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Energy saving design for urban sewage pumping station

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Abstract: *Sewage pumping station is one of the important components of the urban sewage treatment process that contains various impurities. Due to the complex composition of sewage, the easy bunching and easy winding fibers in the transport medium are easy to cause pump channel blockage, precipitation accumulation, toxic odor and other problems, resulting in reduced sewage efficiency and can not work normally, while affecting urban life and the environment. To solve the above problems, a more stable and energy-saving sewage pumping station is designed. Through the structural design of the main and auxiliary blades of the double drum, the problem of uneven force and easy wear and winding of the traditional blade sequence structure of the crushing grate device is solved. The fine particles after crushing will not be deposited under the stirring action of the bottom turbine and can enter the lifting pump smoothly. The toxic and harmful gases above the pump station are treated by UV photocatalytic device, which can effectively degrade odor molecules and prevent secondary pollution through carbon dioxide catalysis.*

Keywords: *Sewage pumping station, Energy conservation, Emission reduction*

1. Introduction

1.1. Research background of works

Urban sewage includes domestic sewage, industrial wastewater, precipitation, etc., which is discharged into the urban drainage system. There will be a lot of garbage in the drainage pipes, such as kitchen waste, solid waste and so on. The sewage is first collected by the city sewer pipe, and then sent to the sewage treatment plant for a series of purification treatment. However, because it contains a large amount of garbage, it brings some difficulties and problems to the sewage treatment plant before treating the sewage.

China has relevant policies to promote the recycling of sewage under economic and reasonable and safe and sanitary conditions. To develop the utilization of recycled water in agricultural irrigation, green space watering, urban utility, ecological restoration and industrial cooling. At the same time, the plan proposes to make up for the shortcomings of urban sewage and garbage treatment, promote the utilization of resources, and promote the ecological protection and high-quality development of the Yellow River basin[1-2].

1.2. Research significance of works

Sewage pumping station is one of the important components of the urban sewage treatment process that contains various impurities. Due to the complex composition of sewage, the easy bunching and winding fibers in the transport medium are easy to cause pump channel blockage, precipitation accumulation, toxic odor and other problems, resulting in reduced sewage efficiency and can not work normally, while affecting urban life and the environment. In view of the above problems, a more stable and energy-saving sewage pumping station is designed. Through the structural design of the double drum main and auxiliary blades, the problem of uneven force on the traditional blade sequence structure of the crushing grille device is solved. The fine particles after crushing will not be deposited under the stirring action of the bottom turbine and can enter the lifting pump smoothly. The toxic and harmful gases above the pump station are treated by the UV photocatalytic device, which can effectively degrade odor molecules and prevent secondary pollution through the catalytic action of carbon dioxide.

Compared with the traditional pump station, the pump station is equipped with a rail of implicated

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grille, which can lift the grille to the ground for cleaning, lower operation and maintenance cost, more stable work has higher efficiency of sewage treatment, and saves energy consumption when the device works inefficiently.

2. Project research content

This paper introduces the design of energy-saving urban sewage pumping station, the specific research content includes the following aspects:

(1) Expatiate the present situation of urban sewage pumping station, improve the current sewage pumping station;

(2) The structure of double drum main and auxiliary blades is designed to solve the problem that the traditional blade sequence structure of the crushing type grille device has uneven force and easy to wear and wound;

(3) The addition of toxic and harmful gases above the pump station is treated by UV photocatalytic device, which can effectively degrade odor molecules and prevent secondary pollution through carbon dioxide catalysis[3-6].

3. Technical route

3.1. Overall device and flow chart

The height of the device is 6m, the diameter is 2.4m, the barrel is made of glass steel with high strength and smooth surface. Sewage from the pipeline flow into the mouth of the pipe, which is mixed with large particles of solid impurities and filamentous impurities by the grate after the formation of a diameter of 5- 8mm fine particles, and fall into the pump body inside, when the water is higher than the pump, the pump will be crushed after the sewage lift pump to the mouth of the pipe, to achieve the preliminary treatment of sewage concentrated and promoted role. During the working period, the turbine blade of the bottom anti-deposition device operates, and the impurities that may accumulate at the bottom are continuously dispersed. Due to the continuous presence of sewage in the pump body, the resulting odor is collected by the hood and treated by the UV catalytic oxidation unit before being discharged by the exhaust pipe. The device is shown in the Figure 1.

Figure 1: Overall picture of the device

3.2. Pulverized grille module

The device improves the shortcomings of the existing double-drum grinding grille, mainly the design and assembly of the blade, the design of the grille part and the driving part. It is used to improve the overall crushing treatment efficiency, reduce energy consumption and replacement frequency. The device is shown in the Figure 2.

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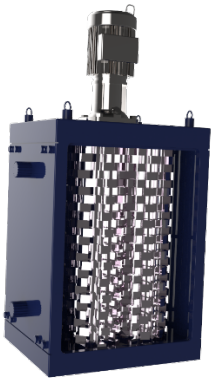

Figure 2: Overall picture of the grinding grille

3.2.1. Crushing Part

(1)Design of the blade

The blade is the core part, and its performance directly affects the work efficiency of the grinding grille. The existing pulverized grille has the problem of blade wear and entanglement by filamentous substances. The accumulation of filamentous substances may cause debris accumulation in the subsequent steps and affect the work of the pump, so it needs to be replaced with regular warranty. The cost is high and the cycle is long at the same time, which will affect the efficiency of sewage treatment. In this design, the blade is divided into two parts: the main blade and the auxiliary blade, which are processed by 3Cr13 steel. The main blade is a gear blade, which is used to crush large particles of solid debris, and the secondary blade is a ratchet blade with a sharp blade, which is used to treat soft filamentous substances in sewage. The left and right teeth mesh with each other to form a dense working face to prevent debris from passing through the gap .The device is shown in the Figure 3.

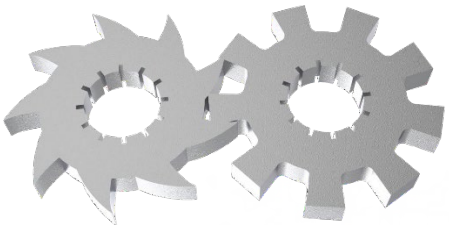

Figure 3: Main and auxiliary blades

(2)Assembly of the blade

The device adopts the staggered arrangement of the main and secondary blades to assemble, forming a single drum, and then forms a double drum blade as a whole in the way of the main and secondary coordination, abandoning the sequence arrangement of the traditional blade each drum, avoiding the uneven cutting force, so as to achieve the effect of efficient treatment of filamentous debris. And the alternating arrangement makes the blades rotate to each other and cut, which has a strong self-cleaning ability. While engaging, the debris that may be temporarily attached and wound on the surface of the blade can be cleaned up, which ensures the efficient cutting ability and also improves the service life. The device is shown in the Figure 4.

Figure 4: Blade assembly diagram

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3.2.2. Driver section

Since the device needs to work in water for a long time, the motor uses both wet and dry motors, and uses the mode of low speed and high torque to run, with low power consumption, little wear and enhance the crushing effect. The motor voltage is AC220V, the rated power is 3.8kW, and the rated speed is 50r/min. The device is shown in the Figure 5.

Figure 5: Drive motor diagram

3.2.3. Grille section

The device adopts a double drum, and there is a cylindrical grating rotating drum on the left and right sides, which is constantly rotating in the opposite direction, which is used to expand the scope of crushing action, and the large particles on both sides are brought to the central crushing part by rotating. Choose a grating with a gap of about 10mm to prevent debris from passing through and reduce the loss of water head. The device is shown in the Figure 6.

Figure 6: Drum grille diagram

3.2.4. Guide rail section

Because the blade part in the grinding grille works for a long time, the drum and the cutter head are consumables, which need to be maintained and repaired regularly. Because it is buried deep underground, the traditional maintenance method is to lift it by a crane, which has high cost and long maintenance cycle. Therefore, the device is equipped with a guide rail for transporting the grille to the top of the device, which is driven by a motor in the top distribution box. The total mass of the grille is about 55kg, the rising speed is set at 0.5m/s, each track is made of C60 concrete, 985mm long, 100mm wide, 50mm thick, the spacing of fastener is 45mm, each track plate is arranged with 3 pairs of fastener[7-9].

3.3. Anti-deposition device at the bottom

After the pulverized grate treatment, the sewage contains a large number of small impurity particles, most of which are extracted from the pump upward with the sewage, but there is still the problem of silt accumulation at the bottom under long-term operation. The turbine blade structure is set at the bottom to achieve the function of stirring the sewage and preventing particle deposition. The device is shown in the Figure 7.

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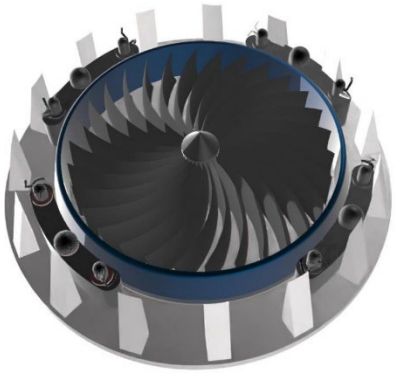

Figure 7: Overall picture of anti-deposition

3.3.1. Centrifugal fan section

The rotating fan blade structure is centrifugal forward bending structure, the outer diameter of the impeller is 52cm, the height of the impeller is 18cm, and the hub ratio is 0.21. The energy obtained by the liquid mainly comes from the rotation of the blade, but too many blades will increase the resistance of the liquid flow and increase the surface stress of the blade. The number of blades of the fan blade is 20. Compared with ordinary water quality, the composition of urban sewage is complex, which has a greater impact on water erosion and corrosion of the blades. Small cracks occur on the edge of the blades, and there is a risk of fracture. Stelli alloy with high hardness and good ductility is used as the blades to improve the resistance to water erosion. The device is shown in the Figure 8.

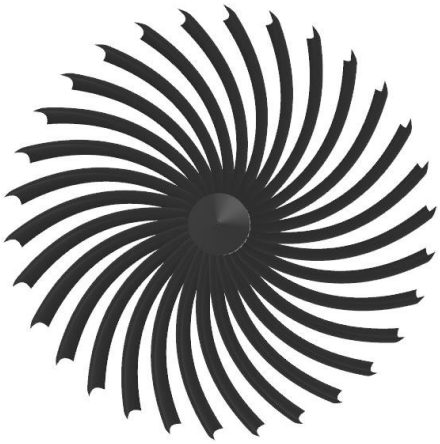

Figure 8: Diagram of turbine fan blades

3.3.2. Enhanced stability section

A ring structure is placed on the outside of the turbine, which is connected with the inner wall of the pump to slow down the rotation of the turbine and make the liquid at the bott om of the pump recoil. To prevent the blade from being subjected to greater pressure during the process of high-speed rotation of the sewage mixing, it may produce torsion, pendulum and other waving forms, which will cause cracks between the material layers inside the blade and cause the material to fall off. According to the stress mode of the simply-supported beam, the root of the blade should be relatively thick from the root to the tip of the blade, and the thickness should gradually decrease.

3.4. Odor treatment module

3.4.1. Treatment principle

The odor treatment device includes odor collecting hood, centrifugal fan, exhaust pipe and UV photocatalytic box, wherein UV photocatalytic box is the main device for odor treatment. The device includes an ultraviolet lamp tube area with an emission wavelength below 200nm and a catalytic area containing titanium dioxide. The device is shown in the Figure 9.

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Figure 9: Odor treatment module

The ultraviolet light emitted by the lamp is in the vacuum ultraviolet band, the wavelength is less than 200nm, the ultraviolet irradiation decomposes the O2 molecule, the generated free oxygen continues to combine with O2 to produce ozone, through ozone oxidation of most odorous substances to produce simple, harmless substances, such as carbon dioxide and water, etc. At the same time, the ozone quickly decomposes, the reaction speed is only 2-3s, to achieve the purpose of rapid deodorization.

In order to inhibit the ultraviolet catalytic removal of ammonia, hydrogen sulfide and other gases when the secondary pollutants, the ultraviolet before and after the increase of titanium dioxide catalytic zone, improve its conversion into sulfate, nitrate selectivity. After the titanium dioxide is bonded by the adhesive, the filter plate is installed on both sides of the UV lamp, and the porous structure is set in the middle to ensure the normal passage of the gas. The device is shown in the Figure 10.

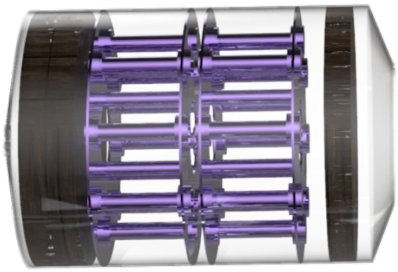

Figure 10: UV photocatalytic box

4. Conclusion and prospect

The device has a height of 6m and a diameter of 2.4m. The motor voltage is AC220V, the rated power is 3.8kW, and the rated speed is 50r/min. The total mass of the grille is about 55kg, the rise speed is set at 0.5m/s, each track is made of C60 concrete, the length is 985mm, the width is 100mm, the thickness is 50mm, the fastener spacing is 45mm, the outer diameter of the impeller is 52cm, the height of the impeller is 18cm, and the wheel hub ratio is 0.21. The inlet diameter is set to 500mm, and the outlet diameter is designed to 200mm. When the water flow speed is 2.15m/s and the coverage rate of garbage covered in sewage is 6.75%, the garbage crushing efficiency of the device is as high as 47.2%. Combined with the above formula, the energy consumption is about 48kw/h by means of least square method and simulation analysis software. According to the data, under the premise of the same water flow speed and the same garbage coverage rate, the garbage crushing efficiency of the existing device is about 42%, and the energy consumption is greater than 74kw/h. Through comparative analysis, it can be seen that under the same conditions, under the premise of a certain garbage crushing efficiency (47.2%>42%), the energy consumption of the device is 48kw/h, less than 74kw/h.

Compared with the existing pumping station, it has the advantages of low energy consumption, no

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cleaning, self-cleaning, low maintenance frequency, short maintenance cycle, low maintenance cost, and can treat the odor produced by sewage with high efficiency and low consumption. The device can also be used to treat and purify other fluid pollutants, such as sludge, etc. The double-drum grille with staggered main and auxiliary blades can be applied to other shredders, such as miscellaneous shredders and waste shredders. Combined with the advantages of the device and the support of relevant national policies, the device has broad application prospects.

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