

# Treatment Process and Systemic Design of Small Drainage Finishing-Leather Wastewater

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**Abstract:** In this paper, the treatment process of small drainage finishing-leather wastewater, two stage coagulation + hydrolysis acidification + bio-contact oxidation + filter, was proposed and the treatment system was designed. When COD<sub>Cr</sub> of the original wastewater was 4000~5000 mg/L, the color was about 1200~1500, pH was 10~12, the treated effluent could meet to the first-class standard of the Integrated Wastewater Discharge Standard (GB8978-1996) and could be reused for cleaning the workshop appliance, which COD<sub>Cr</sub> was less than 100 mg/L, the color was below 50, pH was 6~9.

**Key words:** finishing-leather wastewater; treatment process; design

## 1 Introduction

Leather industry is faced with serious challenges due to the improvement of state environmental protection policy regulations and people's environmental awareness. At the same time, it will bring opportunity of special leather manufacture production pattern. The pattern is that enterprises in a leather manufacture industrial park or different regions have managed different special sections of leather manufacture. It has changed the customary intensification pattern which has accomplished all the production process from the raw hide and skin to the finished leather by a enterprise independently. Special leather manufacture production is not only benefit the stability of product quality and improvement of grade, but also convenient for implement of cleaner production and specific treatment and reuse of wastewater.

The wastewater of finishing-leather enterprise is mainly from the drainage of cleaning equipment every day. Emission of finishing-leather wastewater is time sequence. It is about one hour before finishing work of each shift generally. The main chemical constituents of wastewater are acrylic resins, polyurethane resins, butadiene resins, dyes and pigments, alkaline detergent and so on. It is characterized by high concentration, high alkalinity, high color degree and hard-degradable organic wastewater. Quantity of water is not large (10~50m<sup>3</sup>/d in general). So wastewater is usually discharged with simply treatment or even without any treatment, it will do harm to environmental, especially to water environment. Therefore, it is important to research treatment process and small equipments suitable for small drainage finishing-leather wastewater, which has practical significance to support sustainable development of finishing-leather enterprises.

At present, it has not yet seen any reports about systematization research of finishing-leather wastewater treatment both in China and abroad. The author holds that: firstly, small drainage finishing-leather wastewater must be taken standardized treatment for the inevitable requirement and

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development tendency of environmental protection. Secondly, the treatment process of small drainage finishing-leather wastewater has been proposed. When  $\text{COD}_{\text{Cr}}$  for the wastewater was 4000~5000 mg/L, the color was about 1200~1500, pH was 10~12. After the treatment of “two stage coagulation+ hydrolysis acidification + bio-contact oxidation + filter”, the effluent could be purified to close to the first-class standard of Integrated Wastewater Discharge Standard (GB8978-1996) and reused for cleaning the workshop appliance, which  $\text{COD}_{\text{Cr}}$  was less than 100 mg/L, the color was below 50, pH was 6~9.

## 2 Effect and Standard of Wastewater Treatment

Design treatment capacity of wastewater treatment equipment was  $30\text{m}^3/\text{d}$  in this project. It was mainly cleaning drainage of finishing-leather equipment, the effluent was batch type. pH was 10~12,  $\text{COD}_{\text{Cr}}$  was high to 4000~5000 mg/L, the color was about 1200~1500, and the biodegradability of wastewater was bad ( $\text{BOD}/\text{COD}=0.2$ ). Water quality of finishing-leather wastewater and designed output water is given in Table 1.

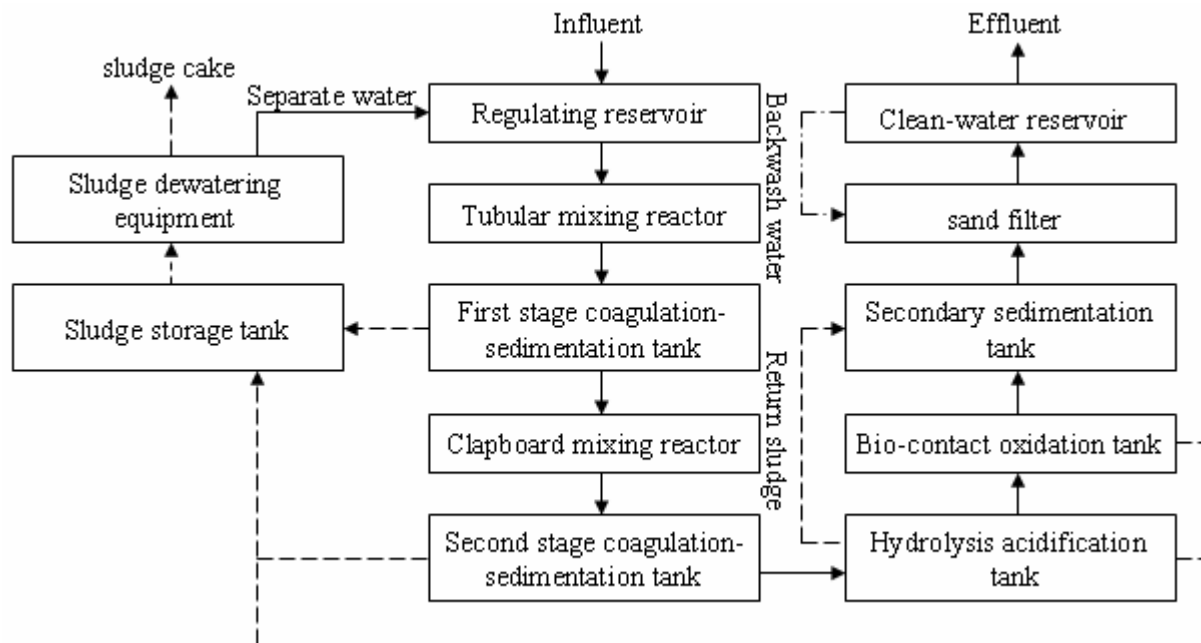
**Tab. 1 The influent quality and discharge standard**

Item	pH	$\text{COD}_{\text{Cr}} / \text{mg}\cdot\text{L}^{-1}$	Color (dilution times)	$\text{SS} / \text{mg}\cdot\text{L}^{-1}$
Influent quality	10~12	4000~5000	1200~1500	1200
Effluent quality	6~9	<100	<50	<40
Discharge standard	6~9	100	50	70

Discharge standard carried out the first-class standard of Integrated Wastewater Discharge Standard (GB8978—1996) .

## 3 Process Flow and Explanation of Finishing-Leather Wastewater Treatment

Figure 1 outlines the process flow of finishing-leather wastewater treatment.



**Fig.1 Process flow of wastewater treatment**

### ***3.1 Regulating Reservoir***

Wastewater of finishing workshop has completed homogenization of water quality and sedimentation of sand in regulating reservoir. Wastewater in regulating reservoir was pumped into coagulation-sedimentation equipment to take further treatment.

### ***3.2 Two Stage Coagulation***

The wastewater was lifted to the first stage coagulating-sedimentation tank by the centrifugal pump, the tubular mixing reactor was installed between the centrifugal pump and coagulating-sedimentation tank, the main coagulant was added to the tubular mixing reactor which made the optimum conditions for coagulation. The main and assistant coagulants were added to the overflow launder of the first stage coagulating-sedimentation tank, and pH of the water was adjusted to appropriate value. The effluent flowed into clapboard mixing reactor by gravity, then to the second coagulating-sedimentation tank.

Tiny suspended solids and colloids in water were condensed into floe and settled to remove in coagulating-sedimentation processing unit, at the same time, the dissolved organic pollutant, inorganic pollutant, color and so on were absorbed to remove in the process of formed and sedimentation floe<sup>[1]</sup>. The developed coagulant for finishing-leather wastewater is cheap in this research and the raw materials are fully supplied in market. The experiment showed that the treatment costs of the developed coagulant were low, and coagulation effect was better than compositional PAC+PAM which was popular currently.

### ***3.3 Hydrolysis Acidification Tank***

The effluent of coagulating-sedimentation tank entered into hydrolysis acidification tank. Under the working condition of oxygen deficit (the dissolved oxygen concentration is kept under 0.5 mg/L), macromolecular and non biodegradable organic contaminants in water were degraded to small molecular organic substance which was biodegradable. The suspended solids and organic pollutant were removed considerably, and load capacity of impact resistance was strong. Hydrolysis acidification tank had a dampening effect to change of influent load, and the biodegradability of wastewater was improved obviously. As a result, stable influent conditions were produced for subsequent aerobic biological treatment of which reaction rate was improved. Biochemical reaction time was shortened; energy consumption and operating costs were reduced.

### ***3.4 Bio-contact Oxidation Tank***

The pollutants were degraded by biomembrane of filled packing in bio-contact oxidation tank, and microbes of biomembrane took in organic matter in water for nourishment by contact with the wastewater, thereby the wastewater was purified. This treatment process had stronger adaptability to the change of influent quality and quantity, and it also need not have return sludge and the risk of sludge bulking in the activated sludge process. All of these have simplified the work of the operation and management, and the power expense is low.

### ***3.5 Sand Filter***

The effluent of bio-contact oxidation tank entered into sand filter, the backwash water of filter was pumped from clean-water reservoir by pump and flowed into regulating reservoir finally. The filter equipment had good filter efficiency with lower cost, easy maintenance and small floor space. Filtering medium after backwashing could reuse repeatedly<sup>[2]</sup>.

Suspended solids and some other impurities in water were intercepted in sand filter by the surface of filtration medium or filtering layers. The remaining colloidal substance in wastewater was taken, adsorbed, filtered by the theory of micro-filter coagulation, and the content of organic pollutant in water was further reduced, at the same time, suspended solids, color, microbe, chlorine and odor were eliminated, the purity of effluent was improved. Three layers filtering mediums were used included

anthracite, quartz sand and coarse sand, also with backwashing system <sup>[2]</sup>.

#### **4 The Design and Operational Parameter of the Main Processing Unit <sup>[3-5]</sup>**

##### **4.1 Regulating Reservoir**

Wastewater was collected and stored by regulating reservoir which could control quality and quantity of the water. Plane dimension of regulating reservoir was  $15.0\text{m}^2$ , the high of catchment area was 2.0m, the gradient of bottom was 0.04, and long conical sedimentation bath was designed in middle of bottom.

##### **4.2 First Stage Coagulating-Sedimentation Tank**

Steel structure inclined plate settling pond was adopted and made up of influent equipment, settling region, buffer, effluent equipment, sludge region and sludge discharge machine. The pond had high precipitation efficiency and short residence times with small floor space. The wastewater ran from lower part of pond to catch basin of water surface for discharging through inclined plates in pond. The sludge was settled to sludge hopper of pond bottom by gravity. Coagulating-sedimentation tank was  $4.20\text{ m}^3$  in volume; inclined plate was 1.00m long and installation angle of  $60^\circ$ . The sludge yield was  $3.60\text{m}^3/\text{d}$  with six times eliminations every day, the volume of sludge hopper was  $0.583\text{ m}^3$ .

##### **4.3 Clapboard Mixing Tank**

The main and assistant coagulants were added to the overflow launder of the first stage coagulating-sedimentation tank, and pH of water was adjusted to appropriate value. The effluent flowed into clapboard mixing reactor by gravity and contacted thoroughly with the coagulants to mixed evenly, then ran to the second coagulating-sedimentation tank. Clapboard mixing tank was  $0.23\text{m}^3$  in volume; there were three clap boards which was 0.50m high in tank and arranged at intervals of 0.40m.

##### **4.4 Second Stage Coagulating-Sedimentation Tank**

The structure was the same as first stage coagulating-sedimentation tank. The sludge yield was  $0.52\text{m}^3/\text{d}$  with once elimination every day. The effluent of the second stage coagulating-sedimentation tank flowed into the hydrolysis acidification tank.

##### **4.5 Hydrolysis Acidification Tank**

Hydrolysis acidification tank used Anaerobic Baffled Reactor; there were some baffles in reactor arrangement vertical to the direction of flow for keeping a high sludge concentration to reduce the hydraulic retention time. Reactor was divided into several upward flow rooms and downward flow rooms. Upward flow room was wider and convenient to gather sludge. Downward flow room was narrow, lower part edge of baffle through upward flow added guide plate of  $60^\circ$ . The water was convenient to flow to the middle of upward flow rooms, so the water and sludge mixed fully to maintain a high sludge concentration. Elastic tridimensional packing was filled in reactor to expand volume of reactor, improved the condition of flow and mass transfer effect, enhanced sedimentation effect and prevented the loss of activated sludge. The designed surface loading was  $0.5\text{m}^3/(\text{m}^2\cdot\text{h})$ , hydraulic retention time was 6 hours. The reactor was divided into five partitions and  $7.5\text{m}^3$  in volume.

##### **4.6 Bio-contact Oxidation Tank**

Straight through flow bio-contact oxidation tank was made up of tank body, packing, bracket, and aerator equipment, influent to effluent and sludge pipes. The tank was aerated at bottom of packing and produced upward flow. Biomembrane was stirred and crashed by air stream, that could accelerate shedding and renewal, also maintain higher activity to avoid the phenomenon of stoppage. The setting height was 2.0m, volume was  $5.0\text{m}^3$ , the effective contact time was 3.6 hours, gas water ratio was 15:1, the packing was HYG semi-soft filter.

#### 4.7 Secondary Sedimentation Tank

Secondary sedimentation tank was circular vertical sedimentation tank. The wastewater flowed from central pipe downward to effluent weir through baffle-board turning to upward flow. The sludge deposited to sludge hopper and discharged by the static force. The designed surface loading was  $2.52 \text{ m}^3/(\text{m}^2\cdot\text{h})$ , the diameter was 0.80m, the height of effective precipitation was 3.78m, the precipitation time was 1.5 hours. The sludge returned entirely to hydrolysis acidification tank.

#### 4.8 Sand Filter

Sand filter reduced suspended solids after coagulating-sedimentation in wastewater, and included effluent weir, filtering layer, influent to effluent pipes, etc. The sand filter was  $1.512\text{m}^3$  in volume; the designed filtration rate was 5m/h. The effluent weir was hackle and could dismount. The thickness of filtering layer was 0.75m, 450mm anthracites, 230mm quartz sands and 70mm coarse sands from the top down. The total quantity of backwash water in filter was  $4.15\text{m}^3$ .

#### 4.9 Clean-Water Reservoir

Clean-water reservoir collected the discharge water of sand filter. The plane dimension was  $2.2\text{m}^2$ , 2.50m high.

**Tab. 2 The schedule of main structures and equipments**

Item	Num.	Size	Power (kw)	Remark
Regulating reservoir	1	$V=37.43\text{m}^3$		
Tubular mixing reactor	1	GH-50		
First stage coagulating-sedimentation tank	1	$V=4.20\text{m}^3$		
Clapboard mixing tank	1	$V=0.23\text{m}^3$		
Second stage coagulating-sedimentation tank	1	$V=4.20\text{m}^3$		
Hydrolysis acidification tank	1	$V=7.50\text{m}^3$		Composite construction with small partitions
Bio-contact oxidation tank	1	$V=5.00\text{m}^3$		
Secondary sedimentation tank	1	$V=4.00\text{m}^3$		
Sand filter	1	$V=1.512\text{m}^3$		
Roots blower	1	$Q=20\text{m}^3/\text{h}$		
Sewage pump	1	$Q=5\text{m}^3/\text{h}$ , $H=8\text{m}$	1.1	Centrifugal pump
Dosing system	2	300L/150L		Four flow meters
Sludge dewatering equipment	1	LW355×1160		Run 1h/d
Electrical control box				
Pipe valve				

Clean water pump	1	IS50-32-160
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#### **4.10 Sludge Storage Tank**

The sludge of coagulating-sedimentation tank was discharged intermittently. The produced sludge last day was treated the next day. The sludge storage tank was designed according to the sludge quantity of 5m<sup>3</sup>/d. The plane dimension was 2.2m<sup>2</sup>, 2.50m high.

#### **4.11 Sludge Dewatering Equipment**

The operating time of sludge dewatering equipment was about one hour every day. The horizontal centrifuge was used to sludge dewatering equipment and the manufacturability was 5m<sup>3</sup>/h. The motor power was 11Kw. The equipment outfitted a submersible sewage pump which had 3~5m<sup>3</sup>/h quantity of flow and 3m total head.

#### **4.12 Summary of Equipments and Structures**

Seven treatment units (including first stage coagulating-sedimentation tank, clapboard mixing tank, second stage coagulating-sedimentation tank, hydrolysis acidification tank, bio-contact oxidation tank, secondary sedimentation tank and sand filter) constituted integrated unit for treating wastewater. The main structures and equipments in this design are showed in Table 2.

### **5 Conclusions**

This paper presented the characteristics of small drainage finishing-leather wastewater such as “high alkalinity, high concentration, high color, hard-degradable”, then selected the treatment process of “two stage coagulation + hydrolysis acidification + bio-contact oxidation + filter” from the view of economic analysis and technology. The process was applicable to treat the small drainage finishing-leather wastewater with lower cost, good treatment effect, easy maintenance, and small floor space, significant environmental and economic benefits.

However, the treatment effect and ability of filter have remained to be further enhanced. Many studies of modified filtration medium (quartz sand etc.) have improved the treatment ability of filtering medium. but these research have focused on the removal of pollutants in drinking water or heavy metals in wastewater, and there are little research on industrial wastewater.

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