Study on Rapid Start-Up Technology Of Hydrolysis Acidification Process

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Abstract. Domestic sewage treatment plant is an important environmental unit in the city. The hydrolysis acidification process after the overhaul of the sewage treatment plant usually had a more than three-month’s slow started-up and run unstable, seriously affecting the daily operation and also existing big environmental risks. This paper mainly expounds the factors affecting rapid start-up such as the type of inoculating sludge, the amount of sludge, the hydraulic conditions and the bacteria start-up agent for hydrolytic acidifying bacteria. The start-up speed and operation effects of hydrolysis acidification process were improved by adjusting process parameters.

Keywords: Domestic Sewage Treatment, Hydrolysis Acidification Technology, Rapid Start-Up

1. Introduction
Hydrolytic Acidification technology is developed on the basis of anaerobic treatment technology. Usually, the process of anaerobic biological treatment of complex organic compounds can be divided into four stages: Hydrolysis; Acidification (Fermentation); Acetic acid Production; Methane Production[1]. Hydrolysis acidification is the first two stages of anaerobic digestion, it’s a new sewage treatment technology developed on the basis of anaerobic treatment technology[2,3]. Hydrolysis and acidification are inseparable under anaerobic conditions[4–6].

This paper takes hydrolysis acidification process of A domestic sewage treatment plant as the object of study. This sewage treatment plant, whose treatment capacity is 60,000 m³/d, adopts hydrolysis acidification &BAF& denitrification biofilter. It shall comply with the Discharge Standards for Pollutants for Municipal Wastewater Plant (GB18918-2002) Standard Grade I A criteria.

Hydrolytic acidizing structures are upflow and integrated with precipitation, adsorption and biodegradation, including physical, chemical and biochemical reactions., which has the following characteristics: Fast reaction speed and short process time; Less mud and sludge degrade easily; No methane production and occupies less space; Strong impact resistance load.

2. The Experiment Of Rapid Start-Up
At present, few studies have been carried out on the start-up process of hydrolysis acidification, and most of them focus on the running status of the process after start-up, ignoring the importance of the
start-up process. In this paper, the key influencing factors are studied by beaker test and gradually enlarged to field test operation.

2.1. Beaker Experiment
Experimental method: The beaker was used to inoculate the sludge and add the water from the sewage treatment plant as the test water sample. The process of primary filtration & mechanical agitation & static sedimentation was adopted to simulate the operation of hydrolysis acidification process. Water samples and mud samples were collected by means of supernatant extraction and sediment extraction to simulate outlet water and mud discharge operation.

| Pollutant | Concentration | Pollutant | Concentration |
|-----------|---------------|-----------|---------------|
| COD       | 450mg/L       | Petroleum | 5mg/L         |
| BOD$_5$   | 220mg/L       | TN        | 60mg/L        |
| SS        | 240mg/L       | NH$_3$-N  | 55mg/L        |
| TP        | 7mg/L         | pH        | 6.5-8.5       |

2.1.1. Sludge Types. The different properties of the inoculation sludge directly affect the growth and composition of the hydrolyzed acidifying bacteria ecological community. The data of the sludge samples are shown in Table 2 & 3.

| No. | Types                  | Source of Sludge                                      | Sludge Parameters                                                                 |
|-----|------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------|
| 1   | Anaerobic Sludge       | Direct extraction from A2O anaerobic process section  | Black, brown, some gray particles, sludge moisture content > 98%; pH = 6.8-7.4; VSS/SS = 0.78; SV = 16% |
| 2   | Mixed Sludge           | The sludge discharged from the coagulation sedimentation tank after dehydration | Black, gray, loose structure, sludge moisture content > 80%; pH = 6.2-7.0; VSS/SS = 0.42; SV = 70% |
| 3   | Activated Sludge       | Throttled activated sludge after backwashing by BAF    | Yellowish brown, composed of some micelles, sludge moisture content > 98%; pH = 6.5-7.8; VSS/SS = 0.66; SV = 30% |

Table 3. Composition of the Sludge

| No. | Types               | Carbohydrate % | Fat, Fatty Acid % | Protein % | C/N          |
|-----|---------------------|----------------|-------------------|-----------|--------------|
| 1   | Anaerobic Sludge    | 28.6           | 27.3              | 38.2      | 5.6~7.8:1    |
| 2   | Mixed Sludge        | 27.2           | 39.0              | 40.3      | 8.6~10.2:1   |
| 3   | Activated Sludge    | 18.5           | 18.6              | 56.2      | 4.6~5.4:1    |

10% of the volume of sludge was inoculated respectively, and domestic sewage was added. The initial COD$_5$ was 533mg/L. After mechanical stirring, it was placed in static settlement, and COD & sediment concentration were measured. See Fig. 2-1 & 2-2.
The adaptive period of sludge inoculation was close to 48h. The inoculation effect of anaerobic sludge was better than other types. The removal rate of COD increased rapidly, reaching as high as 60%. The adaptation period of sludge concentration was slightly higher than that before adaptive period. Considering that anaerobic sludge is expensive in actual process operation, mixed sludge will be used as inoculation sludge. The mixed sludge contains a large number of coagulants and flocculants, and its special structure is conducive to the attachment and growth of hydrolytic acidifying bacteria, so as to ensure the inoculation requirements and engineering practice of hydrolytic acidifying bacteria.

2.1.2. Sludge Dosing Volume Proportional. The amount of sludge added affects the basic amount of inoculated hydrolyzed acidifying bacteria. However, the appropriate sludge dosage can not only ensure that the amount of hydrolyzed acidification bacteria inoculated, and it can Start-Up quickly, but also prevent the sludge loss, swelling, decomposition, microbial competition caused by the inhibition of dominant bacteria and other problems.

Control sludge Dosing Volume Proportional as 5%, 10%, 15%, and COD removal rate had been detected after sewage added. See Figure 2-3.

In the early stage of inoculation, the more the sludge input, the faster the process started. However, with the extension of time, the treatment effect of volume proportional as 10% and as 15% of mixed sludge was similar. Considering that in the actual operation, every 5% increase in the volume proportional of sludge required a large increase in transportation costs. Therefore, the optimum dosage should be controlled at 10% of the structure volume in the filling process to ensure the biomass can be start-up quickly.

2.1.3. Hydraulic Condition. Hydraulic conditions play a crucial role in the rapid start-up of hydrolytic acidification process, and simulate the influences of static placing time, single inlet volume, inlet COD loading, and microbial domestication cycle on the rapid start-up.

(1) Static Placing Time

Control sludge Dosing Volume Proportional as 10%, after static placing time for 0h, 12h, 24h, 48h, and COD removal rate had been detected after sewage added. See Figure 2-4.

It was found that the static placing time had little influence on sludge inoculation and rapid start-up, and it was generally believed that the inoculation time should be more than 24h.
Figure 2-4. Influence of Static Placing Time

(2) Single Inlet Volume
Control sludge Dosing Volume Proportional as 10%, after static placing time for 24h, 10%, 20%, 30%, 50% of the sewage had been invested respectively and COD removal rate had been detected. See Figure 2-5.

It was found that the Single Inlet Volume of sewage had little influence on the rapid start-up. The single inlet volume of sewage was controlled at 20% of the total volume, which can be stable at 10% of the total volume, so as to achieve the purpose of rapid start-up and ensure the domestication effect.

(3) Inlet COD Loading
Control sludge Dosing Volume Proportional as 10%, after static placing time for 24h, 100mg/L, 200mg/L, 300mg/L, 500mg/L of the sewage had been invested respectively and COD removal rate had been detected. See Figure 2-6.

It was found that Inlet COD Loading had a significant effect on the inoculation of hydrolytic acidifying bacteria. With the increase of inlet load, the inoculation speed was accelerated. However, the maximum COD concentration controlled in the experiment is below 500mg/L. Otherwise, COD should be added in the operation of sewage treatment plant, which is not in line with the actual production.

Figure 2-5. Influence of Single Inlet Volume

Figure 2-6. Influence of Inlet COD Loading

(4) Domestication Cycle
Control sludge Dosing Volume Proportional as 10%, after static placing time for 24h, 500mg/L of the sewage had been invested. After static placing time for 6h, 12h, 24h and 48h respectively, 20% of the supernatant liquid volume was extracted. And Replenish 500mg/L of sewage. The above operation had repeated 3 times. COD removal rate had been detected in the end. See Figure 2-7.

It was found that domestication cycle was 12h, which can improve COD removal rate, increase start-up speed, and ensure the concentration of pollutants required by microorganisms.

Figure 2-7. Microbial Domestication Cycle

2.1.4. Study of Agents. The composition of wastewater was analyzed, the main components of the agent were designed, the growth factors were added, and the microorganism growth environment was optimized, so as to rapidly enter the logarithmic phase. The main components of the start-up agent should include carbon source, nitrogen source, trace elements, metal elements, pH buffer, coagulant, etc.

(1) Analysis of Wastewater quality
The parameters of a general anaerobic reactor are C:N:P=100:5:1. Compare with the composition of wastewater from sewage treatment plants, C:N:P=220:60:1. Consideration should be given to adjusting the proportion of sewage pollutants and adding certain nutrients.
(2) Carbon Source
Generally, carbon sources are not added in the pretreatment stage. Carbon-containing organic pollutants are the main pollutants to be removed. It was found that the COD concentration in sewage was suitable for the start-up of hydrolysis acidification. Therefore, no other carbon sources had been added.

(3) Nitrogen Source
Nitrogen source is an essential nutrient for microbial growth and affects microbial metabolism and synthesis. In the analysis of water quality, it was found that the nitrogen source in the sewage was too high to adapt to the optimal ratio of anaerobic start-up. In the experimental study, nitrogen removal was made more suitable by adding agents, and the removal effect of ammonia nitrogen could also be improved by adding agents.

Control sludge Dosing Volume Proportional as 10%, after static placing time for 24h, Magnesium sulfate and sodium dihydrogen phosphate were added, pH=7. Adjust ton(Mg):n(N)=0.5, 0.7, 1.0 and n(P):n(N)=0.9, 1.1, NH4-N removal rate had been detected in the end. See Figure 2-8.

![Influence of the Mixture Ratio](image)

Figure 2-8. Influence of the Mixture Ratio

Through orthogonal test, the optimal reagent ratio was determined. The removal rate of ammonia nitrogen can be stable. When the control parameter were n(Mg):n(N)=0.7 and n(P):n(N)=1, it had stabilized at C:N:P=120:11:1, and it can adapt to microbial growth.

(4) Other Auxiliary Agents
Trace Elements, including iron, cobalt, molybdenum, nickel, magnesium, and biological activation of zinc, manganese, copper, cesium, tungsten and so on. PH-buffer, sodium bicarbonate was added as buffer to control H+ concentration in water.

(5) Effects of Agents
After the addition of agents, the start-up time was reduced by more than 20%, the adaptation period of hydrolytic acidifying bacteria was reduced by 10-12 days, and the overall start-up time was shortened by 15-18 days.

2.2. Field Test
According to the previous method to guide the field test, the start-up of hydrolysis acidification can be divided into five steps: inoculation of sludge, static adaptation, adjustment of acclimation, load lifting, start-up of consolidation.

After 42 days of start-up, COD removal rate was stable at about 40%, SS removal rate was above 50%, sludge sludge level was above 3.0m, sludge concentration was stable at 30g/L, and hydrolysis acidification was successfully started. See Figure 2-9,10,11.
3. Conclusion
Through the research, a technical scheme can be formed to guide the actual production operation, to ensure the rapid start-up of hydrolysis acidification process, and effectively reduce the cost of rapid start-up and operation.

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