

Umbrella Labyrinth Sedimentation Device Study

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Abstract: Umbrella-type mud-water diversion labyrinth sedimentation device, which is characterized by the combination of two swash plate and wing plate into an umbrella type with a set angle, the angle range of the two swash plate is 15° -- 100° , the vertical height of the swash plate is 60-70 mm, the parallel axis of the wing plate is the vertical direction, the height is 10-20 mm. the whole adopts the modular combination mode, and can be freely combined and disassembled according to different pond design, swash plate The interval (sedimentation distance) can be freely adjusted, mud take the mud road and water take the water road, to avoid the mutual interference of the water and mud road, to achieve the stability of the water quality. The turbidity of the sedimentation pond is low, stable in 0.3-2.0 NTU.

Keywords: Umbrella-type mud-water diversion labyrinth sedimentation device; Filter load; Water quality; Sedimentation tank

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1 Problems of traditional sedimentation device inclined plate or inclined pipe sedimentation tank

Regardless of the swash plate (tube) sedimentation tank (anisotropic, isotropic) they all deviate from the core of the shallow pool theory in structural design. First, the swash plate (pipe) by solar radiation easy to age, usually three, four years that is many parts of the aging, the need for renewal. Secondly, the swash plate (pipe) is installed at an angle of 60° with the level, the water

flowing through the swash plate (pipe) changes the direction of water flow, the water flowing upward, the sediment falls from top to bottom, mud and water mixed flow, due to the role of top support, the precipitation effect is poor, small vitriol and light vitriol is easy to float, not conducive to the precipitation of suspended solids, resulting in unstable water quality. Thirdly, the suspended particles that have been precipitated are always in a space with the flowing water before sliding into the bucket, and the water flowing through the swash plate (pipe) repeatedly flushes and disturbs the suspended particles that have been precipitated. On the one hand, the suspended particles in the water are precipitated by their own gravity, on the other hand, the suspended particles that have been precipitated are stirred by the flowing water and return to the water current, and the second precipitation occurs. This leads to a decrease in precipitation efficiency, and the actual operating effect deviates from the theoretical calculation results. Fourth, the swash plate (tube) installation in the precipitation pool front-end upper and end lower will form two triangular dead zone, reducing the effective use area. And in the two triangular area is easy to cause water short circuit, precipitation efficiency is reduced, further affecting the reduction of turbidity of the water. Fifth, the bottom water distribution as well as the upper water collection is easy to appear uneven, resulting in local short circuit, causing vitriol floating; six, easy to clog, often need manual cleaning, labor intensity. Otherwise, often clogged silt, slanting plate (pipe) was crushed damage; seven is the length and width of the pool must pay strict attention to, and affect the layout of the total plane, the pool depth of the basic fixed; eight is a small impact load, only for small changes in turbidity range of small water plants and small sewage treatment depth treatment process; nine is inconvenient maintenance and repair of the bottom of the pool. This

makes the further application of the technology and research is greatly limited.

2 Umbrella-type mud-water diversion labyrinth sedimentation device

2.1 Basic points of the study of the device

The basic starting point of this device research is how to solve the deficiencies that appear in the process of years of operation of the inclined plate (inclined pipe) sedimentation tank, so that the sedimentation method is closer to the shallow pool theory. The umbrella swash plate is installed in multi-layer combination, the water flows horizontally along the longitudinal direction, and the suspended particles of sediment fall vertically along the umbrella swash plate, which realizes the diversion of water and suspended particles without changing the direction of water flow in the sedimentation pond, i.e. the water takes the water road and the mud takes the mud road. On the one hand prevents the suspended particles of sediment from blocking the channel of the swash plate (inclined pipe) and the occurrence of the phenomenon of alum running due to the disturbance of water flow, and improves the sedimentation efficiency, on the other hand, it reduces the water content of the precipitated sediment.

2.2 The structure of the umbrella device is shown in Figure 1.

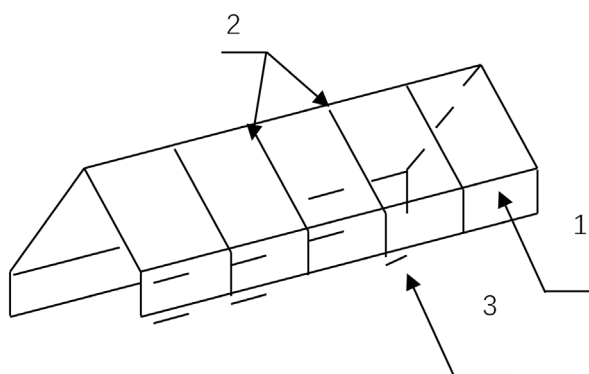


Figure 1. Schematic diagram of the umbrella labyrinth sedimentation device

The mud-water diversion umbrella labyrinth device includes mounting bracket, connecting clips, two swash plates and two wing plates. The characteristics are that the umbrella swash plate adopts modular assembly mode with stable shape and convenient installation and maintenance; the two swash plates and wing plates are

combined into umbrella shape at a set angle, the angle range of the two swash plates is $15^{\circ}\sim 100^{\circ}$, the parallel axis of the wing plates is vertical direction and the height is 10~20mm.

The mud-water diversion umbrella type labyrinth sedimentation device adopts engineering plastic once casted, the upper side is equipped with ribs of regular division, the spacing of the ribs is 8mm-90mm, the height of the ribs is 8mm-90mm. In the vertical direction according to the same axis and the same spacing combination, after the application of the combination of the adjacent two swash plate and the adjacent two ribs between the formation of post-flocculation sedimentation unit.

The mud-water diversion umbrella labyrinth sedimentation device deposited by the water flow in the mud-water diversion and umbrella-type precipitation device slide down the two wings and fall into the mud collection area, which separated the suspended particles precipitated by the flow of water from the horizontal flowing water body, avoiding the reversible sedimentation caused by the suspended particles precipitated by the perturbation of water flow in the water body.

The whole adopts module combination mode, according to the size of the water volume can increase or decrease the number of layers, or increase the number of groups, the suspended matter precipitated down along the two wing plate slide distance is very short, reducing the precipitation distance, increasing the precipitation area, avoiding the suspended particles precipitated down in the swash plate (pipe) to gather and block the channel or even collapse the device. It solves the problem of poor sedimentation effect caused by the long slurry route and poor connection between upper and lower layers in the labyrinth type inclined plate (pipe) sedimentation pond. The device makes the water flow in the sedimentation pond along the water distribution area to the buffer water collection area direction of the horizontal flow, suspended particles of accumulated mud along the umbrella wing plate vertical direction of the fall, to avoid the water and mud road in the same area to interfere with each other, the treatment effect is good.

2.3 Design of inlet and outlet zones

There is no need for a water collection tank, but the method of distributing water at the front end and collecting water at the end reduces the types of equipment, avoids the short circuit caused by uneven

distribution and collection of water, and enhances the stability of operation. The length of the water distribution area is 1.5-2.5 m. The water is collected at the end and the upper weir plate collects the water, and the length of the water collection area is 2-3 m. The water is distributed at the front and the splash wall at the bottom.

3 Calculation of process parameters of mud-water diversion umbrella type labyrinth sedimentation device

3.1 China's water treatment plant is currently used more anisotropic flow inclined plate (inclined tube) sedimentation tank, stratospheric sedimentation tank and high-density clarifier

Stratospheric sedimentation tank is the most widely used large and medium-sized water plant pool type, simple structure, low consumption of vitriol, good adaptability to changes in water and water quality, convenient operation and management. Its disadvantage is a large area, civil construction investment to teach high. Inclined pipe sedimentation tank in small and medium-sized water plant more applications, with a small footprint, the advantages of low investment in civil engineering. Compare the process parameters of the umbrella mud-water diversion device and the anisotropic flow inclined tube device, the advantages and disadvantages of the two devices will be very clear, the anisotropic flow inclined plate (inclined tube) water flow rate selection principle: due to the inclined tube flocculated particles precipitation direction is along the inclined plate from top to bottom and the opposite direction of water flow, so the water flow rate can not be greater than the flocculated particles in the inclined tube fall velocity.

Table 1. Falling velocity of floc particles

Item	Falling velocity (mm/s)
Large particle flocs	4.8
Medium particle flocs	3.6
Reprecipitation of dispersed particle flocs	1.8

According to the above table: the maximum flow rate is 4.5mm / s, the minimum flow rate is 3.0mm / s. The flow rate of anisotropic flow slanting pipe is chosen between 3.0 ~ 4.5mm / s, and the maximum cannot

exceed 4.5mm / s. The flow rate of water in the slanting plate (pipe) is usually chosen to be 3.5mm / s. When the flow rate is higher than the fall rate of floc particles, the floc particles cannot be discharged completely. Even "run alum". In the precondition that does not cause sediment accumulation mud erosion, the appropriate acceleration of the horizontal flow rate of the sedimentation tank, is conducive to improve the volume of the sedimentation tank utilization coefficient, at the same time can increase the stability of the water flow, in order to reduce the temperature difference, different weight flow and wind influence on the water flow, but the horizontal flow rate should not be too high, otherwise it will increase the turbulence of water, affect the settlement of flocculated particles, but also easy to cause bottom mud erosion. The factors affecting the precipitation effect are the different flow states formed by the different horizontal flow rates, and its characteristic value is Reynolds number, and Reynolds number is large on the particle settlement interference, which is also the root cause of the anisotropic flow ramp (tube) operation elasticity is small.

3.2 Using the umbrella labyrinth sedimentation device, the horizontal flow rate is not limited by the falling velocity of flocculated particles, and there is no phenomenon of blockage and accumulation and alum running

After testing the horizontal flow of water, the velocity of large suspended solids falling is 4.5mm/s, the velocity of medium-sized suspended solids falling is 3.2mm/s, the highest velocity is calculated to be 30mm/s, the lowest velocity is 25mm/s.

Using the umbrella sedimentation device horizontal flow rate has little influence on the speed of falling suspended solids. The water flow follows the horizontal direction and slowly enters the area of the umbrella labyrinth sedimentation device, the water flows along the length direction, the flocculated particles accumulate mud and fall along the vertical direction, so that the larger particles gradually settle on the slanting surface of the inclined plate 1 and then fall along the wing plate 3 vertically and are removed, the particle settlement speed is 0.5-3mm/s, the head loss of the sedimentation part is not more than 0.3m. Smaller particles follow the water flow along the slanting surface of the inclined plate 1 and then fall along the wing plate 3 vertically and are removed, the particle settlement speed is 0.5-3mm/s, the head loss of the sedimentation part is not more than 0.3m. Horizontal movement, through the adjacent two

inclined plate 1 and between the two adjacent ribs 2, so that the fluid to form a number of micro whirlpools, small particles in the fluid at the ribs 2 collision, and then flocculated to form larger floc particles precipitation, in the water body of small particles and ribs 2 after a number of collisions, flocculation to form large floc particles precipitation to the inclined plate and then along the wing 3 vertical fall was removed. The suspended particles precipitated from the umbrella swash plate 1 slide down along the wing plate 3 in time to fall to the mud discharge area, and the flowing water was separated, the time for the suspended particles precipitated and the flowing water to coexist in one space is very short, only about 10 seconds under normal circumstances, but the time for the suspended particles precipitated at the top of the anisotropic flow swash plate (slant tube) device to coexist with the flowing water in one space is very short, normally only about 10 seconds. But in differential flow inclined plate (inclined tube) device, the suspended particles deposited at the top need to coexist in a single space with the flowing water for 1000 seconds (as the flocculated particles fall from the very top to the outlet), the length of the umbrella sedimentation device sedimentation particles falling out of the water flow channel is only one-twelfth of the length of the swash plate (tube), thus avoiding the occurrence of reversible sedimentation phenomenon and improving the sedimentation efficiency. See the mud-water diversion diagram2

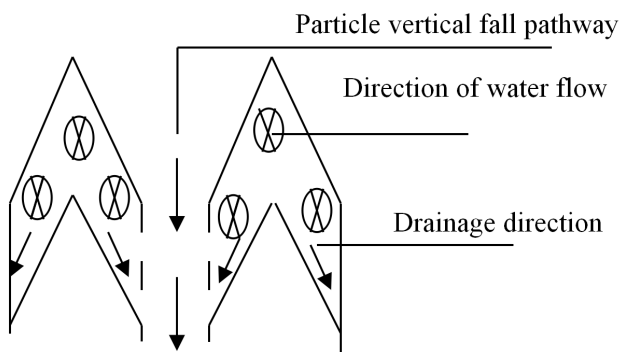


Figure 2. Schematic diagram of mud and water diversion

3.3 Test case of the umbrella labyrinth sedimentation device

The Plexiglass plate is used to make a test chamber device, the cross-sectional shape is rectangular, the cross-sectional size is 2000(mm) × 600mm × 700mm, there is a 100mm water intake area at the front and a 100mm water intake area at the back, the length of the flocculation precipitation area is 1800mm, an

umbrella type precipitation device is installed in the device, the umbrella type swash plate is 250mm long, the wing plate is 20mm high, and the vertical direction is 1.5m long. Pitch is 65mm, two slanting plate angle 55 degrees. Device with two lower mud trough, next to two mud discharge valve. Device see figure 3, test process see figure 4.

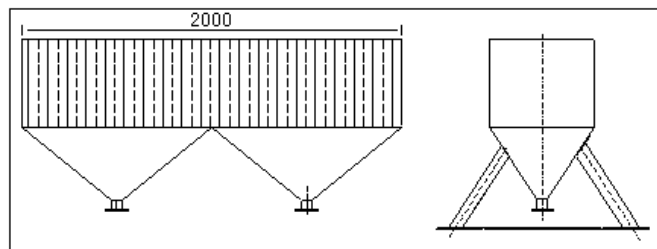


Figure 3. Test set-up

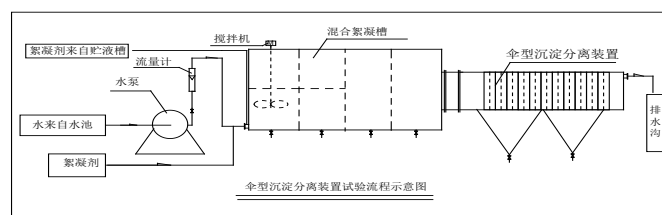


Figure 4. Test procedure

Pump the raw water in the pool through the flowmeter to adjust the size and send it to the (grating + screen) mixed flocculation tank, add flocculant at the entrance of the mixed flocculation area, the mixed flocculation from the flow into the precipitation area umbrella device, suspended particles separated by the umbrella device precipitation into the mud tank, the water through the outlet pipe into the trench.

Conclusion of test operation: The water flow in the umbrella labyrinth sedimentation device is horizontal and parallel, suspended particles fall vertically, the mud discharge is smooth, and there is no clogging and vitriol running phenomenon. There is no clogging phenomenon in the operation process. According to the design flow rate of 10 m³ / h to calculate, the horizontal flow rate can reach above 22mm / s about 5 times of the anisotropic flow inclined tube, the mixing time is 3.5s, the precipitation time is (2-4 minutes). The umbrella labyrinth sedimentation and separation device is novel in design, and has the advantages of short residence time, high sedimentation efficiency, large hydraulic load, etc., which is much better than the inclined plate (inclined pipe) sedimentation pond and flat flow sedimentation pond.

3.4 Umbrella precipitation device in different inlet water flow and different inlet water turbidity operating

Umbrella precipitation device in different inlet water flow and different inlet water turbidity operating under the effect of testing, we improved the inlet and outlet pipes, adjusting the inlet water flow, inlet water turbidity between 4 to 10 NTU for adjustment, the discharge turbidity fluctuates between 0.5 to 1.0, when the inlet water turbidity fluctuates significantly change. The turbidity of the effluent only fluctuates within a small range and is relatively stable; when the hourly flow rate reaches 14m³/h, the flow rate of the device can reach 14mm/s, the flow rate of the umbrella device can reach 20mm/s, which is in accordance with the theoretical calculation results, and no alum running phenomenon occurs. The test results are as follows.

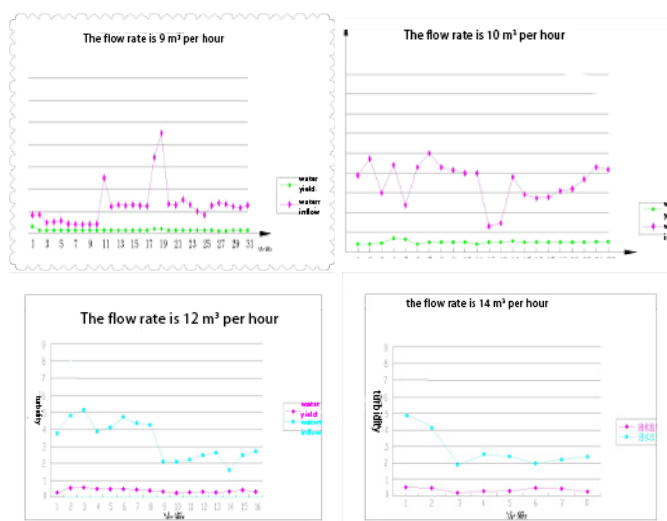


Figure 5. Turbidity variation data for different influent flows.

3.5 Comparison of floc particles fall time calculation.

Puyang First Water Treatment Plant is a slanting pipe sedimentation tank: set the slanting length of 1000mm, water flow rate of 3mm / s, floc falling speed of 4mm / s, then the floc particles from the top of the slanting pipe to fall to the bottom of the slanting pipe time required is $t = 1000s$. Umbrella precipitation device: the floc particles fall in two steps inside the umbrella device. The first step, floc particles in parallel flowing water vertical precipitation, fall on the umbrella swash plate, the longest distance is 50mm, set the floc particles fall speed 5mm / s, the time required is 10s, from the main body of the water flow only 1% of the time of the anisotropic flow slant tube. The second step, the flocculated particles fall along the vertical wing into the mud discharge area, the height of each layer is different, the layer spacing 60-80mm such as the same calculation by 1000mm, from the top of the glide to the bottom,

the average fall height of 500mm, the time required is $t = 500 / 4 = 125s$, supply and demand time is $125 + 10 = 135s$, according to the highest layer of the actual fall sedimentation time of 600s. The sedimentation time required for this device is only 60% of the sedimentation time of the swash plate (pipe).

This device is installed as a modular combination, and there is no triangular death formed by the sedimentation tank of the inclined plate (pipe). The overall layout is rectangular. In the front and rear water inlet area and water intake area are equipped with flower wall cloth water device, in order to ensure that the water flowing through the device up and down the flow rate is uniform, in order to improve the precipitation effect. The overall installation diagram is shown in Figure 6

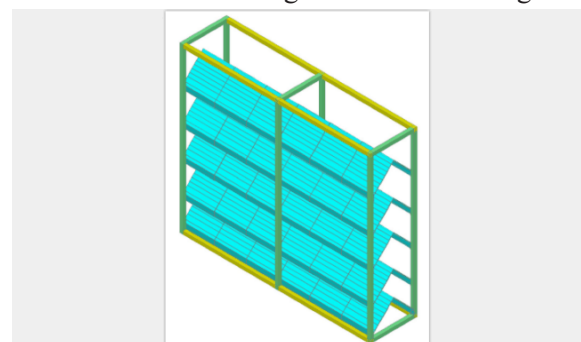


Figure 6. Umbrella labyrinth sedimentation unit assembly

4 Analysis of the causes of clogged slope pipes

Anisotropic flow ramps have a small difference between the velocity of water flow and the velocity at which the floc particles fall, and are therefore less resistant to load impacts. As the water flows through the pipe, the inlet end of the water is also the outlet end of the floc particles, and the accumulation of floc particles inside the pipe increases from top to bottom. The largest amount of floc particles accumulate at the inlet side of the water, occupying a certain cross-sectional area of the slanting pipe, where the velocity of water flow is the largest, and the velocity of water flow decreases along the length of the slanting pipe, making the water flow through the slanting pipe a variable speed process. As the velocity of the water is greatest at the inlet, it becomes more difficult for the floc particles to slip out of the pipe, resulting in an increase in the velocity of the water in adjacent pipes when one of the pipes becomes clogged. When the flow velocity is greater than the rate at which the floc particles fall, a chain reaction occurs in the other slants, resulting in clogging, vitriol runoff,

excessive turbidity and deterioration of the operation.

5 Causes of reversible precipitation

In the process of water flow through the slanting pipe, there is a problem that the water flows upward, the flocculated particles fall from above, mud and water mix, that is, the suspended particles that have been precipitated always coexist with the flowing water in one space, the suspended particles that have slipped out of the bottom of the slanting pipe will be washed and perturbed due to the action of the top support of the rising water, and the fine alum flowers and light alum flowers are easy to float back to the water body, forming a secondary precipitation. The bottom water distribution as well as the upper water collection is prone to unevenness, causing a local short circuit, causing vitriol to float, resulting in unstable water quality.

6 Conclusion

The mud-water diversion umbrella type labyrinth sedimentation device solves the above problem very well.

(1) This device flows along the horizontal direction, suspended particles of sediment along the umbrella plate vertical fall precipitation, without changing the direction of water flow in the precipitation pool to achieve water and suspended particles of shunt, that is, water to go water road, mud to go mud road, high separation efficiency, will not appear vitriol floating, water short circuit phenomenon.

(2) The device sediment particles slip out of the water flow channel length is only one twelfth of the swash plate (tube), mud discharge adapt bucket type mud discharge, perforated mud discharge or bottom scraper scraping mud. The water quality is stable and the impact resistance load is strong. So as to avoid the occurrence

of reversible sedimentation phenomenon and improve the efficiency of sedimentation.

(3) The device put an end to the suspended particles clogging the pipe and the water and mud path between each other top support interference, the phenomenon of running alum in the precipitation tank, to avoid and its structural form to avoid the traditional way of blocking the mud and easy to collapse the disadvantages of damage.

(4) The device as a whole adopts the modular combination mode, reducing the precipitation distance, increasing the precipitation area, high precipitation efficiency, which is 4-6 times of the efficiency of other similar products, reducing the turbidity of the water, reducing the load of the filter, reducing the depth of the precipitation pond, saving infrastructure investment and reducing the area of the land. In the sedimentation pond can be taken in parallel or in series form of assembly to ensure the quality of the water.

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