that are difficult to biodegrade in water, converting them into simple aliphatic hydrocarbons and changing their biochemical characteristics. In addition to oxidizing certain harmful organics into harmless substances, ozone can also objectively increase small-molecule organics, enabling better performance of the biodegradation function of subsequent processes.

Fenton catalytic oxidation mainly applies the Fenton oxidation reaction generated by Fe^{2+} and H_2O_2 under the action of catalysts. Using the principles of catalytic oxidation, catalytic reduction, and catalytic condensation, it effectively removes refractory organic pollutants. Its cost is lower than ozone, and it has no selectivity for oxidizing organics, with high oxidation efficiency. Ferrous sulfate acts as a catalyst for the reaction system at the front end and forms a high-efficiency iron salt coagulant at the back-end solid-liquid separation unit, eliminating the need for additional coagulant dosing. Through iron salt entrapment, coagulation, adsorption, and complexation bridging, the coagulation effect is promoted.

Considering operating costs, treatment load, and shock load resistance comprehensively, the Fenton catalytic oxidation process is adopted as the advanced oxidation treatment after biological treatment to stably treat refractory COD and ensure water quality compliance.

(2) Coagulation and filtration

The advanced treatment process is based on the coagulation-sedimentation-filtration theory in water treatment, usually a combination of flocculation, sedimentation, filtration and other processes. Each treatment unit has different forms of process types. Since this project requires strict implementation of Class 1A discharge standards with TN less than 10 mg/L, and to further remove nitrogen and phosphorus and reduce refractory soluble organic matter concentrations, this feasibility study recommends a combined treatment process of high-density sedimentation tank + denitrification biofilter, which features advanced technology, high treatment efficiency, good operating results, and land saving.

Pre-positioned Fenton can effectively reduce impurity treatment and improve SS treatment efficiency. In addition, among the enterprises to be connected, there are fluoride characteristic pollutants. Low-concentration fluoride can be effectively removed in the high-density sedimentation tank by dosing PAC (polyaluminum chloride) or defluorinating agents, through mixing flocculation and inclined plate sedimentation.

The high-density sedimentation tank is followed by a deep-bed filter (denitrification biofilter), which further removes SS on one hand; at the same time, by dosing external carbon sources to form a denitrification filter, it can further denitrify and remove SS and TN, playing a gatekeeping role for effluent TN. In spring, autumn, and summer, the denitrification filter is converted to an ordinary filter without external carbon source dosing, mainly controlling SS and TP.

3.4 Effluent Disinfection Process

Current disinfection methods for wastewater treatment plants can be broadly divided into two categories: physical methods and chemical methods. Physical methods mainly include heating, freezing, irradiation, ultraviolet and microwave disinfection. However, the most commonly used at present is the chemical method using chemical reagents.

Sodium hypochlorite has broad-spectrum and high-efficiency bactericidal properties, with strong killing ability against viruses and spores. It requires low dosage, short contact time, and good effect. Sodium hypochlorite has high solubility in water, and very little volatilizes from water during disinfection, with almost no detectable odor.

After comprehensive consideration, sodium hypochlorite disinfection process is recommended for wastewater effluent. The sodium hypochlorite dosing point is set at the front end of the contact disinfection tank influent.

3.5 Sludge Treatment Process

The main purposes of sludge treatment and disposal include: reduction, stabilization, harmlessness, and resource recovery.

The engineering values of dry sludge yield for urban wastewater treatment plants in multiple regions of China are as follows: Beijing and Shanghai take 1.5 t/10^4 m^3 wastewater, Tianjin takes 1.6 t/10^4 m^3 wastewater, Guangzhou takes 1.2 t/10^4 m^3 wastewater, and Shenzhen takes 1.3 t/10^4 m^3 wastewater.

This project is an industrial wastewater treatment plant equipped with a Fenton catalytic oxidation advanced treatment unit, with large chemical dosage and significantly higher sludge yield than conventional municipal wastewater treatment plants. Based on comprehensive comparison with similar industrial wastewater engineering cases, the dry sludge yield of this project is determined to be 3.0 t/10^4 m^3 wastewater.

The designed treatment scale of the project is 30,000 m^3/d. After calculation, the average daily dry sludge production is 9 t/d.

At present, mainstream sludge dewatering equipment is divided into three categories: belt filter press, plate and frame filter press, and centrifugal dehydrator. Comparison can be carried out from dimensions such as treatment effect, engineering investment, operating cost, operation and maintenance difficulty, and practical application cases.

Combined with the treatment scale, plant land use, operation and maintenance management capacity, and project investment conditions of this project, focusing on equipment operation stability, automation level, dewatering performance, infrastructure investment and comprehensive chemical energy consumption, the plate and frame filter press is recommended. This equipment has excellent sludge dewatering efficiency, strong adaptability to biochemical sludge and Fenton chemical sludge, and the sludge cake moisture content can be stably controlled below 60%, meeting disposal requirements.

Sludge transport and disposal are coordinated with the regional comprehensive sludge disposal special plan. The dewatered sludge of this project is transported in sealed containers to local thermal power enterprises for co-incineration disposal, achieving sludge volume reduction and energy utilization.

3.6 Odor Control Process

Combined with the treatment scale and organized emission control standards for malodorous gases of this project, a combined odor control process of chemical washing + biofilter is determined. All odor-generating structures in the plant are sealed and covered, equipped with FRP gas collection ducts for unified negative pressure collection. All waste gas pipelines are collected and sent to the integrated odor control equipment located above the emergency tank for centralized purification treatment.

4. Engineering Design

4.1 Process Design

Combined with current influent data, data of enterprises to be connected to the pipe network, as well as the operation requirements of the builder and local engineering experience, the process flow of this industrial wastewater treatment plant is determined as follows: the wastewater treatment process recommends “influent → coarse screen and influent pump house → fine screen and aerated grit chamber → emergency tank/equalization tank → anaerobic hydrolysis tank → modified A²/O tank → secondary sedimentation tank → intermediate lift pump house → Fenton catalytic oxidation tank + stabilization neutralization tank → high-density sedimentation tank → denitrification deep-bed filter → contact disinfection tank → discharge”.This process flow is long, with strong shock load resistance and strong advanced treatment water quality assurance capability, ensuring the treatment volume and water quality.

4.2 Plant Layout

This industrial wastewater treatment plant project is planned to be built on the east side of the existing Chengnan Wastewater Treatment Plant. According to the process flow and land use layout, the north side of the plant area is mainly the primary and secondary treatment section, including coarse screen and influent pump house, fine screen and aerated grit chamber, equalization tank, emergency tank, hydrolysis acidification tank, modified A²/O tank, and secondary sedimentation tank; the advanced treatment section is located on the south side of the plant, including intermediate lift pump house, Fenton catalytic oxidation tank, stabilization neutralization tank, high-density sedimentation tank, denitrification deep-bed filter, and contact disinfection tank; the blower room and power distribution room are located in the middle area,

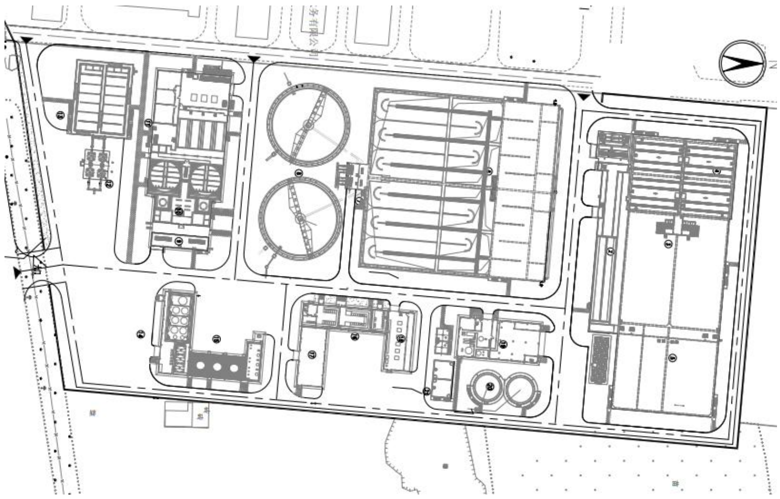

Figure 9. Overall Layout of the Plant

4.3 Design of Main Treatment Structures

(1) Coarse screen and influent pump house

Coarse screen: mainly intercepts large floating objects in wastewater to ensure normal operation of pumps; Influent pump house: lifts wastewater into treatment structures.

The design flow of the coarse screen equipment is 2,125 m³/h, with a total variation coefficient of 1.7 and bar spacing of 20.0 mm.The influent pump house is equipped with 5 pumps, 4 in operation and 1 standby, with variable frequency control. Single pump Q=540 m³/h, H=16 m, N=45 kW.

(2) Fine screen and aerated grit chamber

1) Fine screen: further screening to remove smaller particles from water, ensuring safe and stable operation of subsequent systems. Each fine screen channel is equipped with a regulating weir gate at the influent section and a sluice gate at the effluent section, enabling each fine screen to operate and backwash independently and automatically. Design screen velocity 0.90 m/s, bar spacing 5 mm, water depth before screen 1.2 m, screen width 1.4 m.

Aerated grit chamber: removes sand particles with particle size ≥0.2 mm and grease from wastewater, avoiding sedimentation in subsequent treatment structures and channels that could cause poor water flow or improper closure of gates (valves) in treatment structures. It also reduces wear on aeration equipment and sludge treatment equipment, reducing the possibility of aeration equipment clogging. Design hydraulic retention time 6 min, one tank with two channels.

(3) Equalization tank

Equalization tank: homogenizes water quality and regulates water volume for time-discharged influent.

A new equalization tank is built to collect incoming industrial wastewater and achieve uniform wastewater quality and volume through mixing and pumping. The plane area of the equalization tank is 2,124 m²; effective water depth 7.7 m; total storage volume 16,355 m³, which can store approximately 7.7 hours of wastewater on the highest day.

To ensure uniform water volume, in addition to the conventional gravity flow discharge outlet, 3 submersible sewage pumps are installed, 2 in operation and 1 standby. Single pump flow $Q=625\ m^3/h$, $H=8.4\ m$, $N=30\ kW$.To ensure uniform water quality, perforated pipe hydraulic mixing is adopted. Flow rate is $80\ m^3/h$, main pipe DN200, flow velocity $v=0.72\ m/s$.

(4) Emergency tank

Function: When industrial enterprises experience leakage accidents, fires and other special situations, resulting in wastewater in the industrial zone containing pollutants and toxic substances far higher than the design concentration, the wastewater is transported to the emergency tank for standing or regulation. The emergency tank is set offline, and after the wastewater treatment plant influent returns to normal, the emergency wastewater is slowly mixed with normal water and then enters the equalization tank.

The plane size of the emergency tank is 1,616 m^2; effective water depth 7.7 m; total storage volume 12,443 m^3, which can store 5.9 hours of wastewater on the highest day.

Emergency tank wastewater is discharged to the equalization tank at a small flow rate. Considering emptying the emergency tank within 48 hours after an accident, pump $Q=260\ m^3/h$, $H=10\ m$, $N=15\ kW$; 1 in operation and 1 standby, both can be used simultaneously during emergencies.

(5) Hydrolysis acidification tank

1) Function:Regulates influent pollutant concentration, and also has the function of using high-concentration facultative microorganisms. Under anaerobic conditions in the tank, a large number of hydrolysis-acidogenic bacteria hydrolyze insoluble organic matter into soluble substances, converting macromolecular and difficult-to-biodegrade substances into easily biodegradable substances.

2) Process design

The hydrolysis acidification process adopts sludge expansion bed technology, using an upflow hydrolysis acidification reactor tank.One hydrolysis acidification tank, divided into 4 channels; effective water depth: $H=8.0\ m$; retention time: 6.45 h,4 sets of adjustable water distributors are installed, each with specification $Q=7{,}500\ m^3/d$; the tank is equipped with mixed liquor return pumps and sludge discharge pumps. 5 return pumps are installed, 4 in operation and 1 standby, single pump flow $Q=180\ m^3/h$, head $H=5\ m$, power $N=4\ kW$; 2 sludge discharge pumps, 1 in operation and 1 standby, single pump flow $Q=95\ m^3/h$, head $H=12\ m$, power $N=5.5\ kW$.

(6) Modified A^2/O tank

1) Function: The modified A^2/O tank is divided into pre-anoxic zone, anaerobic zone, anoxic zone, facultative zone and aerobic zone, mainly removing pollutants such as organic matter, ammonia nitrogen, total nitrogen and total phosphorus from wastewater.

2) Process design

Both civil works and equipment are constructed and installed at one time according to the scale of 30,000 m^3/d. Plane dimensions: $L \times B=77.8\ m \times 80.0\ m$, total tank height 7.75 m, effective water depth 6.55 m, retention time 23.8 h.

(7) Biochemical tank sludge pump house

1) Function:Return sludge pumps return activated sludge to the A^2/O biochemical tank to ensure good operation of the biological system. Waste sludge pumps lift sludge to the sludge thickener.

2) Process design

Sludge return ratio: 100%, Q=1,250 m^3/h

Moisture content 99.4%, sludge volume 380 m^3/d.

The sludge return and waste pump house is located within the sludge pump house, equipped with sludge return pumps and waste sludge pumps. 4 sludge return pumps, 3 in operation and 1 standby, Q=420 m^3/h, H=9 m, N=22 kW; 2 waste sludge pumps, 1 in operation and 1 standby, Q=100 m^3/h, H=13 m, N=11 kW.

(8) Secondary sedimentation tank

Both civil works and equipment are constructed and installed at one time according to the scale of 30,000 m^3/d (1,250 m^3/h). The diameter of the secondary sedimentation tank is 35 m, surface load at maximum flow: 0.892 $m^3/m^2 \cdot h$. Total variation coefficient K_total=1.25.

One radial flow sedimentation tank with center influent and peripheral effluent is adopted. Each tank has an inner diameter of 35 m, effective water depth of 3 m, flat bottom, freeboard of 0.5 m, and total height of 4.5 m. The sedimentation tank effluent adopts an annular collection trough with double-side overflow weir effluent. The maximum weir load is 0.99 L/s·m, which is less than the maximum load of 1.7 L/s·m specified in the code.

(9) Fenton catalytic oxidation tank

1) Function:To address refractory pollutants not removable by conventional processes, an advanced oxidation step is employed. In the Fenton catalytic oxidation zone, 98% sulfuric acid is first added to bring the pH to 3–5, then ferrous sulfate and hydrogen peroxide are introduced to oxidize organics. The effluent passes by gravity to a stabilization tank, which buffers flow and allows the reaction to reach completion; at the tank outlet, 32% caustic soda is dosed to raise the pH back to 6.8–7.2, after which the stream enters the high- efficiency sedimentation tank.

2) Process design

Treatment scale: 30,000 m^3/d, variation coefficient 1.25. One tank with two channels, effective water depth 6 m, hydraulic retention time 2 h.

Stabilization tank process design summary table.

(10) Intermediate lift pump house and high-density sedimentation tank

1) Function:Lifts secondary sedimentation tank effluent to the high-density sedimentation tank; chemical dosing flocculation and sedimentation to reduce phosphorus content in wastewater.

2) Process design

The high- density sedimentation tank is an integrated unit combining reaction, clarification, thickening, and sludge return, consisting of mixing, reaction, and sedimentation/thickening zones. Sludge return and chemical dosing promote the formation of large, dense flocs; inclined plate settlers are also installed to enhance separation. A high-efficiency defluorinating agent and PAM are dosed, with pH adjustment points ($NaOH/H_2SO_4$) reserved to precipitate fluoride ions.

The intermediate lift pump house is integrated with the sedimentation tank and houses five submersible sewage pumps (four duty, one standby), each rated at Q = 391 m³/h, H = 21 m, with a 37 kW variable-frequency motor.

The tank comprises two flocculation basins and two sedimentation basins, with a mixing time of 3 min, flocculation time of 18 min, clear-water area of 124.15 m², and an inclined-tube upflow velocity of 6.3 m/h.

(11) Denitrification deep-bed filter and backwash pump house

The civil works and equipment of the denitrification biofilter are constructed at one time according to the scale of 30,000 m³/d, with a single row of four channels.

1) Function: further removes SS from effluent.

2) Design parameters:

Filtration rate v: 6.67 m/h, checked forced filtration rate v'=8.89 m/h

The filter is built together with the backwash pump house, with homogeneous sand filter media 1.0-2.0 mm, plane dimensions: 36.0 m × 32.0 m.

Filter backwashing is divided into three stages: separate air scouring, air-water combined scouring, and water flushing. The working process is as follows:

A. Separate air scouring: time 2 min, air scouring intensity 20-25 L/(m²·s);

B. Air-water combined scouring: time 3 min, air scouring intensity 20-25 L/(m²·s), water scouring intensity 3.9 L/(m²·s);

C. Separate water flushing: time 6 min, flushing intensity 7.8 L/(m²·s);

D. Surface sweep washing: throughout the process, intensity 2.0 L/(m²·s)

(12) Contact disinfection tank and effluent pump house

1) Function:The disinfection tank disinfects the treated effluent using sodium hypochlorite.

2) Process design

A new sodium hypochlorite contact disinfection tank is built, with civil works constructed at one time for a scale of 30,000 m³/d. Submersible sewage pump Q=781.25 m³/h, H=10 m, N=37 kW, 2 in operation and 1 standby.

5. Operation Effect Analysis

After completing design, civil construction and commissioning, the industrial wastewater treatment plant was officially put into operation at the end of 2023. After commissioning, the plant gradually connected production wastewater from various enterprises in the jurisdiction. Currently, the actual treatment volume has approached the design scale of 3×10^4 m³/d, and the effluent quality has been stably meeting standards for a long time. It ensures effective treatment of enterprise wastewater and provides water environment support for the green and high-quality development of local industries.

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